# THORACO-ABDOMINAL TRAUMA IN CHILD ABUSE

—by Dirk Huyer

Inflicted thoracoabdominal injuries are relatively uncommon but represent a serious source of morbidity and mortality in childhood (Cooper et al., 1988; Peclet et al., 1990). Blunt thoracoabdominal trauma accounts for the majority of injuries. Penetrating injuries are less common, although a higher incidence of such injuries in urban settings has been reported (Meller, Little, and Shewmeta, 1984). Abdominal injuries are second only to head injuries in causing death in inflicted childhood trauma. Between 0.5 and 8% (Cooper et al., 1988; O'Neill et al., 1973) of physically abused children suffer serious abdominal injury, with a 40-50% mortality rate (Cooper et al., 1988; McCort and Vaudagna, 1964; Sivit, Taylor, and Eichelberger, 1989). While serious inflicted thoracic trauma is observed less frequently, a 40-50% mortality rate has also been reported (Peclet et al., 1990).

***Abdominal injuries are second only to head injuries in causing death in inflicted childhood trauma. Between 0.5% and 8% of physically abused children suffer serious abdominal injury, with a 40-50% mortality rate.***

High mortality rates in cases of inflicted thoracoabdominal trauma may be explained in a variety of ways. Delay in medical treatment results from delay in presentation, inaccurate or misleading historical information provided by parents, and lack of information from the child. Because these features are frequently coupled with a lack of obvious external injury, a high index of suspicion is required.

Mortality rates are higher also because of unique anatomical and physiologic features of children. With smaller blood volumes, significant difficulties may occur from hemorrhagic injuries, especially when the proportionately larger size of pediatric organs is considered. Both the abdomen and the thorax are relatively small, with close proximity of major organs. A single blow may involve more than one organ, with greater consequences than in an adult. The abdominal wall offers limited protection because the muscles are less developed and only a small layer of fat is present. The thoracic wall muscles are similarly less developed, with flexible cartilaginous ribs allowing greater compressibility. These features allow for transmission of large forces to the structures within the cavities, often without evidence of external trauma.

Serious thoracoabdominal injuries result from significant force. The majority of similar accidental injuries result from falls from a great height and from motor vehicle accidents (with the child as a pedestrian more commonly than as a passenger).

### Abdominal Trauma

Blunt abdominal injuries result when forces are produced (1) from direct blows, such as a punch or a kick; or (2) from indirect shearing forces generated during rapid deceleration of the body, as when a child is thrown across a room and hits a wall.

Direct blows crush organs against the immobile vertebral column or the lower rib cage with resultant laceration and hemorrhage. The hollow visceral organs (the stomach and intestine) are filled with food, liquid, air, or stool. A direct blow compresses the contents, leading to sudden overdistension, with rupture spilling the contents into the abdominal cavity. With rapid deceleration of the body, internal partially mobile organs continue in motion with resultant tearing of the intestinal mesentery.

In accidental abdominal trauma, single solid organ injuries are more frequently observed, whereas in abusive injuries hollow viscus injuries are more common, although overlap exists between the two. The kidney, spleen, and liver are most frequently injured in accidents. In contrast, kidney and spleen injuries are infrequent in inflicted trauma, with the liver being the most common solid organ injured. Pancreatic and mesenteric injury are not uncommon in cases of abuse. Improved imaging studies coupled with increased awareness have shown that nonfatal abdominal injuries may be more common than previously reported and at times are asymptomatic (Coant et al., 1992; Hennes, et al., 1990; Sivit, Taylor, and Eichelberger, 1989). This is not surprising because one of the classical findings in child abuse is the discovery of occult injuries.

### Hollow Viscus Injury

Gastric rupture from abusive trauma has been reported (McCort and Vaudagna, 1964). It may be more likely to occur in children who suffer direct blows soon after a large meal. Children present in serious condition with substantial free air demonstrated on the plain abdominal radiograph.

Intestinal injuries are relatively common in children who suffer abusive injuries to the abdomen, with the small intestine being the most common location for these injuries (Ledbetter et al., 1988; McCort and Vaudagna, 1964). Perforations of the small intestine are seen most often in the jejunum (60%) with 30% in the duodenum and 10% in the ileum (Kleinman, 1987b). The frequent finding of damage in the duodenum and the jejunum, typically close to the Ligament of Trietz, suggests that the proximal small intestine is more susceptible to compression injury because of its fixed location. Deceleration forces or direct local traumatic blows are likely to be responsible for intestinal injuries in those portions suspended by mesentery.

