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Original Article

Surgical management of traumatic extra dural hematoma in children: Experiences and analysis from 24 consecutively treated patients in a developing country

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Abstract

Background: Children with epidural hematoma (EDH) present differently than adults. The outcome of treatment is also different. We aim to report our experiences with EDH in pediatric age group in terms of mode of injury, presenting features, management, and outcomes. We also aim to identify different prognostic indicators in pediatric patients with EDH.

Methods: We prospectively collected data from 24 consecutively surgically treated pediatric patients. The data collected included presenting features, radiological imaging, details of management, and outcomes. Descriptive analysis was performed and different variables were tested for any statistical significance with Glasgow Outcome Score (GOS).

Results: There were 19 male and 5 female patients. The mean Glasgow Coma Scale (GCS) score at presentation was 9.3 ± 4.4. Falls were the most common cause of EDH. Outcome assessment was done at 3 month follow up. A total of 15 patients had a GOS score of 5, 4 patients had a GOS score of 4, 2 patients had a GOS score of 3, while 3 patients had a GOS score of 1. On univariate analysis, admitting GCS score, patient's age, the time from injury to admission and injury to surgery, anisocoric pupils at presentation and effacement of basal cisterns were significantly associated with the outcome of GOS score.

Conclusion: Falls are the most common mode of injury leading to EDH in children. Lower GCS at presentation, younger age at trauma, increased time since trauma to surgery and admission, anisocoria and effacement of basal cisterns are statistically significant variables in surgically treated pediatric patients of EDH that confer a poorer prognosis. A timely surgical intervention can result in excellent outcomes.

Key Words: Children, craniotomy, epidural hematoma, glasgow coma scale score, prognostic indicators, surgical management

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INTRODUCTION

Epidural hematoma (EDH) is a potentially life threatening complication of traumatic brain injury. The incidence of EDH has been reported between 1% and 6% of hospitalized patients following a traumatic brain injury.[5,8,14,24] Children with EDH are less likely to lose consciousness from the traumatic event and require immediate surgery less frequently. They also show a lower incidence of intradural hematomas compared with adults.[8,12] The incidence of associated skull base fractures is lower, the course is more insidious and the signs, symptoms, and outcomes are different from adults.[8,12,14] These make them difficult to diagnose and manage. The reported mortality rates are between 0% and 12%.[8,11,12,14] Timely diagnosis and management can be life saving.[24]

There is scare literature reported on traumatic EDH in the pediatric population from the developing countries where resources are limited. According to an estimate, there is only one neurosurgeon for 1.37 million population and 35 neurosurgical centers in our country, which has a total population of more than 180 million.[22] An effective emergency transport system is lacking, especially in the rural areas. Some of our patients present after a major time delay without having been initially diagnosed or managed. The presenting nature of patients is thus different from the developed countries.

As neurosurgeons in other developing countries would be faced with a similar situation, the aim of this study is to report our experiences with EDH in the pediatric age group in terms of mode of injury, presenting features, management, and outcomes. We also identify prognostic indicators in pediatric patients with EDH.

MATERIALS AND METHODS

Patient population

Between January 2008 and August 2012, 70 pediatric patients (pediatric patients were defined as patients with age less than or equal to 18 years) were managed for EDH at our tertiary care hospital in a developing country. Exclusion criteria included patients managed conservatively, patients who were initially treated at other institutions, patients whose computed tomography (CT) scans were not done at our hospital, and patients who were dead on arrival. For the remaining 24 patients, data were collected prospectively and a database was created. Variables included in the database were demographic details, the time since injury and admission in ER, the cause of injury, the presenting symptoms, Glasgow Coma Scale (GCS) score, pupillary characteristics, any cerebellar signs, facial nerve weakness, cervical tenderness, any other finding on neurological examination, the respiratory pattern, signs of skull base fracture, lucid interval, radiological findings, details of patient management, post operative recovery, complications, and Glasgow Outcome Score (GOS) score at 3-month follow up.

