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Original Research Article

Exploratory laparotomy for abdominal injuries in children: a retrospective review of 36 cases

Rajendra K. Ghritlaharey*

Department of Pediatric Surgery, Gandhi Medical College and Associated Kamla Nehru and Hamidia Hospitals, Bhopal, Madhya Pradesh, India

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***Correspondence:**
Dr. Rajendra K. Ghritlaharey
E-mail: drrajendrak1@gmail.com

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ABSTRACT

Background: Abdominal injuries are a major cause of morbidity and mortality in children. The objectives of the current study were to review the demographics of children with abdominal injuries (blunt and penetrating) who required laparotomy. The study also aimed to identify the causes of injuries, organs involved, and outcomes of the surgical therapy provided.
Methods: This retrospective and descriptive study was conducted for a period of 10 years from January 1, 2013, to December 31, 2022, at the author's department of Pediatric Surgery. The study included children aged ≤12 years who needed exploratory laparotomies for abdominal injuries caused by either blunt or penetrating trauma.
Results: During the study period, 36 children (30 boys and 6 girls) needed laparotomy for the management of abdominal injuries. Most children were aged 7 to 12 years (n=30; 83.33%). Indications for abdominal exploration included bowel perforation (n=20), penetrating abdominal injuries (n=9), and hemoperitoneum (n=7). Fifteen children were treated with repair or resection of bowel perforation(s). Nine required the creation of an ileostomy. Four children underwent splenectomy for shattered splenic injuries. Two deaths were documented.
Conclusions: Children aged 7 to 12 years were the most frequently injured, and this study also evidenced male preponderance. Bowel perforation(s) were documented in two-thirds of children. One-fourth of the cases needed the creation of a temporary terminal ileostomy for managing their bowel injuries.

Keywords: Abdomen, Children, Ileostomy, Injury, Intestine, Laparotomy, Trauma

INTRODUCTION

Trauma is also one of the leading causes of morbidity and mortality in children.[1,2] In children, the abdomen is one of the commonly injured anatomical sites, and it is only after trauma to the head and extremities.[1,3-5] Abdominal trauma in children is mostly blunt trauma, and penetrating abdominal injuries are less common.[6-8] Blunt abdominal trauma may affect/involve an intra-abdominal solid organ, hollow viscus, or both.[5-9] Additionally, abdominal trauma may also injure/involve the pancreas, mesentery, and diaphragm.[10-12] The spleen is the most frequently injured solid organ involved in blunt abdominal injuries in children.[5,6] The bowel is the most common non-solid organ involved in abdominal injuries.[6,7] Ultrasonography of the abdomen is the standard initial evaluation tool for abdominal injuries.[13-15] Computed tomography (CT) scan of the abdomen is a standard radiological tool for investigating a child with a blunt injury to the abdomen; it not only helps in making a diagnosis but is also helpful in planning for management.[16,17] Most abdominal injuries caused by blunt objects, involving solid organs, are managed non-operatively (without any surgical intervention) in children.[18,19] Surgical intervention is necessary in only 10-15% of blunt abdominal injuries involving solid organs.[5,7,9,20] Surgical intervention is essential for abdominal injuries leading to hollow viscus/bowel

perforation, and for children presenting with penetrating injuries.[8,21] This report is a retrospective review of n=36 children who underwent/required abdominal exploration for the management of their abdominal injuries caused by either blunt or penetrating trauma.

METHODS

This retrospective and descriptive study was conducted over a period of 10 years from January 1, 2013, to December 31, 2022. This study was conducted at the Department of Pediatric Surgery, Gandhi Medical College, and the associated Kamla Nehru and Hamidia Hospitals, Bhopal, Madhya Pradesh, India. The study included children aged ≤12 years who needed exploratory laparotomies for abdominal injuries caused by either blunt or penetrating trauma.