The signs of intestinal perforation in a child are frequently subtle with a variable delay in the appearance of symptoms. Pneumoperitoneum is seen on plain radiographs of the abdomen only in a minority of children with intestinal perforations (Brown et al., 1992; Bulas, Taylor, and Eichel-

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berger, 1989) because early sealing of the perforation may occur. If clinically stable, the most sensitive radiographic view to detect pneumoperitoneum is an upright chest film. CT scan may assist in establishing the diagnosis, although false negative examinations do occur (Bulas, Taylor, and Eichelberger, 1989). Discovery of intraperitoneal fluid on CT scan, in cases of suspected abdominal trauma without evidence of other injury, is suggestive of a sealed hollow viscus perforation. The most reliable indicator of perforation is repeated clinical examinations looking for the development of peritoneal irritation.

Intramural hematomata of the intestine are frequently the result of inflicted abdominal injuries. Without definite history of blunt trauma to the upper abdomen, duodenal hematomata are highly suspicious for child abuse. Located in a fixed position close to the vertebral column, the duodenum is susceptible to crushing injuries with resultant intramural hematoma (Woolley, Mahour, and Sloan, 1978).

The clinical picture is one of vomiting, often bilious (dehydration may occur), abdominal pain, and tenderness without other observable abnormality. Appearance of some symptoms may be delayed following the injury with delays of one hour to 2 5 days reported (Woolley, Mahour, and Sloan, 1978). Because of the close association of the pancreas with the duodenum, concurrent injury is not uncommon and amylase levels should be measured. Upper GI (gastrointestinal) series is the gold standard for diagnosis of intramural hematomata. Ultrasound and CT scans may also demonstrate these.

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Hematoma of the intestine distal to the Ligament of Trietz are typically located at the mesenteric borders, frequently with accompanying mesenteric hemorrhage.

### Pancreatic Injuries

Pancreatitis in children is uncommon and should raise the question of trauma (Slovis et al., 1975), although medical causes should be considered. Because the organ is deeply situated in the abdomen, injury is uncommon, although its fixed position immediately anterior to the vertebral column makes it susceptible to deep crushing injuries. Isolated accidental pancreatic injuries have been reported following falls onto small objects such as bicycle handlebars (Dahman and Stephens, 1981; Sparnon and Ford, 1986). Severe pancreatic trauma may result in complete transection of a portion of the organ.

Clinically, abdominal pain, vomiting, and fever are seen with pancreatic injuries. These symptoms may gradually develop after the injury, leading to occasional delay in presentation. Epigastric tenderness with an accompanying abdominal mass may be found. Serum and urine amylase levels are significantly elevated. With severe traumatic transections, chemical peritonitis may result with serious clinical implications.

Most pancreatic pseudocysts in the pediatric age group arise after blunt trauma to the abdomen (Dahman and Stephens, 1981; Kilman et al., 1964). Abdominal pain, fever, vomiting, elevation of the urinary and serum amylase levels, and the presence of an abdominal mass are the presenting clinical features. The time interval between injury and diagnosis may vary from six days to 16 weeks (Sparnon and Ford, 1986).

In acute pancreatitis, ultrasound often reveals enlargement of the gland owing to edema (Kleinman, 1987b). Ultrasound allows non-invasive repetitive evaluation of pancreatic size and for early diagnosis of pseudocyst formation (Kleinman, 1987b). Spontaneous resolution of pseudocysts occurs and is well documented with ultrasound. Computed tomography of the abdomen clearly delineates the pancreas and any accompanying pseudocysts.

### Liver Injuries

The liver is the most commonly injured solid organ in cases of inflicted abdominal trauma (Coant et al., 1992). The organ is injured by a direct crushing blow, although decelerating injuries also occur. Lacerations of the liver parenchyma result from direct trauma with resultant hemorrhage. Decelerating injuries may result in damage to areas of ligamentous attachment with vascular disruption. Vascular injury and significant parenchymal lacerations may lead to serious blood loss and death prior to hospital arrival. Bile duct injury has been reported (Oldham et al., 1986). In accidental liver injuries, the right lobe is frequently injured, in contrast to the frequent left lobe injury in abusive trauma (Coant et al., 1992). This finding likely represents trauma from anterior abusive blows.

In cases of serious liver injury, the child will present in shock with marked intraperitoneal bleeding. Abdominal distention may be found as well as decreased or absent bowel sounds. Pain in the upper right abdomen coupled with tender enlargement of the liver may be observed if the child is conscious without other significant intra-abdominal injury. Minor liver injuries may remain asymptomatic (Coant et al., 1992; Sivit, Taylor, and Eichelberger, 1989).

Elevation of liver function tests (SGOT, SGPT) may predict the presence of liver injuries (Coant et al., 1992; Hennes et al., 1990; Oldham et al., 1986). Plain abdominal radiographs may demonstrate gross abnormalities in the liver size and shape as well as rib fractures. Computed tomography is the most sensitive non-invasive

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technique to assess for hepatic injury (Kleinman, 1987b) and allows survey of the entire abdomen and retroperitoneum. Scintigraphy in the form of liver-spleen scanning was previously used to assess for injury but anatomical detail is poor (Kleinman, 1987b). Ultrasound may identify hepatic hematoma but often misses small lacerations, although it has proven useful in following the progression of liver lesions (Kleinman, 1987b)

### Kidney and Speen Injuries

The kidneys are the second most commonly injured solid organs in abusive abdominal trauma. These likely result from direct blows to the flanks as well as decelerating forces. Children may present with flank pain and tenderness with an accompanying mass and external bruising. Hematuria is generally present in cases of renal trauma and the quantity of blood may be predictive of the seriousness of injury.

