

TRAUMA OF THE ABDOMINAL PARENCHYMATOUS ORGANS IN CHILDREN

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Abstract

Trauma of the abdominal parenchymatous organs is a major cause of morbidity and mortality in children, following craniocerebral, vertebro-medullary and thoracic trauma, which result primarily from car accidents, sports injuries, accidental falls impacting the abdominal region, physical aggressions and, particularly for newborn babies, obstetrical trauma. In order to highlight the repercussions of physical trauma on abdominal parenchymatous organs, we conducted a retrospective analytical study on patients admitted to and treated in the Pediatric Surgery Clinic of the “Sfânta Maria” Clinical Emergency Children’s Hospital in Iași over a period of approximately 2.5 years. Of a total 5,812 emergency admissions, 125 were for severe lesions of the abdominal parenchymatous organs. Of these patients, 8% underwent immediate or deferred surgery, which translated into three splenectomies, three surgical interventions for removing hepatic hematoma and hemoperitoneum, two interventions for renal ruptures, one hepatic suture and one drainage of a post-traumatic pancreatic pseudocyst. One of the interventions for hepatic hematoma drainage was performed in a newborn with obstetrical trauma. One of the multiple trauma patients that underwent splenectomy died 10 days after hospital admission, while postoperative evolution in the other patients was favorable, yet required extended hospital stay and repeated follow-ups. In conclusion, owing to the anatomic and physiological particularities of pediatric patients, any abdominal trauma in children can result in severe lesions of the parenchymatous organs, particularly affecting the liver and spleen, and with severe repercussions on the patient’s health status and even on their life.

Keywords: accident; child; parenchymatous organ rupture; abdominal trauma.

Introduction

Trauma of the abdominal parenchymatous organs is a major cause of morbidity and mortality in children, following craniocerebral, vertebro-medullary and thoracic trauma. Abdominal trauma is associated with a high risk of morbidity and mortality, particularly when

in association with other traumatic lesions, such as cerebral ones. The main symptoms are abdominal pain and distension, absence of intestinal sounds and signs of peritoneal rash, the latter indicating the possibility of surgical exploration. The American Association for the Surgery of Trauma (AAST) classifies lesions to parenchymatous organs into 5 or 6 grades

(Table I), the classification being useful in establishing the therapeutic plan and assessing patient prognosis (1). Over the last four decades there was a major change in the management of pediatric patients with parenchymatous organ trauma, from surgical treatment to conservative selective treatment, based on the technological advances in terms of imaging investigations. The choice between surgical or conservative treatment shall be made considering the patient's hemodynamic stability more than the degree of the organ rupture (2).

Trauma occurrence mechanism

Parenchymatous organ lesions in children primarily result from the following: car accidents, accidental falls impacting the abdominal region, sports injuries, physical aggressions and, particularly for newborn babies subject to difficult delivery, obstetrical trauma (Fig. 1). Abdominal trauma in children largely present as blunt abdominal trauma, and less often as penetrating abdominal trauma, the latter affecting cavitory organs in particular. In children with traumatic abdominal sign caused by wearing the seatbelt, first there will be a suspicion of intestinal, renal and vertebral lesions. Hepatic and splenic lesions are the most frequent in the case of blunt abdominal trauma, as the subcostal anatomic position of these organs protects them from the direct mechanism of the traumatic agent, but they can be affected via an acceleration-deceleration mechanism, via compression between the abdominal wall and the hard plane of the spine, or via the action of the tearing forces due to the ligaments they are fixed with and that cause parenchymatous lacerations. For instance, up to 25% of patients with lower rib fractures (ribs 9-12) also have associated splenic lesions (3). In the case

of children with suspected physical abuse, even in the absence of obvious clinical signs, a screening must be performed for occult abdominal trauma by measuring the level of hepatic transaminases and amylasemia, and when high levels of these enzymes are found, by performing abdominal ultrasound or CT. Also in the case of these children, clinical assessment by a pediatric surgeon and a team in charge of child protection is mandatory. Although many of the identified lesions do not entail therapeutic issues, identifying them is important to confirm and determine the extent of the physical abuse against the child, to avoid the recurrence of such situations (4).

