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Anticipation of Dural Tear in Patients with Blunt Head Trauma

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Abstract

Background: Dural tears are considered among the neurosurgical challenges to be dealt with during management of head trauma patients; it's important to anticipate such pathology pre-operatively; the purpose of this study is to discuss and analyze various predictors of dural tear as a sequala of blunt head trauma. Methods: Patients with blunt head trauma who underwent surgery during the year 2020 were analyzed; operative data were reviewed; only patients with reported dural repair as a step during surgery were included. Patients with penetrating head injury were excluded. Preoperative radiology, epidemiological and clinical details were analyzed to conclude specific criteria for dural tear. Results: Twenty-three patients were involved in the study; male predominance was evident. The most common primary injury was depressed fracture (73.9%), while the most common mode of trauma was domestic injury (43.5%), especially in pediatric group (76.9%). Two cases of growing skull fracture were involved, and both were in pediatric group. CT findings were conclusive for immediate dural tear findings, however, suggestive for patients with growing skull fractures. Mean depth of depression for depressed fracture group was 15.07 mm. Conclusion: Dural tears are not a serious complication of head trauma, however, their sequalae are life-threatening. Anticipation of dural tear is feasible radiologically pre-operatively for immediate dural repair and craniotomy fashioning; for cases of growing skull fractures, it's difficult to anticipate the course from time of impact till time of presentation.

Keywords

Dural Tear, Growing Skull Fracture, Head Trauma, Depressed Fracture

1. Introduction

Dural tear is considered one of the sequalae of head trauma, which is mostly, but

not exclusively, associated with depressed fractures as many reports in literature have reported its incidence with fissure fractures, epidural hematomas and skull base fractures [1] [2].

Skull fractures are indicative for intracranial damage and the severity of injury, depressed skull fractures, as well as other pathologies, is associated with dura matter injury. Dealing with dural tears, especially in dural venous sinus related regions require certain degree requires a certain degree of experience and microscopic surgical skills in certain situations [3] [4].

Pre-operative assessment of dura matter integrity is essential, since its tearing indicates cortical laceration which requires certain care during surgery and water tight closure with or without pericranium graft to prevent infections such as meningitis, encephalitis and abscess [5].

Anticipation of dural tear pre-operatively, although not critical, is important data to be considered during surgery planning and can be proven only intra-operatively. In this study, we analyzed radiological data of patients whose operative details confirmed dural tear, to predict its presence either immediately or later as a part of the growing skull fracture.

The aim of this study is to analyze radiological factors which were related to dura matter injury and proven intra-operatively.

2. Patients and Methods

The study is retrospective analysis of medical records of a tertiary referral emergency hospital for the year 2020, patients' records with diagnosis: depressed fracture, epidural hematoma, skull base fracture and growing skull fractures were reviewed; those who underwent surgery for the mentioned pathologies, or another associated injury were reviewed. Patients whose operative details included dural repair were pooled. Clinical, epidemiological and radiological data were analyzed. Risk factors, clinical and radiological predictors for dural injury were identified.

All patients with penetrating head injuries were excluded, patients with struggle where sharp object was used for assault were also excluded.

Imaging: all patients underwent non contrast computed tomography of the head (NCCT) as part of the trauma surveillance. Radiological data retrieved: primary pathology, pneumocephalus, cerebral contusion and skull base fractures.

Operative procedure: all patients underwent treatment of primary pathology with dural repair. Craniotomy was pathology tailored, for depressed fractures where dural tear was suspected a wide craniotomy was performed aiming at landing into a healthy dura for repair.

3. Results

Twenty-three patients were involved in the study, 15 of them were males, mean age was 13.5 years with pediatric group predominance with 13 patients (56.5%).

Domestic injuries were the most common mode of trauma with an incidence of 43.5% (10/23), followed by struggle (6/23), road traffic accidents (5/23) and animal kick (2/23) (Table 1).

Depressed fracture was the most common associated injury with an incidence of 73.9% (17/23) patients, 12 of them where compound, two epidural hematomas, two tension pneumocephalus and two growing skull fracture. Thirteen patients showed pneumocephalus, two of them were tension pneumocephalus. The most common region of injury was the parietal bone with an incidence of 60.9% (14/23) patients (Table 2).

