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Brief Reports

EMERGENCY DEPARTMENT SKULL TREPHINATION FOR EPIDURAL HEMATOMA IN PATIENTS WHO ARE AWAKE BUT DETERIORATE RAPIDLY

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☐ **Abstract—Background: Blunt head trauma patients who have been alert but are deteriorating (talk and deteriorate [T&D]) due to a rapidly expanding epidural hematoma (EDH) usually have poor outcome if they must wait for hospital transfer for evacuation. We therefore have continued to teach skull trephination to emergency physicians (EPs). We are unaware of any literature on EP trephination for EDH in the age of computed tomography (CT) scanning. Methods: Patients with EDH from blunt trauma, either in our institution or known to our graduate network, who were T&D with anisocoria despite intubation plus medical therapy, and who had pre-transfer EP trephination, were compared to those who were transferred without trephination. Results: There were 5 patients with blunt trauma and CT-proven EDH who were T&D with anisocoria who underwent Emergency Department (ED) trephination at outlying hospitals before transfer. All 5 had improvement in condition and good outcomes. Three had complete recovery without disability and 2 others had mild disability with good cognitive function. None had complications. Two patients with T&D and anisocoria were transferred without trephination. Both had good neurologic outcomes. The mean time to pressure relief in the trephination group vs. transfer group was 55 vs. 207 min, respectively. Conclusion: In T&D patients with CT-proven EDH and anisocoria, ED skull trephination before transfer resulted in uniformly good outcomes without complications. Time to relief of intracranial pressure was significantly shorter with trephination. Neurologic outcomes were not different.**

☐ **Keywords— hematoma; epidural; cranial; anisocoria; emergency treatment; talk and deteriorate; head trauma**

INTRODUCTION

Emergency Department (ED) skull trephination is no longer part of the Emergency Medicine Core Curriculum and is rarely undertaken by emergency physicians (EPs). Most hospitals do not have neurosurgical capabilities; however, for salvageable patients who have been alert but are deteriorating due to a rapidly expanding epidural hematoma (EDH), the outcome is poor if they must wait for transfer to a tertiary care institution for evacuation (1). Severe shortages of neurosurgical services are expected in the future (2). Poon and Li found that patients with EDH who were rapidly deteriorating and presented to a neurosurgical institution had a mean time to EDH evacuation of 0.7 ± 1.0 h, and 9 of 11 had a good outcome (1). For 12 similar patients who had to be transferred before evacuation, the time to evacuation was 3.2 ± 0.5 h, and the mortality was 67% (8 of 12); furthermore, 0 of 12 had a good neurological outcome (1). Cohen et al. found that EDHs that are not drained within 70 min of onset of anisocoria are associated with a poor outcome (3,4). Thus, the talk-and-deteriorate (T&D) patient with EDH is unlikely to have a good outcome unless he or she presents to a neurosurgery-

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capable hospital. On the other hand, if EPs can temporarily release the elevated intracranial pressure by performing skull trephination (drilling a burr hole), the patient may be salvaged. Skull trephination does not require extensive training and results in few complications (5). We therefore have continued to teach skull trephination to EPs at Hennepin County Medical Center (HCMC). The procedure is also taught to rural EPs in the Comprehensive Advanced Life Support (CALS) course, which was developed at HCMC. We continue to encourage the use of trephination in the appropriate circumstances: the comatose T&D patient with anisocoria and epidural hematoma who has not responded to osmotic agents and hyperventilation. Subsequently, graduates of our program and of CALS have used the procedure at outlying hospitals. We report their experience with skull trephination for blunt trauma in the era of routine and fast computed tomography (CT) scanning. We are unaware of any literature on ED trephination by EPs for EDH in the age of CT scanning.

METHODS

This was a three-part retrospective chart review using the Institutional Trauma Registry. The Institutional Review Board determined that the study was exempt from formal review. First, we searched for all patients in the Trauma registry database, from 1990–2007, with "skull trephination," a field in the database. Second, among graduates of our residency program and of the CALS course, we collected all known cases of skull trephination done by EPs at a non-neurosurgical institution before transfer to a neurosurgical institution. Third, we searched for all EDH patients with CT-proven isolated EDH transferred into our institution, with prior skull trephination. For all cases, we then searched the medical records for initial

Table 1. Clinical Details of the Five Talk and Deteriorate Patients who Underwent Pre-transfer Skull Trephination