The variables/data extracted from the case sheet included the age and sex, mechanism and cause of injury, clinical findings, radiological investigations needed, organ(s)/system(s) involved, the indication for exploratory laparotomy, operative findings, surgical procedures executed, and the outcome. The analysis of the included data and the results obtained are presented as numbers, means, ranges, and percentages. Children who were treated conservatively for blunt abdominal injuries during the above-mentioned period were excluded from this study. Additionally, children who were operated upon for blunt and penetrating abdominal injuries during the study, but had incomplete details/missing details, were also excluded from this study. Although institutional ethical committee approval was not obtained, consent for publication and presentation was received from the parents of all children included in this study.

RESULTS

During the above-mentioned study period, 36 children under 12 years of age underwent exploratory laparotomy for abdominal injuries. Table 1 presents demographic characteristics, injury causes, indications for surgery, operative interventions, and outcomes for these children. Figure 1 displays the age and sex distribution of the cases. Abdominal injuries occurred more frequently in boys (n=30) than in girls (n=6). The mean age of children was 9±2.75 years and ranged from 3 to 12 years.

The majority (n=30; 83.33%) of cases involved children aged 7 to 12 years. Figure 2 represents the causes of abdominal injuries in children. The most common causes were bicycle accidents, road traffic accidents (RTA), falls from height, and falls onto hard or sharp objects. Blunt injuries occurred in 27 cases, while 9 children sustained penetrating injuries. Clinical examination revealed prolapsed bowel in 4 cases (Figure 3) and prolapsed omentum in 2 cases. All patients underwent abdominal and chest X-rays, with additional imaging as needed. An abdominal and pelvic X-ray in one child also identified a radio-opaque foreign body in the pelvic region. All children underwent abdominal sonography, while only four underwent abdominal CT scans. A contrast CT scan of the abdomen in a child revealed a rupture of his left renal pelvis, an undetected left hydronephrotic kidney due to pelvi-ureteric junction obstruction, and a perinephric collection (Figure 4). Bowel perforation (n=20) caused by blunt injuries, penetrating abdominal injuries (n=9), and hemoperitoneum (n=7) were the reasons for abdominal exploration. Abdominal exploration revealed bowel perforation(s) in 24 children.

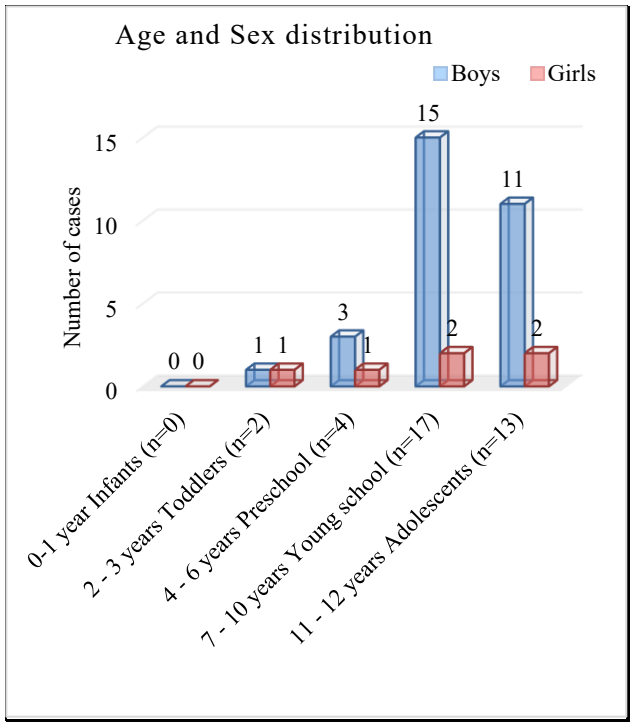

Figure 1: Age and sex distribution.

