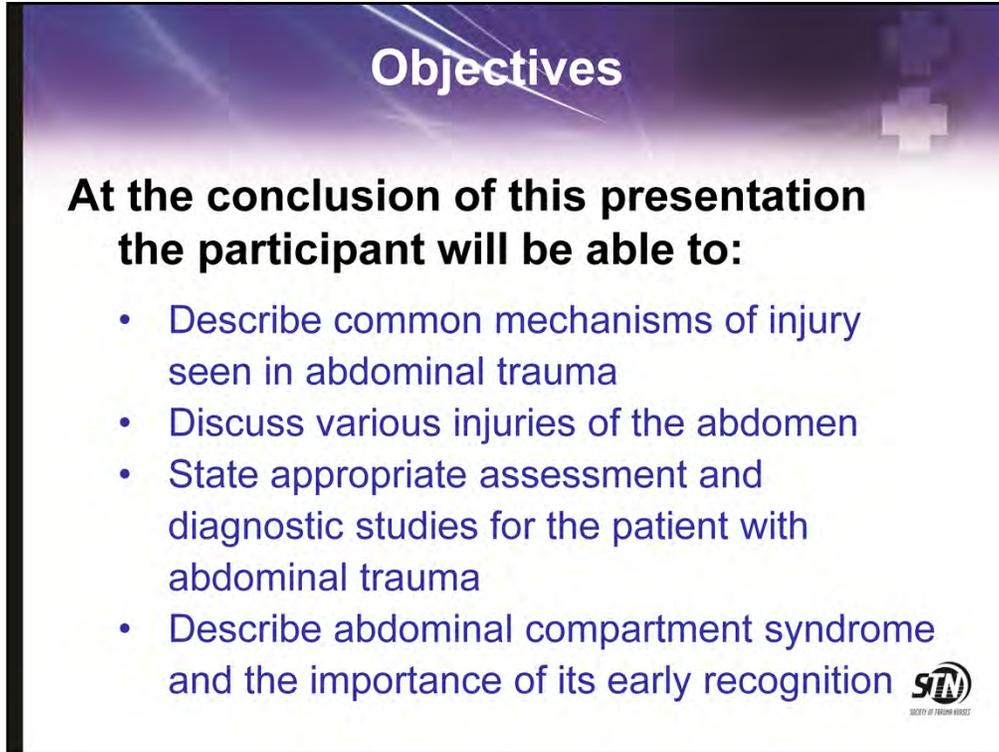




Abdominal Injuries





Objectives

At the conclusion of this presentation the participant will be able to:

- Describe common mechanisms of injury seen in abdominal trauma
- Discuss various injuries of the abdomen
- State appropriate assessment and diagnostic studies for the patient with abdominal trauma
- Describe abdominal compartment syndrome and the importance of its early recognition

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The abdomen contains numerous organs and related structures that can be injured. It is beyond the scope of the presentation to provide in-depth review of each potential injury and its detailed evaluation and surgical management, however, the most common injuries will be discussed as an overview with key points noted.

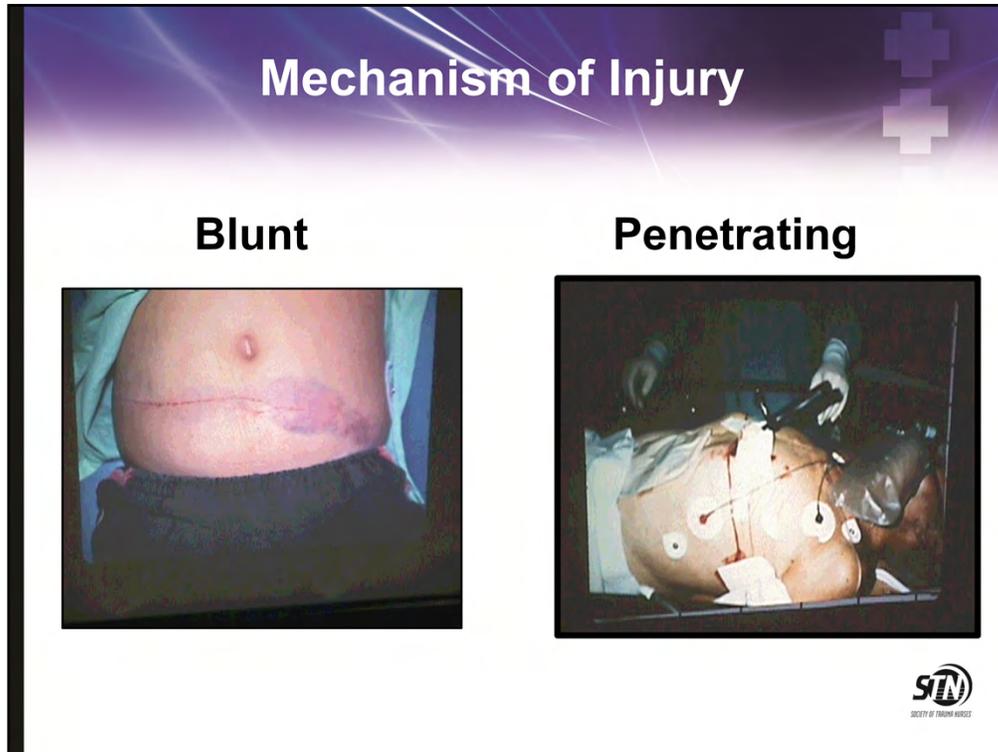
Note the objectives.

Epidemiology

- Incidence
 - Abdominal injuries rank 3rd as a cause of death
 - Account for 13% to 15% of trauma deaths
 - Seldom a single system injury



- Abdominal trauma ranks 3rd as a cause of death and is preceded only by head and chest injuries.
- Death is primarily a result of hemorrhage, however, after 48 hours, sepsis and complications lead to higher incidence of morbidity and mortality.
- Usually it is accompanied by other injuries and this leads to an increase in morbidity and mortality.
- Whether it is the acute injury or the complication of the injury, the failure to diagnose and treat early increases the morbidity and mortality.



Abdominal injuries are divided into two broad categories based on the mechanism of injury, blunt and penetrating.

Blunt trauma is the most common injury pattern with motor vehicle crashes being the most common mechanism accounting for approximately 75%.

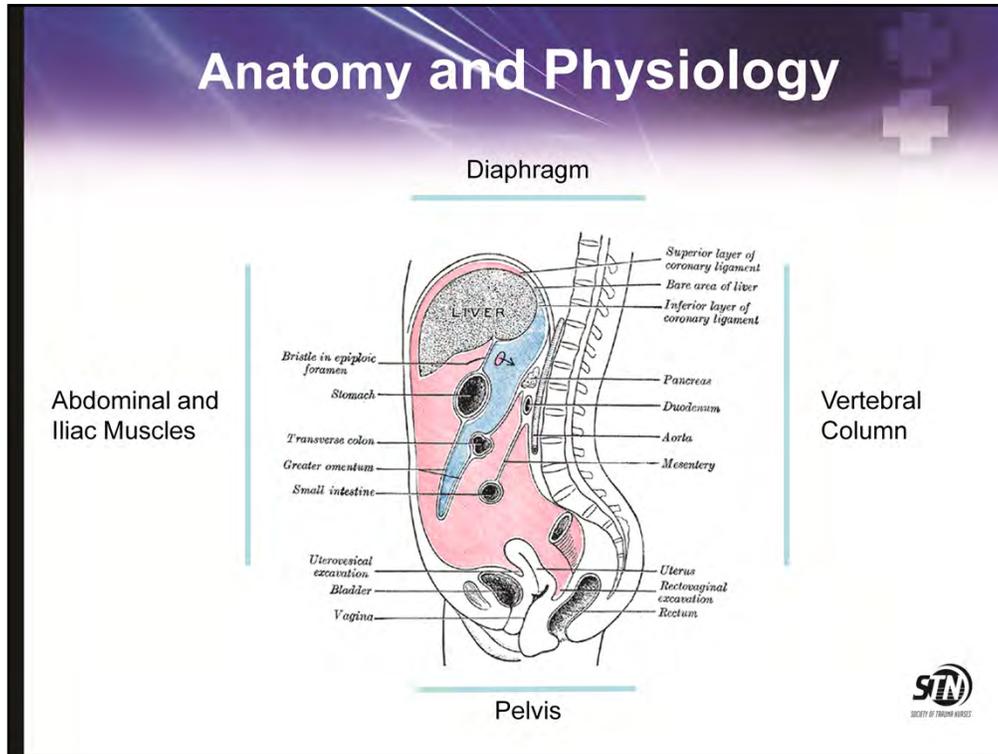
Diagnosing blunt abdominal trauma can be very challenging. It is often difficult to make a definitive diagnosis especially when there are either multiple organ injuries, competing injuries, and/or altered mental status from head injury or alcohol/drug intoxication that may cloud the clinician's assessment. Regardless, the symptomology is often subtle and may gradually progress, necessitating serial assessment and alterations to the plan of care. Unrecognized, abdominal trauma is a frequent cause of preventable death.