Case	Initial Examination	CT Findings	Medical Therapy	Examination before Trephination	Examination after Trephination
29-year-old man, MVC	Awake, talking, agitated. Equal and reactive pupils at 2 mm. Left temporal hematoma.	Left temporal EDH with midline shift and depressed temporal bone fracture (see Figure 1)	Intubation, paralysis, hyperventilation	Left pupil dilated to 4 mm and non-reactive	Active, pulsatile bleeding from trephination site, pupil 3 mm and reactive
32-year-old man hit his head during syncope	Alert, oriented, wanting to go home, then developed headache	Temporal bone fracture, Large left EDH with midline shift	Intubation, paralysis, hyperventilation, phenytoin, mannitol	GCS = 7; dilated and non-reactive left pupil; seizure activity	Pupil 3 mm and reactive; continued arterial bleeding from burr hole
67-year-old woman in MVC	GCS = 15	Large parietal skull fracture with large EDH and midline shift, temporal lobe contusion, traumatic SAH	Intubation, paralysis, hyperventilation, dexamethasone, mannitol	GCS = 7; dilated and unreactive left pupil	Pupil 3 mm and reactive; continued arterial bleeding from burr hole
39-year-old male bicyclist	Awake, alert, and ambulatory, with a headache. Quickly had a deteriorating level of consciousness	Large right EDH with maximum diameter of 4 cm and 24 mm of midline shift.	Intubation, paralysis, hyperventilation, phenytoin, mannitol	GCS = 7; dilated and unreactive right pupil	Pupil became reactive
30-year-old man after fall	At scene, returned to work. Became dizzy, then seized	Very large left frontal-temporal-parietal EDH with large midline shift and tonsillar herniation. Multiple fractures of orbital, sphenoid, and middle fossa	Intubation paralysis, hyperventilation	Cyanotic and decerebrate. GCS = 4	Brisk bleeding, pupil reactivity not documented

CT = computed tomography; EDH = epidural hematoma; SAH = subarachnoid hemorrhage; GCS = Glasgow Coma Scale score; MVC = motor vehicle collision.

Glasgow Coma Scale (GCS) score ≤ 8 (standard definition of coma), and for T&D status and anisocoria unresponsive to medical therapy at the outside hospital. Good outcome was defined as independent function (6).

RESULTS

For Part 1, 20 cases of "skull trephination" were found; they are described below. For Part 2, 2 additional cases were supplied: one case that was referred to a second tertiary care center was supplied by one of our residency graduates, and yet another referred to a third center was supplied by a rural emergency physician who had learned the procedure at the CALS course. Upon review of the 20 cases in Part 1, 15 were excluded: 2 had only a ventriculostomy or an intracranial "bolt" placed; 6 had trephination done in the operating room (not in the ED); and one other had trephination done in the surgical intensive care unit. One had a subdural hematoma. Two others were full craniotomies; three others were a result of gunshot wounds (GSW) to the head, all of whom died. Thus, there were 7 patients with EDH from blunt trauma who had ED trephination. All were done at outlying hospitals without neurosurgical capabilities and were done before transfer to a neurosurgical receiving facility. Five of 7 of the patients were alert before deteriorating; 3 had complete recovery without disability, and 2 others had mild to moderate disability but with good to excellent cognitive function. The other 2 had a GCS score of 3 and 4, respectively, when initially seen by medical personnel; both died. None had complications from the procedure other than external bleeding from the already lacerated middle meningeal artery. In 4 of 5 cases, the times were recorded. Mean time from ED presentation to trephination was 55 min, and mean time from ED to craniotomy was 173 min. The mean time saved was 118 min, or approximately 2 h.

Table 1. (Continued)

Amount Drained	Time from Presentation to Trephination	Time from Presentation to Craniotomy	Status at Discharge	Long-term Outcome
20 mL	60 min	180 min	Near normal	Back to work in 2 weeks
60 mL dark clot	60 min	180 min	Awake and oriented, moving all extremities but with right side weakness, following complex commands	Mild and resolving right hemiparesis, no activity limitations, back to work 31 days after injury
60 mL of clot	Not documented	Not documented	Not documented	Fluent speech, no weakness, but some mild neuro-psychiatric deficits including some anterograde amnesia
Not documented	60 min	210 min	Awake and alert, intermittently responsive to commands, with left side weakness; had 23-day course with pneumonia and sepsis	Conversing normally and was ambulatory but with a left hemiparesis
Unknown amount of dark clot suctioned	40 min	120 min	Severe brain swelling needing craniectomy. Multiple doses of mannitol and hypertonic saline over 48 h. 14 h after surgery, the left pupil was reactive and there were purposeful movements on the left. Pupils were equal and reactive on day 5. At discharge, he was interactive and ambulating with assistance	Symmetric strength and no speech impairment but some short-term memory deficits