Management and imaging studies

All the patients were treated according to Advanced Trauma Life Support (ATLS) guidelines. Initial resuscitation involved venous access, endotracheal intubation, and mechanical ventilation in some patients. After hemodynamic stabilization, a complete neurological examination was performed. Head CT scan and abdominal ultrasound was performed in all patients. Mannitol, antiepileptics, and antibiotics were administered depending on individual patient characteristics.

The CT scans were interpreted by consultant radiologists and the volume of hematoma was calculated by the Peterson and Espersen equation ($A \times B \times C/2$) where A, B, and C represent the largest diameters in the sagittal, axial, and coronal planes.[21] The location of hematoma and midline shift was also noted. The presence of any other intradural abnormality was also noted. Data on the patency of basal cisterns, fractures, and hematoma density was also recorded.

The indications for surgery included (i) increase in size of hematoma, (ii) the presence of anisocoria, (iii) clinical deterioration of the patient despite the best supportive measures, and (iv) GCS score of less than 13 post resuscitation. The surgical management involved a craniotomy and evacuation of hematoma. Any surgery done after 12 hours of trauma was considered as delayed surgery.

Statistical analysis

The data was entered into and analyzed using the SPSS software version 17 (IBM, Armonk, New York). The data is presented as proportions for categorical variables and means ± SD for continuous variables. A Mann-Whitney U test was used to check the statistical significance of sex, anisocoric pupils, effacement of basal cisterns, presence of contusions, abnormal respiratory movements, delayed surgery, and presence of skull base fractures on CT with GOS score at 3 months. A Spearman's correlation was used to quantify the association between admitting GCS, age at trauma, hematoma volume, midline shift, time since injury and surgery, and time since injury and admission with GOS outcomes. A P value of less than 0.05 was considered statistically significant.

RESULTS

Patient characteristics

Out of the 24 patients that were included in this analysis, 19 were male and 5 were female [Table 1]. The mean age was 8.6 ± 6.1 years. One patient had preexisting epilepsy, one patient had fibrinogen deficiency, while one patient had tuberculosis. The median time since injury to surgery was 10 hours ($Q_1 = 2$, $Q_3 = 33.75$, IQR = 31.75).

The cause of injury included road traffic accidents in 9 (37.5%) cases, impact with a blunt object in 2 (8.3%) cases, falls in 12 (50%) cases, and dropping of a heavy weight on head in 1 (4.6%) case [Table 1]. The most common presenting complaint was loss of consciousness observed in 70.8% (n = 17) patients followed by vomiting observed in 45.8% (n = 11) patients [Figure 1]. Understandably, some patients had multiple presenting complaints. The mean GCS was 9.3 ± 4.4. A total of 12 (50%) patients had a GCS score of less than or equal to 8, 4 (16.7%) patients had a GCS score between 9 and 12, while 8 (33.3%) patients had a GCS score of 13 or more. Anisocoria was present in nine patients. One patient had nonreactive pupils; pupillary response was sluggish in five patients while three patients had fixed pupils. No patient presented with positive cerebellar signs, facial nerve weakness was present in one patient; abnormal respiratory movements were present in four patients while five patients had cervical tenderness. Ten (41.6%) patients were transferred to our center via ambulances while 14 (58.4%) patients were transferred via personal modes of transportation not including ambulances.

Table 1: Presenting characteristics of patients

Patient characteristics	Number (%)
Gender	
Male	19 (79.2)
Female	5 (20.8)
Mode of injury	
RTA	9 (37.5)
Hit with a blunt object	2 (8.3)
Falls	12 (50)
Dropping of a heavy weight on head	1 (4.6)
Presenting GCS score	
3-8	12 (50)
9-12	4 (16.7)
13-15	8 (33.3)
Anisocoria	
Present	9 (37.5)
Absent	15 (62.5)
Cervical tenderness	
Present	5 (20.8)
Absent	19 (79.2)
Irregular breathing pattern	
Present	4 (16.7)
Absent	20 (83.3)
Pupillary response	
BERL	15 (62.5)
Nonreactive/fixed	4 (16.7)
Sluggish	3 (12.5)
Lucid interval	
Lucid interval present	2 (8.3)
Lucid interval not present	22 (91.6)
Modality of reaching hospital	
Ambulance	10 (41.6)
Personal transport not ambulance	14 (58.4)