Mechanism of Injury

- Heightens suspicion for certain injuries
- Blunt injury and types of forces
- Use of restraint devices
- Penetrating trauma



- Acceleration and deceleration injuries are self explanatory.
 - Blunt forces compressing anteriorly on the abdomen compress the abdominal viscera against the posterior rib cage or vertebral column causes crushing type injuries. Solid organs are most susceptible to this mechanism.
 - Shearing forces caused by sudden deceleration can result in lacerations to both solid and hollow organs. These forces may also cause “stretch” injuries resulting in some intimal vessel tears with subsequent organ infarction.
 - The use of safety belts and air bags has helped decrease injuries and fatalities, but it cannot totally eliminate them.
 - The seat belt “sign” indicates intra-abdominal injury in about one third of patients.
 - Classic seat belt injuries include abdominal wall disruption, hollow viscus injuries, and flexion-distraction fracture of the lumbar vertebrae (Chance fracture).
-
- Penetrating injuries result from stab, impalement, or missile incident.
 - The degree of penetration may be estimated by the length of the stabbing instrument.
 - Impalement injuries result in a higher mortality as they are considered a dirty wound and result in bacterial contamination leading to multiple organ involvement.
 - Missile injuries are difficult to assess, and it must be noted that the appearance of the wound may not compare to the magnitude of the destruction caused by a bullet. Bullets may ricochet off organs or bones and move throughout the body.
 - Hemorrhage and hollow viscus injuries with resultant chemical and bacterial peritonitis must be considered and promptly treated.



In review, the abdomen can be described as a contained structure that is bordered superiorly by the diaphragm, inferiorly by the pelvis, posteriorly by the vertebral column and anteriorly by the abdominal and iliac muscles.

Peritoneal Cavity

Stomach
 Liver
 Gallbladder
 Spleen
 Transverse Colon
 Sigmoid Colon
 Upper third of rectum
 Uterus in women

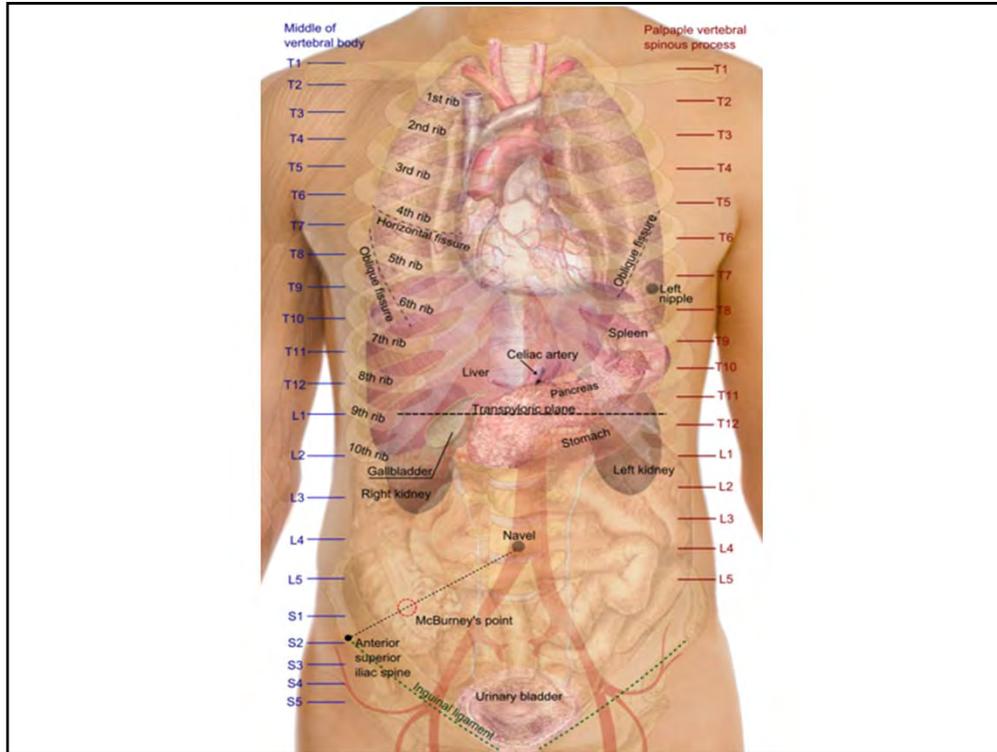
Retroperitoneum

Ascending and descending colon
 Small intestine
 Kidneys
 Pancreas
 Adrenal glands
 Aorta
 Vena cava
 Part of duodenum

Major vessels

- The basic divisions include those structures located within the peritoneal cavity and those located within the retroperitoneum.
- Injury to abdominal organs, especially those in the retroperitoneal space, can bleed as the space can hold a great deal of blood, up to four liters. Solid organs, such as the liver and spleen bleed profusely as do the major abdominal blood vessels, the aorta and vena cava.
- Injury to hollow organs such as the stomach and bowel presents a serious risk of infection, especially if there is a delay in diagnosis.
- One or more of the intra-abdominal organs may be injured in abdominal trauma given the close proximity and the typical associated pattern of injury.

Note: As part of the review, the esophagus has been mentioned as it passes through the diaphragm connecting to the stomach, however, it is also covered in the neck module. Genitourinary injuries are covered in a separate session and will not be addressed.



There are four key abdominal sections with their related structures. Review anatomy on diagram.

The first section is the intrathoracic abdomen, or the portion of the upper abdomen that lies beneath the rib cage which makes the area inaccessible to palpate. Its contents include the diaphragm, liver, spleen, and stomach..

The second is the pelvic abdomen and is defined by the bony pelvis. Its contents include the urinary bladder, urethra, rectum, small intestine, and, in females, ovaries, fallopian tubes, and uterus. If injury occurs to these structures, diagnosis may be difficult as they are extraperitoneal in nature.

The third is the retroperitoneal abdomen containing the kidneys, ureters, pancreas, aorta, and vena cava. The findings on physical exam do not reveal specific injuries to these structures, and evaluation of the structures in this region may require radiologic tests to include computed tomography (CT) scanning and angiography.

The fourth is the “true” abdomen, which contains the small and large intestines, the uterus (if gravid), and the bladder (when distended). Perforation of these organs is associated with physical findings, and the patient usually complains of pain and tenderness from peritonitis.

Author released diagram into the public domain and *grants anyone the right to use this work **for any purpose**, without any conditions, unless such conditions are required by law.*

Abdominal Assessment

- Inspection
- Auscultation
- Percussion
- Palpation



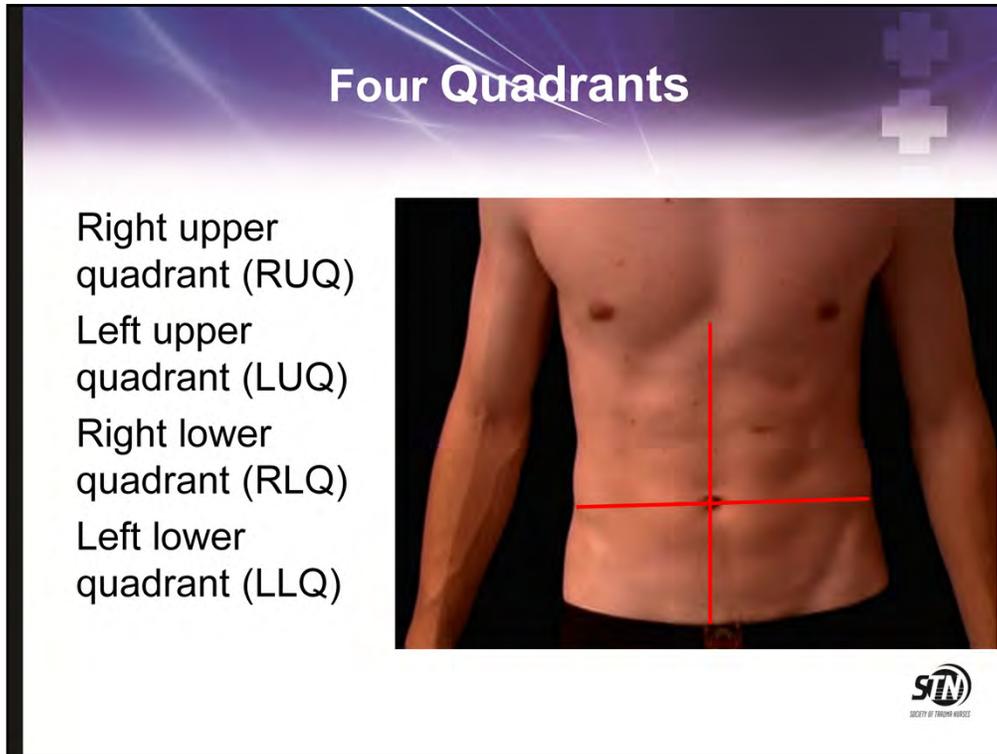
The image contains two visual elements. On the left is a black and silver stethoscope. On the right is a photograph showing a person's bare abdomen being touched by a hand, illustrating the process of abdominal assessment.