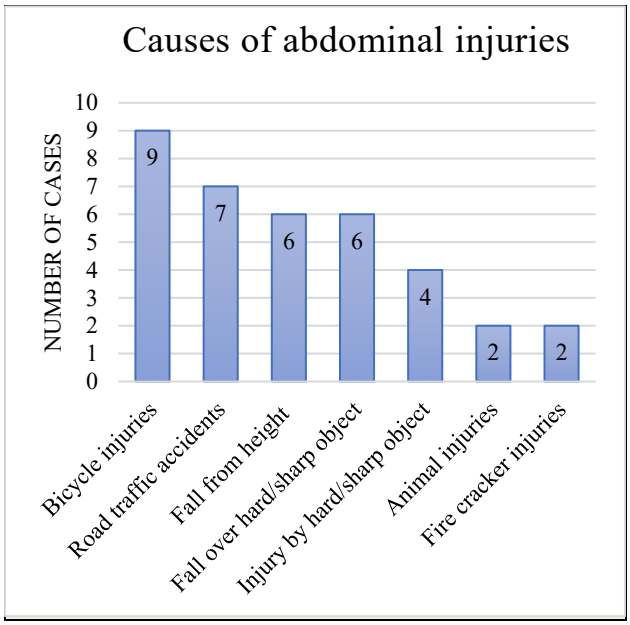

Figure 2: Causes for abdominal injuries in order of frequency in children.

Figure 3: Clinical examination showing prolapsed bowel caused by the bursting of firecrackers.

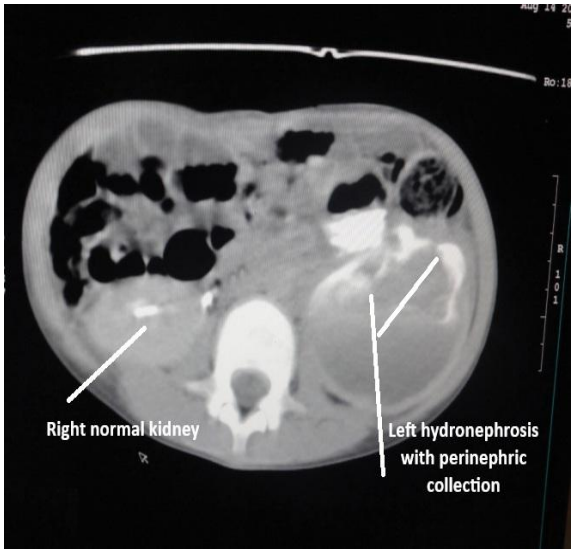

Figure 4: Computed tomography scan showing left hydronephrotic kidney with perinephric collection.

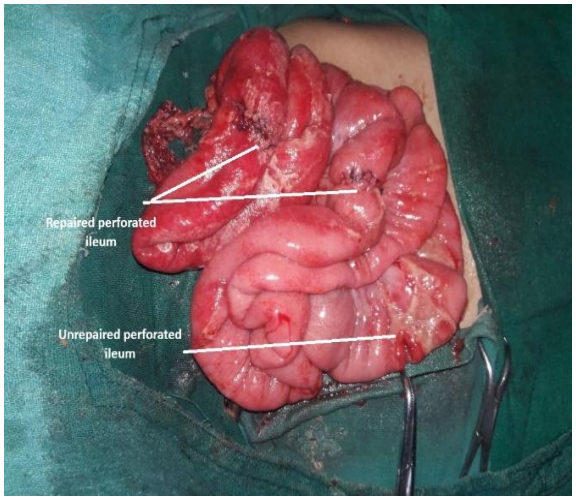

Figure 5: Operative photograph showing bowel (ileal) perforations at three sites.

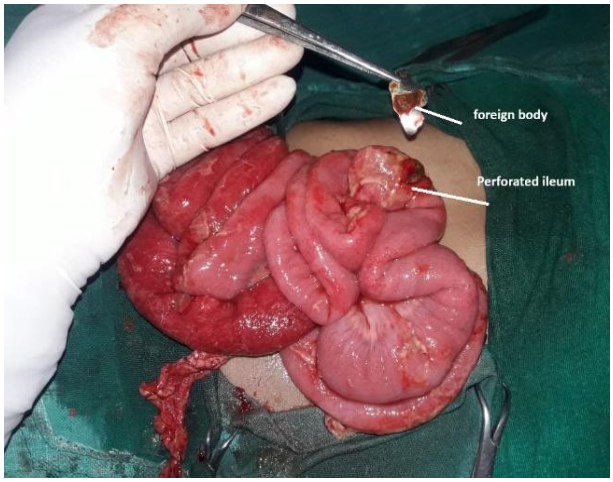

Figure 6: Operative photograph showing a foreign body and bowel perforation.

