Abstract Book

Hydrocephalus2023

Hamburg, Germany | **Aug 25-28**

The Fifteenth Meeting of the Hydrocephalus Society

www.hydrocephalus-meeting.com

Hydrocephalus Society

International Society for Hydrocephalus
and Cerebrospinal Fluid Disorders

Hydrocephalus2023

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Hydrocephalus 2023 - The Fifteenth Meeting of the International Society for Hydrocephalus & Cerebrospinal Fluid Disorders, Hamburg, Germany, 25-28/08/2023 has been accredited by the European Accreditation Council for Continuing Medical Education (EACCME®) with 21 European CME credits (ECMEC®s).

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Each participant can only receive the number of credits he/she is entitled to according to his/her actual participation at the event once he/she has completed the feedback form.

Meeting President's Welcome Address

Dear Friends and Colleagues,

It is my great pleasure and honor to welcome you to Hydrocephalus 2023 in Hamburg, Germany – the 15th Meeting of the Hydrocephalus Society.

We had a highly successful meeting in Gothenburg, Sweden last year, and we acknowledge that topping such a mega event will be a challenge. Nonetheless, we have made enormous efforts to organize an exciting and memorable event for you in Hamburg.

The venue is the newly renovated Congress Center of Hamburg, conveniently located within walking distance from the city center and in the neighborhood of "Planten and Blomen," an evergreen leisure park in the middle of the city.

We are thrilled to have received almost 250 submissions from all of you – the highest number ever. Furthermore, we are thrilled to announce the could add a number of special sessions featuring world-renowned speakers, covering a diverse range of topics such as pediatric neurosurgery, cutting-edge insights into pathophysiology, treatment complications, hydrocephalus and spinal stenosis, and even a dedicated session on hydrocephalus in cats and dogs. Additionally, we are delighted to have a joint session with the EANS focusing on Arnold Chiari malformations.

Hamburg is the second-largest German city, with approximately 5 million inhabitants in the metropolitan area. It is a verdant city offering ample opportunities for relaxation during your free time. Among its many cultural highlights, the famous concert house "Elbphilharmonie" stands out as just one of the hundreds of cultural hotspots.

Make sure not to miss our official meeting dinner on the "Louisiana Star" boat – a relaxing cruise through Hamburg's picturesque harbor, providing fantastic scenery and excellent networking opportunities.

The success of this conference depends greatly on your active participation!

On behalf of the Hydrocephalus Society and the local organizers, I sincerely thank you for attending the 15th Meeting of the Hydrocephalus Society in Hamburg!

Sincerely yours,

Uwe Kehler
Hydrocephalus 2023 President
President of the Hydrocephalus Society

Meeting President

Uwe Kehler

Meeting Scientific Chair

Sevil Yasar

International Organizing Committee

Mark Hamilton
Giorgio Palandri
Mats Tullberg
Richard Edwards
Benjamin Elder
Carolyn Harris
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Fernando Gomes Pinto
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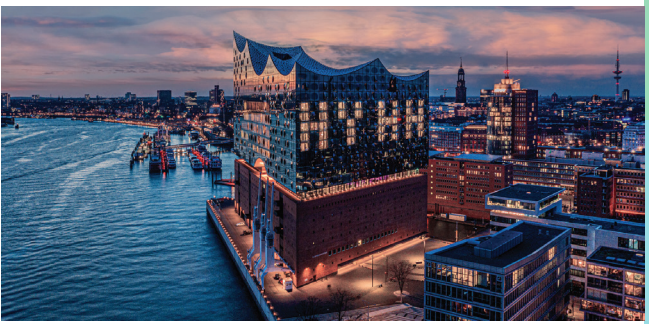

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International Society for Hydrocephalus and Cerebrospinal Fluid Disorders

Program Overview

Friday, August 25th 2023

Pre Meeting Seminar

CCH - Hall A

12:30 - 16:15	Normal Pressure Hydrocephalus - PreMeeting Educational Seminar

Saturday, August 26th 2023

CCH - Foyer

07:00 - 08:00	Registrations

CCH - Hall G

08:00 - 08:30	Opening of the Meeting
08:30 - 09:00	Session 1: Marmarou Lecture
09:00 - 10:00	Session 2: Pediatric Hydrocephalus

CCH Hall D

09:00 - 10:00	Session 3: Adult Hydrocephalus Oral Presentations

CCH - Foyer

10:00 - 10:30	*Coffee Break & Exhibition*

CCH Hall G

10:30 - 11:40	Session 4: Young Investigators Awards I
11:40 - 12:40	Hydrocephalus Society Annual General Meeting
12:40 - 13:50	Industry Sponsored Lunch Seminar
13:50 - 15:30	Session 5: Physiology of CSF Circulation

CCH - Hall D

13:50 - 15:20	Session 6: Congenital and Pediatric Hydrocephalus Oral Presentations

CCH - Foyer

15:30 - 16:15	*Coffee Break & Exhibition*

CCH - Hall G

16:15 - 17:45	Session 7: NPH and Spinal Stenosis - A chicken/egg problem? - Roundtable

CCH - Hall D

16:15 - 17:40	Session 8: Experimental Hydrocephalus Oral Presentations

Sunday, August 27th 2023

CCH - Hall G

08:30 - 09:00	Session 9: Hydrocephalus in Animals
09:00 - 10:15	Session 10: Young Investigators Awards II
10:15 - 10:45	Special Session: ChatGPT jeopardy

CCH - Hall D

09:00 - 10:30	Session 11: Adult Hydrocephalus Oral Presentations

CCH - Foyer

10:45 - 11:20	*Coffee Break & Exhibition*

CCH - Hall G

11:20 - 12:40	Session 12: Neuroimaging
12:40 - 13:50	Industry Sponsored Lunch Seminar
14:00 - 15:30	Session 15: Hydrocephalus Society - EANS Joint Session on Arnold Chiari

CCH - Hall D

11:35 - 12:40	Session 13: Adult Hydro cephalus/ Clinical Symptoms, differential diagnosis - Oral Presenta tions
13:50 - 15:50	Session 16: Technical Advances in Treatment and Diagnostics Oral Presentations

CCH - Hall E

11:35 - 12:40	Session 14: Technical Advances in Treatment and Diagnostics Oral Presentations
13:50 - 15:40	Session 17: Adult Hydrocephalus Oral Presentations

CCH - Foyer

15:50 - 16:20	*Coffee Break & Exhibition*

CCH - Hall G

16:00 - 17:30	Session 18: NPH Guidelines - Update on recent developments

CCH - Hall D

16:20 - 17:40	Session 19: Intracranial Pressure Oral Presentations

CCH - Hall E

16:20 - 17:30	Session 20: Adult Hydrocephalus Oral Presentations

Monday, August 28th 2023

CCH - Hall G		CCH - Hall D		CCH - Hall E	
08:00 - 09:15	Session 21: Adult Hydrocephalus - CSF leaks and ICP hypotension	08:00 - 09:15	Session 22: Adult Hydrocephalus Oral Presentations	08:00 - 09:15	Session 23: Adult Hydrocephalus Oral Presentations
09:15 - 10:15	Session 24: Technical Advances in Treatment and Diagnostics Oral Presentations	09:15 - 10:15	Session 25: Idiopathic Intracranial Hypertension Oral Presentations	09:15 - 10:15	Session 26: Neuroimaging Oral Presentations

CCH - Foyer

10:15 - 11:00	*Coffee Break & Exhibition*

CCH - Hall G		CCH - Hall D		CCH - Hall E	
11:00 - 12:30	Session 27: Shunt Complications	11:00 - 12:30	Session 28: Oral Flash Presentations of e-Posters	11:00 - 12:30	Session 29: Oral Flash Presentations of e-Posters
12:30 - 13:40	Industry Sponsored Lunch Seminar				
13:40 - 15:10	Session 30: NPH: Diagnostics and treatment for all? - Thinking globally	13:40 - 15:20	Session 31: Oral Flash Presentations of e-Posters	13:40 - 15:15	Session 32: Oral Flash Presentations of e-Posters
15:25 - 16:25	Session 33: Closing of the Hydrocephalus Meeting				

Detailed Program

Friday, August 25th 2023

Pre Meeting Seminar

CCH - Hall A

12:30 - 16:15	**Normal Pressure Hydrocephalus - PreMeeting Educational Seminar** **Chairs: Uwe Kehler, Mats Tullberg, Sevil Yasar**
12:30 - 13:00	Welcome and get together
13:00 - 13:10	Introduction to NPH **Uwe Kehler**
13:10 - 13:20	Symptoms and signs **Mats Tullberg**
13:20 - 13:30	Radiology **Karin Kockum**
13:30 - 13:40	Supplementary tests **Giorgio Palandri**
13:40 - 13:50	Treatment - Insertion of the ventricular catherer **Mitsuhito Mase**
13:50 - 14:00	Treatment - Surgical techniques of VP-shunts **Laurence Watkins**
14:00 - 14:10	Treatment - Surgical techniques of VA-shunts **Fernando Hakim**
14:10 - 14:20	Treatment - Surgical techniques of LP-shunts **Yasuaki Inoue**
14:20 - 14:30	Complications **Uwe Kehler**
14:30 - 15:00	***Coffee Break***
15:00 - 15:10	Longitudinal care **Uwe Kehler**
15:10 - 15:20	Outcome **Michael Fritsch**
15:20 - 15:30	Is age only a number for the treatment of NPH? **Sevil Yasar**
15:30 - 15:35	Why is NPH underdiagnosed **Mats Tullberg**
15:35 - 15:40	Why is NPH undertreated **Uwe Kehler**
15:40 - 16:15	Discussion

Saturday, August 26th 2023

CCH - Foyer

07:00 - 08:00	**Registrations**

CCH - Hall G

08:00 - 08:30	**Opening of the Meeting** **Chairs: Uwe Kehler, Mats Tullberg, Giorgio Palandri, Sevil Yasar**
08:00 - 08:15	**Welcome Address** **Uwe Kehler - Hydrocephalus Society and Hydrocephalus 2023 President**
08:15 - 08:30	**NPH, the Historical Perspective** **John Pickard**
08:30 - 09:00	**Session 1: Marmarou Lecture** **Chair: Uwe Kehler**
08:30 - 09:00	**The Journey through CSF** **Laurence Watkins**
09:00 - 10:00	**Session 2: Pediatric Hydrocephalus** **Chairs: Ulrich Thomale, Sylvia Shitsama**
09:00 - 09:20	**New Developments in the Treatment of Pediatric Hydrocephalus** **Ulrich Thomale**
09:20 - 09:30	**Differences in treatment of Pediatric and Adult Hydrocephalus** **Richard Edwards**
09:30 - 09:40	**Pediatric Hydrocephalus in East Africa** **Sylvia Shitsama**
09:40 - 09:50	**Non-invasive Techniques for assessing to ICP in Hydrocephalus** **Llewellyn Padayachy**
09:50 - 10:00	Discussion

CCH Hall D

09:00 - 10:00	**Session 3: Adult Hydrocephalus Oral Presentations** **Chairs: Nicole Keong, Jenny Larsson**
	Abstracts for this session are on pages 37-42
09:00 - 09:10	Idiopathic Normal Pressure Hydrocephalus (iNPH) is common among noneagenarian in the Takahata Cohort **Chifumi Iseki**
09:10 - 09:20	iNPH in advanced age: profiling patients through quantitative variables. **Liliana Mazza**
09:20 - 09:30	Prevalence of idiopathic normal pressure hydrocephalus in older adult population in Shanghai, China—A population-based observational study **Xuhao Fang**
09:30 - 09:40	In 2023 is NPH still underdiagnosed? The social and economic burden of the problem **Gianpaolo Petrella**

09:40 - 09:50	Levels of inflammatory cytokines MCP-1, CCL4 and PD-L1 in CSF differentiate idiopathic normal pressure hydrocephalus from neurodegenerative diseases **Madeleine Braun**
09:50 - 10:00	A model of normal pressure hydrocephalus as a disorder of intracranial thermodynamics **Michael Egnor**

CCH - Foyer

10:00 - 10:30	***Coffee Break & Exhibition***

CCH Hall G

10:30 - 11:40	**Session 4: Young Investigators Awards I** **Chairs: Sevil Yasar, Mats Tullberg**
	Abstracts for this session are on pages 43-49
10:30 - 10:40	Anti-biofouling self-cleaning ventricular catheter for hydrocephalus patients **Haritosh Patel**
10:40 - 10:50	Polyvinylpyrrolidone-coated catheters decrease choroid plexus adhesion and Improve flow/pressure performance in an In-vitro model of hydrocephalus **Jordan Davies**
10:50 - 11:00	Directed topographical changes to reduce cellular adhesion and ventricular wall pull in **Aaron Gonzales**
11:00 - 11:10	An In-vitro setup for testing of ventricular catheters under physiologic and pathophysiologic flow rates (Virtual) **Ahmad Faryami**
11:10 - 11:20	Novel 3D printed microfluidic chip for hydrocephalus treatment: Fabrication and in vitro evaluation **Seunghyun Lee**
11:20 - 11:30	Computer vision pipeline to synchronize cranio-spinal pressures with posture in chronic in-vivo trials **Anthony Podgorsak**
11:30 - 11:40	Prolonged spaceflight alters intracranial tissues, fluids and ccular morphology **Katherine Warthen**
11:40 - 12:40	**Hydrocephalus Society Annual General Meeting**
12:40 - 13:50	**Industry Sponsored Lunch Seminar**
13:50 - 15:30	**Session 5: Physiology of CSF Circulation** **Chairs: Ahmed Thoma, Mark Luciano**
13:50 - 14:05	**Physiology of CSF Circulation** **Mirsolav Vukic**
14:05 - 14:20	**Glymphatics** **Per Kristian Eide**
14:20 - 14:35	**What can imaging tell about CSF Physiology** **Shigeki Yamada**
14:35 - 14:50	**Pathophysiology of Normal Pressure Hydrocephalus** **Mats Tullberg**

14:50 - 15:05	**NPH - Why does a shunt work?** **Anders Eklund**
15:05 - 15:30	Discussion

CCH - Hall D

13:50 - 15:20	**Session 6: Congenital and Pediatric Hydrocephalus Oral Presentations** **Chairs: Sylvia Shitsama, Kristopher Kahle, Richard Edwards**
	Abstracts for this session are on pages 50-57
13:50 - 14:00	Modeling congenital hydrocephalus genes SMARCC1 and TRIM71 in the Xenopus model system **Ergin Deniz**
14:00 - 14:10	Genetic determinants and molecular mechanisms of human cerebral ventricular size and congenital hydrocephalus **Kristopher Kahle**
14:10 - 14:20	Cerebrospinal fluid oscillations and cerebral blood flows in hydrocephalus premature infants who have had intraventricular hemorrhage **Olivier Baledent**
14:20 - 14:30	CSF-based extracellular vesicle signaling and related T-cell activation mediate the pathogenesis of post-hemorrhagic hydrocephalus **Pat McAllister**
14:30 - 14:40	The aetiological distribution of paediatric hydrocephalus in Asia: a systematic review and meta-analysis **Eleanor Ferris**
14:40 - 14:50	Patterns of clinical presentation of pediatric hydrocephalus at The National Center for Neurological Sciences 2017-2021 (Virtual) **Nidaa Ahmed**
14:50 - 15:00	“Virtual Off” on CertasPlus programmable valve… Not really off: Serendipitous clinical utility in patients with over-drainage symptoms **Michael Muhonen**
15:00 - 15:10	Adjustable ventriculoperitoneal shunt valve for the treatment of hydrocephalus in newborns **Thomas Freiman**
15:10 - 15:20	Discussion

CCH - Foyer

15:30 - 16:15	***Coffee Break & Exhibition***

CCH - Hall G

16:15 - 17:45	**Session 7: NPH and Spinal Stenosis - A chicken/egg problem? - Roundtable** **Chairs: Jan Malm, Giorgio Palandri**
16:15 - 16:35	**Lumbar Spinal Canal Stenosis and Hydrocephalus** **Luca Papavero**
16:35 - 16:55	**Cervical Spinal Stenosis and Hydrocephalus** **Benjamin Elder**
16:55 - 17:15	**Hydrocephalus and Spinal Canal Stenosis – the Influence on CSF Dynamics** **Anne Benninghaus**
17:15 - 17:45	Panel Discussion

CCH - Hall D

16:15 - 17:40	**Session 8: Experimental Hydrocephalus Oral Presentations** **Chairs: Carolyn Harris, Pat McAllister, Olivier Baledent**
	Abstracts for this session are on pages 58-65
16:15 - 16:25	What can be learned from hydrocephalus induction failures? **Maria Garcia Bonilla**
16:25 - 16:35	Modulation of TLR-calpain pathway may prevent acquired hydrocephalus **Lenadro Castaneyra Ruiz**
16:35 - 16:45	Brain pathologic change due to ciliary dysfunction in chronic hydrocephalus model mice **Kaito Kawamura**
16:45 - 16:55	Exploring the influence of catheter materials on neuroinflammation and the intracranial microbiome **Mark Luciano**
16:55 - 17:05	Acute hydrocephalus and cortical neurodegeneration in Dnah5 knockout mice: exploring mechanisms and pathogenesis **Koichiro Sakamoto**
17:05 - 17:15	In-vitro evaluation of shunt valve flow dynamics **Gwendolyn Williams**
17:15 - 17:25	Quantitative analysis of flow and pressure changes through explanted biobank ventricular catheters (Virtual) **Ahmad Faryami**
17:25 - 17:35	A flow optimized ventricular catheter; flow redistribution, shear reduction, and reduced astrocytic activation **Ahmad Faryami**
17:35 - 17:40	Discussion

Sunday, August 27th 2023

CCH - Hall G

08:30 - 09:00	**Session 9: Hydrocephalus in Animals** **Chairs: Uwe Kehler, Pat McAllister**
08:30 - 08:50	**Internal Hydrocephalus in Dogs and Cats - From Animal Models to Veterinary Neurosurgery and Back** **Martin Schmidt**
08:50 - 09:00	Discussion
09:00 - 10:15	**Session 10: Young Investigators Awards II** **Chairs: Ben Elder, Anne Benninghaus**
	Abstracts for this session are on pages 66-73
09:00 - 09:10	Age at time of surgery does not influence the outcome in Idiopathic Normal Pressure Hydrocephalus – A population-based study **Christine Chidiac**
09:10 - 09:20	Prevalence of idiopathic normal-pressure hydrocephalus in Sweden - a population- based study of clinical and MRI findings in 70-year-olds **Clara Constantinescu**
09:20 - 09:30	Vascular risk factors, causes of death and 10-year mortality in INPH **Sanna Eklund**
09:30 - 09:40	Smartphone monitoring of multidomain gait parameters to facilitate remote monitoring of gait in Normal Pressure Hydrocephalus **Aida Kamalian**
09:40 - 09:50	Genome-wide association study in 1022 idiopathic normal pressure hydrocephalus patients **Joel Rasanen**
09:50 - 10:00	Aquaporin 4 in CSF in a large iNPH-cohort **Johan Eriksson De Ryst**
10:00 - 10:10	Endoscopic third ventriculostomy versus Ventriculoperitoneal shunt in the treatment of normal pressure hydrocephalus, Preliminary results of a randomized approach **Loay Shoubash**
10:10 - 10:15	Discussion

CCH - Hall D

09:00 - 10:30	**Session 11: Adult Hydrocephalus Oral Presentations** **Chairs: Kyunghun Kang, Michael Williams, Thomas Freiman**
	Abstracts for this session are on pages 74-82
09:00 - 09:10	Cerebrospinal fluid and intracranial blood rapid interactions in normal pressure hydrocephalus **Olivier Baledent**
09:10 - 09:20	Characteristics of human meningeal lymphatic vessels **Per Kristian Eide**
09:20 - 09:30	Urinary Incontinence and Normal Pressure Hydrocephalus: Some clues for what is still uncertain **Isabella Mejia Michelsen**

09:30 - 09:40	Multi-domain assessment of gait at baseline visit in Idiopathic Normal Pressure Hydrocephalus (iNPH) **Megha Patel**
09:40 - 09:50	Audiovestibular symptoms in shunted idiopathic Normal Pressure Hydrocephalus **Mark Luciano**
09:50 - 10:00	AQP4 levels in CSF correlates with clinical severity in iNPH patients. A preliminary report **Francesco Tuniz**
10:00 - 10:10	Does ventriculomegaly correlate with intelligence and cognition? Neuropsychological findings and profile in longstanding overt ventriculomegaly of adults (LOVA) **Lucia Darie**
10:10 - 10:20	Cerebrospinal fluid formation rate in normal pressure hydrocephalus **Sara Qvarlander**
10:20 - 10:30	Reproducibility of The Timed 10 meter walking test in Normal Pressure Hydrocephalus (Virtual) **Kanza Tariq**

CCH - Hall G

10:15 - 10:45	**Special Session: ChatGPT jeopardy**
10:15 - 10:45	Interactive discussion with the attendees **Sevil Yasar, Richard Edwards**

CCH - Foyer

10:45 - 11:20	***Coffee Break & Exhibition***

CCH - Hall G

11:20 - 12:40	**Session 12: Neuroimaging** **Chairs: Shigeki Yamada, Karin Kockum, Katharina Wolf**
	Abstracts for this session are on pages 83-89
11:20 - 11:35	**Advances in 3D and 4D Imaging of Cerebrospinal Fluid and AI-Based Diagnosis of DESH** **Shigeki Yamada**
11:35 - 11:45	Distinct cerebral cortical microstructural changes in idiopathic normal-pressure hydrocephalus **Kyunghun Kang**
11:45 - 11:55	Radiological morphological features and the associated intracranial pressure waveform components of idiopathic normal pressure hydrocephalus **Matthias Jaeger**
11:55 - 12:05	Reversibility of the radiological signs of raised intracranial pressure following intraparenchymal brain tumour resection (Virtual) **Kanza Tariq**
12:05 - 12:15	Iron-sensitive MR imaging of substantia nigra in normal pressure hydrocephalus. A quantitative approach **Lubin Klotz**
12:15 - 12:25	Respiratory and cardiac signal analysis of CSF dynamics in normal pressure hydrocephalus and Alzheimer's disease **Petrice Cogswell**

12:25 - 12:35	Structural volumetric and periodic table DTI patterns in Complex Normal Pressure Hydrocephalus – towards the principles of a translational taxonomy **Nicole Keong**
12:35 - 12:40	Discussion

CCH - Hall D

11:35 - 12:40	**Session 13: Adult Hydrocephalus/Clinical Symptoms, differential diagnosis - Oral Presentations** **Chairs: Neill Graff-Radford, Laurence Watkins, Lucia Darie**
	Abstracts for this session are on pages 90-94
11:35 - 11:45	The relationship between dual-task cost and cognitive performance among patients with probable idiopathic Normal Pressure Hydrocephalus **Elizabeth Cray**
11:45 - 11:55	Diffusion Tensor Imaging helps identify shunt-responsive Normal Pressure Hydrocephalus patients amongst probable iNPH cohort **Adela Bubenikova**
11:55 - 12:05	Long-term care in older person suspected of iNPH **Eric Schmidt**
12:05 - 12:15	Thirty years of experience in CSF dynamics testing in adult hydrocephalus **Zofia Czosnyka**
12:15 - 12:25	Cognitive changes after Tap Test in patients with Normal Pressure Hydrocephalus **Isabella Mejia Michelsen**
12:25 - 12:40	Discussion

CCH - Hall E

11:35 - 12:40	**Session 14: Technical Advances in Treatment and Diagnostics Oral Presentations** **Chairs: Ki Su Park, Bryn Martin, Fabian Fluerenbrock**
	Abstracts for this session are on pages 95-100
11:35 - 11:45	Use of non-invasive ICP waveform monitoring in a CSF collection laboratory: experience and learning points **Raphael Bertani**
11:45 - 11:55	In vivo performance of the Kitea ICP System **Sarah-Jane Guild**
11:55 - 12:05	Validation of the Kitea ICP monitoring system over 6 months in sheep **Sang Ho Kim**
12:05 - 12:15	Safety of the Kitea ICP implant in the growing brain **Sarah-Jane Guild**
12:15 - 12:25	AI-trained mixed reality head-mounted display to place ventricular catheters -preliminary data **Martin Mersch**
12:25 - 12:35	Comparison of conventional- und robotic endoscopic third ventriculostomy in occlusive hydrocephalus **Thomas Freiman**
12:35 - 12:40	Discussion

CCH - Hall G

12:40 - 14:00	**Industry Sponsored Lunch Seminar**
14:00 - 15:30	**Session 15: Hydrocephalus Society - EANS Joint Session on Arnold Chiari** **Chairs: Mansoor Foroughi, Giorgio Palandri**
14:00 - 14:20	**Defining Chiari, Chiari/Syrinx Aetiology & Surgery Techniques (Redo Surgery) (Virtual)** **Andrew Brodbelt**
14:20 - 14:40	**Surgical Principles, Risks, and Challenging Cases of Syringomyelia** **Marcus Stoodley**
14:40 - 15:00	**Complex Chiari/Redo Surgery & MIS Technique** **Paolo Bolognese**
15:00 - 15:30	Discussion

CCH - Hall D

13:50 - 15:50	**Session 16: Technical Advances in Treatment and Diagnostics Oral Presentations** **Chairs: Richard Edwards, Ki Su Park, Martin Mersch**
	Abstracts for this session are on pages 101-111
13:50 - 14:00	Unravelling mechanisms driving ventricular catheter obstruction - a multicenter shunt biobank approach (Virtual) **Prashant Hariharan**
14:00 - 14:10	Blood GFAP, NFL and abeta42/40 Correlate Modestly With CSF levels in iNPH But Do Not Predict Short Term Response To CSF Diversion **Abhay Moghekar**
14:10 - 14:20	Watkins 2.0: the next generation In Gait-Assessment apps For Normal Pressure Hydrocephalus And decompensated long-standing overt ventriculomegaly Patients (Virtual) **Kanza Tariq**
14:20 - 14:30	Quantitative measurement of finger tapping before and after the tap test in idiopathic normal pressure hydrocephalus **Yoko Shimizu**
14:30 - 14:40	Machine learning analysis of voice data from patients with normal pressure hydrocephalus **Ki-Su Park**
14:40 - 14:50	Optimizing Gait and Balance Metric Acquisition from The “Tap Test” in Normal Pressure Hydrocephalus **Philip Tipton**
14:50 - 15:00	LP shunt in the patients with iNPH : Surgical technique **Naoyuki Samejima**
15:00 - 15:10	Neuralgia after Lumboperitoneal Shunt Can Be Reduced with Surgery under Local Anesthesia **Yasuaki Inoue**
15:10 - 15:20	Influence of ventricular size and surgical approach on flow distribution in ventricular catheters **Cristopher Roberts**
15:20 - 15:30	Impact of shunt placement in CSF dynamics **Olivier Baledent**
15:30 - 15:40	Shunt testing in vivo: Performance of Certas Valve integrated with SiphonGuard **Marek Czosnyka**
15:40 - 15:50	Discussion

CCH - Hall E

13:50 - 15:40	**Session 17: Adult Hydrocephalus Oral Presentations** **Chairs: Laurence Watkins, Masakazu Miyajima, Stefanie Kaestner**
	Abstracts for this session are on pages 112-121
13:50 - 14:00	Prognostic Significance Of Cerebrospinal Fluid production rate In Idiopathic Intracranial Hypertension and the impact of medical therapy (Virtual) **Kanza Tariq**
14:00 - 14:10	The PUMCH Evaluation System of Idiopathic Normal Pressure Hydrocephalus and Clinical Practice **Junji Wei**
14:10 - 14:20	Consistency and sensitivity analysis of instrumental and traditional methods for evaluating the CSF tap test (CSF-TT) responsiveness in patients with iNPH. **Chunyan Liu**
14:20 - 14:30	CSF dynamics in long-standing overt ventriculomegaly in adults **Alessandro Pirina**
14:30 - 14:40	Effectiveness of the Clock Drawing test in the Tap Test **Koichi Miyazaki**
14:40 - 14:50	Efficacy and safety of a novel programmable valve (Sphera Pro®) in the treatment of idiopathic normal pressure hydrocephalus: a multicenter study. **Rodolfo Reis**
14:50 - 15:00	Shunting for idiopathic Normal Pressure Hydrocephalus: a Cochrane Systematic Review **Christopher Carswell**
15:00 - 15:10	Placebo–controlled effectiveness in INPH shunting (PENS) – Study Update **Mark Luciano**
15:10 - 15:20	Safety of Ventriculoperitoneal Shunt Placement in Patients with Idiopathic Normal Pressure Hydrocephalus in the Setting of Systemic Anticoagulation **Benjamin Elder**
15:20 - 15:30	Frailty and medium-term overall survival following ventriculoperitoneal shunting for patients with idiopathic Normal Pressure Hydrocephalus **Elisabeth Cray**
15:30 - 15:40	Discussion

CCH - Foyer

15:50 - 16:20	***Coffee Break & Exhibition***

CCH - Hall G

16:00 - 17:30	**Session 18: NPH Guidelines - Update on recent developments** **Chairs: Mats Tullberg, Michael Williams**
16:00 - 17:30	**Update on NPH Guidelines** **Mats Tullberg**

CCH - Hall D

16:20 - 17:40	**Session 19: Intracranial Pressure Oral Presentations** **Chairs: Marek Czosnyka, Aruna Rao**
	Abstracts for this session are on pages 122-129
16:20 - 16:30	Analysis of Intracranial Pressure Pulse Shape Index in Normal Pressure Hydrocephalus **Magdalena Kasprowicz**
16:30 - 16:40	Oscillation of ICP during walking is locked to head motion **Eleanor Moncur**
16:40 - 16:50	Cut-off point of the noninvasive measurement of intracranial compliance for the diagnosis of idiopathic Normal Pressure Hydrocephalus **Gabriel Mendes**
16:50 - 17:00	Relationship between body mass index and intracranial pressure waveform components in a cohort of patients with suspected idiopathic normal pressure hydrocephalus **Matthias Jaeger**
17:00 - 17:10	Prediction of optimal ICP level to achieve normalization of pulse amplitude **Leon Gramms**
17:10 - 17:20	Characteristics of the M.scio Telemetric ICP Measurement System with Lumbar Catheter **Anders Eklund**
17:20 - 17:30	Early feasibility study of implantation of a telemetric ICP sensor in a commercial spaceflight participant **Michael Williams**
17:30 - 17:40	Effect of shunt adjustment on short term telemetric ICP readings **Karina Hoffmann**

CCH - Hall E

16:20 - 17:30	**Session 20: Adult Hydrocephalus Oral Presentations** **Chairs: Madoka Nakajima, Per Kristian Eide, Giorgio Palandri**
	Abstracts for this session are on pages 130-135
16:20 - 16:30	Age-stratified presentation and outcomes of ventriculoperitoneal shunt implantation in a cohort of normal pressure hydrocephalus (NPH) patients **Zeid Abussuud**
16:30 - 16:40	Effective shunt surgery for elderly patients after a fall with definite idiopathic normal pressure hydrocephalus can prevent the following fall **Ryo Oike**
16:40 - 16:50	Comparison of female and male outcomes in a cohort of normal pressure hydrocephalus (NPH) patients undergoing ventriculoperitoneal shunt implantation **Zeid Abussuud**
16:50 - 17:00	Baseline PROMIS Score Characteristics and Temporal Changes Following Shunt Placement in Patients with Idiopathic Normal Pressure Hydrocephalus **Benjamin Elder**
17:00 - 17:10	Self-experienced outcome after shunt surgery in patients with idiopathic normal pressure hydrocephalus in relation with objective clinical outcome and preoperative factors **Johanna Rydja**
17:10 - 17:20	Long-term cognitive and gait outcomes after primary endoscopic third ventriculostomy (TV) in adults from the AHCRN with chronic obstructive hydrocephalus **Thomas Zwimpfer**

Monday, August 28th 2023

CCH - Hall G

08:00 - 09:15	**Session 21: Adult Hydrocephalus - CSF leaks and ICP hypotension** **Chairs: Ahmed Toma, Eleanor Moncur, Thomas Zwimpfer**
	Abstracts for this session are on pages 136-140
08:00 - 8:20	**Spontaneous intracranial hypotension and CSF venous fistula** **Parag Sayal**
08:20 - 08:30	Safety, sequelae, and efficacy of nerve root clipping in patients with spontaneous spinal CSF leaks. **Amir El Rahal**
08:30 - 08:40	Prognostic significance of cerebrospinal fluid production rate in the management of cerebrospinal fluid leak (Virtual) **Kanza Tariq**
08:40 - 08:50	Surgical closure of spinal CSF leaks improves symptoms in patients with superficial siderosis **Amir El Rahal**
08:50 - 09:00	CSF hydrodynamics in prolonged disorders of consciousness **Eric Schmidt**
09:00 - 09:10	Recovery and long-term outcome after neurosurgical closure of spinal CSF leaks in patients with spontaneous intracranial hypotension (SIH) **Amir El Rahal**
09:10 - 09:15	Discussion

CCH - Hall D

08:00 - 09:15	**Session 22: Adult Hydrocephalus Oral Presentations** **Chairs: Ben Elder, Daniele Rigamonti, Johan Virhammar**
	Abstracts for this session are on pages 141-147
08:00 - 08:10	Impact of Ventriculoperitoneal Shunt on Systemic Hypertension (Virtual) **Kanza Tariq**
08:10 - 08:20	Cognitive Improvement after Endoscopic Third Ventriculostomy Surgery in Long-standing Overt Ventriculomegaly in Adults **Daniele Piccolo**
08:20 - 08:30	Estimation of ventricular volume changes for smart shunt systems **Fabian Fluerenbrock**
08:30 - 08:40	Reversal of apparent cerebral atrophy (Cerebral Pseudoatrophy) in Normal Pressure Hydrocephalus patients who have undergone ventricular shunt surgery **Isabella Mejia Michelsen**
08:40 - 08:50	Transcranial direct current stimulation for cognition improvement in postoperative normal pressure hydrocephalus patients with programmable pressure valves: A pilot study **Tamires Giumaraes Cavalcante Carlos de Carvalho**
08:50 - 09:00	Shunt readmission rates and factors influencing them in hydrocephalus of all etiologies across the age spectrum **Abhay Moghekar**
09:00 - 09:15	Discussion

CCH - Hall E

08:00 - 09:15	**Session 23: Adult Hydrocephalus Oral Presentations** **Chairs: Llewellyn Padayachy, Mitsuhito Mase**
	Abstracts for this session are on pages 148-154
08:00 - 08:10	Mechanical complications of Sophysa SM8 shunt in adult hydrocephalus: a monocentric experience **Marta Arrighi**
08:10 - 08:20	Incidence and nature of complications associated with ventriculoatrial shunt placement: A meta analysis **Leonardo Oliveira**
08:20 - 08:30	After 15 years, what is changed in the knowledge of hydrocephalus? Survey of Harold O. Conn 15 years later **Gianpaolo Petrella**
08:30 - 08:40	Reducing Over-Drainage Complications in Idiopathic Normal Pressure Hydrocephalus **Adam Nunn**
08:40 - 08:50	Time to Resolution of NPH-associated Subdural Hematomas **Mark Luciano**
08:50 - 09:00	Abdominal pain after ventriculoperitoneal shunting for normal pressure hydrocephalus (NPH): prevalence, timeline, and impact of quality of life **Uwe Kehler**
09:00 - 09:10	Frequency of abdominal pain related to types of shunt tubing: The difference in the tubing (Virtual) **Kanza Tariq**
09:10 - 09:15	Discussion

CCH - Hall G

09:15 - 10:15	**Session 24: Technical Advances in Treatment and Diagnostics Oral Presentations** **Chairs: Anne Benninghaus, Kanza Tariq, Magnus Tisell**
	Abstracts for this session are on pages 155-159
09:15 - 09:25	Transendoscopic Ultrasound for Neuroendoscopy **Klaus D M Resch**
09:25 - 09:35	Choroid plexus-on-a-chip: a microfluidic model to study how cerebrospinal fluid secretion and blood-cerebrospinal fluid barrier function are affected by inflammation associated with hydrocephalus (Virtual) **Prashant Hariharan**
09:35 - 09:45	Patient-specific automated cerebrospinal fluid pressure control to augment spinal wound closure: A case series using the LIQUOGUARD (Virtual) **Kanza Tariq**
09:45 - 09:55	Validation and application of in silico and in vitro modeling to optimize cerebrospinal fluid drug delivery to the brain **Bryn Martin**
09:55 - 10:05	Quantification of Regional Neural Tissue Strain in Type I Chiari Malformation **Gwendolyn Williams**
10:05 - 10:15	Discussion

CCH - Hall D

09:15 - 10:15	**Session 25: Idiopathic Intracranial Hypertension Oral Presentations** **Chairs: Ignacio Jusue Torres, Abhay Moghekar**
	Abstracts for this session are on pages 160-165
09:15 - 09:25	Correlation of cerebrospinal fluid and plasma adipokines in obese versus non-obese idiopathic intracranial hypertension (IIH) patients **Sara Ho**
09:25 - 09:35	A comparison of outcomes between pediatric and adult patients with idiopathic intracranial hypertension (IIH) **Thaddeus Harbaugh**
09:35 - 09:45	Long-term outcomes after dural venous stenting in Idiopathic intracranial hypertension: a single centre experience **Muhammad Ahmad Kamal**
09:45 - 09:50	IIH Intervention: opening of a randomised clinical trial comparing Dural Venous Sinus Stenting with Cerebrospinal Fluid shunting in Idiopathic Intracranial Hypertension **Gopiga Thanabalasundaram**
09:50 - 10:00	ICP dynamics during movement in Chiari malformation and idiopathic intracranial hypertension **Eleanor Moncur**
10:00 - 10:10	Synthetic MRI: a fast and reliable method for ventricular volumetry **Rafael Holmgren**
10:10 - 10:15	Discussion

CCH - Hall E

09:15 - 10:15	**Session 26: Neuroimaging Oral Presentations** **Chairs: Madoka Nakajima, Ville Leinonen**
	Abstracts for this session are on pages 166-170
09:15 - 09:25	Non-invasive phase-contrast MRI in idiopathic intracranial hypertension - first promising data from a prospective study **Katharina Wolf**
09:25 - 09:35	Cerebral arterial dynamic in hydrocephalus patients **Kimi Owashi**
09:35 - 09:45	Intracranial CSF-ISF Flow Patterns in Large Animal Model **Mark Luciano**
09:45 - 09:50	Optic nerve sheath diameter distension in normal pressure hydrocephalus: a potential marker for shunt responsiveness **Linda D'Antona**
09:50 - 10:00	Potential impact of non-invasive phase-contrast MRI in the diagnosis of spontaneous intracranial hypotension **Katharina Wolf**
10:00 - 10:15	Discussion

CCH - Foyer

10:15 - 11:00	***Coffee Break & Exhibition***

CCH - Hall G

11:00 - 12:30	**Session 27: Shunt Complications** **Chairs: Uwe Kehler, Mats Tullberg**
11:00- 11:05	**Announement Honorary Member: Hazel Jones** **Introduction: Mats Tullberg, Uwe Kehler**
11:05 - 11:20	**Avoidable Complications in Hydrocephalus** **Stefanie Kaestner**
11:20 - 11:30	**Complications of Ventricular Shunt Placement** **Mitsuhito Mase**
11:30 - 11:40	**Complications of VA Shunts** **Giorgio Palandri**
11:40 - 11:50	**Complications of VP Shunts** **Fernando Hakim**
11:50 - 12:00	**Complications of LP Shunts** **Ahmed Toma**
12:00 - 12:30	Panel Discussion
12:30 - 13:40	**Industry Sponsored Lunch Seminar**

CCH - Hall D

11:00 - 12:30	**Session 28: Oral Flash Presentations of e-Posters** **Chairs: Fernando Pinto, Eric Schmidt, Nina Sundstroem**
	Abstracts for this session are on pages 173-191
11:00 - 11:05	Reversible dementia project (REVERT): impact on improvement in awareness, diagnosis and management of normal pressure hydrocephalus **Peter Smielewski**
11:05 - 11:10	Bowel and urinary incontinence in idiopathic normal pressure hydrocephalus **Andreas Eleftheriou**
11:10 - 11:15	Temporo-spatial gait parameters alteration after tap test in patients with idiopathic normal pressure hydrocephalus **Sunee Bovonsunthonchai**
11:15 - 11:20	Incidence and outcomes of chronic secondary hydrocephalus at a tertiary neurosurgical centre: a 3.5 year retrospective observational study **Fatema Rezai**
11:20 - 11:25	Expression analysis of motor activity related genes to predict idiopathic normal pressure hydrocephalus **Madoka Nakajima**
11:25 - 11:30	Long-term outcomes of normal pressure hydrocephalus patients with CSF shunt: A systematic literature review and meta analysis **Kim Wouters**
11:30 - 11:35	The incidence of postdural puncture headache by lumbar puncture in patients with hydrocephalus is lower than in younger patients **Masayuki Yamagishi**
11:35 - 11:40	Contemporary management of patients with normal pressure hydrocephalus (NPH) - an international survey **Ganesalingam Narenthiran**

11:40 - 11:45	Our preliminary experience on the combination of neuropsychological assessment and intrathecal pressure measurement to settle the diagnostic dilemma of the normal pressure hydrocephalus **Gianpaolo Petrella**
11:45 - 11:50	A multidisciplinary team approach to managing normal pressure hydrocephalus: insights from a new service at the Royal Victoria Infirmary **Ian Coulter**
11:50 - 11:55	Variation of intracranial pressure and pulse amplitude amongst different types of hydrocephalic conditions and cerebrospinal fluid dynamic disorders **Lucia Darie**
11:55 - 12:00	A decade of academic publications on NPH and IIH **Linda D'Antona**
12:00 - 12:05	Concussions and idiopathic normal pressure hydrocephalus: Is there a correlation? **Mack Hancock**
12:05 - 12:10	Low Pressure Hydrocephalus **Adela Bubenikova**
12:10 - 12:15	CSF biomarkers as predictive markers of outcome after CSF diversion in patients with normal pressure hydrocephalus **Zeid Abussuud**
12:15 - 12:20	Non-Invasive ICP Waveform Monitoring for Assessment and Treatment Response in CSF Hypotension due to Spontaneous Occult CSF Fistulas: A Case Series **Raphael Bertani**
12:20 - 12:25	Exploring neurophysiology through monitoring the ICP waveforms in shunted pregnant patients with a non-invasive device - a case series **Tamires Giumaraes Cavalcante Carlos de Carvalho**
12:25 - 12:30	Patients with normal pressure hydrocephalus have fewer enlarged perivascular spaces in the centrum semiovale **Aaron Switzer**

CCH - Hall E

11:00 - 12:30	**Session 29: Oral Flash Presentations of e-Posters** **Chairs: Mark Luciano, Bryn Martin**
	Abstracts for this session are on pages 192-207
11:00 - 11:05	Beyond antibiotics: the therapeutic benefits of ventricular irrigation for ventriculitis **Ahmed Al Menabbawy**
11:05 - 11:10	When you think the shunt is working, but it's not: Distal catheter obstruction in patients with ventriculoperitoneal shunt, a case series **Isabella Mejia Michelsen**
11:10 - 11:15	Exteriorization of a Ventriculoperitoneal Shunt through the urethra in a pediatric patient: Literature review and case report **Silvio De Oliveira Junior**
11:15 - 11:20	Deaths due to Hydrocephalus treatment in Brazil from 2012 to 2022 **Silvio De Oliveira Junior**
11:20 - 11:25	Is a Ventriculoatrial Shunt the first-line option for management of hydrocephalus in adult patients? **Isabella Mejia Michelsen**

11:30 - 11:35	Managing Shunt Dysfunction with Non-invasive Intracranial Pressure Waveform Monitoring **Raphael Bertani**
11:35 - 11:40	Trends in hydrocephalus and CSF dynamics disorders research: A qualitative analysis of the hydrocephalus society abstracts **Linda D'Antona**
11:40 - 11:45	Dural venous stenting for treatment of idiopathic intracranial hypertension **Petr Skalicky**
11:45 - 11:50	How change the vestibulo-oculomotor reflex (VOR) in NPH shunted patients: study on the use the Video Head Impulse **Gianpaolo Petrella**
11:50 - 11:55	mFI11 as a Predictor of Post-Operative Infections in Ventriculo-Peritoneal Shunt Surgery **Francesco Tuniz**
11:55 - 12:00	Callosal angle is more useful than Evans index for postoperative follow-up of normal pressure hydrocephalus **Hisayuki Murai**
12:00 - 12:05	Non-invasive P2/P1 Ratio Analysis as a Potential Auxiliary Diagnostic and Follow-up Criterion for Normal Pressure Hydrocephalus in Patients Undergoing Ventriculoperitoneal Shunt Surgery **Raphael Bertani**
12:05 - 12:10	Do Evans index and callosal angle correlate with neurological improvement after shunt surgery in idiopathic normal pressure hydrocephalus? **Rodolfo Reis**
12:10 - 12:15	Development of web-apps for calculating Evans' Index, iNPH Radscale, iNPH Scale and ETVSS **Ganesalingam Narethiran**
12:15 - 12:20	Is the valve really necessary in patients with normal pressure hydrocephalus? Lowering the opening pressure to zero - a prospective single center observational study. **Michele Dibenedetto**
12:20 - 12:25	A Review of Psychiatric and Cognitive Morbidity in Adult Idiopathic Intracranial Hypertension **Ian Coulter**
12:25 - 12:30	Discussion

CCH - Hall G

13:40 - 15:10	**Session 30: NPH: Diagnostics and treatment for all? - Thinking globally** **Chairs: Uwe Kehler, Michael Williams, Sylvia Shitsama**
13:40 - 13:50	**Introduction and: What is the Minimum we Need to Diagnose NPH** **Uwe Kehler**
13:50 - 14:00	**Affordable Imaging Techniques with High Predicable Values** **Karin Kockum**
14:00 - 14:10	**What is the Most Affordable but Still Acceptable Shunt Device?** **Fernando Pinto**
14:10 - 14:20	**What is the Age Limit for NPH Treatment?** **Sevil Yasar**
14:20 - 14:30	**Cost of Hydrocephalus Treatment in Developing and Low-Income countries** **Magnus Tisell**
14:30 - 15:10	Panel Discussion

CCH - Hall D

13:40 - 15:20	**Session 31: Oral Flash Presentations of e-Posters** **Chairs: Yasuaki Inoue, Anders Eklund**
	Abstracts for this session are on pages 208-224
13:40 - 13:45	Verification of the Stroop test Application Software for patients of idiopathic Normal Pressure Hydrocephalus **Chihiro Kamohara**
13:45 - 13:50	Evaluation of non-invasive ICP waveform and intracranial compliance monitoring technology in a pediatric neurosurgical outpatient clinic **Raphael Bertani**
13:50 - 13:55	What can the prevalence of pediatric hydrocephalus in Colombia - an upper-middle-income South-American country - tell us? **Isabella Mejia Michelsen**
13:55 - 14:00	Epilepsy in Hydrocephalus Patients (Virtual) **Mohammed Nooruldeen Jabbar**
14:00 - 14:05	Polyvinylpyrrolidone-coated Ventricular Catheter did not show Cellular Immunoreaction or Adhesion in Choroid Plexus Obstruction **Michael Muhonen**
14:05 - 14:10	Traumatic stress and shunt failure: a link between psychology and inflammation **Brandon Rocque**
14:10 - 14:15	Time course and Clinical Presentation variants for Cerebrospinal fluid diversion device failure in Slit ventricle syndrome. An observational study with 5 years follow up **Mohamed Alsawy**
14:15 - 14:20	Shift of blood and CSF volume between the intracranial and intraspinal compartments during positional change **Andreas Spiegelberg**
14:20 - 14:25	Volume changes in cerebral vascular and CSF compartments in hydrocephalus patients **Kimi Owashi**
14:25 - 14:30	Analysis of transcranial Doppler pulse waveforms in the diagnosis of hydrocephalus **Arkadiusz Ziolkowski**
14:30 - 14:35	Pulsatility and CSF flow resistance in patients with suspected idiopathic hydrocephalus **Olivier Baledent**
14:35 - 14:40	Two HTRA1-related autosomal dominant cerebral small vessel disease combined normal pressure hydrocephalus **Qiong Yang**
14:40 - 14:45	Assessing the relationship between ventricular catheter obstruction and flow using computational fluid dynamics and a multicenter clinical biobank **Christopher Roberts**
14:45 - 14:50	Shunting in normal pressure hydrocephalus: Are we reaching their full potential? **David Rowland**
14:50 - 14:55	The importance of hydrostatic compensation in lumboperitoneal shunts in Hydrocephalus communicans **August von Hardenberg**
14:55 - 15:00	Impact Of Global Warming On Brain Temperature (Virtual) **Kanza Tariq**
15:00 - 15:05	Craniometric points for ventricular access, analytical study between history and current trends **Ehab El Refaee**
15:05 - 15:20	Discussion

CCH - Hall E

13:40 - 15:15	**Session 32: Oral Flash Presentations of e-Posters** **Chairs: Sara Qvarlander, Zofia Czosnyka, Doerthe Ziegelitz**
	Abstracts for this session are on pages 225-242
13:40 - 13:45	Machine Learning-led Exploration of Imaging Biomarkers distinguishing NPH vs. controls: Pilot and Test Perturbations Reveal the Robustness of Feature Extraction **Nicole Keong**
13:45 - 13:50	Cerebrospinal fluid oscillations and cerebral blood flows during breathing **Olivier Baledent**
13:50 - 13:55	Monitoring patients with CSF disorders – potential use of phase-contrast MRI **Katharina Wolf**
13:55 - 14:00	Negative pressure Hydrocephalus and its great therapeutic challenge: Experience in our center **Patricia Barrio Fernandez**
14:00 - 14:05	Posterior Reversible Encephalopathy Syndrom (PRES) secondary to two cases of intracranial hypotension **Patricia Barrio Fernandez**
14:05 - 14:10	Bone Regrowth After Burr Hole Craniostomy: Establishing natural history and implications for post-operative trans-burr hole ultrasound **Mark Luciano**
14:10 - 14:15	Preclinical quality testing of the M.scio system for the early feasibility study of telemetric intracranial pressure monitoring in spaceflight **Andreas Bunge**
14:15 - 14:20	Slow waves of ICP and blood flow velocity in hydrocephalus **Marek Czosnyka**
14:20 - 14:25	Telemetric intracranial pressure recordings in patients with shunts for complex hydrocephalus **Ajmal Bin Hassan**
14:25 - 14:30	Changes in the shape of intracranial pressure pulse waveform correlate with cerebrospinal compliance during lumbar infusion tests **Agnieszka Kazimierska**
14:30 - 14:35	Phasic alertness and working memory improvements following lumbar puncture in iNPH patients differ from other age-associated cognitive syndromes **Nicolas Loebig**
14:35 - 14:40	Trends in ICP waveform in the early postoperative period: Does sedation play a relevant role? **Eleanor Moncur**
14:40 - 14:45	Exchange of Fixed Pressure Gravitational Unit to an Adjustable Gravitational Valve is Safe and Effective Procedure **Ivan Matvejevs**
14:45 - 14:50	Chiari malformation type 1 without hydrocephalus and third ventriculotomy **Ivona Nemeiko**
14:50 - 14:55	Cerebrospinal fluid tau biomarkers show strong potential in early selection for shunt surgery **Yan Xing**
14:55 - 15:00	Effect of shunt treatment on Epworth sleepiness scale score in normal pressure hydrocephalus **Simon Liden**
15:00 - 15:05	Cerebral Blood Flow and Autoregulation in Normal Pressure Hydrocephalus **Afroditi Lalou**

15:05 - 15:10	Explore the relationship between global white matter and idiopathic normal pressure hydrocephalus triad **Hongliang Li**
15:10 - 15:15	Discussion

CCH - Hall G

15:25 - 16:25	**Session 33: Closing of the Hydrocephalus Meeting** **Chairs: Uwe Kehler, Sevil Yasar, Mats Tullberg, Mitsuhito Mase, Jan Malm**
15:25 - 15:40	**Higlights from Hydrocephalus 2023** **Jan Malm**
15:40 - 15:50	**Announcement of the Young Investigators Awards Winners** **Sevil Yasar**
15:50 - 16:00	**Closing Address** **Uwe Kehler**
16:00 - 16:10	**Hydrocephalus Society Change of Presidency Ceremony** **Mats Tullberg, Uwe Kehler**
16:10 - 16:20	**Welcome to Hydrocephalus 2024** **Mitsuhito Mase**
16:20 - 16:25	**End of Hydrocephalus 2023** **Uwe Kehler**

e-Posters - All days - available through the mobile app and screens

Abstracts for this session are on pages 245-270

HYDROFLEX: THE USE OF PATIENT REPORTED OUTCOMES IN A CLINICAL SETTING AMONG PATIENTS WITH HYDROCEPHALUS
Anne Sofie Graversen

INFLAMMATORY MARKERS AS PREDICTORS OF SHUNT DEPENDENCY AND FUNCTIONAL OUTCOME IN PATIENTS WITH ANEURYSMAL SUBARACHNOID HEMORRHAGE
Marianne Juhler

NON-INVASIVE ASSESSMENT OF INTRACRANIAL PRESSURE AMONG OUTPATIENT SUBJECTS
Raphael Bertani

RISK FACTORS FOR SLIT VENTRICLE IN THE HYDROCEPHALUS CHILDREN TREATED WITH VENTRICULO-PERITONEAL SHUNT
Sadahiro Nomura

METABOLISMS REGULATING GENES OF CHRONIC HYDROCEPHALUS IN THE AGED HUMAN CAUDATE NUCLEUS
Joon Shim

AN INVESTIGATION OF THE USEFULNESS OF THE REY-15 COGNITIVE PERFORMANCE VALIDITY TEST, TO DETECT SUBOPTIMAL EFFORT ON PATIENTS WITH SUSPECTED INPH
Elizabeth Cray

ASSESSMENT OF POSTURAL STABILITY IN PATIENTS WITH IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS
Eunhee Park

DISTAL CATHETER MIGRATION IN VENTRICULOPERITONEAL SHUNT: GASTRIC PERFORATION AND SCROTAL MIGRATION - REPORT OF TWO UNCOMMON CASES
Patricia Barrio

GAIT IMPROVEMENT FOLLOWING CEREBROSPINAL FLUID TAP TEST IN NORMAL PRESSURE HYDROCEPHALUS PATIENTS WITH STRIATAL DOPAMINERGIC DEFICIT: A PRELIMINARY STUDY
Minju Kim

SLIT VENTRICLE WITHOUT SUBDURAL HEMATOMA AFTER VENTRICULO-ATRIAL SHUNT FOR INPH
Kiyoshi Takagi

IS NAUSEA DURING LUMBAR DRAINAGE A USEFUL PREDICTOR OF SHUNT RESPONSIVENESS?
Zeid Abussuud

EARLY EMERGENCE OF ISOLATED FOURTH VENTRICLE FOLLOWING MENINGITIS IN ADULT: A CASE REPORT
Han Lin Yen

DOES THE INTENSIVE CARE MONITOR SHOW THE CORRECT INTRACRANIAL PRESSURE? COMPARISON OF MONITOR OUTPUT VALUES WITH RAW DATA FROM HIGH-FREQUENCY RECORDINGS
Carl Benjamin Bluemel

THEOPHYLLINE A DRUG EFFICIENT TO INCREASE INTRACRANIAL PRESSURE: CASE REPORT AND REVIEW OF LITERATURE
Lucia Darie

SPINAL TUMOURS AS CAUSE OF NORMAL PRESSURE HYDROCEPHALUS: A CASE SERIES
Zeid Abussuud

SYNDROMIC VALIDITY OF INPH
Eric Schmidt

MANAGEMENT OF A MASSIVE LATERAL MYELOMENINGOCELE AND HYDROCEPHALUS: A SURGICAL PERSPECTIVE AND LITERATURE OVERVIEW
Ahmed Al Menabbawy

ABMS-2 EVALUATION IN INPH DIAGNOSIS
Masamichi Atsuchi

SHUNT-DEPENDENT POST-TRAUMATIC HYDROCEPHALUS: PREDICTORS AND LONG-TERM FUNCTIONAL OUTCOMES
Hao Xu

THE IMPACT OF A STANDARDIZED SURGICAL PROTOCOL ON SHUNT REVISION IN PEOPLE WITH IDIOPATHIC INTRACRANIAL HYPERTENSION AND A PRE-EXISTING SHUNT.
Yousra Rasool, Joseph Welch

LONG-TERM FUNCTIONALITY AND REVISION RATE OF TWO DIFFERENT SHUNT VALVES IN PEDIATRIC AND ADULT PATIENTS
Thomas Freiman

PACKAGING DESIGNS FOR MEDICAL DEVICE DRUG COMBINATION PRODUCTS - IMPACT ON REQUIRED STORAGE CONDITIONS AND SHELF-LIFE
Lucas Thieme

TECHNICAL ANALYSIS OF HYDROCEPHALUS SHUNT REVISIONS: HOW DO WE INVESTIGATE? WHAT DO WE LEARN? THE IMPORTANCE OF DATA FOR PATIENTS, CLINICS & INDUSTRY!
August von Hardenberg

NORMAL PRESSURE HYDROCEPHALUS AND CEREBRAL ATROPHY: A SCOPING REVIEW
Afroditi Lalou

MINIMAL INVASIVE NEUROSURGERY (MIN) AND OPHTHALMOLOGY: OBSERVATION SERIES OF COMPLEX HYDROCEPHALUS CASES
Klaus D M Resch

IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS IN A KLINEFELTER SYNDROME THE FIRST CASE IN THE LITERATURE
Gianpaolo Petrella

KEY CONCEPTS IN MIN: APPLICATION IN COMPLEX HYDROCEPHALUS
Klaus D M Resch

Announcing the Hydrocephalus Society Global Webinar Series 2023-2024: Adult CSF dynamics disturbances: Basics and Management

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Programme

Part 1: Adult Hydrocephalus; The basics
Saturday 11 Nov 2023, 17:00 CET

- CSF Physiology
- Anatomy & Histopathology
- Intracranial Pressure

Part 2: Adult Hydrocephalus; Diagnosis
Friday, 9 Dec 2023, 11:00 CET

- Biomarkers
- Imaging
- Infusion studies

Part 3: Acute Hydrocephalus
Saturday, 13 Jan 2024, 17:00 CET

- Clinical Picture and Diagnosis
- Principles of Shunt Surgery & ETV
- Work up of possible shunt malfunction

Part 4: NPH/Hakim's Disease: New International Guidelines
Friday, 10 Feb 2024, 11:00 CET

Part 5: NPH/Hakim's Disease: Differential Diagnosis
Saturday, 9 Mar 2024, 17:00 CET

- Clinical Features
- NPH vs AD
- NPH vs PD
- NPH vs PSP
- NPH vs Vascular Dementia

Part 6: Caring for NPH Patients
Friday, 13 Apr 2024, 11:00 CET

- Preoperative Counseling

Part 7: Other Chronic Hydrocephalus Conditions
Saturday, 11 May 2024, 17:00 CET

- Midlife hydrocephalus management
- Compensated hydrocephalus management
- Transitional hydrocephalus management
- Genetic Hydrocephalus management

Part 8: SIH and CSF leak
Friday, 8 June 2024, 17:00 CET

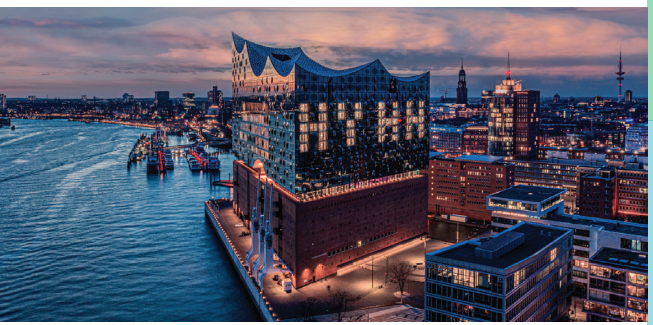
- Diagnosis
- Imaging
- Surgery
- Image guided intervention

Part 9: IIH and Chiari
Saturday, 13 Jul 2024, 17:00 CET

- IIH medical vs surgical management
- Chiari medical vs surgical management

Part 10: Colloid Cyst
Friday, 10 Aug 2024, 11:00 CET

- Basics
- Endoscopic Treatment
- Open surgical approach



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International Society for Hydrocephalus and Cerebrospinal Fluid Disorders

IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS (INPH) IS COMMON AMONG NONAGENARIANS IN THE TAKAHATA COHORT

Chifumi Iseki,[1,2] Yoshimi Takahashi,[3] Michito Adachi,[4] Shigenori Kanno,[1] Ryosuke Igari,[2] Hiroyasu Sato, [2] Kyoko Suzuki, [1] Takeo Kato, [5] Yasuyuki Ohta [2]

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INTRODUCTION: We aimed to discover the epidemiology of iNPH in nonagenarians.

