Hydrocephalus Workflow UK

Lewis Thorne

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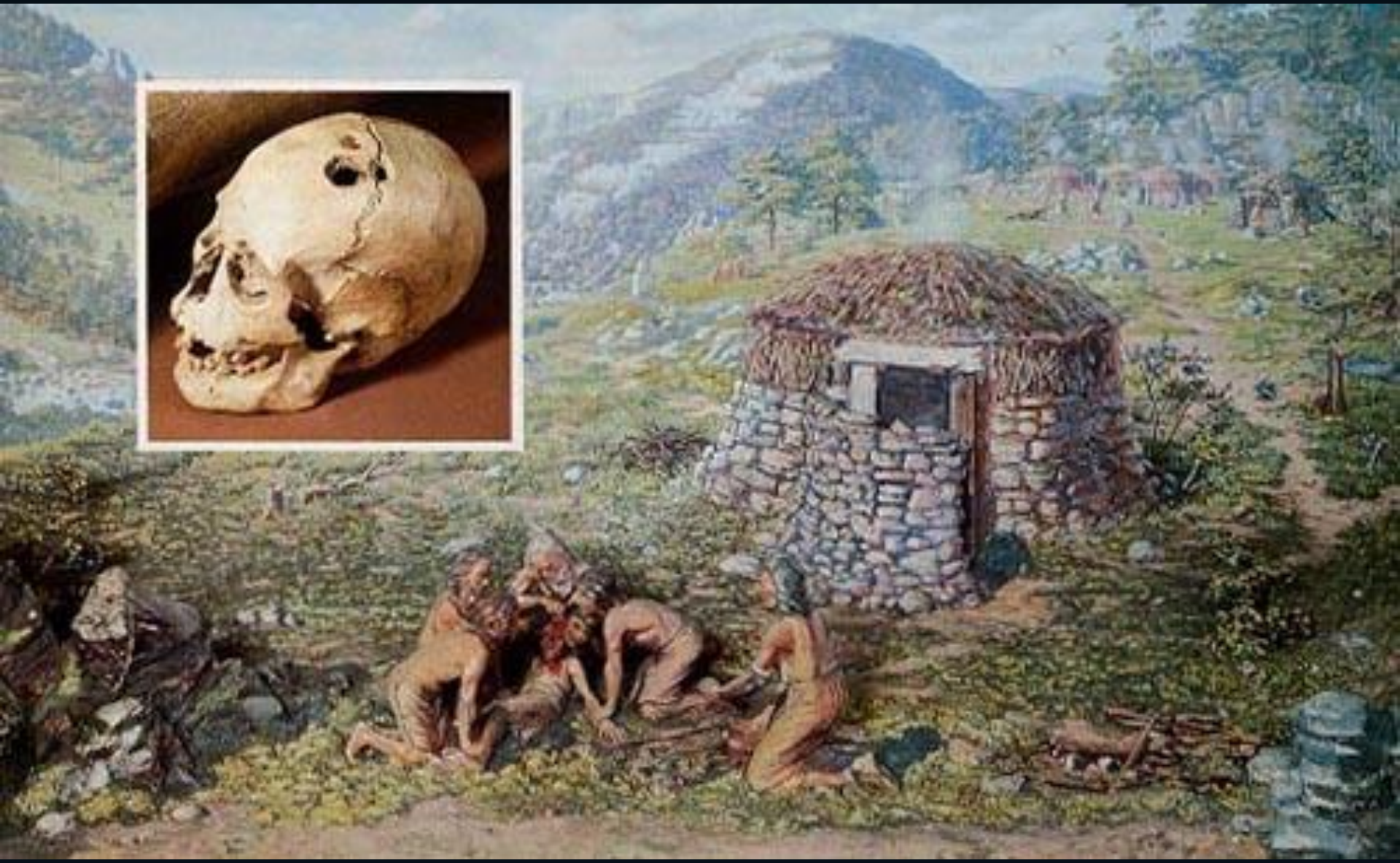
Disclosures

- Honorarium B Braun



Current State

- Quality
  - Team Working
  - Standardization
  - Research
  - Patient Optimization
- Sustainability
  - Future Proofing

Current State

- Quality
  - Specialization
  - Team Working
  - Standardization
  - Research
  - Patient Optimization

Risk of infection after cerebrospinal fluid shunt: an analysis of 884 first-time shunts

B M Borgbjerg [1], F Gjerris, M J Albeck, S E Børgesen

Affiliations + expand

PMID: 8748819 DOI: 10.1007/BF01411427

884 first-time shunted patients 1958-1989
The overall infection rate for all implanted CSF shunts was 7.4% (5.7-9.3%) and the acute rate of infection was 6.2% (4.6-7.9%).

	Standard shunt	Antibiotic shunt	Silver shunt	Total
Surgeries				
Patients eligible for primary outcome*	533	535	526	1594
No shunt removal or revision	403 (76%)	403 (75%)	390 (74%)	1196 (75%)
Shunt removal or revision (for any cause)	130 (24%)	132 (25%)	136 (26%)	398 (25%)
Reason for revision as classified by central review				
Patients revised for infection	32 (6%)	12 (2%)	31 (6%)	75 (5%)
CSF or peritoneal infection				
Definite (culture-positive)	22/32 (69%)	6/12 (50%)	25/31 (81%)	53/75 (71%)
Probable (culture-uncertain)	1/32 (3%)	..	2/31 (6%)	3/75 (4%)
Probable (culture-negative)	3/32 (9%)	3/12 (25%)	1/31 (3%)	7/75 (9%)
Possible (culture-uncertain)	1/32 (3%)	..	1/31 (3%)	2/75 (3%)
Clinically classified infection†	1/32 (3%)	..	..	1/75 (1%)
Shunt deep incisional infection	4/32 (13%)	3/12 (25%)	2/31 (6%)	9/75 (12%)
Patients revised for other reason (no infection)	98 (18%)	120 (22%)	105 (20%)	323 (20%)
Reason for shunt revision as classified by treating neurosurgeon				
Suspected infection	33 (6%)	15 (3%)	30 (6%)	78 (5%)
Revision for other reason (no infection)	97 (18%)	117 (22%)	106 (20%)	320 (20%)

Data are n, n (%), or n/N (%) of patients. *Randomised participants who did not receive a shunt (n=4) and had infection at time of insertion (n=7) were excluded from the primary outcome set (figure 1). †In one case the committee was unable to classify the infection, so the infection was clinically identified from the case report forms.