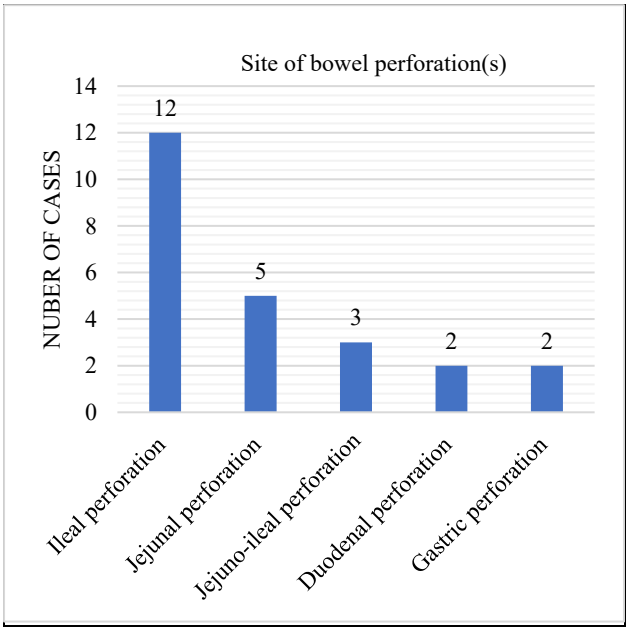

Figure 7: Bowel perforation observed during abdominal exploration in children (n=24).

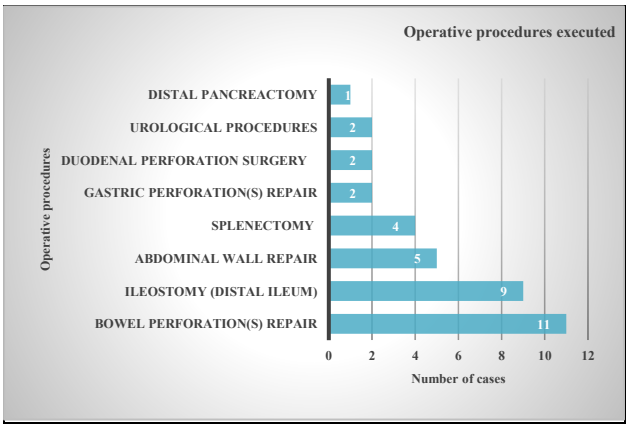

Figure 8: Operative procedures executed for abdominal injuries in children (n=36).

Notably, one child suffered bowel perforations at three separate sites (Figure 5), which were caused by penetrating trauma from firecracker explosions. A small piece of a drinking glass vessel made of steel was also removed from a perforated bowel (Figure 6). The sites of bowel perforation(s) detected during surgical procedures are depicted in Figure 7. Abdominal exploration also revealed solid organ injuries in 10; spleen (n=4), liver (n=2), pancreas (n=1), kidney (n=1), and omentum (n=2). The operative procedures performed on 36 children are summarized in Figure 8. Fifteen children required bowel repair or resection, and nine (one-fourth) underwent ileostomy creation. Post-operative major complications occurred in six children, and two deaths were documented. The summary of the results obtained from this paper is provided in Table 2.

Table 1: Demographics and other details of children who needed operative procedures for their abdominal injuries (n=36).

