Chapter 10. Cerebrospinal fluid drainage

I. RECOMMENDATIONS

Strength of Recommendations: Weak.

Quality of Evidence: Low from poor- and moderate-quality class III studies with some contradictory findings.

A. Level I

There are insufficient data to support a level I recommendation for this topic.

B. Level II

There are insufficient data to support a level II recommendation for this topic.

C. Level III

Cerebrospinal fluid (CSF) drainage through an external ventricular drain may be considered in the management of increased intracranial pressure (ICP) in children with severe traumatic brain injury (TBI).

The addition of a lumbar drain may be considered in the case of refractory intracranial hypertension with a functioning external ventricular drain, open basal cisterns, and no evidence of a mass lesion or shift on imaging studies.

II. EVIDENCE TABLE (see Table 1)

III. OVERVIEW

With the use of the external ventricular drain as a common means of measuring ICP of patients with TBI, the potential added therapeutic benefits of CSF drainage is of interest. Before the use of the external ventricular drain in TBI, the principal use of CSF drainage was in patients with hydrocephalus, but the ability of this procedure to potentially affect ICP led to its increased use as a therapeutic device for TBI. The role of CSF drainage is to reduce intracranial fluid volume and thereby lower ICP. Both intermittent and continuous drainage approaches have been reported in the pediatric literature (1). Therapy may be associated with an increased risk of complications from hemorrhage and malpositioning.

IV. PROCESS

For this update, MEDLINE was searched from 1996 through 2010 (Appendix B for search strategy), and results were supplemented with literature recommended by peers or identified from reference lists. Of six potentially relevant studies, one was added to the existing table and used as evidence for this topic.

V. SCIENTIFIC FOUNDATION

Four class III studies met the inclusion criteria and are used as evidence for this topic (2–5). Ventricular drainage alone was used in two studies, and lumbar drainage in combination with an external ventricular drain was used in the other two.

A study by Shapiro and Marmarou (4) retrospectively studied 22 children with severe TBI defined as a Glasgow Coma Scale score of ≤ 8, all of whom were treated with ventricular drainage. Parameters measured included ICP, pressure–volume index, and mortality. Draining CSF increased pressure–volume index and decreased intracranial hypertension. Two neurologic deaths occurred in patients with refractory intracranial hypertension; however, the ICP of the other three patients who died, and the four survivors with severe disability, is not reported. Consequently, the absolute influence of CSF drainage in this sample cannot be determined.

A study by Jagannathan et al (5) retrospectively studied 96 children with severe TBI comparing management of ICP alone vs. ICP along with surgery using either external ventricular drainage or operative treatment (evacuation of hematoma or decompressive craniectomy). ICP control was achieved in 82 patients (85%). Methods used to achieve ICP control included maximal medical therapy (sedation, hyperosmolar therapy, and neuromuscular blockade) in 34 patients (35%), external ventricular drain in 23 patients (24%), and surgery in 39 patients (41%). Refractory ICP resulted in 100% mortality. Authors concluded that controlling elevated ICP is an important factor in patient survival after severe pediatric TBI. The modality used for ICP control appears to be less important. No long-term follow-up to determine neurocognitive sequelae was performed.

Drainage of CSF is not limited to the ventricular route. The other level III recommendation is that although CSF drainage can be accomplished through an external ventricular drain catheter alone or in combination with a lumbar drain, the addition of lumbar drainage should only be considered in the case of refractory intracranial hypertension with a functioning external ventricular drain, open basal cisterns, and no evidence of a major mass lesion or shift on imaging studies. A study by Baldwin and Rekate (2) reported a series of five children with severe TBI, in whom lumbar drains were placed after failure to control ICP with both ventricular drainage and barbiturate coma. Three children had quick and lasting resolution of raised ICP, two of them with good outcome and one with moderate remaining disability. In the other two cases, there was no effect on ICP and both children died.

In a later paper from the same institution, Levy et al (3) reported the effect on outcome of controlled lumbar drainage with simultaneous external ventricular drainage in 16 pediatric patients with severe TBI. In two patients, ICP was unaffected and both died. The remaining 14 survived, eight having a good outcome, three with moderate disability, and three having severe disability. Although there was no direct outcome study or analysis on the use of barbiturates in this series, the authors proposed that barbiturate coma and its associated morbidity could be avoided by the use of lumbar drainage, based on their findings in this series that not all patients were given barbiturates (five of 16 patients received no barbiturates and six of 16 received only intermittent dosing). The use of lumbar drainage, however, was contraindicated in the setting of a focal mass lesion or shift and the authors recommended the use of lumbar