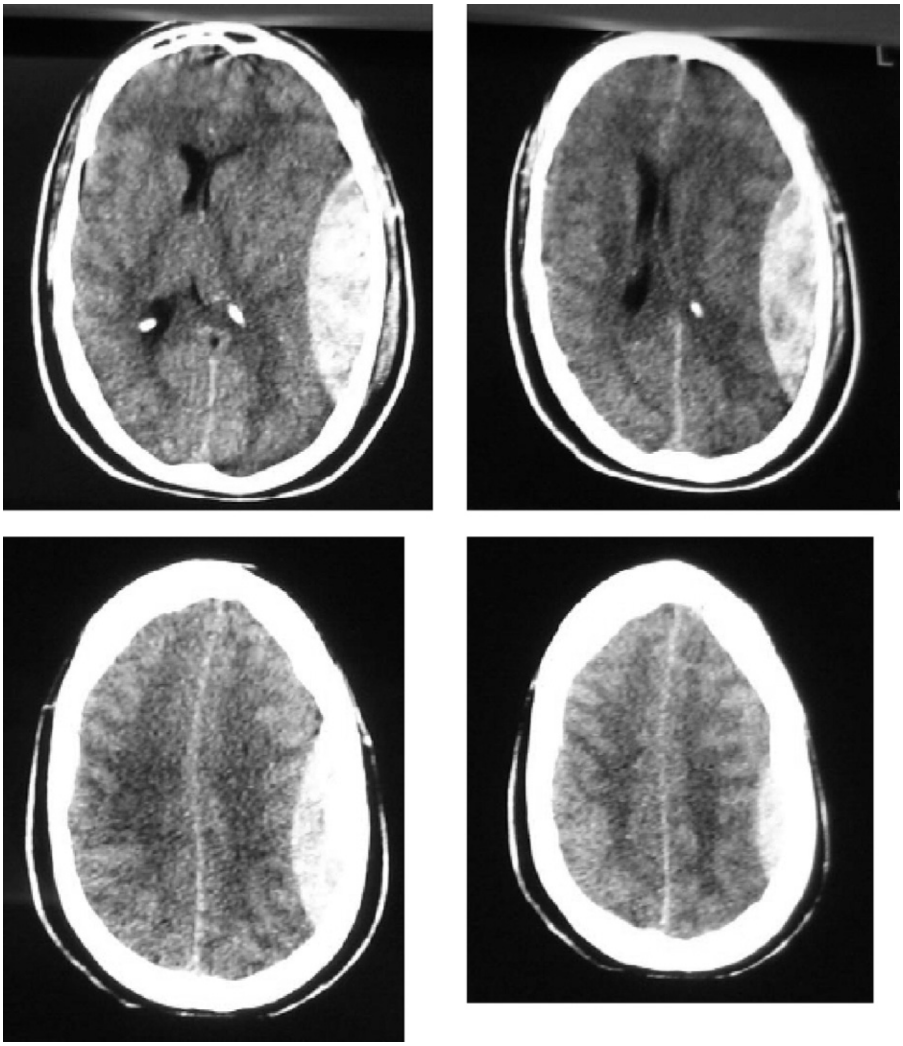

Figure 1. CT scan of the patient in Case 1, with a large left temporal epidural hematoma, with left to right midline shift.

The 5 survivors are described in Table 1 (see also Figure 1). All trephinations were done by emergency physicians, only 2 of whom were board certified; the others were board certified in family practice. All physicians received training in skull trephination as part of the HCMC Emergency Medicine Residency or as part of the CALS course. Training was very brief and involved discussion of the treatment of EDH, review of a CT scan of EDH, and hands-on practice on the skull of a dead sheep, using the Galt trephinator. No physician had previously performed the procedure on a human or living animal. In all cases, there was a single CT-guided burr hole drilled using the Galt trephinator. The method is described below.

For Part 3, there were 113 patients with EDH transferred in, 5 of whom were T&D to coma with anisocoria. Three did undergo pre-transfer skull trephination and are included under Part 1; 2 others did not undergo skull trephination and both had good outcomes. Times from ED presentation to craniotomy for these 2 patients were 264 and 150 min, respectively.