S. no.	Age (year) / Sex	Cause for injury	Type of injury	Organ involved	Operative findings	Operative procedures performed	Remark
1.	9/Male	Injury by hard object (Cow's leg)	Blunt	Solid organ	Pancreatic injury and hemoperitoneum	Distal pancreactomy for transected tail of pancreas	R
2.	5/Male	Fall from height	Blunt	Bowel	Ileal perforation and hemoperitoneum	Resection of small segment of ileum involving perforation and ileo-ileal anastomosis. Re-exploration and ileostomy for burst abd and leakage	R
3.	10/Male	Fall from height	Blunt	Solid organ, urological and skeletal	Liver injuries, rupture of urinary bladder and pelvic bone fracture	Rail roading of urethra and supra-pubic cystostomy for floating urinary bladder. Pelvic fracture treated conservatively. Urethral and supra-pubic catheters removed afterward.	R
4.	11/Male	Fall from height (Fall from tree)	Blunt	Bowel and thoracic	Jejunal tear and bilateral hemopneumothorax	Repair of jejunal tear and bilateral ICDs	R
5.	7/Male	RTA	Blunt	Urological, mesenteric	Tear left renal pelvis and retroperitoneal hemoperitoneum	left nephrostomy for renal injury, peritoneal drainage, and others. Planned left pyeloplasty done for hydronephrosis.	R
6.	7/Male	Injury by sharp object (fall over sharp object)	Penet-rating	Abd wall (Soft tissues)	Anterior abd wall (Soft tissues injuries)	Repair of abdominal wall injuries	R
7.	8/Male	RTA	Blunt	Solid organ and skeletal	Splenic injuries, hemoperitoneum, and fracture left tibia	Splenectomy for shattered spleen. Transferred to orthopedics ward for bony injury.	R
8.	12/Female	Injury by sharp object (fall over sharp object)	Penetra ting	Abd wall and Solid organ	Anterior abd wall and prolapsed omentum	Repair and reposition of prolapsed omentum and repair of abd wall injuries	R
9.	10/Male	RTA	Blunt	Solid	Liver and splenic	Splenectomy for shattered	R

Continued.

S. no.	Age (year) / Sex	Cause for injury	Type of injury	Organ involved	Operative findings	Operative procedures performed	Remark
				organs	injuries, and hemoperitoneum	spleen and repair of liver tears	
10.	12/Male	Injury by sharp object (fall over wooden object)	Pene-trating	Bowel	Prolapsed bowel and gastric perforation	Reposition of prolapsed bowel and repair of anterior wall of gastric perforation	R
11.	11/Male	RTA	Blunt	Bowel	Duodenal perforation	Repair of duodenal perforation	R
12.	12/Male	Bicycle injury	Blunt	Solid organ	Splenic tears and hemoperitoneum	Splenectomy for major splenic injuries	R
13.	11/Male	Injury by hard object (fall of wall)	Blunt	Bowel	Jejunal and ileal perforations	Resection of small segment of jejunum involving perforation, jejuno-jejunal anastomosis and repair of ileal perforation	R
14.	12/Female	Bicycle injury	Blunt	Bowel	Duodenal perforation	Repair of duodenal perforation and gastrojejunostomy. Died during re-admission due to respiratory failure.	Death
15.	12/Male	Bicycle injury	Blunt	Bowel	Ileal perforation	Peritoneal toileting and terminal ileostomy for ileal perforation for severe peritonitis	R
16.	11/Male	Bicycle injury	Blunt	Bowel	Jejunal perforation	Repair of Jejunal perforation	R
17.	12/Male	Injury by hard object (fall over iron object)	Pene-trating	Bowel and thoracic	Gastric perforation and Left plural effusion	Repair of gastric perforation and left-sided ICD for plural effusion	R
18.	7/Male	Fall from height	Blunt	Bowel	Ileal perforation	Terminal ileostomy for ileal perforation and peritonitis	R
19.	3/Female	Injury by sharp object (fall over sharp sickle)	Pene-trating	Abd wall and bowel	Anterior abd wall injuries and prolapsed bowel	Reposition of prolapsed bowel and repair of abd wall injuries	R
20.	7/Male	RTA	Blunt	Solid organ and limbs injuries	Splenic injuries, and bony (limb) injuries	Splenectomy for shattered spleen. Transferred to orthopedic ward tor bony (limb) injury	R
21.	10/Male	Fall from height	Bunt	Bowel	Ileal perforation and hemoperitoneum	Repair of ileal perforation	R
22.	8/Male	RTA	Blunt	Bowel	Ileal perforation	Repair of ileal perforation	R
23.	8/Male	Bicycle injury	Blunt	Bowel	Jejunal perforation and retroperitoneal hematoma	Repair of jejunal perforation	R
24.	10/Female	Bicycle injury	Blunt	Bowel	Jejunal and ileal perforations	Repair of jejunal perforation and terminal ileostomy	R

Continued.