Diagnosis principles

After ensuring airway permeability and adequate oxygen delivery, abdominal trauma patient management entails ensuring a venous line for restoring hemodynamic balance, assessing the vital signs and neurological status, performing the clinical abdominal examination and monitoring diuresis. The abdominal cavity shall be subject to imaging exploration as early as the emergency room, by performing a focused ultrasound on potential traumatic lesions (FAST – Focused Assessment with Sonography for Trauma), which can determine the presence hemoperitoneum in case of lesions to the parenchymatous organs or intestinal fluid in case of lesions to the cavitory organs. A thoracoabdominal radiography in orthostatism shall be performed in any hemodynamically stable patient; this investigation can determine the presence of rib fractures and associated hemopneumothorax, the presence of spine lesions or pelvic bones fractures, also raising suspicion of urethral rupture, and in case of pneumoperitoneum the diagnosis shall be that of cavitory organ rupture.

Radiological visualization of rib or spine fractures can also be a sign of associated parenchymatous lesions (liver, spleen, kidneys, pancreas). The initial set of biological investigation must necessarily include a complete blood count, liver and pancreas enzyme concentrations, urinalysis.

After the patient is admitted, imaging investigations shall be particularized function of the clinical state, subsequent evolution, and the results of laboratory analyses. These can indicate repeating the thoracoabdominal radiography in orthostatism, abdominal ultrasound, diagnostic peritoneal lavage, abdominal computed tomography (CT) and/or exploratory laparoscopy. Abdominal ultrasound is a noninvasive, cheap and readily available investigation, that requires neither sedation, nor contrast substance, and that also has a high level of accuracy in identifying traumatic abdominal lesions, particularly lesions to parenchymatous organs, as well as in identifying peritoneal fluid effusions. However, in the presence of hemodynamic stability, ultrasound identification of a quantity of intraperitoneal free fluid cannot clearly set the indication for laparotomy (is it blood or digestive contents?). Peritoneal puncture and lavage for diagnostic purposes are relatively simple maneuvers, can identify a hemoperitoneum via parenchymatous organ rupture or an intestinal perforation by underlining the intraperitoneal intestinal effusion, but they are not specific and moreover they are invasive, less often performed in small uncooperative children, being replaced by abdominal ultrasound and CT. Contraindications for diagnostic peritoneal lavage include obesity, coagulopathies, previous abdominal surgical interventions, pregnancy.

Before the routine use of CT in assessing abdominal trauma, exploratory laparotomies were a lot more frequent (also due to the increased sensitivity, yet low specificity of the diagnostic peritoneal lavage), and few traumatic lesions were missed. Nowadays, owing to the information offered by advanced imaging investigations, more than 50% of lesions to parenchymatous organs are treated conservatively; however, there is an increased possibility of “missing” cavitory organ lesions (5). For this reason, a high degree of suspicion is necessary, and the regular clinical and biological evaluation of the patient is essential. Abdominal computed tomography has become the gold standard in the initial assessment of abdominal trauma patients that are hemodynamically stable, as it ensures optimal sensitivity and specificity in diagnosing parenchymatous organ trauma. In addition to FAST and diagnostic peritoneal lavage, CT scans can determine and locate the source of an intraperitoneal bleeding and can diagnose retroperitoneal lesions. However, performing a CT scan in an emergency regime is expensive and has a few disadvantages: risk of allergy to the contrast substance, risk of nephropathy, sometimes having to sedate the patient, it is time consuming and, moreover, each abdominal CT in one-year-old children increases their risk of developing cancer throughout their lifetime by 0.18% (6). A less expensive and less invasive means of monitoring liver lesions is determining hepatic transaminases concentrations, aspartate aminotransferase (AST) and alanine aminotransferase (ALT), where their high levels in the blood are correlated with the severity of hepatic lesions (7). Along with FAST (focused assessment sonography in trauma), liver enzyme monitoring is particularly useful in the initial assessment and the therapeutic

algorithm of abdominal trauma patients. When hemodynamically stable abdominal trauma patients have normal levels of AST and ALT (below 50 UI/L) at the time of admission, emergency performance of abdominal CT can be avoided and may be used subsequently if hepatic transaminase levels increase or if the symptoms so require (8).