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Table 1. Evidence table

Reference	Study Description	Data Class, Quality, and Reasons	Results and Conclusion
Studies from previous guidelines			
Baldwin and Rekate, 1991 (2)	Design: case series N = 5 Age: 8–14 yrs Protocol: external ventricular drain, then lumbar drain; lumbar drain should only be considered in the case of refractory intracranial hypertension with a functioning external ventricular drain, open basal cisterns, and no mass lesion or shift on imaging studies	Class III Poor quality: no control for confounders, small sample size	3 of 5 survived; (1 moderate disability, 2 good recovery) all had decrease in ICP after lumbar drainage
Levy et al, 1995 (3)	Design: case series N = 16 Age: 1–15 yrs Protocol: external ventricular drain, then lumbar drain; lumbar drain should only be considered in the case of refractory intracranial hypertension with a functioning external ventricular drain, open basal cisterns, and no mass lesion or shift on imaging studies	Class III Poor quality: no control for confounders, small sample size	ICP lowered in 14 of 16; 2 of 16 died, both of whom had uncontrolled ICP Of 14 survivors, 8 had good recovery; 3 moderate disability, 3 severe disability
Shapiro and Marmarou, 1982 (4)	Design: case series N = 22 Age: 2–15 yrs Protocol: external ventricular drainage, ICP/ PVI measured	Class III Poor quality: small sample size with narrow spectrum of patients	5 of 22 died 4 of 17 survivors were severely disabled; 13 of 17 had a good outcome or were moderately disabled 16 of 22 patients had PVI measured before and after therapy. Drainage increased PVI and decreased ICP in 14 of 16. 2 of the 5 deaths were due to uncontrolled intracranial hypertension
New study			
Jagannathan et al, 2008 (5)	Design: case series N = 96 Age: 3–18 yrs, mean 15.1 yrs Protocol: compared management of ICP alone (N = 34) vs. ICP along with surgery using an external ventricular drain (N = 23) or operative treatment (N = 39; 14 mass lesion evacuation, 25 decompressive craniectomy)	Class III Moderate quality: control for confounders unclear for ICP	ICP control achieved in 82 of 96 (85%) overall 20 of 23 (87%) achieved ICP control with external ventricular drain; of 3 not achieving ICP control, 2 died, 1 had craniectomy Refractory ICP was associated with 100% mortality; the method used to control ICP had no correlation with mortality

ICP, intracranial pressure; PVI, pressure–volume index.

drainage only in conjunction with a functioning external ventricular drain in the setting of open basal cisterns based on imaging.

VI. INFORMATION FROM OTHER SOURCES

A. Indications From the Adult Guidelines

The adult guidelines do not address CSF drainage as a treatment for TBI.

B. Information Not Included as Evidence

In one study that was not included as evidence because it did not report functional outcomes, Anderson et al (6) retrospectively studied 80 children with severe TBI, all of whom were treated with an ICP monitor or an external ventricular drain (EVD) or both. The authors observed a fourfold increase in the risk of complications for EVD as compared with a fiberoptic monitor (p = .004). These included: greater hemorrhagic complications with the EVD in 12 of 62 (17.6%); fiberoptic in four of 62 (6.5%) (p = .025); malposition of the EVD requiring replacement in six of 68 (8.8%); and infection in one of 62 (1.5%). They concluded that the use of an EVD may be associated with increased risk of complications from hemorrhage and malposition.

Following earlier reports of an effect on ICP by drainage of CSF, Ghajar et al (7) performed a prospective study, without randomization, of the effect of CSF drainage in adults with TBI. Treatment was selected by the admitting neurosurgeon and, after evacuation of mass lesions, patients either received ventriculostomies with drainage if ICP exceeded 15 mm Hg along with medical management (group 1) or medical management only (group 2). The medical management consisted of mild hyperventilation to P_{CO_2} 35 mm Hg, head-of-bed elevation, normovolemia, and mannitol (although only on admission). Patients in group 2 had no ICP monitor of any kind. The outcome measures were mortality and degree of disability. Mortality was 12% in group 1 vs. 53% in group 2. Of the patients in group 1, 59% were living independently at follow-up vs. 20% of group 2.

A study by Fortune et al (8) studied the effect of hyperventilation, mannitol, and CSF drainage on cerebral blood flow in TBI. Twenty-two patients were studied with a mean age of 24 yrs (range, 14–48 yrs). Children were not reported separately. Although patient outcome was not reported, this study established that CSF drainage, hyperventilation, and intermittent mannitol were all effective in reducing ICP. They also found that mannitol use increased cerebral blood flow, CSF drainage had a negligible impact on cerebral blood flow, and hyperventilation decreased cerebral blood flow.

VII. SUMMARY

Four class III studies provide the evidence base for this topic resulting in a level III recommendation for the therapeutic use of CSF drainage for the management of intracranial hypertension. Two of these studies supported the use of ventricular CSF drainage. Although most commonly achieved with an EVD, a randomized controlled trial comparing the efficacy of treatment of intracranial hypertension in pediatric TBI with or without CSF drainage has not been carried out. In the setting of refractory intracranial hypertension, a lumbar drain may be considered but only in conjunction with a functional ventricular drain in patients with open cisterns on imaging and without major mass lesions or shift. This was also supported only as a level III recommendation. A randomized controlled trial comparing the different available approaches to the treatment of refractory intracranial hypertension has also not been carried out. Overall, it is possible that control of refractory ICP may be the most important aspect of treatment in children with severe TBI and may not depend on a single modality of treatment, i.e., in this case, CSF drainage.

VIII. KEY ISSUES FOR FUTURE INVESTIGATION

- Prospective studies as to the risks and benefits of placement of an ICP monitor alone vs. placement of an EVD catheter.
- Prospective studies on the outcome benefits of CSF drainage vs. other therapies.
- Role of surrogate markers of outcome using CSF drainage.
- Studies to compare CSF drainage with other therapeutic modalities used in TBI management such as osmolar therapy, barbiturates, or surgery.
- Studies about the technical aspects of drain use such as continuous vs. intermittent drainage, age-specific use, and use related to mechanism of injury.
- Comparison of lumbar drainage with other second-tier therapies such as decompressive craniotomy/craniectomy.
- Study of the potential role of subgaleal drainage in infants.

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