Venous Sinus Stenosis Phantom

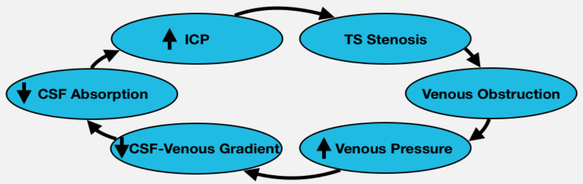
Keerthi Valluru, MS[1], Thomas Shen, MS[2], Kevin O'Reilly, BS[1], Henrik Haraldsson, PhD[1], Evan Kao, PhD[1], Joseph Leach, MD, PhD[1], Alexandra Wright, MD[1], Megan Ballweber, BS[1], Karl Meisel, MD[3], David Saloner, PhD[1], Matthew Amans, MD[1]

[1]UCSF Department of Radiology and Biomedical Imaging, [2]UC Davis School of Medicine, [3]UCSF Department of Neurology

INTRODUCTION

Idiopathic intracranial hypertension (IIH)

- Elevated intracranial pressure (ICP) with no clear cause [1]
- Results in stenosed venous transverse sinus (TS) [2]
- Stenosis causes pulsatile tinnitus [1]



Treatment – Venous Sinus Stenting (VSS)

- Performed when the intravascular pressure (IVP) gradient across the stenosis is above 8 mmHg [3]
- 10.3% revision surgery rate [4]
- Most common reason for revision is the occurrence of a new stenosis upstream of the stent [5]
- There is currently no standardized criteria for the selection of stents to be used in this procedure; they are used off-label

OBJECTIVE

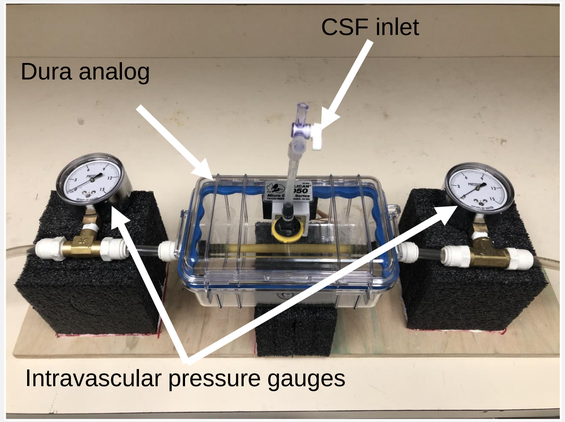
To create a model which can simulate the conditions in the transverse sinus and intracranial space which create a venous sinus stenosis. This model can be used to optimize stent selection in order to minimize the revision surgery rate.

MATERIALS

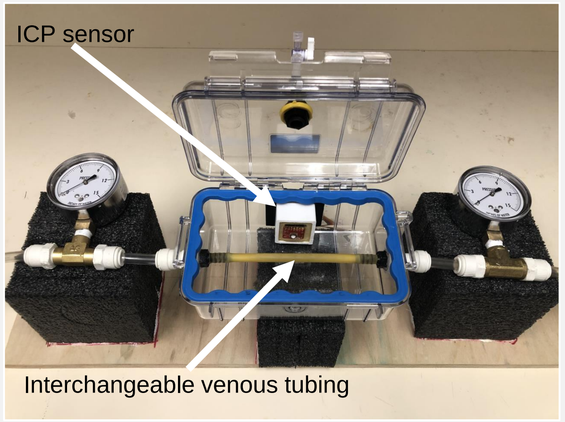
- Phantom consisting of a transverse sinus model (interchangeable flexible tubing) mounted inside a rigid walled vessel (1050 Micro Case, Pelican Products, Inc., Torrance, CA)
- Several thin-walled tubing materials (transverse sinus model): Silicone 50A, Latex 40A, Agilus (30A – 50A), and Tango Black Plus (27A – 60A)

METHODS

- 40% water 60% glycerol pumped through the transverse sinus model at 5 cc/s
- ICP varied from 0-60 cm H_2O in 5 cm H_2O increments
- IVP gradient measured at each tested ICP
- Each transverse sinus model subjected to 3 trials

