

Clinical evaluation of the MMS-10 tympanic membrane displacement analyser in the non-invasive assessment of raised intracranial pressure

Kathryn Banister[†]
Iain Chambers[‡]
David Mendelow[‡]

[†] Regional Medical Physics Department and
[‡] Department of Neurosurgery,
University of Newcastle, Newcastle upon Tyne

Summary

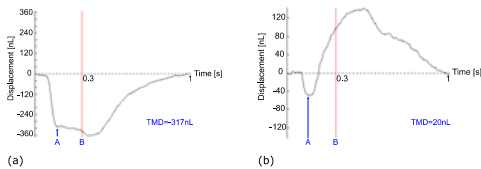
Shunt malfunction in hydrocephalus is a common problem and the insertion to revision ratio is high¹. Intracranial pressure (ICP) measurement is invaluable in the assessment of shunt malfunction but it is highly invasive, poorly tolerated and involves extensive in-patient episodes. A non-invasive ICP assessment technique (Marchbanks Measurement Systems) has recently become available which measures tympanic membrane displacement (TMD) after stimulation of the acoustic reflex² and is easily repeatable.

Objectives

To evaluate independently the use of TMD measurements in predicting raised ICP in patients with abnormal CSF pathology.

Introduction

This non-invasive technique is based upon the fact that the resting position of the stapes depends on ICP. This is because ICP is transmitted to the middle ear via the cochlear aqueduct. An assessment of ICP can then be obtained by measuring the tympanic membrane displacement after stimulation of the acoustic reflex. The direction and amplitude of the tympanic membrane displacement can therefore give an indication of ICP. High ICP is characterised by a more negative tympanic membrane displacement.



Sample reflex response from (a) a patient with raised ICP (>15mmHg supine) and (b) a patient with normal ICP (<15mmHg supine). The stimulus is switched off at 300ms. The TMD measurement is given as the mean displacement from A to B.

Methods

- Patients:** Those requiring CSF pressure measurement as part of their clinical management were recruited into the study.
- Data collection:** Tympanic membrane displacement measurements were obtained at the time of invasive pressure measurement for direct comparison. Patients were excluded if a postural test indicated that the cochlear aqueduct was obstructed.
- Stimulus:** 1kHz tone of 300ms duration repeated 10 times 10-20dB above acoustic reflex threshold (max 110dB).
- Data analysis:** Receiver Operator Characteristic (ROC) curves were plotted to determine a threshold of TMD for detection of raised ICP. The sensitivity and specificity were calculated using a threshold of TMD from -350nL to +300nL in 50nL steps.



The non-invasive ICP assessment being performed on a volunteer. The system is PC based and uses a headset to deliver the sound and measure the tympanic membrane displacement with a simple tympanometer probe placed in the ear canal.

Results

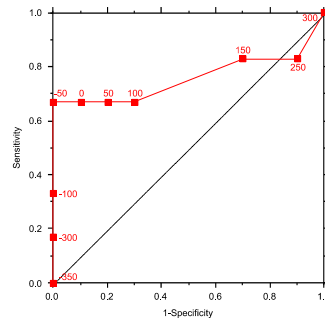
A comparison of ICP and TMD was made on 16 occasions. Median age was 34 (range 17 to 93).

Intracranial pressure measurement was by Camino transducer on 9 occasions, by external ventricular drain on 1 occasion and by lumbar puncture on 6 occasions.

Raised ICP was defined as greater than 15mmHg when in the supine position. There were 6 instances of raised ICP.

Tympanic membrane displacement in the supine position ranged from -332nL to 284 nL (mean 52nL). The mean difference between TMD for high and normal ICP values was 177nL with a 95% confidence interval of (6nL, 348nL).

ROC curve analysis: A threshold of supine TMD less than -50nL indicated raised ICP with a sensitivity of 0.67 and a specificity of 1. This gives a positive predictive value of 1 and a negative predictive value of 0.83.



ROC curve to assess the optimum threshold of TMD for prediction of raised ICP. The numbers in red above each data point correspond to the TMD in nL taken as the threshold for each calculation of sensitivity and specificity. The optimum threshold from this plot is a TMD of less than -50nL.

Conclusions

- In the patients studied, there is a difference between the TMD in patients with high ICP compared to normal ICP
- A threshold of -50nL detected raised ICP with maximum specificity
- The TMD test may be useful for detection of raised ICP in hydrocephalus
- A larger series of measurements is required to define more accurately the sensitivity and specificity of this technique

References

1. UK Shunt Registry Annual Report, 1999
2. Samuel M, Burge DM, Marchbanks RJ. Tympanic membrane displacement testing in regular assessment of intracranial pressure in eight children with shunted hydrocephalus. Journal of Neurosurgery 88: 983-995, 1998.