The appearance of the abdomen should be described with any abnormalities noted to include size, shape, and location. The back and flank areas should be included in the evaluation.

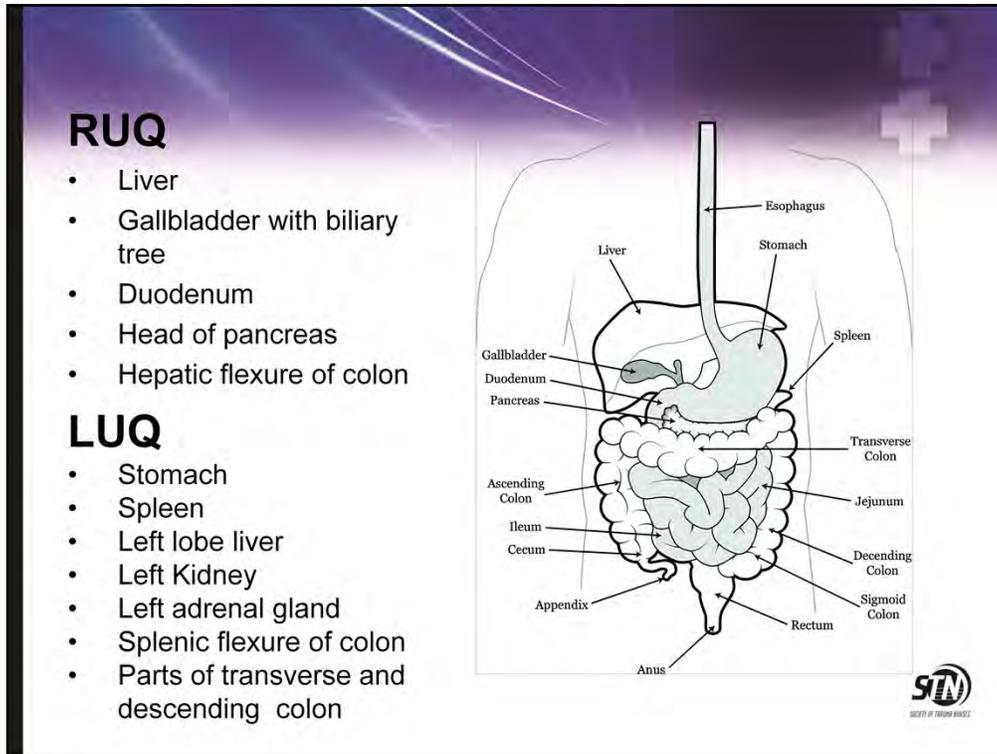
During the resuscitative phase, auscultation is difficult due to the noise level in the resuscitation room. This can be controlled somewhat with an organized team leader, both physician and nursing. Auscultation may be performed before percussion and palpation because vigorously touching the abdomen may disturb the intestines, and perhaps alter their activity and as a result, the bowel sounds. Serial auscultations that reveal absence of bowel sounds may indicate an ileus or peritonitis.

Percussion is rarely used in the resuscitative phase, however, the presence of air is indicated by tympanic sounds as found in hollow or air filled organs whereas a dull sound is elicited over abdominal solid organs or space filled with blood. Tenderness on percussion constitutes a peritoneal sign and mandates further evaluation.

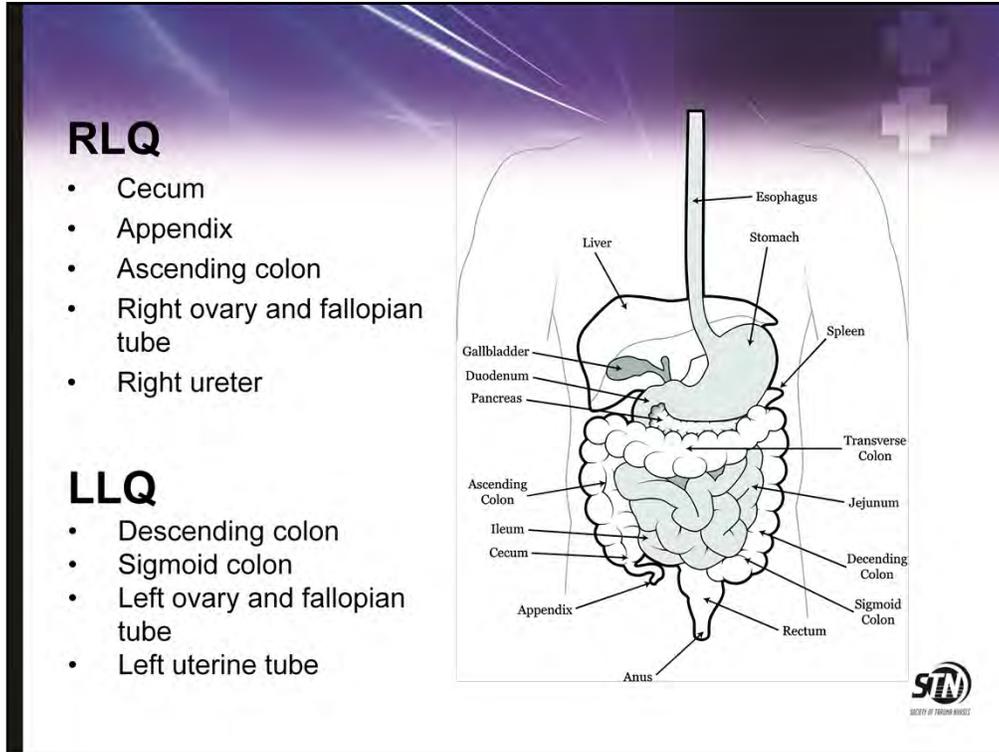
To evaluate abdominal tenderness, all four quadrants are assessed using light to deep palpation. Guarding, distention, and signs of peritoneal irritation can indicate organ rupture. Kehr's sign, pain in the left shoulder, secondary to irritation of the diaphragm via the phrenic nerve from a ruptured spleen is a common example of "referred pain".



For ease of examination and consistency in documentation, the abdomen is divided into four common quadrants, different from the previously described four AREAS. Point out the structures in each on the following slides.



Review locations



Review Locations

Ongoing Assessment



- Delayed diagnosis or missed injuries
- Frequent serial and systematic examinations
- Tertiary exam



The care of the trauma patient is demanding and requires rapid evaluation. This continues to be one of the most challenging and resource intensive aspects of trauma care. Some injuries may not manifest themselves until hours, days, or weeks following the injury, and therefore, repeat assessments are important as some injuries evolve over time.

Missed intra-abdominal injuries are causes of increased morbidity and mortality, especially in patients who survive the initial phase after an injury. The value of frequent serial examinations cannot be stressed enough. Tertiary exams are also important to ensure everything is followed and documented during the hospitalization.

Examples: Development of a chemical ileus secondary to late pancreatic rupture and/or small diaphragmatic tears missed during the initial assessment and/or surgery.

A good example of a complication to watch for is GI bleeding. GI bleeding can result from trauma causing gastric mucosal erosion over time.

Note seatbelt mark on image.

Diagnostic Labs

Are they necessary? Reliable?

- Hematocrit
- WBC
- Electrolytes
- Pancreatic enzymes
- Liver function tests




Another debated issue is that of labs needed in the trauma bay, what is necessary and what is not. What do you need to “ACT UPON” immediately? What labs can be done point of care, and which ones cannot. There are many labs and some that will be done based on local trauma center criteria. The ones noted here are those commonly associated with the abdomen and are in no way an all inclusive list.

The hematocrit may be useful as a baseline, however, it must be interpreted in the clinical context related to extent of hemorrhage, time of injury, and the amount of fluid resuscitation. The initial hematocrit may be normal or falsely high in consideration of actual blood loss. It is most helpful when it is serially measured and trended.

The WBC is nonspecific and of little value. Elevated WBC count is the body's normal response to trauma, and this value is of little significance in the acute setting. Epinephrine release may elevate the WBC to 12,000 to 20,000. Solid or hollow viscus injury can cause elevations as well, and serial evaluations noting neutrophilia may indicate an inflammatory process in the peritoneal cavity indicating peritonitis secondary to hollow viscus injury or splenic injury. During later phases of care, an elevated WBC may indicate a wound infection, pulmonary infection, sepsis, etc.

Serum electrolytes, BUN, and creatinine are sometime done for baseline values in patients with significant medical history of hypertension, diabetes and renal disease.



Serum amylase and lipase levels alone are not diagnostic as they have poor negative and positive predictive value, meaning normal levels do not exclude pancreatic injury and elevated levels may be caused by extra-abdominal injuries. Routine amylase testing is not recommended in the resuscitation phase and should be individualized.

Serum transaminase may be elevated in liver injuries but does not distinguish between major or minor injury, and it is normally high in patients with co-morbidities such as alcohol induced liver disease.

