# Cranial burr holes in the emergency department: to drill or not to drill?

Alan Howard [1], Vinaithan Krishnan,[1] Gerard Lane,[1] John Caird[2]

[1]Emergency Department, Letterkenny University Hospital, Letterkenny, Donegal, Ireland
[2]Department of Neurosurgery, Beaumont Hospital, Dublin, Ireland

**Correspondence to**
Dr Alan Howard, Emergency Department, Letterkenny University Hospital, Letterkenny, Donegal, Ireland; alandoc@hotmail.com

Received 19 July 2019
Revised 22 November 2019
Accepted 9 December 2019



**To cite:** Howard A, Krishnan V, Lane G, *et al*. *Emerg Med J* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/emermed-2019-208943

## ABSTRACT

The practice of *trepanning* (referred to today as a craniotomy) dates back to the Neolithic period. Reasons for drilling a hole through the skull evolved from releasing evil spirits and curing insanity to practical management of head injuries in ancient Greece and Rome. Today, craniotomy or drilling a burr hole through the skull is very much the purview of the neurosurgeon. Yet one could argue that the procedure itself is more 'bone surgery' than 'brain surgery'. Nevertheless, despite the fact that head injury is a common presentation at district general hospitals and traumatic extra-axial haemorrhages are encountered often, the straightforward skillset required to drill a burr hole as a pretransfer, temporising, life-saving measure is seldom taught and has never gained traction. What we advocate in this article is the adaptation and novel application of an old, tried and tested technique in new hands. The critical pathophysiological turning point of any expanding extra-axial haemorrhage is the inflection point on the volume/Intracranial pressure (ICP) curve beyond which compensation is impossible. The subsequent rising ICP initiates a predictable continuum of clinical signs signalling progressive herniation. There are few emergencies as time-critical as a patient with an isolated, expanding extradural haemorrhage embarking on a trajectory of rostrocaudal deterioration and inevitable death. In many cases, the tragedy is compounded by the knowledge that such a patient probably has a healthy underlying brain, often evidenced by a lucid period after trauma. Our emergency department is attached to a small 300-bed District General Hospital (DGH) on the rural North West coast of Ireland. We are 262 km distant by road from a national neurosciences department that can, at best, be reached in 2 hours and 30 min. Quality improvement review of years of dismal outcomes in patients such as those described earlier with potentially remediable pathology prompted research and development of the skillset we are now able to offer, an old technique in new hands.

## CASE 1

A 32-year-old man was involved in a high-speed motor vehicle collision (MVC). On arrival in the emergency department (ED) 90 min after the collision, he was agitated, tachycardic (102 beats/min) and in acute respiratory distress (respiratory rate 30 breaths/min), and his Glasgow Coma Score (GCS) was 11/15 (E4 V3 M4). Blood pressure was 116/80 mm Hg on arrival. Minutes after arrival, he had a seizure and was intubated emergently using a neuroprotective strategy. A portable chest X-ray demonstrated multiple left rib fractures, a right pneumothorax, pneumomediastinum and extensive bilateral surgical emphysema tracking into the neck. Bilateral intercostal chest drains were inserted. A haemotympanum with a CSF leak was noted on the right. A Focused Assessment with Sonography in Trauma (FAST) examination was negative. While in the CT suite, our patient developed bilateral anisocoria and was shown to have a 3.5×7.5 cm extradural haemorrhage overlying his left temporal lobe, a small volume of subarachnoid blood in the right parietal lobe and midline shift posing an immediate life threat (figure 1). A burr hole was drilled in the ED by a consultant in emergency medicine using an ACRA-CUT DGR-0 cranial perforator and guided by surface anatomy landmarks identified by the consultant radiologist. The haematoma was largely evacuated using irrigation and gentle suction, and the wound was loosely occluded with a sterile dressing. It was noted that immediately on evacuation of the haematoma, the patient's pupils returned to normal size and reactivity. The patient was transferred to a neurosurgical unit, where he underwent a craniectomy. En route in a land ambulance, he required further decompression of the extradural collection using irrigation and gentle suction. He arrived at the neurosurgical unit 8 hours after the collision and 3 hours and 40 min after the burr hole was drilled. He made an uneventful recovery and achieved a Glasgow Outcome Score of 5.

