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Technical notes & surgical techniques

Predicting dural tear in patients will skull fractures secondary to assault

Patrick Lekgwara (FC Neurosurgery (SA))[a], Adrian Kelly (MMed Neurosurgery cum laude (SMU), FC Neurosurgery (SA))[a,*], Aftab Younus (FC Orthopedics (SA))[b]

[a] Department of Neurosurgery, Dr George Mukhari Academic Hospital, Sefako Makgatho Health Sciences University, Pretoria, South Africa
[b] Department of Orthopedics, Helen Joseph Hospital, University of the Witwatersrand, Johannesburg, South Africa

A B S T R A C T

Aim: Skull fractures of the calvarium associated with a dural tear are regarded as neurosurgical emergencies to prevent potentially devastating infective complications. We aimed to determine the significance of pre-operative clinical and radiological variables in predicting dural tear in 135 patients admitted over a 2 year period with skull fractures secondary to assault whom went for operative intervention.

Methods: Retrospective data analysis of 135 patients admitted with skull fractures secondary to assault from January 2015–December 2016 was performed. Medical records were analyzed for patient demographics, mechanism of injury, CT scan findings, pre-operative suspicion including evidence for this suspicion of a dural tear, operative confirmation of a dural tear, and Glasgow Outcome Score. Management involved surgery with antibiotic cover.

Results: Considering the mechanism of injury being assaulted with a brick was significantly associated with the absence of a dural tear and being stabbed in the head with significantly associated with the presence of a dural tear ($p = 0.02$). On bivariate analysis having a depressed skull fracture ($p = 0.002$), pneumocephalus ($p = 0.02$) or an intracerebral hematoma ($p = 0.001$) were each statistically associated with the operative confirmation of a dural tear. Neither the combined presence of a skull fracture with an acute subdural hematoma or an intracerebral contusion was statistically associated with an intra-operative dural tear.

Conclusion: In patients with a skull fracture secondary to assault considering the mechanism of injury being assaulted with a brick significantly excluded, and being stabbed in the head significantly predicted, the intra-operative finding of a dural tear. Considering pre-operative radiology having a depressed skull fracture, pneumocephalus, or intracerebral hematoma were each significant predictive variables of there being an intra-operative dural tear.

1. Introduction

The presence of a skull fracture in a patient incurring a traumatic brain injury is a possible important marker of a serious underlying brain injury, examples of which include an extradural hematoma, intracerebral contusion, intracerebral hematoma and acute subdural hematoma [1,2]. Even in linear skull fractures the incidence of extradural hematomas has been reported to be as high as 35% [3]. While skull X rays are of screening value to detect a skull fracture a computed tomographic scan of the brain is invaluable to exclude a possible clinically significant intracranial lesion [4]. In addition to the significance of a skull fracture an accompanying dural tear carries with it a risk of sepsis [5]. The importance of recognizing a dural tear and performing a dural repair is well recognized and evidence exists to support the consideration that all compound skull fractures of the cranial vault should be afforded a formal operative intervention to exclude a dural tear [5–7]. Skull fractures can be of two types, depressed or linear, depending on the amount of displacement of the fractures edges. Depressed skull fractures must by definition have displacement of bone greater than the full thickness of the adjacent calvarial thickness [8,9]. Various authors have evaluated the incidence of dural tear in depressed skull fractures and the range reported is 25–68% [10,11].

With such a considerable range Salia et al. looked at predicting dural tear in compound depressed skull fractures based on radiological markers and noted fracture depression (odds ratio 1.3 $p < 0.001$), pneumocephalus (odds ratio 2.8 $p < 0.001$) and brain contusions (odds ratio 5.5 $p < 0.001$) to be significantly associated with a dural tear on univariate and multivariate analysis. In this study the incidence of dural tears in compound depressed skull fractures was 55% [12].

There is currently no South African literature focusing exclusively on establishing the incidence of dural tear in patients whom incur skull fractures secondary to assault. There is also no South African literature determining the statistical significance of pre-operative clinical and radiological variables that can be used to predict the incidence of an intra-operative dural tear. We analyzed 135 patients with skull fractures secondary to assault that were taken for operative intervention with regards patient demographics, mechanism of injury, CT scan findings, pre-operative suspicion including evidence for this suspicion of a dural tear, operative confirmation of a dural tear and Glasgow Outcome Score at a single neurosurgical unit situated in the province of

* Corresponding author at: Department of Neurosurgery, 3rd floor Sciences Building, Sefako Makgatho Health Sciences University, Garankuwa, Pretoria, South Africa.
E-mail address: adriankelly1000@yahoo.co.uk (A. Kelly).

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Gauteng, South Africa, over a 2 year period.