PT, PTT, and INR are indicated in patients with history of coagulopathy, cirrhosis, or those on anticoagulation therapy. These are also important to monitor in patients receiving massive blood transfusions.

Gross hematuria is suggestive of renal injury, and since microscopic hematuria can be missed by visualization, a microscopic or dipstick urinalysis is recommended for all with blunt abdominal trauma.

Some believe that ABGs can provide most of the information needed early in the resuscitation of a patient. If injured and compensating, a metabolic acidosis will be noted. A moderate base deficit (e.g. more than -6) indicates the need for aggressive resuscitation and determination of the etiology. This is not only impacted by blood loss and the need for resuscitation but can be altered in the elderly and those with alcohol intoxication.

Diagnostic Modalities

- Radiographs
- Diagnostic peritoneal lavage (DPL)
- Ultrasonography (US)
- Computed tomography (CT) scan
- Angiogram
- Diagnostic laparoscopy



The goal of initial evaluation is to determine if there is a serious injury that may require immediate operative intervention. We will review each briefly prior to discussing specific injuries.

Radiographic Films

- CXR
 - Concomitant pulmonary and cardiac injuries
 - Displacement of abdominal organs
- Pelvis
- Plain abdominal films have limited if any role in the acute resuscitation
 - AP and lateral films may identify fluid or air
 - Upright film for free air; may disclose ruptured hollow viscus



An initial CXR is really the most important tool providing useful info in the early minutes. It will provide valuable information and can identify other major sources of blood loss from injuries in the chest or elevated diaphragm with displacement of abdominal organs.

A pelvic film can be valuable in diagnosing pelvic fractures and determining the need for a pelvic binder, anticipation of blood transfusion, etc, especially, if CT scan is going to be delayed. However, many times the patient is rushed off to CT scan and this is not necessary.

Plain abdominal films have limited value in the acute resuscitation setting, but can reveal free air. This is in the ACUTE first few minutes...And, most patients will not be upright in the first few minutes following trauma.

Diagnostic Peritoneal Lavage

- Used to diagnose intra-abdominal bleeding
- Indications
 - Unexplained hypotension, decreased hematocrit, or shock
 - CT or ultrasound not available
 - Equivocal abdominal examination
 - Altered mental status
 - Spinal cord injury
 - Distracting injuries



Once considered the gold standard in unstable patients, this diagnostic procedure's use has slowly declined with advances in ultrasonography and multidetector helical CT scan. It is still a useful tool for someone not trained in ultrasound or one that does not have US as a resource available to assist in the evaluation process. It is also useful in situations of multiple patients and the need for rapid triage. However, in these situations it is more of a DPA (Diagnostic Peritoneal Aspirate) **..a tiny stab wound is made in abdomen, a catheter such as a CVC catheter is used to penetrate the peritoneum. If 10 ml of gross blood is readily drawn back, the unstable patient goes to the OR.**

DPL

Advantages	Disadvantages
<ul style="list-style-type: none">• Quick, simple• Safe• Low cost• Relatively accurate• Grossly positive result	<ul style="list-style-type: none">• Difficult to perform in some patients• Invasive procedure• Can miss certain injuries

Note: A urinary catheter and gastric tube should be in place prior to the procedure



DPL is used to diagnose intra-abdominal bleeding and is sensitive and accurate. A grossly positive result in a hemodynamically unstable patient requires operative intervention without delay or further workup.

DPL is difficult to perform in the obese trauma patient, those with previous laparotomies, and those in the third trimester of pregnancy. The procedure does carry the risk of omental laceration and visceral or vascular perforation. It is most useful in patients who are at high risk for hollow viscus injury, however, it can miss certain injuries such as those to the bowel, diaphragm and retroperitoneum. Also, if the procedure is performed too early, injuries may have not manifested themselves as in the case of bowel or pancreatic injury.

Review pros and cons.

Note foley and gastric tube placement prior to procedure.

Ultrasound

- FAST
- Focused
- Assessment
- Sonography
- Trauma

Ultrasound probe locations and sequence

- Epigastrium
- RUQ
- LUQ
- Pelvis



M-Turbo Courtesy of Sonosite



Focused Assessment with Sonography in Trauma (FAST). Bedside ultrasonography is useful in abdominal evaluation to detect free peritoneal fluid or hemoperitoneum. Free fluid appears “black” and a certain amount is required to be seen and quantifiable on the scan. Amounts range in the literature from 75 ml to 250 ml. It is not intended to replace other modalities. It is a rapid, portable, noninvasive, and accurate examination that can be performed to detect hemoperitoneum. In many medical centers, the FAST examination has virtually replaced DPL as the procedure of choice in the evaluation of hemodynamically unstable trauma patients.

Based upon Advanced Trauma Life Support (ATLS) principles, the hemodynamically unstable trauma patient with a positive FAST scan is taken to the OR for laparotomy.

If the patient has positive free fluid on US but is hemodynamically stable, a CT scan is done to determine location of injury and extent of hemorrhage. As long as the patient remains hemodynamically stable, it is highly likely that the patient will be managed nonoperatively.

Ultrasound

Advantages	Disadvantages
<ul style="list-style-type: none">• Reliable, fast, safe• Cost effective• Noninvasive• Equipment portable• Performed simultaneously• Fast exam detects free fluid• Serial exams	<ul style="list-style-type: none">• Clinician expertise variable• Lacks specificity• Not intended to replace DPL or CT scan• Reliability is questionable• May not reveal free fluid if performed too early



US is fast, noninvasive, and may be performed simultaneously at the bedside while other interventions are ongoing, thus, eliminating the need for transporting the patient out of the department.

US does not detect injuries to the diaphragm, intestine and pancreas. It may not detect free fluid which would provide the clinician information to evaluate further. Reliability in some patients with obesity, ascites, and subcutaneous emphysema is questionable.

A certain amount of fluid is necessary to quantify and be visible for a positive US reading, so if performed too early, one may have a negative exam. Serial US should be performed on patients with significant mechanism of injury and on those for whom a high index of suspicion is indicated.

Computed Tomography

- Used for hemodynamically stable patients
- Advantages
 - Noninvasive procedure
 - Better defines organ injury
 - Estimates amount of blood in spaces
 - Retroperitoneum and vertebrae can be assessed
- Helical scanners



CT scan is the currently accepted standard of evaluation used in hemodynamically stable patients with abdominal trauma. Any unstable patient should be in the OR, and should not be taken to CT scan.

The information obtained with CT scan of the abdomen can provide surgeons and radiologists the ability to grade injuries thus assisting them in the decision of operative vs.. nonoperative management. Many institutions have implemented care guidelines based on certain grades of injury. One can refer to the www.aast.org for specific organ grading charts.

Abdominal computed tomography (CT) has better specificity than DPL for intra-abdominal injury in BAT but can be difficult to perform in hemodynamically unstable patients. As with any radiologic test that requires transport out of the resuscitation area, many things should be considered such as the ease and safety of transporting a patient with various lines, equipment, appropriate staff, etc. A patent airway is of utmost importance. The CT scan has been referred to as the “tunnel of death” due to suboptimal anticipation for what could occur while in CT scan.

IV contrast is utilized for the most accurate, detailed imaging. The use or nonuse of oral contrast has been debated. While those arguing that oral contrast is not necessary in the acute traumatically injured patient, others still believe in its value in diagnosing bowel injuries. Regardless, instillation of oral contrast adds additional time, puts the patient at increased risk for vomiting and aspiration, and carries a risk of an allergic reaction, hence it is usually not done in the acute resuscitative phase. In the elderly patient, administration of contrast of any route should be used prudently given their predisposition to renal problems.

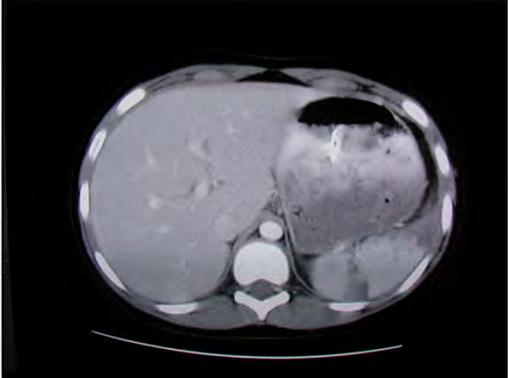
New generation multidetector helical scanners have improved dramatically in terms of image

quality and speed. Many “pan scan” trauma panels (head, cervical spine, chest/abdomen/pelvis) can be completed in minutes.

The use of a CT in a penetrating trauma is of limited value and should be carefully considered before performing. Trajectory can be determined utilizing CT. A triple contrast CT has been shown useful.

CT Scan in Trauma

- Visualizes abdominal solid organs and vessels well
- Does NOT see hollow viscus, duodenum, diaphragm, or omentum well
- Whole body scans on all trauma
- Radiation long term effects



The image is an axial CT scan of the abdomen. It shows a cross-section of the abdominal cavity. On the left side of the image (patient's right), there is a large, dark, irregularly shaped area within the spleen, which is a splenic laceration. The surrounding abdominal organs, including the liver on the right and the kidneys, are visible. The spine is seen in the center of the image.