## CASE 2

A 31-year-old man was involved in a single-vehicle MVC. He sustained isolated, significant head trauma. He was communicating coherently on scene (GCS 14). On arrival in our ED 70 min after the collision, his GCS had reduced to 13/15 (E4 V4 M5) and further deteriorated to 7/15 (E2 V2 M3). An Extended Focused Assessment with Sonography in Trauma (eFAST) ultrasound examination was negative. Blood and brain matter was visible at the right auditory meatus. He was restless and combative. His respiratory rate increased to 16 breaths/min, and of concern was a declining pulse rate (reaching 50 beats/min) and a blood pressure

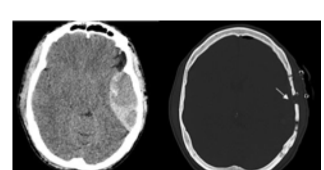

Figure 1 CT scans from case 1 showing the large left temporal extradural haematoma and the position of the Burr hole (arrow) drilled in the emergency department.

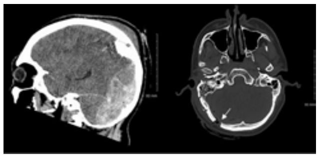

**Figure 2** CT scans from case 2 showing the large right parieto-occipital extradural haematoma and the position of the Burr hole (arrow) drilled in the emergency department.

that rose from 140/8 to 165/106mm Hg. Our patient was intubated using a neuroprotective strategy. His CT scan showed an extensive, compound, comminuted fracture of the right parietal and occipital bones with intrusion of fracture fragments into brain substance and fractures of the right temporal bone and mastoid. Intraventricular, petechial and subarachnoid haemorrhages with significant mass effect caused by a large 10×4 cm extradural haemorrhage in the right parieto-occipital region were demonstrated on CT (figure 2). Uncal herniation was already evident on CT, as was descent of the right cerebellar tonsil. On our patient's return to the resuscitation area, and in spite of administration of intravenous mannitol (1 g/kg) and moderate hyperventilation to an $EtCO_2$ of 3.5 kPa, it was evident that herniation and death were imminent, heralded by significant systolic hypertension and bradycardia.

A burr hole was drilled in the ED by a consultant in emergency medicine using an ACRA-CUT DGR-0 cranial perforator over the right occiput. A consultant radiologist identified the deepest part of the haematoma relative to the occipital protruberance and right external meatus. These landmarks were used to locate a point of intersection in centimetres using a sterile, disposable tape. A large amount of haematoma and blood was evacuated, and our patient's blood pressure and pulse rate normalised immediately, reducing to 130/80 mm Hg and 70 beats/min, respectively. A combination of cefotaxime, flucloxacillin and metronidazole was administered intravenously and an orogastric tube was inserted, avoiding any form of nasal instrumentation. Our patient was transported to a neurosurgical unit while on a continuous propofol infusion with rocuronium and fentanyl administered intermittently. As in case 1, he required further irrigation and evacuation of blood from the craniotomy en route when coning was again considered imminent, evidenced by Cushing's triad. Again this intervention normalised his haemodynamics, reducing his systolic blood pressure from 160 to 130 mm Hg.

An extensive craniectomy was performed shortly after arrival at the neurosurgical unit 3 hours and 30 min after the burr hole was drilled. Our patient was weaned from the ventilator on day 7, communicating and sitting out in a chair on day 9, and moved out of the intensive care unit on day 10. Our patient is cognitively normal and has an improving central cord syndrome.

## DISCUSSION

Closed head injuries do not evoke the same visceral response and call to action in the ED as a dying trauma patient with a tension pneumothorax or visible massive haemorrhage. A more clandestine killer, the extra-axial haemorrhage wreaks its havoc out of sight and does not leak on the floor as it claims its victims quietly and terribly effectively. Yet the mass effect of expanding extradural and subdural haemorrhages on the brainstem is akin to and equally as lethal as a tension pneumothorax compromising cardiac output and oxygenation. In the latter case, and on pain of being found guilty of professional misconduct (should we delay), we delve into the chest with intercostal drains to save the day, an intervention far more invasive and potentially dangerous than drilling a burr hole.

In his study published in 2011,[1] James Nelson investigated the effect of non-neurosurgeon pretransfer drainage of extradural haematomas on neurological outcomes in patients demonstrating signs of herniation. Notwithstanding methodological limitations and small sample sizes, Nelson concluded that 'Best available evidence suggests that herniating patients have improved outcomes with drainage procedures before transport'. Nelson identified two critical time frames in patients with proven extradural haematomas outside of which outcomes were dismal.

First, evacuation (even partially) of an extradural haematoma within 2 hours of the onset of witnessed deterioration of GCS (often following a typical intervening 'lucid period') was associated with favourable outcome, while the converse was equally telling.