2. Method and materials

This is a retrospective chart review of 135 patients whom incurred skull fractures secondary to assault and went for operative intervention within the Department of Neurosurgery at Dr. George Mukhari Academic Hospital located in Pretoria, Gauteng, South Africa. The study period was from January 2015–December 2016. The study was granted approval by the Medical Research Ethics Committee of Sefako Makgatho Health Sciences University, reference number SMUREC/M/38/2017:PG.

A total of 135 patients with skull fractures secondary to assault were admitted and taken for formal operative intervention during the study period. Post irrigation with limited debridement and simple suturing in the Emergency department under local anesthetic cover, the indications for formal operative intervention at our institution are 1. Brain matter or CSF oozing from the wound; 2. Depressed compound skull fractures; 3. Skull fractures with associated intracranial lesions for example extradural hematomas, intracerebral hematomas, intracerebral contusions and acute subdural hematomas which are managed according to the guidelines of the brain trauma foundation.org [13]. Additional indications for surgery are 4. Fractures involving the posterior wall of the frontal sinus; 5. Contaminated fractures and 6. Fractures which are septic. Closed fractures are rarely managed operatively however will be taken to the operating room if the depression is causing a focal deficit through pressure on the adjacent cortex or if the closed fracture is depressed and causing a cosmetic abnormality.

The local policy at our institution is to perform a craniectomy in all compound depressed skull fractures and we remove loose bone fragments to minimize the sepsis risk. We rarely perform a primary cranioplasty except in the rare instance when the depressed skull fracture is closed but even this is at the discretion of the attending surgeon. Dural repair is a special consideration and post debridement it is our experience that the dura is rarely able to be closed primarily. Harvested pericranium is our dural substitute of choice and we commonly suture this with 4/0 silk, in a water-tight manner, to the debrided dural edges.

We utilize 72 h of empiric prophylactic intravenous antibiotics in all patients with compound skull fractures irrespective of whether we suspect that a dural tear has occurred. An antibiotic with gram positive cover namely intravenous cloxacillin 500 mg 6 hourly and gram negative cover namely intravenous ceftriaxone 1 g 12 hourly are used. We add anaerobic cover in the form of intravenous metronidazole 400 mg 8 hourly. In patients where the scalp is copiously irrigated and meticulously debrided and a craniectomy and dural repair performed we continue these antibiotics for 5 days post-operatively if there is any intra-operative suspicion of sepsis. In clean wounds these antibiotics are stopped post-operatively and are replaced by a first generation cephalosporin namely intravenous cephazolin 1 g 8 hourly which we continue for 72 h. A pus swab is taken intra-operatively and antibiotics are adjusted to directed therapy based on culture and sensitivity results.

Seizure prophylaxis is administered to all high risk patients and is stopped on the 7th post-operative day if the patient does not have a seizure. High risk patients include patients whom have a seizure history or have already had a seizure by the time they are admitted. Radiologically depressed skull fractures with cortical injury, patients with extradural hematomas, intracerebral hematomas, intracerebral contusions or acute subdural hematomas are all considered high risk and receive seizure prophylaxis. We administer an intravenous phenytoin loading dose of 15 mg/kg over 30 min (50 mg/min) and the maintenance dose is 100 mg administered 8 hourly intravenously.

The data captured and analyzed in this study included patient demographics, mechanism of injury, severity of head injury, CT scan findings, pre-operative suspicion including evidence for this suspicion of a dural tear, operative confirmation of a dural tear, and Glasgow Outcome Score.

3. Results

A total of 135 subjects were admitted over the study period with skull fractures secondary to assault and were taken for formal operative intervention. There were 126 (93.3%) males and 9 (6.7%) females. The mean age was 31.4 ± 12.3 years and the median age (± IQR) was 29 ± 23–36 years. The youngest patient was 3 years old and the oldest was 73 years.

Defining the mechanism of injury from most common to least common we found that 39 (29%) of our subjects had been assaulted with a brick and 16 (12%) of subjects had been victims of community assault. Additional mechanisms of injury included having been assaulted with a bottle in 11 (8%) subjects, incurring a gunshot to the head in 11 (8%) subjects, being stabbed with a knife in 6 (4.4%) subjects, being hit with an axe in 6 (4.4%) subjects, and 4 (3%) subjects reported having been assaulted with a spade. In 42 (31%) of our subjects the mechanism of injury was unknown.

Table of mechanism of injury (n = 135).

Brick	39 (29%)
Community assault	16 (12%)
Bottle	11 (8%)
Gunshot	11 (8%)
Knife	6 (4.4%)
Axe	6 (4.4%)
Spade	4 (3%)
Unknown	42 (31%)

Considering the mechanism of injury it was found that being assaulted with a brick to the head was significantly associated with the intra-operative absence of a dural tear and being stabbed with a knife in the head was statistically associated with the intra-operative finding of a dural tear (p = 0.02). None of the other mechanisms of injury had significance in predicting the finding of an intra-operative dural tear.