METHODS: The cohort study, which analyzed gait, cognitive functions, and brain MRI or CT for all participants, started in 2000 when 272 at 70 in Takahata town participated. In 2022/2023, at age 92, of 102 living individuals, 78 participated in at least one interview alone or with their families to evaluate their clinical dementia rating (CDR) and modified Rankin scale (mRS). iNPH is diagnosed as having "possible iNPH with brain MRI support (defined by Japanese guidelines)," dementia of CDR > 1, and gait disturbance. The asymptomatic individual with findings of DESH (disproportionately enlarged subarachnoid space hydrocephalus) was called AVIM—asymptomatic ventriculomegaly with features of iNPH on MRI. DESH was defined as lateral ventricular enlargement (VE) plus tight high convexity (THC). When THC was not complete, we called it non-DESH iNPH. Imaging was retrospectively checked.

RESULTS: Sixteen individuals (16/78, 20.5%) were considered as iNPH—nine of DESH iNPH, five of non-DESH iNPH, and two suspected of the transitional periods from AVIM. Of the cohort, twenty individuals stayed in nursing homes; ten (10/20) were iNPH, and all except one presented the CDR of 3 and mRS of 5. Two individuals had Alzheimer's dementia several years before iNPH. In progression styles of iNPH, the THC-preceding, the VE-preceding type, and the unclassified were four, nine, and three individuals, respectively. Almost all individuals with AVIM in the study progressed, although some were asymptomatic for at least 20 years.

CONCLUSIONS: The disorder of the ventricular system may be common in people in their 90s. The major style of iNPH progression at ages > 85 was not from AVIM but from the VE-preceding type, which was difficult to recognize for both symptoms and brain imaging in each person.

INPH IN ADVANCED AGE: PROFILING PATIENTS THROUGH QUANTITATIVE VARIABLES.

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INTRODUCTION: Idiopathic Normal Pressure Hydrocephalus (iNPH) frequently affects people of advanced age. Gait and/or balance disturbance often occurs as the first symptom. For this reason, multiple scores are used to evaluate functional disability. The aim of the present study is to explore the gait and balance characteristics of iNPH subjects to define profiles of patients.

METHODS: Data for the present analysis were provided by the Bologna PRO-Hydro multidisciplinary team and include patients with diagnosed iNPH from 2014 to 2023. Variables of interest include demographic (age, education), clinical (Rankin score, iNPH Grading Scale), and functional (Tinetti, Timed Up and Go score - TUG) data collected for a subset of patients. Principal Component Analysis (PCA) was adopted to unveil the latent traits of these individuals, while a clustering technique (K-means) was carried out on the two main dimensions of PCA ("tandem" approach) to distinguish two different groups of subjects.

RESULTS: 138 patients with iNPH were included. The mean age was 75.4 years old (SD = 5.7) and 85 were males (62%). Gait disturbance was the first symptom in 57% of cases (79 patients), while balance disturbance was the first symptom in 20 patients (14%). Two main dimensions of PCA carried out on the six quantitative variables explained 63.5% of the total variability. The first dimension (45.1%) was mainly driven by clinical and functional scores (TUG, Tinetti, Rankin, iNPHGS) while, in the second dimension (18.4%), age and education were well represented. Cluster analysis designed two profiles of iNPH patients: those older, with worse functional scores, and those younger and/or educated with better performances.

CONCLUSIONS: Gait, balance and disability are the most relevant characteristics of subjects with iNPH. Nonetheless, age itself plays a non-negligible role, especially when combined with levels of education, to define iNPH patients' profiles.

PREVALENCE OF IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS IN OLDER ADULT POPULATION IN SHANGHAI, CHINA - A POPULATION-BASED OBSERVATIONAL STUDY

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INTRODUCTION: To explore the prevalence of modified probable idiopathic normal pressure hydrocephalus (m-probable iNPH) among the older adult population in Shanghai, China.

METHODS: From January, 2018 to July, 2022 cross-sectional survey of all retired older adults ≥ 60 years old from three large institutions in Shanghai was conducted. Their information including demography, clinical symptoms and brain imaging were collected. We calculated the total prevalence rate and the rate by age and sex of m-probable iNPH among the surveyed population and further estimated the disease prevalence in Shanghai.

RESULTS: The median age of the 1838 participants was 77.0 years (IQR: 86.0-66.0 years) ranging from 60-103 years old and the proportion of male was 61.5%. The overall prevalence of m-probable iNPH was 4.19%(77/1838), 3.37%(62/1838) and 2.34%(43/1838) respectively when DESH score≥4 or DESH score≥5 or DESH score≥6 was taken as the key imaging diagnostic standards, and it was 4.35%(80/1838), 2.99%(55/1838), 1.96%(36/1838) and 1.20%(22/1838) respectively when Radscale score≥5 or Radscale score≥6 or Radscale score≥7 or Radscale score≥8 was taken as the key imaging diagnostic standards. The prevalence differed between age groups and gender (P<0.001), it was much higher in male and was the highest in the 90-99 age group followed by 100-104 age group, and the third at the age of 80-89. After the adjustment for age and gender, the estimated prevalence rates of m-probable iNPH among the older adult population in Shanghai were 1.03% (53240/5187254) and 0.81% (42060/5187254), respectively when DESH score≥5 and Radscale score≥6 were taken as the key imaging diagnostic standards.

CONCLUSIONS: The prevalence of m-probable iNPH in older adult population was considerable, and it increased significantly with age; more diagnosis & treatment methods should be applied and prevention measurements should be paid to this disease that specifically exists in older adult populations.

IN 2023 IS NPH STILL UNDERDIAGNOSED? THE SOCIAL AND ECONOMIC BURDEN OF THE PROBLEM.

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INTRODUCTION: Normal Pressure Hydrocephalus (iNPH) is typically affects the elderly and, yielding to a cognitive decline, enters in a differential diagnosis with other neurodegenerative conditions. However, it is to consider underdiagnosed: this does not allow the patient to receive the right treatment and significantly affects quality of life and life expectancy.

METHODS: The present investigation is a in depth analysis of the real incidence of iNPH in the population of the province of our Hospital(circa 580000 individuals). The first phase of this study was conducted by visualizing a brain CT done in a week on the emergency department. We visualized a total of 308 brain CT scans performed on patients accessing for different complaints in the Emergency Departments of the four hospitals of our network and screened those suspicious for iNPH. Subsequently, the corresponding Emergency Department medical records were investigated, with the aim of understanding the medical history of each patients in search of elements attributable to an alteration of the CSF dynamics.

RESULTS: The cohort of positive CT scans, according to the radiological and clinical inclusion criteria included 48 patients. Among the reason to require acute medical care, "Fall" was the most common. The period prevalence of CT scans suggestive of iNPH among the patients undergoing CT scans was as high as 15.58% and the incidence calculated on the ground of the total amount of patients accessing the emergency departments was 1.084%.

CONCLUSIONS: The real incidence of iNPH in the population may be underestimated, and the social burden linked to the assistance of patients suffering from such untreated condition could be significantly relieved.

LEVELS OF INFLAMMATORY CYTOKINES MCP-1, CCL4 AND PD-L1 IN CSF DIFFERENTIATE IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS FROM NEURODEGENERATIVE DISEASES.

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INTRODUCTION: Neuroinflammation have been suggested to play a role in the pathophysiology of neurodegenerative diseases and posthemorrhagic hydrocephalus but have rarely been investigated in patients with idiopathic normal pressure hydrocephalus (iNPH). The aim of this study was to investigate whether the levels of inflammatory proteins in CSF are different in iNPH compared to healthy controls and patients with selected neurodegenerative disorders and whether any of these markers can contribute to the differential diagnosis of iNPH.

METHODS: Lumbar CSF was collected from 172 patients from a single center and represented iNPH (n=74), Alzheimer's disease (AD) (n=21), mild cognitive impairment (MCI) due to AD (n=21), stable MCI (n=22), frontotemporal dementia (n=13) and healthy controls (HC) (n=21). Levels of 92 inflammatory proteins were analyzed by proximity extension assay. Protein differences between iNPH and HC were compared in a second step with the other groups. The linear regressions were adjusted for age, sex, and plate number.

RESULTS: Three proteins showed higher (MCP-1, $p = 0.0013$; CCL4, $p = 0.00082$; CCL11, $p = 0.0022$) and one lower (PD-L1, $p = 0.0051$) levels in patients with iNPH compared with controls. Further MCP-1 was higher in iNPH than in all other groups. CCL4 was higher in iNPH than in all other groups except in MCI due to AD. PD-L1 was lower in iNPH compared with all other groups except in stable MCI. Levels of CCL11 did not differ between iNPH and the differential diagnoses. In a model based on the four proteins mentioned above, the area under the curve to discriminate between iNPH and the other disorders was 0.91.

CONCLUSIONS: The inflammatory cytokines MCP-1 and CCL4 are present at higher, and PD-L1 at lower, levels in iNPH than in the other investigated diagnoses. These three cytokines may have diagnostic potential in the work-up of patients with iNPH.

A MODEL OF NORMAL PRESSURE HYDROCEPHALUS AS A DISORDER OF INTRACRANIAL THERMODYNAMICS

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INTRODUCTION: The etiology of NPH remains obscure. Using flow MRI, investigators have shown that NPH is characterized by diminished CSF pulsatility in the subarachnoid space, increased CSF pulsatility in the ventricles, and increased pulsatility in the brain parenchyma compared with controls. This redistribution of CSF pulsatility is caused by restriction of wall motion in the large subarachnoid arteries due to arteriosclerosis, and ventriculomegaly is caused by increased pulse pressure on the periventricular white matter. The increase in brain pulsatility implies that NPH is a disorder of the cerebral windkessel. We have developed a thermodynamic model of the windkessel as a tuned band stop filter centered at the heart rate, and we apply this model to a new understanding of NPH based on MRI flow evidence.

METHODS: We use a simple tuned electrical tank circuit model of the cerebral windkessel. The effectiveness of the windkessel is (W is windkessel effectiveness, I is inertance which is the size of the pulse, E is the elastance of the CSF space, and R is the resistance to the pulse): We model NPH as a disorder of the cerebral windkessel by decreasing the windkessel inertance (which corresponds to diminished CSF pulsatility in the subarachnoid space caused by arteriosclerosis of large subarachnoid arteries) and increasing brain compliance (due to age-related brain atrophy)

RESULTS: Simulation shows decreased subarachnoid pulsatility, increased ventricular pulsatility, and increased brain parenchymal pulsatility.

CONCLUSIONS: NPH is characterized by high impedance to AC power in the subarachnoid CSF path due to arteriosclerosis and high subarachnoid CSF compliance due to brain atrophy, with redistribution of AC power to the ventricular CSF path and high amplitude pulsatile stress on the periventricular white matter. This can be simulated in a circuit model of the cerebral windkessel. We propose that NPH is a disorder of intracranial thermodynamics.

ANTI-BIOFOULING SELF-CLEANING VENTRICULAR CATHETER FOR HYDROCEPHALUS PATIENTS

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INTRODUCTION: Ventricular catheters (VCs) for treatment of hydrocephalus are fraught with high failure rates of obstruction and infection. We present a new VC optimization strategy that includes: liquid-infused materials that reduce risk of bacterial adhesion, in silico computational fluid dynamics (CFD) model to simulate catheter behavior in the ventricular space, and a novel curved flanged design that possess self-cleaning capability to remove biodebris.

METHODS: Broth of S. epidermidis, the most common pathogen leading to infections post-surgery, at 105 CFU/mL concentration was prepared to mimic bacterial meningitis, and incubated for 24 hours with flat sheets of various VC surfaces. An array of standard-of-care (SoC), commercially-available VCs were evaluated against our novel liquid-infused material, NuSil polydimethylsiloxane (PDMS) infused with 350 cP silicone oil, quantified by crystal violet optical density measurement taken at 570 nm. The self-cleaning ability of the catheter is developed in silico using CFD to achieve a design wherein fluid flow shear forces automatically detach any cellular debris.

RESULTS: The liquid-infused PDMS showed at least 90% reduction in bacterial adhesion ($P \leq 0.001$; n=6) compared to SoC materials. We developed an anatomically accurate CFD model which can mimic the conditions of varying degrees of hydrocephalic condition; this enabled the optimization of new catheter designs with curved flanges. CFD simulations of our curved flanged designs showed a 10-fold increase in shear forces which combined with the 90% decrease in detachment forces shown from prior studies of lubricous surfaces enables self-cleaning capabilities.

CONCLUSIONS: Preliminary results of the novel VC that possessed liquid-infused polymer and self-cleaning flange design showed promising outcome in reducing the chance of post-implantation infection and obstruction for treating hydrocephalus. Human astrocytes and microglial cell studies, as well as 4D-MRI fluid analysis are currently underway to further validate decreased adhesion and simulation accuracy, respectively.

POLYVINYLPYRROLIDONE-COATED CATHETERS DECREASE CHOROID PLEXUS ADHESION AND IMPROVE FLOW/PRESSURE PERFORMANCE IN AN IN-VITRO MODEL OF HYDROCEPHALUS

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INTRODUCTION: The leading cause of ventricular shunt failure in pediatric patients is proximal catheter obstruction, in which choroid plexus tissue is a putative causative agent. We evaluated various types of shunt catheters to assess in vitro cellular adhesion and obstruction when exposed to cultured choroid plexus epithelial cells.

METHODS: Four catheter types were tested: 1) antibiotic- and barium-impregnated, 2) polyvinylpyrrolidone coated (PVP), 3) barium stripe, and 4) barium-impregnated. Catheters were seeded with choroid plexus epithelial cells to test cellular adhesion and to test flow/pressure performance under cellular attachment conditions. Ventricular catheters were placed into a three-dimensional printed phantom ventricular replicating system through which artificial cerebrospinal fluid (CSF) was pumped. Differential pressure sensors were used to inflow and outflow pressures and catheter flow.

RESULTS: PVP catheters had the lowest median cell attachment (10 cells) compared to antibiotic-impregnated (230 cells), barium stripe (513 cells), and barium-impregnated (146 cells) catheters after culture ($p < 0.01$). In addition, PVP catheters (-0.494 cm H2O) and antibiotic-impregnated (-0.848 cm H2O) catheters had significantly lower pressure in the phantom ventricular system compared to the barium stripe (0.233 cm H2O) and barium-impregnated (0.353 cm H2O; $p < 0.01$) catheters.

CONCLUSIONS: PVP catheters showed less cellular adhesion and, together with antibiotic-impregnated catheters, required less change in pressure differential to maintain consistent flow. Our findings provide insight towards identifying materials that may experience less proximal catheter malfunction in ventricular shunts due to choroid plexus adhesion.

DIRECTED TOPOGRAPHICAL CHANGES TO REDUCE CELLULAR ADHESION AND VENTRICULAR WALL PULL IN

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INTRODUCTION: Ventricular shunt design has remained largely stagnant since it's early development. Perhaps the most widely used advancement is the implementation of antibiotic impregnated catheters. Although this application has helped to improve device functionality, our biobank of explanted catheters still suggests that cellular attachment, growth, and tissue infiltration are prominent issues within the hydrocephalus community. Herein, we discuss the effects of nano to macro scale topographical features on human astrocyte adhesion and ventricular wall pull in which can easily work in conjunction with anti-microbial agents to further reduce revisions rates.

METHODS: The relationship between topographical features and cell adhesion, proliferation, and activation was determined using a high-throughput design that allowed the testing of unique patterns under static environments. Human astrocytes were cultured on the surfaces and analyzed using immunofluorescence and ELISA. Additionally, the effect of macroscopic changes to the catheter surface was analyzed. The likelihood of tissue pull in to occur was investigated in vitro and with computer simulations.

RESULTS: The results showed that the topographical changes had an effect on astrocyte adhesion, proliferation, and activation. The degree of pull in of large ventricular wall tissue masses was manipulated by macroscopic size changes in surface structure. It was found that the likelihood of tissue pull in to occur was lower when these structures were utilized compared to the control.

CONCLUSIONS: The use of nano- to microscale topographical features to manipulate cellular effects to achieve a desired outcome is new to the field of hydrocephalus. We believe that this emerging field of mechanobiology and functional macrostructures can be used to create a new generation of highly engineered catheters that reduce adhesion and pull in. Most promising of all is that this technology can be used with antibiotic coating technologies with hardly any difference to the naked eye.

AN IN-VITRO SETUP FOR TESTING OF VENTRICULAR CATHETERS UNDER PHYSIOLOGIC AND PATHOPHYSIOLOGIC FLOW RATES

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INTRODUCTION: The mechanism of shunt failure is still not fully understood; A variety of methods including in-vitro experiments, in-vivo animal studies, and clinical studies have been utilized to identify the mechanism of obstruction formation that preludes shunt failure. These studies have primarily focused on endpoint analysis of the catheter without incorporating any dynamic, quantitative, or qualitative outcomes throughout the study. The absence of a tested and validated, long-term in-vitro model has significantly limited progress in understanding the pathogenesis of obstruction formation on ventricular catheters and improving treatment. Therefore, a novel setup was developed to recapitulate the relevant shear stresses and to investigate the interaction between immune cells and shunt hardware.

METHODS: The setup consisted of three main components: A control unit, positive displacement pumps, and bioreactor chambers. Computational fluid dynamics (CFD) simulations were utilized to design the bioreactor chambers. The capacity, consistency and long-term fluidic performance of 135 purpose-built bioreactor chambers were investigated. Physiologic and pathophysiologic CSF flow rates were simulated through the bioreactor chambers and the flow of CSF through a partially obstructed explanted catheter was visualized using confocal microscopy.

RESULTS: No leaks or ruptures were observed in bioreactor chambers. All chambers withstood 10 pressurization cycles to 140.7 cmH2O gauge pressure: significantly beyond the reported ICP domain (0-25 cmH2O) in most pediatric and adult hydrocephalus patients. There were no statistically significant differences between the bulk flow output of the setup at 0 Days, 15 Days, and 30 Days respectively.

CONCLUSIONS: the use of bioreactors as an intermediary between computer models and complex biological systems in the context of hydrocephalus treatment was previously proposed. This in-vitro setup is the first high-throughput testing platform for recapitulating patient-specific in-vivo conditions and rigorous real-time data collection across up to 50 concurrent channels.

NOVEL 3D PRINTED MICROFLUIDIC CHIP FOR HYDROCEPHALUS TREATMENT: FABRICATION AND IN VITRO EVALUATION

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INTRODUCTION: To overcome the limitations of current shunt systems, which are prone to catheter-related infections and blockages, innovative solutions are required. To this end, we introduce a new microfluidic chip that utilizes 3D printing technology constructed of biocompatible flexible resin, eliminating the need for catheters, and offering an alternative approach for the treatment of communicating hydrocephalus.

METHOD: The microfluidic chip is designed to shunt CSF from the subarachnoid space to a venous sinus. It has a ring-shaped structure at the inlet to prevent CSF backflow, sealing the inlet hole at low ICP and deflecting upwards when ICP surpasses the target chip opening pressure determined by device dimensions. Flow/pressure performance was measured across the chip under various inlet pressures (-100 to 100 cmH2O) with a flow rate of 450 µl/min. Astrocytes were cultured on the device to assess potential cell obstructions.

RESULTS: The microfluidic chip effectively served as an alternative shunt system in benchtop functional tests. In response to pressure changes due to input flow accumulation, the chip effectively drained excess flow with an opening pressure of 50 to 100 mmH2O and prevents backflow to at least -400 mmH2O. The chip also showed few cellular attachment and obstruction.

CONCLUSION: The study presents a promising microfluidic chip for the treatment of hydrocephalus, fabricated by 3D printing technology. The chip provides a solution to the limitations of current shunts with following novel functions: i) Enabling CSF shunting without catheters ii) Minimizing cellular blockage, and iii) Simplicity in design/fabrication process. Future studies will focus on in vivo experiments to validate the efficacy and safety of the chip in the treatment of hydrocephalus.

COMPUTER VISION PIPELINE TO SYNCHRONIZE CRANIO-SPINAL PRESSURES WITH POSTURE IN CHRONIC IN-VIVO TRIALS

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INTRODUCTION: Animal studies allow multimodal data to be acquired under more diverse conditions when compared to humans. Postural impacts on physiological pressures have been studied, however, a unified pipeline to synchronize, quantify, and analyze pressures to posture in chronic settings is not yet developed.

METHODS: A custom computer vision pipeline was developed. After pressure (via telemetric sensors) and video (via dual-camera stereoscopic setup) data are acquired, 15 2-Dimensional keypoints are detected on each frame and triangulated into 3-Dimensions. Three anatomical angles, (a) abdominal and (b) neck both relative to ground and (c) angle between neck and abdomen are calculated and synchronized with pressure data into a single dataset. Finally, the sheep's position is classified into seven buckets (standing, laying, walkup, walkdown, kneeling, sitting, other). 2/8 pressures are evaluated in three sheep: intracranial (ICP) and lumbar intrathecal (ITP) pressure. Average precision (AP) and percent correct classifications were used to evaluate the pipeline's performance.

RESULTS: The pipeline detected keypoints with an AP of 97.5. The position classifier classified positions with 95.2% accuracy (465/488 positions). Of the evaluated sheep, a Pearson correlation of −0.78 (0.74) was found between ICP (ITP) and angle (a) of 96.2±1.4° during chair postures. Similarly, correlations of −0.77 (0.39) were found between ICP (ITP) and angle (b) of 59.7±4.8° during walkup postures. During walkup and kneeling positions, angle (b) influenced ICP more strongly than angles (a) and (c) (−0.77 (b) vs. −0.33 (a) and −0.28 (c) during walkup and −0.62 (b) vs. −0.43 (a) and 0.13 (c) during kneeling).

CONCLUSIONS: The pipeline shows great promise and flexibility as an all-in-one analysis tool for multimodal datasets in chronic in-vivo trials. Insights gained from this pipeline can not only improve our understanding of cranio-spinal and adjacent physiology but also support the development of novel hydrocephalus shunts.

PROLONGED SPACEFLIGHT ALTERS INTRACRANIAL TISSUES, FLUIDS AND OCULAR MORPHOLOGY

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INTRODUCTION: Long duration spaceflight (LDSF) is known to affect both the eye and brain, although exact effects are still being quantified. Astronauts experience prolonged reduced gravitational pull, which can result in increased ventricular cerebrospinal fluid (CSF) volume, displacement of the posterior optic globe, and optic disc edema and choroidal engorgement along with brain structure alterations. We analyzed ophthalmic globe displacement, brain and CSF volumes, and brain and CSF shifts within the skull in a group of 11 astronauts (~6 months in space) compared to a group of healthy controls (n=10).

METHODS: We used a previously validated in-house method to automatically segment the eye. Brain and CSF tissues were automatically segmented using Charm. FSL was used to calculate volumes and center of gravity of each tissue type. A control group was used to determine both the reliability of the technique as well as how much natural variation may exist in healthy adults.

RESULTS: We found a significant increase in optic globe volume displacement among astronauts (p=0.002, mean=8.97mm3), and a lack of change among controls. Astronauts also showed significant increases in gray matter volume (p=0.007, mean=7.97cm3), trending increases in white matter volume (p=0.083, mean=5.96cm3) and an increase in lateral ventricular volume in all but one astronaut case (p=0.002, mean=3.2mL). We also observed a dorsal brain shift (p=0.04, mean=0.62mm) and ventral (p=0.001, mean=-2.24mm) and anterior total intracranial CSF shift (p=0.002, mean=1.03mm) as calculated by center of gravity. None of these changes were observed in the control group.

CONCLUSIONS: Long duration spaceflight was found to be associated with significant increases in ophthalmic globe displacement, brain volume and ventricle increases, as well as brain and CSF shift within the skull. This methodology could be applied to quantify brain and CSF shifts in a multitude of disorders, including hydrocephalus and idiopathic intracranial hypertension.

MODELING CONGENITAL HYDROCEPHALUS GENES SMARCC1 AND TRIM71 IN THE XENOPUS MODEL SYSTEM

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INTRODUCTION: Congenital hydrocephalus (CH), characterized by the pathological expansion of the brain ventricles, is a common birth defect affecting ~ 1/1000 births. Studies estimate that ~40% of cases have a genetic etiology, yet only a few candidate genes have been studied. TRIM71 and SMARRC1 have recently been identified as CH-risk genes. To analyze their role in hydrocephalus, we developed an innovative approach that leverages the genetically tractable frog Xenopus. The tadpole brain is semi-transparent, enabling Optical Coherence Tomography (OCT) imaging, which allows us to visualize the entire embryonic CSF circulation in 3D in real-time and can demonstrate the hallmarks of human hydrocephalus including aqueductal stenosis and ventriculomegaly. By combining CRISPR-based gene depletion with the Xenopus system's speed, low cost, and efficiency, we have transformed our ability to investigate candidate CH genes. Using the Xenopus model, we evaluated TRIM71 and SMARCC1 for hydrocephalus phenotypes.

METHODS: We generated trim71 and smarcc1 G0-Xenopus mutants using CRISPR/Cas9. Starting post-neurulation, we performed OCT imaging to analyze brain morphology to determine precisely when CH phenotypes develop and examined pathogenesis using in situ hybridization and immunofluorescence.

RESULTS: smarcc1 mutant tadpoles exhibited aqueductal stenosis that was transmitted to G1 mutant progeny. In contrast, when we depleted trim71, tadpoles developed severe ventriculomegaly. Both results phenocopied the core brain pathology of the patients. Neither gene affected CSF circulation, and further analysis revealed cortical and midbrain dysgenesis in both cases resulting from alteration of the expression of key transcriptional regulators involved in neuroprogenitor growth and proliferation.

CONCLUSIONS: We show that OCT imaging coupled with the Xenopus model system is an efficient platform to functionally screen candidate CH genes and improve our understanding of hydrocephalus pathogenesis. Our data further provide evidence that Xenopus SMARCC1 and TRIM71 affect early neurogenesis rather than CSF circulation, which may not be the primary defect in these subtypes.

GENETIC DETERMINANTS AND MOLECULAR MECHANISMS OF HUMAN CEREBRAL VENTRICULAR SIZE AND CONGENITAL HYDROCEPHALUS

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INTRODUCTION: The leading cause for pediatric neurosurgical intervention, congenital hydrocephalus (CH), affects 1/1,000 live births and is associated with neurodevelopmental disorders, but CH etiology remains mysterious. Currently, surgical cerebrospinal fluid (CSF) shunting or endoscopic third ventriculostomy procedures aimed at reducing CSF accumulation, are the mainstay of treatment for patients with CH. While these procedures could be lifesaving, they carry high rates of morbidity, complication, and failure, often requiring lifelong neurosurgical management. These outcomes reflect a poor understanding of the underlying pathogenic mechanisms governing.

METHODS: To advance our understanding of CH pathogenesis we performed an integrative analysis of exomes from 2,697 CH patient-parent trios as well as 1,798 control trio exomes, 848,020 single cell transcriptomes of the developing human brain, 432 histologically-verified developing brain tissue samples from post-conception week 9 to post-natal age 3, and artificial intelligence-assisted clinical phenotype profiling of proband medical records

RESULTS: We found damaging, de novo variants were significantly enriched in the CH cohort relative to control (P=3.03x10-122) with 35 genes reaching the threshold for genome-wide significance. Weighted genome correlation network analysis revealed significant enrichment of CH genes in processes related to epigenetic regulation and neuro-gliogenesis (P=7.36x10-48) in early/mid-fetal development (P=1.26x10-11). AI-assisted clinical phenomic and complementary risk gene homology analysis found significant enrichment for neurodevelopmental disorders (P=3.16x10-73) and hypotonia (P=7.72x10-71), with phenotypic frequency associated with variants in specific genes.

CONCLUSIONS: Together, these analyses suggest CH exists as a manifestation of a deeper insult to neurodevelopment, rather than simply a disease of CSF malabsorption. Moreover, in some cases correlated to specific risk genes, CH phenotypes may arise from impaired mid-fetal cortical neurogliogenesis and cell migration. Better patient outcomes can be realized by considering genomic factors in neurosurgical decision-making.

CEREBROSPINAL FLUID OSCILLATIONS AND CEREBRAL BLOOD FLOWS IN HYDROCEPHALUS PREMATURE INFANTS WHO HAVE HAD INTRAVENTRICULAR HEMORRHAGE

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INTRODUCTION: Intraventricular hemorrhage (IVH) in newborns induces hydrocephalus that must be treated surgically in the worst situations. Morphological MRI can describe the morphology of the brain and the bleeding location but cannot describe how active is the hydrocephalus. We previously have shown that Phase contrast MRI (PCMRI) can quantify neurofluids in newborn. Today our objective is to evaluate the IVH impact in CSF oscillations and blood flows in Hydrocephalus premature infants.

METHODS: 15 preterm infants born between 24 and 34 weeks of amenorrhea who had HVI underwent morphological MRI and PCMRI between 34 weeks of amenorrhea and 6 years. We quantified CSF flows in the aqueduct of Sylvius and in the spinal canal. In addition, we quantified cerebral arterial and venous blood flow.

RESULTS: Dilatations were bi, tri or tetra ventricular. The aqueduct was stenotic in 1 patient, of normal caliber in 5 patients and was widened in 9 patients. The CSF flow in the spinal canal was very low in 8 subjects, hyper dynamic in 1 and normal for the others. CSF flow in the aqueduct was null in 7 patients, very low in 4, normal and hyper dynamic respectively in 2. Morphological analysis of the spinal canal did not allow apprehending the PCMRI results. For the aqueduct the concordance was present in only 3 cases. Arterial Cerebral arterial blood flows varied function of age between 33 ml/min to 1162 ml/min and was correlated (R2=0.77) with jugular veins flows. Oscillatory spinal CSF volume correlated (R2=0.91) with cerebral volume expansion during cardiac cycle.

CONCLUSIONS: PC-MRI can quantify CSF and blood flows in the newborn within 5 minutes. It highlights CSF blockage or hyper dynamism when morphologic analysis does not. It provides complementary information to the morphological analysis that could be useful to understand the pathophysiology and help in surgical decision.

CSF-BASED EXTRACELLULAR VESICLE SIGNALING AND RELATED T-CELL ACTIVATION MEDIATE THE PATHOGENESIS OF POST-HEMORRHAGIC HYDROCEPHALUS

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INTRODUCTION: Preterm intraventricular hemorrhage (IVH) is closely associated with the development of post-hemorrhagic hydrocephalus (PHH), the most common cause of pediatric hydrocephalus in the industrialized world. PHH neuropathology is multifactorial and includes ventricular/subventricular zone (V/SVZ) disruption, inflammation, and subsequent eruption of cells into the cerebrospinal fluid (CSF). Extracellular vesicles (EVs) are involved in intercellular communication and may contribute to the neuropathogenesis of the disease. We hypothesized that CSF-based EV signaling and related CSF T-cell activation mediate the pathogenesis of PHH.

METHODS: EV and cell profiles from CSF of human neonates with PHH were compared to IVH grade 1-2, congenital hydrocephalus (CH), and controls (no known neurological injury). EVs were isolated and analyzed by mass spectrometry-based high-throughput proteomics. Cells were analyzed by single-cell RNA sequencing (scRNAseq) and flow cytometry. T-cell activation after EV exposure was studied in vitro by RNAseq, flow cytometry, and ELISA; and in post-mortem brain samples by immunofluorescence.

RESULTS: PHH CSF samples contained a significant increase in EV pro-inflammatory proteins compared to control and CH. Furthermore, monocytes/macrophages as well as a robust population of activated T-cells were detected in the CSF of PHH cases. EVs activated T-cells to produce the pro-inflammatory cytokines interleukin 1 beta (IL1β), IL6, and tumor necrosis factor-alpha (TNFα) in PHH. EV-mediated activation in T-cells occurred through the Nf-kB pathway. Finally, T-cell recruitment and the same cytokine production were detected in the choroid plexus of post-mortem IVH/PHH samples.

CONCLUSIONS: PHH is associated with increased pro-inflammatory EVs that can activate T-cells to produce pro-inflammatory cytokines, exacerbating the inflammatory milieu in the CSF and choroid plexus. Thus, neuroinflammation and modulation of stem cell biology for neural injury and repair after PHH may be mediated through EV signals and T-cells. Defining EV and cell profiling will lead to new directions to improve outcomes for patients with hydrocephalus.

THE AETIOLOGICAL DISTRIBUTION OF PAEDIATRIC HYDROCEPHALUS IN ASIA: A SYSTEMATIC REVIEW AND META-ANALYSIS

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INTRODUCTION: Understanding the aetiological distribution of hydrocephalus can inform clinical guidelines and public health decisions. Here, we present the first systematic review and meta-analysis on the aetiological distribution of paediatric hydrocephalus in Asia.

METHODS: We searched Embase, MEDLINE, CENTRAL, Global Health, Global Index Medicus and Scopus with no language restriction from inception to 27th January 2023. Observational or experimental studies with paediatric data on the causes of hydrocephalus in a country within Asia were included. Only studies that did not exclude participants based on the aetiology of hydrocephalus were included. We also searched the relevant grey literature. The aetiology of hydrocephalus was classified as postinfectious, non-postinfectious, dysraphism and unclear; pooled proportions were calculated, and subgroup analyses performed on pre-specified moderators.

RESULTS: 84 studies were included in the meta-analysis, containing data from 11359 children across 18 countries in Asia. A negative association existed between the proportion of postinfectious hydrocephalus and both human development index (-0.69 [95%CI: -1.03, -0.36], p<0.0001) and latitude (-0.0062 [95%CI: -0.011, -0.0016], p=0.0087). Low-middle income countries had a higher proportion of postinfectious hydrocephalus compared to high income (0.15 [95%CI: 0.056, 0.24], p=0.0016) and upper middle income (0.14 [95%CI: 0.043, 0.25], p=0.0052) countries. Cultural region accounted for 24.3% of between study heterogeneity for the proportion of postinfectious hydrocephalus with more postinfectious hydrocephalus in South Asia compared to East (0.19 [95%CI: 0.089, 0.29], p=0.0003) and West Asia (0.21 [95%CI: 0.11, 0.31], p<0.0001). In contrast, there was a greater proportion of hydrocephalus secondary to dysraphism in West Asia compared to East Asia (0.18 [95%CI: 0.0091, 0.36], p=0.040).

CONCLUSIONS: Geographical and economic characteristics account for significant heterogeneity in the aetiology of paediatric hydrocephalus across Asia. This has potential implications for regional guidelines on the management of paediatric hydrocephalus.

PATTERNS OF CLINICAL PRESENTATION OF PEDIATRICS HYDROCEPHALUS AT THE NATIONAL CENTER FOR NEUROLOGICAL SCIENCES 2017-2021

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INTRODUCTION: Hydrocephalus is an increase in CSF (Cerebrospinal Fluid) consequent to physical or functional obstruction, or increased CSF production leading to ventricular system enlargement. The worldwide incidence of HCP (Hydrocephalus) is more than 380,000, mainly in Africa, Latin America, and Southeast Asia. The disease can be classified as congenital and acquired (or secondary to e.g. hemorrhage, infection, or neoplasms), with the post-infective HCP being the most frequent etiology in pediatrics. Clinical presentation varies; in infants includes abnormally increasing head size, irritability, vomiting, bulging anterior fontanelle, and splaying of the cranial sutures, while beyond infancy, comprises headache, vomiting, loss of developmental milestones, diplopia, and papilledema. The principal investigation is brain imaging. The treatment involves CSF diversion; e.g. temporal with the use of external drains and permanent using the Ventriculoperitoneal Shunts.

METHODS: Hospital-based retrospective descriptive cross-sectional study at the National Center for Neurological Sciences (NCNS) in Khartoum, Sudan, including all pediatric cases aged 1 day to 18 years with HCP from years 2017 to 2021.

RESULTS: The study included 555 cases. The male-to-female ratio was 1.2:1. 471 cases (84.86%) presented between the age of one day to three years, mostly 148 were between 2-3 months. The commonest presenting symptom was abnormally increasing head size in 367 cases (66.13%), with a maximum head circumference of 81 centimeters. The most common type was congenital in 384 cases (69.19%), while the acquired was 160 cases (29%) with 74 obstructive due to neoplasms and 72 post-infective.

CONCLUSIONS: Hydrocephalus is considered to be a profounding problem in pediatrics in Sudan, with a distinctive clinical picture due to late presentation; significantly the enlarged head sizes, and in divergence from the literature, the dominant type was congenital enlightening the prospect of the genetic predisposition of this disease or the successful prevention and treatment efforts for the post-infective cases.

"VIRTUAL OFF" ON CERTASPLUS PROGRAMMABLE VALVE… NOT REALLY OFF: SERENDIPITOUS CLINICAL UTILITY IN PATIENTS WITH OVER-DRAINAGE SYMPTOMS

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INTRODUCTION: The Codman CertasPlusTM programmable valve is widely used for its range of 7 standard performance settings and a "virtual off" setting with a manufacturer described opening pressure of >400 mmH2O (Integra LifeSciences, Princeton, New Jersey, USA). To our knowledge, we describe the first reported cases utilizing the "virtual off" position to manage refractory over-drainage symptoms in two patients. We also analyzed the flow dynamics in-vitro and present these results.

METHODS: A 7-year-old male with a history of hydrocephalus and multiple ventriculoperitoneal shunt (VPS) revisions. He had a Codman CertasPlus programmable valve set at 4 adjusted upwards to settings of 5, 6, and 7. Patient presented with ongoing episodes of headache, nausea, and emesis. Head CT revealed minimal interval ventricular caliber change and his CertasPlus valve was reprogrammed to the "virtual off" position. The patient had complete resolution of his presenting symptoms. A 16-month-old female with shunted hydrocephalus presented with over-drainage symptoms. In a hospital setting, her VPS was adjusted serially upwards to a setting of 8 ("virtual off") and she demonstrated complete resolution of her symptoms.

RESULTS: Radiographic follow-up revealed an appropriate interval increase in size of ventricles. At the "virtual off" setting, there was no dramatic change in the degree of hydrocephalus. In-vitro testing of the CertasPlus valve showed the opening pressure of this valve to be about 550 mmH2O at a flow rate of 330 uL/min.

CONCLUSIONS: Management of over-drainage symptoms in patients with the "virtual off" setting on a CertasPlus valve demonstrated no clinical decline to suggest increased intracranial pressure at this setting. This would suggest that CSF drainage is achieved by intermittent physiologic events, causing CSF to flow appropriately through the shunt.

ADJUSTABLE VENTRICULOPERITONEAL SHUNT VALVE FOR THE TREATMENT OF HYDROCEPHALUS IN NEWBORNS

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INTRODUCTION: Ventriculoperitoneal shunts (VPS) with adjustable differential pressure valves are commonly used to treat hydrocephalus in infants under 6 months old. However, determining the optimal pressure valve values for these patients can be challenging. The aim of this study was to analyze the influence of VPS adjustable differential pressure valves on head circumference (HC) and ventricular size (VS) stabilization in infants with post intraventricular hemorrhage, acquired and congenital hydrocephalus.

METHODS: In this prospective study conducted for four years, 43 hydrocephalic infants under 6 months old were treated with a VPS with an adjustable differential pressure valve. HC and transfontanelle ultrasonographic VS measurements were regularly performed, and valve modifications were made when HC measurement was below the 10th percentile or exceeded the 90th percentile. The patients were divided into two groups based on the cause of hydrocephalus: intraventricular hemorrhage (IVH) and other etiologies (OE).

RESULTS: The results showed that the mean number of pressure valve modifications per patient was 4 cm H2O in the IVH group and 3 cm H2O in the OE group. The median of the last pressure valve value was higher at 8.5 cm H2O in the IVH group compared to 5 cm H2O in the OE group. This suggests that infants with IVH may need a higher pressure valve value compared to infants with OE. After a mean follow-up of 18 months and several pressure valve modifications, normalizing HC and VS was possible.

CONCLUSION: In conclusion, determining the optimal pressure valve value for infants with hydrocephalus can be challenging. However, this study suggests that long-term follow-up and several pressure valve modifications can lead to the normalization of HC and VS. Infants with IVH may require a higher pressure valve value compared to infants with OE.

WHAT CAN BE LEARNED FROM HYDROCEPHALUS INDUCTION FAILURES?

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INTRODUCTION: For more than a century, preclinical models of acquired hydrocephalus have been developed using a wide variety of induction methods and vertebrate species. Practically all are designed to promote ventriculomegaly. The most popular have been chosen in part to optimize the severity of ventriculomegaly, the yield of animals that exhibit hydrocephalus, and the overall cost of the experiments.

METHODS: This review seeks to summarize experimental induction methods and the extent of ventriculomegaly achieved, as well as the possible neurobiological mechanisms for the lack of ventriculomegaly.

RESULTS: The most widely-used induction methods include mechanical and/or inflammatory impairment of cerebrospinal fluid pathways (e.g., intracisternal kaolin) and intraventricular or intracerebral injections of blood or blood products. No induction methods produce ventriculomegaly in 100% of attempts, although many achieve 70-95% success rates. These "induction failures" are usually omitted from further analyses, and no reports have emerged that include these "negative" results, even though these brains have been subjected, at least for a short time, to perturbations that usually cause hydrocephalus. This is unfortunate, because much can be learned about the threshold for ventriculomegaly and the potential endogenous mechanisms that may counteract the cause and progression of hydrocephalus. Furthermore, the lack of research on induction failures avoids the fact that, depending on the primary event, a relevant number of patients subjected to the main causes of hydrocephalus do not develop this disorder. For example, only about 30% (published estimates vary) of children with documented intraventricular hemorrhage (IVH) develop post-hemorrhagic hydrocephalus. This correlates well with our 10-15% rate for infant ferrets with IVH that develop ventriculomegaly, and the 15% of juvenile pigs that do not develop ventriculomegaly post-kaolin.

CONCLUSIONS: Research into hydrocephalus "induction failures" is timely and should provide new insights into the causes and treatments for hydrocephalus.

MODULATION OF TLR-CALPAIN PATHWAY MAY PREVENT ACQUIRED HYDROCEPHALUS

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INTRODUCTION: Adherens junctions (AJ) disruptions are crucial in the pathogenesis of congenital hydrocephalus, as they affect the stability of the ventricular zone (VZ) and the endothelial cells. It has been reported in vitro, in vivo, and in postmortem human subjects that alterations in AJ are associated with the origin of acquired hydrocephalus. Recently, several authors have proposed inflammatory mechanisms as the primary trigger of acquired hydrocephalus. Thus, Toll-like receptors (TLR) recognize pathogen-associated molecular patterns (PAMPs) such as toxins or bacteria and damage-associated molecular patterns (DAMPs) like blood or blood subproducts as inflammatory triggers. Therefore, PAMPs and DAMPs are involved in the origin of postinfectious (PIH) and posthemorrhagic hydrocephalus (PHH). Calpains are intracellular proteases that activate when TLR detects DAMPS or PAMPS. Preliminary data support the hypothesis that calpains may underlie AJ cleavage under both conditions, PAMPs or DAMPs, as a fundamental trigger in the origin of hydrocephalus. This project aimed to modulate the TLR-Calpain pathway as a possible treatment to prevent acquired hydrocephalus

METHODS: Calpeptin (calpain inhibitor) was used to prevent VZ, endothelial disruption, and ventriculomegaly. The activity of this inhibitor was tested in 1-3 days old C57BL mice inoculated intraventricularly with LPS. After 15 days of treatment, histology was performed to evaluate the integrity of AJ and the viability of the VZ and endothelial cells. MRI was used to quantify ventricular volumes.

RESULTS: The inhibition of the TLR-Calpain pathway after LPS intraventricular injection significantly increased the mice's survival and reduced the ventricular volumes compared to untreated mice ($p<0.05$). Calpeptin also contributed to maintaining the integrity of the endothelial cells and the VZ.

CONCLUSIONS: This research opens the possibility of using calpeptin to treat acquired hydrocephalus.

BRAIN PATHOLOGIC CHANGE DUE TO CILIARY DYSFUNCTION IN CHRONIC HYDROCEPHALUS MODEL MICE

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INTRODUCTION: We have previously reported the DNAH14-/- mice model of a chronic hydrocephalus harboring ciliary dysfunction, that demonstrated chronic progression of ventriculomegaly followed by cognitive decline. Although ciliary dysfunction is known as a possible cause of hydrocephalus, its pathology remains unclear. The present study aims to evaluate brain pathologic changes in DNAH14-/- mice caused by ciliary dysfunction.

METHODS: To evaluate brain pathologic change in DNAH14-/- mice, we performed microarray analysis using hippocampus collected from 16 week-old mice, followed by reverse transcription qPCR (RTqPCR) using 8, 16, 24 and 48 weeks old mice for validation. To evaluate neuro inflammatory changes in hippocampus (CA1/2, CA3, hilus), we performed immunohistochemistry (GFAP and Iba1) to measure number of astrocyte and microglia using 48 weeks old mice.

RESULTS: Microarray analysis showed hypo-expression of RNA related to dopamine receptor (GPR88, DRD2) in DNAH14-/- mice compared with WT. RTqPCR showed decreased expression in both of GPR88 and DRD2 at 24 and 48 weeks, while not at 8 and 16 weeks. Immunohistochemistry showed increased number of GFAP or Iba1 positive cells in DNAH14-/- mice compared with WT in each region ($p=0.006$, 0.006, 0.003 for GFAP, <0.001, <0.001, 0.044 for Iba1, respectively).

CONCLUSIONS: DNAH14-/- mice showed hypo-expression of RNA related to dopamine receptors in 24 week-old mice. Immunohistochemistry showed neuro-inflammation in hippocampus of DNAH14-/- mice. As it was reported that hippocampus-entorhinal cortex network is engaged in spatial memory, these results are matching the cognitive decline in 24 week-old DNAH14-/- mice. From these results, impaired neuro-transmission due to neuro-inflammation in hippocampus can be considered a key pathology for cognitive decline in chronic hydrocephalus. The results from RTqPCR imply that impairment of neuro-transmission in DNAH14-/- mice is observed later in life and not congenitally, and has still unclear relation to ciliary dysfunction that will be clarified in future.

EXPLORING THE INFLUENCE OF CATHETER MATERIALS ON NEUROINFLAMMATION AND THE INTRACRANIAL MICROBIOME

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INTRODUCTION: Ventricular catheter obstruction remains one of the most frequent causes of shunt failure. Standard silicone or antibiotic infused (AI) – for infection reduction - catheter materials are commonly used, with unkown impact on obstruction mechanisms. Recent discovery of the brain's microbiome using intracranial 16sRNA detection allows evaluation of another potential modulator of the neuroinflammatory reaction. In this study we investigated the level of neuroinflammation in response to standard silicone and AI catheters using MRI and 16sRNA analysis.

METHODS: A total of 29 rodents were used in this study. Eight rodents in each group were implanted with either silicone or AI catheter fragments. Six rodents received sham-surgery where the catheter material was immediately removed. Seven controls without surgery were used. Two AI, two silicone implanted and one control subject were scanned on an 11.7 Tesla MRI with intravenous ferumoxytol contrast agent to stain activated macrophages at 1-, 4-, 8-, and 16-weeks post implantation. Analysis was performed on T2, flair and SWI sequences. Six rodents per group were perfused and sacrificed at 1- and 4-weeks post implantation for 16sRNA analysis.

RESULTS: Peri-implantation edema on MRI was similar in both implanted groups and resolved by week 4. AI implanted rodents had less macrophage activity on MRI than the silicone implant group after week 4. 16sRNA analysis showed an increase in the microbial class of Bacterioides (+50% in dominance), and a decrease of Beta- and Gammaproteobacteria (-18.7 and -17%) over the post-implant time. Negative controls and sham-surgery showed an inverse pattern, with a decrease of Bacterioides (-18%) and increase of Gammaproteobacteria (+22%).

CONCLUSIONS: In this pilot antibiotic impregnation demonstrated overall decreased levels of neuroinflammation, as indicated by macrophage activity, and an alteration of the brain microbiome. The relationship of these changes to incidence of catheter obstruction and infection rates is currently unknown.

ACUTE HYDROCEPHALUS AND CORTICAL NEURODEGENERATION IN DNAH5 KNOCKOUT MICE: EXPLORING MECHANISMS AND PATHOGENESIS

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INTRODUCTION: Hydrocephalus has been reported to occur due to dysfunction of ependymal cilia, as cilia are thought to contribute to the maintenance of cerebrospinal fluid circulation and ventricular morphology. Mice lacking Dynein axonemal heavy chain 5 (Dnah5), which is expressed in the outer arm of the cilia, develop cerebral aqueduct occlusion and acute hydrocephalus early after birth, leading to death within one month. We have created a Dnah5 knockout (KO) mice, observed the ventricles and cerebral parenchyma, and aimed to elucidate the mechanism of congenital hydrocephalus based on the morphological changes and cellular differences.

METHODS: Microarray analysis was performed on mouse brain tissue from 3-day-old mice before cerebral aqueduct occlusion to extract Target genes. We also performed pathological and histological evaluation of Dnah5 KO mice brain and analyzed ciliary movement.

RESULTS: We found that the number of neurons in the selected cortical area of the Dnah5 KO mouse brain was reduced by approximately 25%. Microarray analysis showed that mutations in the NeuroD6 gene pathway, which is involved in neural development, were strongly reduced. The expression of the dync1h1 gene encoding dynein, a motor protein involved in ciliary motility, was also found to be downregulated. Cytoplasmic dynein plays an important role in axon elongation and neuronal migration and development, but Dnah5KO mice showed significant increase in neuronal development defects. Fluorescent immunostaining showed the decrease of dync1h1 expression and the reduction of mature neurons.

CONCLUSIONS: The Dnah5 gene is involved not only in ciliary movement but also in the formation of brain parenchyma. Dnah5 KO mice are considered to have abnormalities in neuronal cells, with reduced neuronal density and enlarged ventricles from birth.

IN-VITRO EVALUATION OF SHUNT VALVE FLOW DYNAMICS

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INTRODUCTION: Hydrocephalus leads to over 30,000 shunt implantations in the US annually in both pediatric and adult populations. When valves are implanted in series, the expectation being that the opening pressures of each valve can be combined in an additive fashion to determine the overall equivalent resistance of the valves in series, though this hasn't been confirmed experimentally. Here, we developed an in-vitro shunt system to investigate flow dynamics of commonly implanted valves in isolation and in series.

METHODS: A gravity-driven in-vitro flow system at 37°C with a simulated ICP of 22 cmH2O and 60 cmH2O from valve to peritoneal cavity was built. Differential pressure (DPV) and gravitational (GV) valves were tested in isolation and series at various settings. The relationship between flow rate and the pressure drop across a valve is expressed with a valve coefficient (Kv). Results of isolated valve trials were used to calculated Kv for each valve, which were then used to calculate combined valve coefficients (Kvv) to predict flowrate of valves in series. Flowrate predictions were compared to experimental results.

RESULTS: In isolation, DP and GV valves had low intra- and inter-valve variability ($p > 0.05$). Valves in series had highly variable flowrates across trials and sets of valves in both supine and upright positions ($p < 0.05$). Using calculated Kvv to predict flowrates of valves in series, the average percent error was $15 \pm 7\%$ and $23 \pm 18\%$ in the supine and upright positions, respectively.

CONCLUSIONS: These results indicate low flowrate variability of isolated valves but high variability of valves placed in series. The unpredictable nature of valves in series seen here makes the theoretical models of additive opening pressures and Kvv seem insufficient. These findings underscore the difficulties faced by physicians in determination of optimal valve settings for shunted patients.

QUANTITATIVE ANALYSIS OF FLOW AND PRESSURE CHANGES THROUGH EXPLANTED BIOBANK VENTRICULAR CATHETERS

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INTRODUCTION: Although shunts are still the neurological devices with the highest failure rate, there are a limited number of methods that yield quick, quantifiable measures of catheter obstruction. A significant degree of inter-patient variation is observed in the frequency of shunt replacement surgeries. And intrinsic and extrinsic variables that impact the degree of shunt obstruction are unknown. The proposed setup is a simple and rapid method to measure the degree of obstruction in an explanted ventricular catheter.

METHODS: The setup is composed of two main components: Fluidic circuit and data acquisition. The data acquisition unit is controlled by a microcontroller and a custom-built program. The flow of distilled water or saline through the catheter is measured with pressure and flow sensors in real-time. The slope of the linear function indicates the resistance value for each test run. The obstruction of the catheters could also be defined as the time elapsed to run each experiment. The degree of obstruction of 80 explanted catheters was quantified and correlations between patient variables and measured resistance were investigated using machine learning. A predictive model was developed to estimate the relative resistance of the explanted catheters.

RESULTS: strong correlation was also observed between semi-quantitative analysis of lateral hole obstructions and relative resistance. A higher relative resistance was measured in catheters removed from neonatal patients compared to pediatric and adult patients. The difference in the relative resistance of catheters received from different centers was also statistically significant.

CONCLUSIONS: this study investigated the variation in the degree of shunt obstructions between explanted catheters in Harris Lab biobank. A significant degree of variation was observed among explanted catheters such that a considerable portion of explanted catheters were comparable to relative resistance of unused catheters. However, a few catheters were also completely obstructed, and no flow was observed.

A FLOW OPTIMIZED VENTRICULAR CATHETER; FLOW REDISTRIBUTION, SHEAR REDUCTION, AND REDUCED ASTROCYTIC ACTIVATION

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INTRODUCTION: Despite 60 years of research and development, shunts are still the neurological devices with the highest failure rate: more than 50% of the shunts fail only after two years of implantation. Our recent analysis of astrocyte cytokine secretion under shear stress revealed a statistically significant increase in pro-inflammatory IL-6 cytokine secretion. These data have pointed us toward attempts to reduce shear with a new shunt design.

METHODS: A catheter optimized to minimize shear was designed and evaluated in-silico. A batch of 10 PDMS catheters were produced, and the surface properties of the manufactured catheters were investigated using scanning electron microscopy. Protein adsorption was investigated in our in-vitro setup under physiologic flow rates.

RESULTS: The shear-optimized catheters demonstrated significantly more uniform distribution of flow through all the lateral holes in silico. Higher protein adsorption was observed in the proximity of the distal holes of catheters with the standard architecture compared to the shear-optimized catheter.

CONCLUSIONS: A truly optimized catheter is the implementation of various modifications to current catheters. This is a brief description of catheter profile with future computational optimization.

PREVALENCE OF IDIOPATHIC NORMAL-PRESSURE HYDROCEPHALUS IN SWEDEN - A POPULATION-BASED STUDY OF CLINICAL AND MRI FINDINGS IN 70-YEAR-OLDS

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INTRODUCTION: Earlier studies report divergent prevalence rates for idiopathic normal pressure hydrocephalus (iNPH), ranging from 0.2-8.9% depending on age-group, probably explained by differences in study sample selection and diagnostic criteria. This MRI-based study aimed to determine the prevalence of iNPH and iNPH-specific radiological changes and their association with clinical symptoms in a large 70-year-old population-based cohort.

METHODS: Data from the Gothenburg H70 Studies included 791 individuals (377 men, 414 women) born 1944 who underwent brain MRI. Disturbances in gait and balance, cognition, and urinary continence were assessed using clinical examination and self-report. Each MRI was evaluated for iNPH-specific imaging markers. Probable iNPH was diagnosed according to International Guidelines (I.G.)1. Further, based on radiological findings, participants were allocated to one of four groups: a. Evans' index (EI) ≤0.3 (reference); b. EI > 0.3 without other iNPH-typical radiological findings; c. Radiological probable iNPH according to I.G. without fulfilling holistic assessment-criteria of d; d. Radiological H-probable iNPH also fulfilling criteria for a highly iNPH-specific holistic classification by an experienced neuroradiologist in addition to I.G. probable iNPH radiological criteria.

RESULTS: The prevalence of iNPH was 1.5% (2.1% for males, 0.96% for females). Ninety participants (11%) had EI>0.3 without other iNPH-typical radiological findings, 29 (3.7%) fulfilled the I.G. radiological probable iNPH criteria alone, 11 (1.4%) were classified as radiological H-probable iNPH, i.e. 40 (5.1%) had radiological features of iNPH with a male preponderance (70% men vs 30% female, p=0.005). EI>0.3 was associated with gait disturbance when compared to the reference group (p=0.006). All clinical symptoms were significantly more common in participants fulfilling criteria for radiological I.G.-probable compared to the reference group (groups c+d, p<0.03).

CONCLUSIONS: The prevalence of iNPH was 1.5%, considerably higher than earlier reported in 70-year-olds. Clinical symptoms and being male were associated with iNPH-specific radiological findings. Ventriculomegaly was associated with gait disorder.

1 Relkin et al. 2005

AGE AT TIME OF SURGERY DOES NOT INFLUENCES THE OUTCOME IN IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS – A POPULATION-BASED STUDY

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INTRODUCTION: Idiopathic normal pressure hydrocephalus (iNPH) affects primarily elderly. Median age when diseased is approximately 70 years of age. Shunt surgery is the only effective treatment for this progressive disease. If there is any upper age limit for surgery has not yet been studied. In the Swedish Hydrocephalus Quality Register (SHQR) all patients from the seven university hospitals operated in Sweden for iNPH, are registered.

AIM: To investigate if outcome after surgery is declining with increasing age.

METHOD: Included in this study were all iNPH patients (n=3950) registered in the SHQR January 2004 – 10th of February 2022. Calculations on outcome on included patients divided into groups of 5 years, using the modified iNPH score (miNPH score), Timed Up and Go (TUG) and Modified Rankin Scale (MRS) used on age divided.

RESULTS: 3178 patients were included. The median age was 75 years (range 28.8 – 91.9; IQR 70.7 – 79.0). There were 1909 men and 1269 females. Their median age was 75.1 years (range 38.8 – 91.9; IQR 70.8 – 78.9) and 75.0 years (range 39.0 – 91.0; IQR 70.5 – 79.2) respectively (p= 0.9400 Wilcoxon Rank Sums). Approximately all patients were ASA-class 2 (n=1657) or 3 (n=1656). At three months there was no difference in outcome with increasing age or age group in regard to miNPH score. No difference was noted between favorable outcome (≥ +5 miNPH points) in different age groups or with increasing age.

CONCLUSION: This population-based study of iNPH patients in Sweden shows that there seems to be no correlation, positive or negative, between age at surgery and outcome.

Key words: Idiopathic Normal pressure hydrocephalus, age, outcome

VASCULAR RISK FACTORS, CAUSES OF DEATH AND 10-YEAR MORTALITY IN INPH

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INTRODUCTION: Idiopathic Normal Pressure Hydrocephalus (iNPH) have both higher mortality and higher prevalence of vascular risk factors (VRFs) compared to the population. INPH mortality studies deviate regarding which VRF that are most important for avoiding premature death. The aim of this study was to investigate 10-year mortality, cause of death and association between individual VRFs and mortality in iNPH.

