PEDIATRICS/CASE REPORT

Intracranial Intraosseous Catheter Placement to Temporize an Epidural Hematoma

William Weber, MD, MPH*; Teri Campbell, MSN; Thomas Papandria, MSN; Arjang Ahmadpour, MD

*Corresponding Author. E-mail: wweber@bidmc.harvard.edu.

Acute epidural hematomas can lead to rapid neurologic decompensation and death. Epidural hematomas may require emergency surgical clot removal, but many patients live far away from a trauma center. This case report describes a pediatric patient with an acute epidural hematoma with significant neurologic compromise who initially presented to a nontrauma center. The emergency department (ED) had no neurosurgeon or equipment to perform burr hole craniostomy. The emergency physician at the nontrauma ED inserted an intraosseous catheter intracranially to temporarily decompress the hematoma due to long transport times. The patient survived with complete neurologic recovery. This is the youngest known patient in whom an intraosseous catheter was used to drain an intracranial hematoma. [Ann Emerg Med. 2023;■:1-4.]

0196-0644/$-see front matter

https://doi.org/10.1016/j.annemergmed.2023.05.009

INTRODUCTION

Intracranial hematomas can lead to rapid neurologic compromise after head trauma. Most epidural hematomas are associated with a temporal skull fracture, with resultant injury to the middle meningeal artery.[1] Given the arterial source of bleeding in most cases, epidural hematomas often exhibit rapid expansion, which leads to elevation of intracranial pressure and eventual uncal herniation. Thus, epidural hematomas require emergency neurosurgical evaluation to prevent irreversible neurologic injury and death.

For patients with large epidural hematomas (>30 mL) or a depressed Glasgow Coma Score and anisocoria, emergency craniotomy is the standard of care. Both the Brain Trauma Foundation and the Congress of Neurological Surgeons recommend that surgical evacuation be performed “as soon as possible” for such patients.[2] Craniotomy serves to evacuate the hematoma and reduce the intracranial pressure while allowing visualization and direct hemorrhage control. One published study reported that evacuation of a posttraumatic epidural hematoma within 2 hours of patient presentation was associated with both a marked reduction in mortality (65% to 17%) and improvement in favorable neurologic recovery (13% to 67%).[3] Craniostomy with a burr hole may be used to temporize an acute epidural hematoma if access to neurosurgical intervention is likely to be delayed or limited.[4,5]

Approximately 10% of Americans live more than an hour’s drive to the nearest level I or II trauma center.[6] As a result, many individuals with head trauma are first evaluated at emergency departments (EDs) that may lack comprehensive neurosurgical services. Clinicians in these EDs may also lack the equipment needed for skull trephination with a burr hole. Intraosseous catheters have become standard alternatives for vascular access in critically ill patients. Intraosseous catheters are likely available in most EDs, emergency medical services, and critical care transport. Intraosseous catheters are designed for the infusion of fluids or medications, but their bidirectionality also allows for withdrawal of fluid. Furthermore, the ability to insert a cannula through bone at a precise depth potentially allows intraosseous catheters to function as a makeshift craniostomy device to temporize before the patient arrives to the definitive trauma center.

A cadaver study demonstrated the feasibility of using an intraosseous catheter as a craniostomy device.[7] Results from case reports of actual patients, however, present limited and mixed results. Intraosseous catheter craniostomy was successfully used for epidural hematomas for both a 43-year-old woman and a 17-year-old adolescent girl, both of whom had complete neurologic recovery.[8,9] In other reports, however, intraosseous catheters were used in patients who ultimately died or had no meaningful neurologic recovery.[10-12] The literature on intraosseous catheter craniostomy in children is especially limited.

CASE REPORT

A 7-year-old boy with mild speech delay presented to a rural ED for altered mental status after falling from a bunk bed. The parents reported that he struck his right temple.

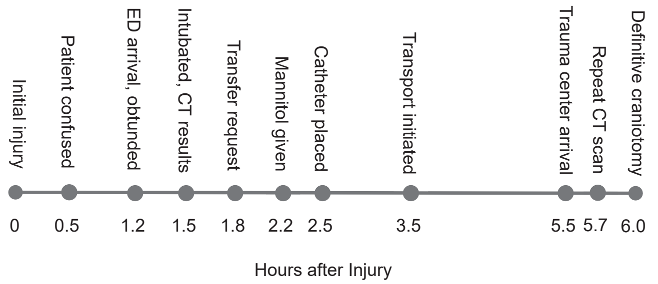

Figure 1. Timeline of events after initial injury.

The parents denied immediate loss of consciousness but noted that the child seemed initially confused and complained of headache. The patient's symptoms worsened over the 30 minutes after the fall, prompting the parents to take him to the ED (see timeline, Figure 1).

