Chapter 10. The role of cerebrospinal fluid drainage in the treatment of severe pediatric traumatic brain injury

I. RECOMMENDATIONS

A. Standards. There are insufficient data to support a treatment standard for this topic.

B. Guidelines. There are insufficient data to support a treatment guideline for this topic.

C. Options. Cerebrospinal fluid (CSF) drainage can be considered as an option in the management of elevated intracranial pressure (ICP) in children with severe closed head injury.

Drainage can be accomplished via a ventriculostomy catheter alone or in combination with a lumbar drain. The addition of lumbar drainage should be considered as an option only in the case of refractory intracranial hypertension with a functioning ventriculostomy, open basal cisterns, and no evidence of a major mass lesion or shift on imaging studies.

II. OVERVIEW

In children with severe traumatic brain injury (TBI) and intracranial hypertension, ventricular CSF drainage is a commonly employed therapeutic modality in conjunction with ICP monitoring. The role of CSF drainage is to reduce intracranial fluid volume and thereby lower ICP. The scientific literature pertaining to CSF drainage in trauma, and in pediatric trauma in particular, was reviewed.

III. PROCESS

We searched Medline and Healthstar from 1966 to 2001 by using the search strategy for this question (see Appendix A) and supplemented the results with literature recommended by peers or identified from reference lists. Of 68 potentially relevant studies, three were used as evidence for this question (Table 1).

IV. SCIENTIFIC FOUNDATION

With the use of the ventriculostomy as a common means of measuring ICP of patients with TBI (see Chapter 7), the potential therapeutic benefits of CSF drainage became of interest. Before the use of the ventriculostomy in TBI, the principal use of CSF drainage was in patients with hydrocephalus, but the ability of this procedure to affect ICP led to its increased use as a therapeutic device.

We found one class III study in children evaluating the use of ventricular drainage in TBI. Shapiro and Marmarou (1) retrospectively studied 22 children with severe TBI—defined as a score ≤8 on the Glasgow Coma Scale (GCS), all of whom were treated with ventricular drainage. Variables measured included ICP, pressure-volume index, and mortality rate. In addition to the finding that draining CSF increased pressure-volume index and decreased ICP, only two neurologic deaths occurred in patients with refractory intracranial hypertension.

Drainage of CSF is not limited to the ventricular route. In response to observations that the ventricles are often small in TBI and that up to 30% of the total compliance of the CSF system is in the spinal axis, a series of articles have addressed the feasibility of using lumbar drains in addition to ventricular drainage. Baldwin and Rekate (2) reported on 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.

Levy et al. (3) reported on the effect of controlled lumbar drainage, with simultaneous ventricular drainage, on outcome in 16 pediatric patients with severe TBI. In two patients ICP was unaffected, and both died. The remaining 14 survived, eight having good outcome, three having moderate disability, and three having severe disability. Although there was no direct outcome study 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. This statement was based on the fact that in this series not all patients were given barbiturates (five of 16 receiving no barbiturates and six of 16 receiving only intermittent dosing).

Key Elements from the Adult Guidelines Relevant to Pediatric TBI

Following earlier reports of an effect on ICP by drainage of CSF (4), Ghajar et al. (5) 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 received either 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 measurements were mortality rate and degree of disability. Mortality ate 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.

Fortune et al. (6) studied the effects of hyperventilation, mannitol, and CSF drainage on cerebral blood flow (CBF) in TBI. Twenty-two patients were studied, with a mean age of 24 yrs (range, 14–48). 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. The authors also found that mannitol use increased CBF, CSF drainage had negligible impact on CBF, and hyperventilation decreased CBF.

Ventricular cerebrospinal fluid drainage in severe pediatric traumatic brain injury is supported as a treatment option in the setting of refractory intracranial hypertension; the addition of lumbar drainage in patients showing open cisterns on imaging and without major mass lesions or shift also is supported as a treatment option.

Table 1. Evidence table

References	Description of Study	Data Class	Conclusions
Shapiro and Marmaron (1), 1982	Retrospective series, 22 patients with EVD, ICP/PVI measured.	III	Drainage increased PVI, decreased ICP, deaths only in patients with uncontrolled ICP.
Baldwin and Rekate (2), 1991–1992	Clinical series, five patients with lumbar drain.	III	Three of five survived after lowering ICP.
Levy et al. (3), 1995	Retrospective study, 16 patients with lumbar drain.	III	ICP lowered in 14/16, deaths in two patients with uncontrolled ICP.

EVD, external ventricular drain; ICP, intracranial pressure; PVI, pressure-volume index.

V. SUMMARY

Ventricular CSF drainage in severe pediatric TBI is supported as a treatment option in the setting of refractory intracranial hypertension; the addition of lumbar drainage in patients showing open cisterns on imaging and without major mass lesions or shift also is supported as a treatment option.

VI. KEY ISSUES FOR FUTURE INVESTIGATION

Future studies in this area should include the following:

Prospective data collection on the outcome benefits of CSF drainage.

Studies to compare CSF drainage with other therapeutic modalities used in TBI management, such as osmolar therapy or barbiturates.

Work on technical aspects of drain usage, 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.

Study of the potential role of subgaleal drainage in infants.

REFERENCES

1. Shapiro K, Marmarou A: Clinical applications of the pressure-volume index in treatment of pediatric head injuries. *J Neurosurg* 1982; 56:819–825
2. Baldwin HZ, Rekate HL: Preliminary experience with controlled external lumbar drainage in diffuse pediatric head injury. *Pediatr Neurosurg* 1991–2; 17:115–120
3. Levy DI, Rekate HL, Cherny WB, et al: Controlled lumbar drainage in pediatric head injury. *J Neurosurg* 1995; 83:452–460
4. Bullock R, Chesnut RM, Clifton G, et al: Guidelines for the management of severe traumatic brain injury. *J Neurotrauma* 2000; 17:451–553
5. Ghajar JBG, Hariri RJ, Patterson RH: Improved outcome from traumatic coma using only ventricular cerebrospinal fluid drainage for intracranial pressure control. *Adv Neurosurg* 1993; 21:173–177
6. Fortune JB, Feustel PJ, Graca L, et al: Effect of hyperventilation, mannitol, ventriculostomy drainage on cerebral blood flow after head injury. *J Trauma* 1995; 39:1091–1099

APPENDIX: LITERATURE SEARCH STRATEGIES

SEARCHED MEDLINE AND HEALTHSTAR FROM 1966 TO 2001

Chapter 10. CSF Drainage

1. exp craniocerebral trauma/
2. head injur$.tw.
3. brain injur$.tw.
4. 1 or 2 or 3
5. lumbar drain$.mp.
6. lumbar shunt$.mp.
7. exp cerebrospinal fluid shunts/
8. *drainage/
9. 5 or 6 or 7 or 8
10. 4 and 9
11. limit 10 to (newborn infant <birth to 1 month> or infant <1 to 23 months> or preschool child <2 to 5 years> or child <6 to 12 years> or adolescence <13 to 18 years>)