THORACIC AND ABDOMINAL TRAUMA IN CHILDREN

Ahmed H. Al-Salem, FRCSI, FICS, FACS; Syed Qaisaruddin, MS

Traumatic injuries are a frequent cause of morbidity and mortality in children worldwide, and are considered the major cause of death in children in developed countries.[1-3] In Saudi Arabia, trauma in children constitutes one of the most common reasons for hospital admission.

Over a period of three years, 479 children were admitted to Sakaka Central Hospital as a result of trauma, with nearly half (41.8%) of the cases being due to road traffic accidents.[4] Of the 916 patients admitted over a one-year period at the Qatif Central Hospital because of trauma, 40.6% were children less than 15 years of age, and 38% of these cases were due to road traffic accidents.[5] In Riyadh Central Hospital, 27% of patients needing laparotomies for blunt abdominal trauma were children less than 16 years of age.[6] There has recently been an increase in the number of publications concerning trauma from different parts of Saudi Arabia, however, there is still a paucity of published studies on trauma in children. Knowledge of the patterns of childhood injuries is of great importance in future planning, as well as in prevention. This report documents our experience of thoracic and abdominal trauma in children from a district general hospital in Saudi Arabia.

Patients and Methods

The records of children who sustained thoracic and/or abdominal injuries at Qatif Central Hospital between 1989 and 1996 were reviewed for age, sex, cause of injury, investigations, organs injured, method of treatment and outcome. The injury severity score (ISS) was used as a measure of the severity of the injuries. The Abbreviated Injury Scale (AIS) assesses injury severity on a scale from 1 (minor) to 6 (fatal) in each of the five body areas. The squares of the three highest AIS scores are added to give the ISS.[7,8] A severe injury for children with blunt or penetrating trauma was categorically defined as an ISS>15.[9]

From the Department of Surgery, Division of Pediatric Surgery, Qatif Central Hospital, Qatif, Saudi Arabia.

Address reprint requests and correspondence to Dr. Al-Salem: P.O. Box 18432, Qatif 31911, Saudi Arabia.

Accepted for publication 10 October 1998. Received 21 March 1998.

Results

Over the eight-year study period, 64 children were admitted to the Qatif Central Hospital, with the diagnosis of abdominal and/or thoracic trauma. There were 51 males and 13 females, with ages ranging from 6 months to 18 years (mean 7 years). The majority of the patients (78%) were less than nine years of age. Of the 64 patients, 60 had blunt trauma and only four had penetrating injuries. In 47 (73.4%), the trauma was due to road traffic accidents, the majority of whom were pedestrians. Other causes of trauma included fall from height in seven patients, injuries caused by the fall of a heavy object in three, and injuries caused by a sibling in another three. In three of the four patients with penetrating injuries, ages 12, 14 and 18 years, respectively, the injuries were due to stabbing, while the fourth, aged 1½ years, had an accidental injury in the epigastrium caused by a nail. After clinical evaluation and radiological investigations, 21 patients were found to be clear from significant abdominal or thoracic injuries, and were discharged home after 48 hours of observation, or kept in the hospital because of associated injuries, which included fractures (7), head injury (4) and cut wounds (4). Seven of the remaining 43 patients were treated conservatively. Two had subcapsular hematoma of the liver, one had liver laceration, another had splenic tear, and three had isolated kidney injuries. These injuries were revealed by ultrasound and/or CT scan of the abdomen. Eight patients had isolated (i.e., without other associated intra-abdominal injuries) chest injuries, 26 had abdominal injuries without associated chest injuries, and nine had concomitant abdominal and thoracic injuries. Diaphragmatic injuries were included under abdominal injuries. The thoracic injuries in the eight patients with isolated thoracic injuries included multiple rib fractures, bilateral hemopneumothorax, tension pneumothorax with multiple rib fractures and lung contusion, hemothorax, pneumothorax, hemopneumothorax and multiple rib fractures with hemopneumothorax. The distribution of organs injured is shown in Table 1.