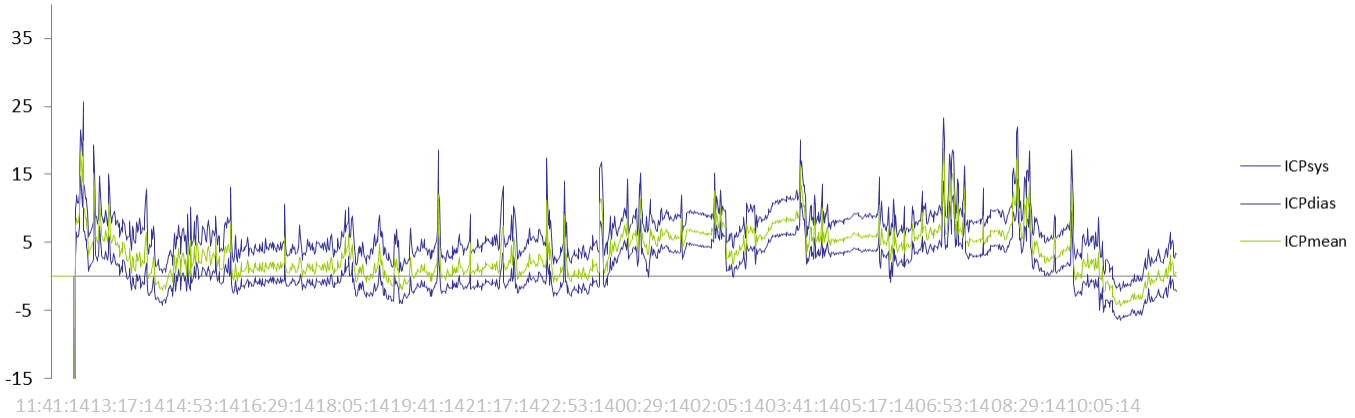
Table 2: **Summary and reasons for revision of first shunt according to catheter type and assessor**

Work to do: shunts still fail

	Age group							
	Paediatric		Up to 65 years		Over 65 years		Total	
	N	%	N	%	N	%	N	%
Eligible for primary outcome [1]	592	.	499	.	503	.	1594	.
No shunt removal/revision	367	62.0	381	76.4	448	89.1	1196	74.5
Revision for other reason (no infection)	178	30.1	95	19.0	50	9.9	323	20.3
Revision for infection	47	7.9	23	4.6	5	1.0	75	4.7

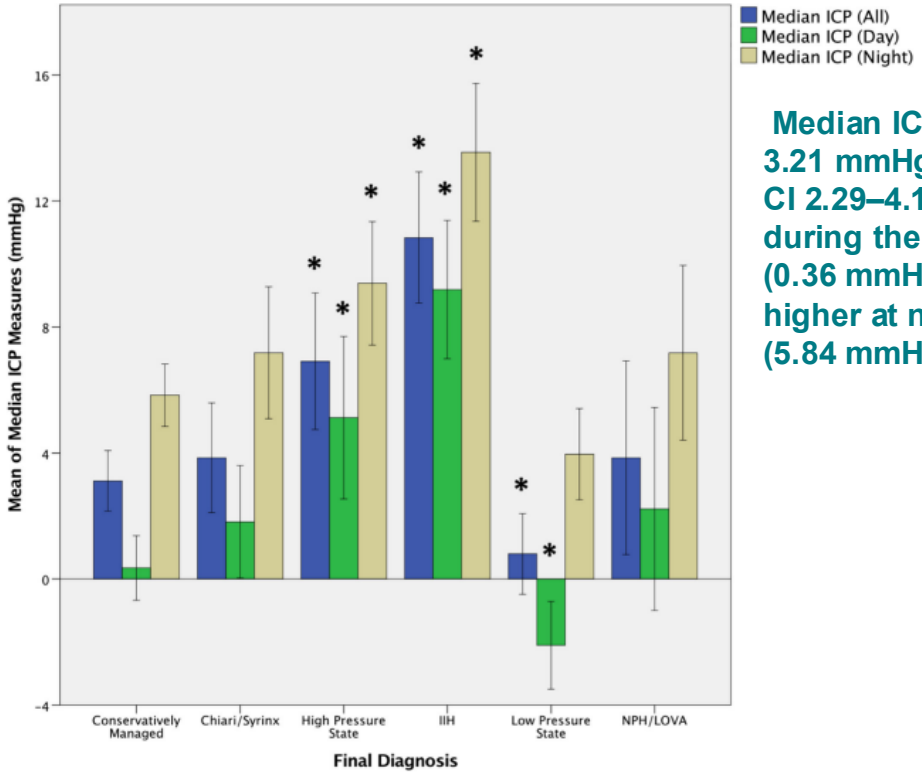
So What Actually is Hydrocephalus?

What Actually is Normal: ICP



Time period	Median Sys	Median Dias	Median ICP	Median Pulse Amp	Peak ICP	Trough ICP	%age Negative ICP	No ICP spikes >25/hr	%ICP > 15	PIP	Indirect com-pliance	PIP at greatest x hour variance
All	6.2705	0.42165	2.9665	5.2175	25.69	-162.6	13%	1	1%	-0.452	-ve	6h -0.765
Day	5.0025	-0.54745	1.8605	5.4095	25.69	-162.6	7%	1	1%	-0.760	-ve	3h -0.829
Night	8.8295	3.811	5.9495	4.7905	20.07	-0.9041	0%	0	0%	0.266	>4	

Insight into ICP and PA in healthy individuals



Median ICP in this population was 3.21 mmHg (95% CI 2.29–4.13), with this being lower during the day (0.36 mmHg, 95% CI -0.62 - 1.34) and higher at night (5.84 mmHg, 95% CI 4.90–6.78)

What Actually is Normal: CSF Production

Cerebrospinal Fluid Production Rate In Various Pathological Conditions: A Preliminary Study

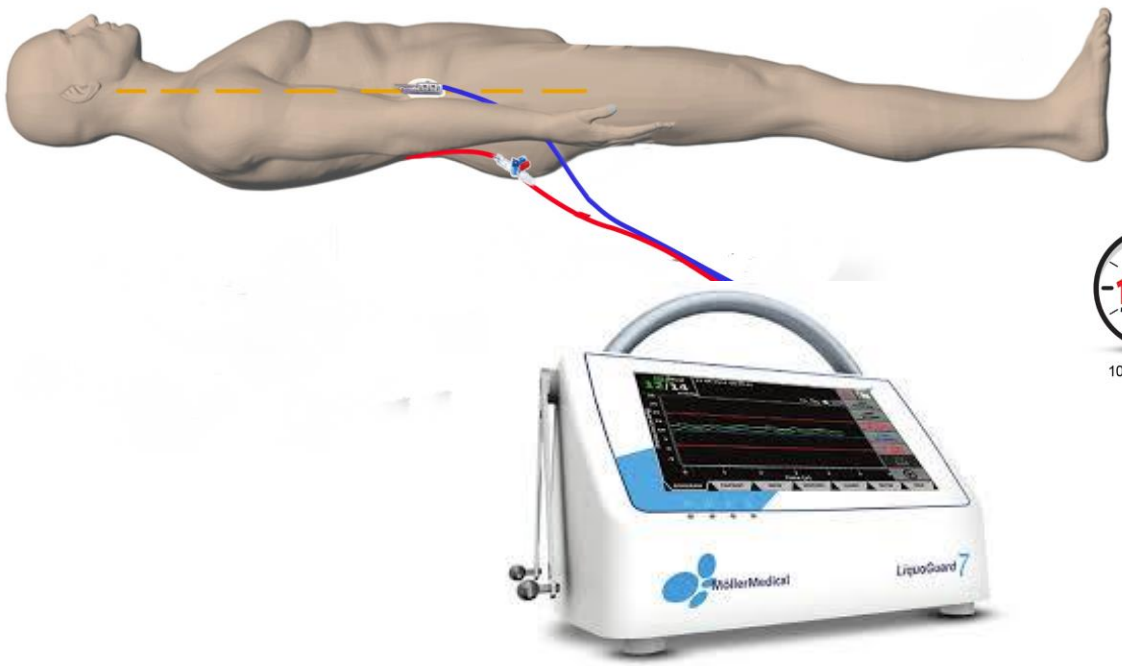
Dr Kanza Tariq, Mr Ahmed Toma, Mr Lewis Thorne, Ms Sogha Khuwari, Ms Meriem Amarouche, Mr Laurence Watkins

