SHORT REPORT

Changes in third ventricular size with neuroendoscopic third ventriculostomy: a blinded study

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The objective was to study the relation between changes in cerebral ventricular size and clinical outcome after neuroendoscopic third ventriculostomy (NTV) in both primary (no previous surgery) and secondary (previous CSF diversion for hydrocephalus) NTV. Changes in ventricular size were related to the need for further surgery for CSF diversion. A blinded retrospective study of the pre-NTV and post-NTV sizes of the ventricles in an unselected series of patients undergoing this procedure was done. A decrease in third ventricular size was seen in significantly more patients in the primary group than in the secondary group. Median change in third ventricle width for those who did not require further CSF diversion was significantly greater than those with no clinical benefit (p=0.01). Positive predictive power for successful outcome was highest for measures of the third ventricle; 73% and 68% for third ventricle width and height respectively, 88% for anterior to posterior commissure distance. In conclusion, third ventricular size reduces after NTV. The use of such a change as an arbiter of success in this procedure is questionable as clinically successful cases can have no change in ventricular size. It is considered that clinical outcome is the most important guide to success or failure as reduction in ventricular size is by no means guaranteed. Radiological outcomes alone may be misleading and reliance on them should be avoided.

Neuroendoscopic third ventriculostomy (NTV) for hydrocephalus produces an internal shunt allowing CSF to spread over the surface of the brain in order to be reabsorbed by the arachnoid granulations. It has been suggested that radiological criteria are important in determining success or failure of NTV in the treatment of hydrocephalus.[1] The experience of our centre is that successful clinical outcome can occur despite no objective reduction in ventricular size.[2 3] This study was performed to determine whether changes in preoperative and postoperative ventricular size occurred, how they related to clinical outcomes, and whether change in ventricular size was influenced by prior CSF shunting.

METHODS

We retrospectively studied 38 patients with an age range from 4.5 to 48 years who had undergone NTV in this centre from February 1994 to July 1997. During this period there were 211 patients who had neuroendoscopic procedures. Patients were selected by the criterion that they had both preoperative and postoperative films taken in the radiological department in this hospital to allow for direct comparisons.

Measurements of ventricular size were obtained on the radiographic hard copies of T2 weighted MR images.[3] The following measurements were obtained from preoperative and postoperative images: on axial images maximum third ventricular width, maximal bifrontal width, maximum lateral ventricular body width, and on the same axial slice both maximum inner diameter of the skull and maximum bifrontal width; on midsagittal images the measurements were third ventricular height, distance between anterior commissure and posterior commissure, height of tegmentum (altitude from tuberculum-torcular line), and distance of pontomedullary junction from the foramen magnum. Maximum third ventricular width and lateral ventricular width had been shown in a previous study to be closely related to their ventricular volume.[4] The other measurements had been shown by Oko *et al*[5] to show restoration of ventricular size after NTV.

Measurements from pre-NTV and post-NTV were performed by a single independent observer (NR) blinded to the surgical outcome, who also performed intraobserver error assessment. To prevent any differences that might arise from different pulse sequences, only patients with similar pulse sequences pre-NTV and post-NTV were included in the study.

Clinical failure of NTV was defined by the requirement for another CSF diversionary procedure for the hydrocephalus at any time after the NTV.

Statistical analysis

χ^2 Tests were performed with a Fisher's exact test due to the small numbers studied. To examine differences between those with clinical improvement and those without Mann-Whitney tests were applied to the ventricular measures. Positive predictive power values were calculated for each study measure by dividing the number of patients with a successful clinical outcome and a decrease in the measure by the total number of patients with a decrease in the measure under consideration, expressed as a percentage.