Second, evacuation of haematoma within 70 min of witnessed anisocoria was associated with very favourable outcomes, while the converse usually resulted in death.

Scotter *et al* investigated the prognosis of patients with bilateral fixed dilated pupils (BFDPs) secondary to an extra-axial haemorrhage who underwent decompressive surgery and published their findings in 2015.[2] They concluded that a low threshold for decompression in patients with BFDP and extradural haemorrhages should be adopted, noting that almost two-thirds of patients with extradural haematomas survived after decompression with over half having a good outcome. Notwithstanding the fact that the evidence for aggressive management of patients with BFDP and traumatic subdural haematoma is less convincing (due to a higher incidence of concurrent primary brain injury), they concluded that there were sufficient patients demonstrating good recoveries to justify an aggressive management strategy in this cohort in the first instance.

Durnford *et al*[3] published a case report in 2018 with striking similarities to our two cases, namely, an adult patient with an isolated head injury, skull fractures and an extradural haematoma. Their patient was also on a precipitous clinical trajectory despite traditional interventions to control rising intracranial pressure. Under remote guidance from a neurosurgeon (who had viewed the CT images), haematoma was aspirated using an EZ-IO device and a 25 mm long intraosseous needle. The article reports that 70 mL of blood was aspirated over 10 min. Notwithstanding a transient reduction in pupil size, the patient deteriorated, was not transferred to a neurosurgical unit and subsequently died.

We hypothesise that given our own recent experiences of evacuating extradural blood and thrombus through a 14 mm burrhole in the skull using irrigation and suction, the lumen of an IO needle is almost certainly inadequate to shift sufficient thrombus. Durnford *et al* concede that extra-axial blood tends to clot rapidly, making their technique better suited to a more liquefactive thrombus. Their method may, therefore, prove more successful in patients already on anticoagulants. Indeed, the fact that both our patients required a repeat irrigation and evacuation of newly formed recalcitrant thrombus en route to the neurosurgical unit suggests that using a needle will have limited efficacy.

It is interesting to note in Durnford's case report that the anticipated time to neurosurgery once bilateral anisocoria became established and the neurosurgeon was contacted was only 40–50 min yet prompted the advice to immediately decompress the haematoma pretransfer. This is less conservative than Nelson's 70 min recommendation in the event of witnessed anisocoria. Our neurosurgical centre is 2.5 hours away by road.

We keep a craniotomy pack in our resuscitation area stocked with adult and paediatric ACRA-CUT cranial perforators, which are driven by a drill that is compatible (using an adaptor) with the

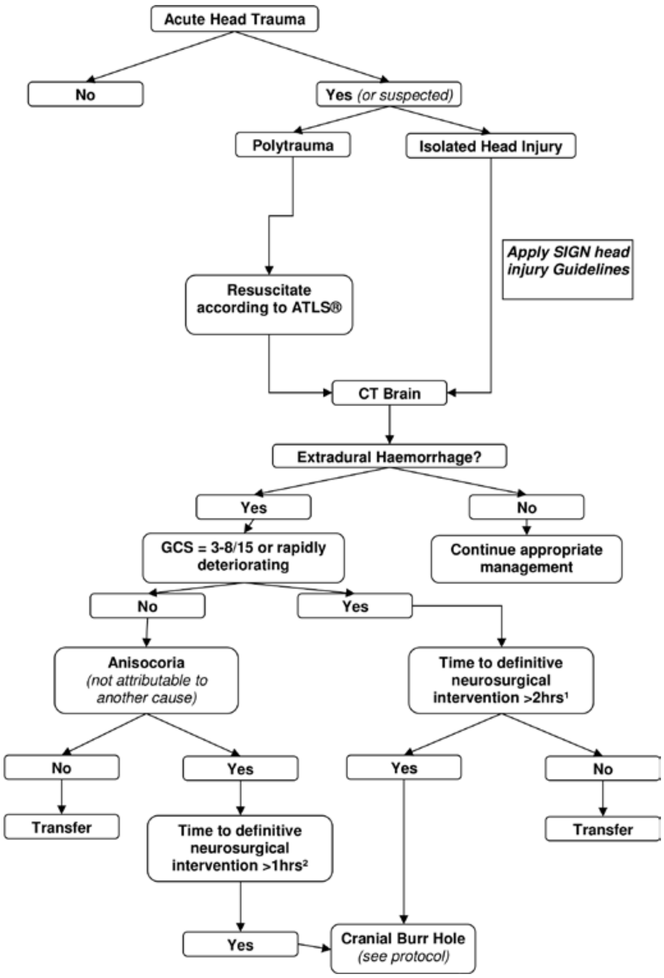


**Figure 3** An algorithm to guide decision making in patients with extradural haemorrhage and delayed access to a neurosurgical facility. (1) Time from witnessed onset of coma (GCS 3–8/15), that is, 'talk-and-deteriorate' or from time of injury if comatose ab initio. (2) Time elapsed since anisocoria was first noted. GCS, Glasgow Coma Score.