RTA: Renal tubular acidosis, BERL: Bilaterally equally reactive to light, GCS: Glasgow coma scale

Radiological findings

The location of hematoma was predominantly frontal in 11 cases, temporal in 6 cases, parietal in 8 cases, and occipital in 9 cases [Figure 2]. Overall, a predominantly multilobar clot was present in four patients. Seven patients (29.1%) showed a midline shift in initial CT imaging. Skull base fractures were present in 19 patients (79.2%). Contusions were present in nine patients (37.5%). Sub dural hematoma (SDH) was present in six patients (25%). The basal cisterns were patent in 13 (54.2%) while effaced in 11 patients (45.8%).

Management and outcomes

Thirteen patients required intubation. Mannitol was administered in 15 patients while phenytoin was administered for epilepsy prophylaxis in all the patients. Two patients required cardiopulmonary resuscitation on admission. All the patients underwent craniotomy and evacuation of hematoma.

Overall mortality occurred in three (12.5%) patients. Postoperatively two (8.3%) patients had seizures while

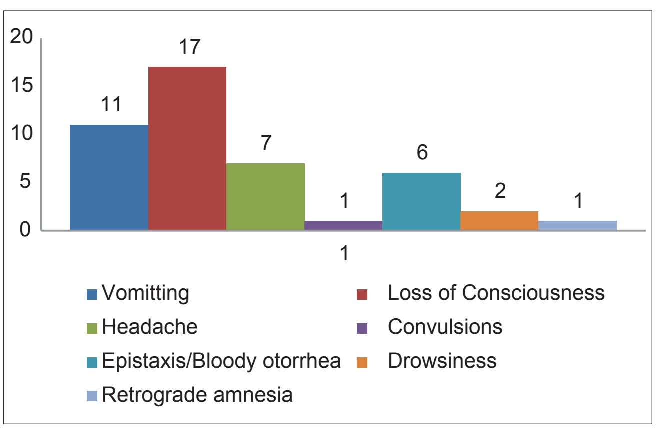

Figure 1: Presenting symptoms

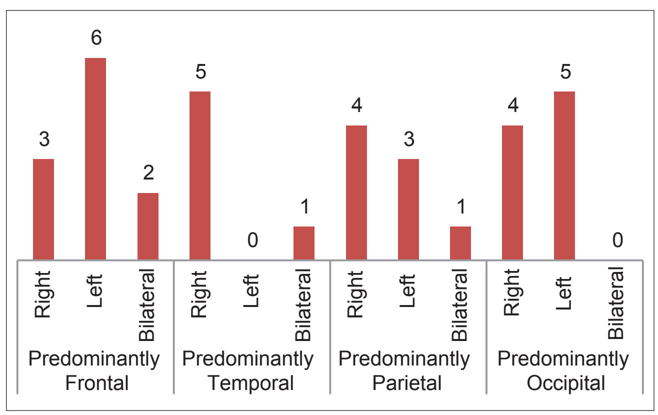

Figure 2: Location of hematoma by lobes predominantly involved

infections occurred in five patients (20.8%). Four (16.7%) patients had residual hematoma on post operative CT scans. On one month follow up, 15 (62.5%) patients had a GOS score of 5, 4 (16.7%) patients had a GOS score of 4, 2 (8.3%) patients had a GOS score of 3, while 3 (12.5%) patients had died (GOS = 1).

Prognostic indicators

A Spearman's correlation was used to quantify the relationship between admitting GCS score and GOS score on 1 month. The admitting GCS was highly prognostic of outcome (ρ=0.566, *P* = 0.006). Age at trauma was also significantly linked to outcome GOS ((ρ=0.471, *P* = 0.021). Time since injury and surgery ((ρ=0.451, *P* = 0.028) and the time since injury and admission ((ρ=0.512, *P* = 0.027) were statistically significantly related to GOS at one month. Anisocoric pupils at presentation (*P* = 0.004) and effacement of basal cisterns (*P* = 0.017) were related to significantly worse outcome. Delayed surgeries were significantly associated with a poorer outcome (*P* = 0.021) [Table 2].