On arrival to the initial ED, approximately 70 minutes after falling, the patient was noted to be obtunded. Key examination findings included anisocoria with right-sided pupillary dilatation and extensor posturing of his arms, concerning for decerebrate posturing. The patient was intubated for airway protection. Soon after intubation, computed tomography (CT) showed a 2.4-cm × 7.4-cm right-sided epidural hematoma, effacement of the ventricle, 8 mm of midline shift, and downward effacement of the suprasellar cistern.

Approximately 110 minutes after the fall, the emergency physician called a pediatric trauma center to request emergency helicopter transfer. Due to inclement weather, the helicopter was not safe to fly. Ground transport to the rural ED and back to the trauma center was estimated to take approximately 3 hours. The emergency physician at the receiving pediatric ED then advised treatment of increased intracranial pressure with mannitol and hypertonic saline as well as consideration of skull trephination. The initial ED had no burr hole craniostomy kit. The emergency physician decided to attempt trephination with an intraosseous catheter. The intraosseous catheter was placed on the basis of the location and depth of the hematoma seen on CT (Figure 2). Approximately 15 mL of blood was evacuated using gentle suction with a large syringe. The intraosseous catheter was then connected to an empty intravenous bag for passive drainage, but the catheter quickly clotted. Additional attempts at gentle suction did not result in removal of additional blood. The patient was given mannitol and tranexamic acid. Approximately 3.5 hours after the fall, a critical care ambulance arrived to the initial ED to transfer the patient to the pediatric trauma center. The ambulance team administered hypertonic saline, which had not been available at the initial ED.

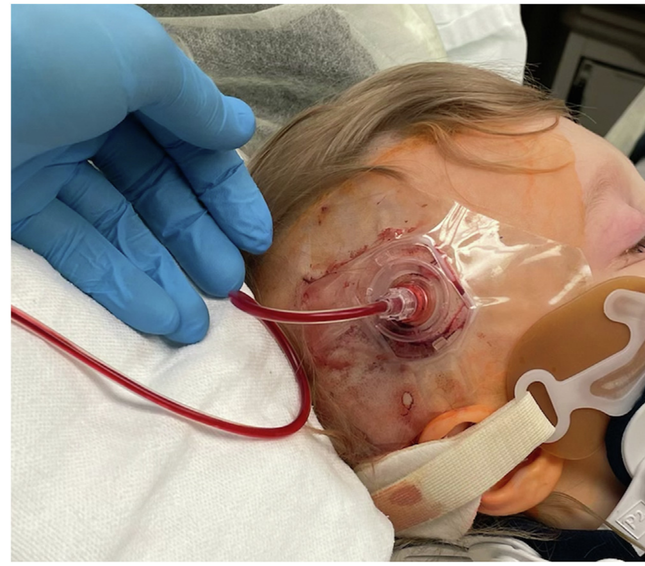

Figure 2. External view of the intraosseous catheter connected to drainage with the hematoma withdrawn.

The patient arrived at the pediatric trauma center approximately 5.5 hours after falling. A second CT showed reaccumulation and worsening of the epidural hematoma, with midline shift increased to 12 mm (Figure 3). Approximately 6 hours after falling, the patient was taken for emergency craniotomy and evacuation of the hematoma.

There were no significant neurosurgical complications and by postoperative day 2, the patient was able to move his extremities and say some words. He was discharged from the hospital on postoperative day 8 at his neurologic baseline and without physical/occupational therapy needs. He currently attends school and enjoys playing the computer game Minecraft.

DISCUSSION

This is the first published use of an intraosseous catheter to temporize an epidural hematoma in a prepubertal child and one of the few reports where the patient had full neurologic recovery. The pediatric patient with developing herniation from a large epidural hematoma had no access to prompt neurosurgical intervention. The initial ED used an intraosseous catheter to successfully remove some of the hematoma. This procedure may have temporarily decreased the intracranial pressure, prolonging the time to herniation/permanent neurologic injury. The hematoma reaccumulated and was larger on repeat imaging, but the hematoma may have been smaller than it would have been had no drainage been performed at the initial ED. Although the actual contribution of the intraosseous catheter

Figure 3. Intracranial placement of the intraosseous catheter after reaccumulation of the epidural hematoma.

craniostomy to the patient's neurologic recovery cannot be definitely determined, the patient's neurologic recovery is evidence of the potential benefit of intraosseous drainage, although the osmotic agents and the patient's young age may have contributed to the neurologic recovery.

Although the intraosseous catheter helped to remove the hematoma, the catheter was not inserted over the area of maximal hematoma. Measuring the precise location for catheter insertion on the basis of CT landmarks could improve accuracy of catheter placement, increasing the margin of error, making more blood accessible to drainage, and decreasing the risk of catheter occlusion. Training on this procedure, especially during emergency medicine training, might also improve its efficacy.

