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Gastrointestinal Perforations in Children: A Continuing Challenge to Nonoperative Treatment of Blunt Abdominal Trauma

Ibrahim Ulman, MD, Ali Avanoğlu, MD, Coşkun Özcan, MD, Mehmet Demircan, MD, Geylani Özok, MD, and Ata Erdener, MD

The present trend towards conservative management of hemodynamically stable pediatric trauma patients may be increasing the risk of delay in the diagnosis of traumatic hollow viscus perforations (HVP). The purpose of this study is to determine whether there is a delay in the diagnosis of HVP because of expectant management. A survey of factors leading to diagnostic delay was also made and the value of current diagnostic tools were reevaluated. In 1,283 trauma admissions between 1980–1994, 34 patients were operated for HVP caused by blunt abdominal trauma. Sites of perforation were; stomach (four), duodenum (five), jejunum (12), ileum (nine), and jejunum/ileum (four). Signs of peritoneal irritation were positive in 32 of 34 patients. There was free air in only six of 24 abdominal roentgenograms. Free peritoneal fluid without solid organ injury was detected in only four out of 13 patients with ultrasound. Peritoneal lavage was diagnostic in eight of nine patients. Time from admission to operating room averaged 24 ± 4.1 (mean ± standard deviation) hours. Eleven patients died after the operation mostly because of accompanying head injury. Only two of the deaths were the result of sepsis originating from the perforated bowel.

There is an apparent delay in the diagnosis of traumatic HVP in this series. Signs of peritoneal irritation are the most consistent findings of HVP after blunt abdominal trauma in children. Persistence of abdominal signs indicates peritoneal lavage, which has a high diagnostic sensitivity for HVP compared to other diagnostic modalities.

Injuries to the bowels after abdominal trauma are more common than is generally appreciated and proper treatment is frequently delayed because the detection of these injuries is often difficult, especially in children. The present trend towards conservative management for most of the pediatric blunt abdominal trauma patients and the decreasing frequency of centers performing diagnostic peritoneal lavage (DPL) may be increasing the risk of delay in the diagnosis of bowel perforation caused by blunt abdominal trauma. Most of the recent studies performed in either adults or children report peritoneal lavage, ultrasound, abdominal computed tomographic (CT) scans, laboratory analysis, and conventional radiology to be of little or no value to consistently diagnose gastrointestinal perforation.[1–5] However, the mortality and morbidity after delayed diagnosis of bowel perforations keep being reported in significant numbers.[1] To evaluate the pitfalls in diagnosis and to determine the best assessment plan that might decrease the risk of delay in diagnosis, a retrospective study on traumatic gastrointestinal perforation cases admitted to our department between 1980–1994 was conducted.

MATERIALS AND METHODS

In 1,283 trauma admissions to the Department of Pediatric Surgery, Ege University, Faculty of Medicine between 1980–1994, 34 patients were operated for gastrointestinal perforations caused by blunt abdominal trauma. The patients ranged in age from 2 to 13 years; the mean age at the time of injury was 7 years. Twenty-eight of the patients were boys and six were girls. Jejunum was the most frequent site of perforation (Table 1).

In the majority of cases, the children were pedestrians that were struck by a motor vehicle, or were seated in a car that was involved in an accident. The other injuries were related to falls, horse kicks, or other miscellaneous causes. Associated injuries occurred in 28 of 34 patients (Table 2).

The patients' records were revisited to determine whether a relationship existed between diagnostic modalities (including physical examination, radiologic investigations, and peritoneal lavage) and the delay in diagnosis.

RESULTS

Signs of peritoneal irritation were positive in 32 of 34 patients. No single physical finding was specific or reliable. There was free air in only six of 24 abdominal roentgenograms. In five patients, air-fluid levels were noted and in 12 of 24 abdominal roentgenograms there was no pathologic finding. Free peritoneal fluid without solid organ injury was detected in only four out of 13 patients with ultrasound (Table 3).

Peritoneal lavage was performed in nine of 34 patients and found to be diagnostic in eight of them (89%). Diagnosis was made by obtaining bilious or feculent material in six patients. In two cases, the high amylase (greater than the normal serum level) or bilirubin levels on laboratory analysis of the lavage material were regarded as positive for DPL, leading to explo

From the Department of Pediatric Surgery, Ege University, Faculty of Medicine, Izmir, Turkey.
Address for reprints: Ibrahim Ulman, MD, Department of Pediatric Surgery, Ege University, Faculty of Medicine, Izmir 35100, Turkey.