There were 50 associated injuries in 34 patients with abdominal injuries. These included limb fractures in 22, head injuries in 10, chest injuries in nine, pelvic fractures

in seven, and spinal injuries in two. Nine patients with abdominal injuries had associated thoracic injuries, which included right hemothorax in four patients, left lung contusion in two, right pneumothorax in one, and left hemopneumothorax with lung contusion in two patients. In three of them there were associated rib fractures.

There were 12 splenic injuries, one of which was managed conservatively. Of the remaining 11 patients who were operated on either because of continued bleeding or other associated injuries, two had splenorrhaphies and nine had splenectomies. The indications for surgery, as well as the surgical procedures, are shown in Table 2. Splenectomy rather than splenorrhaphy was done because the spleen was shattered in four patients, splenic tears going through the hilum in another four, and transection of splenic artery in one patient.

There were 10 liver injuries, three of which were treated conservatively, while the remaining seven were repaired surgically. In no case was lobectomy necessary, but in one patient the injury was extensive, with torn right hepatic vein. This patient required two laparotomies before bleeding was controlled. The type of injuries, associated injuries and operative procedures are shown in Table 3.

Seven patients had kidney injuries in the form of right subcapsular hematoma (3), right perinephric hematoma (3), and thrombosis of the left renal artery (1). (The patient with thrombosis of left renal artery was discovered on follow-up). They were all treated conservatively. Two patients had ruptured urethra, and one had contused urinary bladder, all associated with fracture of the pelvis. The ruptured urethras were repaired surgically. Two patients had pancreatic injuries, and one had contusion of the tail of the pancreas treated conservatively, while the other patient had distal pancreatectomy because of transection of distal third of the pancreas. Seven patients had bowel injuries, small bowels in five and large bowels in two. Of the five small bowel injuries, one had serosal tears which were repaired, another had contusion and hematoma which were treated conservatively, while the other three had jejunal perforations. In one there was a defect in the mesentery which required resection and end-to-end anastomosis, while in the other two, the perforations were only repaired. Two patients had colonic injuries, one had seromuscular tears in the sigmoid colon which were repaired, while the other had contusion and hematoma of splenic flexure treated conservatively.

TABLE 1. *Distribution of abdominal organs injured in 34 patients.*

Organs injured	Number of patients (%)
Spleen	12 (35.3)
Liver	10 (29.4)
Kidney	7 (20.6)
Retroperitoneal hematoma	6 (17.6)
Diaphragm	5 (14.7)
Small intestine	5 (14.7)
Large intestine	2 (5.9)
Urinary bladder and urethra	3 (8.8)
Pancreas	2 (5.9)
Stomach	1 (2.9)
Biliary tree	1 (2.9)

TABLE 2. *Splenic injuries.*

Indication for operation	# of patients	Surgical procedure
Increased blood transfusions (≥40 mL/kg)	6	Splenectomy
Increased blood transfusions and other associated abdominal injuries	2	Splenectomy
Penetrating injury and associated diaphragmatic injury	1	Splenectomy
? Associated traumatic left diaphragmatic hernia*	1	Splenorrhaphy
? Intestinal injury**	1	Splenorrhaphy

*This patient was operated on because of traumatic left diaphragmatic hernia, but was found to have splenic tear and bilateral congenital Morgagni's hernias; **this patient had free fluid in the peritoneal cavity and normal spleen and liver by ultrasound. Intraoperatively was found to have splenic tear.

Five of our patients had traumatic diaphragmatic hernias. Their clinical features are shown in Table 4. All survived. One had bilateral diaphragmatic ruptures, and the rupture on the right side was diagnosed only intra-operatively because of continuous bleeding due to associated torn right hepatic vein. The diagnosis in the other two patients with right-sided ruptured diaphragm was suspected because of raised right hemidiaphragm and associated hemothorax, but the diagnosis was confirmed after CT scan, which showed herniation of the liver into the chest (Figure 1). The two patients with traumatic diaphragmatic rupture on the right side were repaired via a right thoracotomy, while the two on the left were repaired transabdominally. The patient with bilateral rupture required laparotomy and thoracotomy. One of our patients with splenic injury was accidentally found to have congenital bilateral Morgagni's hernia, which was repaired transabdominally.