Some recent surgery literature advocates pan scanning while others call for a more judicious use in select patients.

What is the right answer?

Despite advances in multidetector helical scanners, they are still not perfect and some injuries are not as readily identifiable, although imaging has improved in recent years. For example, subtle findings such as bowel wall thickening or “stranding” may be the only subtle sign for a bowel injury.

Keep in mind that there is an increase in mortality related to cancer from CT scans. One should give careful consideration the diagnostic tests that are needed. There is still much debate over “pan scanning” versus a much more judicious approach in consideration of an increasing amount of literature reviewing the effects of radiation exposure.

As with any modality, there are advantages and disadvantages, and patient safety from a risk of injury (omitting) vs. a risk of radiation (committing) should be our guide.

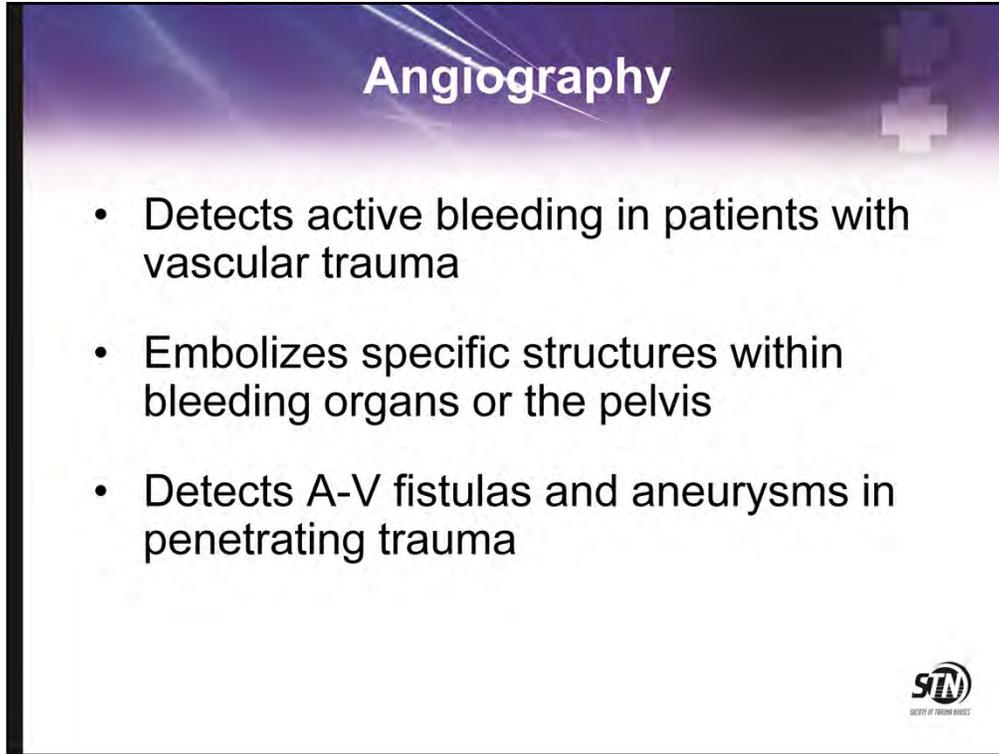
Image is of a large splenic laceration

CT Scan Disadvantages



- Takes time to perform
- Cost
- Transport of patient
- Requires stable and cooperative patient
- Less reliable in diagnosing some injuries
- IV contrast
- Radiation exposure



A presentation slide with a purple gradient background and a white cross in the top right corner. The title "Angiography" is centered at the top in a white, bold, sans-serif font. Below the title, there is a bulleted list of three points in black text. In the bottom right corner, there is a small logo for STN (Society of Trauma Nurses) with the tagline "SOCIETY OF TRAUMA NURSES" below it.

Angiography

- Detects active bleeding in patients with vascular trauma
- Embolizes specific structures within bleeding organs or the pelvis
- Detects A-V fistulas and aneurysms in penetrating trauma

STN
SOCIETY OF TRAUMA NURSES

In 1972, a publication described the first embolization of the internal iliac artery to control hemorrhage associated with pelvic fractures. Since that time, the role of interventional radiologists in trauma has evolved to include definitive treatment of injuries.

Interventional radiology continues to be particularly useful for embolization of unrelenting hemorrhage in patients with unstable pelvic fractures. Embolization can also be done for hemorrhaging in liver and splenic injuries. In fact, it is such an important tool in the armamentarium of treatment options, some centers are developing hybrid OR suites that can handle cases combining various specialties, (trauma, ortho, neuro, IR, etc) without having to move the patient.



Hybrid OR with all the technology.

Patient's one stop for OR, Angio, etc. Does not require the patient to be moved.
Teams rotate in / out.

Diagnostic Laparoscopy (DL)

- Screening or diagnostic tool
- Invasive procedure with some limitations
- Used to detect or exclude certain findings
- May reduce the rate of negative laparotomies



Diagnostic laparoscopy can be used to detect or exclude findings of hemoperitoneum, organ injury, intestinal spillage, or peritoneal penetration. There is limited visibility regarding the extent or depth of injury as well as injuries in the retroperitoneal space. However, diagnostic laparoscopy has been most useful in the evaluation of possible diaphragmatic injuries, especially in penetrating thoracoabdominal injuries on the left side. This is beneficial to reduce the rate of unnecessary laparotomies.

Other Studies

ERCP

- May be indicated in the stable trauma patient suspected of having biliary tract or pancreatic duct injury
- Most accurate test in the patient with hyperamylasemia and in those following pancreatic surgery



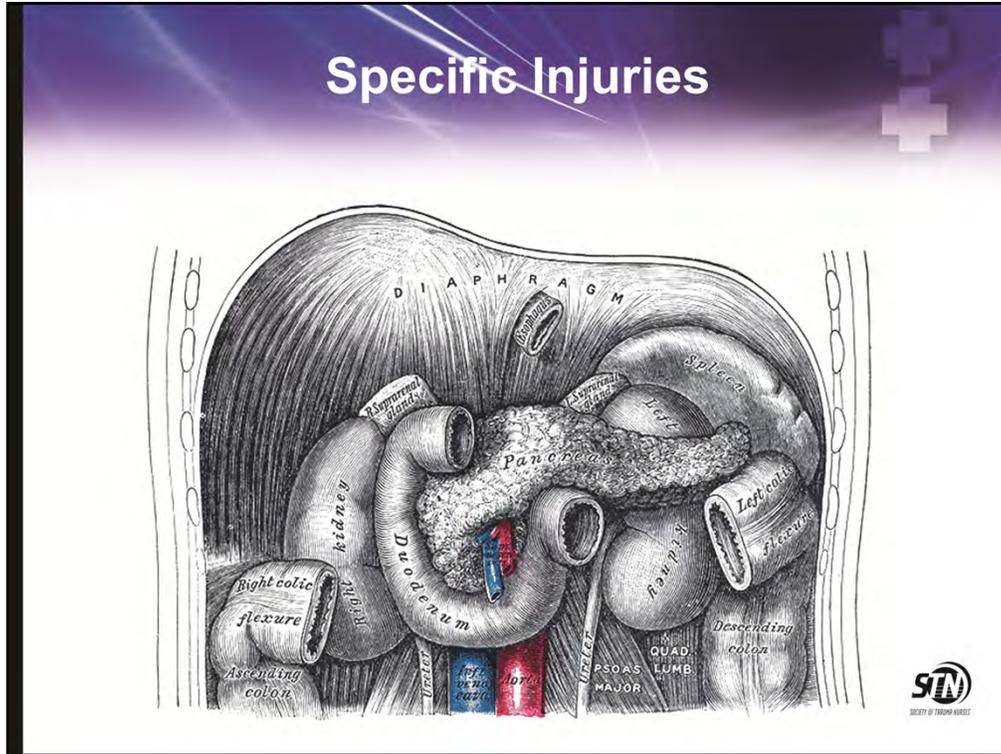
Endoscopic retrograde cholangiopancreatography (ERCP) may complement CT scanning to rule out a ductal injury.