available 400 kPa piped medical air supply. Self-retaining retractors, a periosteal elevator and a dural hook are included. An algorithm was developed to guide decision making based on the critical time frames identified by Nelson (figure 3).

To our knowledge, analogue trainers for drilling burr holes are not readily available, and we considered sourcing sheep skulls. Access to cadavers would be ideal. A few among our our cohort of consultants in emergency medicine have spent time in neurosurgery during their training and were therefore more confident. However, all have experience in anaesthesia, sterile technique, minor surgery, the use of intraosseous drills and drainage of haemothoraces. Augmenting this foundation of skills with procedure-specific decision making and equipment assembly was straightforward. Hands-on training in the assembly of the air hose, drill, Hudson chuck and perforators is conducted with both medical and nursing colleagues in our department. Proprietary videos prove very useful in explaining and demonstrating the patented antiplunge release mechanism and antiskid tip of the ACRA-CUT perforators, and this further ameliorates anxiety in those who might be called on to perform the procedure. A video demonstrating the assembly and use of the drill in the familiar environment of our resuscitation area was produced and is accessible to all staff. We emphasise that those performing the procedure do so at the behest of and as the remote hand of a receiving neurosurgeon who has studied the CT images and has been apprised of the clinical status of the patient.

The procedure is carried out in the resuscitation area of our ED on an anaesthetised patient and under a sterile field. The assistance of a radiologist is engaged to determine the best location to access the deepest part of the haematoma using surface anatomical landmarks such as the external auditory meatus and occipital protruberance.

Equipment is assembled and checked. The head is widely shaved around the site and surgically prepped. The scalp is incised down to the periosteum and bleeding controlled with direct pressure or diathermy. A self-retaining retractor is used to optimise the field. The periosteum is incised and stripped away with a periosteal elevator. The burr hole is drilled, maintaining steady pressure and speed with the ACRA-CUT perforator held vertical to the skull until the inner table is penetrated and the perforator automatically stops turning (antiplunge feature). During drilling, an assistant irrigates around the perforator with sterile saline from a catheter tip syringe. A shallow plug of bony inner table is retrieved from the base of the hole, allowing direct access to the extradural space and haematoma. Blood should flow freely from the hole and recalcitrant thrombus can be evacuated using sterile saline irrigation from a catheter tip syringe and gentle suction with a catheter or paediatric Yankhauer. Sterile gauze and a dressing are loosely applied.

In both of our reported cases, further irrigation and aspiration of accumulated haematoma were required en route, mandating preparation for this eventuality and accompaniment by a trained individual.

In both of our cases, relatives of the patients were notified about the dire clinical circumstances and availability of the novel intervention offered by our department before the procedure was undertaken. In both cases, support was immediately forthcoming.

It is our firm belief that consultants in emergency medicine in remote locations with CT capability should acquire the straightforward skillset and equipment needed to perform pretransfer emergency cranial burr holes. This life-saving intervention should move out of the 'once in a lifetime heroic procedure' category and become a reasonable standard of care.

**Contributors** AH was the lead author and was responsible for researching and initiating the pretransfer emergency department (ED) cranial trephination pathway. AH and VK conducted the procedure successfully in the ED, assisted in the second case by GL. JC was the receiving neurosurgeon in the second case. All authors contributed meaningfully to the drafting and revision of the article submitted.

**Funding** The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

**Competing interests** None declared.

**Patient consent for publication** Not required.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Author note** This article is dedicated to the fond memory of my dearest friend, colleague and co-author Vinaithan Krishnan, who was suddenly taken from us on 13th August 2019.

**ORCID iD**
Alan Howard http://orcid.org/0000-0002-6357-6483

## REFERENCES

1 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.
2 Scotter J, Hendrickson S, Marcus HJ, *et al*. Prognosis of patients with bilateral fixed dilated pupils secondary to traumatic extradural or subdural haematoma who undergo surgery: a systematic review and meta-analysis. *Emerg Med J* 2015;32:654–9.

3 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;19:76–9.