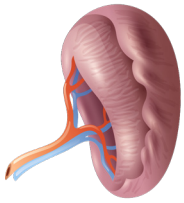
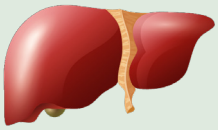
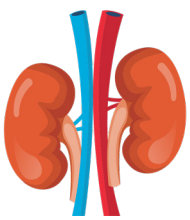
ABDOMINAL INJURIES COMPARISON CHART

SOLID ABDOMINAL STRUCTURES

Tissue Characteristics	Traumatic Mechanisms	Clinical Findings
Spleen The spleen is an encapsulated solid organ located in the left upper abdominal quadrant. It is minimally elastic and highly vascular. This combination makes the spleen vulnerable to hemorrhage when the capsule is torn. However, an intact capsule prevents frank hemorrhage, even in the face of serious parenchymal injury. The spleen stores platelets and filters aging red cells. It also has immune functions including antibody production. The spleen provides protection against encapsulated bacteria and parasitic infections. This immune function is most important in childhood, but remains beneficial throughout life. 	The spleen is often reported to be the most frequently injured abdominal organ in blunt trauma. (The liver is usually #2 on the list.) When subject to force (direct or referred), the non-elastic spleen will crack (lacerate) or shatter. Anticipate splenic injury in patients with left rib fractures.	*Local exam findings* Look for left upper quadrant bruising, pain, and tenderness indicating trauma to the area. Abdominal distention and rigidity occur when blood leaks into the peritoneal cavity. *Signs of blood loss* Tachycardia, hypotension, orthostasis, decreased hemoglobin and hematocrit levels. *Kehr's sign* Kehr's sign is pain from diaphragmatic irritation, caused by blood contact with the diaphragm. Irritation stimulates the phrenic nerve, which the brain interprets as shoulder pain. LEFT shoulder pain is most common. In the abdominal trauma patient, this finding strongly suggests splenic injury, although there are other Kehr's sign etiologies.
Liver The liver is located in the right upper abdominal quadrant. It is the largest solid organ. Like the spleen, the liver is encapsulated, non-elastic, and highly vascular. The liver is a vital organ with over 500 functions that include glucose production and storage, clotting factor production, protein synthesis, toxin metabolism, and bile production. The liver also performs many digestive and immune functions. 	The liver is commonly injured in both blunt and penetrating trauma. Because of its solid tissue characteristics, the liver will crack or shatter when exposed to force. Look for concomitant right rib fractures. The ligamentum teres hepatis divides the liver into 2 lobes. It is a fixed point that is prone to shearing with rapid deceleration.	*Local exam findings* Look for right upper quadrant bruising, pain, and tenderness. Abdominal distention and rigidity occur when blood from a torn capsule leaks into the peritoneal cavity. *Signs of blood loss* Tachycardia, hypotension, orthostasis, and decreasing hemoglobin and hematocrit levels. Icterus (jaundice) appears as a late finding as the liver fails.
Kidneys Like the spleen and liver, the kidneys are solid encapsulated organs, but they are located completely within the RETROperitoneal space. Major functions include fluid and electrolyte balance, acid/base regulation, hormone synthesis, blood pressure regulation, and urine production. 	The kidneys are most commonly injured by direct or referred blunt trauma, which causes the renal parenchyma to crack or shatter. Shearing of the major vascular structures and the ureters can occur as well. Injury often occurs in conjunction with rib fractures. Damage to the adrenal glands may also be present.	*Local exam findings* Assess for flank pain, flank bruising (Grey Turner sign), a palpable flank mass, abdominal distention, and blood at urinary meatus. Fever and hypertension are delayed findings. Hematuria is usually present, but the degree of hematuria is not a good predictor of the extent of renal injury. *Signs of blood loss* Tachycardia, hypotension, orthostasis, decreased hemoglobin and hematocrit levels.