METHODS: This prospective cohort study included 176 iNPH undergoing CSF shunt surgery, and 368 age- and sex-matched controls. At inclusion, participants were medically examined, had blood analysed for lipids, creatinine and glucose and answered a questionnaire. The VRFs investigated were smoking, diabetes, body mass index (BMI), blood pressure (BP), hyperlipidemia, kidney function, atrial fibrillation and, cerebro- and cardiovascular disease. Survival after surgery was followed for 10.3±0.84 years. Causes of death were categorised into disease groups using ICD-10. COX-regression and independent sample t-test were used for analysis.

RESULTS: iNPH had an increased risk of death compared to controls (hazard ratio (HR)=2.5, 95%CI 1.86-3.36; p<0.001). After 10 years, 50% (n=88) of INPH patients and 24% (n=88) of the controls were dead (p-value <0.001). Systolic BP (HR=0.985 95%CI: 0.972-0.997, p=0.018), atrial fibrillation (HR=2.652, 95%CI: 1.506-4.872, p<0.001,) and creatinine (HR=1.018, 95%CI: 1.010-1.027, p<0.001) were independently associated with mortality for iNPH. The most common cause of death in iNPH were diseases of the circulatory system (14%) and for controls neoplasm (7%) and diseases of the circulatory system (7%). Compared to controls, cerebrovascular disease, dementia and falls were overrepresented causes of death in iNPH (p<0.05).

CONCLUSIONS: INPH have a higher mortality than a matched population and the risk of lethal falls is imminent. Overrepresented causes of death in INPH are diseases of the circulatory system, cerebrovascular diseases and dementia, highlighting why vascular risk factors should be systematically assessed and treated in iNPH.

SMARTPHONE MONITORING OF MULTIDOMAIN GAIT PARAMETERS TO FACILITATE REMOTE MONITORING OF GAIT IN NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Gait dysfunction is a classic symptom of Normal Pressure Hydrocephalus (NPH). While current instrumented measures have focused on gait speed, we aimed to establish the reliability of smartphone monitoring of gait in NPH patients in three domains of gait using CDC recommended measures of gait function.

METHODS: We recruited 15 (mean age 73.5 ± 7.1) probable NPH patients undergoing large volume lumbar puncture (LVLP) or extended lumbar drainage (ELD) at Johns Hopkins to determine their eligibility for ventriculoperitoneal shunt surgery. We recorded their gait tests before and after the procedure using Mon4t application concurrent to the physiotherapists' (PT) assessments. The gait tests covered all three domains: Speed (Timed-Up-Go), balance (30-second sit-to-stand and 4-stage-balance test), and endurance (2-Minute-Walk Test). We used Pearson correlation and ANOVA tests for data analysis.

RESULTS: Results obtained with Mon4t app showed a significantly positive correlation with the PT results both in the absolute measures and the magnitude of change before and after procedure in each patient. Correlation coefficient for different gait tests included: Timed-Up-Go = 0.96, change in Timed-Up-Go = 0.87, 30-second sit-to-stand = 0.97, change in 30-second sit-to-stand = 0.73, 2-Minute-Walk test = 0.99 in ELD and 0.96 in LVLP settings, change in 2-Minute-Walk test = 0.8 (P-value < 0.05). Moreover, anteroposterior sway in the first stage of the balance test as measured by Mon4t increased in patients who were able to successfully finish more stages in the balance test (ANOVA p-value = 0.053).

CONCLUSIONS: The results of this pilot study suggest that smartphone monitoring of gait using the Mon4t Clinic application is a reliable and valid tool for assessing gait in NPH. The strong correlation between the results indicates that the app can be used as an adjunct to clinical assessment in the management of NPH if validated in an ongoing larger cohort.

GENOME-WIDE ASSOCIATION STUDY IN 1022 IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS PATIENTS

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INTRODUCTION: Large-scale genome-wide studies of idiopathic normal pressure hydrocephalus (iNPH) have been lacking. Here we conducted a genome-wide association study (GWAS) in iNPH to better understand the pathophysiology of iNPH.

METHODS: We used a Finnish population-specific and nationwide genotype database FinnGen. The database included altogether 1456 NPH patients (ICD-10 G91.2). To select iNPH patients we excluded the NPH patients with a potential known secondary etiology of the condition with a robust algorithm based on the disease history. The final analysis included 1022 iNPH patients and 426491 age-matched controls.

RESULTS: The GWAS found 3 novel genetic loci significantly ($p<5.0e-8$) to be associated with iNPH. These top hits were rs7962263 in SLCO1A2, rs10828247 in MLLT10 and rs798495 in AMZ1,GNA12. Additionally, the GWAS that included all the 1456 NPH patients found overall 7 significant loci ($p<5.0e-8$) associated with NPH. These were rs7962263 in SLCO1A2, rs561699566 in CDCA2, rs798495 in AMZ1/GNA12, rs10828247 in MLLT10, rs78534650 in ZNF423, rs11217863 in ARHGEF12 and rs4843226 in C16orf95.

CONCLUSIONS: This is the largest genome-wide study in iNPH so far. The GWAS found a genetic variation in the SLCO1A2, AMZ1/GNA12 and MLLT10 genes that were potentially associated with iNPH. These genes have been linked previously with the function of the blood-brain barrier and associated with increased lateral ventricle volume in the brain. Still, the exact mechanisms of these genes are unknown requiring further studies.

AQUAPORIN 4 IN CSF IN A LARGE INPH-COHORT

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INTRODUCTION: The glymphatic hypothesis postulates that AQP4 is a key component for the clearance of solutes e.g., β-Amyloid from the brain parenchyma. CSF AQP4 has been suggested as a biomarker for iNPH. However, results are conflicting. The objective of this study was to compare CSF levels of AQP4 between INPH and healthy elderly.

METHODS: The study population consisted of 285 patients (mean age 74 ± 6 years; 68% male) fulfilling diagnostic criteria according to the international guidelines for iNPH. The control group was 29 patients (mean age 73 ± 6 years; 38% male) going through hip surgery. AQP4-levels were analyzed with an antibody-based suspension bead array technique.

RESULTS: iNPH patients had lower CSF levels of AQP4, (mean signal intensity 1177 ± 266 AU) than controls (mean signal intensity 1351 ± 279 AU; $p = < 0.001$). No difference was seen in mean signal intensity in iNPH regarding sex (male 1213 ± 271 AU, female 1161 ± 269 AU; $p = 0.4$).

CONCLUSIONS: CSF levels of AQP4 are detectable with suspension bead array technique and are lower in iNPH patients than in age matched controls. In future studies we plan to analyze correlations between AQP4-levels and CSF dynamic parameters, MRI features as well as AD biomarkers.

ENDOSCOPIC THIRD VENTRICULOSTOMY VERSUS VENTRICULOPERITONEAL SHUNT IN THE TREATMENT OF NORMAL PRESSURE HYDROCEPHALUS: PRELIMINARY RESULTS OF A RANDOMIZED APPROACH

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INTRODUCTION: Diagnosis and selecting the best treatment option for idiopathic normal pressure hydrocephalus (iNPH) is challenging. Ventriculoperitoneal shunt (VPS) and endoscopic third ventriculostomy (ETV) are part of the surgical options. Very low level of evidence is available on ETV outcomes. We report a randomized study to explore both treatment outcomes.

METHODOLOGY: Prospective randomized, parallel, open-label trial included patients over 60 years with iNPH, and with positive responses to the tap test (TT) or lumbar drain trial (LDT) from 2016 to 2022. The functional outcomes were assessed according to the Kiefer index (KI). Standard gait exam and mini-mental state exam (MMSE) were also used. The minimum follow-up time was set at 2 years. ETV was performed with a rigid endoscope with a 30° lens (KARL STORZ SE & Co. KG), and VPS was performed with a fixed-pressure valve (ProGAV 1.0/2.0 Christoph Miethke GmbH & Co. KG).

RESULTS: 31 Patients were included, and the randomization elicited 16 ETV Group and 15 VPS Shunt. Nine patients from the ETV Group received VP Shunt due to failure of improvement after the procedure. The outcome in VPS Group showed statistically significant improvement compared to ETV within the first year. At 2 years follow-up (still not completed by all patients), there was no significant difference due to secondary worsening or return to baseline of VPS group (35%). Interestingly, the patients who received both treatments had the best outcome. This study is currently being stopped.

CONCLUSION: VPS was significantly better in treatment than ETV, especially in the early phase after treatment. However, some patients treated with VPS showed a secondary worsening in outcome after a long follow-up. This could be part of the progressive nature of the disease.

CEREBROSPINAL FLUID AND INTRACRANIAL BLOOD RAPID INTERACTIONS IN NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Changes in intracranial pressure amplitude within the cardiac cycle are dependent on cerebral arteriovenous volume change and intracranial compliance. Cerebrospinal fluid (CSF) oscillation from the cranial compartment to the spinal compartment is a factor determining intracranial compliance. Our objective was to quantify how CSF oscillations apply to balance intracranial blood volume change during cardiac cycle in suspected hydrocephalus patients.

METHOD: Patients with suspected normal pressure hydrocephalus (NPH) undergoing an infusion test and MRI were included. Based on Rout, patients were divided into an NPH+ group with Rout>12mmHg/mL/min, and an NPH- group with Rout<12mmHg/mL/min. Cerebral arterial blood flows, cerebral venous blood flows and CSF oscillations in the cervical spaces during cardiac cycle were quantified using phase-contrast MRI. From these dynamic curves, tailored software automatically calculated arteriovenous volume change (SVAV) and intracranial CSF volume change (SVCSF) during cardiac cycle.

RESULTS: We included a total of 23 patients (73±8 years), with 13 patients in the NPH+ group and 10 in the NPH- group. SVAV values were heterogeneous and not significantly different between the groups (SVAV =0,71+/-0,17 in NPH+ and 0,82+/-0,29 NPH-). Similar results were found for the SVCSF (SVCSF =0,42+/-0,20 in NPH+ and 0,53+/-0,18 NPH-). We found a significant correlation (R2= 0,76; p=0,001) between SVAV and SVCSF in NPH- patients whereas this correlation was not significant (R2= 0,17, p=0,16) in NPH+ patients.

CONCLUSIONS: Intracranial compliance is a complex concept resulting from dynamic CSF and tissues compartments volume change. Two mechanisms co-exist: one to compensate large but slow intracranial volume change (infusion test) and one to compensate small but rapid intracranial volume change (systolic arterial flow, as revealed by PC-MRI). Our preliminary results show that, during the short time of cardiac cycle, the mobile CSF, which is part of rapid intracranial compliance, is altered in suspected NPH with elevated Rout.

CHARACTERISTICS OF HUMAN MENINGEAL LYMPHATIC VESSELS

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INTROUDCTION: In recent years, renewed interest for meningeal lymphatic vessels and their role in health and disease has led to numerous studies, primarily studies in animal models and from human autopsy material. The meningeal lymphatic vessels are found mainly along the walls of dural sinus veins. The present work addressed i) methodological aspects of visualization of lymphatic vessels in the dura of humans, and ii) characteristics of meningeal lymphatic vessels in various locations.

METHODS: Dura biopsies were obtained during neurosurgical procedures in varying locations, including shunt surgery for idiopathic normal pressure hydrocephalus (iNPH), and craniotomies for meningiomas, aneurysms, and other pathologies. The dura mater samples were examined through immunohistochemistry using the lymphatic cell markers lymphatic vessel endothelial hyaluronan receptor 1 (LYVE-1), podoplanin, (PDPN) and vascular endothelial growth factor receptor 3 (VEGFr3).

RESULTS: We have characterized three types of meningeal lymphatic vessels in human dura: 1) Lymphatic vessels in near proximity to blood vessels. 2) Lymphatic vessels without nearby blood vessels. 3) Clusters of lymphatic structures. Generally, lymphatic vessels were observed most frequently towards the arachnoid membrane. Furthermore, positive immunoreactive lymphatic endothelial cells were found in the dura mater at the temporal skull base, frontal convexity, posterior fossa and craniocervical junction far from dural sinus veins.

CONCLUSIONS: We conclude that visualization of meningeal lymphatic vessels in live humans seems to be highly sensitive to the tissue processing method. Our observations also show that meningeal lymphatic vessels in humans can be found spread throughout the dura mater and not solely lining the dural sinuses. Further studies need to explore how meningeal lymphatic vessels are affected in disease.

URINARY INCONTINENCE AND NORMAL PRESSURE HYDROCEPHALUS: SOME CLUES FOR WHAT IS STILL UNCERTAIN

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INTRODUCTION: Urinary incontinence is part of the classical symptom triad in normal pressure hydrocephalus (NPH), and greatly affects patient and caretaker quality of life. 45-95% of patients with NPH report urinary symptoms. However, data for characterization of urinary incontinence in NPH, improvement after shunt surgery and associations with demographic and clinical factors is scarce. Research in this area is important due to the prevalence of other causes of urinary incontinence in older adults, which may impact urinary symptoms at presentation and after surgical management.

METHODS: This study aimed to evaluate the prevalence of urinary incontinence in patients with NPH, as well as symptom improvement after shunt surgery, and associations with demographic and clinical factors. We reviewed the medical records of all patients diagnosed with NPH at our institution between 2016 and 2022, where the ICIQ-UI-SF questionnaire was applied at diagnosis and post-operatively.

RESULTS: We found 117 patients diagnosed with NPH; 75 underwent shunt surgery. The average age was 78.7 years, and 69.2% were male. 82% had urinary symptoms at diagnosis, with a mean ICIQ score of 10.6/21 (SD 6.5). 46.9% reported only urge incontinence; 5.2%, only stress incontinence; and 25% reported mixed symptoms. For 83.6% of patients, ICIQ score improved in postoperative follow-up; however, 10.8% of these patients deteriorated to baseline in further follow-up. Symptoms of urge incontinence (OR=7.2, p=0.0214), body mass index >25 (OR=14.4, p=0.0036), and age <80 years (OR=1.28, p=0.7510) were associated with increased chance of post-operative improvement.

CONCLUSION: We found a post-operative improvement rate similar to that reported in literature. 30% of patients with NPH and urinary symptoms had either mixed or stress incontinence, highlighting the importance of a multidisciplinary approach for management of these symptoms. We found few statistically significant associations, signaling the need for continued research in this field with larger, prospective studies.

MULTI-DOMAIN ASSESSMENT OF GAIT AT BASELINE VISIT IN IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS (INPH)

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INTRODUCTION: Though gait dysfunction in iNPH has been investigated intensively, most studies have focused on gait speed, a few studies on components of balance, and none on endurance. While cognitive assessments are often analyzed in terms of the domains affected, similar domain-based assessment of gait in iNPH has been lacking.

METHODS: Probable iNPH patients (n=322) referred to the Center for CSF Disorders for assessment of shunt candidacy underwent multi-domain gait evaluation at baseline visit. Speed was assessed using the Timed Up and Go (TUG) test and the 10-Meter Walk (10MW) test. Static and dynamic balance was assessed using the 4 Stage Balance (4SB) test and the 30-Second Sit to Stand (30STS) test. Endurance was assessed using the 2-Minute Walk (2MW) test. The performance on each of these tests was compared to age and sex adjusted norms.

RESULTS: There were 186 males and 136 females with a mean age of 74.4 (SD: 8.46) years. The most affected domain was balance, with 95% of patients testing abnormally on the 30STS test compared to 92% of patients when tested using the 4SB test. The TUG test was abnormal in 92% while the more widely used 10MW was abnormal only in 64%. Endurance was abnormal in 68%. 238 patients had all three domains tested. Of these, 70% performed abnormally in at least one of the tests in each domain.

CONCLUSIONS: Gait speed, balance and endurance of gait are impacted differentially in iNPH. Therefore, it is important to evaluate each domain independently. Assessment of gait speed just by the 10MW test is insufficient to capture the burden of gait dysfunction in iNPH. More emphasis needs to be placed on balance measures in iNPH assessment.

AUDIOVESTIBULAR SYMPTOMS IN SHUNTED IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Patients with idiopathic normal pressure hydrocephalus (iNPH) can experience complications like headache and infection after ventriculoperitoneal (VP) shunt placement. However, atypical symptoms including tinnitus, vertigo, hearing loss (HL), and aural fullness can be significant debilitating symptoms and may be underrecognized and underreported. In this study, our main objective was to characterize the frequency, severity, and duration of audiovestibular (AV) symptoms in iNPH patients following VP shunt placement.

METHODS: A retrospective chart review of iNPH patients who underwent VP shunt placement at the Johns Hopkins University, Department of Neurosurgery between June 2016 and December 2022 was conducted. Pre- and postoperative audiograms, when available, were analyzed.

RESULTS: Of 390 patients with iNPH, 28 (7.2%) reported AV symptoms after surgery. Median +/- SD age was 71.5 +/- 7.2 years. Subjective HL (18, 64%), vertigo (14, 50%), tinnitus (11, 39%), and aural fullness (3, 11%) were noted postoperatively. Only 9 patients (32%) experienced resolution of at least one postoperative symptom, namely tinnitus, vertigo, or dizziness. Spontaneous resolution was noted in 2 patients. Tinnitus (1, 14%) or dizziness (3, 43%) resolved with higher shunt settings, vertigo (1, 14%) or dizziness (2, 29%), with lower shunt settings. Postoperative audiograms were available for 5 of 18 patients reporting HL. In the postoperative period, hearing thresholds increased at frequencies ranging between 250 and 800 Hz, reaching statistical significance at 1000 and 2000 Hz for air conduction. The average rate of hearing loss for all frequencies was 5.23 dB per year, nearly four-fold greater than published rates of HL.

CONCLUSIONS: VP shunt placement in iNPH patients can lead to short- and long-term AV complications that may be insidious and more often do not resolve. Of those who reported symptom resolution, most did after shunt setting adjustments. Prompt recognition and appropriate adjustments may increase recovery rate.

AQP4 LEVELS IN CSF CORRELATE WITH CLINICAL SEVERITY IN INPH PATIENTS. A PRELIMINARY REPORT

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INTRODUCTION: AQP4 (Aquaporin-4) is involved in the regulation of brain water homeostasis and in the function of the glymphatic system. In iNPH (idiopathic Normal Pressure Hydrocephalus), there is an altered parenchymal expression of AQP4, contributing to glymphatic dysfunction. This study aimed to test AQP4 and AQP1 (Aquaporin-1) levels in the Cerebro-Spinal Fluid (CSF) of iNPH, NOT-NPH, and controls to evaluate their role as a diagnostic tool and their correlation with clinical parameters.

METHODS: CSF samples were collected at the time of the Tap test (TT). Patients who responded to the TT or with a Rout (Resistance to outflow) ≥12 mmHg/mL/min, performed ventriculoperitoneal shunting (VPS); patients with a negative response to the TT and with a Rout <12 mmHg/mL/min did not perform surgery (NOT-NPH group). 10 CSF samples from healthy Controls were collected from our biobank. We performed an ELISA test to measure levels of Aquaporin 1 (Human AQP-1 E-EL-H0487, Elabscience) and Aquaporin 4 (Human AQP-4 E-EL-H0490, Elabscience). Clinical parameters were collected before and after the TT. A total of 16 iNPH patients, 10 NOT-iNPH patients, and 10 controls were involved in this study.

RESULTS: AQP-1 levels were higher in iNPH versus NOT-NPH and controls (489±97 vs 404±52 vs 372±54 pg/mL, p<0,005); AQP-4 levels were significantly higher in iNPH patients when compared with controls (1.40±0.35 vs 1.16±0.09 ng/ml p=0.07) only. In iNPH patients there is a significant correlation between AQP-4 CSF levels and mUPDRS-III (rho= 0.76, p< 0.001), TUG (TimeUp-and-Go) (rho= 0.58, p<0.05) and an MMSE (Mini-Mental State Examination) (rho= -0.55, p=0.05).

CONCLUSION: AQP-4 CSF levels correlate with the severity of the disease in iNPH patients and may be used as a possible surrogate marker of glymphatic dysfunction.

DOES VENTRICULOMEGALY CORRELATE WITH INTELLIGENCE AND COGNITION? NEUROPSYCHOLOGICAL FINDINGS AND PROFILE IN LONGSTANDING OVERT VENTRICULOMEGALY OF ADULTS (LOVA)

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INTRODUCTION: Ventriculomegaly has been often associated with cognitive impairment, nevertheless objective data defining this patient cohort is lacking, signalizing a knowledge gap. With increasing availability of imaging comes a subsequent rise in the number of cases referred to hydrocephalus services. Our aim was to outline the neurocognitive findings in this patient group.

METHODS: This is a prospective, single-center, case-series study of patients diagnosed with longstanding overt ventriculomegaly of adults (LOVA). Demographic and radiological data as well as symptoms at presentation, profession, employment and detailed neurocognitive profile was collected.

RESULTS: A total of 30 both symptomatic and asymptomatic LOVA patients with a mean fronto-occipital horn ratio (FOHR) of 0.49 (SD+/-0.06) were included. The mean age was 47.9 years (SD+/-16.8). On imaging, Aqueduct stenosis was present in 18 patients (60%). 10 (33%) and 8 (27%) out of 30 patients were found to have an above average verbal intelligence quotient (IQ) and a performance IQ respectively. No significant correlation (p 0.42) was found between FOHR and IQ in t-test. Only two patients (6.7%) were unemployed. On focal testing 3 out of 7 patients with the highest IQ showed executive function impairment and slow speed of processing. The exact neurocognitive profile is yet to be completed. To date, a comparison between pre- and post-surgery could be drawn in 3 patients, with 7 additional patients expected to have imminently complete data.

CONCLUSION: A wide variability in terms of cognition was observed in patients with ventriculomegaly that could mirror the normal distribution in the general population, concluding that ventriculomegaly should not automatically be associated with cognitive dysfunction.

Keywords: LOVA, ventriculomegaly, neuropsychology, intelligence quotient

CEREBROSPINAL FLUID FORMATION RATE IN NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Formation rate of CSF may contribute to the effectiveness of brain clearance via the recently suggested glymphatic system. The CSF formation rate should determine how much fluid is available for flushing of the brain. The aim of this study was to investigate the CSF formation rate, and its variability, in normal pressure hydrocephalus (NPH).

METHODS: During a 12-year period, CSF formation rate was estimated in 137 (75 ± 6 years old, 65/72 men/women) undergoing investigation for hydrocephalus. A lumbar infusion test was performed (CELDA, Likvor AB, Umeå, Sweden) including 15 minutes with drainage of CSF at zero pressure, with flow regulated to maintain a stable pressure level. CSF formation rate was defined as the mean flow of the last 10 minutes.

RESULTS: Mean CSF formation rate was 0.44 ± 0.16 ml/min (26.4 ± 10.2 ml/hour). There was no difference between subjects with different diagnoses (idiopathic NPH/secondary hydrocephalus/other, ANOVA, p=0.714) or between men and women (t-test, p=0.236). There was no correlation between CSF formation rate and intracranial pressure (r=0.136, p=0.115, N=135) or age (-0.02, p=0.803, N=135).

CONCLUSIONS: The CSF formation rate was similar to previous findings in healthy using a corresponding method (Ekstedt 1978, 0.40 ± 0.08 ml/min). The variability was large in our study, suggesting that the CSF flow rate available for glymphatic clearance may vary to a relatively high degree between individuals, possibly related to this being a patient group where disturbed CSF dynamics is part of the pathophysiology.

REPRODUCIBILITY OF THE TIMED 10-METER WALKING TEST IN NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Gait disturbance is one of the features of normal pressure hydrocephalus (NPH). The timed-10-meter-walking test (10MWT) is frequently used diagnostic and prognostic tools for gait and balance disturbances in NPH, along-side several other disorders. We aimed to demonstrate the reproducibility of the 10MWT in NPH patients.

METHODS: 10MWT was performed with timed slow-pace and fast-pace in 67 NPH patients using both the smart-phone app 'Watkins' as well as with a clinical observer using a stopwatch. The patient was requested to perform each test twice and the tests were repeated after 2 weeks. Statistical analysis used SPSS (version 25.0, IBM) by paired t-test, comparing the results of the 10MWT using 'Watkins app' performed over 2 weeks, as well as comparing the 10MWT with the clinical observer performed over 2 weeks for individual patients. Finally the results of 10MWT using 'Watkins app' and a clinical observer were compared with each other using paired t-test for individual patients.

RESULTS: No statistically significant difference was found between the results of timed slow-pace and fast-pace 10MWT performed by individual patients over 2 weeks using either 'Watkins app' (p=0.1419) or with a clinical observer (p=0.4512) individually. For an individual patient, comparison of results of 10MWT as performed by 'Watkins app' to those performed by a clinical observer with a stopwatch showed no statistically significant difference in the measure of whole number of seconds taken to cover the distance (p=0.3910) and statistically significant difference in number of steps taken to cover the distance (p=0.0163) with an average error of ± 1-3 steps.

CONCLUSION: 10MWT is reproducible with high accuracy in individual patients using either smart-phone app 'Watkins' or clinical observer with a stopwatch. These results may vary following an intervention or change in disease status.

ADVANCES IN 3D AND 4D IMAGING OF CEREBROSPINAL FLUID AND AI-BASED DIAGNOSIS OF DESH

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INTRODUCTION: Cerebrospinal fluid (CSF) moves pulsatile to smooth cerebral circulation in the closed space skull. Recent developments in magnetic resonance imaging (MRI) technology have made it possible to visualize the CSF dynamics. However, it is difficult to accurately reproduce the CSF dynamics in the complicated 3D structure of ventricle and subarachnoid spaces. Therefore, we aimed to develop computational simulation model of brain aging and chronic hydrocephalus in adult. Moreover, we developed AI model for automatic detection/diagnosis of disproportionately enlarged subarachnoid-space hydrocephalus (DESH) to detect patients with idiopathic normal pressure hydrocephalus (iNPH).

METHODS: This study included 180 participants (42 iNPH patients and 138 healthy adults in their 20s to 80s). They underwent 3D T1- and T2-weighted MRI, 3D time-of-flight MRA, 4D flow MRI for CSF (venc:5cm/s) and for the circle of Willis (venc:120cm/s), and intravoxel incoherent motion (IVIM) MRI.

RESULTS: We obtained 3D morphological information of the brain, intracranial arteries, ventricles, and subarachnoid spaces, and the pulsatile complex motion of the CSF in the whole intracranial CSF spaces and arterial flow in the circle of Willis using various MRI sequences in healthy adults and iNPH patients, to reproduce the 3D intracranial environment on a computer. Moreover, we successfully developed an automatic detection/diagnosis of DESH with deep learning.

CONCLUSIONS: 3D digital information will be integrated to predict environmental changes in the brain and cerebrospinal fluid space with aging and simulate the development of iNPH. Accurate segmentation of the regional volumes and automatic determination of DESH from 3D T1- and T2-weighted MRI can improve the precision of iNPH diagnosis.

DISTINCT CEREBRAL CORTICAL MICROSTRUCTURAL CHANGES IN IDIOPATHIC NORMAL-PRESSURE HYDROCEPHALUS

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INTRODUCTION: The aim of the study is to evaluate idiopathic normal-pressure hydrocephalus (INPH)-related cortical mean diffusivity (MD) abnormalities.

METHODS: We investigated cortical MD utilizing surface-based diffusion tensor imaging analysis in three groups: INPH patients, Alzheimer's disease (AD) patients, and healthy controls. Forty-two INPH patients, 51 AD patients, and 23 healthy controls were imaged with MRI, including three-dimensional T1-weighted MR images, for automated surface-based analysis across the entire brain.

RESULTS: Compared with age- and gender-matched healthy controls, INPH patients showed a statistically significant reduction in MD in the high convexity of the frontal, parietal, and occipital cortical regions. In clusters of lower MD in INPH patients, INPH patients, when compared to AD and control groups, showed a statistically significant decrease in average MD values. Additionally, a significant increase in MD, mainly in the ventromedial frontal cortex, ventrolateral frontal cortex, supramarginal gyrus, and temporal cortical regions, was observed in the INPH group relative to the control group. In clusters of higher MD in INPH patients, INPH patients, when compared to AD and control groups, showed a statistically significant increase in average MD values. In clusters of higher MD in INPH patients, AD patients, when compared to controls, showed a statistically significant increase in average MD values. The mean MD of clusters of lower MD in INPH patients compared with healthy controls yielded an area under the curve of 0.857, differentiating INPH from AD.

CONCLUSIONS: A distinctive pattern of cortical MD changes was found in INPH patients. The mean MD for clusters of lower MD in INPH patients compared with healthy controls distinguishes INPH from AD with good diagnostic sensitivity and specificity. Our findings suggest microstructural changes in cortical integrity can help differentiate INPH and AD in elderly patients.

RADIOLOGICAL MORPHOLOGICAL FEATURES AND THE ASSOCIATED INTRACRANIAL PRESSURE WAVEFORM COMPONENTS OF IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Enlarged brain ventricles, compressed parasagittal cerebrospinal fluid spaces, steep callosal angle, dilated sylvian fissures and focal cortical sulcal dilatation are typical imaging features of idiopathic normal pressure hydrocephalus (iNPH). The pathophysiological mechanisms behind these morphological changes are poorly understood, but the hydrodynamic concepts of communicating hydrocephalus suggest that increased heartbeat related intracranial pulsations are involved in ventricular enlargement. In this cross-sectional study we analysed the association between the radiological findings of iNPH and the physiological intracranial pressure (ICP) waveform components.

METHODS: 117 patients with suspected iNPH underwent computerised overnight ICP monitoring with calculation of heartbeat related ICP pulse wave amplitude (calculated in the frequency domain, AMP, and time domain, MWA), index of cerebrospinal compensatory reserve (RAP) and power of slow vasogenic waves (SLOW). Radiological morphological data was recorded from computed tomography using Evans Index (EI), frontal occipital horn ratio (FOHR), and disproportionately enlarged subarachnoid space hydrocephalus (DESH) score.

RESULTS: The strongest correlation was observed between SLOW and DESH ($r=0.44$, $p<0.001$). SLOW also correlated with ventricular size as measured with EI ($r=0.23$, $p=0.01$) and FOHR ($r=0.26$, $p=0.006$). AMP and MWA were not correlated with the radiological data. SLOW predicted DESH and EI in a linear regression model.

CONCLUSIONS: Mainly SLOW showed correlations with the morphological imaging features of iNPH. SLOW is influenced by intracranial compliance, vasomotor and CSF dynamic components. This study suggests that the amplitude of ICP slow wave activity is related to the size of brain ventricles and DESH in iNPH, whereas AMP and MWA are not.

IRON-SENSITIVE MR IMAGING OF *SUBSTANTIA NIGRA* IN NORMAL PRESSURE HYDROCEPHALUS. A QUANTITATIVE APPROACH.

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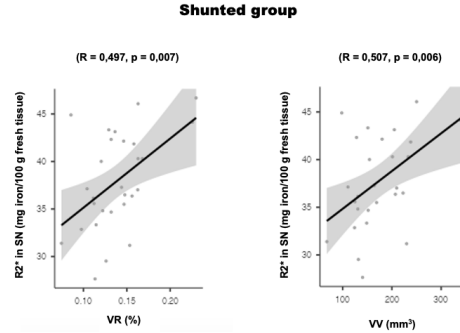
INTRODUCTION: Iron overload in the basal ganglia is involved in Parkinson disease (PD) and other related movement disorders. Iron content measured in vivo by MRI is increased in the substantia nigra (SN) of PD patients, correlated with dopaminergic cell loss. Idiopathic normal pressure hydrocephalus (iNPH) shares common phenomenology with PD but differs in terms of pathophysiology. In order to clarify the contribution of PD-related neurodegeneration in iNPH, we explore susceptibility MRI measurements to capture iron-related nigral pathology in iNPH.

METHODS: 70 patients suspected of iNPH (30W/40M mean age 74,2 years) were included in a prospective cohort. All participants underwent the same 3T brain MRI protocol with T1 and T2*-weighted scanning. Anatomical T1 images were processed to measure callosal angle (CA), Evans' index (EI), ventricular volume (VV) and ventricular ratio (VR = ventricle volume / whole-brain volume). A voxel-by-voxel analysis were processed with the T2* images in the substantia nigra (SN) of each patient to calculate the iron-related relaxivity values R2* which reflect the iron content.

RESULTS: 29 patients with clinical signs, ventriculomegaly and altered CSF circulation were shunted (resp. 41 patients were not shunted). In the shunted group, CA was smaller (p<0,001) and VV larger (p=0,039); but EI and VR were similar in both groups. The mean R2* calculated in NS of the shunted and non-shunted group were respectively 37,9 and 38,4 mg iron/100 g fresh tissue (ns). In the shunted group, SN R2* was positively correlated with VV and VR (figures provided). In the non-shunted group, SN R2* was correlated neither to VV nor VR.



CONCLUSIONS: In iNPH, SN iron content is correlated to ventricular enlargement; the latter may impact the former. Our data are in line with experimental and clinical data suggesting that CSF iron participate to ventricular enlargement in children and adults.

REVERSIBILITY OF THE RADIOLOGICAL SIGNS OF RAISED INTRACRANIAL PRESSURE FOLLOWING INTRAPARENCHYMAL BRAIN TUMOUR RESECTION

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INTRODUCTION: Intraparenchymal brain tumours are often associated with raised intracranial pressure(ICP), which can be identified by radiological signs of raised ICP. Surgical evacuation of the tumour in most cases leads to normalisation of the ICP. In this single-centre study we aimed to examine the rate of reversibility of radiological signs of raised ICP following resection of intraparenchymal brain tumours.

METHODS: A retrospective-observational study was performed in 42 patients who underwent excision of intraparenchymal brain tumours in the National Hospital for Neurology and Neurosurgery during 2021 and 2022. The electronic-health-records(EHRs) of the patients were evaluated. Basic demographic information(age, gender, underlying pathology) was recorded. Pre and post-operative magnetic resonance imaging (MRI) scans of the patients were studied for signs of raised ICP, including optic-nerve sheath diameter(ONSD) and pituitary thickness. Heed was paid to the time duration between surgery and the amelioration of radiological signs of raised ICP. Statistical analysis was done by SPSS(version 25.0, IBM) by paired t-test comparing the radiological features of raised ICP in pre and post-op MRI scans of the patients.

RESULTS: 33 patients demonstrated radiological features of raised ICP. 6 patients showed tortious optic nerve, optic-nerve sheath distension and empty sella. 15 patients featured tortious optic nerve and optic-nerve sheath distension. 12 patients showed optic-nerve sheath distension and empty sella. Post tumour excision 9 patients showed complete resolution of radiological features of raised ICP within 1-6 months($p<0.0001$). 22 patients showed progressive amelioration in the signs of raised ICP from 1 month post-op onwards, with tortuosity of optic-nerves being first thing to correct, followed by improvement in ONSD, followed-by optic nerve-sheath distension and lastly pituitary thickness($p<0.0001$). 2 patients showed no improvement in radiological features on account of recurrence of disease.

CONCLUSION: Radiological features of raised ICP can be reversed following excision of intraparenchymal brain tumours.

RESPIRATORY AND CARDIAC SIGNAL ANALYSIS OF CSF DYNAMICS IN NORMAL PRESSURE HYDROCEPHALUS AND ALZHEIMER'S DISEASE

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INTRODUCTION: Normal pressure hydrocephalus (NPH) is a CSF dynamics disorder, which in some patients is associated with elevated flow through the cerebral aqueduct. CSF flow is usually evaluated with a cardiac-gated 2D phase contrast (PC) acquisition through the cerebral aqueduct. This approach is limited by evaluation of a single location and does not account for respiration effects on flow. In this study we apply a real-time 2D PC acquisition at multiple locations to evaluate both the cardiac and respiratory contributions to flow in patients with NPH compared to cognitive unimpaired controls (CU) and patients with Alzheimer's dementia (AD).

METHODS: The study included 25 participants, 6 NPH, 9 AD, and 10 CU. Imaging was performed on a 3T Philips system. A 2D real-time echo-planar imaging-based PC acquisition was performed at the foramen magnum, fourth ventricle, and cerebral aqueduct. The standard deviation of the velocity vs time curve was used as a metric of flow excursion/magnitude of flow. The cardiac and respiratory contributions to flow were estimated by the area under the curve of the power spectral density (PSD) around the cardiac and respiratory frequencies, respectively.

RESULTS: Standard deviation of velocity did not show statistically significant differences between groups. Area under the curve of the PSD around the cardiac frequency was higher in AD than CU (Welch's t-test, Wilcoxon rank sum test) at the fourth ventricle. Area under the respiratory frequency was higher in NPH than CU at the aqueduct with based on the Wilcoxon rank sum test.

CONCLUSIONS: The 2D phase contrast imaging provides information about respiratory and cardiac contributions to the CSF flow. Imaging of CSF flow should not be limited to the cerebral aqueduct only. Flow in other locations may differ between groups and provide further insight into the mechanism of CSF dynamics disorders.

STRUCTURAL VOLUMETRIC AND PERIODIC TABLE DTI PATTERNS IN COMPLEX NORMAL PRESSURE HYDROCEPHALUS – TOWARDS THE PRINCIPLES OF A TRANSLATIONAL TAXONOMY

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INTRODUCTION: Diffusion tensor imaging (DTI) measures are highly dependent on technical factors and not comparable between study sites/ across groups, limiting interpretation in small cohorts, such as Normal Pressure Hydrocephalus (NPH). To address this gap, we previously proposed a novel strategy – a periodic table of DTI elements; a taxonomic framework to describe white matter tracts by their diffusivity and neural properties. In this iteration of the periodic table, we examined patterns of tissue distortion in Complex Normal Pressure Hydrocephalus (CoNPH) and validated the methodology of the periodic table against an open-access dataset of healthy control subjects to expand its accessibility to a larger community of users.

METHODS: Structural volumetric and DTI measures for 12 patients with CoNPH with multiple comorbidities and 45 healthy controls from the ADNI database were derived using image processing pipelines on the brainlife.io cloud computing platform (Freesurfer 7.1.1, FSL and MRTrix3). Statistical analyses were performed for comparisons between cohorts. Differences in FA, MD, L1, and L2and3 between CoNPH vs. controls were then mapped according to the periodic table algorithm.

RESULTS: We found widespread and significant reductions in subcortical deep grey matter structures, in comparison to healthy controls (left thalamus, left putamen, bilateral hippocampi, $p = 0.007, 0.030, 0.004$ and 0.028 respectively). DTI tissue signatures in the cerebral and cerebellar white matter demonstrated more potential reversibility of injury as compared to cerebral and cerebellar cortices. The use of the periodic table algorithm allowed for greater consistency in the interpretation of DTI results and aided in areas of concurrent but conflicting profiles.

CONCLUSIONS: Our study findings support the hypothesis that Complex NPH cohorts retain imaging features of Classic NPH. Our aim, in evolving towards controls-in-common, is to provide a prototype that could be refined and improved for an approach towards the concept of a "translational taxonomy".

THE RELATIONSHIP BETWEEN DUAL-TASK COST AND COGNITIVE PERFORMANCE AMONG PATIENTS WITH PROBABLE IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS

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OBJECTIVE: The dual-task gait assessment is frequently used to highlight cognitive inefficiency in idiopathic Normal Pressure Hydrocephalus (iNPH). There is, however, little evidence demonstrating its utility as a clinical marker of treatment responsiveness in these patients. The objective was to investigate the relationship between dual-task cost (DTC) during gait assessment and overall cognitive performance following cerebrospinal fluid (CSF) drainage in patients with iNPH.

METHOD: Patients with probable iNPH who underwent CSF drainage with either high-volume lumbar puncture (LP) or 3-day lumbar drain (LD) between May 2020 and December 2022 were included. Prospectively collected data from 10-metre single and 10-metre dual-task gait assessments, along with tests for phonemic and semantic fluency before and after CSF drainage were analysed. The DTC, which is the difference between single and dual task performance, was calculated and expressed as a percentage. Spearman's correlation was used to analyse the relationship between this DTC and overall cognitive performance.

RESULTS: 26 patients with probable iNPH, as defined by an improvement in gait velocity following CSF drainage were included. Median age was 75 (SD±8.85) years. Before CSF drainage the mean single and dual-task times were 26.0 and 30.0 seconds respectively, improving to 17.0 and 25.4 seconds after drainage. The mean DTC before CSF drainage was 27.1% and this increased to 54.4% after drainage. In this cohort there was a significant improvement in tests of phonemic and semantic fluency ($p.<0.001$) following CSF drainage, however there was no correlation between improved cognitive performance and DTC.

CONCLUSION: Although walking speed during both single and dual tasks improved following CSF drainage, the dual-task cost deteriorated despite an overall improvement in cognitive performance. The dual-task gait assessment is a useful clinical marker of the effect of cognitive loading in iNPH but provides little value during supplementary testing in our diagnostic pathway.

DIFFUSION TENSOR IMAGING HELPS IDENTIFY SHUNT-RESPONSIVE NORMAL PRESSURE HYDROCEPHALUS PATIENTS AMONGST PROBABLE INPH COHORT

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INTRODUCTION: The aim of this study was to investigate whether white matter changes as measured by Diffusion Tensor Imaging can help differentiate shunt-responsive idiopathic normal pressure hydrocephalus (iNPH) patients from patients with other causes of gait disturbances and/or cognitive decline with ventriculomegaly whose clinical symptoms do not improve significantly after cerebrospinal fluid derivation (non-iNPH).

METHODS: Between 2017 and 2022, 85 patients with probable iNPH underwent prospective preoperative MRI and comprehensive clinical workup. Patients with clinical symptoms of iNPH, positive result on lumbar infusion test (LIT) and gait improvement after 120-hour lumbar drainage were diagnosed with iNPH and underwent shunt-placement surgery. DTI data acquired during preoperative MRI were processed using the TBSS pipeline in FSL toolkit and fractional anisotropy (FA) and mean diffusivity (MD) values for individual regions-of-interest (ROI) were extracted using JHU white-matter atlas. FA and MD values were then compared to results of clinical workup and established diagnosis of iNPH. An identical MR protocol was performed on 13 age- and sex-matched healthy volunteers.

RESULTS: ROI that showed best diagnostic ability when differentiating iNPH from non-iNPH were uncinate fasciculus ($p<0.001$), cingulate gyrus ($p<0.001$) and the inferior longitudinal fasciculus ($p=0.02$). The highest area under the curve (AUC) was obtained from FA values in uncinate fasciculus (AUC=0.74). By means of distinction between iNPH and healthy controls, white matter structure with the strongest diagnostic accuracy was uncinate fasciculus when evaluating both MD and FA values (AUC=0.88), followed by cingulate gyrus (MD values with AUC=0.84), corpus callosum (both FA and MD values with AUC=0.81), and inferior longitudinal fasciculus (AUC=0.80).

CONCLUSIONS: DTI methods of white matter analysis using standardised methods of ROI extraction can help in differentiation of iNPH patients not only from healthy patients, but also from patients with other causes of gait disturbances with cognitive decline and ventriculomegaly.

LONG-TERM CARE IN OLDER PERSON SUSPECTED OF INPH.

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INTRODUCTION: Older person with clinical and imaging signs of iNPH have excess mortality and increased risk of dementia. Shunt surgery for iNPH improves gait, functional independence and seems to normalize survival.

Long-term care involves a variety of services designed to meet older person care needs, in order to live as independently and safely as possible when they can no longer perform daily living activities on their own.

We want to understand whether identification and treatment of iNPH promote functional autonomy and, consequently, independent living at home and has an impact on long-term care. In this preliminary study, we hypothesize that shunt surgery improves survival and reduces the admission in long-term care facility (LTCF).

METHODS: 100 older patients suspected of iNPH (46W/54M mean age 74,6 years) were included in our geriatric prospective cohort. Inclusion criteria were: clinical signs (gait or balance disorder, cognitive impairment or urinary incontinence) and ventriculomegaly (i.e. Evans Index > 0.3). Multidimensional markers of aging and neurodegenerative pathologies were analyzed, including CSF outflow resistance (Rcsf) measured with lumbar infusion test. Patients with clinical signs, ventriculomegaly and Rcsf ≥ 12 mmHg/mL/min were shunted. In this geriatric cohort, we analyzed 10 years survival rate and the percentage of patient admitted to LTCF.

RESULTS: 42 patients were shunted (resp. 58 non-shunted). 10-years survival rate was 71% in the shunted group (30 patients alive) and 48% in the non-shunted group (28 patients alive). 10 years after inclusion, 29% of the shunted patients were in LTCF (12 patients) and 34% of the non-shunted patients were in LTCF (20 patients). Kaplan Meier graphs are provided.

CONCLUSIONS: In our geriatric cohort, identification and treatment of iNPH was associated with higher 10-years survival rate and lower admission rate in LTCF. Exploring and treating older person suspected of iNPH seems to have an impact on long-term care.

THIRTY YEARS OF EXPERIENCE IN CSF DYNAMICS TESTING IN ADULT HYDROCEPHALUS

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INTRODUCTION: Abnormal CSF dynamics is an important component of hydrocephalus. It may manifest with increased resistance to CSF outflow (Rout), abnormal elasticity, excessive ICP waves, distortion of pulse amplitude of ICP, etc.

METHODS: Lumbar infusion test supported with computer identification of Marmarou's CSF dynamics model was designed in Poland in 1985-87 and later implemented in ICM+ software. Since 1992 over 6000 infusion studies haves been performed in both shunted and non-shunted hydrocephalus patients in Cambridge.

RESULTS: 1. Infusion test is safe. There were no serious complications. Infection rate was less than 1%
2. Knowledge of compensatory parameters helps in making decision about patients' management. Increased Rout is positively correlated with better outcome following shunting ($p<0.004$; $N=352$)).
3. In adults, Rout increases with age, while estimated CSF production rate decreases ($p<0.01$).
4. In shunted patients, reservoir infusion study helps to objectively assess shunt function and avoid unnecessary revisions. Yearly savings are estimated to amount to £1 million in our hospital.
5. Defective CSF dynamics may overlap existing cerebrovascular disease contributing to poor clinical status. In patients with normal CSF circulation autoregulation of CBF estimated with transcranial Doppler was worse ($p<0.002$).
6. In adults with idiopathic NPH, white matter CBF (PET) decreases towards surface of ventricles. Also autoregulation of CBF is worse in this region. This may illustrate transependymal route of CSF absorption and its interference with regional CBF around ventricles.
7. Even moderate rise in ICP during infusion study slightly but significantly increases heart rate variability, suggesting possible existence of 'brain baroreceptors'

CONCLUSION: Ccontinuing studies in CSF dynamics elucidate pathophysiology of hydrocephalus and other CSF disorders and helps in better management of patients.

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COGNITIVE CHANGES AFTER TAP TEST IN PATIENTS WITH NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Normal pressure hydrocephalus (NPH) leads to cognitive impairment (CI) as part of its symptom triad. Assessing CI before and after a tap test can inform diagnosis, differentiate NPH symptoms from alternative causes of CI, and suggest potential benefits of valve placement. The aim of this study was to describe the domain-specific cognitive performance of patients with NPH diagnosis before and after a tap test, assessed as part of the diagnostic workup upon initial NPH suspicion.

METHODS: Before-and-after study of NPH patients who underwent cognitive assessment by neuropsychologists before and after tap test. Clinical features at baseline and results in neuropsychological tests were recorded. The test scores were converted to z-scores according to age and level of education, and are described for each domain and according to the presence of dementia. Changes after tap test were assessed with paired-samples hypothesis testing.

RESULTS: 76 NPH patients were included, with a median age of 81 years (77-83). 65 NPH patients (87.8%) were considered to have improved cognitive performance after tap test. We detected small differences in scores of praxis ($p=0.018$) and executive function ($p<0.001$) between pre- and post-tap test assessments. No difference in the proportion of patients with altered cognitive performance was detected in this short 24-hour interval. Dementia was concomitant in 68.4% of patients, was negatively associated with improvement in verbal fluency (2.9% vs. 28.6%, $p=0.003$) and executive function (0% vs. 16%, $p=0.014$), and may have affected detection of improvement for other tests.

CONCLUSION: Executive function and praxis are the cognitive domains more susceptible to improvement in NPH patients upon initial assessment after a tap test. These results are of interest to multidisciplinary groups involved in the diagnosis of NPH and could help inform patient selection for valve placement.

USE OF NON-INVASIVE ICP WAVEFORM MONITORING IN A CSF COLLECTION LABORATORY: EXPERIENCE AND LEARNING POINTS.

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INTRODUCTION: Intracranial compliance (IC) is the ability of the central nervous system to absorb changes in volume without increasing the intracranial pressure (ICP), it is associated with the ICP waveform (ICPw) and predicts intracranial hypertension (IH). Noninvasive technology for IC monitoring was incorporated into the laboratory routine for a trial period to evaluate synergy with cerebrospinal fluid puncture and TAP Test exams.

METHODS: The brain4care (b4C) sensor was positioned on the patient's scalp, in the frontotemporal region. Monitoring of 330 patients was done before lumbar punctures and the TAP tests, for 5 minutes in the supine and standing position. Through artificial intelligence, b4c has automatically generated indicators related to intracranial compliance. The relationship between the amplitude of the subcomponents of the noninvasive ICP waveform (nICPw) P2 and P1 (P2/P1 ratio) and the time to the highest point of the wave (Time to peak - TTP) were calculated and inserted into the patient's report.

RESULTS: nICPw monitoring provided results consistent with patient's clinical symptoms and history, as well as other exams showing potential to be used as a screening method for cerebrospinal fluid puncture and adjunct to the TAP test analysis.

CONCLUSIONS: The monitoring of nICPw demonstrated safety, usability, and reproducibility, presenting the required characteristics for incorporation into the diagnostic routine.

IN VIVO PERFORMANCE OF THE KITEA ICP SYSTEM

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INTRODUCTION: The Kitea ICP System is designed to allow long-term home monitoring of ICP in patients with hydrocephalus. A discrete micro-implant is placed within the cortex at the same time as a shunt. ICP values are obtained by passing a Wand over the implant. The system is designed to provide not only the mean ICP level but also ICP waveforms. This study investigated the stability and performance of the Kitea ICP system over a 4-week implantation period and examined the ICP waveforms obtained.

METHODS: Six female sheep were implanted with the Kitea Implant next to ventricular shunt (Medtronic) via a burr hole in the skull. Additionally, a MEMS based pressure catheter (Millar Inc/Integra) inserted into the cortex on the opposite side of the midline allowed comparison of the Kitea ICP data to a gold-standard wired catheter. ICP measurements were made using both pressure systems three times a week for the next four weeks. At the end of 4 weeks, the sheep were anesthetized and a second Millar catheter was placed in the cortex to check the accuracy of the Kitea ICP Implant and the original Millar catheter. To assess the ability to measure a range of ICP, an intracerebroventricular canula was inserted and sterile saline infused into the ventricle to increase ICP.

RESULTS: In all 6 sheep, ICP measurements with successfully made using the Kitea ICP system throughout the entire 4-week period. Comparison of the Millar and Kitea ICP data show the Kitea System can accurately measure ICP in the conscious sheep both at baseline and in response to induced increased in ICP. Waveform analysis showed that the Kitea ICP System accurately captures features such as the cardiac and respiratory components of the ICP waveform.

CONCLUSIONS: We are confident that the Kitea ICP System can accurately measure ICP.

VALIDATION OF THE KITEA ICP MONITORING SYSTEM OVER 6 MONTHS IN SHEEP

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INTRODUCTION: The Kitea ICP System is designed to allow long-term home monitoring of ICP (intracranial pressure) in patients with hydrocephalus. The system is comprised of a discrete micro-implant placed within the cortex at the same time as a shunt. ICP values are obtained by passing a wand over the implant. The wand provides power wirelessly at a depth of up to 12 cm. The implant size is 2 x 3 x 20 mm. Prior to first clinical use it is important to demonstrate the ability to obtain ICP recordings in animals over an extended period.

METHODS: 10 adult female sheep were implanted with a Kitea ICP Implant placed next to a ventricular shunt catheter (Medtronic). The sheep were allowed to recover from surgery indoors for 2 weeks before being moved to the paddock for the remainder of the 6-month study period. ICP recordings were made weekly. Three ICP recordings were collected in each sheep at each weekly session and were recorded along with the head position for each reading.

RESULTS: Data were obtained on 100% of the occasions that a reading was attempted. On every occasion, values of ICP were within normal range and there was no sign of drift. Over 700 discrete measurements of ICP were made.

CONCLUSIONS: Along with separate histological evidence of safety and bench testing we are confident that the Kitea ICP system can be used to obtain ICP over an extended period. The next phase of this program will see the first clinical use.

SAFETY OF THE KITEA ICP IMPLANT IN THE GROWING BRAIN

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INTRODUCTION: The purpose of the Kitea ICP System is to allow better management of hydrocephalus in paediatric patients through home monitoring of ICP. The system is comprised of a discrete micro-implant placed within the cortex at the same time as a shunt. The external brain contacting parts of the Kitea implant are all glass. We have shown previously that the Kitea Implant does not cause significant tissue damage and does not move significantly in the adult sheep brain during implantation for 6 months. The purpose of this study was to assess the safety of the Kitea Implant in the growing brain using a lamb model.

METHODS: Twenty 4-week-old lambs were implanted with the Kitea Implant next to a piece of shunt tubing (Medtronic). Ten of the lambs were euthanized after 1 week to assess the acute response to the implant placement and the other half were kept for 6 months. Lateral radiographs were taken to document the position of the implants after surgery and before euthanasia.

RESULTS: Histological analysis of the brain tissue was used to characterize the response of the tissue around the implant and shunt. Stains for cellular and tissue structure (H&E), astrocytes (GFAP), microglia activation (IBA-1), myelinated axons, (LFB) and degenerating neurons (FJB). No signs of implant migration were seen in either the histology or analysis of the radiographs.

CONCLUSIONS: Using the lamb as a model of brain growth we have shown that the Kitea Implant does not migrate within the brain and has a stable tissue response.

AI-TRAINED MIXED REALITY HEAD-MOUNTED DISPLAY TO PLACE VENTRICULAR CATHETERS -PRELIMINARY DATA

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INTRODUCTION: Artificial intelligence (AI) and mixed reality holographic navigation technology are currently a much-researched topic in surgery. In neurosurgery, there is little data on practical clinical application. The purpose of our study is to test the applicability of a mixed reality head-mounted display (HMD) for the placement of ventricular catheters in ventriculoperitoneal shunt surgery. The ethical committee allowed a series with 10 patients.

METHODS: In advance, we trained an AI with 71 MRI T2 data sets to automatically recognize the ventricles. Thereafter, we used the HMD to visualize the lateral ventricles on the head of five patients with normal pressure hydrocephalus while performing ventriculoperitoneal shunt surgery. An evaluation was carried out regarding the number of ventricular punctures, the surgeon's subjective comfort and the safety gain.

RESULTS: We applied this technique in 5 patients so far. One patient dropped out for a reason unrelated to the HDM. In 50 % (2 of 4) of the cases, the ventricle could be punctured the first time, in 50 % (2 of 4) the 2nd or the following times, the surgeon rated the comfort as good in 50 % (2 of 4) of the cases. An increase in safety due to the HDM was recorded in 25 % (1 of 4) of the cases, no loss of security was reported.

CONCLUSIONS: First results show that the HDM for ventricles imaging has a high potential for safe ventricular puncture. To date, however, the rate of first-time ventricular punctures is low. Inaccuracies, especially regarding referencing and stability during surgeries due to movements of the operating table and patient's head, need to be improved by intraoperative real-time adjustments of preoperative imaging. However, developments already underway will take these requirements into account.

COMPARISON OF CONVENTIONAL- UND ROBOTIC ENDOSCOPIC THIRD VENTRICULOSTOMY IN OCCLUSIVE HYDROCEPHALUS

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INTRODUCTION: Causes for occlusive hydrocephalus are congenital aquaeductal stenosis, cerebellar-, skull base- or pineal tumors. Endoscopic third ventriculostomy (ETV) is considered as the primary therapy in occlusive hydrocephalus.

METHODS: A neurosurgical robot (Robotic Surgery Assistant, ROSA) was used since several years for stereotaxic procedures and was adapted for the endoscopic procedure. Since the selection of an ideal trajectory through the Foramen monroi towards the prepontine cistern is crucial, robotic technology may be beneficial. In this study 11 robotic of the last two years and the previous 11 conventional ETV procedures are compared. The method of conventional and robotic procedure consisted of a preoperative three-dimensional (3D) MRT with T1 and T2 weighted images. Imaging was programmed into the robotic planning software, referenciation with the head-clamp-fixed patient was achieved by a semi-robotic laser scan of the face. In the conventional group the trajectory and burr hole were identified by measurements of the imaging. Patients were controlled clinical and by MRI T2 imaging straight-, three- and twelve months after surgery.

RESULTS: As results in the robotic group the mean age was 39 years (Range 4-80), in the conventional 36 years (Range 9-73), the age match in the robotic group, only one female was identified versus seven in the conventional group. The duration of surgery amounted to 117 min (range 63-177) in the robotic- and 79 min (Range 54-150) in the conventional group. Surgery was successful in ten of eleven patients in the robotic- and in all patients in the conventional group. One patient from the robotic group required a ventriculo-peritoneal shunt after two months, one patient in the conventional group had a thalamic lesion related to the endoscope.

CONCLUSION: In conclusion, the robotic procedure takes more time, however results in an optimal trajectory avoiding friction in the Foramen monroi and lesions ion the surrounding ventricular structures.

UNRAVELLING MECHANISMS DRIVING VENTRICULAR CATHETER OBSTRUCTION - A MULTICENTER SHUNT BIOBANK APPROACH

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ABSTRACT: Hydrocephalus patients have a severely diminished quality of life because of the failure and ineffectiveness of current treatments, which involve diversion of cerebrospinal fluid (CSF) with shunts. To investigate factors that affect shunt failure, we established a multicenter biobank. Our project aims to create a comprehensive dataset that can help us understand the mechanisms driving shunt obstruction and the factors that may help predict the performance of a shunt in a specific patient.

METHODS: To date our biobank has recruited 6 centers across the United States and collected over 500 failed ventricular catheters (VCs) with relevant clinical data. Each VCs was analyzed using bright field and confocal microscopy, immunofluorescent labelling, histology, and immunohistochemistry.

RESULTS: Of the VCs determined intraoperatively to be obstructed by surgeons, 36% were found to be unobstructed on microscopic analysis. Of the obstructed VCs, 61.5% had tissue aggregates occluding at least one hole (n = 211) however most holes (70%) showed no tissue aggregates. Contrary to previous belief, choroid plexus (in 24% of VCs) and microglia (2–6% of the cells in obstructing tissue) are not major contributors to obstruction. Large tissue aggregates with comparable cell density were observed in VCs after different durations of implantation suggesting mechanisms that may not increase in severity over time. VCs from patients with 0 to 2 lifetime revisions had a larger fraction of VC holes obstructed than VCs from patients with 10+ revisions ($p = 0.0484$). VCs contacting the ventricular wall were more likely to have holes with protruding tissue aggregates as compared to VCs that did not ($p = 0.005$).

CONCLUSIONS: VC obstruction appears to be a multifactorial problem with no single factor independently predicting the degree of obstruction or the potential duration of patency. Grouping patients by multiple factors may improve our ability to predict and prevent obstruction.

BLOOD GFAP, NFL AND ABETA42/40 CORRELATE MODESTLY WITH CSF LEVELS IN INPH BUT DO NOT PREDICT SHORT TERM RESPONSE TO CSF DIVERSION

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INTRODUCTION: The role of biomarkers in the selection of idiopathic normal pressure hydrocephalus (iNPH) patients for shunt surgery has been studied in small populations and mainly in CSF. In this study, we evaluated CSF and plasma from a large cohort of iNPH patients referred for shunt surgery. The study aimed to evaluate the correlation of plasma and CSF biomarkers and determine if plasma measures could help in selecting patients for shunt surgery.

