Gastrointestinal injuries from blunt abdominal trauma in children


1. Resident Radiologist, Clínica Alemana Faculty of Medicine – Universidad del Desarrollo. Santiago, Chile.
2. Radiologist, Clínica Alemana de Santiago. Santiago, Chile.

Abstract: Trauma is the leading cause of death in pediatric patients older than 1 year, with abdominal trauma accounting for 10% of causes of death. Hollow viscera injuries are less than 1%, however its mortality is 20% in the case of intestinal perforation. Computed tomography is the method of choice for the identification and quantification of abdominal trauma injuries, given its excellent performance for solid viscera injuries, with less sensitivity in hollow visceral injuries, so that in the latter a high clinical suspicion and thorough analysis of the images by radiologists is important. A retrospective review was conducted of the findings in pediatric patients, with a history of blunt abdominal trauma, referred to computed tomography. The main findings on computed tomography suggestive of hollow visceral injury were: extraluminal air, extravasation of contrast medium, the presence of free intraperitoneal fluid, sentinel clot adjacent to the affected loop and thickening of the bowel wall.

Keywords: Abdomen, Bruising, Computed tomography, Hollow viscera, Intestine, Pediatrics, Trauma.

Resumen: El trauma es la principal causa de muerte en los pacientes pediátricos mayores de 1 año, siendo el trauma abdominal responsable del 10% de las causas de muerte. Las lesiones de vísceras huescas es inferior al 1%, sin embargo, su mortalidad es del 20% en el caso de perforación intestinal. La tomografía computada es el método de elección en la identificación y cuantificación de las lesiones en trauma abdominal, dado su excelente rendimiento para lesiones de vísceras sólidas, con menor sensibilidad en lesiones de vísceras huescas, por lo que en estas últimas es importante una alta sospecha clínica y análisis minucioso de las imágenes por parte de los radiólogos. Se realizó una revisión retrospectiva de los hallazgos en pacientes pediátricos referidos a tomografía computarizada, con historia de trauma abdominal contuso. Los principales hallazgos en tomografía computada sugerentes de lesión de víscera hueca fueron: aire extraluminal, extravasación de medio de contraste, presencia de líquido libre intraperitoneal, coágulo centinela adyacente al asa comprometida y engrosamiento de la pared intestinal.

Palabras clave: Abdomen, Contusión, Intestino, Pediatría, Tomografía computarizada, Trauma, Víscera hueca.


Contact: Javiera Valentina Aguirre F. / javiera.aguirre.fe@gmail.com

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Blunt abdominal trauma in children

Trauma is the leading cause of death in pediatric patients older than one year, with abdominal trauma accounting for 10% of the causes of death(1). 90% are lesions secondary to traffic accidents, other less common causes include recreational activities and child abuse(1). Abdominal trauma is a threat to the survival of the victim due to mechanisms such as bleeding as a result of injury to blood vessels or solid organs and peritonitis secondary to hollow viscera injuries(1).

The anatomical characteristics of the child, such as a short trunk and lower osteo-muscular development, predispose him/her to a variety of injuries in abdominal trauma(2).

Hollow viscera injuries are rare and difficult to diagnose due to its low suspicion and nonspecific findings, however, these lead to high morbidity and
mortality. Computed tomography (CT) is the method of choice for the identification and quantification of injuries in abdominal trauma\(^{(3)}\), given its excellent performance for lesions of solid organs, with lower sensitivity in lesions of hollow viscera, so that in the latter a high clinical suspicion and a careful analysis of the images by radiologists is important.

The aim of our paper was to review the CT protocol used in the study of trauma in the pediatric abdomen.

A retrospective study was performed for a selection of gastrointestinal lesions in computed tomography of blunt abdominal trauma in children between the years 2010 and 2013.

CT Protocol

CT is the technology of choice in the study of emergency trauma in children. It has a sensitivity of 85% to 95% in lesions of the gastrointestinal tract\(^{(12)}\). The examination must be performed by imaging from the base of the thorax to the base of the thighs, removing metal braces in the event that they could generate artifacts that could compromise the correct diagnosis\(^{(3)}\).

Rarely is sedation required, because current scanners require very little time for image acquisition\(^{(9)}\). Helical CT is about 10 times faster than conventional CT, which is very useful in these types of patients\(^{(12)}\). Given its high speed the examination is performed in a single sweep and also allows for the complete study to be carried out at times when the iodinated contrast medium reaches its highest concentration and thus obtains a better opacification of the organs studied\(^{(6)}\).

Adequate immobilization should also contribute to the reduction of motion artifacts\(^{(4)}\).