As a final diagnostic resource, laparoscopic exploration has the great advantage of accurately pinpointing lesions, while also aspirating, washing and suturing any single intestinal perforations, with minimum bacterial contamination, or of evacuating a hepatic hematoma or bile collection and performing hemostasis.

Therapeutic management

Conservative treatment has become the gold standard for traumatic lesions of the parenchymatous organs in hemodynamically stable children, even when there are severe lesions (IV, V grade) or when there are several associated visceral lesions (3). Emergency laparotomy is recommended only in the case of liver or spleen lesions, where bleeding cannot be stopped or where there are cavitory organ lesions (pneumoperitoneum). There are studies that prove the efficiency of conservative treatment in 80-90% of splenic or hepatic rupture cases in adults, where hemodynamic stability could be easily achieved via perfusions or by transfusing a small quantity of blood (9). In hemodynamically stable children without other signs of trauma to the abdominal viscera, the conservative treatment of hepatic trauma is effective in 85-95% of cases (10, 11). Patients are clinically monitored by measuring blood pressure and pulse every 4 hours over the first 24

hours, and then three times a day over the next 24 hours and until hospital discharge, as well as by monitoring hepatic transaminase concentrations, amylases, urinalysis, using abdominal ultrasound, contrast CT or angiography, function of the lesions ascertained in the initial assessment and function of the clinical evolution. Repeated clinical examination remains the most important element for trauma patient triage, the presence of peritonitis signs along with hemodynamic instability being the indicators for necessary surgical exploration. However, clinical examination does have major limitations in small uncooperative children that may have significant internal blood loss without any obvious clinical manifestations. Multiple trauma patients or those with severe craniocerebral or medullary trauma are another category of patients where clinical examination has a limited importance in the decision-making algorithm; in such cases, the results of an emergency CT is extremely important in such cases.

Immediate imaging reevaluation is recommended if the patient's hemodynamic status worsens, in case of an active bleeding, or if there is a suspicion that complications such as hepatic ducts lesions with bile leaks might occur. For this reason, conservative treatment is only recommended in centers where such imaging investigations are readily available, where there is at all times a pediatric surgeon on-call, a pediatric intensive care unit provided with suitable equipment and an operating room that is always ready for emergency procedures (12).

Complications following hepatic trauma treated conservatively are rare, below 8%, and generally consist of bile leaks, manifested via abdominal pain, distension, vomiting; the majority can be

treated using ultrasound guided percutaneous drainage, a laparoscopic method or a classic open approach (13). Surgery can be avoided even in cases where the bleeding continues but patients are hemodynamically stabilized, yet by performing an arterial embolization (14). Hospital admission for hepatic or splenic lesion patients without other associated trauma is recommended for a period of one day more than the degree of the parenchymatous organ lesion (15). Bed rest is not compulsory, but activity restrictions are recommended for two weeks more than the degree of the parenchymatous lesion, while sports activities shall be resumed on a patient-specific basis (15). Most hepatic lesions treated conservatively heal within 8-12 weeks (3).

In the case of renal lesions, 80% thereof are caused by blunt trauma, and more than 85% of these post-traumatic lesions can be treated conservatively, monitoring them via CT, ultrasound and urinalysis (hematuria). Potential complications such as perirenal hematoma or urinoma can be treated using ultrasound guided percutaneous drainage, using endoscopically placed stents or via interventional radiology procedures. Up to 5% of severe trauma cases can associate with kidney failure (3).