METHODS: CSF and plasma were obtained from patients referred for a CSF diversion procedure after a baseline assessment at the Johns Hopkins Center for CSF Disorders. All patients had a battery of cognitive and gait testing prior to their procedure. Patients deemed to be responders were referred for surgery based on iNPH guidelines. Plasma and CSF [Neurofilament Light (NF-L) and Glial fibrillary acidic protein (GFAP)] and canonical Alzheimer's disease related biomarkers [abeta-42 (aβ42), abeta-40 (aβ40), were analyzed on the Quanterix HDX platform.

RESULTS: 338 patients (211 male, 127 female) underwent a lumbar puncture or extended CSF drainage as part of their INPH assessment. 135 patients were selected for shunt surgery. Plasma NFL correlated modestly with CSF NFL ($R=0.42$; $p < 0.001$). Plasma GFAP correlated modestly but significantly with CSF GFAP ($R=0.34$; $p < 0.001$). Plasma aβ42/aβ40 correlated weakly with CSF aβ42/aβ40 ($R=0.2$; $p < 0.001$). The median plasma biomarker levels were not statistically different in those selected for surgery. Plasma measures could not reliably predict who improved short term after the diversion procedure.

CONCLUSIONS: Similarly to CSF, plasma measures could not predict who would improve after a CSF diversion and cannot be used in selection for shunt surgery. Plasma levels of GFAP and NFL along with the aβ42/aβ40 ratio did correlate modestly with respective CSF levels and an ongoing study will determine if they predict long term improvement.

WATKINS 2.0: THE NEXT GENERATION IN GAIT-ASSESSMENT APPS FOR NORMAL PRESSURE HYDROCEPHALUS AND DECOMPENSATED LONG-STANDING OVERT VENTRICULOMEGALY PATIENTS

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INTRODUCTION: The timed-up-and-go(TUG) test and the timed-10-meter-walking test(10MWT) are frequently used assessments tools for gait and balance disturbances in normal pressure hydrocephalus(NPH) and long-standing overt ventriculomegaly(LOVA). We aimed to make a smart-phone app which performs both the 10MWT and the TUG-test, thus making it possible for patients to perform repeat assessments in their home environment and have an objective measure of their progress for themselves and for their clinical team.

METHODS: 10MWT and TUG-test were performed by 50 healthy adults, 67 NPH, 10 LOVA and 5 elderly patients with other conditions, using the Watkins2.0 app. The 10MWT was assessed with timed slow-pace and fast-pace. Statistical analysis used SPSS(version25.0, IBM) by paired t-test, comparing the healthy and the NPH cohorts. Level of precision of the app (as compared to a clinical observer using a stopwatch) was evaluated using a receiver operating characteristics(ROC) curve.

RESULTS: As compared to a clinical observer using a stopwatch:
10MWT the app showed 100% agreement to the number of whole seconds in the time taken to cover distance, 95% accuracy in the number of steps taken(error ± 1-3 steps), and 97% accuracy in the measure of total distance covered(error ± 0.25-0.50meters).
The TUG test has 100% agreement to the number of whole seconds in the time taken to complete the test, 97% accuracy in the number of steps (error of ± 1-2 steps) and 87.5% accuracy in the distance covered with error of ± 0.50 meter. In the measure of time, the app was found to have equal sensitivity as a clinical observer. In measure of number of steps and distance, the app demonstrated high sensitivity and precision(AUC>0.9). The app also showed significant level of discrimination between healthy and gait-impaired individuals.

CONCLUSION: Watkins2.0 is an efficient app for objective performance of 10MWT and the TUG-test.

QUANTITATIVE MEASUREMENT OF FINGER TAPPING BEFORE AND AFTER THE TAP TEST IN IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Several previous studies reported that patients with idiopathic normal pressure hydrocephalus (iNPH) have not only the lower limb dysfunction but also the upper limb.
We have already reported that finger dexterity of iNPH patients is obviously impaired by quantitative assessment of finger tapping (F-T) with auditory stimuli. Based on this, we analyzed how the finger dexterity of iNPH patients changed before and after tap test (T-T).

METHODS: Subjects were 51 possible iNPH patients that underwent T-T, 18 T-T non-responders (mean age 79.6±7.1 years; male 9/18) and 33 T-T responders that were probable iNPH (76.3 ± 7.8 years; male 15/18) according to the Japanese Guidelines for NPH.
Twenty of the 33 probable iNPH underwent shunt surgery and were diagnosed with definite iNPH.
We performed F-T measurements before and after T-T as well as after shunt surgery.
F-T performance of the index finger and thumb was quantified using magnetic sensing device.
The participants performed repetitive tapping , following to the pace at the rate of 2.0Hz. We evaluated F-T parameters including the mean of maximum amplitude (M-Amplitude), and closing velocity(cl-Velocity).

RESULTS: In non-responders of T-T, there was no significant difference in both M-Amplitude and cl-Velocity between before and after the T-T. In patients with probable iNPH, M-Amplitude (P=0.04) and cl- Velocity (P=0.01) were significantly increased after T-T.In difinite iNPH patients, M-Amplitude (P = 0.006) and cl-Velocity (P = 0.001) showed significantly much larger incresed after T-T. (These increases reflect improvements in finger dexterity.)

CONCLUSIONS: The paced F-T test could become a new tool for evaluating the upper extremities function in iNPH before and after T-T.

MACHINE LEARNING ANALYSIS OF VOICE DATA FROM PATIENTS WITH NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Several studies have reported an association between normal pressure hydrocephalus (NPH) and speech impairment. However, there has been no analysis of the relationship between voice and NPH using artificial intelligence (AI) techniques. The study aimed to explore the possibility of identifying acoustic features that can differentiate NPH from other neurodegenerative diseases by analyzing the voice of patients with NPH using machine learning (ML).

METHODS: We enrolled 54 patients with NPH from a total of 196 patients with cognitive impairment who had a score of 24 or less on the Korean Mini-Mental State Examination. We analyzed the following acoustic parameters using a boosting ML algorithm: (a) the prolongation of vowels as /a/, /i/, and /u/; (b) the alternative motion rate (AMR) as /puh-puh-puh/, /tuh-tuh-tuh/, and /kuh-kuh-kuh/; (c) the sequential motion rate as /puh-tuh-kuh/; (d) the maximum phonation time (MPT); (e) voice quality; (f) voice variability; and (g) speech rate.

RESULTS: First, we found that the meaningful speech tasks related to the discrimination between neurodegenerative brain diseases and other diseases were the MPT (precision: 0.643 and recall: 1) and the AMR as /kuh-kuh-kuh/ (precision: 1.000 and recall: 0.667). Next, the speech tasks that can differentiate NPH from other neurodegenerative brain diseases were /tuh-tuh-tuh/ (precision: 1.000 and recall: 0.875) and /kuh-kuh-kuh/ (precision: 0.889 and recall: 1.000) of AMR.

CONCLUSIONS: Although this was an artificial intelligence analysis using a small number of voice data, it suggests that there may be acoustic features that can differentiate NPH from other diseases.

OPTIMIZING GAIT AND BALANCE METRIC ACQUISITION FROM THE "TAP TEST" IN NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Gait and balance impairments are hallmarks of normal pressure hydrocephalus (NPH). Ambulatory and balance improvement following high-volume lumbar puncture (HVLP) predicts shunt responsiveness, the so-called "Tap Test." However, it is uncertain which and when gait and balance measures should be acquired after the HVLP.

METHODS: This pilot study identified 12, of 14 shunted, patients whose ambulation improved after shunting. All patients underwent gait/balance assessments prior to (Pre), within 1 hour of (Post1), and within 24 hours (Post2) of a HVLP. We assessed changes in the time to complete a Timed Up and Go (TUG), 25-feet extended Timed Up and Go (ETUG), and 360-degree turn and counted the steps needed to turn 360 degrees. We acquired truncal sway metrics from a lumbar-positioned wearable inertial measurement unit (OpalTM, APDM) while patients completed brief quiet standing tasks including feet apart/eyes open (FAEO), feet apart/eyes closed (FAEC), feet together/eyes closed (FTEC). We used paired t-tests to assess changes from Pre to Post measures.

RESULTS: We observed that ≥ 92% of subjects improved on Post2 TUG time, ETUG time, 360-degree turn time, and 360-degree turn step number. Fewer patients improved on Post1 assessments ($p > 0.05$). FAEO centroidal frequency in the sagittal plane significantly increased by 12-16% in 83% and 75% of subjects at Post1 and Post2 assessments, respectively. FAEC frequency dispersion in the sagittal plane significantly decreased by 5-6% in 67% and 75% of subjects at Post1 and Post2 assessments, respectively.

CONCLUSIONS: These pilot data suggest that longer measures of gait (ETUG) and turning at 24 hours, rather than within 1 hour, of a HVLP may be more predictive of surgical outcomes. Balance measures require additional study. With these preliminary data, we can design a prospective study to show which of these metrics, or combinations, is the best predictor of surgical outcomes.

LP SHUNT IN THE PATIENTS WITH INPH: SURGICAL TECHNIQUE

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INTRODUCTION: The SINPHONI-2 study (Japanese prospective multicenter cohort studies) was carried out and showed the safety and efficacy of LP shunt surgery for iNPH. Although our high level of success with surgery may be considered to be a minor point, it is worth reporting, as minor differences in technique and know-how can markedly affect the efficacy of shunt surgery. We show a video of our LP shunt procedure.

METHODS: A total of 758 probable iNPH patients underwent LP shunt surgery at our NPH center between April 2009 and December 2021 (mean age 77.5 ± 6.5). Aspects of our surgical technique include: 1) General anesthesia, 2) Use of the original drape, 3) Upward insertion of the spinal tube through L2/3 via a paramedian puncture for highly deformed lumbar spine patients, using the intraoperative C-arm imaging. 4) Placement of a Codman-Hakim programmable valve with Siphonguard™ in the back, 5) Inclination of the table at 30°angle. 6) Laparotomy via rectal muscle splitting, and 7) Running the peritoneal tube obliquely from upper lateral to lower medial (to eliminate the space permitting tube expulsion)

RESULTS: Of the 693 patients followed up at our NPH Center for 1 year after LP shunt surgery. During the first year after surgery, 68 of 693 patients(9.8%) developed postoperative complications including tube occlusion in 24(3.5%), chronic subdural hematoma requiring evacuation in 18(2.6%), migration of the spinal or abdominal tube in 12(1.7%), lower limb numbness in 7, rupture of the spinal tube in 5, and shunt infection in 2.

CONCLUSIONS: Our LP shunt procedure generally seems to be acceptable from the viewpoint of complications. The low-invasive LP shunt that does not require ventricular puncture is preferred and has become the first-line procedure for iNPH in Japan. We would like to popularize the use of this surgical procedure worldwide in the future.

NEURALGIA AFTER LUMBOPERITONEAL SHUNT CAN BE REDUCED WITH SURGERY UNDER LOCAL ANESTHESIA.

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INTRODUCTION: Controlling complications after shunt surgeries for idiopathic normal pressure hydrocephalus (iNPH) is essential. We report the data of complications and the preventive measures from a facility where lumboperitoneal shunt (LPS) is the first-line treatment for iNPH. We initiated LPS under local anesthesia, believing that asking the patient if they feel any pain while inserting the spinal catheter can decrease the incidence of neuralgia. The result is discussed.

METHODS: We reviewed the medical records of consecutive iNPH patients for whom a shunt surgery was provided from 5/1/2020 to 3/16/2023. The incidence and the characteristics of postoperative complications were compared between LPS and ventriculoperitoneal shunt (VPS) and between LPS under local anesthesia and LPS under general anesthesia.

RESULTS: A total of 218 patients were included, with 152 LPS (69.7%), 60 VPS (27.5%), and six ventriculoatrial shunts (0.8%). The overall rates of complication were 16.6% (36/217) 1 month after surgery (POM1), 9.8% (19/193) 3 months after surgery (POM3), 4.4% (7/159) 6 months after surgery (POM6), and 1.9% (2/106) 12 months after surgery (POM12). Complications after LPS were reported in 18.5% (28/151) POM1, 12.9% (17/132) POM3, 4.9% (5/103) POM6, and 3.1% (2/64) POM12, respectively. In the LPS group, CSDH was seen in 10 (8.1%) patients POM1 and 5 (3.8%) POM3, while headache was experienced in 8 (5.3%) POM1 and 2 (1.5%) POM3. These conditions likely related to intracranial hypotension were statistically more significant in LPS than in VPS (13.9 % vs. 3.3%, $p = 0.026$). A significantly smaller number of patients complained of neuralgia after LPS under local anesthesia than general anesthesia (1.2% vs. 7.7%, $p = 0.042$).

CONCLUSIONS: LPS may carry a greater risk of reversible intracranial hypotension than VPS, while neuralgia after LPS can be reduced with surgery under local anesthesia.

IMPACT OF SHUNT PLACEMENT IN CSF DYNAMICS

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INTRODUCTION: in so called "normal pressure hydrocephalus" paradoxically Intracranial pressure and CSF dynamics are not normal. We also know that there are hyper dynamic CSF flows in the aqueduct but also flow alterations in the spinal compartment. The aim is to investigate how CSF dynamics change after ventricular shunt surgery in hydrocephalus patients who have improved.

METHODS: We included 14 patients with hydrocephalus who had improved after ventriculoperitoneal shunting. We referred to these patients as patients with active reversible hydrocephalus (ARH). These patients underwent phase contrast MRI preoperatively, at 6 and 12 months postoperatively. We quantified the oscillating CSF (stroke volume) in the aqueduct (SVaqu) and in the cervical canal (SVcerv). We calculated the ratio of SVaqu to SVcerv called CSFratio, which reflects the participation of the intraventricular compartment in the overall pulsatility of intracranial CSF through the spinal canal.

RESULTS: 6 months after shunt placement SVAQU significantly (p=0.003) decreased from 240±114µL/cc to 214±157µL/cc. (In two cases, SVaqu increased). 12 months after shunt placement SVaqu volume continue to decreased non significantly (p=0.12) to 193±145µL/cc. (In two cases, SVaqu increased)
SVcerv significantly (p=0.007) decreased from 627±229µL/cc to 557±234µL/cc and 12 months after shunt placement SVcerv continue to significantly (p=0.001) decreased to 496±234µL/cc. CSFratio was not changed by surgery. It was measured at 40±20%.

CONCLUSION: Our study showed that intraventricular and spinal CSF dynamics increased in patients with ARH and decreased only slightly after shunt placement. Shunt placement primarily treats symptoms rather than CSF dynamics. CSF dynamics may help to diagnose shunt dysfunction only if CSF dynamics begin to increase again compared with previous measurements. In these patients who have improved after shunt but continue to have elevated CSF ventricular dynamics, such CSF dynamics do not appear aggressive but instead is important to ensure a secondary compliance to the one probably altered.

INFLUENCE OF VENTRICULAR SIZE AND SURGICAL APPROACH ON FLOW DISTRIBUTION IN VENTRICULAR CATHETERS

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INTRODUCTION: Incremental progression has been made with ventricular catheter (VC) design apart from antibiotic impregnation. Prior work using computational fluid dynamics (CFD) has used a cylinder to replicate a hydrocephalic ventricle to study CSF behavior in VCs. Accurate representation of cerebrospinal fluid (CSF) flow patterns is difficult in these models because of the lack of dynamic ventricular shape. Capturing the complex ventricular morphology is imperative to investigate CSF flow patterns. Using patient-specific ventricles generated from MRIs, we investigate the impact of ventricular size and shape with various VC designs, including CSF parameters of mass flow rate, shear stress, and pressure gradient. We aim to elucidate the influence of ventricular size and surgical trajectory on these parameters to optimize VC design.

METHODS: Enlarged lateral ventricles were extracted from MRIs to create computational 3D renders. Catheters were inserted into the lateral ventricles using anterior and posterior trajectories. Physiological boundary conditions were placed at the choroid plexus and catheter outlet. Flow parameters, including mass flow rate, shear stress, and pressure gradients, were quantified in the catheter drainage holes and lumen under steady-state conditions.

RESULTS: These data suggest that the mass flow rate, shear stress, and pressure gradient within the catheter holes display no significant variation across different ventricular volumes, irrespective of the surgical approach employed. Nevertheless, a discernible variation in the ventricular pressure is observed, which may be attributed to the different resistances to flow among the catheters, causing variations in ventricular pressure without affecting the mass flow rate, shear stress, and pressure gradients in the catheter.

CONCLUSIONS: The present findings suggest that the current commercial catheters exhibit similar flow characteristics across all tested parameters concerning surgical approach and ventricular size. However, the overall resistance to flow of the catheters appears to vary depending on the surgical approach rather than the ventricular size.

SHUNT TESTING IN VIVO: PERFORMANCE OF CERTAS VALVE INTEGRATED WITH SIPHONGUARD

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INTRODUCTION: Testing of hydrocephalus shunt using infusion test through prechamber proved to be both precise and objective. It's most important advantage is avoidance of unnecessary revision of a properly working shunt in patients presenting with symptoms similar to those caused by blockage. But not all shunts can be tested in this way. We recently discovered that testing Certas Valve integrated with SiphonGuard (siphon controlling device) should be interpreted with special caution.

METHODS: Since finishing of first COVID lockdown (2020) 12 patients with implanted Certas Valve were tested. Two 25G butterfly needles were inserted through triple-cleaned skin in shunt prechamber. One needle was connected to pressure transducer, another to infusion pump. Baseline pressure with present pulsatile waveform was recorded over a 10 minute period. Then infusion of Hartmann's solution with a rate of 1.5 ml/min started and pressure increased gradually to plateau value. If the plateau is lower than shunt performance level plus infusion rate times hydrodynamic resistance of shunt system, the system is judged to drain properly.

RESULTS: In 7 cases test revealed properly working shunt. But in 5 cases, after reaching plateau at 12-18 mm Hg (depending on shunt setting) during infusion, pressure suddenly increased to value 40 mm Hg or above showing shape of ICP resembling plateau wave. Infusion was discontinued immediately and the test was reported as indicating inability of shunt to stabilize ICP at safe level. Further inspection and use in one case infusion with decreasing rate (1.5, 1 and 0.5 ml/min) showed that 'plateau wave' disappears with lower infusion rate.

CONCLUSION: SiphonGuard works as flow regulator. During infusion through the shunt prechamber switching from low to high resistance state may happen. It results in sudden, plateau wave -like rise in ICP. For testing Certas valve with SiphonGuard lower infusion rate should be used.

PROGNOSTIC SIGNIFICANCE OF CEREBROSPINAL FLUID PRODUCTION RATE IN IDIOPATHIC INTRACRANIAL HYPERTENSION AND THE IMPACT OF MEDICAL THERAPY

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INTRODUCTION: The management of idiopathic intracranial hypertension (IIH) is quite varied. While the Idiopathic Intracranial Hypertension Treatment Trial advocates the efficacy of acetazolamide in the treatment of IIH, the VISION study is comparing the effectiveness of venous stenting to CSF shunting. Our study aimed to demonstrate net cerebrospinal fluid production rate (PRcsf) as a potential prognostic tool for the management of IIH.

METHODS: A prospective observational study was performed in all IIH patients in our hospital who required CSF drainage as part of their ongoing management. The drain was connected to a LiquoGuard7 (Möller-Medical, Germany) with the intracranial pressure sensor at the level of the external auditory meatus. The internal software and flow-rate data of the LiquoGuard7 pump was used to calculate net PRcsf in the patients. Patients were flat for 30 minutes during the measurement. Patient's notes and electronic health records were reviewed daily. The events occurring during the course of hospital stay for each patient, and prognosis and patient outcome was recorded as well as resolution of papilledema. Statistical analysis used SPSS (version 25.0, IBM) by multivariate multiple regression, comparing the resolution of papilledema to the measured PRcsf, age, gender, body-mass-index, co-morbidities, and the type of medical treatment received.

RESULTS: 15 IIH patients were studied. IIH patients not using acetazolamide (n=9) demonstrated average PRcsf of 86ml/hour±10SD. These patients benefitted from CSF-shunting, even if they had previously undergone stenting (n=2). Acetazolamide (AZM) influenced PRcsf in a dose-dependent manner: AZM-Dose 250mg thrice daily (n=5), average PRcsf of 45ml/hour ± 3SD, papilledema resolved with stenting; AZM-Dose 1000mg twice daily (n=1), average PRcsf of 22ml/hour ± 3SD, no additional treatment required.

CONCLUSION: PRcsf may hold prognostic value towards treatment-response in patients with IIH.

THE PUMCH EVALUATION SYSTEM OF IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS AND CLINICAL PRACTICE

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INTRODUCTION: Differentiating idiopathic normal pressure hydrocephalus (iNPH) from other neurodegenerative diseases is challenging. Only a portion of the patients clinically suspected of iNPH would respond to surgical intervention. CSF tap test is usually used to predict surgery outcomes and hence aid clinical decision-making, but the work-up varies from center to center.
Objective: Introduce the PUMCH evaluation system which we conducted at our center during CSF tap test and examine its power by analyzing data from a series of iNPH cases underwent shunt placement. Analyze common features in the past medical history of our patients and investigate whether they are related to the etiology of iNPH.

METHODS: Data from 20 patients who were positive in the tap tests pre-operatively with PUMCH evaluation system and received ventriculoperitoneal shunting were retrospectively analyzed. Pre-operative and post-operative performance data were analyzed. History of any underlying medical conditions was also taken into consideration.

RESULTS: We performed VP shunt placement in 20 NPH patients from October 2019 to February 2022. 80% of them exhibited improvement in at least 1 of the clinical triad, proving the predictive power of the PUMCH test workflow. The underlying conditions like hypertension, diabetes and insufficiency in cerebral blood supply were also found to be associated with the onset of NPH.

CONCLUSION: Our PUMCH evaluation system is a valid tool for NPH assessment and can guide clinical decision-making. Comorbidities should be taken into consideration as they contribute to the pathogenesis and progression of NPH. Better identification of potential iNPH patients will lower the burden exerted on the family and the aging society.

CONSISTENCY AND SENSITIVITY ANALYSIS OF INSTRUMENTAL AND TRADITIONAL METHODS FOR EVALUATING THE CSF TAP TEST (CSF-TT) RESPONSIVENESS IN PATIENTS WITH INPH.

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INTRODUCTION: The idiopathic normal pressure hydrocephalus (iNPH) is characterized by gait, cognition and urinary dysfunction. Here we evaluate the consistency and sensitivity of the instrumental. (ReadyGo motor function quantitative evaluation system) and traditional manual gait measurement methods (10-meter walk test (10MWT) and 3-meter timed up and go test (3m-TUG)) for evaluating the CSF tap test (CSF-TT) responsiveness in patients with iNPH.

METHOD: 40 iNPH patients (21 males and 19 females, with an average age of 71.71 ± 4.43 years) were prospectively enrolled and subjected to CST-TT. ReadyGo and 10MWT and TUG were done simultaneously.

RESULTS: Instrumental gait analysis parameters were highly linearly correlated with manually measured parameters: ReadyGo was highly linearly correlated with 10MWT (speed correlation coefficient is 0.81, step number correlation coefficient is 0.70, and step frequency correlation coefficient is 0.77); ReadyGo was highly linearly correlated with 3m-TUG(r=0.89). The sensitivity of gait analysis recorded by instrumental recorders is higher than that of traditional manual gait measurements, and can provide more dimensional parameters for gait evaluation.

CONCLUSION: The ReadyGo quantitative motor function assessment system showed more advantages in objection, quantitation, and automated calculation, and showed the potential for clinical application.

KEYWORDS: CSF tap test (CSF-TT); idiopathic normal pressure hydrocephalus (iNPH);10-meter walk test (10MWT) ; 3-meter timed up and go test (3m-TUG)

CSF DYNAMICS IN LONG-STANDING OVERT VENTRICULOMEGALY IN ADULTS

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INTRODUCTION: Long-standing overt ventriculomegaly in adults (LOVA), is a form of chronic hydrocephalus, and its pathophysiology and treatment remain debated. CSF dynamics analysis in this condition has been scarcely reported.
In this study we analyze the hydrodynamic characteristics of patients with a suspect of LOVA, to discuss its pathophysiological mechanisms and the importance of CSF dynamics analysis in these patients.

METHODS: This retrospective cohort study included adult patients (age>18) explored in our department of neurosurgery, through a lumbar infusion study (LIS), for suspicion of LOVA (n=23). They were compared with a control cohort of patients explored for suspicion of idiopathic normal pressure hydrocephalus (iNPH, n=30). We compared 2 hydrodynamic parameters: resistance to CSF outflow (Rout), which relies to CSF resorption, and pressure volume index (PVI), which reflect the overall cranio-spinal compliance. LIS was considered pathological when at least one of these parameters was altered.

RESULTS: Rout was significantly less frequently increased (cutoff ≥ 12 mm Hg/ml/min) in patients with LOVA (52%) than in those with iNPH (97%; $p < 0.001$). In contrast, PVI was impaired (cutoff ≤ 25 ml) in both cohorts, in 61% of patients with LOVA and in 83% of patients with iNPH. Overall, the rate of pathological LIS in LOVA (87%) was not statistically different than in iNPH (100%). However, PVI was the only impaired parameter most frequently found in those with LOVA (35%) compared with those with iNPH (3%; $p = 0.002$).

CONCLUSIONS: There is a differential CSF dynamics pattern when comparing patients with LOVA versus those with iNPH. A higher proportion of patients with LOVA showed isolated compliance impairment. These findings highlight the utility of LIS for the evaluation of patients with suspected chronic obstructive hydrocephalus such as LOVA. Future research may help define diagnosis and treatment algorithms of chronic obstructive hydrocephalus based on CSF dynamics analysis, in addition to clinical and radiological criteria.

EFFECTIVENESS OF THE CLOCK DRAWING TEST IN THE TAP TEST

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INTRODUCTION: The Clock Drawing Test (CDT) is a simple and effective test to evaluate cognitive function, often used for diagnosing dementia. We have been applying the CDT in addition to the MMSE and the FAB in the Tap Test (TT). In this study, we retrospectively examined the effectiveness of the CDT in the TT.

METHODS: We analyzed the data of consecutive 56 patients with iNPH who underwent TT at our hospital. The CDT score was assessed using Freedman's 15-point scoring system, and we evaluated the change in values before and after the tap. The value after tap was the highest score observed between the day of tap and the 7th day. We also similarly compared the changes values of MMSE and FAB. Furthermore, we compared the changes in values among three groups according to comorbidities: iNPH without comorbidities (iNPH group), iNPH with Alzheimer's disease (AD-iNPH group), and iNPH with vascular dementia (VaD-iNPH group).

RESULTS: In the analysis of all subjects, the CDT score before tap was 10.2 ± 3.2, and we observed an increase of 2.6 ± 2.0 points after tap ($P < 0.0001$). In the analysis by comorbidity, the AD-iNPH group showed a smaller increase in MMSE score after tap than the iNPH group (2.0 ± 2.3 points, $P = 0.099$) but showed a significantly larger increase in CDT score (3.6 ± 2.3 points, $P = 0.022$) similar to the iNPH group (2.7 ± 2.0 points, $P < 0.001$). The VaD-iNPH group showed a tendency to have a smaller increase in CDT score than the iNPH group, with an increase of 1.9 ± 1.7 points ($P = 0.013$).

CONCLUSIONS: The CDT is an effective useful indicator as an evaluation item for the TT, especially in cases of comorbid AD.

EFFICACY AND SAFETY OF A NOVEL PROGRAMMABLE VALVE (SPHERA PRO®) IN THE TREATMENT OF IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS: A MULTICENTER STUDY.

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INTRODUCTION: Idiopathic normal pressure hydrocephalus (iNPH) is a syndrome characterized by gait disturbance, cognitive impairment, and urinary incontinence, affecting mainly the elderly. Recently we showed in a pilot study that treating iNPH with a novel programmable valve (Sphera Proâ) is cost-effective. Here we aim to describe the efficacy and safety of Shpera Proâ valve in a large cohort of patients.

METHODS: A prospective cohort of iNPH patients treated with Sphera Proâ programmable valve with gravitational unit was followed for one year in two tertiary public hospitals. Clinical improvement, measured by NPH Japanese Scale and compared pre- and postoperatively (3, 6 and 12 months), and complications were registered. Differences in the evolution of the NPH Japanese scale score over time were assessed using generalized estimating equations (GEE).

RESULTS: A total of 30 patients with probable iNPH were prospectively recruited. Mean age of patients was 75.7 (±7.87) years-old, 53.3% were female. Cognitive impairment was present in 90% of patients, meanwhile gait disturbance and urinary incontinence in 96.6%. Time from the onset of symptoms to surgery was 37.2 (±13.2) months. NPH Japanese Scale score decreased over time ($p<0.001$) from 6.1 (±2.2) preoperatively to: 4.0 (±2.9), 3.8 (±2.6) and 3.8 (±2.5), 3, 6 and 12 months postoperatively (respectively). 86.6% of patients had a sustained decrease in NPH Japanese Scale score during follow-up. Only two patients (6.6%) had complications during follow-up, which were chronic subdural effusions needing surgery. There were no deaths during the study.

CONCLUSIONS: In this prospective multicenter study, Sphera Proâ valve with gravitational unit was effective in treating iNPH patients, with few complications.

SHUNTING FOR IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS: A COCHRANE SYSTEMATIC REVIEW

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INTRODUCTION: Meta-analyses have reported the benefits of cerebrospinal fluid (CSF)-shunting idiopathic Normal Pressure Hydrocephalus (iNPH), but there has been a lack of randomised, controlled trials (RCTs) to confirm this effect with certainty.

METHODS: In line with Cochrane methodology, we searched the medical literature for randomised, controlled studies assessing the effect of CSF-shunting in iNPH which fulfilled our PICOS criteria. Data were extracted from selected studies to RevmanWeb for meta-analysis. We assessed risk of bias using the ROB2 tool and graded evidence certainty using GRADEProGDT.

RESULTS: We detected 5 RCTs and excluded 1 unpublished RCT. We excluded 1 RCT with no population variation data from quantitative analysis. The 3 remaining RCTs included 140 participants (73 immediate and 67 delayed shunting). Gait speed improved significantly with shunting with a "moderate" Cohen's effect size. Disability improved with a risk ratio of 2.08 for functional independence and a number needed to treat of 3.4. There was no significant effect of shunting on cognitive screening. Urinary dysfunction improved with shunting by an uncertain effect-size. Risk of bias was low in all outcomes evaluated. There was "moderate" certainty of effect size for gait, and disability. Adverse events occurred in 29% but cranial surgery post shunt was rare (2%) and there was no mortality clearly associated with shunt surgery.

CONCLUSIONS: There is now some high-quality RCT evidence to support the use of CSF-shunting in iNPH but more studies are needed to increase the certainty of this evidence.

PLACEBO–CONTROLLED EFFECTIVENESS IN INPH SHUNTING (PENS) – STUDY UPDATE

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INTRODUCTION: The Placebo–controlled effectiveness, in INPH shunting (PENS) trial is now in its second year. We will give an update of the trial's clinical site development and early accrual. Issues in the development of the project will be discussed including screening, criteria for capacity and issues of obtaining consent. Exclusion criteria, either designed to decrease surgical risk, such as anticoagulation, or to optimize shunting, such as gait speed and co-morbidities, will be discussed in the context of an effectiveness versus an efficacy study.

METHODS: 19 study sites are currently enrolling patients scheduled for ventriculoperitoneal shunting based on response to CSF drainage. Patients are randomized to a Codman® Certas® Plus valve with SiphonGuard® at either setting 4 (Active, N=9) or setting 8 /"virtual off" (Placebo, N=9). Patients and assessors are blinded to the shunt setting. Outcomes include 10-meter gait velocity (primary outcome), cognitive function, bladder activity, depression, Modified Rankin scale, and Lawton ADL/IADL scores. The primary analysis is gait velocity improvement in the Active versus Placebo groups at 4-months. Afterwards all shunts are blindly adjusted to the active setting. The long-term evaluation of active shunting in all patients is ongoing.

CONCLUSIONS: While the trial is moving forward, multiple issues based on site differences and local PI judgment are critical to maintain the validity of the trial and will be presented.

SAFETY OF VENTRICULOPERITONEAL SHUNT PLACEMENT IN PATIENTS WITH IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS IN THE SETTING OF SYSTEMIC ANTICOAGULATION

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INTRODUCTION: Since the iNPH patient population is elderly, many patients have significant medical comorbidities that may require treatment with systemic anticoagulation or antiplatelet therapy. Therefore, the objective of this study was to determine the safety of shunting iNPH patients on systemic anticoagulation.

METHODS: A total of 232 patients > 60 years of age diagnosed with iNPH underwent shunt placement from 2018-2022. Patients were included in this study if they were treated with anticoagulation preoperatively including warfarin, direct Xa inhibitors (apixaban and rivaroxaban), direct thrombin inhibitors (dabigatran), or antiplatelet therapy with clopidogrel. The patients were retrospectively reviewed for baseline demographics, perioperative complications, and overdrainage.

RESULTS: A total of 47 patients were identified who underwent VP shunt placement in the setting of systemic anticoagulation or antiplatelet medication use. The mean modified frailty index was 1.45, and Charles comorbidity Index was 2.98. Seven patients had a history of myocardial infarction, and 18 patients were anticoagulated for treatment of atrial fibrillation. 15 patients were treated with apixaban, 15 patients with coumadin, 1 patient with dabigatran, 9 patients with rivaroxaban, and 6 patients with clopidogrel. Two patients had a minor postoperative tract hemorrhage and five patients had small intraventricular hemorrhages, though none were clinically symptomatic or required intervention. At 1-month follow-up, seven patients (14.9%) had evidence of subdural hematoma formation, with 1 patient in the setting of a traumatic head injury. Two patients (4.3%) required further surgery for treatment of the subdural hematoma, though one of these patients was due to the traumatic injury.

CONCLUSIONS: Patients with iNPH on long-term anticoagulation or antiplatelet treatment can be safely treated with VP shunt placement, though there is a potentially higher risk of overdrainage and subdural hematoma formation. However, only 1 patient out of the series of 47 required surgical treatment of a subdural hematoma from the shunt.

FRAILTY AND MEDIUM-TERM OVERALL SURVIVAL FOLLOWING VENTRICULOPERITONEAL SHUNTING FOR PATIENTS WITH IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: The aim was to evaluate the utility of the modified Frailty Index-11 (mFI-11) in predicting overall survival following ventriculoperitoneal shunt (VPS) surgery for idiopathic Normal Pressure Hydrocephalus (iNPH).

METHODS: Patients, 65 years and above who underwent VPS for iNPH between 2013 and 2022 were included. Patients were retrospectively scored using the mFI-11 to categorise frailty as low (mF-11 score 0–2), moderate (mFI-11 score 3–5) or high risk (mFI-11 score 6–7). Kaplan–Meier survival curve analysis and log-rank test were used to estimate overall survival and to test for differences amongst frailty groups following surgical intervention.

RESULTS: A total of 109 patients (109 procedures) were included; 72 (66%) were males and the mean age was 75.17 (±5.25). The median length of hospital stay was 3.56 days. The mean mFI-11 score was 1.91 (SD 1.259). 75/109 (69%) were categorised as low risk and 34/109 (31%) as moderate risk. There were no patients with a high frailty risk score. In this cohort, univariate analysis showed no significant association between level of frailty and length of stay. Median length of follow up was 55 months and at the time of analysis 86/109 had reached 2 years and 49/109 had reached 5 years of follow up. The estimated median survival following shunt insertion was 6 years and the 5-year cumulative survival was 75%. There was no difference in survival between frailty risk groups (p=0.66).

CONCLUSION: The mFI-11 is a useful tool that can be readily calculated using available patient data. Frailty is prevalent in this patient group and can be a valuable predictor of mortality. In our patient cohort however, those with low and moderate frailty risk scores had similar medium-term survival. Correlation with prospective assessment of frailty and with functional outcomes following shunt surgery is needed.

ANALYSIS OF INTRACRANIAL PRESSURE PULSE SHAPE INDEX IN NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Years ago, it was observed that as craniospinal compliance (C) decreases, the shape of intracranial pressure (ICP) pulse waveforms gradually shifts from a three-phasic to a sinusoidal-like morphology. However, analysis of ICP pulse shape has not been widely used in clinical practice until recently, mainly due to the challenges with processing large amounts of high-resolution ICP data. With the recent developments in artificial intelligence (AI), this limitation no longer exists. In this study, we applied an AI-based metric called the Pulse Shape Index (PSI) to automatically analyze the morphology of ICP pulses recorded in normal pressure hydrocephalus (NPH) patients. Additionally, we assessed the clinical usefulness of ICP pulse shape analysis by comparing the PSI with the elastance coefficient (E) and resistance to cerebrospinal fluid outflow (Rout).

METHODS: We retrospectively analyzed ICP recordings performed in 40 NPH patients during intraventricular infusion tests. A residual network model was applied to classify ICP pulse waveforms into four classes: from 1 (normal) to 4 (pathological). PSI was calculated as the weighted sum of class numbers in moving 30-sec windows. Compensatory parameters E and Rout were calculated based on the infusion test. The Wilcoxon signed-rank test was used to compare PSI at baseline and during the plateau phase of the infusion test. Results are presented as median ± IQR.

RESULTS: Pre-infusion PSI was elevated in comparison to values previously reported in patients after head injury without deep intracranial hypertension. PSI increased slightly during the infusion test (2.96±1.26 vs. 3.05±0.84, $p<0.0001$). Pre-infusion PSI was significantly correlated with E ($R=0.41$, $p<0.008$) but did not correlate with either Rout or baseline ICP.

CONCLUSIONS: In general, the shape of ICP pulse is altered in NPH. Patients with higher E demonstrate more pathological ICP pulse morphology. Further studies are required to confirm the usefulness of PSI in clinical practice.

OSCILLATION OF ICP DURING WALKING IS LOCKED TO HEAD MOTION

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INTRODUCTION: Patients with ICP disturbances often report worsening symptoms upon active movement, such as walking. However, the effect of movement on ICP has received little attention, and instead is typically studied whilst a patient is stationary. We recently reported that ICP is modulated systematically over the stepping cycle when walking. Here we investigate potential explanations of the effect of walking on ICP.

METHODS: Ambulatory patients undergoing routine ICP monitoring (n=27) stood upright and still for 2 minutes, then walked back and forth along the hospital ward at a self-selected pace for 2 minutes, followed by another 2 minutes of standing. A subset of patients (n=4) completed two further recordings where they walked faster and slower than their self-selected pace. ICP was measured by intraparenchymal probe (Raumedic Neurovent-P). Body kinematics were measured from inertial measurement units attached to the head, chest, pelvis and bilateral feet, upper and lower legs. ICP and kinematic data were both recorded at 100Hz and synchronised precisely.

RESULTS: The classically-shaped, cardiac cycle-driven ICP waveform observed during standing was immediately abolished upon initiation of walking and replaced by an ICP waveform with greater mean, and oscillations with larger amplitude and higher frequency than when standing. ICP oscillations during walking were tightly linked to body kinematics such that their frequency corresponded to the stepping rate and their magnitude corresponded to the degree of vertical head motion. The temporal lag between head motion and ICP oscillation was small (<25ms on average) further suggesting a tight relationship. On average, vertical head displacement and acceleration each explained ~60% of variation in the magnitude of ICP oscillation. Both step rate and vertical head motion increased with walking speed which subsequently increased the frequency and magnitude of ICP oscillations, respectively.

CONCLUSIONS: We demonstrate that ICP oscillations during walking are locked to head motion.

CUT-OFF POINT OF THE NONINVASIVE MEASUREMENT OF INTRACRANIAL COMPLIANCE FOR THE DIAGNOSIS OF IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Normal Pressure Hydrocephalus(NPH) is a disease directly related to changes in intracranial compliance. Non-invasive measurement of the intracranial pressure curve may provide a new reliable way of assessing brain compliance and reduce costs with imaging tests and invasive procedures. The present study proposes to evaluate the performance of the P2/P1 ratio (provided through the non-invasive device from the company Brain4care®) as a diagnostic criterion and define a cutoff point for NPH.

METHODS: Twenty-five patients were evaluated and submitted to TAP tests. Non-invasive evaluation of intracranial compliance was performed before and after puncture of 50mL of CSF. All evaluations were performed in the lying position. The performance of P2/P1 was evaluated taking into account the timing (pre- and post-puncture), in addition to the evaluation of the cut-off points from 0.8 to 1.2.

RESULTS: The results obtained show that pre-puncture, a P2/P1 ratio of 1.1 is the best cut-off point, with a sensitivity of 83%, a sensitivity of 71%, an accuracy of 80%, a positive predictive value of 88%, and a negative predictive value of 63%.

CONCLUSIONS: A value of 1.1 with the patient lying down before the puncture is the appropriate cut-off point for the variable P2/P1 ratio in the noninvasive assessment of intracranial compliance.

RELATIONSHIP BETWEEN BODY MASS INDEX AND INTRACRANIAL PRESSURE WAVEFORM COMPONENTS IN A COHORT OF PATIENTS WITH SUSPECTED IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Previous studies suggested an association between the body mass index (BMI) and intracranial pressure (ICP). However, little is known about the relationship between BMI and the waveform components of ICP. With this study we investigated the correlation between BMI and the ICP waveform components in a cohort of patients with probable/possible idiopathic normal pressure hydrocephalus (iNPH).

METHODS: 109 patients with suspected iNPH (mean age 77.8 years, range 66-91) underwent computerized intracranial pressure monitoring with calculation of heartbeat related ICP pulse amplitude (calculated in the frequency domain, AMP, and time domain, MWA), index of cerebrospinal compensatory reserve (RAP), amplitude of respiratory waves (RESP) and the power of slow vasogenic waves (SLOW). Individual patient's body mass index (BMI) was recorded from height and weight.

RESULTS: Mean ICP was 4.2 ± 3.7 mmHg; mean BMI was 28.8 ± 4.6 kg/m2. Mainly RESP demonstrated a correlation with BMI ($r = 0.45$; $p < 0.001$). The correlations between BMI vs. SLOW ($r = 0.30$, $p < 0.001$) and BMI vs. ICP were weaker ($r = 0.2$, $p = 0.03$). No correlations were found between BMI and AMP/MWA or RAP. In a linear regression model BMI predicted RESP and SLOW.

CONCLUSIONS: Our data demonstrated a relationship between BMI and mainly the respiration induced waves of ICP in patients with iNPH. Significant correlations were also observed with SLOW and ICP. This suggests that RESP should be interpreted in context with BMI data. Further investigations are needed to evaluate the relationship between BMI and ICP waveform components in other diseases such as traumatic brain injury.

PREDICTION OF OPTIMAL ICP LEVEL TO ACHIEVE NORMALIZATION OF PULSE AMPLITUDE

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INTRODUCTION: Shunt setting adjustments are based on patients' signs and symptoms, and/or intracranial pressure (ICP) readings. Pulse amplitude (PA) is a useful marker of brain compliance. Valve setting adjustments usually aim at the normalization ICP, but this does not necessarily correspond to normal PA. It would be useful to be able to predict the level of ICP that results in normalization of PA. This pilot study describes the prediction of PA from ICP values in adult patients undergoing elective 24-hour intraparenchymal ICP monitoring.

METHODS: Single-centre retrospective observational study. Patients undergoing valve setting adjustments guided by 24-hour intraparenchymal ICP monitoring were included. Patients with suspected shunt blockage were excluded. For each patient, the minute-by-minute ICP and PA measurements taken in the first 24 hours ('baseline' dataset) were used to build linear regression models to predict PA from ICP. This model was then tested against the 24-hour ICP monitoring recording performed after valve setting adjustment ('test' dataset) and used to calculate a 'predicted PA'. Differences between 'predicted PA' and actual PA measurements are described.

RESULTS: Seven patients (6F, 1M, mean age 37±11 years) were selected. They had heterogenous diagnoses and shunt types. The 'baseline' minute-by-minute data included a total of 16114 observations (average 2302 per patient), the 'test' minute-by-minute data included 19546 observations (average 2792 per patient). For all the patients, the linear regression models demonstrated a significant association between PA (dependent variable) and ICP (independent variable) ($p<0.05$). The difference between 'predicted PA' and actual PA measurements was negligible (range 0.05 to 0.68 mmHg, mean 0.02). The optimal mean ICP, achieving PA<5mmHg was 6±3 mmHg but varied among patients (ranging 0-10 mmHg).

CONCLUSIONS: It is possible to predict optimal ICP levels that would achieve normalization of PA, this is potentially useful when planning valve setting adjustments. Larger studies will be needed to confirm these findings.

CHARACTERISTICS OF THE M.SCIO TELEMETRIC ICP MEASUREMENT SYSTEM WITH LUMBAR CATHETER

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INTRODUCTION: Astronauts in microgravity develop symptoms that raise suspicion of elevated ICP. One option to investigate this is to surgically implant a lumbar catheter attached to a Telemetric Intracranial Pressure Monitoring (M.scio, Miethke) in astronauts and measure ICP. We evaluated the capability of this assembly to detect mean ICP and ICP pulsatility.

METHODS: We bench tested six M.scio sensor and Medtronic lumbar catheters for sinusoidal frequency response, including the effect of different catheter lengths, including evaluation with an ICP-waveform signal, and accuracy of measuring static mean pressure.

RESULTS: The variable frequency measurements showed that pressure amplitude dampening increased with both frequency and catheter length. With a 44 cm catheter, the amplitude transfer drops from 79% to 20% when going from 1 to 5 Hz. The corresponding change for an 84 cm catheter was from 59% to 13%. The dampening was not affected by the mean pressure. The detected amplitude for a 3 mmHg ICP waveform was reduced by 28% with heart rate increase from 56 to 112 bpm. Static measurements showed that the within-sensor response to changes from -5 to 20 mmHg was, on average, 92% of the reference change and the bias was -2.0 ± 1.1 mmHg at zero ref pressure. The M.Scio system had a noise level of SD=0.4 mmHg, which affects the amplitude assessment.

CONCLUSIONS: A lumbar approach with the M.scio for investigating astronaut CSF dynamic changes in microgravity is feasible, but considering the system characteristics, the ICP could be underestimated. Our findings suggest that one should use the shortest possible catheter, apply post processing to reduce the effect of noise, and adjust for changes in HR.

Supported by the Baylor College of Medicine Center for Space Medicine through a gift from the Polaris Dawn Program.

EARLY FEASIBILITY STUDY OF IMPLANTATION OF A TELEMETRIC ICP SENSOR IN A COMMERCIAL SPACEFLIGHT PARTICIPANT

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INTRODUCTION: Spaceflight Associated Neuro-ocular Syndrome (SANS) may be caused by abnormal ICP. Non-invasive ICP methods researched by NASA lack the accuracy to make this determination. Lumbar puncture is considered unsafe for spaceflight. Methods to assess ICP directly during spaceflight are needed.

METHODS: To obtain U.S. Food and Drug Administration (FDA) approval to surgically implant a telemetric ICP sensor (Miethke M.scio) attached to a lumbar catheter to evaluate its safety and effectiveness for ICP monitoring in a commercial spaceflight participant (SFP), we: 1) designed the surgical and research protocol and safety evaluations for high G forces; 2) submitted an FDA Investigational Device Exemption (IDE) application; 3) collaborated with Miethke GmbH and SpaceX to test the equipment for spaceflight conditions; and 4) conducted bench testing of the implant assembly.

RESULTS:

- April 18, 2022 – FDA pre-application submitted
- July 5, 2022 – Teleconference with FDA reviewers
- August 19, 2022 – Teleconference with FDA/NASA liaisons, and TRISH and NASA leaders
- October 24, 2022 – Teleconference with FDA reviewers
- November 2022 –M.scio system preclinical quality testing by Miethke GmbH
- January 3, 2023 – IDE early feasibility study and research protocol with safety assessments submitted
- February 14, 2023 – IDE approved by FDA
- March 2023 – Bench testing of M.scio implant assembly by Umeå
- March 16, 2023 – Baylor College of Medicine IRB approved the protocol
- May 1, 2023 – Awaiting spaceflight opportunity

CONCLUSIONS: If the research protocol proceeds as planned, it will be the first-ever direct ICP recording in an SFP before, during, and after spaceflight, yielding significant insight into the role of ICP and craniospinal compliance in the early development of SANS.

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EFFECT OF SHUNT ADJUSTMENT ON SHORT TERM TELEMETRIC ICP READINGS

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INTRODUCTION: The advent of telemetric intracranial pressure (ICP) reading shunt components (M.Scio, Miethke), has improved the management of patients with cerebrospinal fluid (CSF) dynamics disturbances, creating the opportunity of frequent non-invasive ICP measurements. These measurements are typically short in time (seconds to few minutes) and are often used to guide shunt adjustments. The effect of shunt adjustments on ICP in the short term is unclear, as the utility of performing immediate post-adjustment ICP measurements. If the human craniospinal compartment behaves as a simple fluid filled compartment, the ICP should be expected to reduce within 2 minutes of a valve setting reduction (tested hypothesis). This ongoing pilot study describes the effect of valve adjustments on post-adjustment telemetric ICP readings.

METHODS: Prospective, single-centre observational study. Patients with a shunt incorporating M.Scio telemetric reader who underwent shunt setting adjustment since March 2023 were included. Patients with suspected shunt blockage were excluded. Baseline (pre-adjustment) and post-adjustment (at various time intervals) ICP was recorded for 30 seconds in sitting, standing and supine position. Mann-Whitney U test was used to compare ICP results.

RESULTS: Five patients (3F, 2M, mean age 67±17 years) with different CSF dynamics disorders were included. All patients underwent downwards valve setting changes. The mean baseline ICP was -11.1mmHg (4.4SD) in sitting, -8.3mmHg (5.5SD) in standing and 18.4mmHg (7.5SD) in supine position. The mean post-adjustment ICP was -10.5mmHg (5.6SD) in sitting, -9.5mmHg (5.9SD) in standing and 15.0mmHg (6.5SD) in supine position. There was no statistically significant difference comparing baseline and post-adjustment ICPs ($p>0.05$ for all 3 positions, Mann-Whitney U). Differences in ICP at later post-adjustment time intervals will be discussed.

CONCLUSIONS: The initial results of this ongoing study showed that ICP does not significantly change 2 minutes after shunt adjustment. These results suggest that CSF dynamics are much more complex than those of a simple fluid filled container.

AGE-STRATIFIED PRESENTATION AND OUTCOMES OF VENTRICULOPERITONEAL SHUNT IMPLANTATION IN A COHORT OF NORMAL PRESSURE HYDROCEPHALUS (NPH) PATIENTS

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INTRODUCTION: NPH is a disorder of cerebrospinal fluid dynamics. The condition is partially reversed by ventriculoperitoneal shunt (VPS) implantation. The majority of patients affected are above the age of 65. NPH patients are often affected by multiple comorbidities; increasing the surgical risk in this population. This study investigates the effects of advanced age on the presentation of NPH and post-operative VPS outcomes by comparing individuals over 80 and below 80 years of age.

METHODS: Patients admitted to the National Hospital for Neurology and Neurosurgery (NHNN), London to undergo VPS implantation for NPH between April 2019-2022 were screened. We recorded standard demographics, symptoms at presentation, pre-operative co-morbidities, medication burden and frailty and co-morbidity markers. The admission length, early post-operative morbidity, VPS mobility outcomes and VPS revision rates were recorded. Pearson's chi-square test and point-biserial correlations were employed to assess the associations between age and investigated factors.

RESULTS: 126 NPH patients, 89 (70.6%) below 80 years and 37 (29.4%) above 80 years were included. There were no significant differences in symptoms duration, symptoms at presentation, comorbidities and medication burden between the two groups. Patients above 80 years of age had higher baseline frailty levels and greater surgical risk parameters as reflected by various anaesthetic, surgical outcome and frailty scores. The older group had post-VPS mobility outcomes comparable to the younger group, with 88.9% and 85.7% improvement rates, respectively (p=1.000). No significant differences in the immediate post-operative morbidity, post-operative hospital stay (p=0.512) or shunt revision rates (p=0.279) were demonstrated. Older NPH patients received more input from the occupational and physiotherapy teams post-operatively (p=0.038).

CONCLUSION: Age alone should not be a factor precluding elderly NPH patients from surgical intervention. Incorporation of comprehensive anaesthetic assessment, adequate pre-operative optimisation and post-operative therapy input should be promoted to maximise the benefits of VPS for older adults.

EFFECTIVE SHUNT SURGERY FOR ELDERLY PATIENTS AFTER A FALL WITH DEFINITE IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS CAN PREVENT THE FOLLOWING FALL.

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INTRODUCTION: We previously reported the benefit of screening for idiopathic normal pressure hydrocephalus (iNPH) in older adults after falls. We assessed whether the shunt surgeries could prevent another fall in those iNPH patients postoperatively.

METHODS: We retrospectively evaluated the consecutive cases diagnosed with probable iNPH after falls to eventually get a shunt surgery between May 2020 and January 2022. We included the patients with the modified Rankin scale (mRS) score of 0 to 3 one year after the shunt surgery. Patients who dropped out from our postoperative follow-up were excluded. We compared the time of the Timed-Up Go test (TUG), the Mini-Mental State Evaluation (MMSE), the utility weighted-mRS (UW-mRS), the iNPH grading scale, and the history of postoperative falls between the shunt responders and the non-responders one year after the surgery. We defined shunt responders one year after the surgery as patients improved in mRS score by at least 1.

RESULTS: Fifty-one patients were included; 40 shunt responders and 11 non-responders. The number of patients who had never fallen until one year after the surgery was statistically more significant in the shunt responders than in the non-responders (33 patients [82.5%] vs. 5 [45.5%]; 95% confidence interval [CI], p = 0.0273). There was no statistically significant difference except for the preoperative UW-mRS (Median [Interquartile range], 6.5 [3.3-7.6] vs. 7.6 [6.5-9.1]; 95% CI, p=0.021).

CONCLUSIONS: Shunt surgeries for elderly patients with definite iNPH after falls can prevent the following fall.

COMPARISON OF FEMALE AND MALE OUTCOMES IN A COHORT OF NORMAL PRESSURE HYDROCEPHALUS (NPH) PATIENTS UNDERGOING VENTRICULOPERITONEAL SHUNT IMPLANTATION

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INTRODUCTION: NPH is a disease of the elderly classically characterized by a triad of gait disturbance, cognitive impairment and urinary symptoms. Symptoms can be partially reversed by ventriculoperitoneal shunt implantation (VPS). Little is known about the disparities between female and male NPH patients. This study aimed to characterise the differences between male and female NPH patients undergoing VPS implantation and their post-operative outcomes.

METHODS: Patients admitted to the National Hospital for Neurology and Neurosurgery (NHNN), London to undergo VPS implantation for NPH between April 2019-2022 were screened. We recorded standard demographics, symptoms at presentation, pre-operative co-morbidities, medication burden and frailty and co-morbidity markers. Additionally, the admission length, early post-operative morbidity, VPS mobility outcomes and VPS revision rates were recorded. The associations between sex and investigated factors were assessed by Pearson's chi-square test and point-biserial correlations.

RESULTS: 126 NPH patients, 80 (63.5%) males and 46 (36.5%) females were included. Gait disturbance and urinary symptoms were more common among females than males (p=0.038). Gait disturbance and cognitive impairment were more prevalent among males (p=0.021). Females experienced a greater burden of mental health illness compared to males (p=0.073). No significant differences in the age of presentation, symptom duration, co-morbidities, medication burden, multiple frailty markers, VPS outcomes or revision rates were found. Females reported severe post-operative pain more than males did) ($p<0.001$) which may have accounted for a longer post-operative stay in females (4.9 versus 3.7 days; p=0.102).

CONCLUSION: Symptomatic differences between sexes and the routine use of objective assessments of cognition, urinary symptoms, and gait disturbance should be considered during the diagnostic process. This may facilitate early NPH treatment and, thus, better outcomes. Additionally, limited data on female and male differences in the NPH cohort calls for further research, including immediate and long-term shunting outcomes.

BASELINE PROMIS SCORE CHARACTERISTICS AND TEMPORAL CHANGES FOLLOWING SHUNT PLACEMENT IN PATIENTS WITH IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Patient reported-outcomes Measurement information system (PROMIS) is currently a widely used tool to provide an overview of baseline quality of life characteristics. The objective was to describe the baseline PROMIS scores in iNPH patients, and to determine the feasibility of PROMIS to document improved quality of life in iNPH patients.

METHODS: 222 patients > 60 years of age were diagnosed with iNPH and underwent shunt placement from 2018 to 2022, were retrospectively reviewed. PROMIS questionnaires were admitted preoperatively and during short- and long-term clinic visits. We primarily evaluated seven PROMIS computerized adaptive testing (CAT) domains including anxiety, depression, fatigue, sleep, pain interference, social ability, and physical function. Additionally, we evaluated four secondary PROMIS domains including upper extremity function CAT, short form pain intensity, and short form global and mental health.

RESULTS: A total of 174 patients completed the main seven PROMIS CAT domains before shunt placement. The average baseline scores were: anxiety (55.85), depression (52.82), fatigue (57.41), sleep (49.15), pain interference (55.51), social ability (42.92) and physical function (33.54). 90 patients completed the PROMIS questionnaire at mean 20 months postoperatively. There was a significant decrease in the mean score for anxiety ($p < 0.007$), and fatigue ($p < 0.001$), and a significant increase in the mean score for social domain ($p < 0.001$) and physical function ($p < 0.001$). However, no significant differences were observed following shunt placement for the other PROMIS CATS domains.

CONCLUSIONS: The data indicate that shunt placement results in significant improvement in patient reported outcomes for depression, fatigue, social ability, and physical function, and indicates that these PROMIS CAT domains may be useful in the iNPH population.

SELF-EXPERIENCED OUTCOME AFTER SHUNT SURGERY IN PATIENTS WITH IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS IN RELATION WITH OBJECTIVE CLINICAL OUTCOME AND PREOPERATIVE FACTORS

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INTRODUCTION: Outcome after shunt surgery in idiopathic normal hydrocephalus (iNPH) is often measured using functional outcome measures and the patient´s subjective experience is seldom described. There is a lack of knowledge regarding which factors that affect the experience and if there is correlation between self-experienced outcome and objective outcome measures. The aim of this study was to evaluate self-experienced outcome after shunt surgery in patients with iNPH, in relation to clinical outcomes, coping factors, symptom duration, anxiety and depression.

METHODS: A total of 58 iNPH patients (27 female, mean age 76.6 years) were consecutively included and evaluated preoperatively and three months postoperatively. Sense of coherence, anxiety, depression and symptom duration were evaluated preoperatively. The self-experienced outcome after surgery was measured with a Global Rating of Change scale (GRC) with the variables total experience, gait, balance, continence and cognition after surgery. The objective outcomes were evaluated with the Hellström iNPH scale (total score, gait, balance, continence and neuropsychology).

RESULTS: Forty-two patients were evaluated postoperatively. The GRC total experience score had a moderate to strong positive correlation with the outcome in the total iNPH scale (rho 0.60, $p<0.01$), as well as the GRC gait score with the iNPH scale gait score (rho 0.60, $p<0.01$) and the GRC continence score with the iNPH scale continence score (rho 0.49, $p<0.01$). The experienced change in balance and cognition did not correlate with the corresponding domains in the iNPH scale. The HAD depression score had a weak negative correlation with the total GRC score (rho -0.32, $p<0.05$). The patients´ preoperative coping capability, anxiety and duration of symptoms did not influence the experienced outcomes.