The use of intravenous contrast is essential for the study of abdominal parenchymal organs as well as for the evaluation of active bleeding. A dose of 2 ml / kg (total maximum 120 ml) is the dose of choice in these cases\(^{(3)}\) with a delay of 60-70 seconds. The slice thickness of 5-6 mm with a pitch of 1.5\(^{(5)}\) and 1 mm reconstructions allows adequate representation of organs and structures, and allows multiplanar reconstructions\(^{(12)}\).

The kilovoltage and milliamperes adjustment for age and weight of the patient should be adjusted accordingly. It is the responsibility of the radiologist and medical technologist to have these protocols in place at each institution according to the equipment available locally\(^{(6)}\). There is a linear relationship between the mAs and the radiation dose. For this tables are available for the calculation of mAs per kilo of weight and area to study which should be adjusted for each case. Regarding kV, if this is reduced the dose is lowered, noise increases and the contrast of the image decreases, but there is no data to suggest that a 80 kV can provide an acceptable image quality in pediatric patients. In summary adjustment must be made to obtain a minimum dosage with sufficient quality to contribute to the diagnosis\(^{(6)}\).

Use of multiple phases should not be performed\(^{(4)}\), except in cases of injury to the renal parenchyma, a late acquisition being useful for lesions of the excretory system and bladder. Time is estimated of 3 to 5 minutes delay for the acquisition of these images\(^{(3,5)}\).

The use of oral contrast material is controversial\(^{(3)}\) and practically not administered in our midst, although its administration is not associated with an increased risk of aspiration, performing a CT with oral contrast delays diagnosis and does not provide an increased sensitivity and specificity for detecting intra-abdominal injuries in relation to the realization of only CT with iv contrast\(^{(3,5)}\).

Causes and mechanisms of gastrointestinal injury

Gastrointestinal lesions are rare, occurring in less than 5%\(^{(1)}\), however, most of these require surgery and mortality in the case of intestinal perforation is 20%\(^{(2)}\).

Traffic accidents are one of the most frequent causes of gastrointestinal injury in children. In these cases, rapid acceleration-deceleration phenomena of intestinal structures close to their point of anatomic fixation and compression of the abdomen between the safety belt and the spine are described among the principal mechanisms\(^{(7,8)}\). The misuse of seat belts in children increases by four times the risk of gastrointestinal lesions. From the clinical point of view, the presence of the “seat belt sign”, which has been described as an area of ecchymosis or abrasion in the abdomen in relation to the area compressed by the seat belt, is associated with a 13 times higher probability of gastrointestinal trauma\(^{(7)}\). Gastrointestinal lesions are not the only ones expected by this mechanism; seatbelt syndrome has been described which groups intestinal injuries, mesentery, stomach, liver, spleen, Chance-type vertebral fractures and fractures of the pelvis\(^{(2)}\).

Another cause of gastrointestinal lesions in children is abuse. In these cases it is common that the caregiver or child denying a history of trauma or trauma referral mechanism is disproportionate and does not explain the extent of the lesions found\(^{(7)}\). In these cases, children usually have an average age of 2-3 years and present more severe injury with a mortality rate ranging from 45-50%\(^{(2)}\). The lesions of the liver and spleen are the most common followed by the duodenum, pancreas, and kidney\(^{(2)}\), hollow viscera injuries being three times more frequent than in accidental trauma\(^{(2)}\). These lesions are due to compression of the abdominal...
viscera against the spine after an abdominal punch or kick\(^{(2)}\). Other injuries associated with abuse include soft tissue injuries (95%), cranioencephalic trauma (45%), fractures of the extremities (27%) and skull fractures (18%)\(^{(2)}\).

**Lesions of the gastrointestinal tract**

The clinical manifestations are varied and depend on the type of injury, ranging from intestinal wall contusions and hematomas to intestinal perforation with extravasation of the contents into the peritoneal cavity\(^{(9)}\).

In the case of the perforations occurring in the proximal gastrointestinal tract (stomach and duodenum), the contents flow into the peritoneal cavity causing a painful chemical peritonitis which is diagnosed early\(^{(8)}\), whereas the more distal perforations of the small intestine where the pH is neutral and there is a low bacterial load\(^{(2)}\), are less symptomatic initially and tend to present later\(^{(10)}\), can be diagnosed 24 to 48 hours after the initial trauma due to the development of abdominal source peritonitis and/or sepsis\(^{(9)}\), a fact that increases morbidity and mortality in this group of patients\(^{(11)}\). This is why CT plays an important role in the initial evaluation\(^{(8)}\).