TABLE 1. Site of perforation

Site	No.	%
Stomach	4	12
Duodenum	5	15
Jejunum	12	35
Ileum	9	26
Jejunum/ileum	4	12
Total	34	100

ration. Time from trauma to DPL was 19.4 ± 14.0 hours, and time from admission to DPL averaged 13.2 ± 13.9 hours. Table 4 shows that DPL was performed immediately in three of nine patients. In this group, there were no deaths because of peritonitis, and average operative delay was 6.6 hours. Six patients whose clinical deterioration prompted a delayed lavage had prolonged preoperative delays and two of them suffered complications. Both deaths and five additional complications occurred in the group in which DPL was not employed.

The jejunoileal perforations were distributed between 10 and 100 cm from the ligament of Treitz. Eight of 25 jejunoileal perforations were found to be single, whereas 13 were multiple. In one case, complete transsection of jejunum was observed and in three cases there were necrosis of the bowel because of mesenteric avulsion without perforation. Because of the multiplicity of injuries, resection and anastomosis, primary repair of perforation, and temporary ostomy were the methods performed in surgical treatment.

Four of five duodenal perforations were into the retroperitoneum. Surgical treatment of these perforations consisted of simple closure in all cases. Gastrojejunostomy and gastrostomy were added in one case.

All of the four gastric perforations were on the anterior wall close to the greater curvature. There was intraperitoneal soiling in three of them. They were treated by simple closure as well.

Eleven patients (32.3%) died after the operation mostly because of accompanying head injury. Only two of the deaths were the result of sepsis originating from the perforated bowel. Complications including ileus in five, wound infection in three, and stercoral fistula in two were encountered.

Time from trauma to admission was 6.5 ± 1.1 hours and time from admission to operating room averaged 24 ± 4.1 hours. Postoperative stay averaged 14.3 ± 17.4 days. There was an association between time from trauma to operating room and the frequency of complications and the duration of hospital stay (the earlier the operation, the fewer the complications, and the shorter the hospital stay). Of the entire group, 21 patients were operated within 12 hours after admission, whereas 13 patients waited more than 12 hours for exploration. In 11 out of 21 patients, perforation was the initial diagnosis leading to exploration. In the rest, exploration was planned shortly after admission because of uncontrolled intraabdominal hemorrhage, and perforation was found incidentally.

The mean time from admission to operating room of the patients with jejunoileal, duodenal, and gastric perforations were 28, 20, and 2 hours, respectively.

TABLE 2. Site of injury associating gastrointestinal perforation

	No.	%
Liver	4	11.8
Pancreas	1	3
Spleen	4	11.8
Kidney	8	23.5
Diaphragm	2	6
Thoracic wall and lung	4	11.8
Head	14	41
Skeleton	11	32
Soft tissue	12	35

DISCUSSION

Blunt abdominal trauma still presents diagnostic difficulties, especially when there are associated injuries to hollow viscus. These types of injuries do not always need to be associated with initial major blood loss that would definitely indicate emergency laparotomy. On the other hand, physical examination may be misleading, even in a conscious child. Thus, the diagnosis may be delayed, resulting in high morbidity and mortality.[1] In the present series, complications were associated with diagnostic delays. In the eight cases with complications, the mean delay was 53 hours, while it was only 19 hours for the 16 uncomplicated cases.

Blunt traumatic injuries to the stomach are particularly uncommon because of protection by the rib cage, and great mobility. The incidence of gastric injury caused by blunt abdominal trauma is 0.9% to 1.8%.[6] Most of the gastric perforation is diagnosed easily, soon after the injury, signs of gross peritoneal irritation from leakage of gastric content, and early shock. In all of the children in this study, the presence of peritoneal irritation on physical examination was evident. All of the perforations were diagnosed within 2 hours of admission.

Duodenal perforation may be diagnosed shortly after injury if it leaks into the peritoneal cavity, as in one of our patients. If the perforation is into the retroperitoneum, peritoneal irritation will not be obvious, and no free air may be seen in roentgenograms, resulting in diagnostic delay.

Injury to the small intestine occurs in 10 to 15% of cases of blunt abdominal trauma. Injuries to jejunum and ileum may occur because of direct blows over a fixed point (e.g., ligament of Treitz, ileocecal valve), and/or sudden deceleration resulting in a shearing force at the mesenteric attachment. In the latter, trauma may cause only local injury to the small bowel wall or its mesenteric supply. This may result in either a very small perforation or delayed perforation owing to necrosis.[2] In such cases, free peritoneal fluid without solid organ injury may be detected with ultrasound.