CONCLUSIONS: The patients´ self-evaluated changes in total experience, gait and continence correlated moderately to strongly with changes in the corresponding objectively measured outcomes after shunt surgery.

LONG-TERM COGNITIVE AND GAIT OUTCOMES AFTER PRIMARY ENDOSCOPIC THIRD VENTRICULOSTOMY (ETV) IN ADULTS FROM THE AHCRN WITH CHRONIC OBSTRUCTIVE HYDROCEPHALUS.

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INTRODUCTION: This study investigated the long-term efficacy of primary ETV on cognition and gait in adults with chronic obstructive hydrocephalus.

METHODS: Patients from the multicenter Adult Hydrocephalus Clinical Research Network (AHCRN) registry, undergoing ETV for untreated congenital or acquired obstructive hydrocephalus, were prospectively accrued. Outcomes were gait velocity (10-meter walk test) and Montreal Cognitive assessment (MoCA) score. Median within-patient change, from pre-ETV to post-ETV evaluation, was assessed (via Signed Rank Test).

RESULTS: 61 patients with both pre- and post-ETV assessments were analyzed. Mean age was 58.1 years and 34 (55.7%) were female. Etiology of CSF obstruction was either congenital (n=37, 60.7%) or acquired (n=24, 39.3%). Pre- and ≤ 6-month post-ETV gait was assessed in 43 patients: Baseline median gait velocity was 0.9 m/s, improving to 1.3 m/s at ≤ 6-mo post-ETV. This improvement was statistically significant with median within-patient change of +0.3 m/s ($p < 0.001$). Gait was assessed ≥ 12-month post ETV (12 to 51 months) in 21 of 43 patients (49%) and improvement persisted: Baseline median gait velocity of 1.1 m/s, improved to 1.4 m/s at ≥ 12-mo post-ETV and the median within-patient change was +0.2 m/s ($p <0.001$). Pre- and ≤ 6-month post-ETV MoCA was conducted in 46 patients: Baseline median MoCA was 24/30, which improved to 26/30. This improvement was statistically significant with the median within-patient MoCA change of +1 ($p = 0.002$). MoCA was performed ≥ 12-month post-ETV (12 to 50 months) in 22 of 46 patients (48%) and improvement persisted: Baseline median MoCA was 23/30, which improved to 25/30 at ≥ 12-month post-ETV, while the median within-patient MoCA change was +1 ($p = 0.03$). However, a ≥ +2 change in MoCA is probably necessary to be clinically meaningful.

CONCLUSION: ETV results in long-term improvement in gait and cognition in adults with chronic obstructive hydrocephalus.

SAFETY, SEQUELAE, AND EFFICACY OF NERVE ROOT CLIPPING IN PATIENTS WITH SPONTANEOUS SPINAL CSF LEAKS.

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INTRODUCTION: Spinal CSF leaks may cause a myriad of clinical symptoms, the most common being orthostatic headache. Leaking cysts (Type II) and direct CSF venous fistulas (Type III) are a subgroup of spinal CSF leaks representing about 1/3 of spinal CSF leaks. To seal the diverticula or the CSF venous fistula the respective nerve root is microsurgically ligated using aneurysm clips.

OBJECTIVES: The study aimed to analyze the incidence of sensory-motor deficits, neuropathic pain, and patient-reported outcome after nerve root clipping.
METHODS: All consecutive patients with Type II and Type III spinal CSF leaks treated with nerve root clipping at our Neurosurgical institution from Mai 2018 to November 2022 were included. Patients were evaluated for post-operative sensory-motor deficits. The incidence of neuropathic pain and patient-reported outcome was assessed via DN4 (Douleurs Neuropathique 4) and PGIC (Patients' Global Impression of Change), respectively.

RESULTS: A total of 40 patients were included in the study (Type II n=31; Type III n=9). In total, 47 spinal CSF leaks were treated via nerve root clipping; the mean age was 46,6. The mean follow-up time was 22 months. Over 80% of patients reported significant recovery. Almost 90% of patients either fully or partially returned to their employment. One patient clipped in the upper thoracic region developed a regressive motor deficit. The incidence of neuropathic pain was 7,5%. Over 80% of patients developed dermatomal hypoesthesia, with no reported effect on life quality.

CONCLUSION: Nerve root clipping is a safe and effective surgical strategy for patients with Type II and Type III spinal CSF leaks. Only 7.5% of patients developed post-operative neuropathic pain, and only 2.5% needed medical treatment. In terms of efficacy, over 98% of patients reported recovery, according to the PGIC score and close to 90% of patients either fully or partially returned to their employment.

PROGNOSTIC SIGNIFICANCE OF CEREBROSPINAL FLUID PRODUCTION RATE IN THE MANAGEMENT OF CEREBROSPINAL FLUID LEAK

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INTRODUCTION: The management of cerebrospinal fluid (CSF) leak is quite varied. Traditionally, CSF leaks are managed by primary repair (with or without augmentation), tissue glue, and CSF diversion (most commonly lumbar drain placement). Our study aimed to demonstrate net cerebrospinal fluid production rate (PRcsf) as a potential prognostic tool for the management of CSF-leaks.

METHODS: A prospective observational study was performed on all CSF leak patients in our hospital who required CSF drainage as part of their ongoing management. The drain was connected to a LiquoGuard7 (Möller-Medical, Germany) with the intracranial pressure sensor at the level of the external auditory meatus. The internal software and flow-rate data of the LiquoGuard7 pump was used to calculate net PRcsf in the patients. Patients were flat for 30 minutes during the measurement. Patient notes and electronic health records were reviewed daily. The events occurring during the hospital stay for each patient and the treatment received was noted. Patients were followed-up at 6 months post-hospital discharge. Prognosis and patient outcome were recorded as complete resolution of symptoms at 6 months post-hospital discharge. Statistical analysis used SPSS (version 25.0, IBM) by multivariate multiple regression, comparing the resolution of symptoms to the measured PRcsf, age, gender, co-morbidities, and the type of surgical treatment received.

RESULTS: 26 CSF leak patients were studied. CSF leak patients with average PRcsf of 55ml/hour ± 10SD (n=9) improved with lumbar drain (average 7-days, average age <40yrs). CSF Leak patients demonstrating average PRcsf of 86ml/hour ± 10SD (n=10) improved following CSF-shunting with no further CSF leak (average age 48yrs). Repair ± augmentation ± CSF-shunt was required in patients with PRcsf of 146ml/hour ± 5SD (n=7, average age 52years). All CSF-leak patients on average demonstrated high intracranial-pressure.

CONCLUSION: PRcsf may hold prognostic value towards treatment-response in patients with CSF-leak.

SURGICAL CLOSURE OF SPINAL CSF LEAKS IMPROVES SYMPTOMS IN PATIENTS WITH SUPERFICIAL SIDEROSIS

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BACKGROUND: Spinal CSF leaks may cause a myriad of clinical symptoms, the most common being orthostatic headache. In addition, ventral spinal CSF leaks are a possible etiology of superficial siderosis (SS), a rare condition characterised by hemosiderin deposits in the CNS. It is caused by chronic or repeated subarachnoid bleeding. It classically presents with progressive cerebellar ataxia, bilateral hearing loss, and myelopathy, for which effective therapy is limited, and symptoms are considered irreversible.

OBJECTIVE: To evaluate if microsurgical closure of the CSF leak can prevent further clinical deterioration or even improve symptoms of superficial siderosis.
METHODS: This cohort study was conducted using data from a prospectively maintained database in 2 large SIH referral centers in Germany and Switzerland of patients who met the modified International Classification of Headache Disorders, 3rd edition criteria for SIH. Patients with spinal CSF leaks were screened for the presence of idiopathic infratentorial symmetric superficial siderosis of the CNS.

RESULTS: In total, 12 patients with a ventral spinal CSF leak and SS were identified. The median latency between the onset of orthostatic headaches, if present, and symptoms attributed to superficial siderosis was 9.5 years. After surgical closure of the underlying spinal CSF leak, symptoms attributed to superficial siderosis improved in 70% and remained stable in 30%. Patients who presented within one year after the onset of superficial siderosis symptoms improved, but those who presented within 8-12 years did not improve at the follow-up time.

CONCLUSION: We conclude that long-standing untreated ventral spinal CSF leaks can lead to superficial siderosis of the CNS and that microsurgical sealing of spinal CSF leaks might stop progression and improve symptoms in patients with superficial siderosis in a time-dependent manner.

RECOVERY AND LONG-TERM OUTCOME AFTER NEUROSURGICAL CLOSURE OF SPINAL CSF LEAKS IN PATIENTS WITH SPONTANEOUS INTRACRANIAL HYPOTENSION (SIH)

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INTRODUCTION: Spontaneous intracranial hypotension (SIH), caused by a spinal CSF leak, may cause many clinical symptoms, the most common being disabling headaches with a high impact on patients' quality of life. While successful closure of the leak is often reported, long-term outcome results regarding patients' symptoms are still scarce. This study aimed to analyze the postoperative course and long-term outcome in patients treated surgically for a spinal CSF leak.

METHODS: Using patient reported outcome measures (PROM), between April 2020 and December 2022, SIH patients treated surgically for a spinal CSF leak completed the HIT-6 questionnaire on a tablet before surgery, and post-operative at 14 days, 3, 6 and 12 months, respectively, via an automated follow-up system.

RESULTS: In total, 80 patients were included. The median HIT-6 score preoperatively was 65, IQR (61-69) representing severely disabling headaches. The score improved to 49 (IQR 44-58) 3 months postoperatively and to 48 (IQR 40-56) 12 months postoperatively, considered to have little to no impact on patients' quality of life.

CONCLUSIONS: Surgical closure of the CSF spinal leak in SIH patients significantly improves headaches in the long term. At least three months should be expected for recovery. PROMs are reliable and applicable in a daily surgical routine in order to assess clinical improvement. Despite these encouraging results, 1/4 of patients still have a relevant long-term impairment, indicating the need for further research on its cause and possible treatment.

CSF HYDRODYNAMICS IN PATIENTS WITH PROLONGED DISORDERS OF CONSCIOUSNESS

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INTRODUCTION: Prolonged disorders of consciousness (PDOC) following brain injury is a major public health problem. Advances in intensive care allow patients to survive after brain injury. However, one third of the patients will not recover consciousness. To date, no specific treatment has shown its effectiveness in the recovery of consciousness. Brain imaging in PDOC patients often shows cerebral atrophy and ventriculomegaly suggesting hydrocephalus secondary to deranged intracranial fluid circulation. Hydrocephalus may participate to PDOC, either quickly or with delay, reducing the potential for natural recovery of consciousness. Controversies remain about how to diagnose hydrocephalus and whether to propose CSF diversion. We hypothesize that CSF hydrodynamics is relevant to better identify hydrocephalus in PDOC patients.

METHODS: We retrospectively analyzed 41 patients (26M/15W) with i) acute brain injury, ii) persistent (i.e.>1 month) disorder of consciousness and iii) ventriculomegaly (i.e. Evan's ratio >0.3). PDOC patients suspected of hydrocephalus we explored (from 12/2010 to 04/2023) with a lumbar infusion test to gauge CSF hydrodynamics using ICM+.

RESULTS: Acute brain injury was related to: head trauma (17), subarachnoid hemorrhage (16), intracerebral hematoma (6), cardiopulmonary arrest (1), metabolic (1). Mean resistance to CSF outflow (Rcsf) was increased (i.e. ≥12 mmHg/ml/min, cf. table 1). 21 patients (51%) exhibit normal Rcsf (i.e. <12) and 20 patients (49%) exhibit increased Rcsf (i.e. ≥12). Raised Rcsf (i.e. ≥12 above dashed line) was identified several months, up to 40 months, after the brain injury (cf. Figure 1).

CONCLUSIONS: Half of the patients with PDOC and ventriculomegaly exhibit altered CSF hydrodynamics. Lumbar infusion test seems to be relevant to better identify hydrocephalus in PDOC patients. Rcsf is an important metric that should be implemented in the management algorithm of PDOC patient to better advocate for CSF diversion when hydrocephalus is suspected, even months or years after brain injury.

IMPACT OF VENTRICULOPERITONEAL SHUNT ON SYSTEMIC HYPERTENSION

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INTRODUCTION: Several studies have supported the hypothesis that rise in systemic hypertension(HTN) leads to a subsequent rise in intracranial pressure(ICP). Systemic hypertension is an established cause of secondary intracranial hypertension. Insertion of ventriculoperitoneal shunt(VPS) is a common neurosurgical intervention to remedy raised ICP. This single-centre study aimed to evaluate whether insertion of VPS led to a subsequent decrease in systemic blood pressure(BP) in known hypertensive patients.

METHODS: A retrospective-observational study was performed in 100 patients who had undergone VPS insertion in the National Hospital for Neurology and Neurosurgery in 2019. The electronic-health-records(EHRs) of the patients were evaluated in depth. After recording demographic information(age, gender, underlying pathology, BMI), heed was paid to past medical history(PMH) of hypertension and drug history including various antihypertensive medication and the doses of these medications. EHRs were studied to note trends in BP measurements prior to and following VPS insertion, and the subsequent need for antihypertensive medication. Statistical analysis was done by SPSS(version 25.0, IBM) by paired t-test comparing BP measurements prior to and following VPS insertion.

RESULTS: 44 patients undergoing VPS insertion had PMH of HTN(average systolic BP 150-200mmHg) with drug history of antihypertensive agents. Of these 28 exhibited normotensive BP immediately following VPS insertion, which was maintained 3 years following VPS insertion. These patients did not require antihypertensive agents any further. On paired t-test this result was statistically very significant($p<0.0001$). 16 patients continued to suffer from hypertension following VPS insertion. 100% of these patients(16/16) demonstrated better control of their BP, with less frequent hypertensive episodes(average systolic BP 130-150mmHg) and 25%(4/16) had a subsequent reduction in the dosage of antihypertensive medication. These results were maintained at 3 years following VPS insertion($p<0.0001$).

CONCLUSION: VPS insertion may lead to decrease in HTN, possibly by decrease in ICP. Validation of the results is required in larger cohorts.

COGNITIVE IMPROVEMENT AFTER ENDOSCOPIC THIRD VENTRICULOSTOMY SURGERY IN LONG-STANDING OVERT VENTRICULOMEGALY IN ADULTS

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INTRODUCTION: Long-standing overt ventriculomegaly in adults (LOVA) is a chronic form of hydrocephalus that may lead to cognitive decline. This study aimed to evaluate the cognitive outcomes of endoscopic third ventriculostomy (ETV) surgery in patients with LOVA hydrocephalus.

METHODS: Twenty consecutive patients with LOVA hydrocephalus underwent ETV surgery, and their cognitive status was assessed before surgery, immediately after surgery, and at four months follow-up. Cognitive function was assessed using a neuropsychological battery that measured six cognitive domains: general cognitive status, attention/executive function, language, visuospatial ability, short-term memory, and long-term memory (LTM). Cognitive reserve was also measured using the Italian version of the National Adult Reading Test (NART).

RESULTS: LTM was the only cognitive domain that was significantly impaired in patients with LOVA hydrocephalus, and immediate postoperative improvement was observed. The amount of immediate improvement in LTM was directly correlated with cognitive reserve, as measured by the NART. Improvement in LTM was maintained at the 4-month follow-up evaluation.

CONCLUSIONS: ETV surgery may lead to immediate improvement in LTM in patients with LOVA hydrocephalus. These findings suggest that ETV surgery may be an effective treatment for LOVA hydrocephalus, and that cognitive reserve may be an important factor in predicting outcomes after surgery. Further studies with larger sample sizes are needed to confirm these findings and to determine the long-term effects of ETV surgery on cognitive function in patients with LOVA hydrocephalus.

A SYSTEMATIC REVIEW OF COGNITIVE ASSESSMENT METHODS AND OUTCOMES FOLLOWING SHUNT SURGERY IN IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS (INPH)

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INTRODUCTION: Cognitive deficits in iNPH include processing speed, psychomotor speed, and executive functioning. The effectiveness of shunt surgery in alleviating iNPH cognitive symptoms is often questioned. A systematic review was conducted to identify and synthesise available evidence on the cognitive assessment methods and outcomes following shunt surgery in patients with iNPH.

METHODS: A systematic search of PubMed, Scopus, PsycINFO and Web of Science was completed without date restriction. The search was restricted to peer-reviewed publications in English featuring adults with iNPH. Studies reporting within-subject investigations of cognition before and after shunt surgery, with extractable cognitive data were included. Articles were assessed for quality prior to extraction. Key descriptive data was extracted: first author, publication year, country, design, follow up time, cognitive assessment method, sample size, sample characteristics and symptom duration (Prospero ID CRD42021296112).

RESULTS: A total of 1435 studies were identified and 158 met the inclusion criteria. Cognitive assessment methods included subjective patient or carer reports, clinician reports, grading scales, brief screening tools and comprehensive neuropsychological assessments. Over 107 different cognitive tests were reported. Most studies used brief non-specific screening tools and 56.3% of studies did not measure outcomes in the key cognitive deficits observed in iNPH. Postsurgical cognitive improvement rates (Range 10.5%–100%) and methods of specifying improvement varied widely between studies.

CONCLUSIONS: There is considerable heterogeneity in the methods of assessing cognition in iNPH patients, and variability in the reported effectiveness of shunt surgery in alleviating cognitive symptoms. When cognitive tests are used, the selected tests often do not measure the cognitive domains affected in iNPH. This indicates the need for standardised assessment tools, tailored to detect the specific pattern of cognitive deficits in iNPH, which are feasible to apply within routine practice.

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ESTIMATION OF VENTRICULAR VOLUME CHANGES FOR SMART SHUNT SYSTEMS

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INTRODUCTION: Shunt therapy for hydrocephalus aims to regulate the volume of cerebrospinal fluid (CSF) within the cranial ventricles. Presently, however, monitoring focuses mainly on intracranial pressure (ICP) and actual CSF drainage rate is controlled by passive differential pressure valves. To narrow the gap between therapy objective and contemporary practice, a sensor technology for continuous estimation of changes in ventricular volume (VV) is developed.

METHODS: A mechatronic test-bench that can simulate VV changes in a saline-filled silicone-carbon brain phantom was used to mimic CSF dynamics and brain tissue properties in-vitro. A measurement catheter with integrated electrodes was inserted into the ventricle. ICP and bioimpedance (BI) were measured simultaneously. A physiological test scenario, including respiratory and cardiac effects, with VV changes up to 9 mL was simulated and the recording split into training and testing data. Different process and measurement models were fitted to the training data and investigated to design Kalman filter (KF) that estimate the unknown VV changes in the testing data.

RESULTS: Changes in ICP and VV are strongly positive correlated (r=0.954), whereas changes in BI and VV are strongly negative correlated (r=-0.996). Affine functions suffice to approximate the dynamic changes of ICP and BI in the training data with a root-mean-squared-error (RMSE) of 0.423 mmHg and 0.057 W, respectively. A simple KF that uses a random walk process model and the affine functions as the measurement model can estimate VV changes in the testing data with an RMSE of 0.137 mL.

CONCLUSIONS: The introduced sensor technology demonstrates how multimodal sensor data can be fused to estimate VV changes that otherwise can only be observed via imaging. The in-vitro test result underlines its potential to improve hydrocephalus patient monitoring and to enable physiological control of CSF drainage for smart shunt systems that could reduce complications like over- and under-drainage.

REVERSAL OF APPARENT CEREBRAL ATROPHY (CEREBRAL PSEUDOATROPHY) IN NORMAL PRESSURE HYDROCEPHALUS PATIENTS WHO HAVE UNDERGONE VENTRICULAR SHUNT SURGERY

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INTRODUCTION: Normal Pressure Hydrocephalus (NPH) is a condition with a high incidence and prevalence in older adults. Treatment involves a cerebrospinal fluid shunting procedure, and has significantly changed the outcome and quality of life for patients and their families. The most important aspect for diagnosis is the symptom triad: cognitive impairment, gait disturbances and urinary incontinence. Additionally, there should be characteristic imaging findings of ventriculomegaly, with transependimary migration and changes in the subarachnoid space. In post-operative follow-up, brain imaging shows a decrease in ventricle size and subarachnoid space. However, in many of the MRI studies, there appears to be an increase of brain tissue volume in addition to CSF changes.

METHODS: This study aimed to establish brain volumetric changes by means of brain magnetic resonance imaging (MRI) in NPH patients after they underwent a CSF shunting procedure, in a before and after cross-sectional study where brain volumes were obtained using the VolBrain and Vol2Brain system for all patients undergoing ventricular shunt surgery at the Fundación Santa Fe de Bogotá between April 2016 and September 2020.

RESULTS: We included a total of 30 patients. The average age was 80.4 years (54 to 92 years), 20 patients were men (66.6%) and 10 women (33.3%). A total of 60 brain MRI studies were reviewed. We found that, after the ventricular shunt, patients had a statistically significant ($p<0.001$) increase in gray matter (95% CI: -105.49 to -98.50), CSF (95% CI: 86.5 to 93.49), total brain parenchyma (95% CI: -106.49 to -99.5) and intracranial cavity (95% CI: -15.49 to -8.50).

CONCLUSION: The atrophy found in the preoperative brain MRI studies of our patients underwent a reversal, achieving an increase in parenchymal volume, a finding we have called Cerebral Pseudoatrophy.

TRANSCRANIAL DIRECT CURRENT STIMULATION FOR COGNITION IMPROVEMENT IN POSTOPEARTIVE NORMAL PRESSURE HYDROCEPHALUS PATIENTS WITH PROGRAMMABLE PRESSURE VALVES: A PILOT STUDY

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INTRODUCTION: The aim of this study was to investigate the impact of transcranial direct current stimulation (tDCS) on cognition in late postoperative patients who had been treated with programmable pressure valves for Normal Pressure Hydrocephalus (NPH) for at least twelve months. tDCS is a non-invasive brain stimulation technique that uses low-intensity continuous current to modulate cortical excitability and influence cognitive functions.

METHODS: Neuropsychological assessments were conducted to examine cognitive profiles of 5 (five) patients before and after tDCS sessions, . Three assessments were carried out: one before treatment initiation, one three days after the 15th tDCS session, and another 30 days after the last tDCS session. Fifteen tDCS sessions were administered over three consecutive weeks. Patients completed an Adverse Effects Scale after first and fifth tDCS sessions, and a second neuropsychological assessment three days after the 15th session. Active or sham maintenance sessions were conducted four and six weeks after the second assessment, followed by a third neuropsychological evaluation 30 days after the last tDCS session. The primary outcome was assessed through post-intervention neuropsychological evaluations.

RESULTS: The study employed a comprehensive battery of neuropsychological tests and scales to assess emotional aspects and quality of life. However, this abstract focused only on the Addenbrooke's Cognitive Examination (ACE), a brief cognitive assessment scale. The Kruskal-Wallis test and multiple Tukey comparisons were applied to the ACE scores at pre-treatment, three days post-treatment, and 30 days post-treatment.

CONCLUSIONS: Preliminary analysis of the ACE scores suggested a significant improvement in cognitive performance 30 days after tDCS treatment compared to pre-treatment scores. However, no significant differences were found between pre-treatment and three days post-treatment or between three days and 30 days post-treatment. Further research with larger samples and additional cognitive tests are warranted to confirm findings and explore the potential benefits of tDCS in such patients.

SHUNT READMISSION RATES AND FACTORS INFLUENCING THEM IN HYDROCEPHALUS OF ALL ETIOLOGIES ACROSS THE AGE SPECTRUM IN THE NATIONWIDE READMISSIONS DATABASE

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INTRODUCTION: A significant portion of the healthcare burden in hydrocephalus is related to readmissions and reoperations. These rates have been described for multiple timeframes from 30 days to 20 years in single-site, multi-site, and population-based studies. However, only a few studies have analyzed population-based data across the entire age spectrum and none with data from last 8 years.

METHODS: A retrospective analysis based on data from the Agency for Healthcare Research and Quality (AHRQ) National Readmission Database (NRD) for the year 2019. The main outcomes analyzed were all-cause and shunt-related readmission rates at 30, 60, 90, and 180 days. Clinical and demographic variables described include hydrocephalus etiology, age, elective versus nonelective admission, sex, income level, readmission diagnosis, expected primary payer, hospital bed size, and hospital type.

RESULTS: In 2019, for hospital admissions related to initial shunt placement and shunt revision, the 30-day all-cause readmission rate was 17.0% (16.2-17.8%) and the 30-day shunt-related readmission rate was 6.4% (5.8-7.0%). Both all-cause and shunt-related readmission rates were twice as high for non-elective admissions compared to elective admissions, 20.6% versus 10.9%, and 7.9% versus 3.8%, respectively (both $p < 0.001$). All-cause readmission rates were highest for admissions with a diagnosis of meningitis, tumor, or spina bifida w/hydrocephalus (27.3%, 23.3%, and 19.4%, respectively), and shunt-related readmission rates were highest for admissions with a diagnosis of spina bifida w/hydrocephalus and congenital hydrocephalus (both 10.5%). 10% of all shunts needed to be revised in the first 180 days after shunt surgery.

CONCLUSIONS: Readmissions related to shunt surgery continue to be a major burden on patients and the health care system despite advances in shunt technology. Hydrocephalus related to infections, neoplasms and spina-bifida are associated with higher readmission rates than other etiologies. Emergency shunt surgery irrespective of etiology continues to be the single most important determinant of readmissions.

MECHANICAL COMPLICATIONS OF SOPHYSA SM8 SHUNT IN ADULT HYDROCEPHALUS: A MONOCENTRIC EXPERIENCE

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INTRODUCTION: The Sophysa SM8 valve is commonly used by neurosurgeons in France, but previous studies on shunt malfunctions in adults included multiple valve types, making it difficult to draw conclusions. This study aimed to specifically determine the incidence of Sophysa SM8 valve dysfunction in adults, focusing on complications related to its opening pressure regulation mechanism.

METHODS: A retrospective analysis of 599 adult patients who underwent CSF shunt placement with Sophysa SM8 between 2000 and 2013 was conducted.

RESULTS: The study included 599 patients, with a mean age at surgery of 64.15 years. The most common causes of hydrocephalus were normal pressure hydrocephalus (49%), traumatic hemorrhages (26.5%), and tumors (15.7%). The overall rate of complications was 22.04%, with disconnection (25%), migration (12.9%), overdrainage (9.1%), and proximal obstruction (6.8%) being the most frequent causes. There were also seven reported cases of infection (5.3%). The risk of shunt failure was 36% at 10 years, with 17% of revisions occurring within the first year. When analyzing mechanical dysfunction related only to the opening pressure regulation mechanism, the intrinsic complication rate was 3.5% for proximal obstructions and overdrainage and 5.3% for complications related to the double connector.

CONCLUSIONS: The study found that disconnections were a frequent complication of the Sophysa SM8 valve and were related to its two-connector system. Based on these results, the authors recommend using a one-piece device to reduce the risk of disconnection.

INCIDENCE AND NATURE OF COMPLICATIONS ASSOCIATED WITH VENTRICULOATRIAL SHUNT PLACEMENT: A META-ANALYSIS

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INTRODUCTION: Ventriculoatrial shunts (VAS) are utilized as a medical device to manage conditions such as hydrocephalus, pseudotumor cerebri, and arachnoid cysts, by diverting excessive cerebrospinal fluid from the brain's ventricles into the right atrium of the heart. This helps relieve symptoms associated with these conditions. However, the use of VAS carries a significant risk of potential complications. Here we conducted a systematic review and meta-analysis to evaluate the complications associated with VAS placement.

METHODS: We conducted a systematic review of observational studies on complications related to VAS placement, following the PRISMA guidelines. Our search encompassed several databases, including PUBMED, Cochrane Library, and Embase, up to the present day. For the purpose of this review, complications were defined as any adverse clinical event occurring after VAS placement. Studies were excluded if they did not report on the presence or absence of postoperative complications or if they had a sample size of less than four patients.

RESULTS: Out of 2.832 articles that were reviewed, 79 were ultimately included in the analysis. The study involved 4416 patients who underwent VAS placement, and the follow-up period ranged from 2 to 308 months. The total rate of complications was 11.7%, with the most common being infections (6.2%) and intracranial hemorrhage (1.8%). Cardiac complications were observed in 0.8% of the cases, followed by hygroma (0.5%), glomerulonephritis (0.5%), and pulmonary complications (0.4%). Mortality related to VAS placement was observed in 0.4% of cases.

CONCLUSIONS: Our findings suggest that the overall rate of complications associated with VAS placement is relatively low, with infections and intracranial hemorrhages being the most commonly observed complications, and cardiac complications being rare.

AFTER 15 YEARS, WHAT IS CHANGED IN THE KNOWLEDGE OF HYDROCEPHALUS? SURVEY OF HAROLD O. CONN 15 YEARS LATER.

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INTRODUCTION: This work is based on the experience of Harold O. Conn, a Yale Medical School faculty member, who developed NPH and for 10 years was erroneously diagnosed as cerebral atrophy and/or Parkinson's disease. In 2008, on recognizing the lack of awareness of NPH by physicians, he initiated a survey to explore this problem.

METHODS: We translated his survey into Italian, with the help of a licensed translator, of 10 – points questionnaire, and submitted it to medical doctors, both specialists and family physicians belonging to the Latina Local Medical Council, via email.

RESULTS: A total of 134 Physicians answered the survey. Impressively, almost one-fifth of the answering physicians had never heard of NPH. The first half of them had learned of NPH in medical school, and the other half learned of it after medical school. A total of 75% of physicians declare to have never seen patients suffering from NPH in the past five years.

CONCLUSIONS: Although the number of physicians aware of NPH appears globally increased, 75% of them still do not recognize/treat NPH patient. Therefore, this condition still remains widely unrecognized and unfortunately, undertreated.

REDUCING OVER-DRAINAGE COMPLICATIONS IN IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Subdural effusion/haematoma (CSDH) is one of the most common complications of shunt surgery in the older population, but estimates of it prevalence vary widely. Here, we investigate the relationship between shunt valve setting, risk of CSDH and outcome from shunting.

METHODS: Complication data was collected retrospectively for all patients shunted for idiopathic NPH in the period April 2004 to April 2019. Patients were excluded if they received a fixed pressure valve. Total follow-up was median 4.0 years. Early in the series, valves were initially set at 120 or 140, but later in the series, settings of 160 or 180 were more common.

RESULTS: A total of 387 patients received programmable valves for suspected iNPH in the study period. 47 patients (12.1%) developed a CSDH which occurred a median 3.0 months after shunt insertion. Age (HR 1.08, p=0.007) and concomitant antiplatelet (HR 2.7, p=0.001) were associated with a higher risk of CSDH but not concomitant anticoagulant (HR 1.8, p=0.16). Shunt valve settings of 120 or 140 were significantly more likely to result in a CSDH compared to settings of 160 or 180 (HR 2.7 [p=0.005]). Patients set at 120 or 140 were also more likely to require evacuation (5.8% vs 0.5%; HR 11.9 [p=0.02]). Among the 240 patients whose shunt valve was not adjusted over 3 months of follow-up, those with a shunt setting of 120 or 140 were similarly more likely to have a CDSH compared to those set at 160 or 180 (HR 3.6, p=0.03) yet there was no difference in the proportion improved at 3 months follow-up (92% vs 88% [p=0.36].

CONCLUSIONS: Valve settings of 160 or 180 are associated with a lower risk of CSDH formation and no significant reduction in treatment effect. Antiplatelet agents increase the risk of CSDH more significantly than oral anticoagulants.

TIME TO RESOLUTION OF NPH-ASSOCIATED SUBDURAL HEMATOMAS

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INTRODUCTION: Ventriculoperitoneal shunting (VPS) introduces a risk of overdrainage-associated subdural hygroma and hematoma. Since chronic SDH/H (cSDH/H) reverses and delays idiopathic normal pressure hydrocephalus (iNPH) treatment, we investigate this "unnatural history" of their resolution and the effectiveness of drainage and/or shunt adjustments.

METHODS: This is a retrospective medical record review of all patients treated for cSDH/H with shunted iNPH between 2017-2022. We reviewed patient demographics, symptoms, shunt settings, head-CT(HCT) and cSDH/H characteristics to evaluate risk factors, time to resolution and time to reinitiate hydrocephalus treatment. CSDH/H treatment consisted generally of shunt adjustment to maximum opening pressure with drainage performed only with progression.

RESULTS: Of 82 patients identified, 65 patients had an adequate available HCT series for evaluation. Unilateral cSDH/H was found in 35, bilateral in 30 patients. The average hematoma size was 1.28cm (± 0.85) for unilateral, 1.01cm (± 0.7) for bilateral. Signs of rebleed were identified in 43% (15) of unilateral and 67% (20) of bilateral cSDH. Median days (±IQR) to resolution in unilateral cSDH/H was 103 (±54.5) days, and 113 (±166) days for bilateral. The most used valve was a Certas+ with Siphonguard. The use of Siphonguard did not specifically seem to protect from cSDH in our cohort. Neither the occurrence of rebleeds, nor the initial use of anti-siphon/gravitational devices influenced time to resolution. Similarly, surgically related (7 day perioperative) versus delayed onset cSDH/H had similar resolution time. Unilateral cSDH/H resolved quicker than bilateral (p=0.01).

CONCLUSIONS: Given the current treatment of cSDH/H, utilizing adjustments, hydrocephalus treatment is delayed by a median (±IQR) of 106 (±110) days. While the effect of cSDH/H and treatment delay on ultimate outcome is uncertain, further evaluation of factors influencing occurrence and resolution is needed.

ABDOMINAL PAIN AFTER VENTRICULOPERITONEAL SHUNTING FOR NORMAL PRESSURE HYDROCEPHALUS (NPH): PREVALENCE, TIMELINE, AND IMPACT OF QUALITY OF LIFE

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INTRODUCTION: The frequency of abdominal pain after ventriculoperitoneal (VP) shunt placement is still largely unknown and underreported. The aim of this study is to determine the prevalence, the time course and the impact to quality of life.

METHODS: In our department 149 patients with NPH were treated with VP-shunts between 2020 and 2021. Data were collected by digital patient records and by a follow-up questionnaire, where patients were asked about pain intensity according to the visual analog scale (VAS), duration of pain (days to weeks, 2-12 months, >12 months), the limitations in daily life (no limitation, barely disturbing, disturbing but tolerable, substantially disturbing), and the use of pain medication. 94 patients responded to the follow-up questionnaire and could be evaluated. Statistical analysis was performed using logistic regression model.

RESULTS: Overall, 39% (n=37) of patients reported abdominal pain. In 16% (n=15), pain occurred during hospitalization. 15% (n=14) reported pain for more than 12 months. The overall pain intensity was: no pain: 61% (n=57), slight (VAS 1-3): 10,6% (n=10), medium (VAS 4-6): 22.3% (n=21), severe (VAS 7-8): 6.4% (n=6). Abdominal pain never reached VAS 9-10. 12 months after surgery pain improved or resolved completely: no pain: 85,1% (n=80), slight: 2,1% (n=2), medium: 8,5% (n=8), severe: 4,3% (n=4). Only 7 patients used medication for abdominal discomfort. In 2.1% (n=2) abdominal discomfort was reported as substantially bothersome. There was no correlation with age or sex.

CONCLUSIONS: Abdominal pain after VP-Shunt is a frequent finding (almost 40%), decreases over time and rarely shows severe impact of quality of life. However, abdominal pain after VP-Shunts can influence the postsurgical course and patients should be informed beforehand. Further studies regarding the cause are recommended for possible improvements.

FREQUENCY OF ABDOMINAL PAIN RELATED TO TYPES OF SHUNT TUBING: THE DIFFERENCE IN THE TUBING

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INTRODUCTION: A retrospective comparative study looking at the incidence of unexplained abdominal pain relative to peritoneal shunt catheters during the period of 2012 to 2020 was performed in our single-centre unit. After evaluation of 426 patient records, it was concluded that Ares shunt tubing was associated with a higher incidence of abdominal pain and revision surgery following peritoneal shunt insertion, as compared to Bactiseal, Silverline or plain tubing. We, therefore, subsequently performed a prospective comparative study evaluating the different antibiotic impregnated peritoneal shunt catheters.

METHODS: A uniform length of Ares, Bactiseal and B.Braun antibiotic impregnated peritoneal shunt catheters were connected to sterile drainage systems, running normal saline continuously through the catheters at 20ml/hour. Samples were collected from the catheters at 1 week, 3weeks, 5weeks and 8weeks and tested for antibiotic concentrations to discern elution rate. The catheters were examined by our mechanical engineering team, exploring the rigidity, elasticity and surface microstructure of each catheter using nano-indentation for elastic modulus and 3-dimentional computerised tomography scan.

RESULTS: Preliminary results from the Bristol antimicrobial reference laboratory indicate highest level of rifampicin and clindamycin in samples collected from Ares catheter indicating a higher antibiotic elution rate. Definitive quantitative results for rifampicin and clindamycin levels from the week to week samples collected for all the catheters, as well as in depth study into the physical properties of the catheters by the engineering team will be available by mid-May 2023.

CONCLUSION: Based on preliminary results it can be concluded that Ares peritoneal shunt catheter is associated with a higher antibiotic elution rate.

TRANSENDOSCOPIC ULTRASOUND FOR NEUROENDOSCOPY

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INTRODUCTION: After trans-endoscopic sono-catheters had been tested in the laboratory for imaging characteristics and practicability, clinical application was studied with special reference to imaging and navigation capabilities, practicability, safety, and indications.

METHODS: Intraoperative ENS images prepared during surgery on 75 selected patients were examined. There were 35 female and 40 male patients, and their mean age was 42 years (range, 2-69 years). Within this series, there were 28 cases of ventricular lesions (ventricular hematomas, tumors, and colloid cyst included, and hydrocephaly).

RESULTS: Imaging: In clinical use, the sono-catheter has superior imaging and navigation abilities to those seen in anatomical laboratory work. Real-time and online characteristics represent changes such as shifting, pulsation, CSF flow, blood flow, and changes in size and form of structures. When confronted with clinical problems, this technique still has some limitations such as short penetration depth of 3-cm radius and lack of scanning anterior to the endoscope. Navigation: The scan is radial 360° and in an orthogonal plane to the axis of the endoscope. At the tip of the endoscope, it delivers an image that looks geometrically like a "brain-radar". Because of its real-time characteristic, ENS has a navigation capacity that markedly differs from usual neuronavigation but is intuitively usable. Endo-Neuro-Sonography (ENS) was applied in 8 hydrocephaly, 3 colloid cysts, 5 intraventricular hematomas, 1 septostomy, 11 ETVs, 2 cystostomies, 4 multiple cysts, and 1 tumor biopsy case. Some illustrative cases are presented.

CONCLUSION: Endo-Neuro-Sonography (ENS) is a tool for intraoperative real-time and online high-resolution imaging, and neuronavigation of endoscopes with a working channel at least 2 mm in diameter; it also has application in a wide variety of ventricular lesions. ENS is limited by small penetration depth and not scanning ahead to the endoscope anteriorly.

CHOROID PLEXUS-ON-A-CHIP: A MICROFLUIDIC MODEL TO STUDY HOW CEREBROSPINAL FLUID SECRETION AND BLOOD-CEREBROSPINAL FLUID BARRIER FUNCTION ARE AFFECTED BY INFLAMMATION ASSOCIATED WITH HYDROCEPHALUS

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INTRODUCTION: Presently, there are no successful, non-surgical, pharmaceutical interventions for hydrocephalus, in part because targeted cerebrospinal fluid (CSF) regulation requires a better understanding of the mechanism of CSF secretion through the choroid plexus (CP). Conventional animal models used to study CSF secretion are expensive, plagued by variability, have limited translatability to humans and involve incredibly challenging surgical procedures. Existing in vitro models are not suited for long term dynamic culture and do not capture the complexity of human physiology. There is a critical need for a highly reproducible, cost-effective, human-relevant model with physiological relevance to study CSF secretion at the CP. To directly address this need we developed an organ-on-a-chip model of the CP that allows us to track and manipulate secretion and barrier function of the CP.

METHODS: Using computational fluid dynamics, 3D printing, and soft lithography we designed and fabricated a 2-compartment microfluidic platform that mimics the luminal and abluminal regions of the CP. The model provides the mechanical cue of physiological shear and maintains physiologically accurate tissue-fluid ratios and fluid turnover times.

RESULTS: Immunofluorescent labeling has confirmed that choroid plexus epithelial cells grown inside the abluminal compartment orient themselves correctly and express critical tight junction components, establishing a low permeability barrier. Barrier function has also been assessed using transepithelial electrical resistance. Lastly, we have also successfully simulated secretion of fluid across compartments.

CONCLUSIONS: The human CP-on-a-chip has the potential to replace currently used pre-clinical animal studies with human-relevant systems in translational research and reveal previously undiscovered transport mechanisms at the CP. Future work involves testing our hypothesis regarding inflammation mediated barrier integrity loss and subsequent CSF hypersecretion at the CP as it pertains to hydrocephalus.

PATIENT-SPECIFIC AUTOMATED CEREBROSPINAL FLUID PRESSURE CONTROL TO AUGMENT SPINAL WOUND CLOSURE: A CASE SERIES USING THE LIQUOGUARD®

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INTRODUCTION: Post-operative spinal cerebrospinal fluid (CSF) leaks are a common and potentially serious surgical complication. The management of intra- and post-operative leaks is heterogeneous. Numerous studies advocate for dural repair and CSF diversion. The LiquoGuard7 allows automated and precise CSF pressure and volume control, with the calculation of cerebrospinal fluid production rate (PRcsf), allowing for tailored CSF drainage. We sought to summarize our experience with patient-specific CSF automated drainage with layered spinal wound closure.

METHODS: This single-centre case series included patients undergoing complex spinal surgery where: 1) a high-flow intra- and/or postoperative CSF leak was expected and 2) concurrent CSF diversion was performed via lumbar drain attached to a LiquoGuard7®. LiquoGuard7® was used to calculate net PRcsf in each patient. CSF diversion was tailored to calculated CSF production rates and other case factors to maintain a neutral pressure across the operative site.

RESULTS: Three patients were included, with a variety of pathologies (T7/T8 disc prolapse; T8-T9; T4-T5 metastatic spinal cord compression). The first two patients underwent CSF diversion to prevent post-op CSF leak, whilst case 3 required this in response to post-op CSF leak. CSF hyperproduction (140-150ml/hr) was evident in all cases. With patient-specific CSF diversion regimes (50-150ml/hour/7days), no cases required further intervention for CSF fistulae repair (including for pleural CSF effusion), wound breakdown or infection.

CONCLUSIONS: Automated patient-specific cerebrospinal fluid drainage, based on patient's net CSF production rate, may have a role in the closure of complex spinal wounds with high-flow CSF leaks, with a smaller risk profile than traditional manual drainage. Further larger studies are needed to explore the comparative benefits and cost-effectiveness of these devices.

VALIDATION AND APPLICATION OF IN SILICO AND IN VITRO MODELING TO OPTIMIZE CEREBROSPINAL FLUID DRUG DELIVERY TO THE BRAIN

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INTRODUCTION: Targeted, consistent, and safe CSF drug delivery of genetic therapies is critical for effective treatment of CNS disorders. There are currently no available validated tools for prediction of CSF-system wide solute transport in nonhuman primates (NHP) or transformation of protocols to humans. We developed and utilized in silico and in vitro model systems to formulate a lumbar-access automated intrathecal catheter infusion system (FalconTM) designed to target the brain only, spinal cord only or brain and spinal cord together while being safe and clinically scalable. The model system predictions were then validated within NHPs in vivo.

METHODS: CSF geometry and flow was collected from NHPs via MRI to define in silico computational fluid dynamics simulations and in vitro 3D printed models of the CSF system. The models were used to optimize delivery device and infusion parameters for widespread brain and spinal cord targeting and compared to lumbar puncture (LP) drug injection. To validate model predictions, seronegative NHPs were co-infused with gadolinium and AAV9.CB.GFP via LP (n=5) or the optimized FalconTM delivery (n=5). Biodistribution was analyzed 3w later by immunohistochemistry, ddPCR and western blots. In vivo drug flow was compared via gadolinium concentration.

RESULTS: We confirmed CSF model predictions with in vivo NHP biodistribution. FalconTM was significantly superior, reaching the cranial space 1-5 min post-injection, while LP required 30-60 min. At 30 mins post injection, gadolinium was significantly greater throughout the cortical gray matter and basal ganglia with FalconTM versus LP. FalconTM vector genome copies per diploid genome was significantly greater throughout brain regions versus LP.

CONCLUSIONS: We developed a novel state-of-the-art in silico and in vitro NHP modeling system and validated model predictions in vivo. The model was used to design and optimize the FalconTM intrathecal catheter delivery system that demonstrated faster and broader distribution of AAV9 to the CNS compared to LP.

QUANTIFICATION OF REGIONAL NEURAL TISSUE STRAIN IN TYPE I CHIARI MALFORMATION

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INTRODUCTION: Type I Chiari malformation (CMI) is believed to be a cerebrospinal fluid (CSF) related disorder, making it a subject of interest for hydrodynamic research. The unique anatomy of CMI at the cervicomedullary junction causes an impedance to CSF flow, resulting in abnormal tissue motion. This abnormal tissue motion and CSF flow may result in altered tissue strain. While it is known that brain tissue is sensitive to low magnitude strains, the exact role of brain tissue strain in CMI pathophysiology is yet to be defined. We hypothesized that tissue motion and strain resulting from the altered flow of CSF in symptomatic CMI patients would be different from healthy controls and asymptomatic CMI patients.

METHODS: Rostral-caudal tissue motion was quantified using displacement-encoding with stimulated echoes (DENSE) MRI. Principle strain in four brain regions was derived from displacement: the pons, medulla, cerebellar tonsil, and upper spinal cord. Peak-to-peak displacement and mean principle compression and extension strains are reported.

RESULTS: Average peak-to-peak rostral-caudal displacements ± STD of the upper spinal cord (SC) for the control, symptomatic, and asymptomatic groups were 0.14 ± 0.06, 0.18 ± 0.10, and 0.11 ± 0.03 mm, respectively and of the cerebellar tonsil were 0.07 ± 0.03, 0.11 ± 0.06, and 0.10 ± 0.03 mm, respectively. The average principles strains (extension % ± STD/compression % ± STD) in the SC for the control, symptomatic, and asymptomatic groups were 1.88 ± 0.71%/1.51 ± 0.60%, 2.18 ± 1.83%/1.66 ± 2.01%, and 2.05 ± 0.93%/1.64 ± 0.66%, respectively.

CONCLUSIONS: Preliminary results presented here indicate abnormal tissue motion and strain in symptomatic CMI patients compared to healthy controls and asymptomatic CMI. These findings indicate DENSE tissue strain measurements could provide utility in better understanding CMI and related pathologies, as well as aid in defining a novel biomarker for CMI.

CORRELATION OF CEREBROSPINAL FLUID AND PLASMA ADIPOKINES IN OBESE VERSUS NON-OBESE IDIOPATHIC INTRACRANIAL HYPERTENSION (IIH) PATIENTS

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INTRODUCTION: Determination of key markers of obesity and inflammation could potentially help elucidate IIH pathophysiology. The aim of this study was to measure adipokines and cytokines implicated in prior pilot studies, in CSF and plasma from IIH patients to determine correlations of these markers in plasma and CSF and assess group differences.

METHODS: Patients seen at the Johns Hopkins Center for CSF Disorders were assessed for IIH using visual field testing and fundus perimetry, as well as lumbar puncture manometry to measure cerebrospinal fluid opening pressure in the left lateral decubitus position. CSF and plasma samples were analyzed for C-peptide, IL-6, insulin, leptin, resistin, tumor necrosis factor alpha (TNF-a), adiponectin, and retinol binding protein 4 (RBP4) by multiplex immunoassay (Luminex, Intelliflex). Pearson correlation was used to determine correlation between CSF and plasma analytes and comparisons between cohorts were determined by ANOVA.

RESULTS: 244 patients (231F, 14M) ranging in age from 15-73 years (Mean 39 ± 12.74) were classified as obese IIH (N=102, Mean BMI 40.11 ± 7.65), non-obese IIH (N=24, Mean BMI 26.25 ± 2.65), obese normal (N=68, Mean BMI 38.12 ± 5.98), and non-obese normal (N=49, Mean BMI 26.29 ± 2.73). In matched CSF and plasma from all patients, leptin, C-peptide, resistin, RBP4, and insulin demonstrated moderate correlations ($r=0.26$, $p<0.01$; $r=0.35$, $p<0.0005$; $r=0.39$, $p<0.00005$; $r=-0.31$, $p<0.001$; $r=0.28$, $p<0.005$ respectively). When stratified by cohort, plasma levels of C-peptide, insulin, leptin, and TNF-a were significantly higher in obese patients, regardless of disease status ($p=0.043$; $p=0.012$; $p=0.0067$; $p=0.019$). In CSF, insulin and leptin were elevated in obese IIH patients ($p=0.012$; $p<0.0001$) but not obese normals, whereas C-peptide was elevated in obese normals ($p<0.0001$).

CONCLUSIONS: Brain-specific adipokines are altered in obese IIH patients but not obese healthy controls, suggesting that these pathways contribute to IIH development and may represent a potential characteristic profile.

A COMPARISON OF OUTCOMES BETWEEN PEDIATRIC AND ADULT PATIENTS WITH IDIOPATHIC INTRACRANIAL HYPERTENSION (IIH)

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INTRODUCTION: Idiopathic intracranial hypertension (IIH) is a condition that occurs due to increased intracranial pressure without an identifiable cause. Symptoms of IIH include headaches, visual disturbances, tinnitus, and nausea. It is important to study this condition due to its serious and potentially permanent consequences, particularly for pediatric patients. Furthermore, the mechanism of this condition and its effects on certain populations are not quite understood.

METHODS: This study aims to compare treatment types and outcomes across pediatric and adult populations. A total of 86,873 adult patients with IIH and 14,446 pediatric patients with IIH were assessed. Treatment types compared across cohorts included Ventriculoperitoneal Shunt (VPS), Endoscopic Third Ventriculostomy (ETV) and Stenting. Outcomes compared included death, infection, seizures, number of CT scans, and number of emergency department visits. Differences in sex, race, BMI were also determined.

RESULTS: Results showed no significant difference in the number of Ventriculoperitoneal Shunt (VPS) placements between pediatric patients and adult IIH patients. However, pediatric patients were significantly more likely to have an ETV done and adult patients were significantly more likely to have stent placement. Additionally, adult patients were significantly more likely to die but were significantly less likely to have an infection or seizure when compared to pediatric patients.

CONCLUSIONS: In conclusion, this study provides valuable insights into the differences in treatment types and outcomes between pediatric and adult patients with IIH. These findings have important implications for clinicians and researchers, as they underscore the need for tailored approaches to the management of IIH in different patient populations. Ultimately, a better understanding of IIH and its management will help improve patient outcomes and quality of life.

LONG-TERM OUTCOMES AFTER DURAL VENOUS STENTING IN IDIOPATHIC INTRACRANIAL HYPERTENSION: A SINGLE CENTRE EXPERIENCE

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INTRODUCTION: Idiopathic Intracranial Hypertension (IIH) is a neurological disorder typically characterised with signs and symptoms of raised intracranial pressure (ICP). This includes high-pressure type headaches and visual disturbances. Dural venous stenosis is a potential cause of IIH. Increased pressure gradients caused by stenosis may contribute to elevated ICPs. Dural venous sinus stents can be used as a treatment to obliterate the pressure gradients. The aim of this study is to evaluate long-term outcomes after stenting for IIH.

METHODS: Retrospective single centre review of case notes and imaging records of 42 patients with Idiopathic Intracranial Hypertension (IIH) and dural venous sinus stenosis who underwent dural venous stenting over an eight-year period (2015-2023) at our regional neurosurgical centre.

RESULTS: 42 patients, 38 female and 4 males with a mean age of 32 years (range 19-52), were treated with dural venous stents. Almost all the patients had transverse sinus stenosis. 90% of patients presented with headaches and 73% had confirmed visual loss on ophthalmological examination. Immediately after stent placement, an improvement of pressure gradients was noted in 78% of patients with a corresponding reduction of intracranial pressures in 75% of patients. Following dural venous stent placement, 88% of patients had improved vision, whilst only 26% of patients reported a sustained improvement in headaches. 38% of patients required further management with cerebrospinal fluid diversion with a shunt. Two patients required re-stenting, and one patient had a partially occlusive thrombus.

CONCLUSION: We describe the use of dural venous stents in the management of patients with IIH. Treatment of IIH aims to reduce ICP and preserve visual loss. Results from this study demonstrated a subsequent reduction in ICP following stent placement and this reflected in objective and subjective improvements in visual symptoms. The long-term complication rate was low.

IIH INTERVENTION: OPENING OF A RANDOMISED CLINICAL TRIAL COMPARING DURAL VENOUS SINUS STENTING WITH CEREBROSPINAL FLUID SHUNTING IN IDIOPATHIC INTRACRANIAL HYPERTENSION

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INTRODUCTION: The morbidity in Idiopathic Intracranial Hypertension (IIH) is primarily related to visual loss and headaches. Patients are at risk of permanent visual loss require urgent intervention to reduce intracranial pressure (ICP). The most widely used surgical procedure is cerebrospinal fluid (CSF) shunting and over the last two decades dural venous sinus stenting (DVSS) has been used as an alternative intervention. Currently, there is no direct comparison of the two interventions or high quality evidence to guide clinical practice.

METHODS: IIH intervention is a multicentre phase IIb randomised trial with integrated health economic evaluation that will compare the effectiveness of DVSS with CSF shunting to prevent visual loss. The target population is 138 people recruited in 15 sites and randomization will be 1:1 for the two interventions. The primary outcome will be visual function over 12 months and secondary outcomes include improvement in headaches, surgical complications and revisions, impact on quality of life and cost-effectiveness.

RESULTS: The study has received regulatory approval and will open in the first sites in April 2023. Each patient will stay in the trial for 2 years, accrual period is 2.5 years and patient data will be collected from a national electronic database for 10 years. The primary outcome measure will be Humphrey Visual Field Perimetric Mean Deviation over 12 months. Secondary measures will assess the impact of the two interventions over 12 and 24 months on vision, headache, tinnitus, quality of life and economic cost.

CONCLUSIONS: IIH Intervention will compare DVSS with CSF shunting and will answer an important clinical question, not least because the incidence of IIH is rising in line with the global obesity epidemic. The results of this trial will change practice and inform development of clinical guidelines on the management of IIH.

ICP DYNAMICS DURING MOVEMENT IN CHIARI MALFORMATION AND IDIOPATHIC INTRACRANIAL HYPERTENSION

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INTRODUCTION: Intracranial pressure (ICP) changes with body movement, however most ICP research has been performed in stationary patients. This is particularly relevant for patients with CSF dynamics disorders such as Chiari malformation and idiopathic intracranial hypertension (IIH) because symptoms and disease severity are affected by body movement and position. Here we investigate ICP dynamics during movement in these groups.

METHODS: Single-centre prospective observational study. Patients undergoing continuous ICP monitoring were fitted with continuous position sensors and underwent set sequences of movements including lying, sitting, standing and head movements. A proportion of patients also underwent passive positional change using a tilt table whilst ICP and position monitoring was ongoing. ICP and postural data were recorded at 100Hz and synchronized. Data were analysed for ICP, PA and waveform ICP behaviour during movement using a regression model adjusted for sex, shunt status and BMI.

RESULTS: Sixty-seven patients (16M, mean age 43±13) were recruited. 16 participants had CSF-diverting shunts in situ, 15 had Chiari malformation and 11 had IIH. A transient increase in ICP occurred during movement that varied in magnitude. After controlling for sex, shunt status and BMI, Chiari participants tend to have a smaller amplitude increase than non-Chiari participants during all active torso movements and participants with IIH tended to have a larger amplitude increase compared with non-IIH participants. In the IIH group, participants with higher BMI had higher increases than participants with normal BMI and this was more pronounced in lying-sitting movements. Differences were also observed between shunt statuses including whether an antisiphon device was present or not. Further analyses will be presented.

CONCLUSIONS: We present data on ICP dynamics during movement in Chiari malformation and IIH. This has implications for understanding the mechanisms of symptomatology and compliance abnormalities in these pathologies and is an avenue that requires more exploration.

SYNTHETIC MRI: A FAST AND RELIABLE METHOD FOR VENTRICULAR VOLUMETRY

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INTRODUCTION: Volumetry of cerebral ventricles is a far more sensitive measure for shunt-induced reduction of ventricular size than traditional 2D-measures, such as Evans index. However, available ventricle segmentation methods are time-consuming, which limits use in clinical practice.

Quantitative MRI (qMRI) obtains quantitative measurements of physical properties of tissues used for automatic segmentation of white and grey matter and intracranial CSF. With a 6-minute 3D qMRI scan all relevant data are acquired to perform tissue-aided ventricle segmentation. The aim of this study was to evaluate and reliability-test a qMRI-software (SyntheticMRI) for ventricle volumetry, including a semi-automated segmentation algorithm.

METHODS: 45 3D-qMRI scans (15 healthy subjects, 15 iNPH-patients, 15 shunted iNPH-patients) were assessed twice for ventricular volumetry by two independent examiners (one neurosurgeon and one neuroradiologist). Total intraventricular CSF-volumes, extraventricular intracranial CSF and required time for manual segmentations were recorded. Segmentations generated by an automated ventricle segmentation algorithm (n=15) were manually corrected by the neurosurgeon to obtain another set of data.

RESULTS: Intra- and interobserver reliability for all segmentations was excellent (ICC 1.000). Ventricular volumes were on average 42 ml (range 17-82) in healthy subjects, 141 ml (range 82-194) in iNPH-patients and 113 ml (range 59-186) in shunted iNPH-patients. The learning curve of manual correction was steep, with average 23% reduction of time between segmentations no 1 and 2. Average time for examiners was 14.75 and 42.75 minutes, respectively. The time spent on manually correcting the automated algorithm was significantly lower, on average 5 minutes and 51 seconds.

CONCLUSIONS: SyntheticMRI is a reliable and efficient method to obtain relevant volumetric measures of intracranial CSF-spaces for both clinical and research purposes. Manual segmentation showed a steep learning curve and especially the manually corrected automated algorithm provides a feasible time expenditure for clinicians caring for patients with iNPH, advanced hydrocephalus and arachnoidal cysts.

NON-INVASIVE PHASE-CONTRAST MRI IN IDIOPATHIC INTRACRANIAL HYPERTENSION - FIRST PROMISING DATA FROM A PROSPECTIVE STUDY

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INTRODUCTION: Idiopathic intracranial hypertension (IIH) is a condition defined by increased pressure in lumbar punction ^{3}25cmH2O, papilloedema and the absence of a competing etiology (Mollan et al. 2019). To date, the only method to measure intracranial hypertension must be invasive. In view of increasing evidence of IIH patients presenting with CSF leaks, IIH without papilloedema, new therapeutic studies, and rebound hypertension after closing of CSF leaks a noninvasive monitoring of patients would be helpful. A previous study has demonstrated that MRI-based measurements of spinal cord motion at segment C2/C3 are increased in patients with CSF leaks (Wolf et al. 2023). It is hypothesized that there is reduced motion in IIH patients due to increased resistance.

METHODS: Prospective, controlled study on 15 IIH patients, 100% female, with proven elevated CSF pressure ^{3}25cmH2O and papilloedema without loss of visual acuity, and 33 female healthy controls. All subjects received axial, ECG-triggered phase-contrast MRI measurements at level C2/C3. Analysis was fully automated (www.nora-imaging.org). The velocity range (mm/s) and the total displacement (mm) of the time-resolved velocity curve over the cardiac cycle was used as the main parameter. Pairwise comparisons were made by Mann-Whitney U test; correlation was determined using regression models.