The mean Glasgow Coma Score (GCS) was 13.5, seventeen patients were fully conscious. Nine lesions were related to one of the dural venous sinuses, all of them were depressed skull fractures except one epidural hematoma patient where the source of bleeding was superior sagittal sinus, and five of those lesions were directly over the related sinus while the other four were within 2 centimeter vicinity of the sinus.

Pneumocephalus was a finding in pre-operative radiology in 16 patients (69.6%) and underlying contusion/intracerebral hematoma in 8 patients (34.8%). Radiological analysis of the depressed fracture group was performed to identify the depth of the depression; depth of the depression was measured on NCCT as the distance between the most inner parts of the depressed segment to the inner table of the normal clavaria (Figure 1). The mean depth of depression value was 15.07 mm.

Dural repair was successfully performed in all cases, except one case where the tear was extending to the skull base and beyond total repair. No patients experienced postoperative leakage or infection.

Figure 1. Non-contrasr CT pf the head showing measuring depth of depression of the fracture.

Table 1. Incidence of dural tear.

Cause	Percent
Domestic	43.5% (10)
Struggle	26% (6)
Road traffic accident	21.7% (5)
Animal kick	8.7% (2)

Table 2. Primary pathology.

Pathology	All patients (23)	Adult (10)	Pediatric (13)
Depressed fracture	73.9% (17)	70% (7)	76.9% (10)
Epidural hematoma	8.7% (2)	10% (1)	7.7% (1)
Tension pneumocephalus	8.7% (2)	20% (2)	0
Growing skull fracture	8.7% (2)	0	15.4% (2)

4. Discussion

Traumatic brain injury (TBI) is considered one of the most common causes of death and disability in the world, the problem's scope and seriousness increases in developing countries. Management of head trauma has evolved vastly in the last three decades, which can be attributed to better understanding of secondary brain injury mechanisms and thus preventing them [6] [7].

Many factors affect the global outcome of traumatic brain injury e.g. mode of trauma, Glascow Coma Score (GCS) and secondary brain injuries among which is dural tear. CSF leakage and secondary infection are fatal complications of dural tear if not treated properly. Primary TBI cannot be prevented, however, secondary fatal sequalae can be prevented and treated when diagnosed and managed in an appropriate timing and maneuver. Predominance of male injuries rather than female is expected regarding all types of head trauma, due to more male involvement in driving and struggle.

Hypothetically, tearing of the dura can be due to penetrating skull injury or sharp bone edge of a depressed fracture, however, other clinical facts denies this as the only theory for dural tear e.g. skull base fractures associated with CSF leakage is a prove that sole fissure fracture may underly a dural tear. Another pathology proves that theory is growing skull fracture, where a fissure fracture gaps under the hammering effect of brain pulsation, which will not take place in cases with intact dura (**Figure 2**).

These observations confirm another mechanism for dural tearing due to high velocity impact due to either dura tension or stretch beyond the elasticity of the dura at time of impaction, or sharp bone edge descent at time of impact before recoiling to normal position.

The most common mode of trauma in our study was domestic head injury, which included household injuries, falling downstairs and falling on heavy objects. Road traffic accidents and struggle followed. This can be attributed to

higher percentage of pediatrics in study population (Table 3). Parietal bone high incidence can be attributed to the size of the bone in comparison to other calvarial bones. Further analysis to our results (Table 3) shows that modes of trauma in this series for adults were exclusively struggle and RTA with incidence of 60% and 40% respectively, which matches results of previous reports of depressed fracture incidence [8] [9].

Similar to previous reports which involved operated upon patients, dural tears were most common in parietal region, this ratio can theoretically decrease in case series involving skull base fractures with evident rhinorrhea and/or otorrhea.