All 135 (100%) subjects had incurred a skull fracture secondary to assault and in 119 (88%) subjects the fracture was compound and in 16 (12%) the fracture was closed. In 117 (87%) subjects the fracture was depressed and in 18 (13%) the fracture was not depressed. The presence of a depressed skull fracture on pre-operative imaging was significantly associated with the intra-operative finding of a dural tear (p = 0.002).

Looking at the associated intracranial abnormalities we found that 50 (49%) subjects had an associated extradural hematoma and 34 (33%) subjects had an intracerebral contusion. An acute subdural hematoma was present in 10 (9.8%) subjects and in 8 (7.8%) subjects an intracerebral hematoma was present. In 33 (24.4%) subjects no associated intracranial abnormality was present. The presence of an intracerebral hematoma underlying the fracture site was significantly associated with the intra-operative finding of a dural tear and the presence of an acute subdural hematoma was significantly associated with an intra-operative absence of a dural tear (p = 0.001).

Table of associated intracranial abnormalities (n = 135).

Acute extradural hematoma	50 (49%)
Intracerebral contusion	34 (33%)
Acute subdural hematoma	10 (9.8%)
Intracerebral hematoma	8 (7.8%)
No associated intracranial abnormality	33 (24.4%)

We suspected a dural tear in 71 (53%) subjects and did not suspect a dural tear in 64 (47%) subjects. The evidence for this suspicion in these 71 (53%) subjects was as follows: In 31 (43.6%) subjects the suspicion was made on the basis of pneumocephalus and in 30 (42.2%) subjects the suspicion was on the basis of in-driven bone. In 4 (5.7%) subjects the suspicion was on the basis of a cerebrospinal fluid leak from the wound and in 6 (8.6%) subjects the suspicion was on the basis of brain

matter oozing from the wound.

Significance was demonstrated between the pre-operative radiological finding of pneumocephalus ($p = 0.02$) and our finding of an intra-operative dural tear. The small number of subjects with CSF or brain matter oozing from the wound prevented statistical significance being established.

At surgery a dural tear was present in 60 (44.4%) subjects and was absent in 75 (55.6%) subjects.

Table of pre-operative suspicion versus intra-operative confirmation of a dural tear ($n = 135$).

	Yes	No
Pre-operative suspicion	71 (53%)	64 (47%)
Intra-operative confirmation	60 (44.4%)	75 (55.6%)

Hence while pre-operatively a dural tear was suspected in 71 (53%) subjects, intra-operatively it was confirmed in only 60 (44.4%) subjects. Using clinical and radiological data hence over-estimated the presence of a dural tear in approximately 11 (10%) subjects.

Summary table of significant pre-operative variables predicting the intra-operative finding of a dural tear.

Mechanism-knife	p = 0.02
Depressed skull fracture	p = 0.002
Pneumocephalus	p = 0.02
Intracerebral hematoma	p = 0.001

4. Discussion

Our study result that almost all patients were male is in keeping with the results found in other studies [14–16]. With regards the patients with a known mechanism of injury our study finding was that the most common mechanism of injury was being assaulted with a brick while the second most common mechanism was having been assaulted by the community. The Study by Zaw and Zofrillo (2016) noted that multiple assailants was the most common mechanism of injury comprising 38% of their cases [16]. Our study found this to be the second most common mechanism of injury.

In our study all of the subjects has a skull fracture secondary to assault in keeping with the study participant criteria. In almost all of our subjects the fracture was compound as well as depressed. Our study finding that by far the majority of the skull fractures seen were compound and depressed illustrates the need for referral to a neurosurgical center as both are indications for operative intervention.

With regards the pre-operative suspicion of a dural tear this was suspected in 53% of our subjects. The evidence for this suspicion was on the basis of, in decreasing order of frequency, pneumocephalus, indriven bone, cerebrospinal fluid leak, and brain matter oozing from the wound. Intra-operatively however only 44% of our subjects had a documented dural tear.

The fact that a dural tear was suspected in 53% of our subjects while intra-operatively only 44% of our subjects had a dural tear indicates that if only clinical and/or radiological evidence were used an approximate error between pre-operative suspicion and intra-operative confirmation of 10% would have occurred. This study finding is evidence confirming that all compound skull fractures should be afforded a formal operative intervention to exclude a dural tear [5,6].

The commonest additional intracranial abnormality was an extradural hematoma in 49% subjects and an intracerebral contusion in 33% subjects. Looking at the literature the study by Auranggzeb (2015) supports the above finding. Auranggzeb noted that with regards a linear skull fracture there was an accompanying 34% incidence of an extradural hematoma [3].

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Declaration of Competing Interest

None of the authors listed below have any financial nor personal relationships with other people, or organizations, that could inappropriately influence (bias) their work, all within 3 years of the beginning the work submitted.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.inat.2019.100506.

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