S. no.	Age (year) / Sex	Cause for injury	Type of injury	Organ involved	Operative findings	Operative procedures performed	Remark
25.	7/Male	Bicycle injury	Blunt	Bowel	Ileal perforation	Repair of ileal perforation	R
26.	4/Male	Injury by hard object	Blunt	Bowel	Ileal perforation	Ileostomy doe for terminal ileal perforation	R
27.	9/Female	Injury by hard object (fall over hard object)	Blunt	Solid organ and bowel	Jejunal perforation, tears and hemoperitoneum	Repair of jejunal perforation and serosal tears	R
28.	10/Male	Fall from height	Blunt	Bowel	Ileal perforation and tears	Repair of ileal perforation and serosal tears	R
29.	12/Male	RTA	Blunt	Bowel	Jejunal perforation	Repair of jejunal perforation	R
30.	10/Male	Injury by hard object (Bull horn injury)	Blunt	Bowel	Ileal perforation	Repair of ileal perforation	R
31.	3/Male	Bicycle injury	Penetrating	Abd wall and Bowel	Anterior abd wall injuries, multiple jejunal and ileal perforations, and prolapsed bowel	Resection of small segment of jejunum involving transected jejunum, jejuno-jejunal anastomosis, repair of ileal perforation, and terminal ileostomy	R
32.	12/Male	Injury by hard object (fall of wooden object)	Blunt	Bowel	Ileal perforations	Repair of ileal perforation and terminal ileostomy	R
33.	10/Male	Bicycle injury	Penetrating	Abd wall and Bowel	Anterior abd wall injuries, prolapsed bowel, and retroperitoneal hematoma	Reposition of prolapsed bowel, and repair of abd wall injuries	R
34.	12/Male	Injury by bursting of fire crackers	Penetrating	Abd wall and Bowel	Anterior abd wall injuries, small bowel perforations, and prolapsed bowel	Removal of foreign body, repair of two ileal perforations, and third ileal perforation created as terminal ileostomy	R
35.	6/Male	Injury by bursting of fire crackers	Blunt	Bowel	Ileal perforations	Multiple ileal perforation repaired and terminal Ileostomy. Died of septicemia on 4th postoperative day.	Death
36.	4/Female	Injury by sharp object (stab injury)	Penetrating	Bowel	Anterior abd wall injuries, and prolapsed omentum	Repair, reposition of prolapsed omentum, and repair of abdominal wall injuries	R

Table 2: Summary of results (Laparotomy done for abdominal injuries in children).

Description (Details ↓)	Description (Details ↓)	Total (%)
Number of cases	Total	36 (100)
Sex distribution	Boys	30 (83.33)
	Girls	6 (16.66)
Age distribution	7-10 years	17 (47.22)
	11-12 years	13 (36.11)
Mechanism of injury	Blunt injury	27 (75)
	Penetrating injury	9 (25)
Organ involved	Hollow viscus (bowel) injuries	24 (66.66)
	Solid organ(s)	10 (27.77)
Indication (abdominal exploration)	Bowel perforation(s)	20 (55.55)
	Penetrating injuries	9 (25)
	Hemoperitoneum	7 (19.44)
Operative procedures	Repair of bowel perforation(s)	15 (41.66)
	Ileostomy (terminal)	9 (25)
	Splenectomy	4 (11.11)
Complication (major)	Post-operative	6 (16.66)
Mortality	Post-operative	2 (5.55)