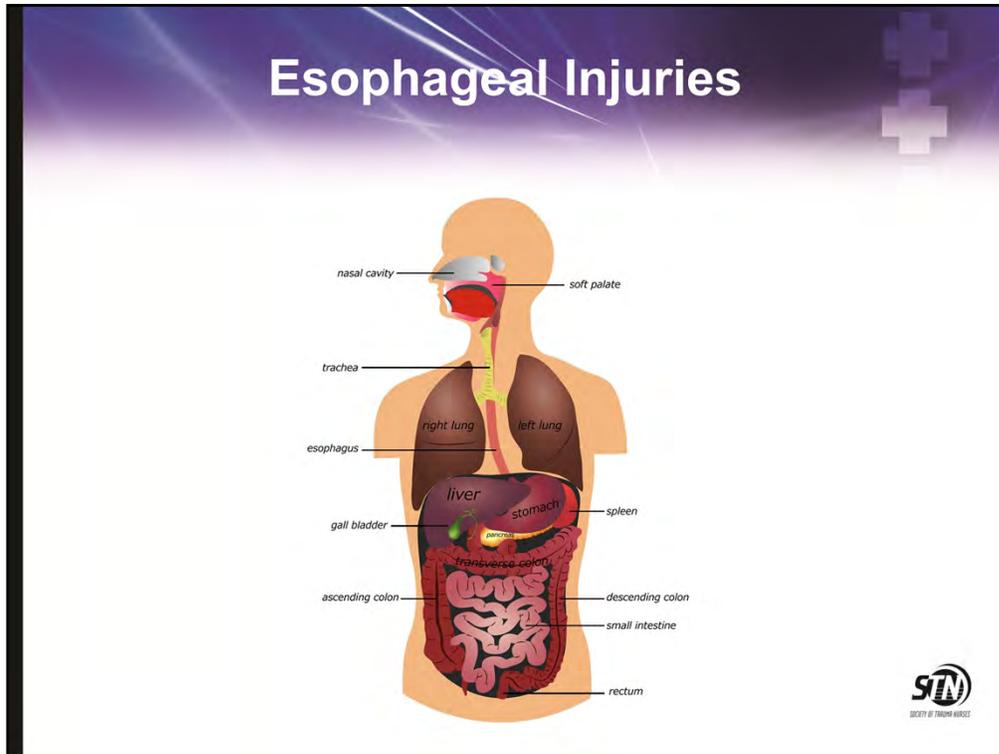
Other Studies

Gastrografin or barium studies

- Helpful in diagnosing injuries to the esophagus, stomach, or bowel
- Contrast enemas are used to diagnose rectal or colonic injury secondary to penetrating trauma







We will first mention the esophagus. Note the location on the slide. There is the origin, neck section, the thoracic, and the abdominal section.

The origin of the esophagus and potential injuries are covered under the neck presentation, however, as part of the GI tract it connects to the stomach and will be reviewed.

Esophagus

Anatomy

- Carries food from pharynx to the stomach
- Joins the stomach at the level of T-10
- Posterior surface overlies aorta
- Anterior surface covered by peritoneum

Predisposing Injury Facts

- Narrow at
 - Cricoid cartilage
 - Arch of aorta
 - Esophagogastric junction
- Lacks serosal layer
 - Integrity of anastomoses
 - Possible leak after surgical repair



Blunt trauma patients rarely sustain esophageal rupture. Penetrating trauma is more likely.

Due to the narrowed areas of the esophagus, it is predisposed to injury. Not only is it predisposed to injury but due to the lack of a serosal layer, the integrity of surgical repairs can be affected and may cause leaks to occur.

Perforation may occur anywhere along the esophagus, but there is a tendency for rupture at three anatomical points of narrowing, the cricopharyngeus muscle, the broncho-aortic constriction, and the entry into diaphragm (esophagogastric junction).

An esophageal perforation is a surgical emergency. Leakage of esophageal and gastric contents into the mediastinum creates a necrotizing inflammatory process that can lead to sepsis, multiorgan failure, and death.

Esophageal Injury

Incidence	Sequelae
<ul style="list-style-type: none">• Higher in cervical and thoracic areas• Majority are due to penetrating trauma• Blunt injury is rare	<ul style="list-style-type: none">• Respiratory compromise• Mediastinitis• Paraesophageal abscess
<ul style="list-style-type: none">• Early diagnosis essential	<ul style="list-style-type: none">• Empyema• Esophageal fistula• Peritonitis
<ul style="list-style-type: none">• Can result in high morbidity and mortality	



Incidence lower to the portion within abdominal cavity. The majority of injuries occur secondary to penetrating trauma and usually involve the cervical portion of the esophagus (95%)

Early diagnosis is key as damage is caused by digestive juices to the tissue and bacterial contamination at the site.

Prompt diagnosis and management is critical to minimizing mortality. A delay of greater than 24 hours in diagnosis and treatment of an esophageal perforation is associated with a higher mortality rate compared with an early diagnosis and treatment initiation

The mortality rate following operative management of an esophageal perforation is dependent on location of the perforation, with cervical perforations having the lowest mortality rate (6 percent) compared with thoracic perforations (27 to 34 percent), and intra-abdominal perforations (21 to 29 percent).

Fluid losses may cause respiratory compromise.

Injuries to the esophagus are rare but are significant due to the increase in morbidity and mortality that occurs with delayed treatment.

Esophageal injuries are often associated with severe concomitant injuries that may mask findings, delaying diagnosis until mediastinitis or an empyema develop

Esophageal Injury



Assessment

- Symptoms of perforation include pain, fever, and dysphagia
- Symptoms of abdominal esophageal tear include signs of peritoneal irritation followed by dyspnea and pleuritic pain

Diagnostic tests

- Endoscopy/Esophagoscopy
- CT



Signs and symptoms vary according to location of injury and the amount of contamination. Perforation of the esophagus may cause pain at the site of injury or radiation of pain to the neck, chest, shoulders, or throughout the abdomen.

A tear in the abdominal portion of the esophagus shows signs of peritoneal irritation from the release of gastric contents. As these contents reflux into the pleural space, more air than fluid is appreciated producing dyspnea and pleuritic pain.

Plain x-ray may reveal pneumomediastinum, pleural effusion, mediastinal contour changes (which progress with inflammation), or a gas bubble in the nasogastric tube or esophagus

Diagnosis is made by endoscopy or esophagography using water-soluble contrast. CT may show subtle air leaks beside the site of perforation

Esophageal Injury



Management

- Initial assessment complex
- Goal is to minimize the bacterial contamination and enzyme erosion
- Gastric decompression
- Antibiotic coverage
- Drainage of wound
- Surgical repair



Evaluation is difficult as esophageal injuries are rare and usually occur in conjunction with other injuries. Depending on the extent of injury, different surgical techniques may be employed to repair esophageal tears.

The general principles for the management of an intra-abdominal esophageal perforation are the same as those of the cervical and thoracic esophagus. A primary repair is the gold standard of care and should be utilized for perforations of the thoracic and abdominal esophagus and for visualized perforations of the cervical esophagus.

These surgical principles include a careful dissection to isolate the esophagus without damaging vital structures, evacuation of debris and devitalized tissues, and debridement of the area of perforation.

Esophageal Injury Management

- Continuous monitoring for injury
- Complications after repair



The slide features a purple header with the title 'Esophageal Injury Management'. Below the title are two blue callout boxes: 'Continuous monitoring for injury' and 'Complications after repair'. To the right is a circular endoscopic image showing a narrowed, scarred esophageal lumen. The STN logo is in the bottom right corner.

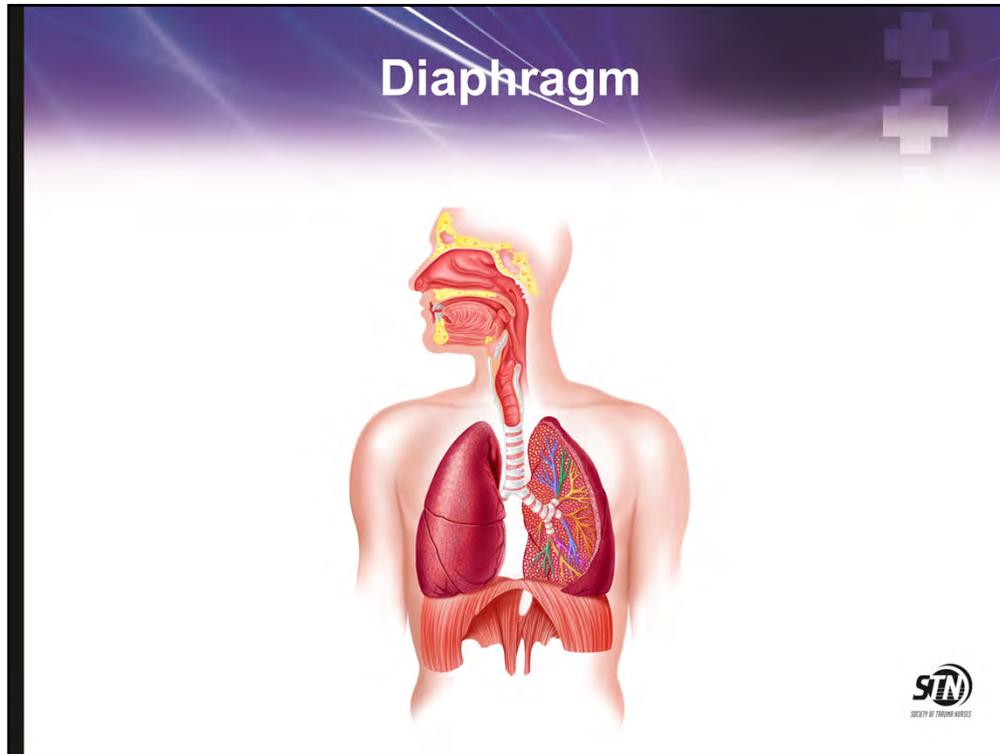
Evaluation for signs of injury should be part of one's assessment from critical care through rehab since these injuries are difficult to diagnose. Ongoing assessment is key as complications can occur at any time and one should be highly observant.

