Shunt malfunction

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Any work that demonstrates a reduction in the failure rate of ventriculoperitoneal shunts is a welcome addition to the literature. In this issue of the Journal of Neurosurgery, Hayhurst et al.1 describe the use of electromagnetic (EM) guidance for placement of the ventricular catheter at the time of shunt insertion. The premise of the study is that accurate placement of the ventricular catheter tip in the occipital horn of the ventricle (away from the choroid plexus) improves shunt survival by decreasing proximal obstruction. Three European centers participated in the study, and prospectively collected information on initial shunt placement using anatomical landmarks for 9 months. Thereafter, from May 2008 through May 2009, all shunts were placed using EM guidance. The grade of shunt placement (catheter tip floating in CSF, catheter tip touching ventricle wall or choroid, catheter tip in the parenchyma) and shunt failure were then compared for the 2 cohorts. The proportion of patients with catheters free-floating in CSF was significantly higher using navigation, and early shunt failure (within 30 days) was significantly lower in the navigation group, but overall shunt failure was reported as not significantly different.

The study is based on sound rationale. In the post hoc analysis of the Endoscopic Shunt Insertion Trial, catheter position with respect to the choroid plexus appeared to be important, with catheters away from the choroid surviving longer (Fig. 1).3 In addition, the Hayhurst et al. study is well done with prospective data collection, multicenter collaboration, and specific outcomes defined a priori. Before we wholeheartedly accept the conclusions and incorporate navigation into shunt surgery, however, some aspects of their work should be discussed.

In any clinical study, clear definition and unbiased evaluation of the outcome are essential. The authors have defined a categorical scale for the position of the catheter on the postoperative image. Their definitions appear reasonable and, if valid, could be applied by clinicians in practice. Unfortunately, it appears that they have missed the opportunity to perform a truly unbiased assessment of catheter position. When imaging studies were reviewed to determine catheter position, the patient name and outcome were blinded, but the study group was apparently not. This could have been performed quite readily and would have strengthened the study conclusions. As reported, the authors have allowed for observer bias, especially since the observers were study participants.

The cause of shunt failure is described by the authors, including the proportion of patients who had proximal obstruction. In the prospective multicenter shunt trials previously reported,2,3 a blinded adjudication process included determination of the cause of shunt failure. Surprisingly, it was sometimes quite difficult to determine whether the malfunction was at the ventricular catheter valve or elsewhere. The criteria for making this decision are not described in this paper, and the limitations of making this decision should be recognized in the interpretation of the results.

The evaluation of short-term outcome is interesting, but the lack of an overall advantage on shunt survival is disappointing. This may be an issue of small sample size for this outcome, but the fact that the group that underwent placement using navigation had a shorter median follow-up makes the lack of difference even more concerning.

Both children and adults were included in this study. The cause of hydrocephalus, ventricle size at baseline, and the change in ventricular size and anatomy over time after shunt insertion are quite different in these 2 populations. I was therefore happy to see separate discussion of pediatric and adult results. It is interesting to see that the early failure rates were identical with and without navigation in the children. There were 4 early failures in 20 children in the standard group and 3 early failures in 15 children in the group in which navigation was used. This result does not leave us with the impression that the technique will help in pediatric hydrocephalus.

One potential disadvantage of navigation is the requirement for additional imaging. If a diagnostic scan is performed when the hydrocephalus is diagnosed, it would
be a disadvantage to perform a second scan to use the navigation. The authors address this issue, stating that diagnostic multislice imaging can be used for navigation, avoiding the additional imaging. I am delighted to note this point. The authors describe a very small increase in radiation exposure for their diagnostic scan to allow navigation.

There is no discussion of the alternative to EM navigation, which is intraoperative ultrasonography; its use for shunt placement has been described. Intraoperative ultrasonography has the advantage of not requiring any preoperative imaging, and it provides real-time feedback, which is a potential advantage over EM navigation. Ultrasonography machines are available in most operating rooms, and the addition of an ultrasound probe that fits in a bur hole is significantly less expensive than the EM guidance system. A prospective multicenter evaluation of ultrasound-guided shunt placement in children is currently in progress and promises to allow further assessment of the potential advantages of ultrasonography in the near future.

Overall, this study is well done and is suggestive that some form of navigation has the potential to improve catheter position and therefore shunt survival. I do not think, however, it provides definitive support of the statement in the discussion that a randomized trial might not receive ethical approval given the “clear advantage” of the technique reported here. Nevertheless, the authors are to be commended for this work. I would hope to see further investigation along these lines in the future, with separate investigations within the pediatric and adult populations. In addition, I look forward to the results of the multicenter study in progress on the use of intraoperative ultrasonography with the same goals in mind.

References


Response

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Dr. Kestle’s editorial discussion of our paper on the routine use of EM placement for ventricular catheters in hydrocephalus is most welcome. His comments and recognized expertise in the delivery of sound, unbiased surgical research trials are well taken. In particular, the opportunity in our study for completely blinded grading of the shunts radiologically was indeed missed, due to the time-based nature of each cohort.

The criteria for adjudicating the cause of shunt malfunction are, however, always prospectively recorded in all our surgeons’ operation records, as shunt revision always begins at the bur hole reservoir in our units and the first maneuver is to always detach the ventricular catheter and evaluate if the ventricular catheter is blocked. Cerebrospinal fluid is always sent to the laboratory for evaluation of occult shunt infection. Thus, there should be little doubt as to the cause of shunt failure in the majority of our cases. The cause of failure was not blinded but recorded prospectively as part of the trial. The concern for the need for an additional diagnostic scan to be able to use navigation at surgery is potentially an issue, but is usually avoided by the fact that all patients with a suspicion of hydrocephalus in our hospitals usually underwent multislice imaging at the outset. This imaging could be used in the operating room for navigation, adding only a small increase in radiation exposure, with the benefit that it may prevent later additional scans because of possible shunt malfunctions.

It is perhaps pertinent that an interest in reducing early shunt failures is becoming reignited since the arrival of appropriate noninvasive technology, where little adjustment to our surgical technique is otherwise required. The key to EM navigation is, of course, the lack of having to fix the patient’s head to navigate (or to make any extra incision), which is most inconvenient in shunt surgery. The reuptake in ultrasonography is presumably partly due to improved bur hole probes with or without the concurrent use of navigation software. The point is that any form of verified, user friendly, reliable, and accurate navigation aid would probably do the same job, once used regularly with appropriate experience. As we all know, badly used navigation equipment by the inexperienced user can equally lead to dangerous results.

Since using EM navigation for shunt surgery, its use has become so routine in our units that one wonders how one managed before it arrived! Of course, we began to use it for difficult cases and have already published a paper on the subject of its use for navigating small and slitlike ventricles. Use of this technique became more routine in more “standard” cases with enlarged ventricles once the whole team mastered its ease of use across units, and after some occasional very poor and avoidable results of shunt placements resulted in a swift return of the patient to the operating room for shunt revision. Even the best of us in our careers will have had moments that we are not proud of when it comes to missing the target in blind ventricular catheter placement!

Given that some form of navigation equipment and/or ultrasonography is present in most neurosurgical units in the developed world, one needs to question why blind shunt placement remains the norm. Why would one not use a navigation aid for shunt placement (or blind trocar