**Stomach:** Gastric rupture is very rare with an incidence of 0.02 to 1.7\%\(^{(13)}\). Traffic accidents are the most frequent cause, with direct contusions in the epigastrium which produce sudden rises in intragastric pressure. There is often the story of a recent meal, trauma to the left side of the body and improper use of seat belts\(^{(13)}\). The most common sites of rupture are the anterior wall and lesser curvature\(^{(13)}\). These are often associated with splenic lacerations\(^{(13)}\) (Figure 1).

**Duodenum:** The retroperitoneal location of the duodenum provides protection, so significant force is required to cause injury\(^{(7)}\). Injuries of the duodenum are rare; in children it accounts for 2 to 3\% of blunt abdominal trauma injuries\(^{(14)}\) and are markers of child abuse in children under 2 years old when diagnosed in the absence of severe trauma\(^{(7)}\). They present in two forms: hematoma and perforation\(^{(2)}\) (Figure 2).

**Figure 1.** Child aged 11, knocked down on a public street. a), b) and c) Contrast-enhanced CT in venous phase, axial slices at different levels. A discontinuity of the stomach walls with flared edges (white arrows) is shown, there is free intra-abdominal fluid with different densities (white curved and white dotted arrows), anterior pneumoperitoneum (asterisk) and splenic lacerations (black arrow). d) Exploratory laparotomy confirmed the diagnosis of gastric rupture with spilling of contents into the abdominal cavity, splenic lacerations. A raffia of the stomach walls and abdominal cavity cleaning was performed.
Most duodenal hematomas are submucosal, but can also be subserosal and intramuscular. Hematomas result from the accumulation of intramural blood secondary to the rupture of vessels between the submucosa and muscle layer, favored by the presence of rich submucosal and subserosal vascular plexus and for the different distensibility by the three layers of the wall that predispose the development of intramural hematomas with closed abdominal trauma. These compromise the lateral duodenal wall, being the second most frequently affected portion (35-60%) and to a lesser extent the third and fourth portion (15% respectively). The commitment of the first portion has been described in 10-14% of cases.

In CT the duodenal hematoma presents as a focal area of thickening of the intestinal wall which is generally eccentric. These can clog the duodenal lumen partially or completely, often causing gastric distension and vomiting. Most duodenal hematomas can be successfully managed with nasogastric decompression and parenteral nutrition. The majority are resolved in 10 days, however, its resolution may take up to three weeks.

Like other intestinal segments, duodenal perforations are difficult to diagnose. They must be suspected for the presence of extraluminal air, free fluid in the absence of solid organ damage and oral contrast extravasation.

Small intestine: The lesions are more often located in the attachment points of the intestine, the proximal jejunum portion (distal to the ligament of Treitz) being the more frequently compromised segment, followed by the distal ileum (proximal to the ileocecal valve).

There are different CT signs for intestinal loops lesions and mesentery, the main being extraluminal air, free retroperitoneal air, the presence of free intraperitoneal fluid, hemat infiltration of the mesentery, thickening of the intestinal wall, defect of the intestinal wall, contrast medium extravasation and active bleeding. These signs have different sensitivities and specificities, the most sensitive signs being nonspecific and the more specific signs insensitive (Table I). However, the presence of a combination of these findings increases the likelihood of intestinal injury.

Colon: Colon lesions occur in 2 to 5% of patients with abdominal trauma. The transverse colon is susceptible to injury by compression against the spine. The sigmoid colon presents high risk of perforation by deceleration mechanisms. However, all segments of colon (excluding the rectum) are susceptible to rupture and mesenteric avulsion.

Table I. Sensitivity and specificity of CT signs for intestinal injury.

<table>
<thead>
<tr>
<th>Sign</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
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<tbody>
<tr>
<td>Free peritoneal fluid</td>
<td>90 - 100</td>
<td>15 - 25</td>
</tr>
<tr>
<td>Mesenteric infiltration</td>
<td>70 - 77</td>
<td>40 - 90</td>
</tr>
<tr>
<td>Extraluminal air</td>
<td>30 - 60</td>
<td>95</td>
</tr>
<tr>
<td>Focal thickening of the parietal</td>
<td>55 - 75</td>
<td>90</td>
</tr>
<tr>
<td>Abnormal parietal enhancement</td>
<td>10 - 15</td>
<td>90</td>
</tr>
<tr>
<td>Extravasation of oral contrast</td>
<td>8 - 15</td>
<td>100</td>
</tr>
<tr>
<td>Intestinal wall discontinuity</td>
<td>5 - 10</td>
<td>100</td>
</tr>
</tbody>
</table>

Reference 11
Figure 3. Two year old child, with a history of vomiting and abdominal pain, with no clear history of trauma, history of diaphyseal femur fracture, child abuse is suspected. a) Axial ultrasound slice at epigastric level, a solid-cystic lesion (thick and thin white arrows) in retroperitoneal location in front of the spine (cv) and the aorta (ao) is observed. b) and c) CT axial slice without and with contrast, shows that the retroperitoneal lesion that is located in the second and third portion of the duodenum is a spontaneously hyperdense mass (white arrow) that does not enhance in the contrast study (black arrow), and refers to a duodenal hematoma obstructing the duodenal lumen showing distension of the gastric cavity. d) Endoscopic study showing an extrinsic compression of the third portion of the duodenum, which completely occludes the lumen.