National Hospital for Neurology and Neurosurgery, Queen Square, London, U.K

Methods

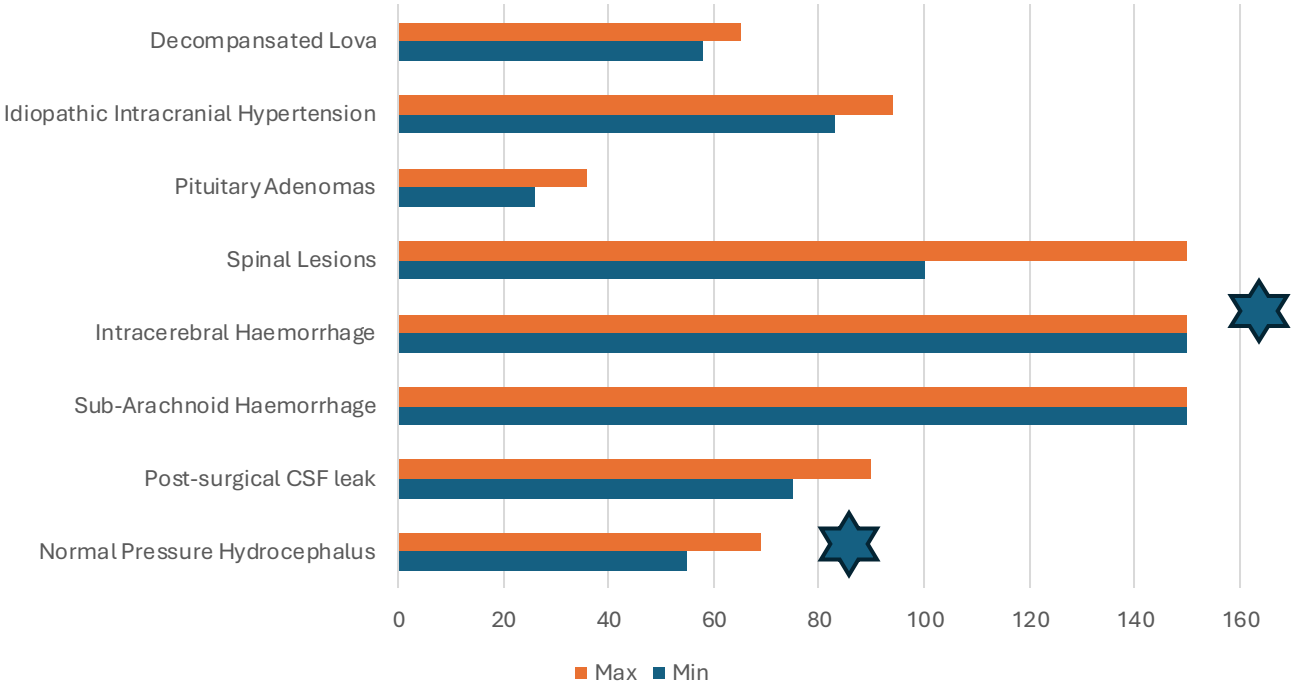
We performed a prospective observational study in all patients in our hospital who required CSF drainage as part of their ongoing treatment.

Statistical analysis used SPSS (version 25.0, IBM) by paired t-test, comparing measured rates to normal CSF production rates calculated and published by Ekstedt (16-34ml/hour).



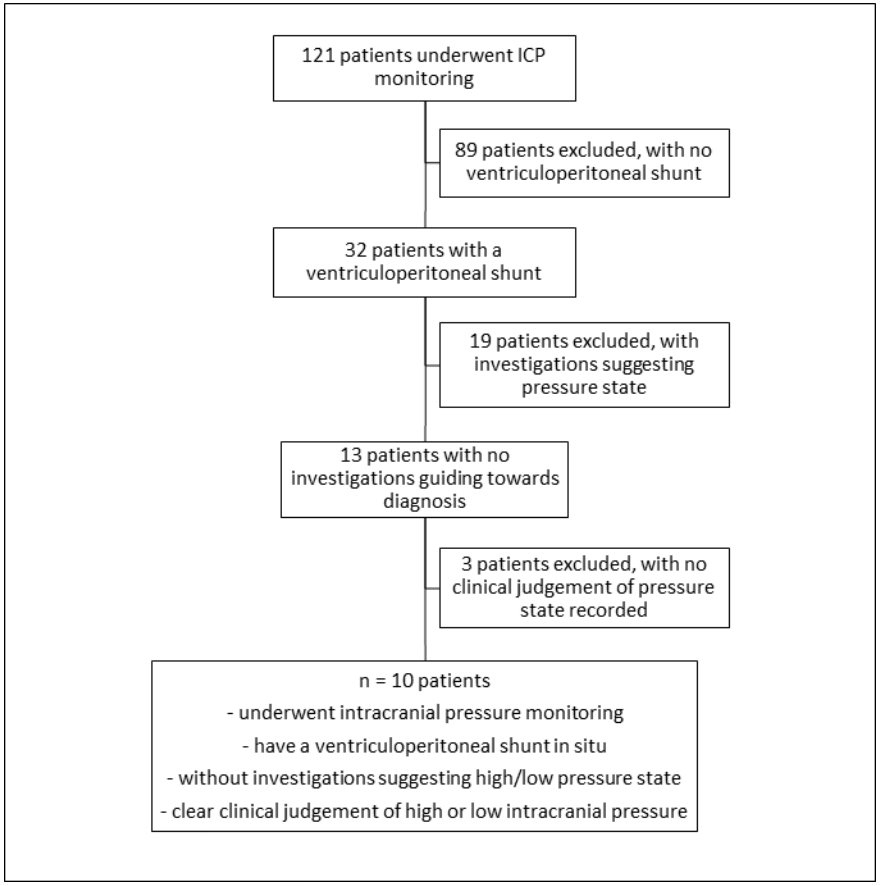
10 Minute Timer

Results



Graph1: Range of PRcsf in various pathological conditions

Optimizing Patients: Intracranial Pressure Based on Clinical Symptoms



High suggested intracranial pressure words. Common words used in clinic letters with clinical suspicion of high intracranial pressure state. Word Visualisation Tool from www.edwordle.net