DISCUSSION

Trauma is one of the leading causes of morbidity and mortality in children.[1,2] Injuries in children cause considerable mortality and lead to significant disabilities worldwide.[22] Trauma kills over 830,000 children under 18 each year, and of these deaths, 95% occur in low and middle-income countries.[22] Abdominal injuries are also one of the causes of morbidity and mortality in children.[5,7] Approximately 8 to 12% of children suffering blunt injury also have an abdominal injury.[23]

A current retrospective study of 36 children below the age of 12 years revealed that boys sustained abdominal injuries more commonly than girls. The ratio of boys to girls was 5:1. Further review revealed that children aged 7 to 12 years sustained abdominal injuries most frequently (n=30; 83.33%). The mean age of children was 9±2.75 years, ranging from 3 to 12 years. These findings are also consistent with earlier studies on the subject.[20,21]

Abdominal trauma in children is mostly blunt, with penetrating injuries less common [6-8, 24]. Consistent with this, the current review found blunt abdominal injuries (n=27; 75%) to be more frequent than penetrating ones (n=9; 25%). The most common causes of abdominal injuries, in descending order, were bicycle accidents (n=9), RTA (n=7), falls from height (n=6), falls on over-hard/sharp objects (n=6), injuries sustained by an animal (n=2), and injuries caused by the bursting of fire crackers (n=2). Three-fourths (n=27) of children sustained blunt abdominal injuries.

Twenty of them had features of peritonitis, and all of them were detected as bowel perforations during radiological investigations and confirmed during surgical interventions. Five children had features of hemoperitoneum. Another n=2 of the cases had features of hemoperitoneum and were diagnosed as having urological injuries on radiological investigations, detected and confirmed during surgical intervention. One third (n=9) of children sustained penetrating abdominal injuries, clinically documented prolapsed bowel in 5, and prolapsed omentum in 2 cases. Two of the cases admitted with features of peritonitis had a sutured abdominal wound.

Abdominal and chest X-rays were obtained for all children in the study. For a few cases, additional imaging was needed for bony injuries. Specifically, gas under the diaphragm was documented in all 20 cases with bowel perforation following blunt injuries. In a child, an abdominal and pelvic X-ray also identified a radio-opaque foreign body in the pelvic region. Subsequently, abdominal USG was performed for all cases, which aided in diagnosis and management planning. A computed tomography scan of the abdomen was obtained only for four cases. Bowel perforation was one of the reasons for abdominal exploration in 20 cases, and was suspected by X-ray and ultrasonographic evaluation of the abdomen and pelvis. Both radiological investigations documented gas under the diaphragm. Abdominal USG evaluation also detected peritoneal fluid collection of variable amounts. Nine children sustained penetrating abdominal injuries, and this was the indication for abdominal exploration. In the remaining 7 children, the indication was hemoperitoneum, which was suspected on clinical examination and USG findings of the abdomen.

The present study revealed that the bowel was the most common non-solid organ involved in abdominal injuries, and was also reported in various previous studies.[6,7,20] Non-solid organ hollow viscus injuries most frequently

involve the bowel and rarely other hollow viscus, such as the urinary bladder and the gall bladder.[25,26] Twenty-four (two-thirds) children documented bowel perforation(s), 10 found to have solid organ injuries, and 2 children revealed urological injuries. The sites of bowel perforation in order of frequency were ileum (n=12), jejunum (n=5), jejunum and ileum both (n=3), duodenum (n=2), and gastric perforation (n=2). Notably, one child suffered bowel perforations at three separate sites, which were caused by penetrating trauma from firecracker explosions. One of the children had a floating urinary bladder and rupture of the urethra due to blunt injury and pelvic fracture. Another child had hemoperitoneum, a hematoma of the left mesocolon, and rupture of his left renal pelvis was detected later, on further radiological investigations. This study also documented that the spleen was the commonly injured solid organ, as reported in various previous studies.[5,6,18,20] Abdominal exploration revealed solid organ injuries in 10 children, in the order of frequency were: spleen (n=4), liver (n=2), omentum (n=2), pancreas (n=1), and kidney (n=1).