Diagnostic Studies	Management
Spleen *Laboratory* Serial hemoglobin and hematocrit levels will show dropping numbers. *Imaging* Ultrasonography (eFAST) is used to identify the presence of free fluid in the peritoneal space, which will usually be blood in a trauma patient. Computed tomography can determine injury severity (grade I-VI). CT is employed liberally in adult patients, but conservatively in children. Unfortunately eFAST is not very sensitive in children. *Diagnostic Peritoneal Lavage* DPL is an infrequently performed, invasive, emergency procedure used to detect hemoperitoneum. The procedure entails inserting a percutaneous catheter into the peritoneal cavity to aspirate blood or other fluid.	*Non-invasive options* If the capsule remains largely intact after injury, bleeding is contained by the capsule (a "subcapsular" hematoma) with limited bleeding into the abdominal compartment. Most adult patients (70-80%) with isolated splenic injury are managed noninvasively. Care includes vital signs monitoring, progressive mobility, serial abdominal exams, and repeat CT for deterioration. Almost all children can be managed non-operatively ("spleen watch"). *Invasive options* Invasive management options for patients with hemodynamic instability and/or multiple traumatic injuries include interventional radiology for angioembolization, splenorrhaphy (repair), or splenectomy (removal). Hemodynamically UNSTABLE KIDS require urgent surgical intervention. Discharge instructions are important for all patients experiencing splenic injury. Teach patients the signs and symptoms of delayed bleeding. Contact sports precautions are required for up to 8 weeks. Splenectomized patients have an increased lifetime risk for pneumococcal sepsis and other serious infections. Instruct patients to use good infection prevention measures and seek immediate medical care for ANY signs of infection. Recommendations include vaccination for pneumococcus, meningococcus, Hemophilus influenza type B, and annual flu shots. Prophylactic antibiotics are indicated in select splenectomized trauma patient populations.
Liver *Laboratory* Monitor serial hemoglobin and hematocrit levels. Liver enzyme levels (AST, ALT) will rise after injury, but this is a delayed finding. Monitor levels serially to recognize trends. Likewise, coagulation studies are tracked serially to identify reduced clotting factor production. *Imaging* Ultrasonography (eFAST) is used for rapid identification of free fluid around the liver. Computed tomography can determine the location and extent of hepatic damage.	*Non-invasive options* This is the preferred approach if the liver injury is small or subcapsular. Care includes vital sign monitoring, serial abdominal exams, and progressive patient mobility. Repeat CT is common for deterioration in adult patients. In hemodynamically unstable children, CT is avoided; UNSTABLE KIDS go directly to surgery. *Invasive options* Damage control surgery is performed for emergent packing and quick repair in the hemorrhaging patient. Angioembolization (interventional radiology) is an option for bleeding control in adults and older children. Injuries to specific hepatic structures (e.g., the large vessels, bile duct) may require definitive surgical intervention. Devitalized (dead/necrotic) tissue is resected.
Kidneys *Laboratory* Serial hemoglobin and hematocrit levels. Serial BUN, creatinine, and BUN: creatinine ratio measurement, urinalysis, urine electrolytes. *Imaging* Ultrasonography (eFAST) for identification of free fluid by a skilled operator. Computed tomography with IV contrast and intravenous urography (IVU)/intravenous pyelography (IVP) are common imaging modalities.	*Non-invasive options* If the renal capsule is largely intact after traumatic injury, hemorrhage remains subcapsular, with limited bleeding into the retroperitoneal compartment. Because the retroperitoneum is not readily distensible, hemorrhage in this space often tamponades itself and is self-limited. Most renal injuries are managed noninvasively. Care includes repeat CT for deterioration, vital signs monitoring, progressive patient mobility, and serial abdominal exams. *Invasive options* Invasive management options for patients with hemodynamic instability and/or urinary extravasation includes indwelling urinary drainage devices, stenting, percutaneous nephrostomy, percutaneous drainage, angioembolization, surgical repair, or nephrectomy.

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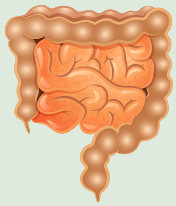
TCAR TRAUMA CARE AFTER RESUSCITATION PCAR PEDIATRIC CARE AFTER RESUSCITATION

ABDOMINAL INJURIES COMPARISON CHART (CONT.)

SEMI-SOLID ABDOMINAL STRUCTURE

Tissue Characteristics	Traumatic Mechanisms	Clinical Findings
Pancreas The pancreas is an unencapsulated semi-solid organ that is NOT highly vascular (unlike the solid organs). The pancreas is a complex organ with vital endocrine and exocrine functions, including insulin production. It is a largely RETROperitoneal structure, located deep within the abdomen. Multiple ductal fixed points make the organ susceptible to shear injury. 	This semi-solid structure is prone to both large lacerations and microscopic cracks. Because of its deep anatomical placement, the pancreas is usually injured by a direct and forceful blow to the epigastrium. Common mechanisms of injury include lap belt-only seat belt placement, steering wheel blows to the abdomen, and handlebar compression injuries (bicycles, scooters, etc.).	*Local exam findings* Pancreatic injuries can be difficult to detect. Grey Turner (flank bruising) and Cullen (periumbilical bruising) signs MAY appear >12-24 hours after injury, but their absence is common in patients with pancreatic injury. Symptoms include the delayed onset of burning epigastric pain due to autodigestion from leaking pancreatic enzymes. In the presence of severe pancreatic injury, look for serum glucose abnormalities due to altered insulin production..