Low suggested intracranial pressure words. Common words used in clinic letters with clinical suspicion of low intracranial pressure state. Word Visualisation Tool from www.edwordle.net

Correct clinical prediction 1 out of 10 cases

Clinical Prediction of ICP state	Wording Used	Actual ICP state	Median ICP (mmHg)	Correct Clinical Suspicion	Patient Outcome
Low	Low pressure headaches when standing	Normal	-1.3	No	Shunt revision to add telesensor
High	Headaches worse in the mornings and when bending over, suggesting raised ICP	Normal	0.0	No	Sleep study referral
Low	Low pressure headaches, worse with upright positions	Normal	0.5	No	No intervention
Low	Progressive headaches suggesting raised ICP	Normal	0.9	No	Neurology headache referral
High	Headaches worse when standing	Normal	0.9	No	Autonomics referral
High	Features of raised intracranial pressure, headaches worse when leaning forward	Normal	2.9	No	No intervention
Low	Headache improves when lying flat, patient may be over-draining	Normal	4.0	No	Neurology headache referral
Low	Postural headaches suggestive of over-drainage	Normal	4.4	No	Neurology headache referral
High	Recurrent raised pressure headache, worse in the mornings	**High**	7.8	**Yes**	Shunt revision
Low	Positional headache worse on standing	**High**	10.0	No	Shunt revision

Towards Personalised Medicine

Paradoxical effect of valve setting adjustment on ICP

D'Antona L[1], Thompson S[1], Chari A[1], Craven C[1], Funnell J[1], Thorne L[1,2], Watkins LD[1], Toma AK[1,2]

[1]The **National Hospital for Neurology and Neurosurgery**, London, UK

[2]The **Wellington hospital**, London, UK

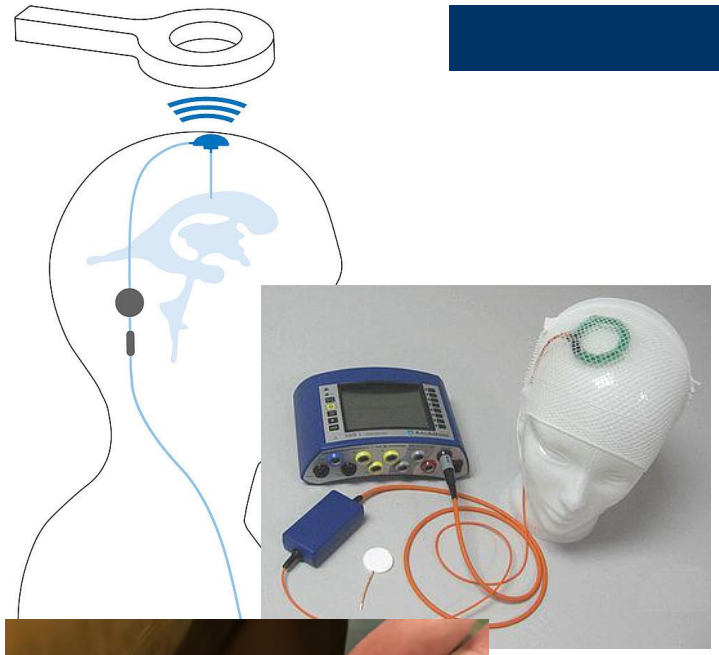
Paradoxical effect

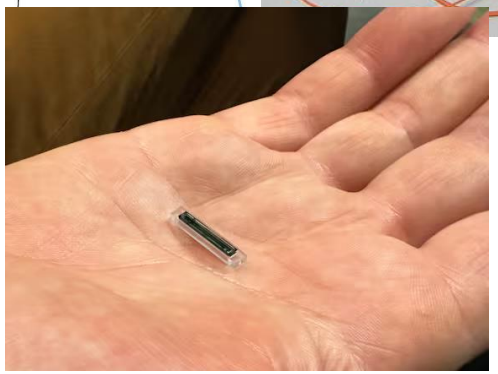
	Valve setting direction	24 hours median ICP direction	N.	Tot N. (%)
			25	**51 (68%)**
			26	
			14	**24 (32%)**
			10	

Median ICP and pulse amplitude change

mm Hg	Mean Valve setting change (SD)	ICP change: Mean of the 24 hours medians change (SD)	Range median 24 hours ICP change	Mean pulse amplitude change (SD)	Range pulse amplitude change
All cases	-0.06 (± 4.3)	-0.06 (± 3.24)	-8.1 to +9.48	-0.1 (± 1.4)	-6.8 to +4.5
Valve setting UP	3.2 (± 2.6)	0`9 (± 2.5)	-3.5 to 5.6	0.1 (± 0.9)	-4.1 to +2
Valve setting DOWN	-3.6 (± 2.5)	-1.1 (± 3.6)	-8.1 to 9.5	-3.5 (± 1.7)	-6.8 to 4.5

Dealing with uncertainty: Telemetry

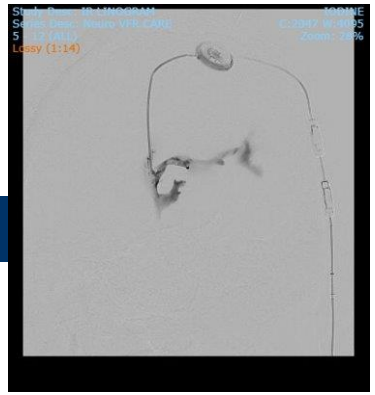




Facilitates routine, non-invasive ICP measurement

The cost of hardware must be outweighed by improvements to management and reductions in service use