Depressed skull fractures are serious sequalae of head trauma with an incidence of 68% to 86% to be compound [9], a category that requires immediate surgical intervention including wound debridement, elevation of the depressed segment and dural repair in case of dural injury. Such surgery can be simple or extensive if dura is torn, the decision to design a craniotomy flap or work through the defect is difficult, since dural tear requires a designed flap which is usually bigger than the depressed defect to reach a healthy dural edge [10]. In

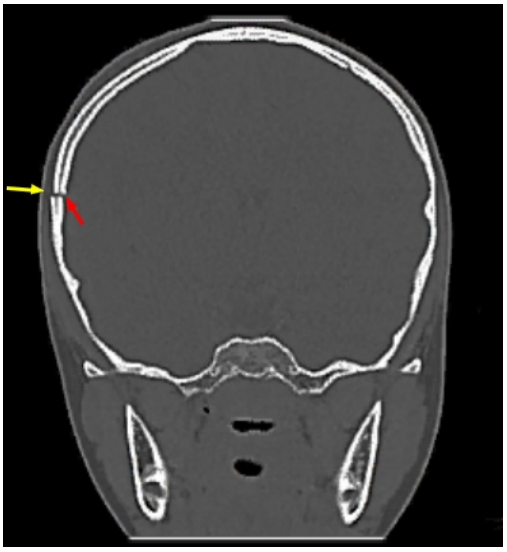

Figure 2. Non-contrast CT of the head, bone window showing right temporal fissure fracture (yellow arrow), illustrating the hypothesis that the sharp edge of the fissure (red arrow) can cause dural injury during high impact.

Table 3. Age specific cause.

Cause	Percent in Adults	Percent in children
Domestic	0%	76.9% (10/13)
Struggle	60% (6/10)	0%
Road traffic accident	40% (4/10)	7.7% (1/13)
Animal kick	0%	15.4% (2/13)

this study, the most common pathology associated with dural tears was depressed fractures (**Figure 3**), as for Hossain *et al.* [3] and Nayak *et al.* [11] with an incidence of 25% and 67.25% respectively. Surgeons should be anticipating dural tears while operating for depressed fractures, however, in this study pneumocephalus was a strong association with dural tear. In contrary to Muhammad *et al.*, our study showed similar dural tear incidence among both pediatric and adult groups, this can be due to involvement of growing skull fractures as a category of post-traumatic dural tear in spite of their delayed presentation. Although Salia *et al.* [12] listed brain contusions and epidural hematomas as predictors for dural tear as signs of the injury severity, cerebral contusions and edema were associated with growing skull fractures to this study.

According to Salia *et al.* [12]; pneumocephalus, cerebral contusion and depth of the depression were the most predictive parameters for dural tears in patients with depressed skull fractures. Our results matched these criteria regarding depth of depression and pneumocephalus, since pneumocephalus was an association for the majority of cases (69.6%), and the mean depth of depression for the depressed fracture group in this study was 15.07 mm matching Salia's criteria who identified a threshold of 14 mm depth for dural tear risk.

Both cases of growing skull fractures had fissure fracture with underlying contusion and brain edema respectively (**Figure 4**), the theory behind growing skull fractures is the hammering effect of the pulsatile nature of the cerebral cortex which is augmented by underlying pathology that raises the intracranial pressure [13] *i.e.* contusion and edema for the two cases in this study. On the other hand, it's impossible to conclude whether or not other cases with mere fissure fracture had already had an underlying dural tear which passes conservatively.

Intra-parenchymal pneumocephalus as well as tension pneumocephalus (**Figure 5**) are sure signs of dural tear. Dural tears, in some cases, act as a ball and

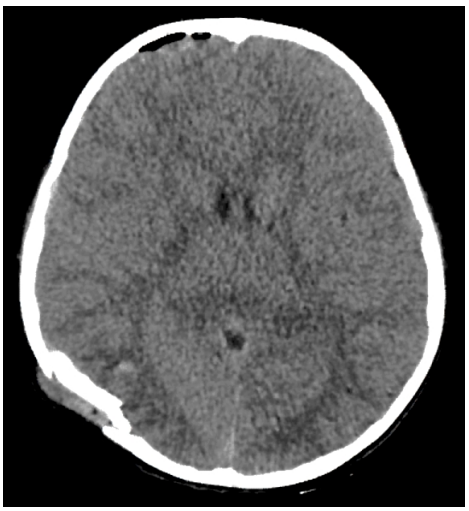

Figure 3. Non-contrast CT of the head showing right occipital depressed fracture with frontal pneumocephalus which indicates dural tear, as per operative data.