HOLLOW AIR- AND FLUID-FILLED ABDOMINAL STRUCTURES

Bowel The bowel is a hollow, elastic, air- and fluid-containing organ that fills most of the peritoneal cavity, with sections extending into the retroperitoneal space. Blunt force, penetrating trauma, and blast waves all cause bowel injury. Primary bowel functions include fluid and electrolyte absorption, immune protection, digestion, and elimination. Different portions of the bowel have different functions. 	The bowel can be contused (bruise it), lacerated (tear it), or ruptured (pop it). Most bowel ruptures will be acute, occurring at the time force is applied. These injuries are usually (but not always) detected early in the course of care. Delayed rupture happens when an area of weakened or damaged bowel necroses and "pops" over time (hours-weeks post injury). Blunt bowel trauma is associated with lap belt-only seat belt placement and hyperflexion mechanisms. Patients with penetrating mechanisms are at high risk for bowel rupture and subsequent peritonitis and other infections.	*Local exam findings* Look for peritoneal signs including rebound tenderness, involuntary guarding, and fetal patient positioning. Diminished bowel sounds, nausea, vomiting, and ileus develop hours-to-days after injury as contusions "blossom". Melena may be present. Progressive infection leads to fever, sepsis, and fistula and abscess formation. Advanced findings include dehydration and abdominal discoloration.
Stomach The stomach is a tough, muscular, and relatively mobile structure that can readily expand and contract in size. The stomach carries out very important digestive functions in a highly acidic environment. Injury is unusual because of the stomach's protective, elastic anatomy. 	The stomach is far more likely to rupture when it is full. Gastric contents (food and acid) are then dumped into the peritoneal cavity. Gastric trauma is associated with rapid deceleration, compression, and crush injury mechanisms. A classic history involves a car bumper blow to the belly of a child shortly after consuming a full meal. Look for concomitant left rib fractures and splenic trauma.	*Local exam findings* Abdominal pain, nausea and vomiting, fever, sepsis *Signs of blood loss* Injury to large gastric vessels may be associated with major hemorrhage. Anticipate tachycardia, hypotension, orthostasis, and decreased hemoglobin and hematocrit levels.

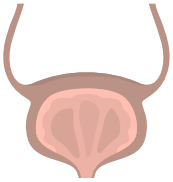
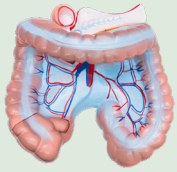
Diagnostic Studies	Management
Pancreas *Laboratory* Monitor serial serum amylase or lipase levels. However, these enzymes may not be elevated, even with significant injury. *Imaging* CT with contrast. The pancreas' retroperitoneal location may limit detection of small injuries on CT or laparoscopy. Magnetic resonance cholangiopancrea-tography (MRCP) is the gold standard for imaging suspected pancreatic ductal injuries. Endoscopic retrograde cholangio-pancreatography (ERCP) may be performed.	Monitor all pancreatic injury patients for complications including intra-abdominal abscess, pseudocyst, and fistula formation. *Non-invasive options* Non-operative management for low grade pancreatic injury may consists of nasogastric tube decompression and total parenteral nutrition (TPN), with gradual resumption of enteral feeding. Provide supplemental insulin as needed. *Invasive options* ERCP and interventional radiology with pancreatic duct interventions such as stenting or sphincterotomy in hemodynamically stable patients.
Bowel *Laboratory* Leukocytosis (elevated white blood cell count) and unexplained metabolic acidosis *Imaging* Computed tomography reveals air outside the GI tract ("free air"), abnormal bowel wall enhancement ("thickening"), and bowel discontinuity (areas of rupture). Plain, upright radiographs are employed to screen for air outside the GI tract, but do not localize the site of injury.	Broad spectrum antimicrobial therapy is used in the setting of suspected or confirmed bowel perforation *Non-invasive options* Management of the hemodynamically stable blunt trauma patient includes vital signs monitoring, bowel rest, decompression with a naso/orogastric tube, nothing by mouth, and serial abdominal exams. Anticipate bowel edema and fluid shifts. *Invasive options* Laparotomy or laparoscopic surgery is performed to "run the bowel" examining for leaks, injury, ischemia, necrosis, and fecal contents in the peritoneal cavity. In damage control situations, the bowel can be quickly stapled or sutured. Future surgery may be required to repair viable bowel and resect devitalized (dead) tissue. Intra-abdominal drains are often placed to prevent fluid pockets. In seriously injured patients, the abdomen is covered, but left open, to accommodate edema and further surgical interventions. Most penetrating abdominal trauma patients will require surgical intervention; most blunt abdominal trauma patients will not.
Stomach *Laboratory* Serial serum chemistry studies, serial hemoglobin and hematocrit levels *Imaging* Ultrasonography (eFAST) for identification of left upper quadrant free fluid and air Computed tomography	*Non-invasive options* The hemodynamically STABLE blunt trauma patient with a gastric hematoma or partial thickness laceration may be managed non-operatively. Interventions include vital sign monitoring, GI rest, serial abdominal exams, and decompression with endoscopically guided gastric tube placement in selected cases. *Invasive options* Operative management includes surgical repair of full thickness lacerations or punctures, and total or partial gastrectomy, depending on the extent of injury to the stomach and its blood supply.