Figure 4. 13 year old boy, co-pilot in a high energy vehicle collision. a) and b) contrast-enhanced CT in venous phase, axial and coronal reformatted slices. Free liquid is observed (curved arrow) and an area of higher density near the second portion of the duodenum (white arrowhead). Duodenal perforation is suspected. c) X-ray of the abdomen with oral contrast, duodenal perforation is confirmed observing extravasation of contrast at the level of the second portion of the duodenum (white arrowhead).
CT Findings
Free intraperitoneal fluid: The presence of intraperitoneal fluid without evidence of solid organ injury is a very suggestive sign of gastrointestinal lesions\(\textsuperscript{(8)}\). In many cases this may be the only manifestation of intestinal injury\(\textsuperscript{(8)}\) (Figures 5 and 6).

Infiltration of the mesentery and fluid in the root of the mesentery: intestinal and mesenteric injuries are often associated with increased attenuation of the mesentery that are secondary to bleeding and swelling of this\(\textsuperscript{(8)}\). In liquid it is often located in the mesenteric root adjacent to the aorta and inferior vena cava\(\textsuperscript{(8)}\).

Free intraperitoneal air: Is a highly suggestive sign of intestinal perforation, however, it is only present in half of the patients with intestinal per-

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**Figure 5.** Nine year old girl. Co-pilot in a high energy vehicle collision. a), b) and c) contrast-enhanced CT in venous phase, axial slices at different levels. Pneumoperitoneum (asterisk), free fluid in the pelvis and interloops (white curved arrow), diffused thickening of intestinal loops wall (white arrowhead) and diffuse dilation of distal ileum loops (white arrow) and inflammatory changes of adipose tissue in the right iliac fossa, are observed. In the soft areas at the level of the right flank is an ecchymotic area of the abdominal wall (circle). These findings in the absence of solid organ injury are suggestive of hollow viscus perforation. Exploratory laparotomy procedure confirmed a distal ileum perforation.

**Figure 6.** Ten year old girl. Rear passenger in vehicle collision. a) Contrast-enhanced CT in venous phase, axial slice b) coronal reformat. Shows moderate amount of free fluid (white curved arrow), thickening and diffuse distension of thin loops (white arrowhead) and a defect in the wall of a jejunal loop with reversed edge (white arrow). Exploratory laparotomy procedure confirmed a wide jejunal perforation.
foration\(^{8,11}\). The revision of the abdominal cavity with lung window is useful in detecting extraluminal air\(^{8}\). The free air is identified more often in the anterior region of the abdomen near the liver and can also be located contained in the mesentery\(^{8}\) (Figure 5).

Free retroperitoneal air: Indicates injury of the retroperitoneal organs, usually the duodenum, but can also be of the colon\(^{8}\).

Thickening of the intestinal wall: The thickness of the normal intestinal wall is 3-4 mm. Thickened segments also often present a higher enhancement\(^{8}\). The thickening of the intestinal wall is initially limited to a focal segment of the intestine\(^{8}\), while in the case of late diagnosis, the thickening is diffuse\(^{8}\) (Figures 5 and 6).

Intestinal wall defect: This sign has a specificity of 100%, but a sensitivity of 5-10\(^{11}\), visualization of the intestinal defect being rare\(^{11}\) (Figure 6).

Extravasation of oral contrast: This is the most specific sign in intestinal perforation, however viewing is infrequent\(^{8}\). The extraluminal contrast is often of higher density near the perforation, however it can be located anywhere in the abdomen\(^{8}\). Diagnostic differences of hyperdense fluid in the peritoneum includes clotted blood, active bleeding and extraluminal contrast extravasation from a ruptured urinary tract\(^{8}\).

Active bleeding: Can be visualized as a focal area of higher contrast attenuation 45-70 HU, near the site of bleeding, a sign called “sentinel clot”\(^{11}\).

Conclusion

Traumatic origin injury of the gastrointestinal tract is rare, being less than 1%, however, mortality is 20% in the case of intestinal perforation. The clinical manifestations are varied and depend on the composition of the extravasated contents. This is usually secondary to sudden deceleration and compression by the seatbelt.

Computed tomography is the method of choice for the identification and quantification of the injuries in abdominal trauma in hemodynamically stable patients.

**Bibliography**