In cases of blunt injury to the small bowel, diagnosis and the decision to operate is made by frequent physical examination demonstrating persistent abdominal pain and peritoneal irritation. Since the jejunal contents are not as irritating as those of the stomach and are essentially sterile at least in the proximal part, and functional closure of the bowel

TABLE 3. Patient characteristics

No.	Age (years)	Site of perf.	SPI*	Plain Abdominal x-ray	Ultrasound	CT	DPL	TOR (hours)	Operative Findings	Outcome
1	9	sto	2	P				3	2 perfs. at stomach	Good
2	2	ile	1	AFL				200	1 perf. at ile	Ex (sepsis)
3	9	jej	2	P				3	2 perfs. at jej	Good
4	8	duo	2	P				1	1 perf. at 2nd portion of duo	Ex (HI)
5	6	ile	2	AFL	LL			2	1 perf. at ile	Good
6	10	jej	1	AFL			+	32	2 perfs. at jej	Good
7	8	ile	1	P			−	29	2 perfs. at ile	Good
8	12	jej	1	N				1	7 perfs. at jej	Good
9	13	jej	2	N				2	Transsection at jej	Good
10	4	ile	1					48	25-cm segmental necrosis of ile	Good
11	9	ile	2	N				1	30-cm segmental necrosis of ile	Good
12	9	jej	2	N				1	1 perf. at jej, SL, KL	Good
13	5	sto	2	P				1	6-cm laceration of anterior wall of sto, SL, LL, RH	Ex (HI)
14	7	ile	2		FF,SL			82	1 perf. at ile, no SL	Good
15	8	jej	0	AFL				72	3 segmental necrosis area at jej	Good
16	7	ile-jej	1					1	5 perfs. at ile and jej	Ex (HI)
17	6	duo	1					1.5	1 perf. at 2nd portion of duo	Ex (HI)
18	5	ile	2	P			+	27	2 perfs. at ile	Good
19	10	jej	2	N			+	48	2 perfs. at jej	Good
20	8	jej	2	N	RH			12	2 perfs. at jej	Ex (HI)
21	13	ile-jej	1					72	2 jejunal, 1 ileal perfs.	Ex (sepsis)
22	5	jej	2		FF†		+	20	1 perf. and 1 segmental necrosis area at jej	Good
23	6	jej	0	N	N		+	5	2 perfs. at jej, diaphragmatic rupture	Ex (RF)
24	2	ile-jej	2				+	7	Transsection of proximal jej, 2 perfs. at distal ile	Good
25	6	jej	2	N	FF†			1	2 perfs. at jej	Good
26	4	duo	1	N	N	N	+	48	1 perf. at 2nd portion of duo	Ex (unknown)
27	8	ile	2	N	N		+	8	1 perf. at ile	Good
28	6	jej	1	N					1 perf. at jej, diaphragmatic rupture	Ex (RF)
29	6	ile	2	N	FF,SL,KL	SL,KL		20	1 perf. at ile, SL, RH	Good
30	13	sto	2		FF†			2.5	8-cm laceration at anterior wall of sto	Good
31	7	sto	2					1	10-cm laceration at anterior wall of sto, LL, SL	Ex (HI)
32	12	duo	2	AFL	N	N		1	1 perf. at 4th portion of duo	Good
33	4	ile-jej	2		FF†			?	4 perfs. at ile and jej	Good
34	6	duo	1	N	FF	FF,KL		48	Rupture of 2nd portion of duo, KL	Good

Perf., perforation; duo, duodenum; jej, jejunum; sto, stomach; ile, ileum; TOR, time to operating room; AFL, air-fluid levels; P, pneumoperitoneum; N, normal; FF, free fluid; FF†, free fluid without solid organ injury; RH, retroperitoneal hematoma; SL, splenic laceration; LL, liver laceration; KL, kidney laceration; RF, respiratory failure; HI, head injury.

* Signs of peritoneal irritation (SPI) were evaluated by a scoring system as; 0: tenderness (−), defense (−), rebound (−); 1: tenderness (+), defense (−), rebound (−); 2: tenderness (+), defense (+), rebound (+).

by spasm and/or omentum may occur, abdominal findings that would lead to an exploratory laparotomy are often ill-defined.[2] Free air may not be seen for several hours or more, and sometimes never in the course. Pneumoperitoneum was seen in three of our 18 (16%) jejunoileal injury cases, which is parallel to the 15 to 17% incidence of pneumoperitoneum given in the literature.[6] The other laboratory examinations are often inconclusive. Hence, jejunal perforation is more difficult to diagnose early.[2]

The detection of intra-abdominal injury after blunt abdominal trauma is often elusive in children.[7,8] No single physical

TABLE 4. Data regarding DPL

	n	Hours to OR[a]	Hospital stay (days)	Complications (%)	Deaths[b]
Early	3	6.6	10	1/3 (33)	
Late	6	34	15.8	2/6 (33)	
Not used	25	22	21.5	5/25 (20)	2
Total	34	24	14.3	8/34 (23)	2

OR, operating room.