Five of our patients died, giving an overall mortality of 7.8%. All were road traffic accident victims. The injury severity score for these were 41, 32, 34, 57 and 41,

TABLE 3. *Liver injuries.*

Age (y)/ sex	Type of injury	Associated injuries	Treatment of liver injury
7/M	Tear right lobe of liver	Bilateral traumatic diaphragmatic hernias with torn left hepatic vein	Repair
4.5/M	Tear inferior surface right lobe of liver	Fracture left tibia	Repair
10/M	Multiple lacerations right lobe of liver, with torn right hepatic vein	Fracture left femur, fracture left clavicle	Repair
7/M	Deep laceration right lobe of liver	Head injury	Repair
1.5/F	Three tears in the liver: two in the left lobe and one in caudate lobe	Bilateral retroperitoneal hematomas	Repair

12/M	Tear left lobe of liver	Transection of splenic artery and distal 1/3 pancreas, thrombosis left renal artery	Repair
7/F	Subcapsular hematoma left lobe of liver	–	Conservative
5/M	Tear right lobe of liver	Right hemothorax, contused right adrenal gland	Conservative
12/M	Subcapsular hematoma right lobe of liver	Fracture right radius and ulna, right hemothorax, right perinephric hematoma	Conservative
7/M	Tear right lobe of liver	Right traumatic diaphragmatic hernia, hemothorax, fracture right acetabulum, fracture right iliac bone	Repair

TABLE 4. *Traumatic diaphragmatic hernias.*

Age (y)/ sex	Cause of injury	Site	Associated injuries	ISS and outcome
6/M	Fall from tree	Right	Fracture right acetabulum, right hemothorax, fracture right iliac bone, liver injury	27, survived
7/M	RTA	Bilateral	Fracture pelvis, torn left hepatic vein, hematuria, liver injury	57, survived
16/M	RTA	Left	Fracture left humerus, laceration left triceps muscles, left radial nerve injury, fracture tibia and fibula, fracture medial malleolus left ankle, fracture right medial femoral condyle, splenic laceration, perforation of stomach	41, survived
14/M	Stab	Left	Splenic laceration	34, survived
5/M	RTA	Right	Right hemothorax, liver injury	34, survived

RTA=road traffic accident; ISS=injury severity score.

respectively. Four died early because of shock and associated head injuries. The fifth died one month after admission because of head injury. In three of the patients, there were associated thoracic injuries, while all of them sustained head injuries. On follow-up, four patients developed various complications. These were hearing loss, blindness and hypotonia of lower limbs in one patient, loss of motor power in both lower limbs and stricture urethra in one, thrombosis of left renal artery in another one, and stricture urethra in the last patient.

Discussion

Road traffic accidents were the most common cause of injuries in this series, while stab wounds were the least at only 4.7%. Whereas road traffic accidents were commonly seen in the 5-9-year age group, stab wounds were seen in an older age group. The 5-9-year age group is more likely to be left unattended playing on the streets than younger children, and the majority of our patients were pedestrians. This is similar to the experience from other parts of Saudi Arabia.[4,10,11] Males outnumbered females in a ratio of 4:1 in our series, which is not unusual, as female children are less likely to stay outdoors in this country. In order to reduce this type of accident, various safety measures as well as education programs must be introduced, stressing to parents the importance of not allowing children to play on the roads, especially when unattended.

