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Original Article

Bicycle handlebar injuries in children: Is "ring sign," an indicator of intra-abdominal organ injuries?

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Abstract

Background: Children are vulnerable to a wide range of bicycle-related traumatic injuries. Bicycle handlebar injuries often cause diagnostic dilemma and delay in diagnosis due to trivial nature of the incident. **Objectives:** To study the bicycle handlebar injuries in children and their management. **Materials and Methods:** A retrospective review of all the children with blunt abdominal injuries secondary to bicycle handlebar injuries at our institution, between April 2011 and March 2015 was done. The patient medical records were examined, and all the data pertaining to the demographic information, clinical history, hematological investigations, imaging studies, operative technique, post-operative recovery and complications, and duration of hospitalization were obtained. **Results:** During the study period of 48-month, 26 children with blunt abdominal injuries were treated at our institution. Among these patients, 7 children had bicycle handlebar abdominal injuries. All 7 patients were male. Mean age of the patients was 9.6 years (range 5-12 years). The average time gap between trauma and presentation to our institution was 46 h (range 22-96 h). All the 7 children had circular patterned abrasion of the bicycle handlebar over the abdominal wall. Mean duration of hospital stay was 16.1 (range: 9-28) days, and the average duration of follow-up was 35.6 months (range 7-55 months). **Conclusion:** "Ring sign" indicates a higher probability of associated intra-abdominal injury, and these children should be thoroughly evaluated and managed with close observation, repeated clinical examination, appropriate imaging studies, and surgical or endoscopic intervention as required.

Key words: *Bicycle handlebar injury, Ring sign, Blunt abdominal trauma, Traumatic pancreatitis*

Accidents represent the largest single cause of death in childhood. Children are vulnerable to a wide range of bicycle-related traumatic injuries. Bicycle accidents account for 5-14% of blunt abdominal trauma in children [1]. Although head injuries are the major cause of mortality and morbidity after bicycle accidents in children, abdominal injuries are also not uncommon. The reported handlebar-related injuries include liver, splenic, renal, intestinal, and pancreatic injuries; traumatic abdominal wall hernia (TAWH); abdominal wall rupture; abdominal aorta rupture; transection of the common bile duct; traumatic arterial occlusion; groin injuries and other site-specific injuries. In general, injuries to the spleen, liver, or kidneys are readily evident soon after the accident; however, injuries to the bowel and pancreas often present late and result in greater morbidity.

Children who sustain high-speed accidents involving a motor vehicle collision suffer head injuries and multiorgan injuries accounting for the most cases of mortality. However, bicycle handlebar injuries constitute a separate category of low-speed accidents that often cause diagnostic dilemma and delay in diagnosis. It can be due to the trivial nature of incident; although, injuries sustained may be quiet severe. We present our study constituting an analysis of data of children who presented to us with trivial bicycle handlebar injuries.

MATERIALS AND METHODS

A retrospective review of all the children with blunt abdominal injuries secondary to bicycle handlebar injuries at our institution between April 2011 and March 2015 was done. The patient medical records were examined, and all the data pertaining to the demographic information, clinical history, hematological investigations, imaging studies, operative technique, post-operative recovery and complications, and duration of hospitalization were recorded.

All the patients underwent an initial abdominal ultrasound examination and contrast enhanced computed tomography (CECT) of the abdomen as a part of imaging studies. Complete blood count, blood grouping and Rh typing, serum amylase and lipase, liver function test, and renal function tests were done for all the patients. The patients were stabilized with

intravenous (IV) fluid resuscitation, IV antibiotics, and nasogastric decompression.

As a protocol, all the patients were initially managed conservatively with close observation as inpatients in the hospital. Repeated clinical examination, laboratory investigations, and imaging studies as and when required were part of the treatment protocol. The patients were discharged once full oral feeds were established. Follow-up evaluation was done at 1 week, 1 month, and 3 months intervals for all the patients, followed by biannual follow-up.

RESULTS

During the study period of 48-month, 26 children with blunt abdominal injuries were treated at our institution. Among these, 7 children had bicycle handlebar abdominal injuries. The sex ratio was 7:0 in favor of males (i.e. all 7 were males). Mean age of the patients was 9.6 years (range 5-12 years). The most common mode of clinical presentation was pain abdomen, followed by vomiting, abdomen mass, abdomen guarding and rigidity, fever, and hypovolemic shock. The average time gap between the trauma and presentation to our institution was 46 h (range 22-96 h). All the 7 children had circular patterned abrasion of the bicycle handlebar ("ring sign") over the abdominal wall (Figs. 1a-c).