A total of 24 children documented bowel perforations. Fifteen children were treated either by the repair or resection of bowel perforations. Nine required the creation of an ileostomy. In the present retrospective study, the ileum was the most frequently injured part of the intestine, which is consistent with the published literature.[21] Most abdominal injuries caused by blunt objects, involving solid organs, are managed non-operatively (without any surgical intervention) in children, as well.[18,19,24] Surgical intervention is necessary in only 10%-15% of blunt abdominal injuries involving solid organs.[5,7,9,20] The present study revealed that 10 children sustained and were diagnosed with solid organ injuries.

Four children required splenectomy for shattered splenic injuries. One child had hemoperitoneum and perinephric hematoma and needed exploration and abdominal drainage. His abdominal drain contained urine and needed further surgical procedures for treatment of his undetected hydronephrosis of the right kidney. A child, operatively confirmed as having distal pancreatic injuries, was treated with distal pancreatectomy. Five children sustained anterior abdominal wall soft tissue injuries and required abdominal wall repair only. A 10-year-old boy, explored for hemoperitoneum, documented a floating urinary bladder and rupture of the urethra, and was treated by rail-roading of the urethra and other procedures. Seven of the cases had associated injuries bony injuries (n=3), haemo-pneumothorax (n=2), and urological injuries (n=2). Additional surgical procedures were also required in 6 cases; intercostal chest tube insertion (2), orthopaedic intervention for bony injuries (2), and urological surgical procedures (2). The operative procedures carried out for the abdominal injuries in children are also associated with morbidities and mortality.[20,21] In the current study, major post-operative complications documented in six children were anastomotic leakage (n=2), burst abdomen (n=2), urinary drainage (n=1), and wound dehiscence (n=1). Case 2, complicated with anastomotic leakage, needed a re-exploration and was managed well with the creation of an ileostomy. Case 5, documented urinary drainage through the abdominal drain tube. Further radiological investigations confirmed rupture of the left renal pelvis and hydronephrosis due to obstruction at the pelvi-ureteric junction. He needed a nephrostomy and planned pyeloplasty for correction of his underlying disease. Case 14, a 12-years-old-girl underwent repair of duodenal perforation and gastro-jejunostomy. Anastomotic leakage was documented in her early post-operative period, but she responded well to the conservative therapy and was discharged. She was re-admitted after a week of discharge in poor general condition for vomiting, respiratory distress, and severe anemia, and died during the treatment. Case 15: he developed a burst abdomen and needed repair. Case 32, a 12-year-old boy, experienced a major wound infection and responded well to conservative treatment. Case 35, a 6-year-old boy, sustained multiple bowel perforations, and he was managed with repair of perforations and ileostomy. He developed a burst abdomen, peritonitis, and septicaemia, and died of poor general condition and septicaemia. This study documented two deaths and observed during the postoperative period.

Case 14, she was re-admitted in a poor general condition for vomiting, respiratory distress, and severe anemia, after a week of discharge, and died during the treatment. Case 35, a 6-year-old boy who sustained severe blunt abdominal injury from bursting of fire crackers, underwent exploratory laparotomy, documented multiple bowel perforations with peritonitis, and was managed with repair of perforations and ileostomy. He died on the fourth post-operative day, due to poor general condition, peritonitis, and septicaemia.

Limitations

The study was limited by its small sample size, single-center retrospective design, and lack of multicenter data and statistical analysis. Detailed, prospective, multicenter, and multi-procedural studies are needed.

CONCLUSION

This study revealed and supports that children aged 7 to 12 years experienced the highest frequency of injuries, with a higher incidence in boys. The study found bowel perforation to be the most common non-solid organ injury, affecting two-thirds of children. In one-fourth of children with abdominal injuries, a temporary terminal ileostomy was required. In the children studied, both blunt and penetrating abdominal trauma and the subsequent surgical interventions were associated with complications and mortality.

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Conflict of interest: None declared
Ethical approval: Consent obtained from parents of children included in this study

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