RESULTS

Median time from NTV to follow up was 1.65 months for both primary and secondary groups. Baseline MRI estimates of hydrocephalus are shown in table 1 A; there were only significant differences between the primary and secondary groups. For postoperative MRI measures there were no significant differences between the primary and secondary groups (table 1 B) although a trend for a greater percentage reduction in the third ventricular width was noted in the primary group (21% *v* 0%, p=0.05, primary *v* secondary respectively). In addition, using width of the third ventricle there were significantly more patients with a positive radiological outcome—that is, decrease in ventricular size—in the primary group than the secondary group (16/21 *v* 6/17, p=0.02).

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Table 1 Baseline and median values (IQR) and percentage change in hydrocephalus

	IIIW*	BF	ER	LVW*	ACPC*	TH	IIIH*	FMPM
(A) Baseline values (IQR) for estimates of hydrocephalus in primary and secondary ventriculostomy groups								
Primary (n=21)	2.00 (1.30 to 2.80)	6.40 (4.39 to 7.78)	0.48 (0.33 to 0.56)	8.56 (5.19 to 9.56)	2.95 (2.44 to 3.33)	1.49 (1.22 to 1.88)	2.38 (1.88 to 2.89)	1.25 (1.02 to 1.59)
Secondary (n=17)	1.82 (1.25 to 2.16)	5.80 (4.12 to 7.39)	0.43 (0.31 to 0.49)	6.67 (5.68 to 9.43)	2.90 (2.45 to 3.35)	1.36 (1.03 to 1.82)	1.70 (1.59 to 2.03)	1.59 (1.13 to 1.80)
(B) Median (IQR) and percentage change for estimates of hydrocephalus shown by primary and secondary ventriculostomy groups								
Primary (n=21)	−0.34 (0.08 to −0.75) 21%	−0.46 (0.06 to −1.23) 9%	−0.03 (0.01 to 0.09) 9%	−0.46 (0.23 to −1.26) 6%	−0.18 (0.00 to −0.64) 8%	0.01 (0.00 to 0.34) 1%	−0.05 (0.46 to −0.3) 2%	0.11 (0.00 to −0.20) 9%
Secondary (n=17)	0.00 (0.22 to −0.40) 0%	−0.31 (0.23 to −0.45) 5%	−0.02 (0.01 to −0.03) 5%	−0.08 (0.46 to −0.80) 1%	−0.07 (0.11 to −0.39) 2%	0.10 (0.00 to 0.35) 22%	−0.20 (0.00 to −0.49) 13%	0.00 (−0.12 to 0.20) 0%
(C) Median (IQR) and percentage change for estimates of hydrocephalus by groups with success or failure in clinical outcome								
Success (n=20)	−0.35 (−0.23 to −0.66) 21%	−0.45 (0.17 to −0.95) 9%	−0.03 (0.01 to 0.07) 9%	−0.60 (−0.2 to −0.95) 9%	−0.22 (−0.11 to −0.62) 8%	0.05 (0.00 to 0.41) 3%	−0.22 (0.00 to −0.69) 13%	0.06 (−0.06 to 0.2) 4%
Failure (n=18)	0.00 (0.24 to −0.29) 0%	−0.28 (0.17 to −0.53) 4%	−0.02 (0.01 to −0.04) 5%	0.01 (0.39 to −0.45) 0%	0.00 (0.20 to −0.33) 0%	0.02 (0.00 to 0.28) 1%	0.00 (0.24 to −0.32) 0%	0.00 (−0.32 to 0.24) 0%

All measureas are in cm except Evans ratio.
*Significant difference (p<0.05) between groups. IIIW, maximum third ventricular width; BF, bifrontal width; ER, Evans ratio; LVW, maximum lateral ventricular body width; ACPC, anterior commissure to posterior commissure distance; TH, maximum tegmental height; IIIH, maximum third ventricular height; FMPM, foramen magnum to pontomedullary junction distance.

Table 2 Positive predictive power values (%) for the study measures

	IIIW	BF	ER	LVW	ACPC	TH	IIIH	FMPM
PPV	73%	58%	54%	65%	88%	52%	68%	56%

IIIW, maximum third ventricular width; BF, bifrontal width; ER, Evans ratio; LVW, maximum lateral ventricular body width; ACPC, anterior commissure to posterior commissure distance; TH, maximum tegmental height; IIIH, maximum third ventricular height; FMPM, foramen magnum to pontomedullary junction distance.