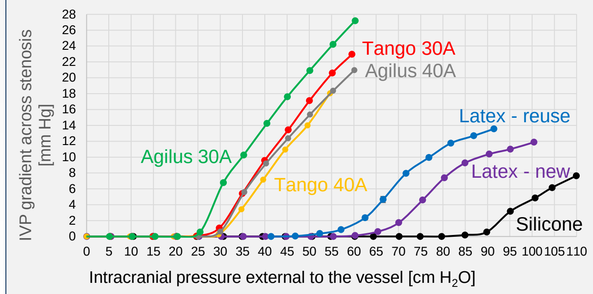


- Intracranial pressure is varied by injecting or removing water through the CSF inlet
- Intravascular pressure is measured with needle gauges

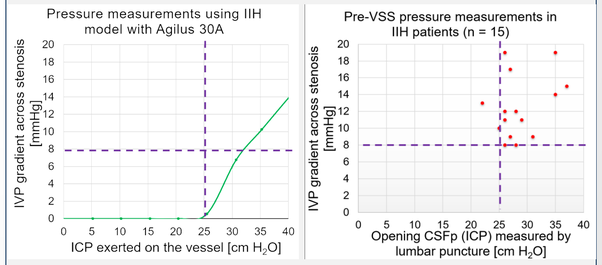


- Intracranial pressure is measured with an electronic sensor mounted inside the phantom

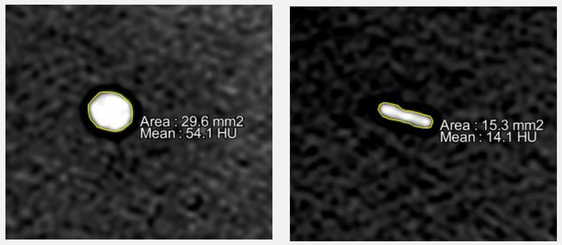
RESULTS



Comparison of mean intravascular pressure gradients (n=3) established across stenosis under increased intracranial pressure using materials with different shore factors. Agilus 30A demonstrated the highest compliance among all the materials tested.



Agilus 30A vs *in vivo* manometry and lumbar puncture measurements



CT cross section, transverse sinus model. Left, maximum lumen. Right, maximum stenosis.

CONCLUSION

The phantom was able to closely replicate the conditions present in a transverse sinus experiencing stenosis due to elevated intracranial pressure. This model will allow future research evaluating the physiological conditions which result in restenosis. It may also aid in the testing of new stent designs which could reduce the revision surgery rate of venous sinus stenting.

REFERENCES

1. Digre, K.B. and J.J. Corbett, *Idlopathic Intracranial Hypertension (Pseudotumor Cerebri): a Reappraisal.* The Neurologist, 2001. **7**(1).

2. Albuquerque, F.C., et al., *Intracranial venous sinus stenting for benign intracranial hypertension: clinical indications, technique, and preliminary results.* World Neurosurg, 2011. **75**(5-6): p. 648-52; discussion 592-5.

3. Corbett, J.J. and M.P. Mehta, *Cerebrospinal fluid pressure in normal obese subjects and patients with pseudotumor cerebri.* Neurology, 1983. **33**(10): p. 1386-8.

4. Satti, S.R., L. Leishangthem, and M.I. Chaudry, *Meta-Analysis of CSF Diversion Procedures and Dural Venous Sinus Stenting in the Setting of Medically Refractory Idiopathic Intracranial Hypertension.* AJNR Am J Neuroradiol, 2015.

5. Raper, D., et al., *Pattern of pressure gradient alterations after venous sinus stenting for idiopathic intracranial hypertension predicts stent-adjacent stenosis: a proposed classification system.* J Neurointerv Surg, 2017.

ACKNOWLEDGEMENTS

We would like to acknowledge the San Francisco VA Medical Center Radiology Department for their assistance with image acquisition. This project was supported by the National Institutes of Health under award R21DC016087-02 and the UC Davis Medical Student Research Fellowship (MSRF).