Pancreatic trauma is rare, with an incidence of 0.4% of all trauma, both in the adult and pediatric population, but has a 10% rate in case of severe abdominal trauma, with a morbidity rate up to 40% and a mortality rate higher than 5% (16, 17). High resolution contrast CT is also the investigation of choice for diagnosing and classifying post-traumatic pancreas lesions, as well as for monitoring potential complications such as pancreatitis or the forming of abscesses, fistulas or pseudocysts. The optimal treatment for

post-traumatic pancreas lesions in children is still a matter of controversy, some authors advocating for conservative treatment even in the case of severe pancreatic lesions, while others champion early surgical intervention (17). A recent study on data published in the specialized literature reveals that pancreatic lesions higher than III degree or complex lesions often associate surgical interventions, while trauma to the pancreatic head can be managed conservatively (18).

The treatment for pediatric trauma patients should also include post-traumatic stress management as a matter of importance, as the effects of stress extend beyond psychological symptoms, with negative repercussions on the hospital admission period and subsequent clinical evolution. Working with a pediatric psychologist, constantly communicating with and education of both parents and patient should start as early as the admission, to prevent the onset or worsening of post-traumatic stress symptoms (19).

Clinical study

To highlight the repercussions of physical trauma on abdominal parenchymatous organs, we conducted a retrospective analytical study on the patients admitted to and treated in the Pediatric Surgery Clinic of the "Sfânta Maria" Clinical Emergency Children's Hospital in Iași from January 2015 to July 2018. The study was conducted in compliance with standards and based on the approval of the Ethics Committee of the hospital. From the database of the hospital, we retrieved – function of the illness code – all the electronic files of patients attended in an emergency regime for various thoracic or abdominal trauma. Thus, over the course of this period, there were 5,812 registered emergency admissions, of which 125

patients were admitted to the Pediatric Surgery Intensive Care Unit for severe lesions of abdominal parenchymatous organs. Surgical intervention was performed in 8% of these patients: two splenectomies and one hepatic suture were performed as immediate surgical interventions; the deferred emergency interventions included three surgical interventions for evacuating hepatic hematomas and hemoperitoneum, two interventions for renal ruptures (of which one lower pole nephrectomy), one splenectomy for two-phase splenic rupture (Fig. 2) and one post-traumatic pancreatic pseudocyst drainage. One of the interventions for hepatic hematoma drainage was performed in a newborn with obstetrical trauma. One of the multiple trauma patients that underwent splenectomy died 10 days after hospital admission, while postoperative evolution in the other patients was favorable, yet

required extended hospital stay and repeated follow-ups.

Conclusions

Owing to the anatomic and physiological particularities of pediatric patients, any abdominal trauma in children can result in severe lesions of the parenchymatous organs, particularly affecting the liver and spleen, and with severe repercussions on the patient's health status and even on their life. These particularities have to be very well-known, all the more as trauma in children is a pathology with an increasing frequency and severity given the rapid pace of development of the civil society. The essentials for minimizing the morbidity and mortality of these lesions resides in the swift diagnosis and treatment decided by a multidisciplinary team.

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Table I. AAST classification of hepatic trauma lesions (one grade is added for multiple lesions, up to grade III)

Grade	Lesion type	Description
I	Hematoma	Subcapsular < 10% surface
	Laceration	Rupture of hepatic capsule, < 1 cm of parenchyma
II	Hematoma	Subcapsular 10-50% surface, intra-parenchymatous < 10 cm diameter
	Laceration	1-3 cm parenchymal depth, < 10 cm length

III	Hematoma	Subcapsular > 50% of the surface or continuously expanding; subcapsular rupture of parenchymatous hematoma; intra-parenchymatous hematoma > 10 cm
	Laceration	> 3 cm parenchymal depth
IV	Laceration	Parenchymatous rupture 25-75% of hepatic lobe
V	Laceration	Parenchymatous rupture > 75% of hepatic lobe
	Vascular	Hepatic lesions adjacent to the retrohepatic venous pedicle – vena cava / main hepatic veins, central
VI	Vascular	Hepatic avulsion