There were no significant differences in baseline MRI estimates between the clinical success and failure groups. Changes in MRI estimates of hydrocephalus in successful and failed patients are shown in table 1 C. The median reduction in the third ventricle width for those who were successful was significantly greater than those with no clinical benefit (−0.345 v 0, p=0.01, success v failure respectively). Significant differences were also present for change in lateral ventricle width (−0.6 v 0.01, p=0.04) and anterior to posterior commissure distance (−0.22 v 0, p=0.03). There was no difference in median scan time from procedure between the success and failure groups (mean 1.48 months v 1.66 months). Eleven out of 21 of the primary group and nine out of 17 of the secondary group were successful; this was not significantly different.

Table 2 depicts the positive predictive values for all the measures.

DISCUSSION

The treatment of choice for many types of hydrocephalus[6]—NTV—is a highly successful procedure allowing many patients to be relieved of the need for a shunt and has proved economical advantage.[7] Determination of success or failure of the procedure has, in this centre, been a relatively simple assessment on the basis of clinical symptoms and signs followed by imaging to determine ventricular size.[2 3] Persistent or new headache typical of hydrocephalus, bulging of the NTV wound, and other symptoms and signs of raised intracranial pressure are considered to be indicators of failure. Only then are imaging correlates considered. This has helped us to identify second membranes[8] and then determine CSF destination,[9] CSF flow, and ventricular size when compared with preoperative images.[10]

Kulkarni et al[1] think that the presence of reduced ventricular size and presence of flow void correlate with clinical success. This is indeed the case but some with smaller ventricles are unsuccessful.[2 3] Thus the assertion by Kulkarni et al[1] that one would still need to include imaging criteria to determine failure and the need for reoperation in a child is not necessarily the case. Goumnerova and Frim[11] agree with the findings in this centre having recorded that 31% of successful patients had a persistent ventriculomegaly and it does not represent failure of the procedure.

The blinded study undertaken in this centre has confirmed that reduction in size of the third ventricle is seen in successful cases with NTV; changes in this index seeming to be most sensitive. Reduction is prompt[5] and changes in it were studied with this in mind, although Schwartz et al[12 13] think that size of the third ventricle is less reliable and advocated the use of lateral ventricles instead. The Evans ratio is thought by some to be a poor measure of ventricular size,[14] but despite this a trend in reduction was shown in this study. We acknowledge that we performed multiple comparisons and recognise the potential of chance results but it is still notable that it is measures of the third ventricle which seem most responsive. The other measures were taken for comparison and to determine which would be the most useful in such a study.

This study has shown that there are significant differences between success and failure groups in third ventricular width,

lateral ventricular body width, anterior commissure to posterior commissure distance, and third ventricular height. Similarly, measures of third ventricular width and height, anterior to posterior commissure distance, and lateral ventricular body width had the highest positive predictive values for a successful outcome. This suggests that, if such an evaluation of success were indicated, other than clinical signs and symptoms, then MRI may well have a role when these indices are measured.

The reduction in size has been found to be 16% in successful cases and 7% in unsuccessful cases,[1] but there was not a significant difference between primary and secondary NTV. Complete reduction to normality should not be expected nor aimed for. Interestingly Oka et al[5] state that NTV does not cause slit ventricle syndrome. However, their series was only followed up for 2 years and this syndrome does not develop for at least 6 years.[15] Moreover, there is no theoretical reason as to why NTV should precipitate slit ventricle syndrome.

CONCLUSIONS
The results of this study confirm that radiological changes suggestive of success in NTV are detectable. However, their importance is very much secondary to the clinical status, so much so that in most cases undertaken in this department there are no check scans performed postoperatively, unless there are clinical signs and symptoms suggestive of failure.

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