RESULTS: Mean opening pressure was 31 ± 5 cmH2O. Spinal cord velocity range and total displacement was significantly lower in IIH patients as compared to controls: 3.9 ± 1.4 mm/s vs. 5.3 ± 1.3 mm/s, p=0.001; 0.5 ± 0.1 mm vs. 0.7 ± 0.2 mm, p=0.002 (Figure 1). Opening pressure and BMI showed no significant impact on dynamic parameters in patients. Data corrected for age did not reveal any change.

CONCLUSIONS: We report first evidence, that in disorders with increased CSF pressure, the physiological oscillation of the spinal cord is dampened. Thus, this method might be helpful to solve clinical and diagnostic ambiguity.

CEREBRAL ARTERIAL DYNAMIC IN HYDROCEPHALUS PATIENTS

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INTRODUCTION: Active reversible hydrocephalus (ARH) is a neurological condition mainly characterized by cerebrospinal fluid (CSF) flow disorders. However, it is known that CSF oscillations during the cardiac cycle are closely related to cerebral blood flow. Rapid intracranial arterial inflow initiates compensatory mechanisms, including CSF oscillations and venous outflow. Since arterial flow is the main driver of these neuro-fluids interactions, this study aims to compare cerebral arterial flow dynamics in healthy elderly volunteers (HEV) and suspected ARH patients as an appropriate short-term step in analyzing ARH physiopathology.

METHODS: Twenty HEV (72±6 years) and thirty suspected ARH patients (73±8 years) underwent 3T MRI. From the value of resistance to CSF outflow (Rout), the patients were classified as suitable (ARH+: n=14) or unsuitable (ARH-: n=16) for shunting. Phase contrast MRI acquisitions were used to quantify the flow dynamics in cerebral arteries during the cardiac cycle. A MATLAB script was implemented to identify main key points (time, amplitude) of the total cerebral arterial flow. Representative arterial profiles were estimated for each group. Moreover, we evaluated the effects of pathological conditions on flow times and amplitude-related parameters.

RESULTS: The patients showed a significant decrease in the average cerebral arterial flow compared to HEV (ARH+: 452±116, ARH-: 456±97, HEV: 607±125 ml/min). Arterial profiles of ARH+ and ARH- presented very close morphologies; however, the intracranial pulsatility index (PI) of ARH+ was importantly higher than that of HEV (1.4±0.4 vs. 1.1±0.2), whereas the PI between ARH- and HEV did not differ significantly.

CONCLUSIONS: ARH+ patients appear to present higher PI values, which may reflect stiffer and less elastic arterial walls that could contribute to the development of the disease. Since the arterial flow is the leading actor in brain dynamics, impaired arterial blood flow could affect CSF oscillations and its distribution in the craniospinal compartments.

INTRACRANIAL CSF-ISF FLOW PATTERNS IN LARGE ANIMAL MODEL

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INTRODUCTION: Intracranial pathways of cerebrospinal fluid (CSF) are unclear to this date. Furthermore, interaction between intracranial fluids, molecules and solutes are ill-defined.
To better understand these complex interactions and fluid pathways, our goal was to create a large animal model to track movements of intracranially injected tracer at different locations and in iatrogenic induced pathophysiological states.

METHODS: Six hounds received baseline MRI followed by a 0.1 mL cisternal or ventricular Gadoteridol injection. Injections were performed either through a left ventricular catheter or cisterna magna. Follow-up MRIs were acquired every 30 minutes for five hours, and at 24 hours post-injection. One subject had partial obstructive hydrocephalus induced by 4th ventricular injection of cyanoacrylic glue, followed by the same MRI protocol. Regions of interest were identified at the aqueduct, 4th ventricle, basal ganglia, parietal cortical and periventricular regions. Onset-time, time-to-peak, and clearance-time were estimated from the dynamic time courses.

RESULTS: Cisternal baseline injections demonstrated fastest intracranial distribution of tracers along major arterial pathways. Signal change was noted among most cortical surfaces, but not at high parietal regions by hour five. Most uptake was noticed at the temporal lobe. Retrograde flow was noted into the ventricles. Ventricular injections showed trans-ependymal enhancement along the entirety of ventricles, with high uptake at the ipsilateral temporal horn, presumably due to gravity driven accumulation. Ventricular injections followed cisternal patterns once they reached extracranial CSF spaces. The average time to peak was three hours for the lateral ventricle and temporal horn area, whereas uptake in basal nuclei, thalamus and 4th ventricle was detectable but noticeably slower.

CONCLUSIONS: Solute distribution in the CNS follows major arterial pathways, and uptake into the parenchyma/interstitial space occurs through cortical as well as trans-ependymal routes. Stereotactical tracer injections may allow for better understanding of CSF interactions in specific brain regions in the future.

OPTIC NERVE SHEATH DIAMETER DISTENSION IN NORMAL PRESSURE HYDROCEPHALUS: A POTENTIAL MARKER FOR SHUNT RESPONSIVENESS

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INTRODUCTION: Optic nerve sheath diameter (ONSD) is a useful noninvasive marker for the identification of patients with abnormal cerebrospinal fluid (CSF) dynamics both in emergency and elective setting. Studies employing ultrasound and MRI techniques have confirmed the association between ONSD distension and raised ICP, however its association with Normal Pressure Hydrocephalus (NPH) has not been described before. This study investigates the prevalence of this sign in NPH and its utility in the identification of shunt-responsive NPH patients.

METHODS: Retrospective single-centre study. Patients admitted for extended lumbar drainage (LD) for suspected NPH since January 2020 were identified. Inclusion criteria were (a) complete recording of pre- and post-LD walking test results; (b) brain MRI performed before treatment with ventriculoperitoneal shunt. Patients with 10% improvement in their post-LD walking test were considered shunt 'responders'. ONSD was measured on axial T2 MRI sequences and considered abnormal or distended if >2mm in thickness in the area immediately behind the globe. Data on walking test results and ONSD were collected by independent assessors.

RESULTS: Thirty-three patients (19M, 14F, mean age 74±8 years) met the inclusion criteria. Twelve patients (36%) had ONSD distension. Based on the post-LD walking test, 26 patients (79%) were classified as 'responders' and 7 patients (21%) were 'non-responders'. 'Responders' had an average walking speed improvement of 26%. Amongst the 'responders', 38.5% had distension of the ONSD (sensitivity), while 71% of the 'non-responders' had normal ONSD (specificity). The patients with distended ONSD were classified as responders in 83% of the cases (positive predictive value).

CONCLUSIONS: These results suggest that despite having a 'normal pressure', NPH patients often have distension of the ONSD. In addition, this sign could be a useful non-invasive marker for the detection of shunt responsiveness. Larger studies will be needed to confirm these findings.

POTENTIAL IMPACT OF NON-INVASIVE PHASE-CONTRAST MRI IN THE DIAGNOSIS OF SPONTANEOUS INTRACRANIAL HYPOTENSION

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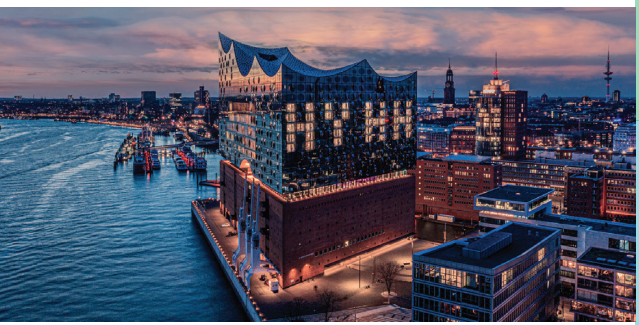
INTRODUCTION: CSF flow velocities and spinal cord motion per each heartbeat can be quantified by phase-contrast MRI. We have recently published a prospective proof-of-concept study showing increased CSF flow velocities and increased spinal cord velocities at the cervical segment C2/C3 in 20 patients suffering from spontaneous intracranial hypotension (SIH) with definite ventral or lateral spinal leaks (Wolf et al. 2023). This new method might add to the diagnostic pathways. Meanwhile, the most challenging cohort among SIH patients are those with subtle leaks and/or CSF venous fistulas that require further invasive diagnostics. The main objective of this study was to test for the reproducibility of our previous findings.

METHODS: Retrospective analysis of phase-contrast MRI measurements at C2/C3 that has been implemented in our current SIH workup since November 2021. All SIH patients with epidural fluid collections and/or localized leak between November 2021 to January 2023 were included (Type I, II, III; Schiewink et al. 2016). Segmentation and processing were fully automated (www.nora-imaging.org). Main parameter of interest was the velocity range (mm/s) in craniocaudal direction.

RESULTS: We included 65 patients with SIH (52% with dural tears (Type I), 25% with meningeal diverticula (Type II), 20% CSF venous fistulas (Type III), 2% unknown leak site), and compared them to 68 healthy controls. CSF and spinal cord velocity ranges were significantly higher in SIH patients: CSF - 42 ± 10 mm/s vs. 58 ± 17 mm/s, $p<0.001$; spinal cord 5.6 ± 1.4 mm/s vs. 7.7 ± 3 mm/s, $p=0.005$ (Figure 1).

CONCLUSIONS: Our previous findings could be reproduced in a large cohort of patients with SIH that now represented a typical SIH cohort. Most importantly, current data included patients with CSF-venous fistulas that are most difficult to detect. These results underline the potential impact of this new diagnostic tool in CSF volume disorders.



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REVERSIBLE DEMENTIA PROJECT (REVERT): IMPACT ON IMPROVEMENT IN AWARENESS, DIAGNOSIS AND MANAGEMENT OF NORMAL PRESSURE HYDROCEPHALUS.

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INTRODUCTION: REVERT, funded in October 2020 by ERDF, an Interreg France (Channel) England Programme, aimed to establish a common clinical and research network of excellence to transform the current management pathway of patients suspected of normal pressure hydrocephalus in the UK-French cross-border region. Following its official completion in March 2023, the goal of this paper is to summarise and discuss its main outputs.

METHODS: A consortium of clinicians, physicists, mathematicians and software specialists from 3 Universities, 4 hospitals and an IT company worked towards addressing the following challenges in the management of NPH:

- insufficient referrals, due to low awareness of the disease in the context of dementia like symptoms
- lack of clear guidelines for optimal diagnostic workup
- incomplete understanding of physiology of pressure-flow-volume relationships in the cerebrospinal space
- inadequate understanding of the interplay between the cerebro-vascular and CSF circulation systems
- limited access and familiarity to advanced supplementary tests (CSF dynamics tests, PC MRI imaging)
- lack of consistent and appropriate outcomes measures to determine improvement after shunting

RESULTS: The three key outputs of the project are: (1) establishment of a multidisciplinary one-stop clinic incorporating a core dataset of cognitive and gait measures for efficient screening and triage of new referrals, (2) refinement of infusion study and phase-contrast MRI mathematical models, and development of clinical protocols for the adoption of these supplementary tests within the routine care pathway, and (3) implementation of a digital portal for integrating data across the clinical pathway and for secondary linkage with national registries and research repositories.

CONCLUSION: Achieving impact from research translation in clinical practice necessitates an integrated approach to the entire patient pathway involving all relevant stakeholders. Novel approaches to the analysis and interpretation of the supplementary tests are essential for improving their predictive power, and require validation with appropriate clinical outcomes.

BOWEL AND URINARY INCONTINENCE IN IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: One of the key symptoms of Idiopathic Normal Pressure Hydrocephalus (iNPH) is urinary incontinence. However, there are very few studies focusing on this topic. The Japanese guidelines for management of iNPH describe that there is no sufficiently strong evidence to make recommendations regarding characteristics and evaluation of urinary incontinence. Furthermore, it is reported that patients with urinary incontinence also may have bowel incontinence. In this single-center prospective study we aimed to investigate urinary and bowel symptoms in patients with iNPH before and after the surgery and compared them with healthy individuals (HI).

METHODS: Fifty-seven consecutive iNPH patients (27f, median age 77) were included. They underwent a pre- and 3-months clinical evaluation after shunt surgery. At the same time the following questionnaires were employed: the International Consultation on Incontinence Questionnaire – Urinary Incontinence Short Form (ICIQ-UI), the Wexner's Fecal Incontinence Score (Wexner's FI) and the Bowel Symptom Questionnaire. Forty-two healthy individuals, HI (25f, median age 71y) answered the questionnaires.

RESULTS: The median disease duration was 24 months (6-120). Six patients (10.5%) had bladder disturbance as first symptom, whereas 46 (80.7%) had gait/balance. The total Hellström scale score, the total ICIQ-UI score and the total bowel function satisfactory scale were significantly improved ($p<0.001$, $p=0.01$, $p=0.03$). Significant differences were found in defecation time, occurrence of abdominal pain, soiling, stool retention time and bowel-related limitation in social life ($p<0.001$, $p=0.04$, $p<0.001$, $p=0.04$ and $p=0.03$) between patients and HI. Eighty-three percent of patients released involuntary gas at least once per week ($p<0.001$), while 12% used protection against stool leakage ($p=0.03$) and 19% could not release gas without stool leakage ($p=0.04$).

CONCLUSION: We expand the knowledge of urinary and bowel symptoms in iNPH with a more detailed description of the urinary symptoms. The patients also report several bowel symptoms, indicating bowel incontinence.

TEMPORO-SPATIAL GAIT PARAMETERS ALTERATION AFTER TAP TEST IN PATIENTS WITH IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: To investigate the alteration of gait parameters after CSF removal using a tap test in patients with idiopathic normal pressure hydrocephalus (iNPH).

METHODS: Sixty-two patients with iNPH were recruited from the OPD clinic, Siriraj Hospital, Thailand. Eleven were excluded from unable to walk (n = 4), exhausted (n = 1), herpes zoster (n = 1), unable to communicate or follow commands (n = 2), gout (n = 1), severe back pain (n = 1), and unable to track the data (n = 1). Gait parameters were recorded at pre- and 24-hour post-tap tests using an objective gait measurement platform with the self-selected speed for 3 trials. A physical therapist walked behind the patient to provide care or assistance as needed. To get rid of the effect of acceleration and deceleration, data at the middle part of the pressure mat were tracked and used in the analysis. The Paired t-test with p-value < 0.05 was used to compare data between pre- and post-tap tests.

RESULTS: Fifty-one patients with iNPH completed the data collection protocol. Of these, 35 reported walking more easily, while the others felt the same (n = 10) or slightly diminished (n = 6). Comparisons of the data showed significant improvements in left and right step length and time, stride length and time, cadence, and velocity ($p < 0.05$) while there was no change in foot rotation angle, step width, stance phase, load response, single limb support, pre-swing, swing phase, and double limb support ($p > 0.05$).

CONCLUSION: Most patients enhanced their gait after the tap test as evidenced by the improvement of step/stride length and time, cadence, and velocity. However, the incremental improvements in stated variables are far from normal range values, and long-term effect is still needed in further study.

INCIDENCE AND OUTCOMES OF CHRONIC SECONDARY HYDROCEPHALUS AT A TERTIARY NEUROSURGICAL CENTRE: A 3.5 YEAR RETROSPECTIVE OBSERVATIONAL STUDY

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INTRODUCTION: Chronic secondary hydrocephalus is a novel diagnosis adopted by the Hydrocephalus Society, described as any CSF accumulation due to a concurrent central nervous system pathology for over 3 months. Causes include subarachnoid haemorrhage, tumour or trauma. There is little evidence on the incidence and outcomes from this condition. Therefore, we sought to investigate outcomes from chronic secondary hydrocephalus at our centre.

METHODS: We conducted a single-centre retrospective cohort study on all patients undergoing a VP shunt insertion at the Queen Elizabeth Hospital, Birmingham between 26/3/2019 and 06/09/2022. All patients with chronic secondary hydrocephalus were included, whilst all other forms of hydrocephalus (e.g. IIH) were excluded. Using our electronic health record, we collected data on patient demographics, indication, duration of symptoms, 30-day complications and patient survival to the present day, excluding duplicates.

RESULTS: Overall, 360 patients underwent 394 VP shunt procedures during the study period. 38 patients with chronic secondary hydrocephalus (10.6%) underwent 43 VP shunt insertions. Within this group, 29 (76.3%) were female with a mean age of 45.8 years. The most common aetiology was tumour (25 patients). Complications were observed following 10 procedures (23.3%), with 8 revisions required. 6 were due to disconnection/fracture of the shunt apparatus in 4 patients, which all occurred within 30 days of the shunt insertion and required revision of the VP shunt. There were no deaths in any of the patients.

CONCLUSIONS: In this 3.5-year follow up study of operated chronic secondary hydrocephalus patients at our centre, we report an incidence of 10.6%, a female sex and tumour aetiology preponderance. Our complication and revision rates were comparable to the literature. In future studies, we aim to provide longer-term follow up data to inform the incidence and outcomes in this cohort of patients.

EXPRESSION ANALYSIS OF MOTOR ACTIVITY RELATED GENES TO PREDICT IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: The aim of this study is to investigate the expression of motor function related genes that can reflect motor activity intensity and detect pre-clinical stages of idiopathic normal pressure hydrocephalus (iNPH).
In a previous study, we performed an expression analysis of microRNAs (miR) in mouse hippocampus of an "exercise" group and found significantly increased miR-532-5P. We hypothesized that this gene may also be upregulated by exercise in humans, and investigated whether the expression of miR in plasma is affected. In addition, it can be predicted that early stages iNPH patients, who have significantly limited mobility, may have it as a biomarker for motor impairment.

METHOD: We measured miR-532-5P in plasma samples from iNPH patients (n=32) and healthy elderly subjects (n=20).
Next, in patients with iNPH who underwent shunt surgery (n=10), we measured miR-532-5P expression before and at least 6 months after surgery in plasma and CSF samples, together with the more relevant Brain-Derived Neurotrophic Factor (BDNF), using ELISA.

RESULTS: We found a significantly lower expression of miR-532-5P in plasma in the iNPH group than in the healthy elderly group, with a cutoff value of 11.2 in ΔCt value distinguishing between the two groups with 0.94 sensitivity and 0.8 specificity (AUC, 0.8). Furthermore, the expression of miR-532-5P in plasma increased after shunt surgery, indicating improved motor activity. miR-532-5P was increased after shunt in iNPH patients, with pre- and postoperative BDNF increased 40% from 8.0 (ng/mL) to 10.8 in plasma and 70% from 0.7 to 0.94 in CSF.

CONCLUSION: Based on our findings, miR-532-5P can be a potential marker in iNPH patients for motor activity-induced upregulation. BDNF increased with miR-532-5P improvement and was thought to help improve activity and cognitive function.

LONG-TERM OUTCOMES OF NORMAL PRESSURE HYDROCEPHALUS PATIENTS WITH CSF SHUNT: A SYSTEMATIC LITERATURE REVIEW AND META-ANALYSIS

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INTRODUCTION: CSF shunt is the standard treatment for NPH and has been used for over 50 years with excellent results in the treatment of NPH but is not free of complications. The aim of this study was to review the long-term outcomes in patients treated with CSF shunt. Our second objective was to determine possible improvements quality of life after shunt surgeries in patients with NPH.

METHODS: We reviewed literature regarding long-term outcomes after shunt surgery in patients with NPH, following the PRISMA guidelines. Our search included PUBMED, ScienceDirect, Google scholar and Cochrane library databases. We did not include papers that report secondary causes of NPH and ages younger than 60 years.

RESULTS: Out of 17000 articles, 12 were select for analysis. The study involved 1402 treated patients who underwent CSF shunt surgery. The long-term outcomes were evaluated in 995 patients with a median time after surgery of 4 years and 2 months. The most reported initial symptoms were gait disorders (97%), followed by complaints related to cognitive impairment, (85%) and urinary incontinence (76%). After 12 months, global improvement was present in 80% of the patients. The most important complications listed in the studies are shunt dysfunction (22%), infections (7%), and subdural hematomas (3%).

CONCLUSIONS: Patients with clinical symptoms of NPH may benefit from a CSF shunt procedure for up to 6 years and 80% of the patients seem to experience an improvement in quality of life, even those with significant co-morbidities. Studies such as this one are extremely relevant to further understanding the role of surgery in for NPH patients. More studies are necessary to serve as basis for larger reviews and metanalysis on this.

Keywords: Normal pressure hydrocephalus, long-term, follow-up, clinical outcome, shunt surgery

THE INCIDENCE OF POSTDURAL PUNCTURE HEADACHE BY LUMBAR PUNCTURE IN PATIENTS WITH HYDROCEPHALUS IS LOWER THAN IN YOUNGER PATIENTS

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INTRODUCTION: Postdural puncture headache (PDPH) is a complication that occurs in 10.9-29.5% of patients after lumbar puncture. Young age, female age, low body mass index, and history of headache have been reported as risk factors, but the pathogenesis is controversial. In our previous study, we suggested that younger patients have a larger intervertebral foramen cross-sectional area than older patients and are therefore more prone to cerebrospinal fluid (CSF) exudation. In the present study, we discussed PDPH in hydrocephalus patients, whose population is older.

METHODS: We examined 283 patients(average age 78.7 years) who had undergone lumbar puncture at our hospital over a 3-year period, and selected those who presented with post-puncture headache. In addition, the cross-sectional area of the intervertebral foramen was measured by computed tomography (CT) in each case.

RESULTS: PDPH had a low incidence in 4 of 283 patients (1.41%), all of whom were female, and the mean age was 76.8 years. When compared to the association between age and intervertebral foramen cross-sectional area in previous studies, the area tended to be smaller, again due to older age.

CONCLUSIONS: Few clinical studies focusing exclusively on elderly patients have been reported. Lumbar punctures in hydrocephalus patients, who are predominantly elderly, have a low incidence of PDPH. This suggests that CSF extravasation from the epidural space of the spinal canal through the intervertebral foramen into the paravertebral space is the mechanism that causes PDPH.

CONTEMPORARY MANAGEMENT OF PATIENTS WITH NORMAL PRESSURE HYDROCEPHALUS (NPH) – AN INTERNATIONAL SURVEY

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INTRODUCTION: The management of patients with suspected NPH has been controversial. The aim of the study was to ascertain current practice and provide data set for identifying future trials.

METHODS: An online survey was created using SurveyMonkey with 60 questions. The questions included open , multiple choice and multiple response questions and logical branching. The survey distributed through Neurosurgery Research Listserv, British Neurosurgery Research Group Mailing list, neurosurgery Facebook groups (Neurosurgery Research Listserv, Neurosurgery Cocktail) and notice posted on LinkedIn and Twitter and emailed to leading neurosurgeons in the care of NPH around the world. The survey ran from 1/9/2022 to 9/12/2022. The data was downloaded from SurveyMonkey in .xlxs file. Then it was cleaned with MS Excel PowerQuery and MS Excel and imported into FileMaker 19 and then analysed with statistical software: Wizard 2 and Stata 15.

RESULTS: There were 64 responses in total. Of the 44 (2/3) from 21 countries provided their localities. Of the 64 respondents, 60 (94%) obtained MRI of the head. Eleven percent restricted ancillary tests to 'DESH negative' patients. 75% respondents undertook Lumbar-tap test routinely and 31% undertook lumbar-drainage test routinely. Gait test was performed by neurosurgical staff in 44% of the patients. Regular NPH MDT was in the practice of 20% of the practices. In 41% of the cases the ventricular catheter was inserted free-hand. Of those responded 45 inserted only VP shunts and 2 inserted on LP shunts for NPH.

CONCLUSIONS: The survey identifies important current trends in the management of NPH

OUR PRELIMINARY EXPERIENCE ON THE COMBINATION OF NEUROPSYCHOLOGICAL ASSESSMENT AND INTRATHECAL PRESSURE MEASUREMENT TO SETTLE THE DIAGNOSTIC DILEMMA OF THE NORMAL PRESSURE HYDROCEPHALUS.

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INTRODUCTION: Normal-pressure hydrocephalus (NPH) is a common condition associated with a cognitive deterioration and possibly involving up to 9% e 14% of all nursing home residents older than 65 years old. The purpose of the present paper is to introduce an inclusive study protocol aimed at increasing the diagnostic precision and follow-up accuracy.

METHODS: A total of 28 patients were operated on for NPH in our institution in the period ranging between January 2015 and December 2019. All the patients underwent MRI of the brain with standard sequences, calculation of the Evans index and corpus callosum angle, and evaluations by means of Montreal Cognitive Assessment (MOCA), Mini-Mental State Examination, and Frontal Assessment Battery (FAB) neuropsychological tests preoperatively and at 1 and 6 months. A preoperative lumbar test infusion (LIT) was performed.

RESULTS: MOCA and FAB proved an overall improvement of the neurocognitive conditions at 1 month postoperatively. The mean pressure at the beginning of the LIT, was negatively associated with the neuropsychological outcome variables (Mini-Mental State Examination, FAB, and MOCA) in the 3 different evaluations, with FAB and MOCA at 6 months. We found a strong positive correlation between the Evans index as measured on the first magnetic resonance imaging scan both with the diastolic and systolic pressure at the beginning of the test.

CONCLUSIONS: Neuropsychological assessment, combined with LIT with intrathecal pressure managements aids the diagnostic process in patients affected by NPH. It allows standardizing in a rigorous fashion the follow-up evaluation of patients undergoing surgery for a ventriculoperitoneal shunt.

A MULTIDISCIPLINARY TEAM APPROACH TO MANAGING NORMAL PRESSURE HYDROCEPHALUS: INSIGHTS FROM A NEW SERVICE AT THE ROYAL VICTORIA INFIRMARY

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INTRODUCTION: Determining the diagnosis of normal pressure hydrocephalus (NPH) and subsequently, which patients may respond to CSF diversion, can prove challenging due to the relatively high prevalence of mimicking conditions. Herein, we present our initial experience of delivering a multidisciplinary team approach to managing patients referred to the service in Newcastle upon Tyne.

METHODS: We have performed an evaluation study in order to describe how the service has evolved. We have interrogated a prospectively maintained a database of patients assessed and managed since commencement of the service.

RESULTS: The service was initiated in June 2021. Our NPH team consists of a neurologist, a neuroradiologist, CSF specialist nurse and a neurosurgeon. We conduct at least one MDT meeting per month as well as joint clinics bimonthly. 165 patients have been discussed in our MDT meeting. Radiological evaluation has included the assessment of the iNPH Radscale score for most of the patients referred. 54 new patients have attended our joint clinic for face-to-face assessment. We have employed a CSF tap test, which involves a) a videoed timed walking test and b) the Addenbrooke's cognitive assessment, pre- and post-lumbar puncture, to try and determine which patients might respond to CSF diversion, in 40 cases. At the time of writing, 14 patients have undergone ventriculo-peritoneal shunt (VPS) insertion (which represents the treatment of choice at our centre) since inception of this service. Of these, 12 patients (86%) have experienced a positive neurological outcome (based on clinical assessment of gait and patient reported outcome) during a follow-up period of 1-18 months (one patient has yet to receive their postoperative review).

CONCLUSIONS: Our MDT approach allows the careful consideration of the patient's diagnosis and suitability for CSF diversion treatment. This approach has led to a high rate of positive neurological outcomes following VPS insertion.

VARIATION OF INTRACRANIAL PRESSURE AND PULSE AMPLITUDE AMONGST DIFFERENT TYPES OF HYDROCEPHALIC CONDITIONS AND CEREBROSPINAL FLUID DYNAMIC DISORDERS

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INTRODUCTION: Intraparenchymal intracranial pressure (ICP) monitoring is a useful took to provide insight and treatment guidance into various types of hydrocephalus and cerebrospinal fluid dynamic (CSF) disorder conditions. This study's intention is to explore the variance of ICP and pulse amplitude (PA) amongst these different conditions and to investigate the correlation between ICP and PA.

METHODS: This is single institution retrospective study analysing various parameters included in our departmental standard 24 hours ICP monitoring. Demographic and radiological data were derived from the electronical charts. Meticulous recordings with a sampling frequency up to 40Hz included ICP, PA (separated into day, night and overall) however also peak ICP, percentage of time spend in negative and compliance. Principle component analysis was utilized to detect the key factors that contribute to the variability in data dispersion.

RESULTS: Over 1200 individual 24 hours recording were analysed. These originate from over 900 patients, with additional 300 24 hours data obtained during valve settings adjustments in the same cohort. A wide range of conditions were included such as: idiopathic intracranial hypertension, longstanding overt ventriculomegaly of adults, Chiari Malformation with or without previous surgery, low pressure states, patients investigated with ICP monitoring for shunt dysfunction and arachnoid cysts. The mean age was 42.7 years (SD+/-14.91) with a good representation of both male and female patients. Significant variations were observed among the diagnostic groups when conducting exploratory comparisons of PA and ICP.

CONCLUSION: This research offers valuable information regarding intracranial pressure parameters observed among various patient groups diagnosed with CSF hydrodynamic disorders.

Keywords: hydrocephalus, CSF dynamic disorders, intracranial pressure, pulse amplitude

A DECADE OF ACADEMIC PUBLICATIONS ON NPH AND IIH

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INTRODUCTION: Normal Pressure Hydrocephalus (NPH) and Idiopathic Intracranial Hypertension (IIH) are disorders of the cerebrospinal fluid (CSF) dynamics that can be encountered by clinicians in neurology and neurosurgery clinical settings. The successful management of these diseases heavily relies on multidisciplinary efforts, with the neurologists often being in the position of making the initial diagnoses and referring to the neurosurgeons when appropriate. Academic publications on peer-reviewed journals should reflect this communal interest. This study is an analysis of peer-reviewed publications on NPH and IIH in the last decade.

METHODS: Analysis of the peer-reviewed literature. Standardised literature searches were conducted on PubMed to identify the number of publications that used the MeSH terms "Normal Pressure Hydrocephalus" or "Idiopathic Intracranial Hypertension" (or "Benign Intracranial Hypertension") since 2012. The searches were conducted in predefined neurology and neurosurgery journals. The number of articles retrieved was quantified and compared to the total volume of papers published by the journals in the same years. A comparison in the proportion of publications about these diseases between neurology and neurosurgery journals was conducted.

RESULTS: Publications in 7 neurosurgery journals and 8 neurology journals were analysed. A total of 89616 peer-reviewed papers were retrieved; of these, 53% were in journals mainly aimed at a neurosurgical audience. Amongst the retrieved articles, 386 used the NPH MeSH term (0.43%) and 186 the IIH MeSH term (0.21%). Over the years, there were clear oscillations in the number of papers published in each topic, but no definite trend. The proportion of publications on these topics was significantly higher in neurosurgery journals compared to neurology journals (Fisher's exact test) for both NPH ($p<0.001$) and IIH ($p=0.027$).

CONCLUSIONS: Despite the fact that NPH and IIH are diseases managed in a multidisciplinary environment, these topics are less discussed in journals aimed at a neurology audience compared to the ones aimed at a neurosurgical readership.

CONCUSSIONS AND IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS: IS THERE A CORRELATION?

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INTRODUCTION: Traumatic brain injury (TBI) is a common cause of morbidity and mortality and some studies have also hypothesized a link between TBI and neurodegeneration. Normal Pressure Hydrocephalus (NPH) is a heterogeneous disorder with different etiology, including TBI. Some NPH patients have no apparent cause, thus are labelled as idiopathic (iNPH), a condition commonly underdiagnosed and poorly understood, especially with respect to its relation with neurodegeneration. Previous studies have shown that concussion or TBI can increase the risk of neurodegenerative diseases such as AD and PD (Fleminger et al., 2003; Bramlett & Dietrich., 2015) and the relationship between TBI and secondary NPH as well as the possible overlap between neurodegeneration and iNPH led us to the question of whether mild TBI plays a role in iNPH, an association unexpectedly not explored before. In this study we gathered data on the association between a history of TBI – even if mild – and later development of iNPH.

METHODS: The history of head trauma was collected in a consecutive series of 54 iNPH patients by means of a case report form consisting of history of TBI assessment through the Ohio State University TBI-ID (OSU TBI-ID) (Corrigan, J. D., & Bogner, J. (2007) and Brain Injury Screening Questionnaire (BISQ) designed by the Icahn School of Medicine (Dams-O'Connor, K., et al., 2014) and compared with 50 patients diagnosed with Parkinson's, as well as an age- and sex-matched control group of 40 healthy subjects.

RESULTS: 74% of iNPH patients reported at least one minor head trauma throughout their lifetime, as opposed to 50% and 27.5% of patients diagnosed with Parkinson's and health controls, respectively

CONCLUSIONS: Our preliminary findings indicate a possible association between TBI and iNPH, association needs to be further explored by future studies.

LOW PRESSURE HYDROCEPHALUS

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INTRODUCTION: Low pressure hydrocephalus (LPH) is an underrecognized subtype of hydrocephalus with a diverse range of etiologies that can be challenging to treat since being initially non-responsive to standard strategies of cerebrospinal fluid shunting.

METHODS: Our experience with four unique cases of LPH are presented, discussing treatment algorithm and decision-making.

RESULTS: One patient developed LPH immediately after uneventful resection of sphenoid wing meningioma, one after VP shunt malfunction, one following traumatic subarachnoid hemorrhage, and one following the resection of posterior fossa hemangioblastoma. Three were adults and one was a 15-year-old girl. Prior to establishing the diagnosis of LPH, multiple revisions did not improve ventricular enlargement nor clinical deterioration. These included shunt revisions with subsequent high external ventricular drain settings (EVD) to deliver a definite diagnosis. The output of EVD was monitored with the setting to 0 cmH2O, in all cases leading to clinical improvement. The long-term management of these patients was successful using low pressure shunt systems.

CONCLUSIONS: Although LPH is an uncommon entity, it represents important differential diagnosis clinicians should be well aware of when dealing with symptomatic hydrocephalus despite low intracranial pressure. Although its development is not connected to one specific etiology, it has three recognition signs: a drop in EVD output, symptomatic ventriculomegaly, and the absence of intracranial hypertension. However, with early recognition, LPH can be effectively managed with either endoscopic third ventriculostomy or low pressure shunt systems.

CSF BIOMARKERS AS PREDICTIVE MARKERS OF OUTCOME AFTER CSF DIVERSION IN PATIENTS WITH NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Biomarkers associated with neurodegeneration, obtained from CSF, may assist in the diagnosis of normal pressure hydrocephalus (NPH) as well as determining the prognostic benefit of CSF diversion treatment. We aim to assess the association of these CSF biomarkers with positive post-operative outcomes.

METHODS: A retrospective analysis of patients that underwent CSF diversion at a single neurosurgical centre between 2009-2019 was conducted. CSF samples were obtained from either lumbar drainage (LD) or ventriculoperitoneal shunt (VPS) and were analysed for biomarkers, including Amyloid-β1-42 and Total-τ. Patients with insufficient documentation, incomplete biomarker data or no diagnosis of NPH were excluded. The associations between CSF biomarkers and post-operative outcomes were determined by Chi-Square test, Independent Sample T-test, and Pearson's correlation.

RESULTS: Our cohort comprised of 69 patients. 64 patients had LD and 52 had VPS insertion. The average value for Total-τ was 702pg/mL (range: 59-13,487pg/mL) and 29 (42.0%) patients had values outside the reference range. The average value for Amyloid-β1-42 was 595pg/mL (range: 111-1339pg/mL) and 13 patients (18.8%) had values outside the reference range. A strong positive correlation was found between the Total-τ value and the improvement of 10 metre walking test time post-LD at fast speed ($r = 0.354$, $n = 41$, $p < 0.05$), and post-VPS at normal speed ($r = 0.329$, $n = 42$, $p < 0.05$). Amyloid-β1-42 levels less than 450pg/mL were significantly associated with a greater improvement of 10 metre walking test time post-LD ($t(54)=2.098$, $p = 0.041$) and subjective improvement in the patient's symptoms (OR 6.790, $p = 0.009$).

CONCLUSION: Raised levels of CSF Total-τ and decreased levels of CSF Amyloid-β1-42 are significantly associated with post-operative improvement in mobility in NPH patients after CSF diversion. Further analysis is required to determine their association with positive neuropsychological and urological outcomes as well as their predictive value in clinical practice.

NON-INVASIVE ICP WAVEFORM MONITORING FOR ASSESSMENT AND TREATMENT RESPONSE IN CSF HYPOTENSION DUE TO SPONTANEOUS OCCULT CSF FISTULAS: A CASE SERIES

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INTRODUCTION: Cerebrospinal fluid (CSF) hypotension due to spontaneous occult CSF fistulas is a condition that can cause debilitating symptoms such as headaches and neck pain. The non-invasive measurement of intracranial pressure waveform (nICPw) may provide a reliable way of assessing this condition. This study aims to evaluate the changes in P2/P1 ratios and time-to-peak (TTP) in different positions in patients with CSF hypotension due to spontaneous occult CSF fistulas and their response to treatment.

METHODS: Three patients with CSF hypotension due to spontaneous occult CSF fistulas were evaluated using the P2/P1 ratio and TTP in different positions (supine, sitting, and standing) before and after treatment. All patients received specific treatment according to each case: one received an epidural blood patch, one received surgery and one received conservative treatment. The P2/P1 ratio was evaluated using a non-invasive device from Brain4care®.

RESULTS: The results showed that the P2/P1 ratios in all three patients varied up to 1.5 and below 0.6 in different positions before treatment, with TTP varying from 0.06 to 0.40. After each patient received specific treatment, the P2/P1 ratios and TTP returned to closer-to-normal levels and less variation in all patients, in different positions, while symptoms also improved.

CONCLUSIONS: The present study suggests that the non-invasive of ICP waveform and its associated parameters (P2/P1 ratio, TTP) may provide a reliable way of assessing CSF hypotension due to spontaneous occult CSF fistulas. The P2/P1 ratios and TTP in different positions varied before treatment, but returned to closer-to-normal levels after treatment. These findings may help further understanding of other causes of CSF hypotension, such as shunt hyperdrainage. Further studies with larger sample sizes are needed to confirm these findings.

EXPLORING NEUROPHYSIOLOGY THROUGH MONITORING THE ICP WAVEFORMS IN SHUNTED PREGNANT PATIENTS WITH A NON-INVASIVE DEVICE - A CASE SERIES

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INTRODUCTION: Pregnancy can exacerbate the symptoms of idiopathic intracranial hypertension (IIH) and hydrocephalus due to increases in abdominal pressure. Non-invasive monitoring of intracranial pressure waveforms (ICPw) may provide insights into the neurophysiology of these conditions during pregnancy. The present case series describes two pregnant patients with IIH and hydrocephalus, respectively, who were monitored with a non-invasive device to assess changes in their P2/P1 ratios during pregnancy.

METHODS: Two pregnant patients, one with IIH and one with hydrocephalus, were monitored with a non-invasive device to assess changes in their P2/P1 ratios during pregnancy. Symptoms were also evaluated.

RESULTS: Both patients showed an increase in their P2/P1 ratios during pregnancy, which correlated with progressively worsening symptoms. After delivery, both patients showed improvement in symptoms, as well as a normalization of their P2/P1 ratios.

CONCLUSIONS: The present case series suggests that non-invasive monitoring of ICPw can provide insights into the neurophysiology of IIH and hydrocephalus during pregnancy. The increase in P2/P1 ratios during pregnancy may be indicative of worsening symptoms, and normalization of P2/P1 ratios after delivery may be coincide with symptom improvement. Further studies with larger sample sizes are needed to confirm these findings and translate them into clinical use.

PATIENTS WITH NORMAL PRESSURE HYDROCEPHALUS HAVE FEWER ENLARGED PERIVASCULAR SPACES IN THE CENTRUM SEMIOVALE

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INTRODUCTION: Enlarged perivascular spaces (ePVS) may be an indicator of glymphatic dysfunction. Limited studies have evaluated the role of ePVS in idiopathic normal pressure hydrocephalus (iNPH), with those studies showing conflicting results. We aimed to characterize the distribution and number of ePVS in iNPH compared to controls.

METHODS: Thirty-eight patients with iNPH and a pre-shunt MRI were identified through clinical practice. Age- and sex-matched controls who had negative MRIs screening for intracranial metastases were identified through a medical record linkage system. Controls did not have cognitive impairment, gait disorder, or reported imaging features of iNPH. All patients were required to have imaging performed on a 3T Siemens system. One reader counted ePVS in the basal ganglia (BG) and centrum semiovale (CS) on the T2 FSE sequence using the Wardlaw method blinded to clinical diagnosis. Imaging features of DESH, Fazekas white matter hyperintensity (WMH) grade, and the presence of microbleeds and lacunes were also evaluated. A second reader counted ePVS on a random sample of 20 participants to determine interrater agreement. The number of ePVS were compared between groups using an independent t-test. Linear regression models were performed in R.

RESULTS: Each group had a mean age of 74±7 years and were 34% female with equal distributions of hypertension, dyslipidemia, diabetes, stroke, and history of smoking. Interrater agreement for ePVS grade was excellent (ICC 0.95, $p<0.001$). There were fewer ePVS in the CS of patients with iNPH compared to controls (12.66 vs. 20.39, $p<0.001$) but a similar number of ePVS in the BG (8.95 vs. 11.11, $p=0.08$). This remained significant in models accounting for vascular risk factors ($p=0.005$) and Evan's index, HCTS, enlarged sylvian fissures, and WMH grade ($p=0.009$).

CONCLUSIONS: Patients with iNPH had fewer ePVS in the CS but not in the BG suggesting that upward displacement of the brain may mechanically occlude PVS.

BEYOND ANTIBIOTICS: THE THERAPEUTIC BENEFITS OF VENTRICULAR IRRIGATION FOR VENTRICULITIS

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INTRODUCTION: Ventriculitis poses a significant challenge in neurosurgical practice due to its unfavorable prognosis, protracted treatment duration, and extended hospitalization. The current standard of treatment has been limited to administering antibiotics and placement of external ventricular drains. However, while this approach is widely used, its efficacy is limited, and new treatment strategies are needed to improve outcomes for patients with ventriculitis. Here, we would like to introduce the different techniques of ventricular irrigation in cases of cerebral ventriculitis and the outcomes associated with this modality.

METHODS: A total of 18 patients underwent ventricular irrigation for cerebral ventriculitis. Lavage/irrigation was performed endoscopically in 7 patients (3 patients required two burr holes while in 3 patients the irrigation was performed via one burr hole). In the remaining 12 patients, the irrigation was done without using the endoscope. The outcomes were compared regarding infection resolution and Hospitalization time and GOS.

RESULTS: Patients' mean age was 116.7 months ± 17.9 [SE]. They were followed up to a mean duration of 8.6 months ± 4.5 [SE] months. Glasgow Outcome Scale was more than 4 (good outcome) in (12/18) 66.7 % of the cases. Mean hospital stay duration was 23.6 days ± 4.8 [SE]. Infection resolution was achieved in average in 17 days ± 4.8 [SE].

CONCLUSION: In the management of cerebral ventriculitis, ventricular lavage has emerged as a valuable treatment modality, offering improved outcomes and shorter hospital stays compared to traditional therapies. These findings highlight the potential of ventricular lavage as a promising approach to the management of ventriculitis and underscore the need for further research to better understand its benefits and limitations.

WHEN YOU THINK THE SHUNT IS WORKING, BUT IT'S NOT: DISTAL CATHETER OBSTRUCTION IN PATIENTS WITH VENTRICULOPERITONEAL SHUNT, A CASE SERIES

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INTRODUCTION: The ventriculoperitoneal shunt (VPS) is currently the most popular technique for management of hydrocephalus; however, complications associated with this procedure are very common, shunt obstruction being the most frequent. The most common site of obstruction is the proximal catheter; however, in a VPS the distal catheter may become obstructed by omentum, a pseudocyst, or peritoneal adhesions. This causes shunt failure that often goes undetected, and requires reintervention.

METHODS: We reviewed all VAS surgeries performed in adult patients at our institution between 2009 and 2022, and identified patients who had a previous VPS and were reintervened due to shunt malfunction. Patients in whom VPS malfunction was due to peritoneal catheter obstruction were selected, and a retrospective review of these patients' clinical history was performed.

RESULTS: We found 12 patients with shunt malfunction due to peritoneal catheter obstruction. 7 were men, and the average age was 55.8 years (20-91). Time from symptom onset to definitive surgical management ranged from 1 day to 2 years, averaging 7.1 months. 2 patients had previously undergone multiple shunt revisions that did not include revision of the peritoneal catheter, with no symptom improvement. Intraoperatively, the peritoneal catheter was found to be completely obstructed in 8 patients and partially obstructed in 4. In all patients, a new distal catheter was inserted to the right atrium, and all reported symptom improvement or resolution in follow-up.

CONCLUSION: A better awareness of peritoneal catheter obstruction as a potential cause for VPS failure is needed, especially since patients may not present with symptoms or findings specific to distal occlusion, and may even have a normal brain CT. Most patients in this case series had chronic symptoms and had previously been misdiagnosed. The key to diagnosis is the finding of a pressure delta between the lumbar puncture and the valve pressure setting.

EXTERIORIZATION OF A VENTRICULOPERITONEAL SHUNT THROUGH THE URETHRA IN A PEDIATRIC PATIENT: LITERATURE REVIEW AND CASE REPORT

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INTRODUCTION: Ventriculoperitoneal shunt surgery is a procedure indicated for hydrocephalus, in which the cerebrospinal fluid is diverted from the ventricles to the peritoneum. There are several complications related to this surgery, which are common in surgical practice. One of the rarest being the exteriorization of the "shunt" through the urethra.

METHODS: To investigate the literature of exteriorization of a ventriculoperitoneal shunt through the urethra, a search was carried out in the MEDLINE/PUBMED database with the following descriptors: ((ventriculoperitoneal shunt[Title/Abstract])) AND (urethral)[Title/Abstract]). Filters were not used, and 20 papers were found between 1992 and 2023, but after reviewing the papers, only 14 were selected for the study, ranging in depth in each one, from epidemiology, etiology, clinical presentation to surgical correction. Case presentation: Female patient, 03 years old, with myelomeningocele corrected at birth, with hydrocephalus, submitted to the ventriculoperitoneal shunt procedure, which complicates the exteriorization of the "shunt" to the urethra. 1 month after the complication, a ventriculoatrial shunt is performed as an alternative to treat hydrocephalus.

RESULTS: The first work that brought urethral exteriorization as a complication of peritoneal diversion was published in 1995. This complication occurs more in female patients, in a ratio of 1.1:1, with a mean age of 6.8 years, in which it is more common during childhood, but can occur during adulthood, in addition to being more common. rare in neonates. Most common clinical presentation is hematuria, dysuria, abdominal pain and neurological symptoms, infection is the major complication in these cases. Surgical management consists of removing the catheter, preferably with disconnection of the drainage system.

CONCLUSIONS: As rare as such a complication may be, it is essential to understand its risks, so that measures and care are taken in order to reduce the chance of this occurring, aiming at a better prognosis for the patient.

DEATHS DUE TO HYDROCEPHALUS TREATMENT IN BRAZIL FROM 2012 TO 2022

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INTRODUCTION: Scientifically, hydrocephalus is defined as the inadequate accumulation of cerebrospinal fluid in the intracranial space, generating enlargement of the ventricular system and intracranial hypertension with their respective consequences. This condition is responsible for both deaths and inability of individuals, and can affect both adult and pediatric patients. The treatment has a good rate of positive outcome, but there are complications such as infection and obstruction of the system. This study aims to analyze the rate of deaths from hydrocephalus treatment in Brazil from 2012 to 2022, and seek to understand the variation in numbers over the years.

METHODS: This is a quantitative, ecological, descriptive study, based on data reported in the Notifiable Diseases Information System (SINAN/SUS) of the Ministry of Health through DATASUS.

RESULTS: In 2012, 3,589,149 patients with hydrocephalus were treated, while 170 died after treatment. In 2017, 6,575,832 patients underwent treatment for hydrocephalus, with the peak in the number of deaths, which reached 2015. In 2022, the number of treatments practically doubled, 6,819,129, but the number of deaths did not follow the same pattern , remaining at 196.

CONCLUSION: The number of records of treated patients increased over the years, most likely due to advances in patient recording techniques, and not due to a disease condition that increased over time. It is possible to verify that the death/treatment ratio decreased over time, which represents something positive and reflects advances in surgical techniques and measures to reduce complications, such as infection and obstructions.

IS A VENTRICULOATRIAL SHUNT THE FIRST-LINE OPTION FOR MANAGEMENT OF HYDROCEPHALUS IN ADULT PATIENTS?

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INTRODUCTION: Hydrocephalus is treated by shunting excess cerebrospinal fluid (CSF) to other body cavities. The use of a ventriculoatrial shunt (VAS) is mostly limited to second-line treatment, and a ventriculoperitoneal shunt (VPS) is preferred. However, recent studies in adult patients have found a similar incidence of postoperative complications in VAS compared to VPS, and even a lower incidence of obstruction and need for shunt revision. This could entail a paradigm shift in the surgical treatment of hydrocephalus.

METHODS: This retrospective cohort study aimed to evaluate the performance of VAS for the treatment of hydrocephalus in adults, as well as diagnostic and surgical factors that may be related to postoperative outcomes, using the experience at our institution. We reviewed the medical record of adult patients with hydrocephalus of any etiology in whom a VAS procedure was performed between January 2009 and July 2022 at Fundación Santa Fe de Bogotá.

RESULTS: We found a total of 208 patients with an average age of 63.9 years; 109 (52.4%) were men. Postoperative complications occurred in 63 patients (30.3%). Infection was found in 8 (3.85%), proximal catheter obstruction in 22 (10.6%), and 2 (0.96%) presented with distal obstruction. 42 patients (20.2%) required shunt revision. Subdural collections were found in 9 patients (4.33%), and 3 (1.44%) required surgery. We identified cardiopulmonary complications in 8 patients (3.85%); however, most had other predisposing factors that were regarded as the cause.

CONCLUSION: We found a lower incidence of infection and subdural collections than that reported in literature for VPS, and a very low rate of distal obstruction. We conclude that VAS is a great alternative and may even be considered superior to VPS as a first-line choice for surgical treatment of hydrocephalus of any kind in adults.

VENTRICULO-GALLBLADDER SHUNT: LITERATURE REVIEW AND CASE REPORT

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INTRODUCTION: Permanent liquor diversion is associated with high risk of failure and often needs re-intervention. Ventriculo-gallbladder shunt (VGS) has been recognized as a last-resort alternative to treat hydrocephalus when the peritoneum or other distal sites can no longer receive shunts. This article's purpose is to report a case from a neurosurgery referral service in Brazil and review literature on that issue.

METHODS: A search was carried out in the MEDLINE/PUBMED database with the following descriptors: ((ventriculo gallbladder shunt [Title/Abstract])) OR ((ventriculo-gallbladder shunt[Title/Abstract])). Filters were not used. Nine papers were found between 1997 and 2023, but, during the analysis of the the papers, only 7 were selected for the study. Case presentation: G.B.S, male, 43 years old, no comorbidities, with a 12-year history of hydrocephalus, with post-surgical chronic fungal meningitis. He underwent a ventriculoatrial shunt (VAS) placement 2 years ago, as he had multiple ventriculoperitoneal shunt (VPS) failures. Endocarditis was suspected and the VAS was withdrawn.As alternative, VGS was placed 6 months ago and, since then there has been no reason for a new system review.

RESULTS: The first work was published in 1997 and brought the gallbladder as an alternative since it would serve as a temporary receptacle for liquor, just as the peritoneal cavity. The gallbladder has an absorptive capacity of 1500 cc liquid daily, which comprises more than the normal CSF daily production. Therefore, it's a good alternative when the ventriculo-peritoneal shunt is not viable due to postsurgical peritoneal adhesions or when there are contraindications for ventriculoatrial or ventriculopleural.

CONCLUSIONS: VGS is an alternative to patients who cannot undergo the most common surgical interventions, such as VPS. The case reported here is a goodillustration of that: VGS was placed as an alternative, with no complications since then, suggesting that it can be a viable option in some cases.

MANAGING SHUNT DYSFUNCTION WITH NON-INVASIVE INTRACRANIAL PRESSURE WAVEFORM MONITORING

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INTRODUCTION: Shunt dysfunction is a potentially severe complication of ventriculoperitoneal shunt (VPS) surgery for hydrocephalus, and, while it can lead to debilitating and worsening symptoms, it may also present with vague or non-specific symptoms. Non-invasive intracranial pressure waveform monitoring (nICPw) is a method that can be used to help diagnose shunt dysfunction and assess patient improvement. The present case report describes a patient with previous hydrocephalus who presented with shunt dysfunction for which nICPw was used during all stages of management.

METHODS: A 30-year-old female with a history of hydrocephalus presented with vision loss after encephalitis. CT scans showed mild increase in ventricle size, nICPw showed an increased P2/P1 ratio and a shunt replacement was performed. After surgery, the patient's vision improved but she began experiencing hyperdrainage symptoms. A programmable shunt was placed, and nICPw was used to assess shunt pressure adjustment and patient improvement.

RESULTS: The nICPw was useful in diagnosing shunt dysfunction and determining a P2/P1 ratio baseline. After the placement of the programmable shunt, the patient's hyperdrainage symptoms improved, and nICPw was used to assess shunt pressure adjustment and patient improvement.

CONCLUSIONS: The present case report suggests that nICPw can be a useful tool in the management of shunt dysfunction in patients with hydrocephalus. It can aid in the diagnosis of shunt dysfunction, assessment of patient improvement, and shunt pressure adjustment.

TRENDS IN HYDROCEPHALUS AND CSF DYNAMICS DISORDERS RESEARCH: A QUALITATIVE ANALYSIS OF THE HYDROCEPHALUS SOCIETY ABSTRACTS

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INTRODUCTION: Hydrocephalus and cerebrospinal fluid (CSF) dynamics disorders are a field of rapidly growing research interest. This qualitative research investigates the trends in this field through the meetings of the International Society for Hydrocephalus and Cerebrospinal Fluid Disorders (ISHCFD).

METHODS: This is a retrospective qualitative analysis of the published abstracts of the ISHCFD meetings. The data collection covered the period between 2015 and 2022. Key terms were identified through the screening of the latest (2022) abstracts book and reviewed by the authors. A word frequency analysis of the preselected words/terms was conducted for each year and quantified (word frequency proportion=N. word was mentioned in the abstract book / N. abstracts published). Terms indicating similar concepts were consolidated (e.g., 'NPH' and 'Normal Pressure Hydrocephalus'), while terms with partial overlap separated (e.g., 'Hydrocephalus' separated from 'Normal Pressure Hydrocephalus').

RESULTS: A total of 774 abstracts, published for 7 ISHCFD meetings were analysed. 122 pre-selected terms were searched and only the most frequent selected for further analysis. The most represented diseases were Normal Pressure Hydrocephalus (NPH) (43.9%) and hydrocephalus (42.3%), followed by idiopathic intracranial hypertension (10.3%), Chiari malformation/ syringomyelia (2.7%), LOVA (0.5%) and spontaneous intracranial hypotension (0.4%). There was a steady increase in the interest in Chiari malformation since 2017. Another interesting trend was the decrease in reports about hydrocephalus relative to NPH between 2015 and 2016. The analysis of investigations revealed a growing interest in biomarkers, optic nerve assessments and the DESH sign, in addition a steady decline of lumbar punctures was observed since 2019. The analysis of treatments confirmed ventriculoperitoneal shunts as the most popular (41%) followed by stenting (26%), lumboperitoneal shunts (20%) and ventriculoatrial shunts (11%); however, a significant steady decline was noted in the interest in stenting from 2016.

CONCLUSIONS: This qualitative research highlighted interesting trends in the research for hydrocephalus and CSF disorders.

DURAL VENOUS STENTING FOR TREATMENT OF IDIOPATHIC INTRACRANIAL HYPERTENSION

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INTRODUCTION: While the etiology of idiopathic intracranial hypertension (IIH) remains unknown, stenosis of one or more of the dural sinuses has been implicated as a possible underlying mechanism. Dural venous sinus stenting (DVSS) is an accepted treatment option in selected patients with medically refractory IIH.

METHODS: Novelties and current diagnostic assessment in the DVSS of IIH are presented, discussing treatment algorithm and decision-making as a systematic review of the topic enriched by the experience with IIH at our institution.

RESULTS: Major DVSS-related complications are low, occurring in approximately 2% of procedures. Clinical improvement is noted in up to 95% of patients, while the most positive clinical outcomes are noted in papilledema improvement, headaches and other visual disturbances. In-stent stenosis remains low during follow-up period, accounting for 3%. Restenosis rate is rather low, only around 10% of IHH patients undergoing DVSS require repeated procedure.

CONCLUSIONS: DVSS for medically refractory IIH suggests that stenting in adequacy selected patients is associated with low complication rates, high technical success, and low repeat procedure rates.

HOW CHANGE THE VESTIBULO-OCULOMOTOR REFLEX (VOR) IN NPH SHUNTED PATIENTS: STUDY ON THE USE THE VIDEO HEAD IMPULSE

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INTRODUCTION: Normal pressure hydrocephalus is a progressive, chronic, extremely complex syndrome. It is the most common form of reversible dementia in the elderly, it is characterized by gait disturbance, dementia, and urinary incontinence.

METHODS: We firstly subjected 9 patients, with symptoms of NPH, to a lumbar infusion test, which resulted positive documenting an elastance index greater than 0.3. The patients underwent a vHIT before surgery, 7 days after and one month after surgery. The exam provides the objective measurement of the vestibulo-oculomotor reflex (VOR) at high frequencies and allows, by making small movements of the head in various directions, to study the functionality of the pairs of semicircular canals. The software, records the reflex eye movements originating from the VOR and compares them with the passive movements of the head, thus providing the gain of the VOR. The aim was to confirm the importance of the index of elastance as a positive predictive value of response to surgery, using the vHIT test.

RESULTS: Our preliminary results showed a generally reduced gain in the preoperative phase and an increase in the postoperative gain, detectable already at the first check-up.

CONCLUSIONS: Firstly, it is conceivable that the chemical-physical variations of the CSF attributable to hydrocephalus and the subsequent variations induced following the peritoneal derivation can induce variations in the pressure and in the composition of the endolymph with consequent repercussions on the canal function. This data confirms the importance of the infusion test in the diagnosis of patients with normal pressure hydrocephalus.

MFI11 AS A PREDICTOR OF POST-OPERATIVE INFECTIONS IN VENTRICULO-PERITONEAL SHUNT SURGERY

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INTRODUCTION: This study aimed to investigate the correlation between the modified frailty index (mFI11) and the rate of postoperative infectious complications in patients with hydrocephalus who underwent ventriculoperitoneal shunt (VPS) placement.

METHODS: We conducted a retrospective analysis of 367 consecutive patients with normal pressure or hydrocephalus who underwent VPS placement at our center between 2015 and 2022. Descriptive statistics were used to characterize the study population, and the correlation between mFI11 and the incidence of postoperative infectious complications was assessed using logistic regression analysis. The effects of age, surgical time, and diagnosis were also examined.

RESULTS: Of the 367 patients, 360 did not experience any postoperative infectious complications, whereas 7 did (1.9%). The mean mFI11 score was significantly higher in patients who experienced postoperative infectious complications (mean 3, SD 1.7) compared to those who did not (mean 1.3, SD 1.2) ($F=12.353$, $p<0.01$). In the multivariate logistic regression analysis, mFI11 was found to be a significant predictor of postoperative infectious complications (OR=2.18, 95% CI: 1.45-3.27, $p<0.01$), while age, surgical time, and diagnosis were not.

CONCLUSIONS: Our study suggests that mFI11 is a valuable tool for predicting the incidence of postoperative infectious complications in patients who undergo VPS placement. It appears that mFI11 is a more important predictor than age, surgical time, or diagnosis in this regard. Further studies are needed to validate these findings and to determine if interventions to improve frailty may decrease the risk of postoperative infections in this patient population.