CECT abdomen revealed various degrees of pancreatic injuries (Fig. 2) in 4 children, Grade 2 duodenal lacerations (Fig. 3) in 1 child, anterior abdomen wall defect with free peritoneal gas in 1 child, and isolated abdominal wall defect in 1 child. The mean duration of hospital stay was 16.1 days (range 9-28 days). The duration of follow-up ranged from 7 to 55 months, average being 35.6 months. All the patients were doing well at follow-up. The cases are briefly summarized in Table 1.

Operative findings among 4 children, who underwent exploratory laparotomy, included necrosis of lateral wall of the second part of duodenum (measuring 2 cm × 1 cm) in first child, abdominal wall dehiscence with intact skin (Fig. 4) and jejunal perforation (Fig. 5) located about 30 cm from the duodenojejunal flexure in second child, peritoneal contamination secondary to infected pancreatic fluid in the third child, and abdominal wall defect in right iliac fossa in the sixth child.

Debridement of devitalized tissue with primary closure of the duodenal perforation, tube cholecystostomy, feeding jejunostomy, and abdominal drainage was done in the 1st patient. Jejunal perforation closure and primary closure of abdominal wall defect were done in the 2nd patient. Laparotomy, peritoneal lavage, feeding jejunostomy, and lesser sac tube drainage were done in the 3rd patient. In the 4th patient attempted pancreatic duct cannulation was unsuccessful; however, internal drainage of lesser sac was achieved by

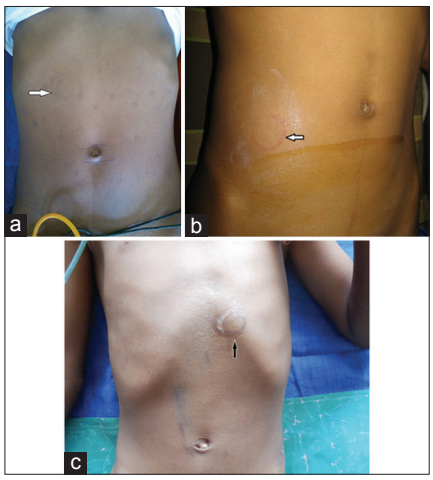

Figure 1: (a) Patterned circular abrasion on the right hypochondrium – "ring sign" caused by the direct impact from the end of the handlebar (indicated by arrow), (b) right lumbar region – "ring sign" (indicated by arrow) and (c) epigastrium – "ring sign" (indicated by arrow)

Figure 2: Contrast enhanced computed tomography abdomen showing collection at the junction of head and body of pancreas indicating pancreatic injury

Figure 3: Three dimensional reconstruction of contrast enhanced computed tomography abdomen showing leak of duodenal contrast from lateral wall of 2nd part of duodenum (indicated by arrow)

Table 1: Summary of all the cases of bicycle handlebar abdominal injuries

Serial number	Age (years)/ sex	Time gap between trauma and hospital presentation (hours)	Clinical presentation	Ring sign on the abdominal wall	Computed tomography	Operative findings and management	Duration of hospital stay (days)	Follow up duration/ remarks (months)
Case 1	12/male	22	Pain abdomen, bilious vomiting and high grade fever	Present	Rupture of posterior wall of 2nd part of duodenum (Grade 2 laceration disruption involving <50% of circumference) with localised pneumoperitoneum around the duodenum	Necrosis of lateral wall of 2nd part of duodenum (measuring 2 cm×1 cm) Debridement of devitalised tissue with primary closure of the duodenal perforation, tube cholecystostomy, feeding jejunostomy and abdominal drainage	28	55
Case 2	12/male	48	Hypovolemic shock. tense, tender, and rigid abdomen, abdominal wall defect with cough impulse	Present	Free fluid and free gas in the abdomen, a defect in the abdominal wall at the site of injury with bowel herniation	Intact skin with dehiscence of all the layers of abdominal wall, perforation of jejunum about 30 cm from the duodenojejunal flexure. Jejunal perforation closure and primary closure of abdominal wall defect	10	49
Case 3	7/male	96	Pain abdomen, bilious vomiting, generalized abdominal tenderness, guarding, rigidity	Present	Near total laceration of body of pancreas, with main pancreatic duct injury, generalized ascites, fluid in the lesser sac and left pleural effusion	Laparotomy - peritoneal lavage, feeding jejunostomy and lesser sac tube drainage	20	47
Case 4	11/male	72	Fever, persistent non bilious vomiting, peri umbilical and epigastric pain	Present	Loculated collection at the junction of head and body of pancreas measuring 4.3 cm×3 cm×7.7 cm and pancreatic laceration with doubtful ductal injury	Attempted pancreatic duct cannulation – unsuccessful, internal drainage of lesser sac achieved by endoscopic cystogastrostomy	25	38
Case 5	5/male	24	Pain abdomen, non bilious vomiting	Present	Pseudocyst in head of pancreas with subhepatic collection; edematous pancreas	Conservative management	10	23
Case 6	12/male	36	Swelling in the right iliac fossa with pain	Present	Defect in the anterior abdominal wall with herniation of bowel loops through the defect	Abdominal wall defect surgically corrected	11	16
Case 7	8/male	24	Pain abdomen, non bilious vomiting	Present	Edematous pancreas; peripancreatic fluid collection	Conservative management	9	7