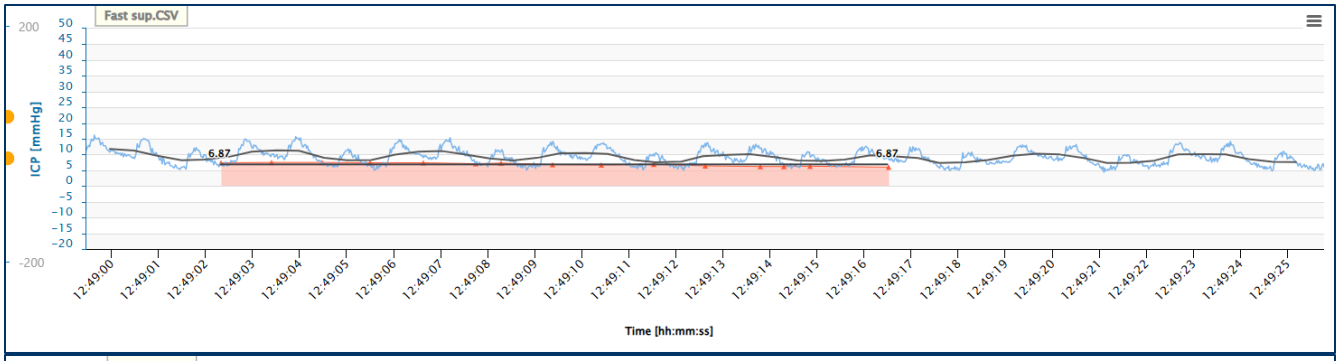
Towards Rapid Optimization

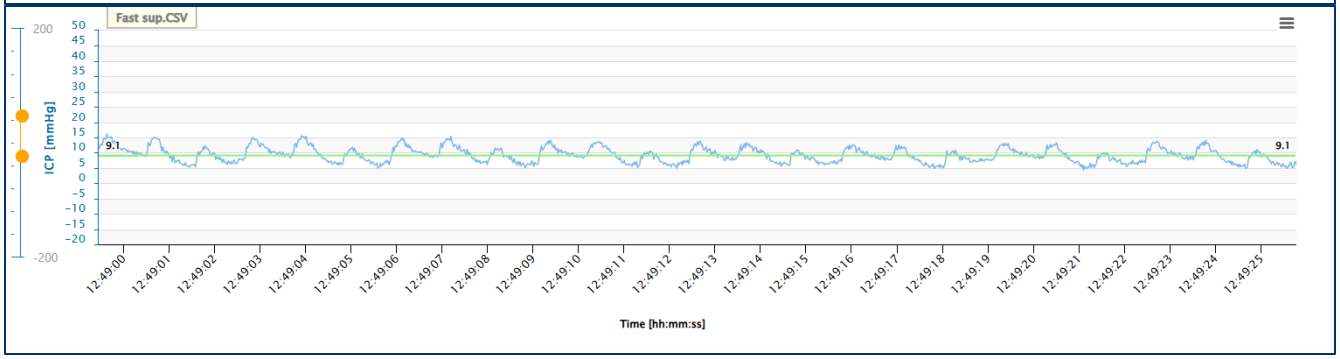


Pre TAP

	Seconds	steps		Median Pressure	Median amplitude
Normal Speed	44	55	Sitting	-9.9	3.94
Fastest Speed	18	32	Supine	9.1	6.89

Amplitude



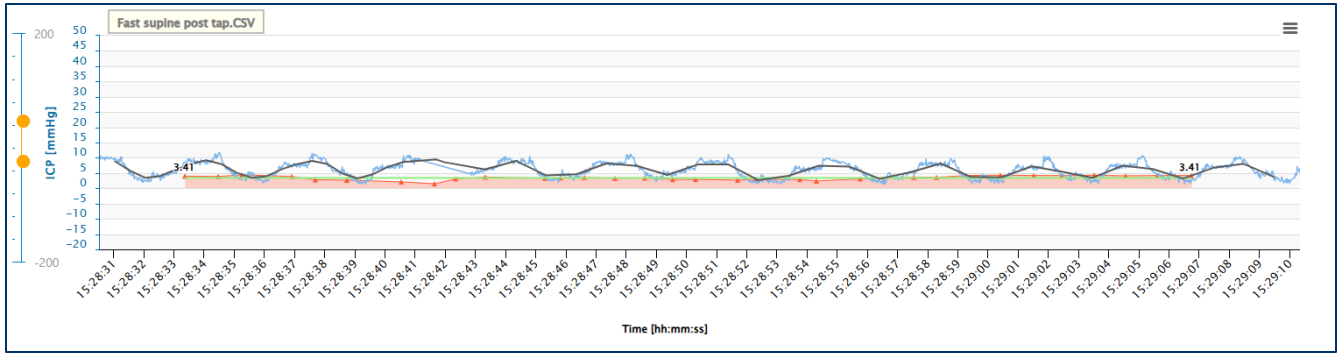


Pressure

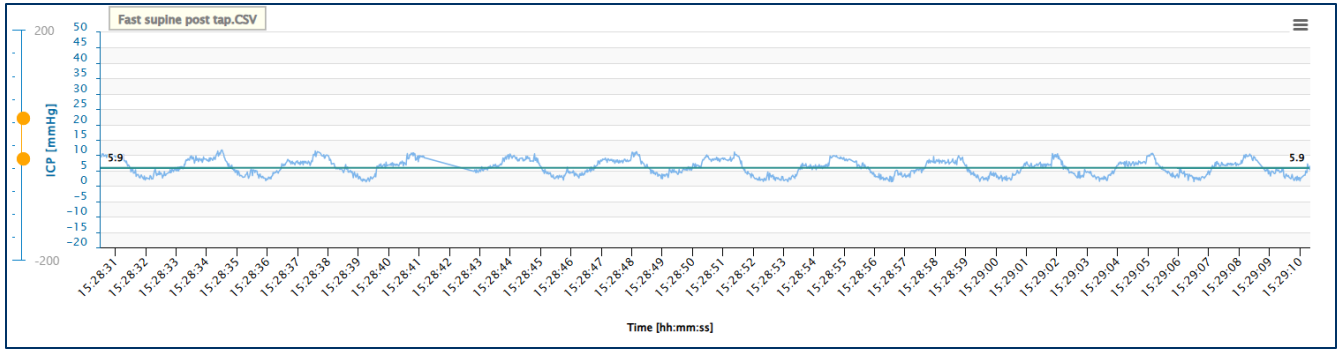
PA To determine shunt settings?

Post TAP

	Seconds	steps		Median Pressure	Median amplitude
Normal Speed	23	32	Sitting	-7.8	3.28
Fastest Speed	12.5	22	Supine	5.9	3.41



Amplitude

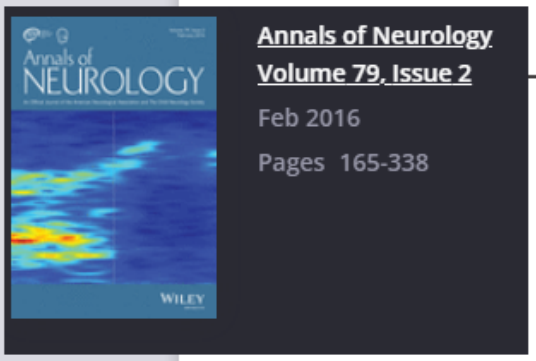


Pressure

OVERALL SERVICE COST

	24m -	18m -	12m -	6m -	- 6m	- 12m	- 18m	- 24m
ICPM	45	25	57	83	13	7	0	10
Other procedure	8	40	35	30	17	7	0	16
NS outpatient	186	187	213	242	340	227	222	169
Neurology	106	198	147	118	97	92	110	79
Ophthalmology	9	2	9	10	10	8	7	6
A&E	25	13	32	17	15	12	0	14
MRI scans	48	69	68	70	61	62	46	114
CT scans	49	57	80	76	70	39	14	69
X-Rays	88	52	95	52	45	45	39	74
Total	565	644	736	698	668	499	437	552