Monitor for

- Peritoneal irritation
- Respiratory compromise
- Fistula formation

Potential complications after repair

- Peritonitis
- Mediastinitis
- Intra-abdominal abscess
- Esophageal stricture (**as seen in image**)
- Esophageal fistula



We will mention the diaphragm next since it is considered both part of the thorax as well as abdomen.

It is important to know that when assessing the spinal cord injured patient, any injury between the third and fifth cervical vertebrae may affect the ability of the patient to breathe due to its affect on the phrenic nerve and diaphragm.

The diaphragm is primarily innervated by the phrenic nerve, formed from cranial nerves C3, C4, and C5. A useful mnemonic to remember this is, "C-3, 4, 5 keep the diaphragm alive."

The diaphragm is dome-shaped and attaches to the chest and abdominal walls circumferentially.

Diaphragmatic injuries are relatively rare and result from either blunt or penetrating trauma.

Diaphragmatic Injury

Incidence

- Usually occurs with other injuries
- Seen in < 5% of blunt trauma patients
- Left side greater incidence than right side
- Commonly associated with penetrating trauma
- Injuries from blunt trauma caused by sudden rise in intrathoracic pressure



Diaphragmatic injury in blunt trauma is relatively rare and is seen in fewer than 5% of all patients with blunt trauma. It is estimated that 80-90% of blunt diaphragmatic ruptures result from motor vehicle crashes and 80-90% of these occur on the left side.

A left hemidiaphragm injury is more common than a right because of the protective effect of the liver on the right side. If a right hemidiaphragmatic injury is present, suspect liver injury. Right-sided ruptures are less common and have more severe associated injuries and result in greater hemodynamic instability.

Some believe that the incidence is most likely equal for right and left sided injuries, however, due to the right side being associated with other injuries more often, these patients may not survive to actually be diagnosed.

Diaphragmatic Injury

Assessment

- Auscultation of peristaltic sounds in chest
- Delayed rupture - unexplained chest pain and increased respiratory rate
- CXR is most important diagnostic study
 - Elevation of hemidiaphragm
 - Bowel pattern in the chest
 - Gastric tube curls in chest
 - Hemothorax – associated injury
- Masked by positive pressure ventilation



Symptoms of diaphragmatic injuries frequently are masked by associated injuries.

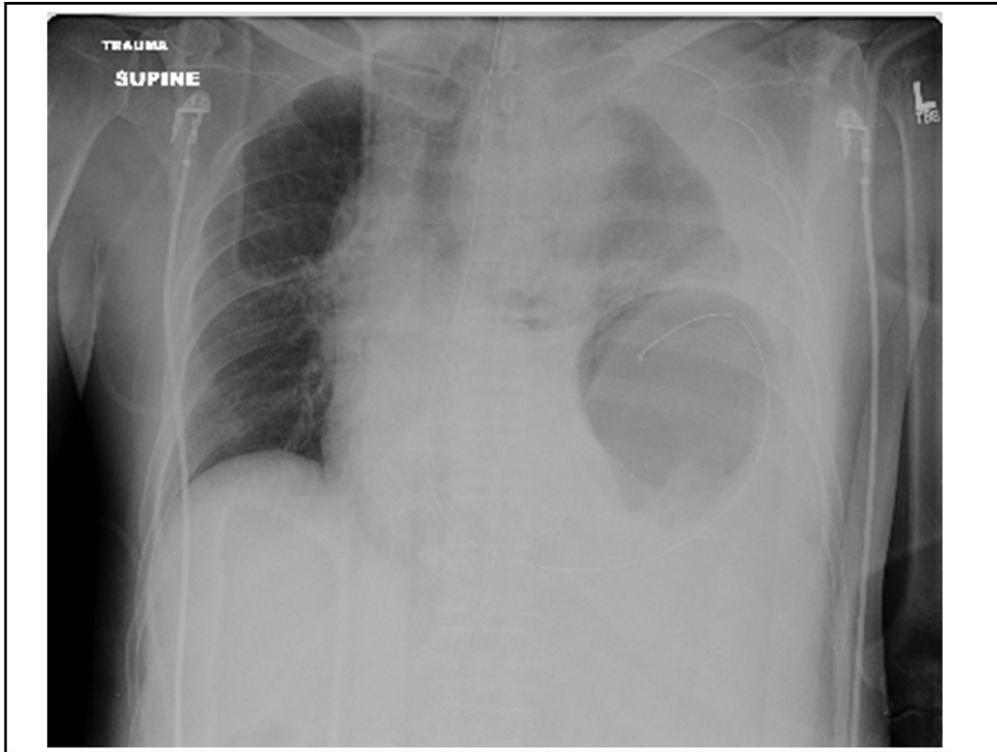
Penetrating trauma may produce a small tear not appreciated on initial exam. As intra-abdominal pressure rises, the defect increases and the possibility of herniation and intestinal strangulation may occur.

In 10-50% of patients, diagnosis is not made in the first 24 hours. Physical examination is limited in its utility in diagnosing this injury, but diaphragm injury may be identified by auscultation. Peristaltic sounds in the chest on auscultation indicate a diaphragm rupture.

With gross herniation of visceral contents into the chest, mediastinal structures shift resulting in respiratory distress and hemodynamic instability.

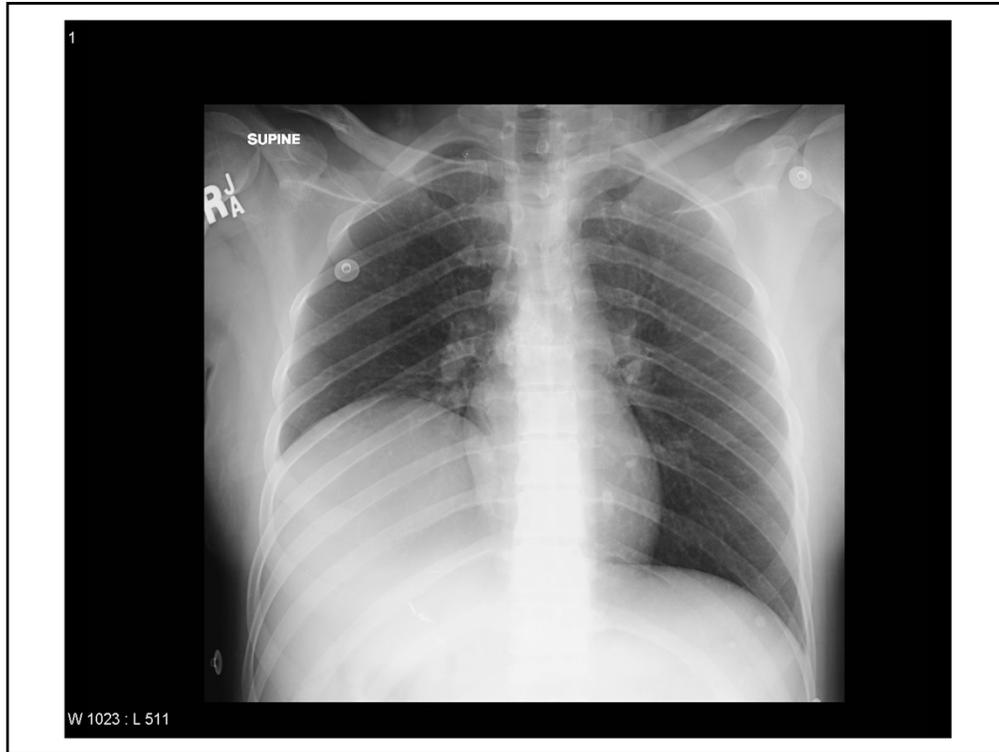
Monitoring for the possibility of delayed rupture should be included in the assessment.

If not made in the first 4 hours, the diagnosis may be delayed for months or years. Up to 50% of blunt trauma injuries to the diaphragm are diagnosed late. It can occur many years post trauma due to gradual weakening of the injured area leading to rupture.



What is wrong with this picture?