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TCAR TRAUMA CARE AFTER RESUSCITATION PCAR PEDIATRIC CARE AFTER RESUSCITATION

ABDOMINAL INJURIES COMPARISON CHART (CONT.)

HOLLOW AIR- AND FLUID-FILLED ABDOMINAL STRUCTURES (cont.)

Tissue Characteristics	Traumatic Mechanisms	Clinical Findings
Bladder The bladder is a fluid-filled, highly elastic organ that functions as a urine reservoir. The bladder responds to compression much like a water balloon. The fuller it is, the more likely it is to "pop". Thus, the probability of rupture is directly related to the degree of distention at the time of force application. 	Bladder injuries are uncommon in general, but occur relatively more frequently in children because of their shallow pelvic depth. Blunt trauma, caused by direct compression, is the usual injury mechanism. Bladder puncture can occur as a result of penetrating trauma and from bony impalement in the patient with an associated pelvic fracture. Anticipate concomitant pelvic and ureteral injuries.	*Local exam findings* Look for gross hematuria, pelvic and flank pain, and blood at the urinary meatus. Bladder/lower abdominal distention is present in patients who have an outflow obstruction. *Signs of blood loss* Tachycardia, hypotension, orthostasis, decreasing hemoglobin and hematocrit levels.
Mesentery The mesentery is a fold in the peritoneum that attaches the stomach, small intestine, pancreas, spleen, and other organs to the posterior wall of the abdomen. The mesentery is highly vascular, containing a web of arteries that perfuse the abdominal organs. 	Traumatic mesenteric injuries involve damage to the mesentery, including its blood vessels, nerves, and lymphatics. These injuries result from blunt or penetrating trauma, such as MVCs and stab wounds. Intestinal damage is caused directly by tearing fixed points or indirectly via vascular compromise and ischemia. Rapid deceleration can cause mesenteric "bucket handle" injuries, a specific type of mesenteric tear that occurs when a section of the mesentery is pulled away from the abdominal wall, creating a "handle" like that of a bucket. These injuries can lead to significant vascular compromise of the affected bowel segment.	*Local exam findings* Abdominal pain, tenderness and distention, and reduced bowel sounds. *Signs of blood loss* Tachycardia and hypotension.

Diagnostic Studies	Management
Bladder *Laboratory* Serial hemoglobin and hematocrit levels, metabolic panel, urinalysis *Imaging* CT cystography is used to identify urine extravasation into the intraperitoneal or extraperitoneal spaces.	*Urology consult* Noninvasive care may include bladder rest and an indwelling urethral or suprapubic catheter. *Invasive options* Involves instrumentation, stenting, or surgical repair.
Mesentery *Laboratory* Monitor serial hemoglobin and hematocrit levels. Leukocytosis (elevated white blood cell count) and unexplained metabolic acidosis *Imaging* Vessel occlusion, hematomas, and bucket handle injuries can be difficult to detect on initial abdominal CT scan. Contrast extravasation indicates bleeding from a mesenteric vessel. Diagnostic laparoscopy may be utilized to identify (or rule out) mesenteric injury	Traumatic bowel and mesenteric injuries, such as perforation or active mesenteric bleeding usually require surgical management.

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