There was a difference between children and adults in terms of causes of trauma, as well as the types of organs injured and methods of treatment provided. The advanced trauma life support (ATLS) system advocates diagnostic peritoneal lavage for patients with blunt abdominal trauma,[12] but this is not the case in children. Unless there are clear and specific indications for operation, laparotomy is to be avoided in children who are stable. The nonoperative management of blunt splenic and liver injury in children is now a well-accepted form of treatment in selected patients.[13-17] Many recent reports suggest that children with either splenic or liver injury after blunt abdominal trauma may be successfully managed conservatively.[13,18,19] This approach will not only obviate the need for a laparotomy, with its sequelae, but will also preserve the spleen, as splenectomized children have an increased risk of life-threatening infections. On the other hand, if a laparotomy becomes necessary, splenorrhaphy should be attempted. Of 12 patients in our series, only one was treated conservatively. Laparotomy was necessary in the other 11 for various reasons (Table 2). Two had splenorrhaphy, while the others had splenectomy. The type of splenic injury in those who had splenectomy was so extensive that splenic salvage was not possible, a fact supported by a high ISS, ranging from 25-41 (mean 34.7), in these patients. To obviate the risk of post-splenectomy sepsis, splenectomized children received pneumococcal vaccine postoperatively, as well as prophylactic antibiotics. On the other hand, three of our patients with liver injury were treated conservatively and the remaining seven were repaired surgically. Two of our patients had grade VII liver injury according to the Hollands and Little[17] classification, or grade V according to the Schweizer et al.[16] classification, yet both patients survived. With well-established guidelines, abdominal ultrasound and CT scan are of great value in evaluating the type and extent of abdominal trauma in injured children.[20] As in other series, we operate on these patients with liver or splenic injury if there is massive bleeding leading to hemodynamic instability.[13,18,19] This also applies to blunt renal injuries in children where conservative treatment is the choice, unless there is massive bleeding.[21]

Traumatic rupture of the diaphragm is rare in children, as it is usually associated with severe thoraco-abdominal trauma, which is commonly fatal. In adults, traumatic diaphragmatic hernia forms about 3%-8% of those with severe blunt trauma.[22] In a large series of 2086 injured children, none had diaphragmatic injury,[23] and Cywes et al.[24] reported only four diaphragmatic injuries studying 587 children with 732 organ injuries over an 11-year

period. Over a shorter period and in a smaller number of injured children, we saw five cases of traumatic diaphragmatic injuries. Whereas left-sided diaphragmatic ruptures are easily diagnosed, the diagnosis can sometimes be delayed. This is more likely in those on the right side, as the liver seals the tear in the diaphragm and prevents bowel herniation. We found an elevated right hemidiaphragm with right hemothorax, an indication of traumatic diaphragmatic rupture which should be investigated. CT scan is of great help in establishing the diagnosis. Other diagnostic modalities include thoracoscopy.[25] Traumatic diaphragmatic hernia rarely occurs in isolation, and is usually associated with severe trauma leading to injury of other organs.[26] This was reflected in a high injury severity score in these patients (Table 4). This association of traumatic diaphragmatic rupture with other injuries is one of the causes of delayed diagnosis. Rupture of a diaphragm is frequently associated with a fractured pelvis.[26,27] This was seen in two of our five patients.

Trauma is a well-recognized major cause of death in children. Our mortality rate of 7.8% does not represent the actual rate, as hospital-based data usually underestimates mortality. Trauma accounted for 41.4% of all the deaths in children in Indiana, USA, from June 1986 to May 1988.[3] Hemorrhage was the main cause of death in our patients, and all those who died sustained severe trauma. Their ISS ranged from 32-57 (mean=41). The coexistence of thoracic injury increases mortality from less than 5% to as high as 25%, and in the presence of head injuries the mortality may reach 100%.[9,28,29] All those who died in our series had head injuries, and in three, there were also associated thoracic injuries. Trauma in children is a major social and health problem, and efforts in terms of education should be made to prevent or reduce its occurrence.