We failed to find a statistically significant correlation between the mode of injury and age in our sample of patients (*P* = 0.798). There was also no association between the location of hematoma and outcomes (*P* = 0.753).

All other variables had no statistically significant relationship with GOS score on univariate analysis.

DISCUSSION

The mortality following EDH in children has been reported between 0% and 12%.[5,8,14,19] Our mortality rate of 12.5% is more than the reported values in the literature. One reason for this could be that we only analyzed patients who were treated surgically and so were presenting in a more serious condition. If the patients who were treated conservatively are included in this analysis, the mortality rate would be 4.9% in this study, which is within the reported range in literature. However, Jung *et al*.[14] achieved a mortality rate of 0% in their series of surgically treated patients. Their mean time to surgery was 23 hours. Our mean time to surgery was 22.1 hours. In our opinion, the main reason for worse outcomes in our patients depended on the differences of presenting GCS in both the studies. Jung *et al*. had only one patient (3.4% of sample size) with a GCS score of less than or equal to 8 while we had 12 patients (50% of sample size) in this category. Thus, while the importance of early neurosurgical care in these patients cannot be stressed enough, presenting GCS, which would also depend on the degree of trauma, is also an important prognostic indicator.

We found that time since trauma and surgery and time since trauma and admission to emergency room were directly related to outcomes and that surgical delay beyond 12 hours resulted in statistically significant worse outcomes. Once the patients presented to the emergency room, the median time from initial evaluation and imaging to the beginning of surgery was 30 minutes (Q_1 = 25 min, Q_3 = 37 min, IQR = 12 min). Since all the patients included in this series underwent emergent surgeries according to the above time schedules, we believe that time from trauma to admission and time from trauma to surgery are equivalent in this case. Further as there was an almost equal difference in both variables for each patient, the results of statistical analysis were also similar. Absence of effective emergency transport meant that many of our patients presented quite a while after the initial trauma. Thus in our opinion, better outcomes can be achieved with earlier diagnosis and rapid referral to centers with neurosurgical expertise.

The incidence of EDH in children is less than that in adults.[8,9,12,24] This has been attributed to the tight adherence of dura to the inner table of skull. Nearly 79% of the patients in our series were boys. A higher incidence of EDH in males has been reported elsewhere in the literature as well.[8,9,14] It may be because more boys indulge in risky play activities and not because of any specific anatomic cause rendering boys more vulnerable. The most common reason for head trauma in our series was falls present in 50% of the patients followed by road traffic accidents observed in 37.5% of the patients. However, within the pediatric age group we failed to establish a trend between age and the mode of head trauma. One reason for this could be our small sample size. Elsewhere in the literature falls have been reported as the most common mode of head trauma leading to EDH in children while road traffic accidents are the most common mode in adults.[3,8,11,12,14] Thus there is

Table 2: Prognostic indicators and *P* values on univariate analysis

Variable	*P* value
Sex	0.637
Anisocoria	0.003
Effacement of basal cisterns	0.008
Contusions	0.234
Skull base fractures	0.111
Abnormal respiratory movements	0.812
Age	0.021
Admitting GCS	0.006
Hematoma volume	0.712
Midline shift	0.517
Time since injury and surgery	0.028
Time since injury and admission	0.027
Delayed surgery	0.021

GCS: Glasgow coma scale

a significant difference in mechanism of injury among children and adults.

In this study, we found that the GCS score at admission, age of the patient, and the time from injury to surgery were significantly related to outcome. These findings are consistent with other reports in literature.[3,10,11] We found that a younger age is related with worse outcomes. This is in accordance with most reports[3,17,18] in literature, however, some authors have reported the exact opposite with an older age being more prone to worse outcomes.[4] Anisocoria was associated with a significantly poor prognosis in our series. Ben Abraham *et al*.[3] noted the same trends in their patients where papillary abnormalities were associated with a poor prognosis.