[a] Average

[b] Caused by peritonitis and sepsis.

or laboratory finding was useful in our series. Most of the cases presented signs of peritoneal irritation but none of them was characteristic for HVP, since peritoneal irritation may also be associated with intraperitoneal hemorrhage. In the majority of patients in this series, signs of peritoneal irritation were present during the initial examination. The persistence of these signs for more than a few hours should be a warning for HVP. Although the diagnosis of HVP can definitely be made by the demonstration of free air beneath the diaphragm or in the retroperitoneum on roentgenograms, this diagnostic sign very rarely occurs before clinical deterioration. Furthermore, free peritoneal air demonstrated on roentgenograms was present in only six out of 24 cases in our series at 1 and 46 hours after injury (mean, 21 ± 20 hours). Injection of air via the gastrointestinal tract with x-ray monitoring is suggested as a simplified approach, although there are not sufficient data in this series regarding the additional benefit obtained from this maneuver. Because of the small number of investigations performed, the role of CT was inconclusive in this series, because the vast majority of the cases were admitted before the introduction of CT to the diagnostic armamentarium in pediatric trauma patients. However, more recent reports still lack a uniform credibility on the merits of CT in the diagnosis of traumatic gastrointestinal perforations.[4,5,9–11]

The value of DPL in diagnosis of blunt abdominal trauma is controversial in the literature.[2,8,11] Some authors report that DPL may not be helpful because jejunoileal perforations do not always lead to peritoneal soiling.[2] On the other hand, many authors suggest DPL as a safe and reliable procedure for establishing an early diagnosis of serious intraperitoneal injury, particularly in cases of perforation or bowel necrosis associated with solid organ injury. In our series, we noted an acceptably high sensitivity rate for DPL, where DPL was indicative of hollow viscus perforations in the eight of nine cases in which it was performed. It is questionable whether the rather late application of DPL to this small percentage of our series had an impact on this high sensitivity rate. A prospective trial, performing DPL on suspected cases of hollow viscus perforations would have clarified this issue. However, the exact criteria for DPL has not been uniformly established, probably to avoid high negative DPL rates. Indeed, DPL is not an invariably accepted practice for children.[1,2,4,8] Apart from its sensitivity, positive DPL immediately performed was associated with reduced mortality and morbidity, and shorter hospital stay. Therefore, we still believe that, being selective for DPL, using reasonable criteria, is the optimal solution. Reviewing our patient data, we suggest that one should proceed with DPL after 12 hours of observation of a hemodynamically stable patient who shows constant signs of peritoneal irritation. This waiting period does not apply to comatose patients.

In conclusion, there is delay in the diagnosis of traumatic gastrointestinal perforations in this series. Signs of peritoneal irritation are the most consistent finding of gastrointestinal perforation caused by blunt abdominal trauma in children. Persistence of abdominal signs indicates peritoneal lavage, which has a high diagnostic sensitivity for gastrointestinal perforations compared to other diagnostic modalities.

REFERENCES

1. Schenk WG, Lonchyna V, Moylan JA: Perforation of the jejunum from blunt abdominal trauma. *J Trauma* 23:54, 1983
2. Mercer S, Legrand L, Stringel G, et al: Delay in diagnosing gastrointestinal injury after blunt abdominal trauma in children. *Can J Surg* 28:138, 1985
3. Chatterjee H, Jagdish S: Intestinal injuries in childhood: Analysis of 32 cases. *J Pediatr Surg* 27:583, 1992
4. Meyer DM, Thal ER, Coln D, et al: Computed tomography in the evaluation of children with blunt abdominal trauma. *Ann Surg* 217:272, 1993
5. Okur H, Küçükaydın M, Turan C, et al: Gastrointestinal injuries in children. *Pediatrik Cerrahi Dergisi* 8:95, 1994
6. Grosfeld JL, Rescorla FJ, West KW, et al: Gastrointestinal injuries in childhood: Analysis of 156 patients. *J Pediatr Surg* 24:580, 1989
7. Balık E, Özok G, Ulman İ, et al: Pediatric trauma score: Is it reliable in predicting mortality. *Pediatr Surg Int* 8:54, 1993
8. Brown RA, Bass DH, Rode H, et al: Gastrointestinal tract perforation in children due to blunt abdominal trauma. *Br J Surg* 79:522, 1992
9. Taylor GA, Guion CJ, Potter BM, et al: CT of blunt abdominal trauma in children. *AJR Am J Roentgenol* 153:555, 1989
10. Cook DE, Walsh JW, Viek CW, et al: Upper abdominal trauma: Pitfalls in CT diagnosis. *Radiology* 159:65, 1986
11. Talton DS, Craig MH, Hauser CJ, et al: Major gastroenteric injuries from blunt trauma. *Am Surg* 61:69, 1995