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CT scans reveal the range of renal abnormalities, delineating the extent of parenchymal damage, perirenal hematoma, extravasation of urine, and renal vascular damage. Ultrasound and intravenous pyelography also have a role in imaging of renal injuries.

Splenic injuries, while common in accidental abdominal injuries, are uncommon in abusive injuries. Left upper quadrant pain and tenderness will likely be present, often accompanied by left shoulder referred pain. Plain films may document rib fractures, and displacement of the stomach medially. CT scanning of the abdomen typically delineates splenic injury.

### Thoracic Trauma

Inflicted thoracic trauma represents 1% to 8% of traumatic thoracic injuries in childhood (Peclet et al., 1990; Newman and Eichelberger, 1991). Rib fractures are the most common finding of inflicted thoracic trauma (Kleinman, 1987a). Underlying injury to the thoracic viscera, while reported, is uncommon (Kleinman, 1987a).

Rib fractures represent 5% to 27% of all fractures found in child abuse (Kleinman, 1987a) with the majority found in children less than two years of age. They are frequently occult injuries discovered on skeletal surveys or through review of chest x-rays done during illness evaluation. Acute fractures, especially when posteriorly located, may be difficult to detect on plain films. Bone scintigraphy may prove beneficial in these situations.

With anterior posterior compression of the chest, the ribs are levered over the transverse spinous process with fracture along the posterior rib arc if sufficient force is applied (Kleinman, 1987a). In abuse, the fractures are predominantly posterior, with lateral fractures and anterior costochondral injuries less common (Kleinman, 1987a). Because of the anterior rib growth, injuries in this area may be difficult to detect. While front-to-back squeezing of the chest, often associated with shaking injuries, is likely the most common cause of abusive infant rib fractures, direct blows should also be considered.

The thorax of the child is compliant because the ribs are pliable. Because of this compliance, substantial and likely more injurious force is required to deform and fracture the ribs. In contrast to adults, CPR (cardiopulmonary resuscitation) has not been shown to cause rib fractures even when performed by inexperienced personnel (Feldman and Brewer, 1984; Spevak et al., 1994).

In one study, when charts of children with traumatic thoracic injuries were evaluated, 32% of these were found to have rib fractures. The presence of rib fractures was a marker for greater injury severity and increased mortality. Of those with rib fractures, 21% were the victims of intentional trauma, with 63% of the fractures in the under three age group abusive in nature (Garcia et al., 1990). A second study which reviewed charts of children admitted for rib fractures found that 24% were abuse victims. In the much younger child abuse group (mean age of three months compared with 8.6 years) the average number of fractures was 11.8 (range 3 to 23) compared with 3.5 (range 1 to 8) in the non-abuse group (Schweich and Fleisher, 1985).

In light of the frequency of abusive rib fractures and the occult nature and the increased mortality of inflicted thoracic injuries, a skeletal survey should be done in all suspicious infant and early childhood deaths (Kleinman et al., 1989).

### Other Thoracic Injuries

Pneumothorax and hemothorax may follow abusive injuries but are rare. A large cylothorax was reported following disruption of the thoracic lymphatic drainage accompanying posterior rib fractures. Multiple other fractures were also present (Green, 1980).

Pulmonary contusion is one of the most frequent intrathoracic injuries found in accidental pediatric chest trauma (Newman and Eichelberger, 1991). This complication, while uncommon, does occur with abusive injuries. If medical attention is not sought, infection of the area of contusion may occur, and if severe may cause significant illness or death.

Cardiac contusions may occur but are rarely clinically significant when found in accidental trauma. An ECG, echocardiogram and CPK-MB may prove helpful diagnostically if significant concern exists. A ventricular septal defect and conduction system abnormalities have been described

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secondary to inflicted trauma (Marino and Langston, 1982; Rees et al., 1975).

Inflicted pharyngeal and esophageal perforations have been reported (Albin and Reinhart, 1990; Kleinman, Spevak, and Hansen, 1992; McDowell and Fielding, 1984). Clinically, these children develop subcutaneous emphysema and mediastinal collections demonstrated by chest x-ray findings of mediastinal widening and/or pneumomediastinum. Forceful insertion of an object (likely a penis in one case [Albin and Reinhart, 1990]) is the probable mechanism of injury.

## Conclusion

Inflicted thoracoabdominal injuries, while infrequent, have significant morbidity and mortality. A high index of suspicion is required in order to reach the correct diagnosis both in the emergency room and the autopsy suite.

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