Future Proofing: iNPH



Annals of Neurology
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Pages 165-338

EDITORIAL

'…shunting procedure often works well if the patient has the classic triad of cognitive and gait impairment and incontinence due to hydrocephalus as a sequel to a previous episode of meningitis or subarachnoid hemorrhage'

The Emperor Has No Clothes

In the story, "The Emperor's New Clothes," a pompous Emperor is tricked by his tailor into accepting a suit made of a marvelous new fabric that is very sheer. The Emperor walks down the street proudly accepting compliments on his new clothes from his courtiers until a me
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"upgraded the strength of evidence" for a positive effect "from very low to low" because 95% of subjects reported "subjective improvement" (although there was no control for a placebo response). The Guideline then goes on to assess whether various tests for cerebrospinal fluid (CSF)

At a minimum, I think it should be a prospective study, with rigorous objective measurements of cognitive function, gait, and if possible, continence. All subjects should have enlarged ventricles on scan with evidence of CSF transependymal resorption, no history of antecedent meningitis or subarachnoid hemorrhage, and a CSF opening pressure of 18cm H_2O or less. The evaluation of the response should be done double-blinded. This could be accomplished in shunting procedures very simply by the neurosurgeon not turning the valve on after the shunt is installed. There would be a preoperative

risk of a serious adverse response such
toma or a shunt infection in the first
not a benign intervention. We shoul
procedure to at least as high a standar
would hold a drug, and if shunting p
were a drug, no one would be doing t

Clifford B. Saper, MD, PhD
Editor-in-Chief

The Response: Yes

- 14 patients randomized to open or closed shunts. At 3/12 patients with ligated shunts had their shunts opened.
- Patients with open shunts improved, 30% motor and 23% psychometric scores
- Those with initially ligated shunts were unchanged but improved in both motor (28%) and cognitive (18%) functions following removal of the ligature.

J Neurosurg 114:1432–1438, 2011

Shunt surgery in patients with hydrocephalus and white matter changes

Clinical article

Magnus Tisell, M.D., Ph.D., Mats Tullberg, M.D., Ph.D., Per Hellström, M.Sc., Mikael Edsbagge, M.D., Mats Högfeldt, M.D., and Carsten Wikkelsö, M.D., Ph.D.

Hydrocephalus Research Unit, Institute of Neuroscience and Physiology, The Sahlgrenska Academy, University of Gothenburg, Sweden

Research paper

Normal pressure hydrocephalus: long-term outcome after shunt surgery

S Pujari,[1] S Kharkar,[2,3,4] P Metellus,[3] J Shuck,[3,4] M A Williams,[2,4] D Rigamonti[3,4]

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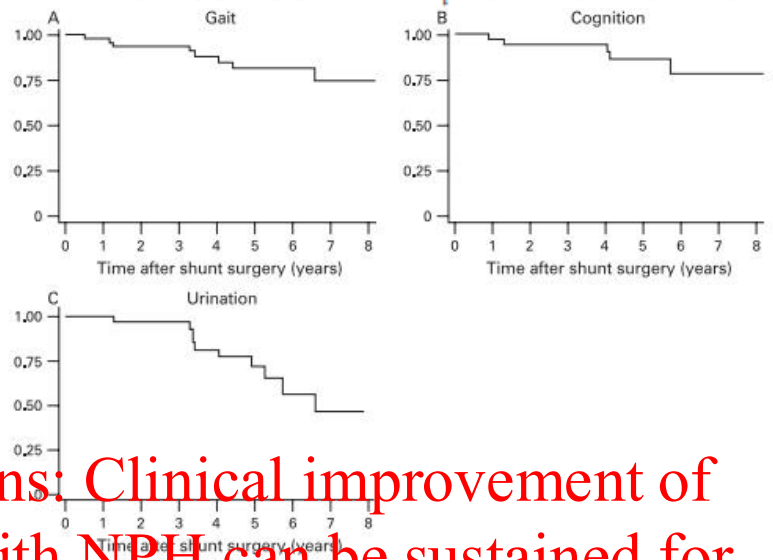
ABSTRACT

Background/objective: Little is known about the long-term clinical course and management of patients with normal pressure hydrocephalus (NPH) treated by cerebrospinal fluid (CSF) shunting.

Methods: We re
patients diagnose
treated with CSF
more than 3 year
each annual follov
Folstein Mini Mer
evaluation of gait
gait or urination, a

Results: The me
years. There was
among all sympto
tenance of impro
and 87% at the l
cognition showed
86%, respectively
least improvemen

Figure 3 First episode of deterioration in patients who had shown initial improvement in that symptom after their original shunt surgery.

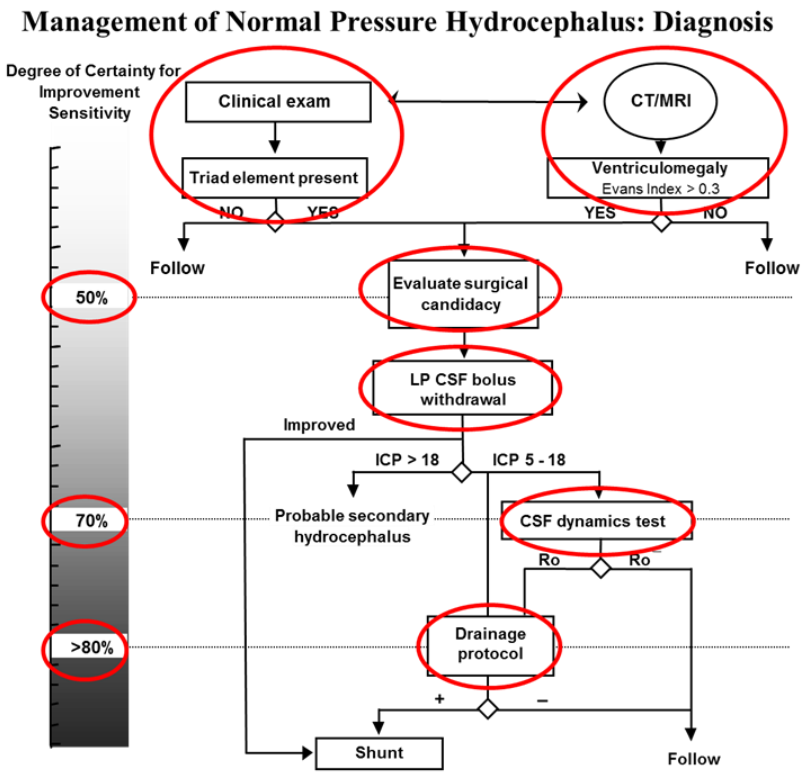


leading to absorption defect. Whereas secondary NPH can present at any age, INPH usually presents in the sixth or seventh decade of life.[7–9]

The mainstay of therapy for NPH is CSF diversion via a ventriculoperitoneal or ventriculoa-

Conclusions: Clinical improvement of patients with NPH can be sustained for 5–7 years in some patients with NPH