Thus, there were a total of 7 EDH patients who had talk and deteriorate into coma from blunt trauma with anisocoria. Five had pre-transfer skull trephination and 2 did not. All had good neurologic outcomes.

DISCUSSION

We have presented all five cases of patients who were initially awake but then deteriorated into coma, had anisocoria, and had epidural hematoma on head CT scan, who underwent ED trephination before transfer to a receiving facility with neurosurgical capability. There were an additional two cases that were transferred without ED trephination. All had a good outcome. Those with

GSW or deep coma at first medical contact did not survive.

Among the 5 who underwent trephination before transfer, we cannot be certain that the outcome would have been worse with delay in therapy; however, in all cases, deferring the procedure in favor of an operating room craniotomy after transfer to the referral institution would have entailed long delays before relief of pressure. The mean difference between the times to trephination vs. time to craniotomy in the four cases measured was 118 min; the actual time saved may be somewhat less due to time taken for the procedure. However, frequently the procedure is done while waiting for transport. Secondly, the procedure takes less than 10 min to perform. There is evidence in the literature that a delay of > 70 min is associated with adverse outcome in patients with EDH, and that transfer for drainage of EDH with deteriorating neurological status results in poor outcome (1,3). Furthermore, it is physiologically intuitive that such an EDH, which is under arterial pressure, will, by equaling the pressure of the arteries perfusing the brain, result in low cerebral perfusion pressure and rapid, irreversible brain damage.

In 1981, Mahoney et al. published their experience of ED skull trephination on 41 patients; all were done before obtaining a CT scan of the head (5,7). Since then, the advent of rapid and available CT scanning has made blind trephination obsolete in the United States, except perhaps in Wilderness Medicine. However, even ED trephination after head CT scan is very unusual, and it is not listed as a procedure in the Core Curriculum of Emergency Medicine (8–10).

There is literature on the "talk and deteriorate" patient and on epidural hematoma generally, but there is very little on the T&D patient with a GCS ≤ 8, a lucid interval, and anisocoria despite aggressive medical therapy.

The T&D patient is a very special head injury patient. The "lucid interval" of relatively good neurological function before deterioration implies minor primary brain injury (11). Epidural hematomas, unlike subdural hematomas (SDH), frequently have no brain parenchymal injury. Deterioration is due to secondary brain insult, and this is a mass lesion in 75–80% of cases (11,12). These patients' outcomes are inversely related to GCS after deterioration, age, degree of midline shift (>5–15 mm), and size of hematoma > 30 cm^3 or > 15 mm thick (in the case of EDH) (4,12–14). Approximately 22% will be due to EDH, and if the EDH is rapidly decompressed, the outcome is significantly better than for deterioration due to other etiologies (12).

Trephination before transfer, but after head CT scanning, also has been described by surgeons who report success if the procedure is performed immediately. In Montana, at Level III hospitals, 6 patients with EDH and 2 of 14 with SDH (for a total of 8 patients), all of whom were deemed too unstable for transport, underwent burr hole decompression followed by immediate transfer. All were approved by the consulting neurosurgeon and were done for CT-confirmed lesions combined with rapid neurologic deterioration and either: GCS score of 8 or less, lateralizing signs (dilated pupil, hemiparesis), or development of combined bradycardia and hypertension. One patient with a GCS score of 3 on arrival died. Seven survivors (mean follow-up 3.9 years; range 1–6.5 years) function independently (15).

In Taiwan, of 13 patients undergoing trephination by CT guidance, five trephinations (3 patients with anisocoria) were done in the ED after rapid deterioration (16). No patient presented with a GCS higher than 11; it is thus unlikely that they were "talk and deteriorate" patients. Clots were suctioned successfully and patients regained consciousness within 2 h without significant sequelae.

Evacuation of intracranial hematoma with mass effect must be done expeditiously. For EDH, this should be done within 60–90 min of onset of anisocoria. Cohen et al. described 10 patients with coma and EDH who developed anisocoria. All 5 who had > 70 min between onset and evacuation had a poor outcome (3). Haselsberger et al. describe 34 patients with EDH and coma (17). Among those treated surgically within 2 h of deterioration, 67% had a good outcome, with mortality of 17%; among those treated beyond 2 h, 13% had a good outcome with mortality of 56%. The Congress of Neurological Surgeons recommends evacuation "as soon as possible" (4). Despite describing some literature on the topic, the Congress gives no recommendation regarding evacuation before transfer by non-neurosurgeons.