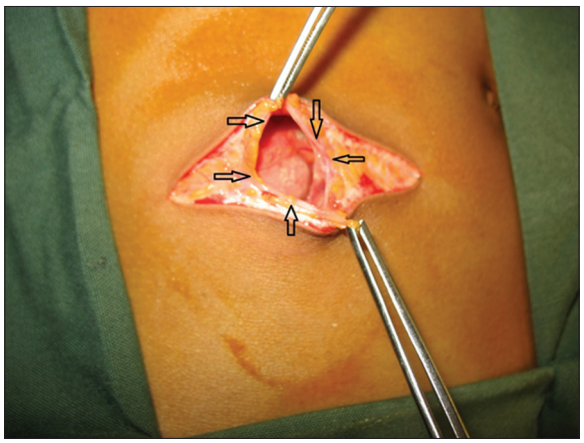

Figure 4: Operative photograph showing circular defect, involving the fascia and muscles (indicated by arrows) with intact overlying skin

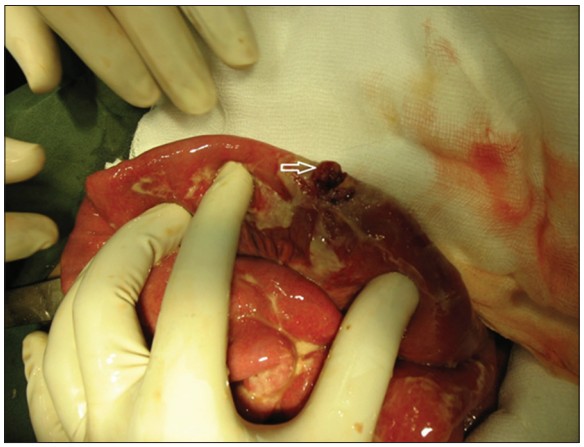

Figure 5: Operative photograph showing jejunum perforation with peritonitis.

endoscopic cystogastrostomy. The 5th and 7th patients were managed conservatively for traumatic pancreatitis. The 6th patient underwent laparotomy and surgical closure of abdominal wall defect. Post-operative course was uneventful in all the patients except in the 2nd patient who had surgical site superficial wound infection. This was treated by pus drainage on the bedside and IV antibiotics.

DISCUSSION

Cycling is the single major activity among children apart from playing, and it accounts for a significant number of injuries sustained by children on the road. Bicycle handlebar injuries range from minor soft tissue trauma to extensive visceral injuries leading to significant morbidity and even death.

There exists apparent discordance between the trivial nature of incidents and the serious nature of injuries sustained in bicycle handlebar-related accidents in children. Winston et al. described two main mechanisms of bicycle-related injuries in children [2]. First, the high-speed injuries, in which the rider is thrown away from the bicycle or the bicycle collides with a motor vehicle or a stationary object. These mechanisms are often associated with multi-system injuries and/or head injury [2]. The second mechanism of injury occurs following relatively low-speed crashes, in which the bicycle handlebars strike the rider in the neck, abdomen, or pelvic region.

In a typical bicycle handlebar injury, the front wheel rotates in a plane perpendicular to the child's body as the child loses control of the bike and begins to fall. Subsequently, the child strikes the end of the handlebars, leading to injury. Among the handle bar related injuries, the impact may be with the stem-crown, crossbar or more commonly direct impact from the end of the handlebar. Approximately 70% of patients injured in handlebar-related mechanisms are injured by a direct impact from the end of the handlebar [2]. Winston et al. reported that in 16% of the child bicyclist, serious injuries resulted from handlebar impact, and the remaining 84% of serious injuries primarily involved bicycle-motor vehicle collisions [2].