How (not) to Diagnose NPH



Provocative Testing Takes Too Long

- 15 VP shunt patients (2/12 sample)
- mean age 75.6 (±3.8) years
- Mean lead time between referral and VP shunting was 321(±104) days.
  - 17(±16) days between referral sending and receipt,
  - 62(±22) days 229(±75) days until shunt surgery.
- Patients undergoing extended lumbar drainage (LD) protocol waited 249 days from referral to shunting
- 188 days for those who proceeded directly to shunt

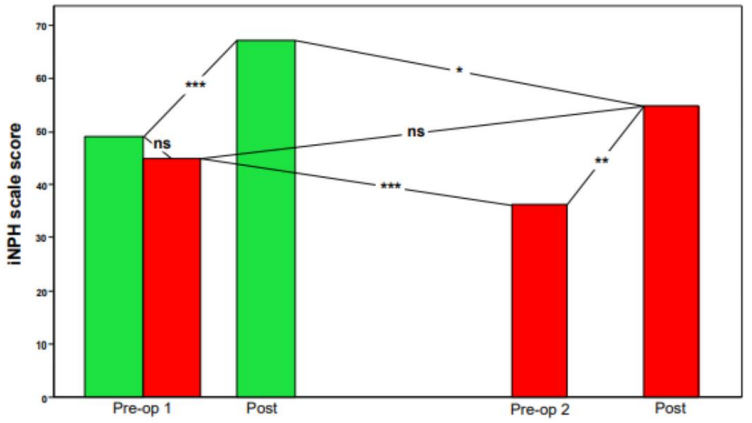
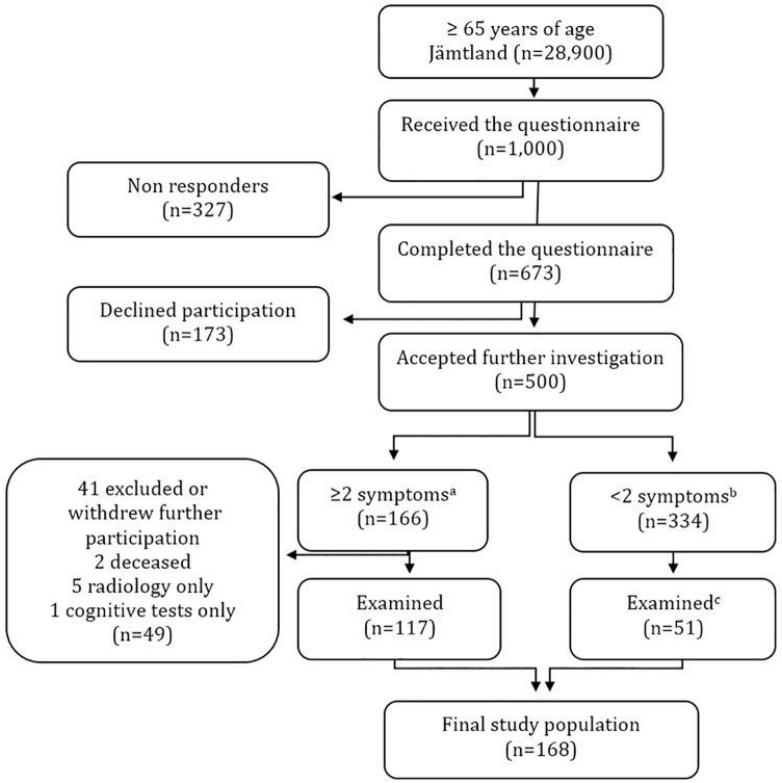


***Figure 7**: Development in total iNPH scale score for iNPH patients with 6-24 months delayed shunt surgery, $iNPH_{Delayed}$ (red bars), and iNPH patients with surgery within 3 months from diagnosis, $iNPH_{Early}$ (green bars).*
p<0.05, **p<0.01, *<0.001; ns, not significant*
Reprinted from Journal of Neurology, Neurosurgery and Psychiatry, 2014 Jul;85(7):806-10, Andrén et al, Natural course of idiopathic normal pressure hydrocephalus, copyright (2014), with permission from BMJ.

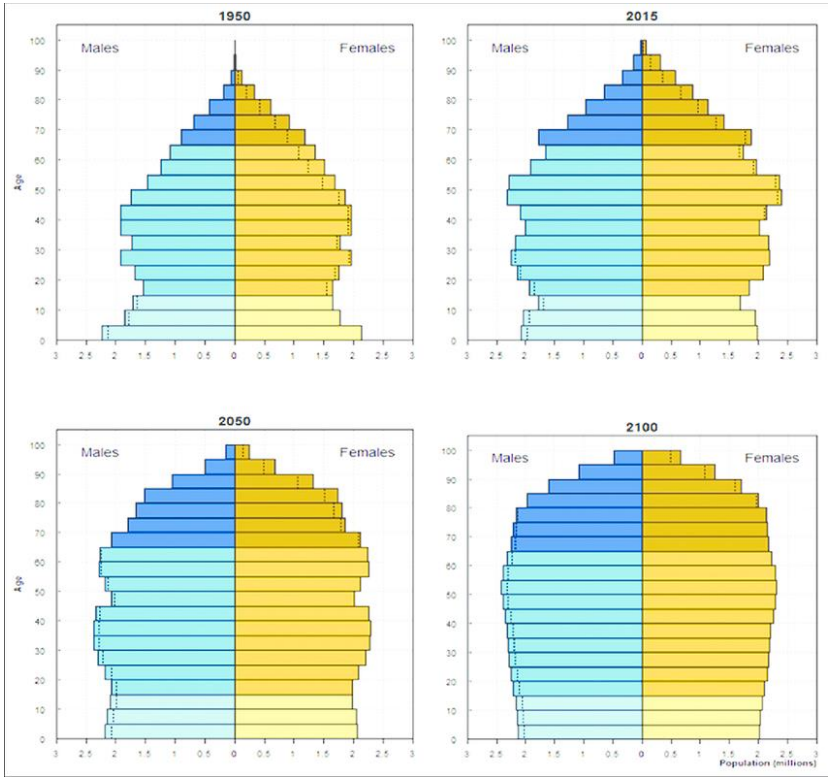
Provocative Testing is Resource Intensive…

- Estimated prevalence of iNPH among individuals 65 years and older was 3.7%
- iNPH was four times as common among those aged 80 years and older (8.9%) than among those younger than 80 years (2.1%)



…and Impractical at Scale

- 18% UK population >65 yr: 11,816,649 (+ 800,000 pa)
- 3.7% ~ 430,000 (+ 29,600 pa)
- 2016/17 243,000 joint replacements in Eng/Wal/NI
- Avg 217 VP shunt/yr over ten years for iNPH UK



Provocative Testing is not Accurate

PAPER

Comparison between the lumbar infusion and CSF tap tests to predict outcome after shunt surgery in suspected normal pressure hydrocephalus