There are two other case series of EDH in which some of the patients were accepted in transfer (18,19). In these series, the populations were very heterogeneous in size and midline shift, in GCS, and in presence or absence of anisocoria. These two large studies on EDH should not be used as evidence against the utility of ED trephination, despite their conclusions. Bricolo and Pasut studied 101 EDHs over a 3-year period (1980–82), representing 4% of all head injuries (18). There were 36% transferred in from a non-neurosurgical institution, all with some "neurological signs." Forty-four had a GCS ≤ 7 by the time of operation and 12 had a poor outcome. Only 22 had a lucid interval and only 8 had anisocoria, all 8 of whom had a good outcome. The authors do not indicate how many had both a lucid interval and anisocoria, whether deterioration occurred at the outlying or at the neurosurgical hospital, or the interval between deterioration and operation. Thus, any conclusions about this group of patients, and especially of the urgency for operation, are speculative. In Norway, Wester studied 83 patients surgically treated for EDH (19). There were 28 seen at a local hospital before being transferred to the neurosurgical unit. Only 7 patients had a GCS < 8, and 22 had anisocoria (4 only transitory). Five of the 22 had poor outcomes. Eleven patients had an "operation" in the local hospital before transfer; seven of the operations were burr holes, all with good outcomes, and four were craniotomies, all with a poor outcome. Pre-transfer craniotomy required much more time and was associated with poor outcome. All patients who had an "operation" before transfer and had a good outcome had a GCS ≥ 7. Eight of 11 operations were "inadequate," meaning the hematoma was not completely drained or there were bleeding complications. Nevertheless, and perplexingly, the authors conclude that decompression should not be done in the local hospital.

Complications

In the studies cited above, there were no direct complications of the trephination procedure itself except for "inadequate evacuation" and bleeding from branches of the middle meningeal artery. Trephination is not meant to achieve full evacuation of the EDH, but only the release of dangerously high pressure. Just as in pericardial tamponade, the last few milliliters of bleeding result in high pressure due to a steepening compliance curve. The goal is to drain enough blood to lower intracranial pressure significantly. Delay to operation is often listed as a complication. There is little operation room literature on trephination complications. Reiss et al. reported on 519 trephinations using a "Rosenbohrer" (a 2.35-mm round dental drill with serrated edges) in the operating room for a variety of indications; they found that the rate of infection was 1.28% and the risk of bleeding was 0.36% (20).

Review of the Method of Trephination

First, trephination of EDH in locations other than temporal (such as in the occipital or parietal regions) may result in hemorrhage or air embolism related to the venous sinuses. Thus, patients with EDH in these areas should not undergo trephination outside of an operating room. Formerly, the location for trephination was determined in a blind fashion, without CT guidance; the recommended location was 2 cm anterior and 2 cm superior to the tragus. However, now we recommend only CT-guided trephination. After locating the area, a 4-cm vertical incision down to the periosteum should be made. A periosteal elevator should be used to expose the skull. At this point, the trephine is applied.

Figure 2. Galt trephinator.

The DeVilbiss® trephine (Miltex Inc., York, PA) was preferred by participants in an animal laboratory because it did not plunge as far as the Galt® trephine (Sontec Instruments, Centennial, CO) and resulted in a large enough hole, unlike the Codman® trephine (no longer available) (21). However, the Galt® trephine produced a hole through which clot could be much more easily extruded. In a sheep study, the respective pressures required for extrusion were 64 ± 23 (confidence intervals) mm Hg for the Galt vs. 248 ± 34 mm Hg for the DeVilbiss (vs. >300 mm Hg for the Codman®) (22). Thus, we recommend the Galt® trephine (Figure 2): it should be applied with gentle pressure and a back-and-forth rotating motion until the skull is penetrated. The bone fragment may come out in the device, or may need to be removed with a forceps. The bone fragment may be placed in a sterile cup with saline. Once the bone fragment is removed, the clot may not immediately extrude, and thus, suction must be employed. Bleeding from the disrupted artery may ensue. A small suction catheter may be placed in the epidural space to facilitate hematoma drainage during transfer. If identified, the bleeding artery (usually the middle meningeal) may be clamped.

CONCLUSION

In this small study of the "talk and deteriorate" patient with CT-proven EDH and anisocoria, ED skull trephination resulted in uniformly good outcomes without complications. Time to relief of intracranial pressure was significantly shorter than it was with transfer for craniotomy without prior trephination (55 vs. 207 min, respectively). Outcomes were not different.

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