CALLOSAL ANGLE IS MORE USEFUL THAN EVANS INDEX FOR POSTOPERATIVE FOLLOW-UP OF NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: When symptoms that had once improved after shunt surgery worsen again in iNPH patients, it is difficult to determine whether the cause is due to shunt dysfunction, progression of comorbidities, or development of a new disease. We examined the image findings of head CT or MRI to find shunt dysfunction more efficiently, based on changes in postoperative image findings and actual cases of shunt dysfunction.

METHODS: From 2020 to 2021, 66 patients diagnosed with iNPH underwent shunt surgery at our hospital. Forty-five patients were included in the study, excluding eleven patients who were unable to evaluate neurological symptoms and MRI at 6 months after surgery. Before the tap test and 6 months after the shunt operation, Timed Up & Go Test (TUG), Evans index, and the callosal angle were evaluated. Those changes were also evaluated in a shunt malfunction case.

RESULTS: TUG showed significant improvement overall, but slight change in mild cases. There was also a significant decrease in the Evans index, but the amount of change was less than 1% in 47% of the cases. There was also a significant distinct angular enlargement of the callosal angle, with an average difference of 18.6 degrees. The change of callosal angle was also distinct in a shunt malfunction case.

CONCLUSIONS: The change in callosal angle was more obvious at postoperative follow-up. It was suggested that focusing on the callosal angle may make it easier to notice shunt malfunction.

NON-INVASIVE P2/P1 RATIO ANALYSIS AS A POTENTIAL AUXILIARY DIAGNOSTIC A ND FOLLOW-UP CRITERION FOR NORMAL PRESSURE HYDROCEPHALUS IN PATIENTS UNDERGOING VENTRICULOPERITONEAL SHUNT SURGERY

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INTRODUCTION: Normal Pressure Hydrocephalus (NPH) is a condition characterized by changes in intracranial compliance. Ventriculoperitoneal shunt (VPS) surgery is a common treatment for NPH, which involves the insertion of a shunt to drain excess cerebrospinal fluid. The present study aims to assess the performance of the P2/P1 ratio of the intracranial pressure waveform, obtained through a non-invasive device, as a diagnostic criterion for NPH in patients undergoing VPS surgery.

METHODS: Seven patients with NPH were included in this study and were evaluated using the P2/P1 ratio before and after VPS surgery. The non-invasive evaluation of intracranial compliance was performed in the lying, sitting or 30 degrees inclination and upright positions, and the P2/P1 ratio was evaluated pre- and post-surgery.

RESULTS: Most patients showed higher P2/P1 ratios, higher TTP, smaller number of valid waveforms and a worse confidence interval before shunt surgery, with improvement of parameters correlating with symptom improvement, as well as initial symptoms. The lying position seems to be more consistent in showing highest P2/P1 values, especially in the post-shunt monitorization sessions.

CONCLUSIONS: The present study suggests that the P2/P1 ratio may be a valid non-invasive diagnostic and follow-up criterion for NPH, as well as a helpful adjunct for shunt pressure adjustment. Although differences in before and after shunt was found, optimization of monitorization routines is still necessary so that potential cut-off values can be found . Larger studies and clinical trials are required to further understand the diagnostic and follow-up potential of non-invasive waveform analysis for the diagnosis of NPH.

DO EVANS INDEX AND CALLOSAL ANGLE CORRELATE WITH NEUROLOGICAL IMPROVEMENT AFTER SHUNT SURGERY IN IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS?

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INTRODUCTION: Idiopathic normal pressure hydrocephalus (iNPH) is a syndrome characterized by gait disturbance, cognitive impairment, and urinary incontinence, affecting mainly the elderly. Although Evans index (EI) and callosal angle (CA) are important radiological markers for its diagnosis, little is known about their changes after ventriculoperitoneal shunt (VPS) surgery among these patients. Here we aim to investigate whether EI and CA change after VPS and if these differences correlate with clinical symptoms.

METHODS: A prospective cohort of iNPH patients treated with Sphera Proâ programmable valve was followed for one year. Clinical improvement, measured by NPH Japanese Scale, EI and CA, measured by CT or MRI, were registered and compared pre- and postoperatively (3, 6 and 12 months).

RESULTS: A total of 19 patients with probable iNPH were prospectively recruited. NPH Japanese Scale decreased over time ($p<0.001$) from 6.0 (±2.0) preoperatively to 4.4 (±2.6), 4.0 (±2.2) and 4.1 (±2.2), 3, 6 and 12 months postoperatively (respectively) . CA was smaller (72±15°) preoperatively than postoperatively: 72±15° in 3, 91±18° in 6 and 91±18° in 12 months after surgery, $p< 0.01$. EI did not change with surgery ($p=0.495$): 0.34 (±0.04) preoperatively, 0.34 ±0.02 in 3, 0.33 ±0.03 in 6 and 0.33± 0.04 in 12 months after VPS.

CONCLUSIONS: In this sample, EI did not change after surgery, and clinical improvement of NPH symptoms occurred concurrently with an increase in CA value. This indicates that CA value could be evaluated further as an indirect method to determine response to treatment and shunt function in patients with iNPH.

DEVELOPMENT OF WEB-APPS FOR CALCULATING EVANS INDEX, INPH RADSCALE, INPH SCALE, ETVSS

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INTRODUCTION: Surgeons and physicians managing patients with hydrocephalus and in particular complex or normal pressure hydrocephalus often use Evans' Index, iNPH Radscale, iNPH scale ETVSS. A calculator for these scales on the web would be useful and efficient in undertaking these calculations. Traditionally web-app development had required information technology (IT) specialists with expertise in this area. The aim of the project was for neurosurgeons to develop these web-apps without help from IT specialists.

METHODS: Two software were used for web-app development. They were Xojo and Notepad (for javascipt). The Evans Index, iNPH RadScale and iNPH scale calculators were developed with Xojo developer software. The developed software were deployed onto Xojocloud server. NotePad was used to write the code in Javascipt for the ETVSS score. The Javascipt was then published on the web using Adobe Dreamweaver software on a web-host.

RESULTS: The Evans' Index, iNPH Radscale, iNPH scale were successfully developed with Xojo and deployed in Xojocloud. The ETVSS calculator was successfully developed and deployed on a web-host. The development using Xojo and Xojo cloud is convenient, and the resultant app is appealing but, relatively expensive. The development of web-software with Javascipt has a more steeper learning curve but is economical. The web-apps can be accessed from https://neuro1.xojocloud.net

CONCLUSIONS: Web-apps useful for physicians involved in the management of complex hydrocephalus can be developed by physicians themselves using user friend software development platforms.

IS THE VALVE REALLY NECESSARY IN PATIENTS WITH NORMAL PRESSURE HYDROCEPHALUS? LOWERING THE OPENING PRESSURE TO ZERO - A PROSPECTIVE SINGLE CENTER OBSERVATIONAL STUDY.

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INTRODUCTION: Normal pressure hydrocephalus (NPH) is a chronic progressive disease that, despite surgical treatment by ventriculoperitoneal shunt placement with consequent improvement in clinical condition, shows an inherent tendency toward deterioration within years after initial treatment. The question of this study is whether switching the valve setting below 5 cm H2O, even reducing it to zero, could delay or limit the progression of the disease.

METHODS: In our prospective single center observational study we enrolled patients with NPH who underwent valve adjustment below 5 cm H2O (range 3 - 0 cm H2O) opening pressure. This was conducted in 26 patients between 2011 and 2021, of whom 22 (84.6%) were idiopathic and 4 (15.4%) were secondary NPH-patients. Changes in the valve setting occurred after initial improvement post shunt implantation and secondary deterioration several years later.

RESULTS: We observed an improvement in the clinical condition in 12 cases (46.2%). As an improvement we counted the lowering of the Kiefer score. No difference was seen in 9 cases (34.6%) and a worsening (any increase in Kiefer score) in 5 cases (19.2%). The small subdural effusions, which were found in a total of 6 cases, showed a complete regression in the further course only by the reincrease of the valve opening pressure. No surgical intervention was required. Out of the 12 patients with improvement, 6 patients improved permanently until the end of the observation period. 6 patients worsened again after a median time of 18 months following valve adjustment.

CONCLUSIONS: Our study proves that lowering the valve opening pressure below 5 cm H2O, even reducing it to zero, in patients with NPH is safe and provides the chance for further clinical improvement in about half of the patients.

VERIFICATION OF THE STROOP TEST APPLICATION SOFTWARE FOR PATIENTS OF IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: The cognitive deterioration of iNPH includes memory impairment, frontal lobe dysfunction, psychomotor slowing, and attention deficits. Hellström's EU-iNPH grading scale thoroughly includes neuropsychological tests that measure all these aspects. We have previously reported that the Stroop test (color naming and interference tasks) which targets psychomotor speed and executive function, was valid in detecting comorbidity of iNPH such as Alzheimer's disease or Parkinson's spectrum (PS) diseases. However, neuropsychological tests are time-consuming and could become a burden for both patients and examiners. This study aims to evaluate and compare the clinical application of a newly created Stroop test Application Software to the Hellström's Swedish Stroop test.

METHODS: The Application Software (Hacaro-Stroop test) that includes 20 items for each task was applied for testing on a tablet device. Patients diagnosed with iNPH at the Juntendo University Hospitals participated. In Study-1, a relationship between the two test methods was evaluated on 92 patients using correlation analysis. In Study-2, the prognostic value of the tap-test results from the Application Software were analyzed in 30 patients who underwent both tap-test and CSF shunt surgery through correlation analysis and ROC analysis.

RESULTS: In Study-1, the Swedish Stroop Test and the Application Software had a strong correlation, especially in the color naming task ($r=0.77$, $p<.001$). In Study-2, applying the Application Software, there was a strong correlation between the result of the tap test and the CSF shunting outcome from the color naming task ($r=0.75$, $p<.001$). The ROC analysis indicated that improvement after the CSF shunting could be predicted by the tap test result (AUC=.76, p=.02, cut-off=1.9, Sensitivity=.70, Specificity=.70).

CONCLUSIONS: The Application Software was successful in shortening the time taken for the test compared to the Swedish Stroop Test. The Application Software may be useful in the pre-tap test evaluation as a substitute for the Swedish Stroop Test.

EVALUATION OF NON-INVASIVE ICP WAVEFORM AND INTRACRANIAL COMPLIANCE MONITORING TECHNOLOGY IN A PEDIATRIC NEUROSURGICAL OUTPATIENT CLINIC

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INTRODUCTION: Diagnosis and follow-up of neurosurgical patients is often challenging, particularly for children. This is a preliminary work of incorporating a non-invasive tool for monitoring the intracranial pressure waveform (nICPw) and therefore estimate intracranial compliance (IC). The study was conducted with 20 patients from the pediatric outpatient neurosurgical clinic at the São Paulo Hospital and Universidade Federal de São Paulo.

METHODS: The study was observational and conducted blindly, without physicians evaluating the relationship between the new monitoring results, symptoms and the outcome of procedures performed. The indicators used were consistency between the result obtained with non-invasive IC monitoring, symptoms and procedural results. The brain4care sensor was positioned in the frontotemporal region and the data were automatically analyzed by the company's system. In total, 20 patients were monitored before and after surgical procedures. All patients had hydrocephalus or other pathologies that, similarly, increase intracranial pressure. Out of this total 12 patients had hydrocephalus, 5 had arachnoid cysts, 1 had pseudotumor cerebri, 1 had an intradural lipoma and one had craniosynostosis. The results obtained were later compared with the clinical findings.

RESULTS: The results showed a level of agreement of 94% with the symptoms and 75% with the results obtained after medical procedures through medical evaluation.

CONCLUSIONS: We conclude that the device may serve as an adjunct diagnostic method for several pathologies that cause increase of intracranial pressure, including hydrocephalus. It may be valuable for evaluating these patients both in immediate as well as long-term follow-up, as it allows for baseline measures of the nICPw. More studies with larger populations and optimized monitorization routines are required to better understand the added value of the method.

WHAT CAN THE PREVALENCE OF PEDIATRIC HYDROCEPHALUS IN COLOMBIA - AN UPPER-MIDDLE-INCOME SOUTH-AMERICAN COUNTRY - TELL US?

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INTRODUCTION: Pediatric hydrocephalus is a common yet complex condition, in which late diagnosis can cause irreversible sequelae. Prevalence worldwide is estimated to be around 88/100,000, but literature suggests it's higher in developing countries, where postinfectious etiologies predominate. Incidence has been found to be inversely associated with a country's income level. South America is among the regions considered most affected by this disease, but very few recent prevalence studies exist. This is the first prevalence study of pediatric hydrocephalus in Colombia, an upper-middle-income country.

METHODS: This study aimed to estimate the prevalence of pediatric hydrocephalus (ages 0 to 17) in Colombia between 2017 and 2022, and determine its etiologic distribution. A search of the public System of Integrated Information of Social Protection was performed, using ICD-10 codes to extract Individual Registries for Provision of Health Services, and compared these data to the population registries of the National Department of Statistics.

RESULTS: We found a nationwide prevalence of 57.2/100,000. 55% of cases were male. Postinfectious etiologies accounted for 24.9% of cases, CNS malformations for 9.9%, posttraumatic 0.3%, and neoplastic 0.3%; in most cases, the etiology was not reported. The underreporting rate was calculated at 31%.

CONCLUSION: In this study, the estimated prevalence of pediatric hydrocephalus in Colombia was lower than the prevalence estimated worldwide, and lower even than that estimated for high-income areas. This is explained in part by an important rate of underreporting; however, even accounting for the underreporting, the prevalence remains lower than worldwide estimates and considerably lower than that estimated for South America. This may speak to a trend of decreasing prevalence in developing countries whose economies have grown in recent years. These findings can guide public policy for adequate surveillance and prevention of pediatric hydrocephalus in Colombia, and highlight the importance for further updated research in the region.

EPILEPSY IN HYDROCEPHALUS PATIENTS

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INTRODUCTION: Epilepsy is not a typical symptom of hydrocephalus but can be associated with hydrocephalus and complication of its treatment. Hydrocephalus may be the consequence of wide variety of congenital and acquired disease affecting brain. It commonly requires surgical treatment, which in turn places the patient at risk for a variety of mechanical and infectious complication. The causes of hydrocephalus, treatment, and the complication of treatment are all potential instigators of epilepsy. Furthermore, the onset of epilepsy may precede, coincide with, or follow the onset of hydrocephalus.

METHODS: 347 patients were enrolled retrospectively who underwent surgical treatment of hydrocephalus in three different hospitals from January 2018 to January 2020 which were identified by file search of diagnosis and treatment. 43 of them had seizures. The date of the first shunt surgery and subsequent revision (if present), cause of hydrocephalus, age of the patients and the site of burr hole were recorded.

RESULTS: 9 patients had epilepsy as one of the presenting features preoperatively. 34 patients developed epilepsy following surgery: either single surgery or after revisions of failed shunt surgery Out of the 347 patients, 87 patients had to have revisions. Out of these 87 patients, 29 developed postoperative epilepsy; while out of the patients with single surgery (260) only 5 had postoperative epilepsy. Out of the 260 patients, 96 patients had frontal burr hole and of these, epilepsy developed in 4 patients. Out of the 260 patients, 164 patients had parietal burr hole and of these, only one patient developed epilepsy. About the age distribution, out of the 347 patients: 262 patients were under 20 years old. Out of the 262 patients, 38 patients developed epilepsy.

CONCLUSIONS: The risk of development of seizures in hydrocephalus patients is associated with shunt revision, age of the patient and site of burr hole.

POLYVINYLPYRROLIDONE-COATED VENTRICULAR CATHETER DID NOT SHOW CELLULAR IMMUNOREACTION OR ADHESION IN CHOROID PLEXUS OBSTRUCTION

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INTRODUCTION: Ventricular shunting is the primary treatment of hydrocephalus. However, it has an unacceptably high rate of failure, with obstruction of the ventricular catheter as the leading cause of failure in pediatric patients. It is speculated that the catheter itself can induce an immune response cascade that triggers obstruction of the device. The richly vascular choroid plexus may play an active role in this immune response and is one of the primary causes of proximal catheter obstruction.

METHODS: The case described herein is a patient with a functionally obstructed Polyvinylpyrrolidone-coated (PVP) catheter by in-growth of choroid plexus. It was explanted during shunt revision and analyzed for cellular occlusion as well as catheter pressure and flow in a ventricular simulator.

RESULTS: There was no immunological response, and no fibrosis or macrophages detected as are generally seen in catheter obstructions from other materials. However, the choroid plexus was shown to obstruct the PVP proximal catheter without immune response, via a lattice of intertwined choroid plexus tissue drawn through individual catheter holes. Pressure differential across the catheter was elevated up to 15cm H2O in order to sustain flow rate.

CONCLUSIONS: The catheter immunological response has thought to be partially responsible for ventricular catheter malfunction but the PVP catheter did not induce cellular attachment or immune response in the brain. Catheter obstruction was from choroid plexus ingrowth instead. This report provides new insights to help design new catheters with non-immunogenic materials and different hole size and configuration to avoid fibrotic ingrowth into the catheter and avoid catheter obstruction.

TRAUMATIC STRESS AND SHUNT FAILURE: A LINK BETWEEN PSYCHOLOGY AND INFLAMMATION

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INTRODUCTION: Children with hydrocephalus have been shown to exhibit elevated levels of post-traumatic stress symptoms. Similarly, inflammatory material such as microglia and astrocytes have been shown to cause ventricular catheter obstruction. Finally, it is known that psychological stress can lead to microglial activation. This study tests the hypothesis that psychological stress is linked to shunt failure via a mechanism of inflammatory material causing shunt obstruction.

METHODS: Children ages 8-17y, undergoing surgery for shunt failure completed the Acute Stress Checklist (ASC-Kids) during hospital admission. Ventricular catheters removed during shunt revision were examined. Immunofluorescence was performed to determine the total cell count, number of astrocytes and microglia, and the proliferation of these cells. Three holes (chosen randomly) were imaged using a resonant scanning confocal microscope on every side of each catheter. Average values per hole were reported for normalization across samples with varying hole number, knowing that large deviations can occur within each sample. Total cells, proliferating cells, number of astrocytes and microglia were calculated and then tested for correlation with ASC-Kid scores using Pearson correlation.

RESULTS: 12 catheters were analyzed. Mean patient age was 12 years; 11 male, 2 female. Mean ASC-Kid score was 13.4 (SD 6.3). Mean cells per catheter hole was 501 (SD 518). Mean number of proliferating cells was 21 (SD 42). Mean number of astrocytes and microglia was 3.1 and 8.1, respectively (SD 3.7 and 12.0). No significant ($P<0.05$) correlations were seen between cell counts and ASC-Kid scores. The strongest observed relationships were between ASC score and number of proliferating cells (Pearson coeff. 0.52, $p=0.081$) and number of astrocytes (Pearson coeff. -0.57, $p=0.054$).

CONCLUSIONS: No definitive correlation is seen between traumatic stress symptom scores and cellular material averages in ventricular catheters in this initial analysis. Larger sample and testing of catheters after serial shunt revisions is planned.

TIME COURSE AND CLINICAL PRESENTATION VARIANTS FOR CEREBROSPINAL FLUID DIVERSION DEVICE FAILURE IN SLIT VENTRICLE SYNDROME. AN OBSERVATIONAL STUDY WITH 5 YEARS FOLLOW UP

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INTRODUCTION: Prolonged over-drainage of the CSF can lead to slit ventricle syndrome that would cause multiple shunt obstructions. In this study, we present the variants of the clinical manifestations that can denote shunt obstruction and needs urgent intervention.

METHODS: we retrospectively collected all clinical data of 6 successive cases that sought medical advice in the outpatient clinic during 2018 that suffered from slit ventricles due to ventriculoperitoneal shunt and started to observe the shunt obstruction episodes and the clinical presentation of such cases.

RESULTS: the most common presentation was Projectile vomiting. History of ventriculitis and infection occurred in 2 out of the 6 cases with 4 cases free of any history of CNS infection. Clinical manifestations for failure varied in time course (escalating in one hour in one case , or two weeks. Incidence of shunt obstruction episodes were 3 times during the follow up period of 5 years. In all cases, proximal obstruction was the cause of failure, with only one case with shunt infection due to reservoir exposure. In two episodes in two different cases, the shunt obstruction episode was temporary, and resolved without the need for shunt revision. 5 of the 6 cases are doing well in education with accepted intellectual functions.

CONCLUSION: Slit ventricle syndrome is a critical condition that needs vast experience in congenital hydrocephalus, where the clinical signs are the most reliable to diagnose obstruction and proceed for surgical intervention.

SHIFT OF BLOOD AND CSF VOLUME BETWEEN THE INTRACRANIAL AND INTRASPINAL COMPARTMENTS DURING POSITIONAL CHANGE

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INTRODUCTION: Compliance is a characteristic of the volume-pressure relation of the CSF system. With volume injections into the CSF space and concomitant pressure measurement, craniospinal compliance is determined. Separate compartments have their own respective compliance, which add up to the total: Intracranial CSF space compliance as a function of arterial and venous compartments, elasticity of the skull, and flexibility of the dura near the foramina. Intraspinal CSF space compliance as a function of intraspinal arterial and venous compartments, elasticity of the thecal sac, and elasticity of the vertebrae. The individual contributions of intracranial and intraspinal CSF space compliance appear characteristically changed in certain disorders, but there is no agreement on the relative contributions and quantitative changes with disease. One approach for probing changes in compliance distribution is tilt testing, which produces fluid shifts between intracranial and intraspinal compartments. However, dynamic measurement of blood and CSF volume redistribution is technically challenging.

METHODS: We applied a recently developed method for capacitive measurement of dielectric properties of the head to healthy volunteers during body position changes. The measured signal was found to provide information on the intracranial blood-CSF relationship.

RESULTS: Pilot data from three healthy volunteers show a decrease of the signal with head-up tilting at angles up to 45°. At larger tilt angles, no further signal decrease was observed.

CONCLUSIONS: We attribute the decrease of the signal at small tilt angles to a downward shift of blood, which is enabled by the open venous compartment with outflow towards the right heart. At larger angles, the collapse of the jugular veins prevents further shift of blood. Since no comparable mechanism exists for CSF, a spinal shift of CSF occurs.

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VOLUME CHANGES IN CEREBRAL VASCULAR AND CSF COMPARTMENTS IN HYDROCEPHALUS PATIENTS

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INTRODUCTION: While active reversible hydrocephalus (ARH) is usually associated with a cerebrospinal fluid (CSF) flow disorder, other factors, such as the arterial and venous compartments and the system's compliance, may also contribute to its pathophysiology. During the short time of the cardiac cycle, CSF and venous volumes must flush out of the cranium to balance the arterial blood expansion. This study aims to estimate how CSF and venous blood flows respond to rapid systolic cerebral arterial inflow in suspected ARH patients.

METHODS: Thirty patients (72±8 years) with suspected ARH were classified, by the value of resistance to CSF outflow (Rout), as suitable (ARH+: n=14, 74±6 years) or unsuitable (ARH-: n=16, 71±9 years) candidates for shunting. All patients underwent phase-contrast MRI to quantify arterial, venous, and CSF flows. We calculated the arteriovenous volume change during the cardiac cycle from cerebral arterial and venous flows measured at the intracranial (Vvasc,i) and extracranial levels (Vvasc,e). Additionally, we calculated a vascular volume ratio (VRvasc) between these two levels as: VRvasc=Vvasc,i/Vvasc,e. From the CSF acquisitions, CSF stroke volumes were calculated through the pontine cistern (SVpc), the aqueduct (SVaq), and the spinal canal at the C2-C3 level (SVc2c3). Similarly, a CSF volume ratio (VRcsf) between intracranial and spinal compartments was calculated as: VRcsf=(SVpc+SVaq)/(SVc2c3).

RESULTS: Individually, volume changes in vascular (Vvasc,i=0.76±0.2; Vvasc,e=1.05±0.4 ml) and CSF (SVpc=0.36±0.2; SVaq=0.18±0.1; SVc2c3=0.5±0.2 ml) compartments were not significantly different between the groups. Similar for VRvasc (ARH-: 0.94±0.4 vs. ARH+: 0.74±0.1). However, interestingly, VRcsf (ARH-: 0.75±0.4 vs. ARH+: 1.17±0.5) were significantly different between the groups.

CONCLUSIONS: These findings highlight the system's complexity since a constant interplay exists between the three main neuro-fluids dependent on arterial inflow. These interactions are variable within the population, which explains the lack of consensus in several proposed parameters where the neuro-fluids are generally studied individually, rather than globally.

ANALYSIS OF TRANSCRANIAL DOPPLER PULSE WAVEFORMS IN THE DIAGNOSIS OF HYDROCEPHALUS

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INTRODUCTION: Normal pressure hydrocephalus (NPH) is associated with alterations in cerebrospinal fluid circulation but often with reduced cerebral blood flow (CBF). It has been suggested that the shape of cardiac-induced cerebral arterial blood volume (CaBV) pulse waveform measured with ultrasound-based method may be altered in NPH patients. In this study we aim to compare the morphology of CaBV pulse waveforms estimated based on transcranial Doppler blood flow velocity (TCDFV) in groups of healthy volunteers and NPH patients.

METHODS: TCDFV signal recorded in NPH patients and healthy individuals at rest and the global CBF model were used to assess the CaBV pulse waveforms. A total of 27 quantitative parameters were proposed to describe the shape of the CaBV pulse waveform. All parameters were compared between NPH patients and healthy volunteers with the U Mann-Whitney test. A decision tree classifier was applied to choose the most prominent parameter for NPH vs. healthy volunteer classification. The accuracy of the predictor was assessed by the area under the receiver operating characteristic curve (AUC).

RESULTS: CaBV pulses from 31 patients diagnosed with NPH (age: 59 years (IQR: 47-67 years), 14 females) and from 23 healthy volunteers (age: 54 years (IQR: 43-61 years), 18 females) were compared. There was no difference in age between these two groups. 18 of the 27 shape-related parameters were different between healthy individuals and NPH patients ($p < 0.05$). The most significant differences were found for the ascending slope of the CaBV pulse with the AUC of 0.87 (95% confidence interval: 0.77-0.97, $p < 0.001$), suggesting that in hydrocephalus arterial bed filling is generally faster than in volunteers.

CONCLUSIONS: The results suggest that the shape of the CaBV pulse waveform is altered in NPH patients. Usefulness of CaBV pulse shape analysis in NPH diagnosis needs to be confirmed in prospective study.

PULSATILITY AND CSF FLOW RESISTANCE IN PATIENTS WITH SUSPECTED IDIOPATHIC HYDROCEPHALUS

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INTRODUCTION: In 2022, the hydrocephalus conference discussed the existence of different potential subtypes of normal pressure hydrocephalus based on disturbances of CSF dynamics. Infusion studies can calculate alterations in CSF outflow resistance (Rout) and PC-MRI can determine alterations in CSF pulsatility. Within the REVERT project, we combined data from infusion tests with the measurement of CSF flows. The objective of this work is to highlight specific groups of alterations in CSF flow and ICP parameters to propose different classifications of CSF dynamics.

METHODS: 54 patients (73±7 years) with suspected active reversible hydrocephalus (ARH) presenting with the symptoms of Hakim's triad underwent PC-MRI to study CSF cardiac oscillations. Aqueductal CSF and spinal CSF stroke volumes were determined from PC-MRI and combined with Rout calculated from infusion tests. Normal ranges for aqueductal and spinal CSF stroke volumes were between 35 and 115 microliters and 300 and 700 microliters respectively. The cut-off for elevated Rout was taken as 12mmHg/(ml/min). We defined 9 classes function of CSF flows level, and combined this with values for Rout.

RESULTS: The majority of patients had an elevated aqueductal SV relative to spinal SV (Class 1, 2, and 4; 31/54; 57%), of which 19 (61%) had an elevated Rout. Out of 11 patients with normal SVs (Class 5), 5 (45%) had an elevated Rout. Only 3 patients had an elevated spinal SV relative to aqueductal SV (Class 6, 8, 9), of which 1 had an elevated Rout.

CONCLUSIONS: The distribution of elevated Rout amongst the CSF pulsatility classes does not seem to follow any particular pattern from our findings. Rout appears to be independent of CSF cardiac oscillations. This confirms the value of these two methods, which may independently describe pathophysiology of hydrocephalus. Both PC-MRI and infusion test may contribute to improved diagnosis and treatment of hydrocephalus patients.

TWO HTRA1-RELATED AUTOSOMAL DOMINANT CEREBRAL SMALL VESSEL DISEASE COMBINED NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: Cerebral autosomal recessive arteriopathy (CARASIL) is a hereditary cerebral small vessel disease (CSVD) caused by biallelic mutations in high-temperature requirement A serine peptidase 1 (HTRA1). However, heterozygous HTRA1 mutations are recently identified to be associated with autosomal dominant CSVD.
There are also some overlaps in clinical and imaging features between CSVD and normal pressure hydrocephalus (NPH). However, the relationship between the two diseases is rarely studied.

CASE REPORTS: We herein report two rare cases with genetically confirmed heterozygous missense variant in HTRA1.They also presented with the clinical features and laboratory results of NPH. After CSF tap test or shunt surgery, the two patients both improved by subjective and objective evaluation.

KEYWORDS: CARASIL, HTRA1, epilepsy, CSVD, NPH

ASSESSING THE RELATIONSHIP BETWEEN VENTRICULAR CATHETER OBSTRUCTION AND FLOW USING COMPUTATIONAL FLUID DYNAMICS AND A MULTICENTER CLINICAL BIOBANK

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INTRODUCTION: Obstruction of flow through the ventricular catheter (VC) is a major contributor to shunt failure. The landmark study by Lin et al. analyzed flow characteristics in VCs using a 2D simulation paired with benchtop experiments on explanted VCs. Expanding on this, Galarza et al. (2014) modeled 3D flow through VC designs and suggested that equal flow across the VC holes would reduce the probability of obstruction. However, a relationship between flow through the VC holes and their obstruction remains to be established. We hypothesized that a higher flow rate through the VC holes would correlate with more significant obstruction. To test this hypothesis, we used computational fluid dynamics to model flow through VCs placed inside the ventricles and compared the flow patterns through the holes with the degree of obstruction in 208 failed VCs from our multicenter clinical biobank of failed VC catheters.

METHODS: Enlarged lateral ventricles were extracted from MRIs to create computational 3D renders. Physiological boundary conditions were placed at the choroid plexus and catheter outlet and flow parameters, were quantified in the catheter drainage holes. A map of VC obstructions was generated using brightfield imaging. Flow distribution in the drainage holes of VCs were compared to distribution of obstructions in VCs collected from five centers.

RESULTS: Preliminary data suggest that the mass flow rate through the VC holes follows a consistent distribution pattern from proximal towards the distal end, regardless of ventricular volume and surgical approach. The flow distribution pattern in our simulations matches the pattern of VC obstruction in 90 of 208 cases and not in 118 cases.

CONCLUSIONS: Preliminary data suggests that our simulations can represent flow through the VC, and flow distribution correlates with obstructions in a subset of catheters. Flow rate through the VC holes does not solely dictate degree of obstruction.

SHUNTING IN NORMAL PRESSURE HYDROCEPHALUS: ARE WE REACHING THEIR FULL POTENTIAL?

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INTRODUCTION: Shunting is the mainstay of treatment for normal pressure hydrocephalus. The maximum potential of improvement in gait after VP shunt is not well understood. We aimed to assess if post extended lumbar drainage walking test should be used as a benchmark to guide shunt valve adjustments in the post operative period.

METHODS: Single centre, retrospective case series of patients undergoing ventriculoperitoneal (VP) shunt for normal pressure hydrocephalus over a 2-year period from 2019-2021. Patients were included who had undergone extended lumbar drainage investigation, with subsequent insertion of a VP shunt and had shown objective improvement on follow up 10m walking tests. Patients without documented 10m walking tests on follow up were excluded.

RESULTS: 23 patients were included, 87% were male with an average age of 76 years. All patient's had gait disturbance prior to shunting and 43% suffered from Hakim's triad. At follow up after VP shunt, 15/23 (65%) of patients achieved greater walking test speeds than the post extended lumbar drainage walking speed. Of these patients 73% of patients achieved this at their first follow up, 20% at second follow up and 7% achieved at their fourth follow up. For those that did not reach the post extended lumbar drain walking speed at their first follow up, reduction in shunt valve settings was utilised in all patients to achieve this. 8/23 (35%) did not achieve post extended lumbar drain walking speed at follow up. This was not achieved despite reduction in shunt valve settings in 7/8 patients.

CONCLUSIONS: The majority of patients with NPH who have undergone VP shunt achieve improvement in their gait that is better than after extended lumbar drainage. For those that do not achieve it, shunt valve adjustments are recommended to target greater than the post extended lumbar drainage walking test results.

THE IMPORTANCE OF HYDROSTATIC COMPENSATION IN LUMBOPERITONEAL SHUNTS IN HYDROCEPHALUS COMMUNICANS.

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INTRODUCTION: The use of lumboperitoneal shunts (LPS) has increased expressively in the last decade, especially in Japan and extensive clinical experience is available. The rise in publication since 1999 reflects and highlights the increasing use of LPS. But recent publications still state the siphoning effect in an LPS is negligible, as the lumbar exit and peritoneal entry for LPS are generally at the same level when patients are upright (Ho et al 2023, Miyake 2016). But as Mirone et al (2019) state LPS may cause similar posture-related problems.

METHODS: The aim of the work is a contribution to the difference between ventriculoperitoneal (VP) and lumboperitoneal (LP) shunts as long-term implants. The flow along the two systems is entirely different when the patient is in vertical position. There is a reversal of flow with different compliance in cranial and spinal derivation. So what is important from clinical perspective?

RESULTS: From an engineering point of view hydrostatic compensation is in LP-shunts as important as it is in VP-shunts. Accordingly Nakajima et al (2018) confirmed good outcomes with the use of gravitational valves (GV) in LPS and stated "outcomes were improved in the LPS group with the GV".

CONCLUSIONS: Although recent studies conclude "LP shunt surgery is equally as effective as the VP shunt surgery" (Wang et al 2019), LPS "might be beneficial" (Kazui et al 2015) or could be "the treatment of choice because of its minimal invasiveness" (Miyajima et al 2016), a broader understanding regarding hydrostatic forces and hydrodynamics in LPS is needed. Moreover, more clinical research is desirable regarding the need of a compensation of the siphoning effect in LPS.

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CRANIOMETRIC POINTS FOR VENTRICULAR ACCESS, ANALYTICAL STUDY BETWEEN HISTORY AND CURRENT TRENDS

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INTRODUCTION: Various Indications are present to gain ventricular access before, during, or after certain neurosurgical procedures. In accordance to the variable pathologies, multiple acess points have been designed.

METHODS: Gathering of data of ventricular access steps during the operative management through the past two years in the current institute. Analysis of the role of navigation, years of experience , and wrong implantation of the ventricular catheter has been performed.

RESULTS: The ventricle was accessed through 5 different access points in 350 successive cases. The incidence of malposition or tapping failure was 10 %. Years of experience was a good prognostic factor for well positioning while neuronavigation, intra operative ultrasound were secondly beneficial.

CONCLUSION: Well orientation of all possible access points for the cereberal ventricles is a mandatory in th neurosurgical practice. Choice of the access point needs well orientation with thee current pathology, postoperative consequences, and the anatomical features.

IMPACT OF GLOBAL WARMING ON BRAIN TEMPERATURE

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INTRODUCTION: The direct impact of global warming on human brain temperature, behaviour and disease burden was studied in the National Hospital for Neurology and Neurosurgery from June 2022 onwards.

METHODS: In this single-centre prospective-observational study, data was collected from patients with an indwelling M.Scio-ventricular-shunt-sensor-reservoir for various illnesses, as out-patient clinic appointments during summers. Demographic data, past medical history, history of incidents of ill health/relapses requiring medical assistance, history of medication, neurological assessment and baseline vitals were recorded. Only healthy patients with no acute illness were included. The temperature, humidity and carbon-dioxide(CO_2) concentration of the clinic-room was recorded using HOBO-MX-CO_2-data logger . The brain temperature and ICP were recorded in lying, sitting and standing positions using M.Scio-ventricular-shunt-sensor-reader unit. Patients were asked survey questions focusing on subjective feelings of wellness, heat-tolerance, noticeable behaviour changes and objective incidents of illness requiring medical attention. Same patients were seen again during winters and same measurements were repeated. Results were compared for the different seasons in individual patients. Comparison of two groups of patients(rise in brain temperature vs maintained core-brain temperature) was done by two sample t-test using SPSS(version25.0, IBM).

RESULTS: After exclusions, brain temperature was measured in 54 patients during both seasons. Room temperature during summers(average 27.5–29.5°C), was an average 2-3°C higher than during winter(average24.5-26.5°C). Room humidity and CO_2-concentration were comparable in both seasons. 34 patients had an increase in brain temperature of 0.7-2°C during summer as compared to winter($p<0.0001$). The average ICP was higher in all individuals during summer(average 2-6mmHg). Patients cohort depicting rise in brain temperature with environmental temperature also had >3 incidents of ill-health/disease-relapse/hospital admissions during summers and rise in anger/aggression.

CONCLUSION: Global warming is likely to have a direct effect on human brain temperature and the presentation of neurological diseases. Validation of the results is required in larger cohorts.

MACHINE LEARNING-LED EXPLORATION OF IMAGING BIOMARKERS DISTINGUISHING NPH VS. CONTROLS: PILOT AND TEST PERTURBATIONS REVEAL THE ROBUSTNESS OF FEATURE EXTRACTION

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INTRODUCTION: In normal pressure hydrocephalus, NPH, contradictory results in radiological biomarkers reflect concurrent but conflicting changes occurring in brain tissues in response to progressive ventriculomegaly. The interrogation of multi-modality variables may be challenging. We aimed to use machine learning (ML) to - i) characterize structural volumetric and diffusion tensor imaging (DTI) metrics that distinguish patients with NPH vs. healthy controls and ii) test for fairness in such ML derivations.

METHODS: The study cohort consisted of 12 patients with Complex NPH and 45 healthy volunteers drawn from the ADNI study. We performed volumetric segmentations on all grey and white matter brain regions (Freesurfer 7.1.1) and generated a full profile of DTI metrics (FSL and MRTrix3; FA, MD, AD and RD) for structural regions-of-interest. We applied ML methodology to interrogate the dataset for best model and top feature predictions. Furthermore, we performed perturbations on the NPH dataset to test for robustness of the measures described in the context of small datasets, missing data and range of metrics.

RESULTS: Using the test perturbations above, we created four training models. The most robust features that distinguished NPH vs. controls were the left inferior ventricular volume, corpus callosum anterior volume, left pallidum RD and left hippocampus AD. Independent statistical analyses confirmed that these measures significantly differed between cohorts ($p < 0.001$, < 0.001, $= 0.014$ and < 0.001 respectively). In tests of full performance, all models demonstrated high accuracy in classifying cohorts (AUC, AUC-weighted and average precision scores of 1.0, log loss 0.007 - 0.009). The feature most impacted from perturbations was the left thalamus proper AD ($p < 0.001$), downgraded from top to fifth. The MaxAbsScaler, LightGBM classifier was the best performing ML algorithm.

CONCLUSIONS: ML approaches may aid in the interpretation of multi-modality/-variable imaging biomarker results in the context of widespread significant but contradictory changes.

CEREBROSPINAL FLUID OSCILLATIONS AND CEREBRAL BLOOD FLOWS DURING BREATHING

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INTRODUCTION: Real-time phase contrast MRI (RT-PCMRI) can generate velocity map in less than 100 ms. Therefore, it is possible to continuously quantify the oscillations of these neurological fluid flows directly during several respiratory cycles without any cardiac or respiratory synchronization. In this work, we applied RT-PCMRI to quantify the influence of free breathing on neurofluid dynamics.

METHODS: 10 healthy volunteers were examined using a 3T clinical MRI. Volunteers maintained free breathing during acquisition. The main parameters of RT-PCMRI were as follows TE/TR/flip=4.9ms/9.4/10°, SENSE=2.5, EPI factor=7, VENC=60cm/s, 5cm/s, and 10 cm/s, acquisition pixel size=2*2 mm2, temporal resolution=75ms/frame to 96 ms/frame for 30s or 45s.
We applied RT-PCMRI to quantify blood flow in the straight and superior sagittal sinuses, internal and basilar arteries, but also CSF flows in the aqueduct and spinal spaces. A new in-house post processing software segmented all cardiac cycles and labeled them according to their position in the respiratory cycle. We then calculated influence of thoracic pressure change during breathing on the neurofluid flow dynamics and cardiac period durations.

RESULTS: During the elevated pressure of the respiratory period, cardiac period duration (0.84s±0.12s) decreased by (7%). Stroke volumes of cerebral arterial inflow (9800±1200 mm3) and output measured venous outflow (6750±1310 mm3) decreased by 10% and 8% respectively. Mean stroke volumes of CSF in the aqueduct (61±33 mm3) and in the spinal canal (657±163 mm3) decreased by 20% and 18% respectively. CSF net flow presented caudal direction during elevated thoracic pressure and cranial direction during low thoracic pressure but upward and downward movements of CSF flows during cardiac cycle were still presents. Net CSF flow of the total acquisition was null.

CONCLUSIONS: RT-PCMRI can assess the influence of respiration on the dynamics of neurofluid flows in free breathing, neurofluids are slightly influenced by variations of the respiratory thoracic pressure.

MONITORING PATIENTS WITH CSF DISORDERS – POTENTIAL USE OF PHASE-CONTRAST MRI

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INTRODUCTION: The spinal cord at the upper cervical spine is moved alongside pulsatile shifts of blood- and CSF volumes. This cardiac-related motion can be depicted by non-invasive phase-contrast MRI. While the detailed physiological mechanisms are yet to be revealed, it has been demonstrated that increased spinal cord motion can be found among patients with spontaneous intracranial hypotension (SIH) (Wolf et al. 2023); thus, in a disorder of spinal CSF leakage. A high reliability and feasibility of this short (1.5 minutes) sequence has been reported. Also, there is first evidence that reduced spinal cord motion can be found in patients with idiopathic intracranial hypertension (IIH) (preliminary data).

METHODS: Case reports on patients with SIH and IIH who received axial, ECG-triggered phase-contrast MRI measurements before and after treatment. Analysis was fully automated (www.nora-imaging.org). The velocity range (mm/s) of the time-resolved velocity curve over the cardiac cycle was used as the main parameter. Additionally, time-resolved curves were interpolated to reflect one standardized heartbeat for visual, qualitative comparison.

RESULTS: Case A, IIH, female, 37 years: before treatment 3.6 mm/s, after Stenting 5.0 mm/s. Case B, IIH, female, 44 years: before treatment 3.1 mm/s, after Stenting 5.3 mm/s. Case C, SIH (CSF venous fistula), male, 35 years: before treatment 11.9 mm/s, after surgery 6.2 mm/s. Case D, SIH (CSF venous fistula), female, 67 years: before treatment 9.5 mm/s, after embolization 4.6 mm/s and highly reduced area under the curve (Figure 1)

CONCLUSIONS: The reported cases show that monitoring of patients with CSF volume disorders might be possible by using a fast and non-invasive MRI technique. It might help to discern rebound intracranial hypertension from recurrent leaks, and it might be of use in clinical trials monitoring the effect of the intervention.

NEGATIVE PRESSURE HYDROCEPHALUS AND ITS GREAT THERAPEUTIC CHALLENGE: EXPERIENCE IN OUR CENTER

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INTRODUCTION: Negative pressure hydrocephalus (NePH) is characterized by ventriculomegaly and symptoms of high intracranial pressure (HICP), despite low or even negative intracranial pressure (ICP) monitoring. Its pathophysiology involves alterations in transmantle pressure, cerebral compliance, and turgor. Diagnostic studies such as elastography have been implemented, and various therapeutic algorithms have been proposed.

OBJECTIVES: To present our center's experience with NePH, describe our results, and review the literature.

MATERIALS AND METHODS: We reviewed the medical records of four patients treated in our center between 2017 and 2022. To diagnose NePH, each patient had a prior history of an intracranial alteration that could affect the normal properties of the brain, clinical signs of HICP, ventriculomegaly on CT scan, and prolonged ventricular drainage with ICP < 5 cmH2O.

RESULTS: The mean age at diagnosis was 42 years, with a 50% female predominance. Most cases were secondary to tumor resection (75%). The mean hospitalization duration was 165.8 days, with nine surgeries and four readmissions. A mean of 3.5 external ventricular drains (EVD) were required, and two patients required third ventriculostomy endoscopy (TVE). As for complications, three patients presented with CNS infections, and two of them had an isolated fourth ventricle. Finally, one patient died, and the remaining three have adjustable low-pressure valves.

CONCLUSIONS: NePH and its treatment remain a significant challenge, requiring multiple interventions, prolonged hospitalizations, and frequent readmissions, with CNS infection being the most serious complication. Our results are consistent with the available literature and suggest the need to implement protocols or therapeutic algorithms in our center to guide decision-making for these patients.

POSTERIOR REVERSIBLE ENCEPHALOPATHY SYNDROM (PRES) SECONDARY TO TWO CASES OF INTRACRANIAL HYPOTENSION

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INTRODUCTION: PRES is a neurological syndrom with specific imaging findings. The clinical manifestations are characterized by headache, visual disturbance, seizures and impaired consciousness. PRES is associated with many clinical entities, the most common of which are eclampsia, hypertension and immunosuppresive treatment. PRES secondary to cerebrospinal fluid (CSF) hypovolemia, also called intracranial hypotension, is not a well - recognized cause of this condition. Two cases of PRES with features of intracranial hypotension are reported.

METHODS: Medical history and updated literature were rewiewed.

RESULTS: CASE 1: A 52 – year – old woman was diagnosed with idiopathic intracranial hypertension, after presenting with papilledema and decreased visual acuity. After a programmable lumboperitoneal shunt was implanted, she complainted of severe headache due to intracranial hypotension despite the valve – opening pressure modification. CASE 2: A 64 – year – old woman with posthemorragic hydrocephalus caused by thalamic bleeding with intraventricular extension, showed excessive drainage after a ventriculoperitoneal shunt was placed. In both cases, cranial CT revealed widespread low – density areas in cerebral white matter. We suspected PRES after performing cranial MRI. Both patients improved the symptoms and radiological findings, after removing the lumboperitoneal shunt and increasing the set pressure of the valve.

CONCLUSIONS: In this work we aim to draw attention to the possible association of PRES with intracranial hypotension after CSF drainage.

BONE REGROWTH AFTER BURR HOLE CRANIOSTOMY: ESTABLISHING NATURAL HISTORY AND IMPLICATIONS FOR POST-OPERATIVE TRANS-BURR HOLE ULTRASOUND

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INTRODUCTION: Burr hole craniostomy is performed for ventriculoperitoneal (VP) shunt insertion or endoscopic third ventriculostomy (ETV) in patients with hydrocephalus or other cerebrospinal fluid (CSF) disorders. Interest is growing in trans-burr hole ultrasound for longitudinal post-operative monitoring of ventricular caliber, but formal study is needed to determine rate and degree of bony regrowth that would prohibit this technique. This study evaluates bone regrowth patterns and implications for transcranial ultrasound monitoring.

METHODS: We retrospectively analyzed CT imaging for 62 adult patients (mean age 61, range 21-85; 81% normal pressure hydrocephalus) with 20mm burr hole and sonolucent PMMA burr hole cover (Longeviti) who underwent VP shunt insertion or ETV, and 39 historical controls (mean age 59, range 19-90; 62% normal pressure hydrocephalus) with standard 14mm perforator burr holes (Acra-Cut) without cover. Bone regrowth was assessed using serial CT scans over up to 1100 days. Linear and logistic regression analyses examined bone regrowth correlations with patient characteristics.

RESULTS: The 20mm sonolucent cover cohort experienced initial bone regrowth at a rate of 1-mm per 40 days, with 33% closure after one year. The matched-control cohort had 1-mm regrowth per 50 days with 33% closure after two years. Regrowth slowed almost completely 6-12 months post-craniostomy in both groups. Bone regrowth was not associated with age, sex, skull thickness, etiology, or implant size.

CONCLUSIONS: Bone regrowth after burr hole craniostomy is common in adults, occurring rapidly within the first 6-12 months and stabilizing thereafter. This pattern translates to a decreased and frequently unusable ultrasound field-of-view for follow-up imaging in VP shunt or ETV patients. New techniques and materials, such as full-thickness sonolucent implants, inhibited burr hole edges, or larger burr holes, are needed to limit bone regrowth after burr hole craniostomy to enable ultrasound to act as a viable long-term imaging alternative in this population.

PRECLINICAL QUALITY TESTING FOR THE EARLY FEASIBILITY STUDY OF TELEMETRIC INTRACRANIAL PRESSURE MONITORING IN SPACEFLIGHT

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INTRODUCTION: After 3-6 months in space, approximately 70% of astronauts develop vision problems, known as Spaceflight-Associated-Neuro-ocular-Syndrome (SANS). Its symptoms are similar to those of Idiopathic Intracranial Hypertension (IIH). It is hypothesized that shift of fluid toward the head in zero G increases the intracranial pressure (ICP).

METHODS: The conventional methods for direct measurement of ICP are too complex for use in space. Instead, the CE-approved telemetric ICP sensor M.scio is planned to be used in an FDA-approved early feasibility study to collect ICP data before, during and after spaceflight. Preclinical quality testing of the devices was performed to ensure that the equipment withstands the challenging environmental conditions encountered during a space mission.

RESULTS: The influence of thermal, mechanical and barometric parameters on the performance of the M.scio and the Reader Unit Set was investigated. The characteristics of the devices were compared before and after exposure to these environmental conditions. First results suggest that the Reader Unit Set functions normally after testing.

CONCLUSIONS: The preclinical quality tests marked an important milestone in the feasibility study, which will be the first to investigate whether and how the ICP changes before, during, and after spaceflight. This study aims to gain a better understanding of how SANS develops and could also provide useful insights for patients with IIH on Earth.

We wish to thank our SpaceX collaborators Marissa Rosenberg and Jaime Mateus.

SLOW WAVES OF ICP AND BLOOD FLOW VELOCITY IN HYDROCEPHALUS

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BACKGROUND: Slow vasogenic waves (period 20 sec to 3 minutes) of ICP , first described by Lundberg as 'B' waves, are commonly observed in patients suffering from hydrocephalus. Elevated average power of B waves was reported as predictor of positive outcome after shunting. Traditionally, slow ICP waves were assessed during overnight ICP monitoring, but recent advance of computer methods allows precise assessment over shorter period, like during infusion test. In this observational study we re-examine basic facts about occurrence and interpretation of ICP slow vasogenic waves.

METHOD: We retrospectively analysed 85 ICP recordings from infusion tests. All patients had clinical and imaging symptoms of communicating hydrocephalus. Using infusion tests data, basic compensatory parameters like resistance of CSF outflow and elasticity were evaluated. During tests, transcranial Doppler blood flow velocity (FV) recordings in the Middle Cerebral Artery were performed. Relative changes of cerebral arterial blood volume (CaBV) were evaluated by time integration of difference between brain blood inflow and mean cerebral blood flow velocity, under assumption of much lower pulsation of cerebral blood outflow than inflow.

RESULTS: In majority of patients slow vasogenic waves in CaBV of average frequency 1.23 +/- 0.23 cycles per minute were recorded at baseline. However, not in all patients slow vasogenic waves of ICP were recorded in the same period. When they were present, they were synchronized and in-phase with slow waves of CaBV (average coherence 0.87 +/- 0.17). Transmission of slow waves from CaBV to ICP was significantly correlated with resistance to CSF outflow ($p<0.05$). Mean ICP, increasing during infusion magnified slow ICP waves but did not affect slow waves of CaBV.

CONCLUSION: Slow waves of ICP are primarily caused by slow fluctuations of arterial cerebral blood volume. They appearance is associated with disturbed CSF circulation and rising mean ICP.

TELEMETRIC INTRACRANIAL PRESSURE RECORDINGS IN PATIENTS WITH SHUNTS FOR COMPLEX HYDROCEPHALUS.

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INTRODUCTION: The use of telemetric intracranial pressure (ICP) sensors in people with shunts is expanding, but there are limited data to help interpretation of the telemetric recordings. People with complex hydrocephalus are likely to be benefited more with the extra information that telemetric systems provide, regarding the function of the shunt. In this study we determined reference values in patients with a shunt using the M.scio system, in order to assist the interpretation of telemetric ICP data.

METHODS: This was a single centre cohort study of patients with complex hydrocephalus of various aetiology that underwent cerebrospinal fluid (CSF) shunt insertion or revision with integration of an M.scio telesensor, between November 2019 and September 2022. The first post-operative telemetric measurements in the sitting and supine position were recorded in order to obtain reference values of functioning shunts. The morphology, mean pressure and amplitude (AMP) of the ICP wave were determined.

RESULTS: Twelve patients with complex hydrocephalus underwent shunt insertion/ revision with insertion of M.scio telesensor over 35 months. The hydrocephalus aetiology included transition, malabsorption, obstructive and Chiari-related hydrocephalus. All patients had a functioning shunt at the time of the recording. The intracranial pressure (ICP) curve demonstrated pulsatility in all patients in the sitting position and in all but one patient in the supine position. In the sitting position, the mean ICP was -8.5 mmHg (SD= 2.5) and the AMP was 4.7 mmHg. In the supine position, the mean ICP was 12.5 mmHg (SD= 5.3) and the AMP was 5.1 mmHg.

CONCLUSIONS: Telemetric ICP recordings provided clinically meaningful information on the function of CSF shunts. Baseline recording should be obtained and can be used for future comparison to exclude shunt malfunction and guide valve adjustment. Larger studies are required to assess the clinical effectiveness of telemetric ICP measurement.

CHANGES IN THE SHAPE OF INTRACRANIAL PRESSURE PULSE WAVEFORM CORRELATE WITH CEREBROSPINAL COMPLIANCE DURING LUMBAR INFUSION TESTS

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INTRODUCTION: Analysis of intracranial pressure (ICP) pulse waveform has long been suggested as an indirect method of assessing cerebrospinal compliance (C). The ratio of characteristic peaks P1/P2 of the ICP pulse seems to correlate with estimates of C. Frailty, as a shift from normal to pathological brain ageing, appears in turn to be correlated to cerebrospinal elastance (E=1/C). It was demonstrated that reduction in C results in increasing prominence of peak P2 and progressive rounding of the pulse. Hence baseline ICP pulse characteristics could be meaningful to depict the shift from normal to pathological brain biomechanical aging. But it remained unclear whether lumbar ICP pulse profile actually reflects changes in C.

METHODS: 41 ICP recordings collected during lumbar infusion tests were selected from a database of 100 normal pressure hydrocephalus patients enrolled in the Proliphyc project (exclusion criteria: insufficient signal quality or peak P1 undetectable over the entire recording period). Peaks P1 and P2 were annotated in individual waveforms using an automated algorithm based on detection of local maxima and pulse curvature. Pulses with indistinguishable peaks were excluded manually. C was estimated using E coefficient calculated from the infusion test. Time courses of mean ICP and C in each patient were compared with peak heights and ratios using Spearman correlation coefficient.

RESULTS: The height of P1 and P2 augmented with increasing mean ICP (median group-averaged correlation coefficient over 0.9). Peak ratio P1/P2 was strongly correlated with model-based C (correlation coefficient median [first-third quartile]: 0.69 [0.44-0.83]).

CONCLUSIONS: Analysis of the relationship between characteristic peaks of lumbar ICP pulse waveform provides an indirect measure of changes in cerebrospinal compliance. Although peak ratios cannot be expressed in absolute units of compliance, this approach could help identify patients with reduced cerebrospinal pressure compensation.

PHASIC ALERTNESS AND WORKING MEMORY IMPROVEMENTS FOLLOWING LUMBAR PUNCTURE IN INPH PATIENTS DIFFER FROM OTHER AGE-ASSOCIATED COGNITIVE SYNDROMES

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OBJECTIVE: Idiopathic normal pressure hydrocephalus (iNPH) is characterized by gait disturbances, urinary incontinence and cognitive impairment. Occurring in older age, iNPH is often mimicked by other neurological conditions. While the pattern of cognitive deficits is known to differ from other age-associated cognitive syndromes (AACS), there is no recommended standard test set for iNPH to date. In this study, we evaluate whether tests of attention and working memory differ between iNPH and AACS.

METHODS: A total of 50 patients with suspected iNPH (23 iNPH, 27 AACS) receiving lumbar puncture (LP) in a neurological acute clinic were consecutively included in the study over 4 years. In a prospective study design, patients completed the WMS-R digit spans, symbol digit modalities test (SDMT) and the Test of Attentional Performance (TAP) alertness subtest prior to and following LP. Subsequent group assignment (iNPH vs. AACS) was based on neurological assessment. Between-group comparisons were analyzed using Mann–Whitney-rank-sum-test, within-group change was analyzed using the Wilcoxon-signed-rank-test.

RESULTS: In the iNPH group, post-LP improvements were found for the TAP index of phasic alertness ($p = .005$) and WMS-R digit span backwards ($p = .008$). Both groups improved in SDMT score while between-group comparisons of this variable revealed a significant difference.

CONCLUSION: Improvements of phasic alertness and working memory hold diagnostic value to differentiate iNPH from AACS. Test-retest effects in the AACS group SDMT results impede differentiation and need to be discussed.

CHIARI MALFORMATION TYPE 1 WITHOUT HYDROCEPHALUS AND THIRD VENTRICULOTOMY

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INTRODUCTION: Third ventriculostomy is described as a treatment option in patients with Chiari malformation type 1 and hydrocephalus (1,2). There just one case report, describing third ventriculostomy as primary treatment option of increased intracranial hypertension due to Chiari malformation without hydrocephalus (3). We present our series of 6 cases with symptomatic Chiari malformation type 1 without hydrocephalus treated primarily with endoscopic third ventriculostomy.

METHODS: We retrospectively reviewed and analyzed the clinical and radiological data of 6 patients with Chiari malformation type 1 who underwent endoscopic treatment at our clinic between January 2020 and December 2022, and reviewed cases reported in the literature.

RESULTS: All patients presented with headaches, and none with radiological hydrocephalus. One patient had coexisting small cervical syringomyelia. Preoperative ICP monitoring was abnormal in all cases with increased amplitude and B-waves high but without increased average ICP values consistent with reduced compliance was found in all cases. 5/6 cases experienced clinical improvement of headaches after primary endoscopic ventriculostomy. Only one patient underwent secondary operation with fossa posterior decompression.

CONCLUSIONS: Third ventriculostomy can be considered as a treatment with acceptable improvement in some patients with Chiari malformation.

TRENDS IN ICP WAVEFORM IN THE EARLY POSTOPERATIVE PERIOD: DOES SEDATION PLAY A RELEVANT ROLE?

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INTRODUCTION: Intraparenchymal intracranial pressure monitoring (ICPM) is used to inform decisions in a variety of clinical environments going from the elective to the acute settings. This procedure is often performed under sedation. There is uncertainty on the effects of sedative agents on ICP and their duration, complete clearance of the sedatives from the body is desirable and can lead clinicians to perform prolongued periods of ICPM. This study investigates the trends in postoperative ICP waveform and their possible associations with sedation.

METHODS: Prospective observational pilot study. Patients admitted for elective intraparenchymal ICPM performed under local anaesthesia with or without sedation were included. Self-calibrating Raumedic ICPM were used. Continuous ICP, pulse amplitude (PA), pCO2 and pO2 were simultaneously recorded and their trends analysed (60-100Hz). PCO2 and pO2 were measured through a noninvasive transcutaneous monitor.