All the children in our study had trivial bicycle falls with a direct impact from the end of the handlebar to child's abdomen. The earliest presentation to our institution was 22 h post-trauma because the initial symptoms were not so dramatic to approach the tertiary trauma care center immediately. Interestingly, all the injured children in our study had circular patterned abrasion ("ring sign") over the abdomen, indicating the focused transfer of a significant amount of mechanical force sufficient to cause major visceral injuries.

Duodenal injuries in children who sustain bicycle handlebar injuries are often secondary to blunt trauma, and most of these are duodenal hematomas. These hematomas gradually give way resulting in delayed presentation of duodenal perforation. According to the American Association for the Surgery, the duodenal injuries are classified into five grades [3]. The majority of the Grade 1 and 2 perforating duodenal injuries can be managed by primary repair whereas higher-grade injuries including Grade 3-5 duodenal injuries need complex surgical procedures such as pyloric exclusion with or without diversion [3]. The child in our study had Grade 2 duodenal injury which was managed successfully with debridement of devitalized tissue and closure of the duodenal perforation with tube cholecystostomy, feeding jejunostomy, and abdominal drainage.

Traumatic abdominal hernias were categorized into three types by Wood et al. depending on the size and cause of the injury [4]: (1) Small defects caused by blunt trauma; (2) larger defects sustained during motor vehicle crashes; and rarely, (3) intra-abdominal bowel herniation in deceleration injuries. All traumatic hernias require prompt surgical repair, either primarily or with reinforcement by a prosthetic mesh [4]. Following focused transfer of energy to abdomen over a small area the more resilient skin remains intact, whereas the contracted and stiff abdominal musculature and fascia disrupt [5].

TAWH secondary to bicycle handlebar injuries can be sometimes missed on clinical examination or ultrasound scan [6,7] or even by CT scan which become evident only through exploratory laparoscopy [8,9]. In this study, 2 patients with abdominal handlebar injuries had TAWH. One patient had isolated TAWH, and the other patient had associated jejuna perforations. Both the patients were managed successfully by open surgical repair of TAWH.

Bicycle handlebar injuries have been reported to account for 14-20% of cases of gastrointestinal perforations among children with blunt abdominal injuries [1,10]. The small intestine is the most common site of perforation, and peritonism may not be evident initially because the content of the small bowel is of a neutral pH, low bacterial density, and low enzymatic activity [11]. Hollow-viscus injuries can be particularly challenging to detect because of delayed presentation, infrequency of related external bruising, and the difficulties associated with detecting these injuries on imaging [1,11].

A bucket-handle tear, which causes devascularization of a segment of bowel over time, has been cited as a cause for gastrointestinal perforation in deceleration injuries [12]. Diagnostic laparoscopy has been used to identify these injuries. Laparoscopic repair of a traumatic jejunal perforation has been reported in hemodynamically stable pediatric patients [8,13,14]. In the present study, 1 child had multiple jejunal perforations and had features of frank peritonitis. This patient was managed successfully by a primary closure of intestinal perforations.

Bicycle accidents are by far the most common cause of pancreatic injuries in children, accounting for 42-75% of cases [15,16]. Handlebar injuries account for 27% of blunt pancreatic trauma in children. The elastic pancreatic parenchyma can resume its normal contour even after a pancreatic transaction during the initial 24 h. Hence, a repeat abdominal CECT after 24-48 h may be necessary to reveal evolving injuries. In children with pancreatic injury, serum amylase levels are elevated in most patients by 24 h after the injury [17]. Parenchymal pancreatic injuries are primarily managed conservatively, whereas major transections with ductal injuries need active surgical intervention. Endoscopic retrograde cholangiopancreatography, if feasible, is an integral tool either to allow for sphincterotomy and stenting for partial ductal injuries or to guide the management in complete transections.

In the present study, out of 4 children with pancreatic injuries, 1 required laparotomy, one was managed by endoscopic procedure, and other 2 were managed conservatively. In patient 3 in whom an exploratory laparotomy was done, endoscopic management should have been the first choice. However, the 4th patient who had pancreatic duct injury underwent endoscopic internal drainage (cystogastrostomy) and responded promptly with complete resolution of symptoms. 5th and 7th patients had pancreatic parenchymal contusion and responded promptly to conservative management.

CONCLUSION

Pediatricians and casualty staff need to have a high index of suspicion while assessing the children who have sustained trauma from bicycle handlebars. “Ring sign” indicates a higher probability of associated intra-abdominal injury. Ultrasound findings may be normal in the early period after the trauma, and therefore, cannot exclude intra-abdominal injury in all cases. These children should be thoroughly evaluated and managed with close observation, repeated clinical examination, appropriate imaging studies, and surgical or endoscopic intervention as required.

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