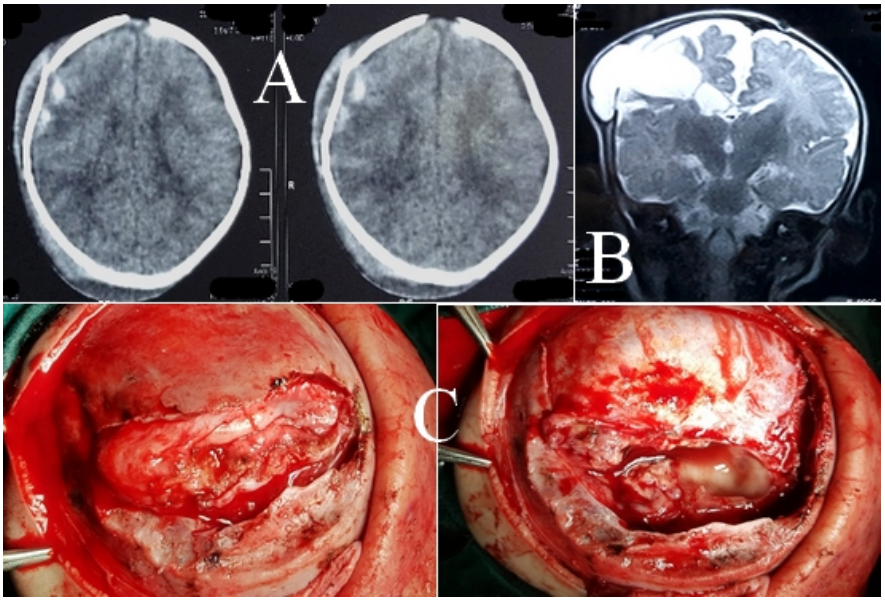

Figure 4. A three years old male patient, presented with domestic head trauma, A: initial CT showing fissure fracture with underlying cerebral contusion, B: MRI follow up after 6 weeks showing herniation of dura and CSF sac through a widened fissure, C: intra-operative images of dural repair showing extension of the defect into the ventricle.

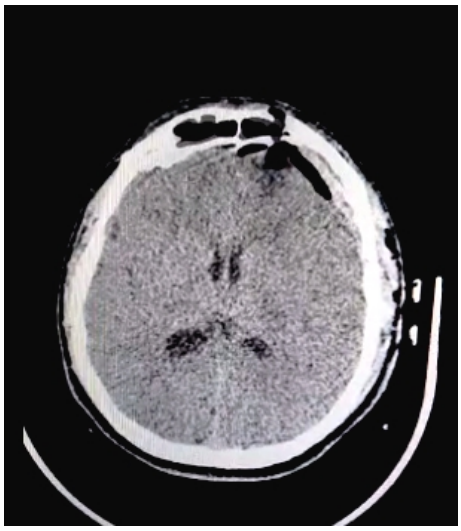

Figure 5. Non-contrast CT of the head showing post traumatic fracture of both walls of ftontal air sinus with extension of pneumocephalus into frontal lobe compressing frontal lobe *i.e.* tension pneumocephalus.

valve mechanism allowing air influx into the cranial cavity which has limited absorptive capacity, without allowing it out leading to tension pneumocephalus [14]. Increasing size of the pneumocephalus leads due neurological deficits and subsequent increase of intracranial pressure requiring urgent surgical intervention [15]. In this study two cases of tension pneumocephalus were enrolled, for one case a depressed segment was identified radiologically and surgical repair

was done, the other case with mount Fujie sign with no detectable dural tear intra-operatively as management line included only subdural drains.

Management of unexpected dural tears intra-operatively requires a certain degree of experience than dealing with uncomplicated cases, anticipating such a pathology pre-operatively based on both clinical and radiological data is useful for perfect operative dealing with such cases to prevent pathological secondary sequalae.

The limitation of this study includes the few number of cases, heterogeneity of the pathologies, as well as the lack of comparison to control group with intact dura.

5. Conclusion

Dural tears can be radiologically anticipated in cases of traumatic brain injury, based on the pre-operative radiological parameters. Depressed skull fractures are the highest risk pathology, especially when associated with pneumocephalus. These predictions are useful for better pre-operative planning and safe handling.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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