The intraosseous catheter clotted after the initial aspiration of blood, rendering it subsequently unhelpful to additional arterial bleeding. A study of craniostomy utilized continuous negative pressure drainage systems.[4] Other forms of low power suction, such as a Jackson-Pratt bulb suction device, might have potentially avoided clot formation within the needle, allowing it to continue evacuating any collecting hematoma.[13]

Traditionally, a sterile saline rinse has been employed in both craniotomy and burr hole placement. However, unlike craniotomy or burr hole placement, an intraosseous catheter forms a closed system when connected to a syringe. If gentle irrigation of the line with low-volume sterile saline is considered after initial hematoma removal, extreme care must be taken not to increase intracranial pressure with irrigation, including for attempts at clearing a clotted catheter.

There are advantages and disadvantages to skull trephination with intraosseous catheter compared with burr hole. Intraosseous catheters can be placed quickly, and almost all EDs have staff familiar with their use. If clinicians have the requisite training, however, burr holes can also be placed quickly and do not require much additional equipment. Burr holes are also larger in diameter than the hole from an intraosseous catheter, which may allow for more effective hematoma removal and less likelihood of clotting. Both intraosseous catheter and traditional burr hole craniostomy are temporizing. A decompressive craniotomy is definitive management and should not be delayed.

SUMMARY

Although the precise contribution of the intraosseous catheter craniostomy is unclear, in settings without prompt access to definitive neurosurgical intervention or burr hole craniostomy equipment and training, intracranial placement of an intraosseous catheter can be considered an alternative, temporizing approach to delaying permanent neurologic injury.

Supervising editor: Benjamin T. Kerrey, MD, MS. Specific detailed information about possible conflicts of interest for individual editors is available at https://www.annemergmed.com/editors.

Author affiliations: From the Department of Emergency Medicine (Weber), Beth Israel Deaconess Medical Center/Harvard University School of Medicine, Boston, MA; the University of Chicago Aeromedical Network (Campbell, Papandria), University of Chicago, Chicago, IL; and the Department of Neurosurgery (Ahmadpour), University of Chicago, Chicago, IL.

Funding and support: By *Annals'* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article as per ICMJE conflict of interest guidelines (see www.icmje.org). The authors have stated that no such relationships exist. The authors report this article did not receive any outside funding or support.

REFERENCES

1. Bonow RH, Barber J, Temkin NR, et al. The outcome of severe traumatic brain injury in Latin America. *World Neurosurg.* 2018;111:e82-e90.
2. Bullock MR, Chesnut R, Ghajar J, et al. Surgical management of acute epidural hematomas. *Neurosurgery.* 2006;58:S7-S15; discussion Si-Siv.

3. Haselsberger K, Pucher R, Auer LM. Prognosis after acute subdural or epidural haemorrhage. *Acta Neurochir*. 1988;90:111-116.
4. Liu JT, Tyan YS, Lee YK, et al. Emergency management of epidural haematoma through burr hole evacuation and drainage. A preliminary report. *Acta Neurochir*. 2006;148:313-317; discussion 317.
5. Nelson JA. Local skull trephination before transfer is associated with favorable outcomes in cerebral herniation from epidural hematoma. *Acad Emerg Med*. 2011;18:78-85.
6. Carr BG, Bowman AJ, Wolff CS, et al. Disparities in access to trauma care in the United States: a population-based analysis. *Injury*. 2017;48:332-338.
7. Gustafson ML, Edwards J, Tager A. Emergency burr hole utilizing the EZ-IO™ drill: a pilot cadaver study. *Am J Emerg Med*. 2021;39:229-230.
8. Bulstrode H, Kabwama S, Durnford A, et al. Temporising extradural haematoma by craniostomy using an intraosseous needle. *Injury*. 2017;48:1098-1100.
9. Grossman M, See AP, Mannix R, et al. Complete neurological recovery after emergency burr hole placement utilizing EZ-IO® for epidural hematoma. *J Emerg Med*. 2022;63:557-560.
10. Barro B, Kobner S, Ansari A. Decompression of subdural hematomas using an intraosseous needle in the emergency department: a case series. *Clin Pract Cases Emerg Med*. 2020;4:312-315.
11. Durnford S, Bulstrode H, Durnford A, et al. Temporising an extradural haematoma by intraosseous needle craniostomy in the District General Hospital by non-neurosurgical doctors—a case report. *J Intensive Care Soc*. 2018;19:76-79.
12. McClung CD, Anshus JS, Anshus AJ, et al. Bedside craniostomy and serial aspiration with an intraosseous drill/needle to temporize an acute epidural hemorrhage with mass effect. *World Neurosurg*. 2020;142:218-221.
13. Singla A, Jacobsen WP, Yusupov IR, et al. Subdural evacuating port system (SEPS)—minimally invasive approach to the management of chronic/subacute subdural hematomas. *Clin Neurol Neurosurg*. 2013;115:425-431.