RESULTS: Six patients (5F, 44±19 years) were included. Four patients underwent ICPM insertion under sedation (propofol, alfentanil and midazolam), while the remaining 2 only received local anaesthetic. From the moment of insertion of the ICP probe, ICP declined until an ICP steady state was achieved. This decline occurred in all the patients, but was steeper for the patients who received sedation. The ICP steady state was achieved on average 30 minutes after insertion. The difference between pre- and post-steady state ICP was on average 4±1 mmHg and was statistically significant (t-test $p<0.001$). There was no significant difference between pre- and post-steady state pCO2 and pO2.

CONCLUSIONS: These preliminary results demonstrate that immediate post-insertion ICP is higher than subsequent recordings, this phenomenon does not seem to be associated with the use of sedative agents and could be the result of local inflammation. Larger studies will be needed to confirm these findings.

EXCHANGE OF FIXED PRESSURE GRAVITATIONAL UNIT TO AN ADJUSTABLE GRAVITATIONAL VALVE IS SAFE AND EFFECTIVE PROCEDURE

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INTRODUCTION: The broadly accepted, predefined indications for an implantation of adjustable gravitational valve (AGV) are prevention and treatment of overdrainage. The purpose of this study was to evaluate safety and efficacy of exchanging the fixed pressure unit to AGV to optimize drainage.

METHODS: We retrospectively analyzed 19 consecutive patients who underwent exchange procedure from 2012 to 2021 in a single centre in the age of 5 to 79 years (mean 60) in different etiologies of hydrocephalus for 4 indications: 1) optimization of drainage excluding patients with idiopathic intracranial hypertension (IIH), n=14, 2) prevention of overdrainage, n=2, 3) IIH, n=1, 4) treatment of overdrainage, n=2. In patients with idiopathic normal pressure hydrocephalus (iNPH, n=7) special parameters were used (Evans ratio, NPH-Recovery-Rate and Black-Score). All the patients received a AGV proSA®, Miethke, with different adjustments (16 to 40 cmH2O, mean 22,84) depending on individual clinical situation. The mean follow-up was 30 months.

RESULTS: In 14 cases (74%) the clinical state improved and in 5 (26%) was constant, no deterioration. In patients with iNPH the Evans ratio analyzed with Spearman correlation decreased significantly ($r(5)= 0.76$, $p = .049$). There were no statistically significant changes in NPH-Recovery-Rate and Black-Score. There were no device-related shunt failures and no mortality. The overdrainage was observed in 8 (42%) of cases. It could be managed non-invasively in 88% of these cases with improvement of overdrainage in 57% cases. The underdrainage was initially present in 14 cases (74%) and was treated non-invasively in 10 cases (71%).

CONCLUSIONS: The exchange of fixed pressure unit to an AGV is safe and efficient procedure leading to improvement of hydrocephalus symptoms with low complication rates.

CEREBROSPINAL FLUID TAU BIOMARKERS SHOW STRONG POTENTIAL IN EARLY SELECTION FOR SHUNT SURGERY

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INTRODUCTION: The idiopathic normal pressure hydrocephalus (iNPH) is a type of neurodegenerative disorder of gait impairment, dementia and incontinence. Here we investigate the correlation between lumbar cerebrospinal fluid (CSF) biomarkers and the CSF tap test (CSF-TT) responsiveness in patients with iNPH.

METHOD: A total of 163 iNPH patients were prospectively enrolled and subjected to CST-TT. The CSF levels of Aβ42, phosphorylated tau 181 (P-tau181) and total tau (T-tau) were analyzed.

RESULTS: The CSF P-tau181and T-tau levels were significantly lower in the CSF-TT responders compared to the non-responders ($P < 0.05$). The lower levels of CSF P-tau181were discovered in the CSF-TT responders with the improvement of gait + cognition or cognition only compared to the non-responders ($P < 0.05$).

CONCLUSION: The CSF tau biomarkers show a significantly negative correlation with the responsiveness to CSF-TT, and the CSF biomarkers exhibit strong potential in early selection for shunt surgery.

KEYWORDS: cerebrospinal fluid (CSF) biomarkers; CSF tap test (CSF-TT); idiopathic normal pressure hydrocephalus (iNPH); shunt surgery.

EFFECT OF SHUNT TREATMENT ON EPWORTH SLEEPINESS SCALE SCORE IN NORMAL PRESSURE HYDROCEPHALUS (MAX 153 CHARACTERS)

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INTRODUCTION: Sleepiness and apathy, symptoms often reported in patients with Normal Pressure Hydrocephalus (NPH), probably contribute to their disability. However, research on outcomes after shunt surgery has mainly focused on other symptoms. This study aimed to be an initial investigation into the effects of shunt treatment on daytime sleepiness and whether there was a relation to changes in ventricular volume (VV).

METHODS: Pre- and postsurgical daytime sleepiness was investigated using the Epworth Sleepiness Scale (ESS) in a sample of 32 patients with NPH. All participants received Strata® shunts at surgery set at an initial performance lever (PL) of 1.5. Data was gathered before surgery and at follow up one month after surgery. Participants answered the questionnaire with the aid of clinical investigators and/or accompanying family members as needed. Ventricular volume of the lateral as well as third ventricles was measured using quantitative MRI.

RESULTS: ESS improved by a median of 1.5 points one month after surgery, p=.026. A subgroup analysis dividing the group by presurgical ESS according to a commonly used cut-off of ESS > 12 revealed a significant effect only in the group with pathological ESS. That group had a median improvement of 12 points (n=6, p=.035) versus a median change of 0 points in the non-pathological group (n=26, p=.47). While VV decreased by a median of 10.25 mL post-surgery (interquartile range 5.75 to 15.9, p<.001), there was no significant correlation between change in VV and ESS.

CONCLUSIONS: Daytime sleepiness seems to be another domain of NPH symptomatology that is responsive to treatment. Although developed for narcolepsy, ESS is a quick test to administer and could be a valuable addition to pre-surgical screening for treatable symptoms.

CEREBRAL BLOOD FLOW AND AUTOREGULATION IN NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: The available evidence, as summarised by a 2001 review, has indicated the necessity of studying the interaction between CSF circulation cerebral blood flow (CBF). We aimed at reviewing the research on the topic after 2001, adding cerebral autoregulation.We aimed to summarise the knowledge in CBF and autoregulation in NPH and to report potential directions for investigations and clinical applications.

METHODS: Systematic review of English and non-English original research papers using PubMed, Cochrane, Scopus, Embase and Web of Knowledge for autoregulation in hydrocephalus published after 2001. Search terms included autoregulation/cerebral autoregulation/cerebrovascular reactivity and hydrocephalus / normal pressure hydrocephalus. We included studies of adult humans under investigation for idiopathic or secondary NPH with measurements of CBF and/or autoregulation.

RESULTS: 436 articles were assessed for eligibility, out of which 59 met our criteria. Global & regional CBF, cerebrovascular reactivity &autoregulation, as well as CBF before & after shunting and temporary CSF withdrawal were reported.

CONCLUSIONS: CBF is most probably not reduced globally, showing regional patterns. There was no evidence for CBF measurement as a prognostication tool for shunting. Shunting probably restores CBF patterns to normal. Autoregulation and reactivity show diagnostic as well as prognostic promise in NPH, however will require further studying, in conjunction with cerebral metabolism.

EXPLORE THE RELATIONSHIP BETWEEN GLOBAL WHITE MATTER AND IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS TRIAD

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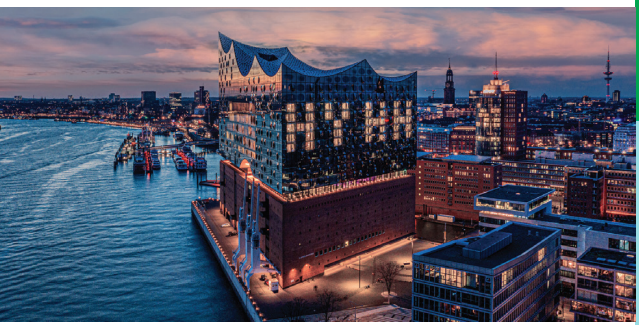
INTRODUCTION: Idiopathic normal pressure hydrocephalus (INPH) triad included cognitive impairment, gait disorders, and urinary incontinence. Few imaging studies have reported the relationship between global white matter (WM) alterations and the hydrocephalus triad. This study explores the relationship between the hydrocephalus triad and global WM in patients with INPH through structural image analysis.

METHODS: 42 patients with INPH and 24 healthy control (HC) subjects were included in this study. The cerebrospinal fluid tap test (CSF TT) was performed on INPH patients, and gait parameters, cognition, and urinary function were assessed CSF TT by using the 3-meter timed up and go test (3-mTUG), the 10-meter walking test (10-MWT), the Mini-Mental State Examination (MMSE) scale and Montreal Cognitive Assessment (MoCA), and urinary frequency, respectively. All subjects underwent 3D T1-weighted MRI. Statistical parametric mapping 12 was used for preprocessing images, statistical analysis, and voxel-based morphometry for white matter volume analyses. Pearson's correlation analysis and Bonferroni's statistic corrected one-way ANOVA were used to determine the relationship among demographic variables.

RESULTS: INPH patients had lower cognitive impairment, gait disorders, and higher urinary frequency compared to the HCs ($p < 0.001$). Compared to the HCs, the INPH patients had significantly reduced WM volumes in the bilateral temporal gyrus, precentral gyrus, inferior occipital gyrus, cerebellum (VIII), and right frontal gyrus, left lingual gyrus, right parahippocampal gyrus ($p < 0.001$). The INPH group had worse MMSE and MoCA scores, and urinary frequency was associated with bilateral temporal gyrus, precentral gyrus, inferior occipital gyrus, cerebellum (VIII), right middle frontal gyrus, left lingual gyrus, right parahippocampal gyrus ($p < 0.001$). The gait disorders were associated with bilateral temporal gyrus, precentral gyrus, left inferior occipital gyrus, lingual gyrus ($p < 0.001$).

CONCLUSION: Compared to the HCs, the INPH patient triad was significantly associated with global white matter alterations.



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IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS IN A KLINEFELTER SYNDROME THE FIRST CASE IN THE LITERATURE

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INTRODUCTION: Idiopathic Normal Pressure Hydrocephalus shows a typical clinical triad consisting of gait disturbance, dementia, and urinary incontinence, often combined with ventriculomegaly. Fortunately, these clinical manifestations are potentially reversible by adequate surgical treatment. Men affected by Klinefelter Syndrome can harbor cognitive problems, those include impairments in both verbal and nonverbal memory, and in executive functions, which could be relate to Idiopathic Normal Pressure Hydrocephalus in these patients. Although correlation between chromosomic disorders and iNPH has been described in Down Syndrome[9], at our knowledge direct association between iNPH and KS has never been discussed in the literature. We first described a case of iNPH in a patient with KS. The relevant literature and clinical implications are also discussed.

CASE REPORT: A 62-year-old-man genetically diagnosed with KS had one year history of gait ataxia determining recurrent falls. He also developed progressive cognitive impairment leading to the impossibility to perform everyday activities. His magnetic resonance (MR) showed ventriculomegaly. A positive lumbar infusion test was then obtained. With these evidences the patient underwent a shunt surgery. At one month follow-up the patient had a significant improvement of the ataxia, and he was able to deambulate with help (see supplemental material).

CONCLUSION: KS is the most frequent chromosomal aberration in men, and besides infertility, it can manifest also with cognitive and neurological disfunctions. When these symptoms appear, even if in younger age than usually, diagnosis of iNPH in those patients should be suspected and investigated. Indeed, its treatment can lead to an opportunity to improve their life quality.

IS NAUSEA DURING LUMBAR DRAINAGE A USEFUL PREDICTOR OF SHUNT RESPONSIVENESS?

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INTRODUCTION: Extended lumbar drainage (LD) is used to identify normal pressure hydrocephalus (NPH) patients who are likely to benefit from the insertion of a permanent cerebrospinal fluid (CSF) shunt system, also referred to as 'shunt-responsive' patients. One of the most common complaints of patients undergoing 3-days LD is nausea, it is possible that excessive drainage of CSF could be a leading cause. This study tested the hypothesis that nausea during LD may have a good negative predictive value (NPV) for shunt-responsiveness in NPH.

METHODS: Retrospective single-centre observational study. Patients admitted for extended LD for NPH since January 2020 were identified. Patients who followed a standard CSF drainage protocol with complete information regarding walking test results, signs and symptoms during drainage, administration of medications (including possible sedatives during procedure) were included. Shunt-responsiveness was defined as a 10% improvement in walking test results after LD (either in number of steps or speed). Fisher's exact test was used to test the association between shunt-responsiveness and nausea.

RESULTS: Fifty-six patients (34M, 22F, mean age 75±7 years) were included. Forty-five patients (80%) were 'shunt-responsive' and had average improvement in post-LD walking test of 25% in terms of speed and 21% in terms of number of steps. The remaining 11 patients (20%) did not have a significant improvement in walking test. Overall, 15 patients (27%) complained of nausea during the lumbar drainage period, of these 11 were in the 'shunt-responsive' group and 4 in the 'non-shunt-responsive' group. The Fisher's exact test did not demonstrate an association between nausea and shunt-responsiveness (p=0.46). No statistical association was found between nausea and other factors tested (age, sex, sedatives, BMI, pain, comorbidity index).

CONCLUSIONS: Nausea is a common finding in NPH patients undergoing LD and, according to the results of this study, it is not a useful indicator of shunt-responsiveness.

PACKAGING DESIGNS FOR MEDICAL DEVICE DRUG COMBINATION PRODUCTS - IMPACT ON REQUIRED STORAGE CONDITIONS AND SHELF-LIFE

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INTRODUCTION: Drug combination products pose the chance to overcome limitations of conventional medical devices. For example, active pharmaceutical ingredients (APIs) coated on stents, help to prevent in stent restenosis. While medical devices mainly made of polymeric, metal or ceramic materials can be considered robust, many APIs are of limited stability because of sensitivity to heat, oxygen and moisture. The limited stability of the APIs limits the shelf life of the medical device itself and poses a challenge during transportation and storage. Sterile barrier systems for conventional medical devices mainly have to make the sterilization process possible and afterwards assure sterility. Additionally, a sterile barrier of a medical device drug combination product has to protect the APIs over shelf life.

METHODS: Various packaging designs for medical devices are available, today. Different sterile barrier systems and suitable sterilization methods have been evaluated and compared to each other, regarding their potential to improve the stability of APIs incorporated in medical devices.

RESULTS: There is no perfect sterile barrier available, that fulfils all requirements and should be recommended in general, today. Each packaging design is associated with individual limitations as well as individual advantages. Depending on the requirements as defined by the medical device and the incorporated APIs, it is possible to recommend a suitable sterile barrier system and sterilization method.

CONCLUSIONS: Adding an API to an established medical device is likely to change the requirements regarding a suitable sterile barrier for a medical device. By selecting a suitable combination of sterile packaging and sterilization process, the requirements of sterilizability and product protection of a medical device drug combinations product can be met.

THEOPHYLLINE A DRUG EFFICIENT TO INCREASE INTRACRANIAL PRESSURE: CASE REPORT AND REVIEW OF LITERATURE.

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INTRODUCTION: Limited information is available regarding the direct effect of drugs prescribed to elevate intracranial pressure in contrast to the abundance of evidence in support of medication utilized to lower intracranial pressure. Theophylline is a methylxanthine derivate used in the treatment of respiratory diseases with only a few randomized control trials or case reports describing pain improvement in low CSF pressure states or spontaneous intracranial hypotension (SIH). We present the case of a recorded increase in intracranial pressure under Theophylline.

CASE REPORT: A 23-year-old female with a complex history of hydrocephalus and syringomyelia was experiencing debilitating symptoms due to refractory intracranial hypotension. Medical management with oral theophylline was attempted for a period of three months. Intracranial pressure measurements were obtained via the telemetric pressure sensor reservoir (Miethke®, M.scio®) incorporated in the patient's ventriculoperitoneal shunt system.

RESULTS: A significant increase in intracranial pressure was recorded at therapeutic drug levels.

CONCLUSION: This is the first report of an increase in intracranial pressure under oral theophylline medication.

KEYWORDS: intracranial pressure, theophylline, hydrocephalus, low pressure CSF states

AN INVESTIGATION OF THE USEFULNESS OF THE REY-15 COGNITIVE PERFORMANCE VALIDITY TEST, TO DETECT SUBOPTIMAL EFFORT ON PATIENTS WITH SUSPECTED INPH

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INTRODUCTION: Cognitive decline is a feature of idiopathic Normal Pressure Hydrocephalus (iNPH) and is routinely assessed by neuropsychological testing. Although cognitive tests are sensitive to iNPH related cognitive change, a patient's performance is also at risk of being influenced by non-organic variables such as anxiety and lack of motivation. It is therefore, common practice to administer performance validity tests (PVTs) to determine data reliability and insight into a patient's cognitive difficulties. The present study evaluates the use of the Rey-15 Item Test (Rey, 1964) in patients suspected of iNPH.

METHODS: A retrospective record review of 38 brief, diagnostic cognitive assessments administered between November 2021 to February 2023 was conducted. Raw scores from the Rey-15 Item Test were obtained and categorised into two groups: valid effort or suspect effort. A cut off score of <21 was used to indicate effort validity. Bayesian Chi-squared tests was used to analyse the relationship between effort outcome and clinical intervention.

RESULTS: Thirty-eight patients (Female n = 16; Male n = 22; age M = 75yrs), referred for suspected iNPH, underwent a brief cognitive assessment during a diagnostic iNPH clinic. After administration, 71% of patients showed suspect effort, 29% showed valid effort. Of the 38 patients, 66% of patients (n = 25) were clinically deemed to have iNPH and warranted further investigation independent of their PVT outcome. Chi square values did not show a significant relationship between effort outcome and clinical recommendation, BF=0.88, $\chi 2$ (1)=0.91, p=0.34.

CONCLUSIONS: Differences in PVT performance in patients suspected of iNPH is not likely due to effort alone. The recommended cut-off score of <21 may be sensitive to disease specific factors such as cognitive dysfunction and apathy. Future research might examine these findings by incorporating PVTs with optimal cut-off scores for disease-specific groups, such as the Dot Counting Test (Boone, 2002).

HYDROFLEX: THE USE OF PATIENT REPORTED OUTCOMES IN A CLINICAL SETTING AMONG PATIENTS WITH HYDROCEPHALUS

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INTRODUCTION: A patient-reported outcome (PRO) measure is defined as "any report of the status of a patient's health condition coming directly from the patient without interpretation of the patient's response by a clinician or anyone else". PRO data are increasingly being used in healthcare to monitor symptoms and identify problems early, and reduce outpatient clinic appointments.

OBJECTIVES: Hydrocephalus is a common neurosurgical condition. We have designed a PRO system specifically for hydrocephalus patients, a program named Hydroflex. The primary objective of Hydroflex is to utilize the PRO responses to evaluate whether the patient needs a contact. The secondary objective is the use of the patients' responses to support patient involvement, communication, and education.

METHODS: Patients receive questionnaires online at home. Based on an automated algorithm, the patients' PRO measures are ranked to guide clinical decision making. PRO responses are automatically assigned a given color code of "green", "yellow", or "red". "Red" answers indicate that the patient needs contact, "yellow" indicates that the patient may need contact and "green" indicates that there is no need for attention currently.

RESULTS: A total of 355 patients, 172 men and 183 women, have been enrolled in Hydroflex since it was launched in October 2017. In total, 1385 responses have been recorded, with 139 (10%) all green responses, 651 (47%) with one or more yellow responses and 594 (43%) with one or more red responses. Decisions in all instances could be made based on the questionnaires; 683 (50%) patients needing to be contacted and 690 (50%) not needing to be contacted.

CONCLUSIONS: We believe, that Hydroflex provides more continuity in the treatment of patients with hydrocephalus. It provides for a more standardized follow-up scheme, and we postulate that this will in turn lead to improved patient satisfaction and involvement and lead to fewer outpatient appointments.

SPINAL TUMOURS AS CAUSE OF NORMAL PRESSURE HYDROCEPHALUS: A CASE SERIES

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INTRODUCTION: Normal pressure hydrocephalus (NPH) is a cerebrospinal fluid (CSF) disorder characterised by ventriculomegaly, cognitive impairment, urinary incontinence and gait apraxia. The role spinal pathology and CSF circulation in this disease remains elusive. Whilst NPH is known to coexist with other comorbidities there are only a few case reports up to date describing spinal tumors causing NPH like symptoms independently. We aim to report a small case series.

METHODS: This is a retrospective case series study of patients presenting with NPH-like symptoms attributed to spinal pathology. Demographic, clinical and radiological data were collected from each patient.

RESULTS: Four (3 males and 1 female) patients, aged 50 to 80 years, with spinal tumors presenting as NPH were identified. Amongst these cases two underwent tumor resection only, one spinal and CSF diversion surgery and the last patient was recommended conservative treatment due to comorbidities. In both cases requiring only spinal surgery the histological diagnosis was schwannoma, with one of the patients showing significant objective improvement in neurocognitive testing and reduction in the ventricular size on subsequent imaging.

CONCLUSION: Spinal tumours are a rare cause of NPH and are often overlooked as a potential differential diagnosis. This case series serves as a reminder that rare causes of NPH should be considered. Nevertheless, it equally highlights a need for better understanding of the role of spinal CSF dynamics in the pathophysiology of this disease.

ASSESSMENT OF POSTURAL STABILITY IN PATIENTS WITH IDIOPATHIC NORMAL PRESSURE HYDROCEPHALUS

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INTRODUCTION: In patients with idiopathic normal pressure hydrocephalus (iNPH), the characteristics of balance and postural stability are less understood than those of gait. We examined the changes in postural stability depending on patient responsiveness after the cerebrospinal fluid tap test (CSFTT) during quiet standing.

METHODS: All patients with iNPH underwent CSFTT and were assessed using a center of pressure (COP) using a force plate with the patient's eyes opened and closed during quiet standing before and after CSFTT. After COP measurement, we calculated COP parameters using time and frequency domain analysis. We determined whether there was an interaction effect on the change in COP parameters over time between the groups, the difference in COP parameters before and after CSFTT using SPSS.

RESULTS: In total, 72 patients with iNPH were recruited, and 67 patients were finally included. We divided the patients into the following two groups: CSFTT responders (56 patients) and CSFTT non-responders (11 patients). Following CSFTT, CSFTT responders with eyes opened had a narrower base of support ($F = 6.141$, $p = 0.016$) and larger Romberg ratio ($F = 5.042$, $p = 0.029$) than CSFTT non-responders. In addition, CSFTT responders with eyes opened showed a lower peak and mean power spectral density in the mediolateral direction at low-frequency than CSFTT non-responders ($F = 12.022$, $p = 0.001$ vs. $F = 4.111$, $p = 0.047$). However, there were no significant differences in COP parameters after CSFTT among CSFTT non-responders.

CONCLUSIONS: In CSFTT responders, spontaneous sway during quiet standing with eyes opened improved after CSFTT.

MANAGEMENT OF A MASSIVE LATERAL MENINGOMYELOCELE AND HYDROCEPHALUS: A SURGICAL PERSPECTIVE AND LITERATURE OVERVIEW

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INTRODUCTION: Although they are quiet rare, lateral meningomyeloceles and meningoceles are challenging regarding their management. Usually they are associated with other craniofacial anomalies, connective tissue alterations or Neurofibromatosis. No definitive treatment plan or guideline is present regarding the paucity of reported cases.

CASE REPORT: The authors report here a case of a huge lateral meningomyelocele (largest reported in the literature) in a 3 months old young girl who was managed surgically with a favourable outcome. The patient was paraplegic since birth. A thorough review of literature was also done regarding similar cases. A Ventriculoperitoneal shunt (VP) was initially inserted with subsequent decrease in the size of the cyst. Re-enlargement of the sac was encountered within one week. A shunt revision followed by excision of the cystic swelling and repari were performed. Intraoperatively neural placode was found arising from a bifid spine from a slightly laterally rotated spine, reduced and the defect was repaired using muscle. On the 12 months follow up visit the patient is doing well with no recurrence of the sac or hydrocephalic symptoms.

CONCLUSION: Management of lateral meningomyeloceles or meningoceles depends widely on the size, age and clinical presentation. Surgical candidates may benefit from decompression with muscle or bone graft repair rather than decompression alone with treatment of the accompanying condition or cause.

DISTAL CATHETER MIGRATION IN VENTRICULOPERITONEAL SHUNT: GASTRIC PERFORATION AND SCROTAL MIGRATION – REPORT OF TWO UNCOMMON CASES

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INTRODUCTION: The ventriculoperitoneal shunt (VPS) is the most commonly used and preferred procedure in the management of hydrocephalus. Various methods for the introduction and fixation of the distal catheter exist, and possible complications include malposition, obstruction, and less frequently, migration, which can be internal, external, or combined. In this report, we present two cases of internal migration.

METHOD: In the first case (C1), a 70-year-old patient with a history of Von Hippel Lindau disease underwent multiple surgeries for cerebellar and suprasellar hemangioblastomas. Twelve years after the placement of a VPS, the patient presented to the emergency department with mammary cellulitis adjacent to the distal catheter of the VPS, which did not improve with antibiotics. Attempted removal and relocation of the distal catheter to the left side proved challenging due to adhesions.
In the second case (C2), a 2-year-old patient with a history of bilateral communicating hydrocele and congenital hydrocephalus associated with a left retrocerebellar cyst underwent uneventful VPS placement. After 10 months, the patient presented to the emergency department with an exacerbation of the hydroceles, and a radiographic examination confirmed the presence of the distal catheter in the right scrotum.

RESULTS: In C1, a thoracoabdominal tomography was performed, revealing intragastric positioning of the catheter. Endoscopic removal was necessary, and the patient received targeted antibiotic treatment based on commensal microbiota and P. mirabilis cultures, resulting in improvement. In C2, surgical intervention was performed for laparoscopic relocation of the distal catheter along with bilateral hydrocelectomy.

CONCLUSIONS: It is important to highlight that internal migration of the distal catheter in VPS is a rare but potentially serious complication due to the risk of intracranial infection, including meningitis, encephalitis, and/or ventriculitis. These two cases illustrate its clinical presentation and the challenges associated with its management.

GAIT IMPROVEMENT FOLLOWING CEREBROSPINAL FLUID TAP TEST IN NORMAL PRESSURE HYDROCEPHALUS PATIENTS WITH STRIATAL DOPAMINERGIC DEFICIT: A PRELIMINARY STUDY

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INTRODUCTION: Although dopamine transporter imaging is considered to show no striatal dopaminergic deficit in patients with normal pressure hydrocephalus (NPH), there have been reported cases of NPH patients exhibiting striatal dopaminergic deficit on dopamine transporter imaging. However, the extent of gait improvement following a cerebrospinal fluid (CSF) tap test in NPH patients with striatal dopaminergic deficit has not been comprehensively investigated.

METHODS: We assessed the walking speed of eight consecutive NPH patients, who had striatal dopaminergic deficit as determined by 18F-N-(3-fluoropropyl)-2β-carboxymethoxy-3β-(4-iodophenyl) nortropane (18F-FP-CIT) positron emission tomography (PET), before and after the CSF tap test using 3D gait analysis. A response to the CSF tap test was defined as an improvement of 10% or more in walking speed.

RESULTS: In the study population, a total of five patients (62.5%) demonstrated a response in walking speed, after undergoing the CSF tap test.

CONCLUSIONS: The findings from our preliminary study suggest that gait improvement can be achieved in more than half of NPH patients with striatal dopaminergic deficit as determined by 18F-FP-CIT PET. Further studies with larger sample sizes are needed to validate these results.

DOES THE INTENSIVE CARE MONITOR SHOW THE CORRECT INTRACRANIAL PRESSURE? COMPARISON OF MONITOR OUTPUT VALUES WITH RAW DATA FROM HIGH-FREQUENCY RECORDINGS

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INTRODUCTION: Monitoring of intracranial pressure is a standard procedure in the intensive care treatment of patients with certain morbidities. The processing of the underlying raw data is not standardized. Post-processing of the data in monitor systems by averaging and/or filtering may lead to significant deviations. The purpose of this study is to compare monitor output and raw data and to examine the suitability of conventional values to serve as a basis for clinical decisions.

METHODS: 39 patients from our ICU with ICH who had a complete 60-minute recording from 2 a.m. on the first day after probe implantation were included. ICP, BP, ECG, pulse oximetry, and various ventilation parameters were collected as raw data. Data were recorded at 100 Hz and automatically stored on a scientific server system. Similarly, the ICP output from the Draeger Infinity Delta XL system was recorded. The starting point of each ICP signal for all 39 data sets was identified and synchronized. Then, ICP was determined for each heartbeat from each waves area integral. The data collected was then compared with the monitor output data.

RESULTS: In 36 patients, significant differences are shown. The median differences are smaller than -2 mmHg in 8 of 39 patients (20.5%), which means that the ICP carrier monitor data are greater than the ICP area calculations by at least 2 mmHg in these patients. If we consider a limit of -1 mmHg then 13 of 39 patients (33.3%) are found in whom the monitor output data are at least 1 mmHg larger than the ICP area calculation.

CONCLUSIONS: The determination of the intracranial pressure using the area integral seems reasonable. The deviations shown in this study are probably due to the morphology of the pressure waves and the way they are processed by conventional monitoring systems.

SLIT VENTRICLE WITHOUT SUBDURAL HEMATOMA AFTER VENTRICULO-ATRIAL SHUNT FOR INPH

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INTRODUCTION: INPH can be treated only by the CSF shunting. One of the most common complications of CSF shunt is overdrainage. The overdrainage results in slit ventricle (SV) in the pediatric CSF shunting, whereas it usually causes subdural hematoma (SDH) in the shunting for iNPH. We retrospectively investigated the incidence and symptoms of SV without SDH after ventriculo-atrial shunt (VAS) for iNPH.

METHODS: We performed 1,023 VASs for iNPH from April, 2004 to March, 2021. Post-operative neuroimaging studies and symptoms were retrospectively investigated to find SV without SDH. Data were shown in mean (SD).

RESULTS: Mean age was 78.3 (6.8) years old (male: 78.1 (6.9), n= 545, female: 78.5 (6.7), n=478). Only four cases with SV without SDH were found. Case 1: Sixty-nine years old woman developed SV one year after the shunt (Codman Hakim Programmable Valve with siphon guard (CHPV-SG)) with excellent outcome. Case 2: Seventy-three years old woman developed SV one week after the shunt (CHPV-SG) without any deterioration. Case 3: Seventy-six years old woman developed SV six months after the shunt (Polaris SPVA-140) with excellent outcome. Case 4: Fifty-eight years old woman received ventriculo-peritoneal shunt (VPS) (Certas-plus) developed SV three months after the VPS with severe headache, involuntary movement, and consciousness disturbance. She received VAS (CHPV-SG) with abdominal catheter ligation one year after the VPS. Although she developed SV six months after the VAS she showed no neurological deterioration.

CONCLUSIONS: Despite male dominancy in our VAS series, all four cases were women. Slit ventricle is a serious complication in the pediatric shunting and in the VPS for iNPH as suggested by case 4. However, no serious deterioration was observed in SV after VAS for iNPH. This observation may suggest that VAS is safer than VPS for iNPH at least regarding to slit ventricle.

EARLY EMERGENCE OF ISOLATED FOURTH VENTRICLE FOLLOWING MENINGITIS IN ADULT: A CASE REPORT

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INTRODUCTION: An isolated fourth ventricle (IFV) is an uncommon phenomenon primarily described in children. Usually, it occurs with ventricular shunts placed for communicating hydrocephalus following hemorrhage or meningitis. We report an early emergence of IFV in an adult following hypervirulent Klebsiella pneumoniae (hvKP) meningitis, the approach to management, and the neurological outcome.

METHODS: We report the case of a 54-year-old woman with hvKP infection caused liver abscess, urinary tract infection, pneumonia, meningitis, and brain abscess. The central neurological system (CNS) infection management includes antibiotics for meningitis, external ventricle drainage for post-meningitis hydrocephalus, and suboccipital craniectomy for removed cerebellar abscesses. She developed early entrapment of the fourth ventricle and compartmentalized hydrocephalus. After controlling the CNS infection, we treated the patient with multiple shunt catheters, including fourth ventriculoperitoneal shunting.

RESULTS: She could go back home, but her daily activity was dependent. She was drowsy; Glasgow Coma Scale was 12/15 (E3, M6, V3), and was bedridden most of the time when six months after her discharge.

CONCLUSIONS: This rare case report serves as a reminder that IFV can emerge early in adults following hvKP CNS infection. Early identification of IFV following CNS infection requires high clinical vigilance. More frequent brain computed tomography can provide valuable information about the posterior fossa and ventricular system in high-risk patients. In general, surgical treatment of an isolated fourth ventricle requires the placement of a shunt catheter into the fourth ventricle.

ABMS-2 EVALUATION IN INPH DIAGNOSIS

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INTRODUCTION: Indicators that demonstrate high improbability in the treatment of idiopathic normal pressure hydrocephalus (iNPH) are required. There are cases where DESH is observed but does not improve even with LP shunt, so we consider ABMS-2, which quantifies basic motor ability, as a simple and useful indicator in addition to DESH findings. Based on our experience using ABMS-2 as an evaluation before and after the tap test, we discuss the usefulness of ABMS-2 in iNPH diagnosis.

METHODS: We conducted ABMS-2 evaluations on all 130 cases with DESH who underwent tap test between January 1 and December 31, 2018. We reviewed the outcomes of LP shunt in 92 cases with ABMS-2 scores of 30 points and in 38 cases with scores below 30 points, and discussed the usefulness of ABMS-2.

RESULTS: Of the 92 cases who underwent LP shunt with ABMS-2 score of 30 points, 45/47 (95.7%) were diagnosed with Definite iNPH. Of the 38 cases who underwent LP shunt with ABMS-2 score of less than 30 points, 21/24 (87.5%) were diagnosed with Definite iNPH.

CONCLUSIONS: iNPH is a disease of "treatable gait disturbance" and shunt surgery is a treatment aimed at "walking in daily life." ABMS-2 is a measure of the remaining motor ability and effort put into rehabilitation, and we consider it a useful indicator for analyzing movement in iNPH diagnosis, in addition to DESH, an image indicator that demonstrates high improbability.

THE IMPACT OF A STANDARDIZED SURGICAL PROTOCOL ON SHUNT REVISION IN PEOPLE WITH IDIOPATHIC INTRACRANIAL HYPERTENSION AND A PRE-EXISTING SHUNT.

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INTRODUCTION: Insertion of a ventriculoperitoneal (VP) shunt in people with idiopathic intracranial hypertension (IIH) is associated with high revision rates. A standardised surgical protocol at our centre significantly reduced revision rates for primary shunts. In this study, we examined the impact of the protocol in people with IIH who had a pre-existing shunt and underwent revision as per the protocol.

METHODS: We analysed data from consecutive patients who underwent VP shunt insertion for IIH since the implementation of the protocol in July 2019. The cohort was divided in two groups: those who underwent shunt insertion for the first time (primary group) and those with a pre-existing shunt that underwent revision (secondary group). We compared shunt failure between the groups, in order to assess the effectiveness of the protocol in revision surgery.

RESULTS: Eighty-eight patients underwent VP shunt insertion during 45 months. Seventy-four had primary shunt and 14 had a pre-existing shunt and underwent shunt surgery based on the protocol. Thirty-day revision rate was 5.4% in the primary vs. 7.1% in the secondary group (p= 0.6). For patients that had completed 1 year follow up, 5/62 in the primary and 4/11 in the secondary group underwent revision (8.1% vs 36.4%, p= 0.02). Overall, 8 patients from the primary (10.8%) and 4 from the secondary group (29%) required revision (p= 0.09) during the study period. In the primary group half of the revisions were due to proximal underdrainage and in the secondary group the majority was due to distal catheter complications.

CONCLUSIONS: Revision surgery is more challenging and our standardized IIH shunt protocol demonstrated favourable revision rates in IIH patients with a pre-existing shunt requiring revision. Our study supports the use of a standardized surgical protocol when inserting shunts for IIH.

INFLAMMATORY MARKERS AS PREDICTORS OF SHUNT DEPENDENCY AND FUNCTIONAL OUTCOME IN PATIENTS WITH ANEURYSMAL SUBARACHNOID HEMORRHAGE

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INTRODUCTION: The mechanisms underlying posthemorrhagic hydrocephalus (PHH) development following subarachnoid hemorrhage (SAH) are not fully understood. This complicates informed clinical decision regarding duration of external ventricular drain (EVD) treatment and prevents prediction of shunt-dependency in the individual patient. The aim of this study was to identify potential inflammatory cerebrospinal fluid (CSF) biomarkers of PHH, and thus shunt-dependency, and functional outcome in patients with SAH.

METHODS: In this prospective observational study patients with SAH who required an EVD between June 2019 and September 2021 at the Department of Neurosurgery, The Neuroscience Centre, Copenhagen University Hospital – Rigshospitalet, Copenhagen, Denmark, were sought included. Oral and written informed consent were obtained from all patients or next of kin depending on the capacity of the patients. CSF samples were collected twice from each patient and analyzed for 92 inflammatory markers by proximity extension assay (PEA) and the prognostic ability of the markers was investigated using area under the curve (AUC) estimates from a receiver operating curve (ROC).

RESULTS: CSF was collected from 31 patients with SAH, with 12 of these developing PHH while 19 were weaned of their EVD. Their 6-month functional outcome was determined with the modified Rankin Scale (mRS). Of the 92 analyzed inflammatory biomarkers, seven markers (SCF, OPG, LAP TGFβ1, Flt3L, FGF19, CST5, and CSF1) were found to be predictors of shunt dependency, and four markers (TNFα, CXCL5, CCL20 and IL8) were found to be predictors of functional outcome.

CONCLUSIONS: Here, we identified promising inflammatory biomarkers able to predict i) the functional outcome in patients with SAH and ii) development of PHH, and thus the shunt dependency of the individual patients. These inflammatory markers may have the potential to be employed as predictive biomarkers of shunt dependency and functional outcome following SAH and could as such be applied in the clinic.

RISK FACTORS FOR SLIT VENTRICLE IN THE HYDROCEPHALUS CHILDREN TREATED WITH VENTRICULO-PERITONEAL SHUNT

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INTRODUCTION: The study analyzes the reasons for slit ventricle (SV) related ventriculo-peritoneal (VP) shunt failure in pediatric patients with hydrocephalus.

METHODS: The study included patients treated at Yamaguchi University Hospital from 1991 – 2022. The initial VP shunts were placed in patients aged 6 days to 14 years (mean age: 1.6 ± 3.0 years). Follow-up periods ranged from 6 months to 27 years. The VP shunts were revised due to SV syndrome or SV related catheter obstruction in 19 patients (SV group). The shunts functioned until the final follow-up day in 39 patients (Control group). The patients with shunt malfunction not related to SV (n = 40) were excluded. Age at surgery, type of hydrocephalus (communicating or non-communicating), absence of brain atrophy, pressure setting of the shunt valve, and implantation of an anti-siphon device were compared between the groups.

RESULTS: The age at surgery in the SV group was 0.7 ± 1.1 years which was significantly younger than that in the Control group at 2.6 ± 4.3 years ($p < 0.05$). The absence of brain atrophy was 94.7% in SV and 51.3% in the Control groups ($p < 0.01$). None of the non-communicating hydrocephalus, low-pressure valve, or no use of anti-siphon device significantly affected the shunt malfunction. Among the 19 patients in SV group, 3 patients developed free from shunt due to compensation hydrocephalus. The other 16 patients received shunt revision with anti-siphon devices, and no shunt malfunction recurred for 12.8 ± 7.6 years.

CONCLUSIONS: Shunts implanted in infancy and in no atrophic brain were the risk factors for SV related shunt malfunction. Type of hydrocephalus and shunt system did not significantly influence shunt malfunction. Anti-siphon device did not prevent SV; however, it did prevent recurrence of SV related shunt malfunction.

NON-INVASIVE ASSESSMENT OF INTRACRANIAL PRESSURE AMONG OUTPATIENT SUBJECTS

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INTRODUCTION: Currently, the diagnosis and monitoring of conditions associated with chronic intracranial hypertension, such as pseudotumor cerebri, depends on lumbar puncture, an invasive and uncomfortable procedure. A novel non-invasive technology that assesses intracranial pressure (ICP) waveform has shown promising results in estimating ICP and intracranial compliance (ICC) among neurocritical patients. In this research, we aimed to evaluate the accuracy of this technology in detecting high ICP among outpatient individuals.

METHODS: Cross-sectional study which enrolled adult outpatient subjects referred by their physicians for cerebrospinal fluid (CSF) analysis through lumbar puncture. Subjects were assessed through the non-invasive device in horizontal decubitus, and waveform-related variables P2/P1, area (A) and time-to-peak (TTP) were measured. Sequentially, the patients underwent lumbar tap in lateral horizontal decubitus. Opening (Po) and closing pressures, and total extracted CSF volume, were registered, and correlated with the waveform-related variables.

RESULTS: Ninety-one subjects were included, 51% were female and mean age was 46.9±15.4. Intracranial hypertension (Po>25cmH2O) was observed in 22.1%. Mean waveform area was smaller among individuals with intracranial hypertension (0.0108) than those without (0.0165, p<0.009). No significant differences were observed for TTP and P2/P1 variables between these groups. An A<0.010 was able to detect high intracranial pressure with 62.4% sensitivity, 64.3% specificity, and an area under curve of 0.661 (CI95% 0.543-0.778).

CONCLUSIONS: The area of the waveform obtained by the non-invasive device may be useful in identifying high ICP among outpatient individuals. However further studies are necessary to assess whether other waveform-related variables or their combination may improve the technology's accuracy.

SYNDROMIC VALIDITY OF INPH

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INTRODUCTION: Hydrocephalus is a disease due to active distension of brain's ventricles resulting from altered CSF circulation. Idiopathic normal pressure hydrocephalus (iNPH) is characterized by a set of core clinical and imaging features (resp. gait, cognitive, urinary dysfunctions and enlarged ventricle). But the evaluation of iNPH is anchored in the description of clinical and imaging phenomena (i.e. phenomenology) that frame the diagnostic process, rather than the characterization of actual root-causes (i.e. aetiology) that ascertain disease identification. iNPH as a disease is often misleading due to the lack of standardized assessments for positive and differential diagnoses. iNPH should be regarded as a syndrome, a set of symptoms suggesting the presence of a certain disease, that take also in account heterogeneity and temporal complexity of neurodegenerative diseases. We would like to provide arguments about the syndromic validity of iNPH.

RESULTS: We identified consistent literature-based evidences of:

1. High prevalence of cardiovascular disease in iNPH patients, suggesting an overlap between iNPH syndrome and vascular dementia.

2. High prevalence of Alzheimer disease in iNPH patients, suggesting an overlap between iNPH syndrome and Alzheimer disease.

3. High prevalence of bradykinesia, akinetic symptoms and sometimes dopaminergic dysfunction in iNPH patients, suggesting an overlap between iNPH syndrome and Parkinson syndrome.

4. The presence of other diseases does not significantly influence the short-term clinical response to shunt.

5. But the presence of other diseases may significantly influence the long-term clinical response to shunt.

This figure emphasizes the required combinatorial framework for identifying commonalities and diversification within the subtypes of neurodegenerative diseases.

METHODS: We reviewed published literature about comorbidities of iNPH in the landscape of neurodegenerative disease and movement disorders.

CONCLUSIONS: Despite decades of research, the etiopathogenesis underlying iNPH as a disease is still poorly understood. We provide a rationale for partial validation of the syndromic validity of iNPH.

LONG-TERM FUNCTIONALITY AND REVISION RATE OF TWO DIFFERENT SHUNT VALVES IN PEDIATRIC AND ADULT PATIENTS

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INTRODUCTION: A frequent therapy of hydrocephalus is implantation of ventriculoperitoneal shunts. We compared two adjustable valves, proGAV and proGAV 2.0, for complications resulting in revision surgery during follow up.

METHODS: The study evaluated 400 patients who received a primary shunt implantation between 2014 and 2020. Factors such as patient demographics, hydrocephalus etiology, implantation site, prior cerebrospinal fluid diversion, and revision cause were considered to determine overall revision rate, one-year revision rate, and revision-free survival.

RESULTS: Of 400 patients (female/male 208/192), 99 patients underwent revision surgery after primary implantation. ProGAV valve was implanted in 283 patients, proGAV 2.0 valves in 117 patients. There was no significant difference between concerning revision rate (p=0.8069), one-year revision rate (p=0.9077), revision free survival (p=0.6921) and overall survival (p=0.3232). Regarding one-year revision rate, we observed no significant difference between the two shunt valves in pediatric patients (40.7% vs 27.6%; p=0.2247). Revision operation had to be performed more frequently in pediatric patients (46.6% vs 24.8%; p=0.0093) with a significant higher number of total revisions with proGAV than proGAV 2.0 (33 of 59 implanted shunts [55.9%] vs. 8 of 29 implanted shunts [27.6%]; p=0.0110) most likely due to longer follow-up in the proGAV-group.

CONCLUSIONS: According to the target variables we analyzed, aside from lifetime revision rate in pediatric patients there is no significant difference between the two shunt valves.

KEY CONCEPTS IN MIN: APPLICATION IN COMPLEX HYDROCEPHALUS

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INTRODUCTION: In the „Key-Concept", we ask for the keys in MIN rather than for the key-holes. Complex hydrocephaly are excellent indications for MIN. The pathology is not incurable, but surgical realization is very difficult, needing the spectrum of key-techniques of MIN. The extreme case is the preterm with very small space conditions and immature tissue additional already traumatized by birth and bleedings.

METHODS: This MIN concept combined 5 MIN-key techniques to assist microneurosurgery: high-end neuro-sonography with small probes („burr-hole-probe 8x8mm, ALOKA/ Hitachi) and mouth-tracking of the microscope, both mandatory. Additionally, we added endoscopy (Wolf, Aesculap, Storz) and LASER (Th-YAG Revolix). Sealing technique (Tachosil/ Takeda) is always used. Combination of techniques were used in each case individually.

RESULTS: This observative series presents 6 cases which each needed a different combination of MIN-Key-Techniques. Most of the mayor conditions for complex hydrocephalus are represented by a case. In all cases a shunt could be avoided, in the preterm at least during the early 6 months. In all cases the combination of techniques enabled very precise individually adapted MIN approaches. The two preterm with fatal prognosis also went home finally.

CONCLUSIONS: Application of MIN-Key-Concepts enabled good results in difficult complex hydrocephalus cases. Combination of Key-Techniques individually in each case allow application in many causes of complex hydrocephaly. This MIN concept and techniques increases the therapeutic options and need to be further examined by research and studies.

Ref.: KDM Resch; Key Concepts in MIN, Vol. 1+2, 2020,2022/ Springer

NORMAL PRESSURE HYDROCEPHALUS AND CEREBRAL ATROPHY: A SCOPING REVIEW

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INTRODUCTION: This scoping review aims to investigate the diagnostic tools and evidence available in differentiating Normal Pressure Hydrocephalus (NPH) from cerebral atrophy. The variable aetiology of NPH, as well as the higher incidence of comorbidities in the ageing population has posed long-term challenges in diagnosing and managing those patients. A scoping review on studies that mention NPH, atrophy and relevant clinic-radiological comorbidities will provide an overview and structure for future research priorities.

METHODS: We conducted a scoping review following the PRISMA January-June 2022. We searched Pubmed, Cochrane, Web of Science, Embase and Scopus. Search terms included normal pressure hydrocephalus and cerebral atrophy, biomarkers and magnetic resonance imaging. We included studies of adult humans investigated for idiopathic or secondary NPH in all languages.

RESULTS: We assessed 13391 articles and included 6. Cerebral Blood Flow has been reviewed separately. CSF biomarkers, fluid dynamics, structural and diffusion imaging have been used to characterise NPH, atrophy and other dementias. Reporting of criteria, clinical presentation and factors influencing diagnosis and shunt treatment showed high variability in reporting and may pose significant challenges in future evidence synthesis.

CONCLUSIONS: Emphasis on a combination of structural and mechanistic studies in assessing NPH with current clinical and scientific tools is essential. Separating surgical treatment and outcomes from pathophysiological and diagnostic investigations as an initial approach may help expand availability of patient cohorts and decrease heterogeneity in reporting.

MINIMAL INVASIVE NEUROSURGERY (MIN) AND OPHTHALMOLOGY: OBSERVATION SERIES OF COMPLEX HYDROCEPHALUS CASES

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INTRODUCTION: Preservation of visual function can be optimized in selective cases only by close cooperation of ophthalmology and MIN. The cases are an in-homogenous series and complex. The analysis of the ophthalmological outcomes to prove the effect of functional recovery by minimal invasive neurosurgical procedures (MIN) enclosed 11 cases of tumor-/ liquor dynamics-diseases, in all cases causing disturbance of visual function.

METHODS: This concept combined 5 MIN-key techniques to assist microneurosurgery: high-end neuro-sonography with small probes, mouth-tracking of the microscope -both mandatory-, endoscopy and LASER. Sealing technique was always used. Ophthalmological standard techniques were perioperatively used to meticulously document ophthalmological functions. Visual acuity, 30°-visual field, RNFL and fundoscopy were examined as the patients´ condition did allow so.

RESULTS: In the tumor-/ liquor dynamics-disease group were 4 males and 7 females. Reasons of the liquor- pathway-obstruction were: 7 tumors, 2 cyst, 6 obstructive hydrocephaly, 2 post-ICH cases and 4 very complex cases. Seven of them were emergency cases regarding "last minute cases" in preservation of visual function. In both groups, fast visual function recovery could be documented. MIN techniques and ophthalmological examinations differ in relation of the patients´ individual conditions.

CONCLUSIONS: Close cooperation of neurosurgery and ophthalmology can preserve visual functions even in emergency cases. Ophthalmological examination-techniques may support the indication making as well as outcomes analysis as an excellent model to show functional recovery after MIN procedures. Ophthalmology plays in this context the rule of an emergency indicator. A close to the patients and an individual management came out to be necessary.

TECHNICAL ANALYSIS OF HYDROCEPHALUS SHUNT REVISIONS: HOW MIETHKE INVESTIGATES? WHAT DO WE LEARN? THE IMPORTANCE OF DATA FOR PATIENTS, CLINICS & INDUSTRY!

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INTRODUCTION: The importance of data is globally obvious. The aim of this work is to highlight the learning outcome and importance of data collection regarding technical analysis of revised shunts for the Hydrocephalus society (patients, clinics and industry).

METHODS: The methods of technical analysis and data collection of examination results of returned products have been redesigned over the last years. In addition, the data collected has been analyzed.

RESULTS: Derived from feedback of neurosurgeons and technical analysis of revised shunts MIETHKE started research projects and developed the valve generation 2.0. Technical analysis show a significant improvement for the MIETHKE valve generation 2.0. But still highlights side effects of the treatment of hydrocephalus by shunting. Thus analysis are driving forces for innovation but also point out a further need for innovation. Results show a correlation regarding patient age and deposits in revised valves. Furthermore 48% of suspected reasons for the malfunction were not confirmed and 32% of the products investigated worked within all product specifications.

CONCLUSIONS: Technical analysis of revised shunts open another part of the black box of shunt revisions. This work highlights the importance of looking at all possible aspects to provide further insights for the hydrocephalus community, particularly patients, neurosurgeons and engineers. A more complete data set of shunt revisions including patient's quality of life on a European (better global) basis is needed. Insights from shunt revision can rise learning curves for neurosurgeons and engineers. In addition, further innovations can be driven by newly gained knowledge.

SHUNT-DEPENDENT POST-TRAUMATIC HYDROCEPHALUS: PREDICTORS AND LONG-TERM FUNCTIONAL OUTCOMES

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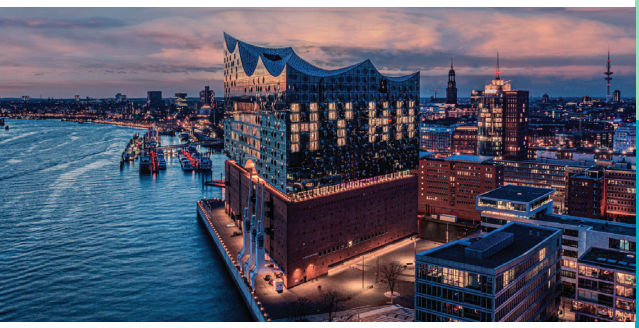
INTRODUCTION: Traumatic brain injury (TBI) is a leading cause of morbidity and mortality in children and adolescents. Post-traumatic hydrocephalus (PTH) is a frequent and serious complication of TBI with may lead to neurocognitive impairment, motor dysfunction, and growth impairment. However, the effect of shunt dependence on long-term functional outcomes is incompletely understood.

METHODS: In this study, 6279 patients between 2012 and 2022 were included in our study. Univariable logistic regression analyses were performed to identify factors significantly associated with shunt-dependent hydrocephalus, and unfavorable functional outcomes. Kaplan-Meier and Log-Rank test was performed to identify the occurrence time of shunt-dependent hydrocephalus.

RESULTS: Of the 6279 PTH patients, 327 developed shunt-dependent hydrocephalus (5.2%). We identified several risk factors for the development of shunt-dependent hydrocephalus including DC (decompressive craniectomy), EVD (externalventricular drain), low GCS (Glasgow Coma Scale), craniotomy, longer initial hospital stay, diabetes, and intracerebral hematoma ($p<0.01$). We also analyzed the factors of unfavorable outcomes after TBI including >80 years, repeated operations, hypertension, EVD, tracheotomy, and epilepsy ($p<0.01$). VPS itself is not an independent factor of the unfavorable outcome but shunt complication is a strong independent factor of unfavorable outcome($p<0.05$).

CONCLUSIONS: Therefore, practices for minimizing risks of shunt complications should be emphasized. Patients with an elevated risk for developing PTH may also benefit from more rigorous clinical and radiographic surveillance.



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Exhibition Area

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"The journey of a game-changing development: From ideas to space"

Speaker 2:
Lewis Thorne, MD
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Involvement of the patient's experience in adult hydrocephalus care – pearls and pitfalls

Introduction
Mats Tullberg, *Professor and Senior Consultant in Neurology, Director of Gothenburg Hydrocephalus Research Unit, UNIVERSITY OF GOTHENBURG, Sahlgrenska Academy, Institute of neuroscience and physiology, Department of clinical neuroscience and Sahlgrenska University Hospital, SWEDEN*

Patient reported measures in health care – an overview. PROM, HRQOL, LIFE-SATISFACTION
Giorgio Palandri *Senior consultant neurosurgeon, Pro-Hydro research team, IRCCS Institute of Neurological Sciences of Bologna, Department of Neurosurgery, Bellaria Hospital, Bologna, ITALY*

What do the patients want the profession to do? Establishing ranked priorities for future hydrocephalus research.
Monica Chau, *PhD, National Director of Research, Hydrocephalus Association, Bethesda, USA*

Use of PROM in assessment of outcome in iNPH – a German experience
Joachim Oertel, *Professor of Neurosurgery, Faculty of Medicine, University of Saarland, Director Department of Neurosurgery, Saarland University Hospital, Homburg, Germany*

Pitfalls – Objective measures vs PROMs
Mats Tullberg, *Professor and Senior Consultant in Neurology, Director of Gothenburg Hydrocephalus Research Unit, UNIVERSITY OF GOTHENBURG, Sahlgrenska Academy, Institute of neuroscience and physiology, Department of clinical neuroscience and Sahlgrenska University Hospital, SWEDEN*

Future perspectives. How can we increase patient involvement? Does HRQOL instruments really measure QOL? Do we need instruments designed for hydrocephalus patients?
Panel Discussion

Monday, 28 August 2023, 12:30 – 13:30, Hall G

SOPHYSA
At the heart of the brain

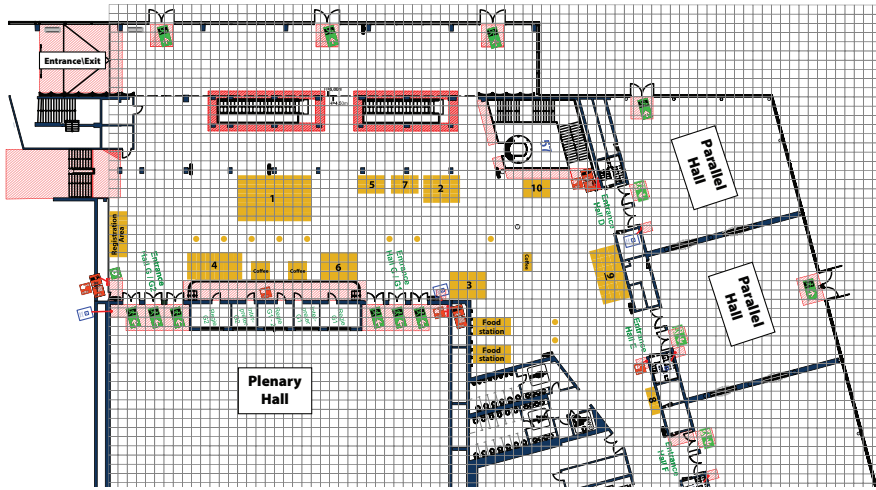
Technical guidance to avoid common pitfalls & refocus on hydrocephalus physiological essence
Drawn on 1000+ clinical cases

Alexandra VALLET, PhD
Department of mathematics, University of Oslo, Norwa

Doctor Guillaume COLL
Clermont-Ferrand Hospital France

Professor Stephane GOUTAGNY
Paris Cité University Paris Hospitals Public Assistance Paris, France

Exhibition Floor Plan



1	Integra	40m²	4	Medtronic	18m²	7	HpBio	6m²
2	Moeller/Spiegelber	12m²	5	Sophysa	6m²	8	EANS Congress	3m²
3	Aesculap	12m²	6	Surgiwear	12m²	9	Rhaeos	18m²
						10	Brain4Care	6m²

Additional Information

Secretariat & Information Desk
The Secretariat Desk will be located at the Meeting Venue and will operate:

Friday, 25 August 2023, 14:00 – 18:00
Saturday, 26 August 2023, 07:00 – 17:00
Sunday, 27 August 2023, 08:00 – 17:00
Monday, 28 August 2023, 07:30 – 16:00

Name Badge
The Name Badge needs to be worn to get access to the Meeting's sessions and its events.

Internet Facilities
WI-FI connection is provided at the Meeting premises.

Publication

Publications Management: ARTION Conferences & Events

For any further information please contact the Meeting Secretariat.

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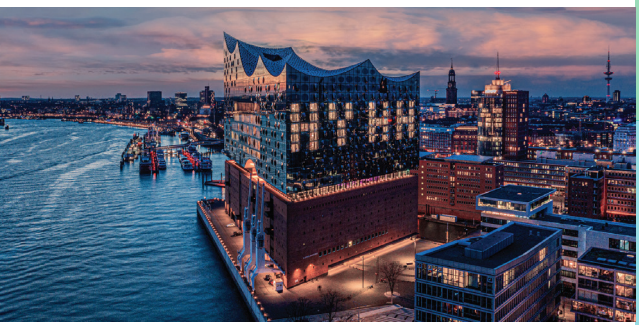

Hydrocephalus2023

Hamburg, Germany | **Aug 25-28**

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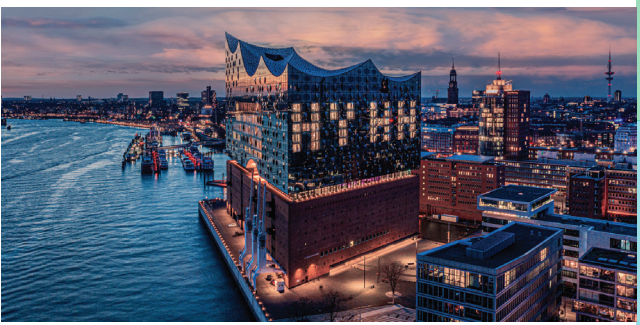

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