References

1. Rivara FP. Epidemiology of childhood Injury. 1: review of current research and presentation of a conceptual framework. Am J Dis Child 1982;136:399-405.
2. Baker SP. The neglected epidemic. J Trauma 1987;27:343-8.
3. Vane D, Shedd FG, Grosfeld JL, Franiak RJ, Ulrich JC, West KW, et al. An analysis of pediatric trauma deaths in Indiana. J Pediatr Surg 1990;25:955-60.
4. Evbuomwan I. Pediatric trauma admissions in the Sakaka Central Hospital, Al-Jouf Province, Saudi Arabia. Saudi Med J 1994;15:435-7.
5. Al-Salem AH, Qaisaruddin S. Trauma in a district general hospital. Saudi Med J 1997;18:49-53.
6. Al-Qasabi QO, Alam MK, Tyagi A, Al-Kraida A, Al-Sebayel MI. Laparotomy for abdominal injury in traffic accidents. Ann Saudi Med 1989;9:39-43.
7. Baker SP, O'Neil B, Haddon W, Long WB. The Injury Severity Score: a method for describing patients with multiple injuries and evaluating emergency cases. J Trauma 1974;14:187-96.
8. Committee on Injury Scaling: the Abbreviated Injury Scale, 1980 Revision. Park Ridge, Illinois. American Association for Automotive Medicine, 1980.
9. Peclet MH, Newman KD, Eichelberger MR, Gotschall CS, Guzzetta PC, Anderson KD. Patterns of injury in children. J Pediatr Surg 1990;25:85-91.
10. Tamimi TM, Daly M, Bhatty MA, Lutfi ARM. Causes and types of road injuries in Asir Province, Saudi Arabia, 1975-1977. Preliminary study. Saudi Med J 1980;1:249-56.
11. Al-Tukhi MH. Road traffic accident statistics and data comprising Gulf countries and Riyadh area. Ann Saudi Med 1990;11:1-3.
12. Subcommittee on Advance Trauma Life Support. Abdominal Trauma. In: American College of Surgeons Committee on Trauma, editors. Advanced Trauma Life Support Course for Physicians. 2nd Impression. Illinois, Chicago: American College of Surgeons, 1990:111-30.
13. Buess E, Illis OE, Soder C, Hanimann B. Ruptured spleen in children: 15 years evolution in therapeutic concepts. Eur J Pediatr Surg 1992;2:157-61.
14. Ein SH, Shandling B, Simpson JS, Stephens CA. Non-operative management of traumatized spleen in children: how and why. J Pediatr Surg 1978;13:117-125.
15. Hebeler RF, Ward RE, Miller PW, Ben-Menachem Y. The management of splenic injury. J Trauma 1982;22:492-5.
16. Schweizer W, Tanner S, Baer HU, Lerut J, Huber A, Gertsch PH, et al. Management of traumatic liver injuries. Br J Surg 1993;80:86-8.
17. Hollands MJ, Little JM. Non-operative management of blunt liver injuries. Br J Surg 1991;78:968-72.
18. Cywes S, Rode H, Millar AJW. Blunt liver trauma in children: non-operative management. J Pediatr Surg 1985;20:14-8.
19. Grisoni E, Ganderer M, Ferron J, et al. Non-operative management of liver injuries following blunt abdominal trauma in children. J Pediatr Surg 1984;19:515-9.
20. Turnock RR, Sprigg A, Lloyd DA. Computed tomography in the management of blunt abdominal trauma in children. Br J Surg 1993;80:982-4.
21. Bass DH, Semple PL, Cywes S. Investigation and management of blunt renal injuries in children: a review of 11 years' experience. J Pediatr Surg 1991;26:196-200.
22. Johnson CD. Blunt injuries of the diaphragm. Br J Surg 1988:226-330.
23. Peclet MH, Newman KD, Eichelberger MR, Gotschall CS, Garcia VF, Bowman LM. Thoracic trauma in children: an indicator of increased mortality. J Pediatr Surg 1990;25:961-5.
24. Cywes S, Bass DH, Rode H, Millar AJW. Blunt abdominal trauma in children. Pediatr Surg Int 1990:350-4.
25. Mealy K, Murphy M, Broe P. Diagnosis of traumatic rupture of the right hemidiaphragm by thoracoscopy. Br J Surg 1993;80:210-1.
26. Christophi C. Diagnosis of traumatic diaphragmatic hernia: analysis of 63 cases. World J Surg 1983;7:277-80.
27. Miller LW, Bennett EV, Rood HD, Trinkle JK, Grorer FL. Management of penetrating and blunt diaphragmatic injury. J Trauma 1984;24:403-9.
28. Velcek FT, Weiss AD, Di Maio D, et al. Traumatic death in urban children. J Pediatr Surg 1977;12:375-85.
29. Smyth BT. Chest trauma in children. J Pediatr Surg 1979;14:41-7.