B Kahlon, G Sundbärg, S Rehncrona

- 81% shunted cases improved
- 84% of these were LIT +ve but only 42% were CSFTT +ve

- CSFTT positive predictive value was 94%
- LIT positive predictive value was 80% and more sensitive

Kahlon et al. JNNP 2002

PAPER

The value of temporary external lumbar CSF drainage in predicting the outcome of shunting on normal pressure hydrocephalus

R Walchenbach, E Geiger, R T W M Thomeer, J A L Vanneste

- CSFTT positive predictive value 100%
- CSFTT negative predictive value 32%

- ELD positive predictive value 87%
- ELD negative predictive value 36%

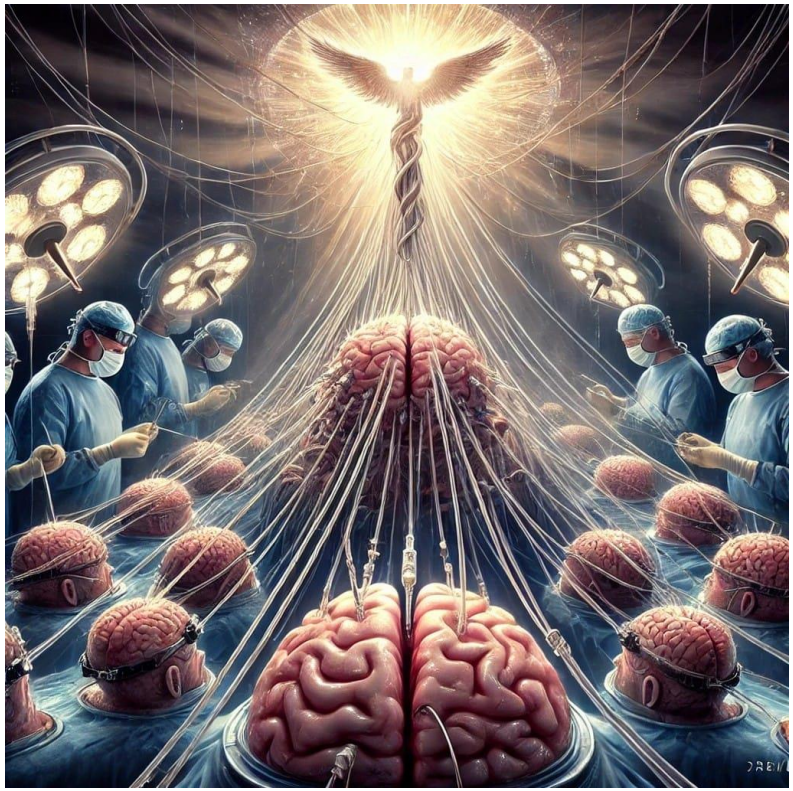
Walchenbach et al. JNNP 2002

Provocative Testing is not Needed

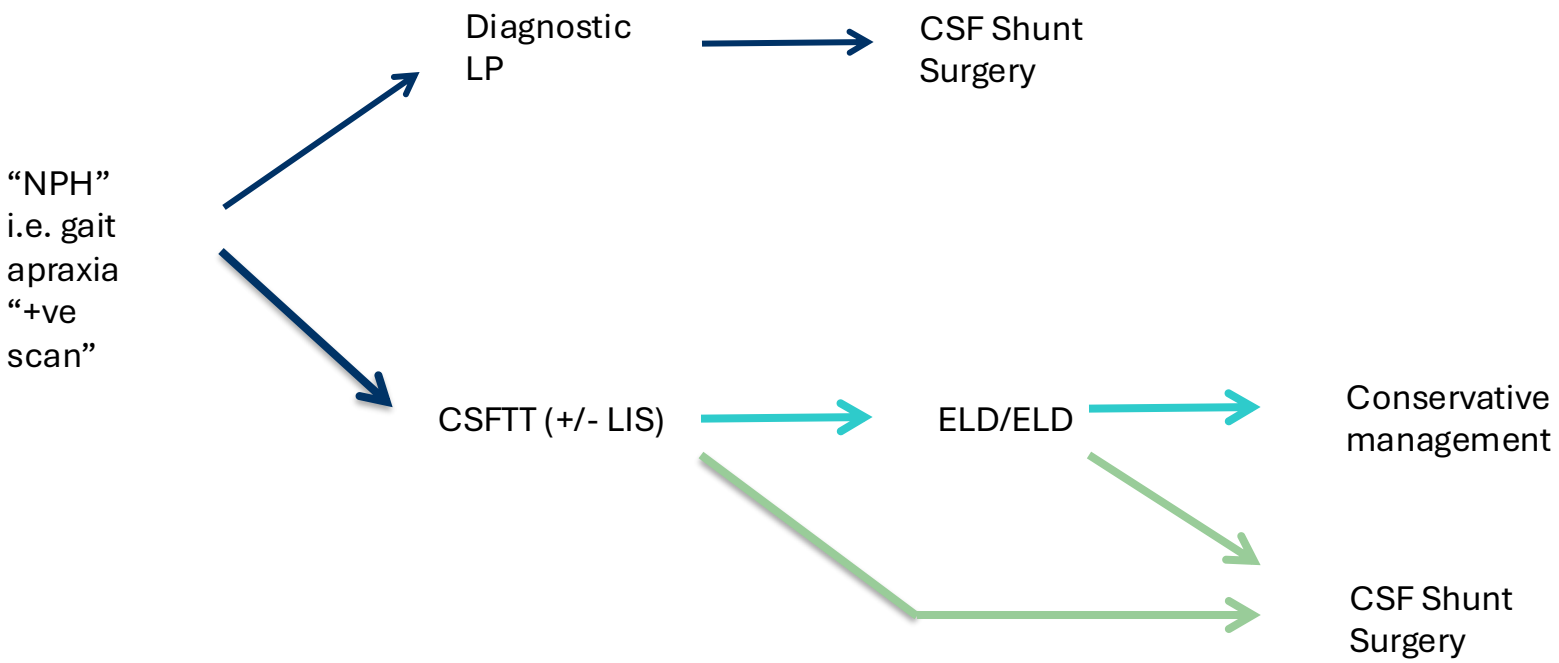
- (DESH)…worthwhile for the diagnosis of iNPH
- Study of iNPH on neurological improvement (SINPHONI) 2010

Summary

- Shunting is effective in most with iNPH with gait impairment
- Predictive tests are good when positive
- Predictive tests are not good when negative
- Practice persists with slow iterative process
- Current practice not compatible with potential future workload



Pragmatic UK NPH Trial (PUNT)



Primary Goals

- Show straight to shunt has therapeutic equivalence with current practice
- Reduces time to treatment
- Improves quality of life
- Improves equity and service
- Reduces complications
- Reduces treatment cost

Secondary Goals

- Patients with specific radiological criteria have a favourable outcome
- Patients with specific neurodegenerative or hydrocephalic profiles have a less/more favourable outcome
- Incorporate AI and mathematical modelling to predict shunt outcome