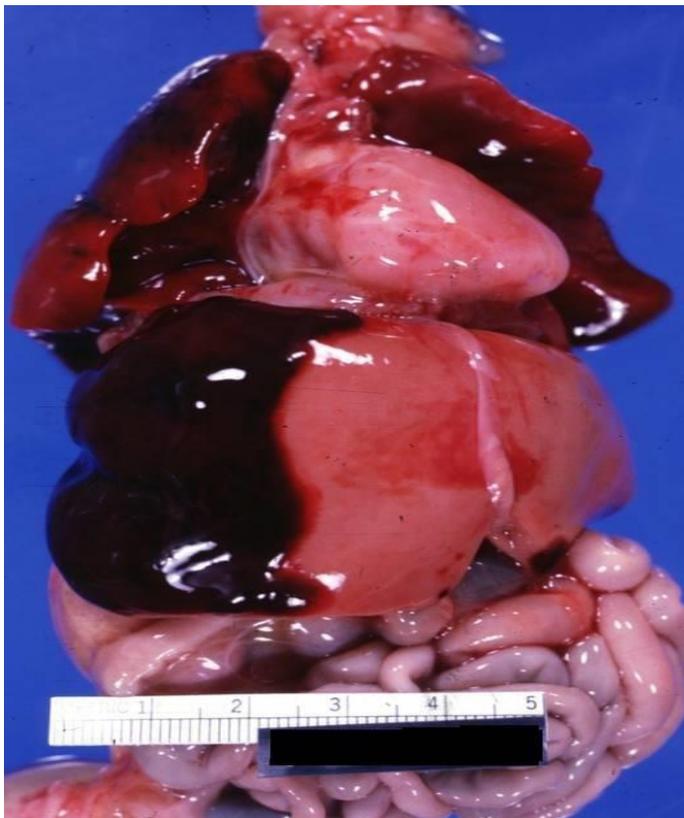


Figure. 1. Post-traumatic hepatic hematoma following obstetrical trauma (necropsy)

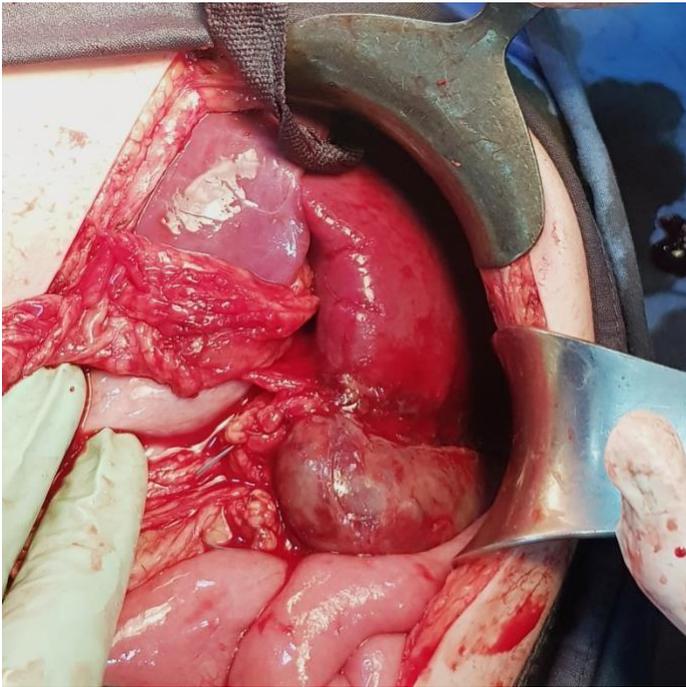


Figure. 2. Two-phase splenic rupture (spleen in situ, during surgical intervention)