The most common presenting complaints in our patients was unconsciousness (70.8%) followed by vomiting (45.8%). These findings are in accordance with other reports in literature.[8,9] The classical finding of lucid interval was present in only 9% of the patients. Our series by far has the lowest reported incidence of this finding. The incidence of lucid interval has been reported to be between 11% and 37%.[8,10] Epilepsy is a known complication of EDH especially in patients with associated contusions. Nearly 4% of our patients had seizures. Ben Abraham *et al*. reported a similar incidence.[3] Chowdhury *et al*. reported an incidence of 13%,[8] which is more than three times our reported values. Based on these figures, we believe that antiseizure prophylaxis should be administered to all the patients, especially to those with contusions.

There are significant differences in the clinical course of EDH between children and adults. Simpson *et al*.[25] pointed out that a diagnosis of EDH may not be made until signs of raised intracranial pressure are noted. Unfused sutures, open fontanelles, large extra cerebral spaces, and basal cisterns allow children to better cope with raised ICP.[1,11,24] The origin of bleed is venous in majority of the cases in children.[1] This insidious course and nonspecific signs and symptoms mean that the diagnosis of EDH is delayed in children if only clinical parameters are considered. We recommend routine CT scanning in all children with head injuries as radiological findings precede clinical findings and can result in earlier diagnosis and better management[7] and outcome.

The most common location of hematoma in our study was frontal followed by occipital. Other studies have reported the temporal,[14] temporoparietal,[8] and parietal[3,11] regions as the most common location. In our study, the site of hematoma was not statistically related to outcomes, which is in agreement with the findings reported by Mohanty *et al*.[20] However, Chowdhury *et al*.[8] found that frontal hematomas have a better prognosis. Contusions have been previously reported to significantly lead to worst outcomes.[8,12,20] Nearly 37% of our patients had contusions. However, we failed to find a statistically significant association between the presence of contusions and patient outcomes. Bejjani *et al*.[2] found that the most important radiological parameters for surgery included a maximum diameter of 18 mm or a midline shift of greater or equal to 4 mm. However, we failed to find any significant association between these radiological parameters and outcomes in our series.

The relationship between cranial fractures and outcomes remains controversial. Cranial fractures were present in 79% of our patients. The reported incidence of fractures with EDH in literature is between 45% and 90%.[5,8,11,14] We did not find a significant relationship with fractures and patients outcomes. Such findings have also been reported by Lee *et al*.[16] However, Kuday *et al*.[15] reported significantly worse outcomes with cranial fractures while Chowdhury *et al*.[8] and Rivas *et al*.[23] reported better outcomes with the presence of cranial fractures.

It is our institutional practice to offer surgery in pediatric patients when the hematoma is rapidly expanding, the presenting GCS score is less than 13, the presence of anisocoria, or when there is clinical neurological deterioration despite the best supportive measures. There is no uniform consensus on when to operate in a child with EDH.[2,6,8,11,14] This has become an increasingly important issue to address as diagnosis of EDH in children who are neurologically stable, conscious or with minimal symptoms has increased owing to greater usage and availability of CT scans.[13] Studies have reported excellent outcomes in these patients following conservative management.[1,13] But Gerlach *et al*.[11] argue that the combined complications of surgery and anesthesia are low and may prevent EDH complications from occurring. The decision to operate would depend upon some degree of subjective opinion of the attending neurosurgeon as well as the resources and staff available. An early (<36 hours) increase in hematoma size has been reported to occur in 23% of the patients.[11] Thus, some centers may prefer an early surgery as resources to provide observation and access to surgery within 2 hours may not be available. Hence in our opinion, management protocols would continue to be influenced by the availability of resources.

CONCLUSION

Falls are the most common mode of injury leading to EDH in children. Lower GCS at presentation, younger age at trauma, increased time since trauma to surgery and admission, anisocoria and effacement of basal cisterns are statistically significant variables in surgically treated pediatric patients of EDH that confer a poorer prognosis. A timely surgical intervention can result in excellent outcomes.

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