Elevation of left diaphragm; gastric tube curled; herniation of abdomen contents into chest

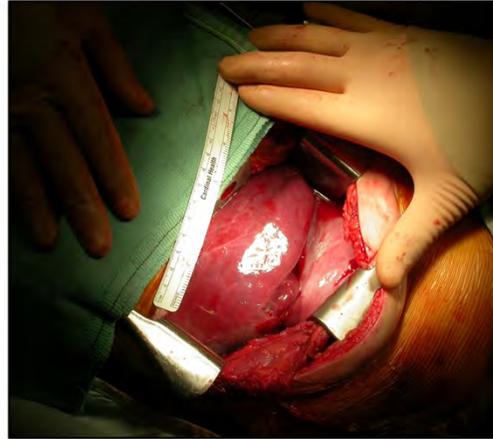


Elevated right hemidiaphragm

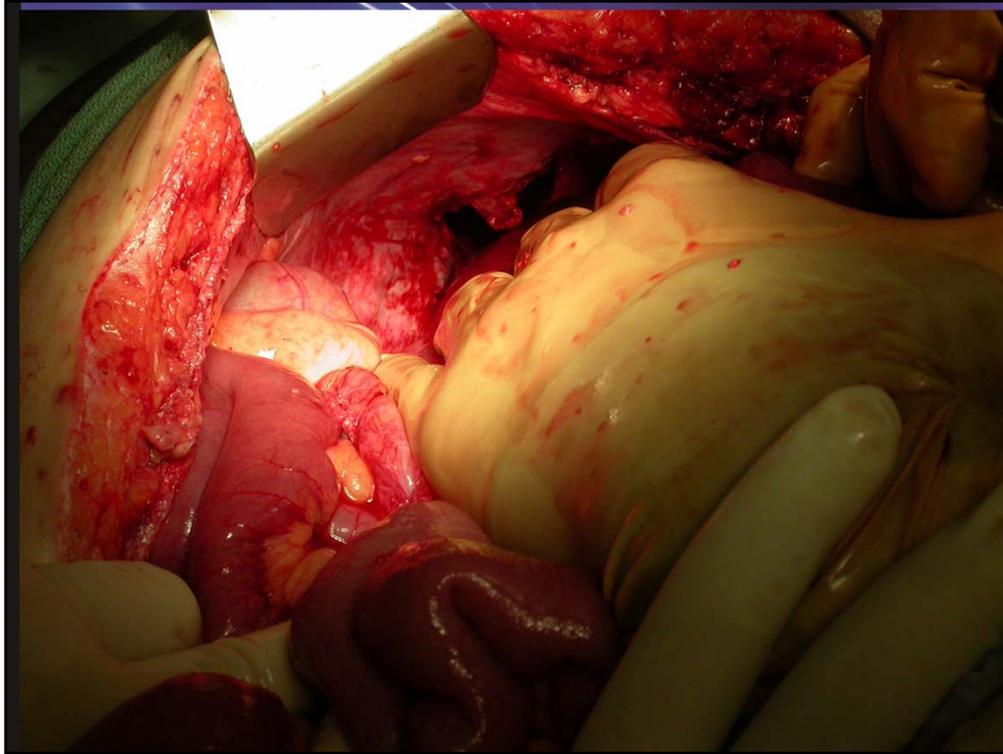
Diaphragmatic Injury

Management

- Exploratory laparotomy
- Diagnostic laparoscopy in penetrating trauma

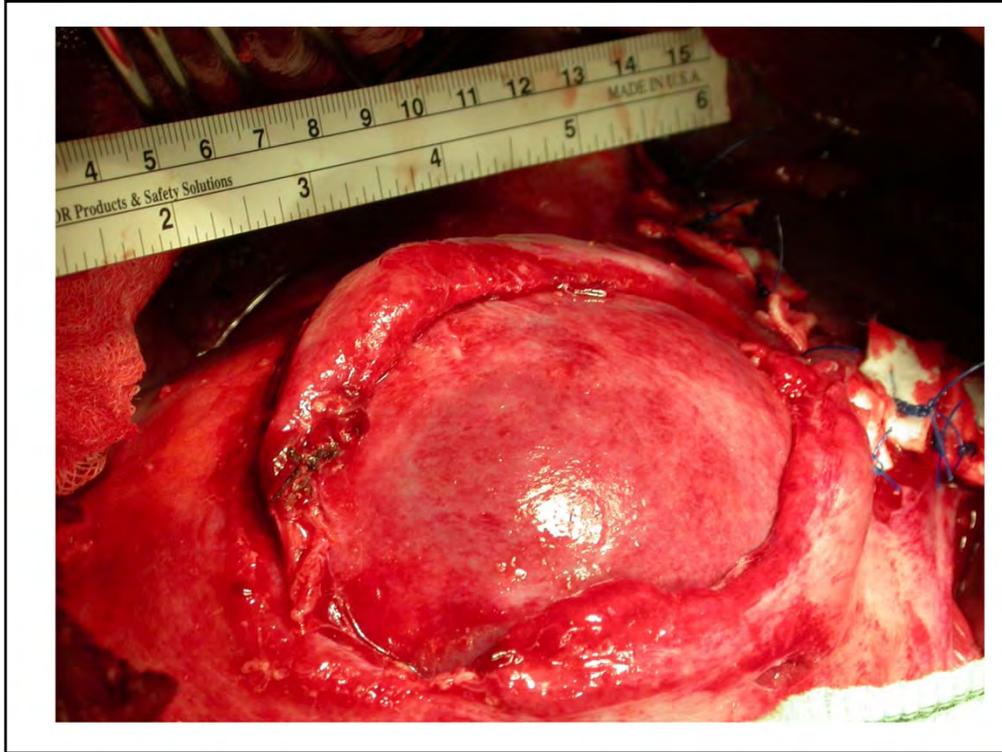


Operative repair is necessary because visceral herniation can occur even in small defects. Laparotomy is preferred for acute traumatic tears unless it is a penetrating trauma where the entrance wound is in the chest and a thoracic approach may be utilized.

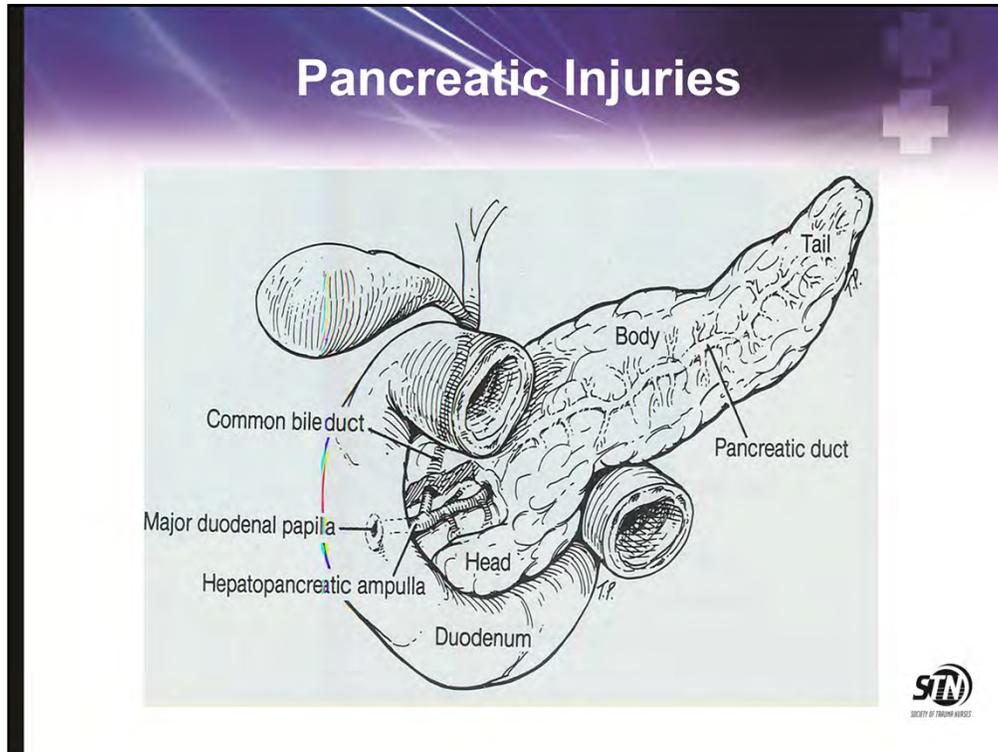


Intraoperative

Note hole in diaphragm



Abdomen contents herniating through diaphragm.



- The illustration shows the location of pancreas to include head, body, and tail as well as ductal system. As well as the relationship to the duodenum.
- Located retroperitoneally at the level of L-2
- Extends from C-loop of duodenum to hilum of spleen
- Rupture often tears ductal system and allows invasion of pancreatic juices
Blood supply is from the splenic artery and vein and the superior mesenteric artery and vein. Due to its location, a blunt trauma mechanism can force the pancreas against the vertebral column causing it to rupture. If rupture tears the ductal system, digestive enzymes invade

Whether minor or major injury, it is usually easy to diagnose but becomes a major therapeutic challenge for the clinical team and the patient, depending on extent of injury.

Pancreatic Injuries

Incidence

- Uncommon
- Associated with other abdominal injuries
- Majority caused by penetrating trauma
- Blunt trauma is usually a direct blow or compression type force
- Mortality is variable



Its location and proximity to other organs and vessels make multiorgan injury a frequent occurrence.

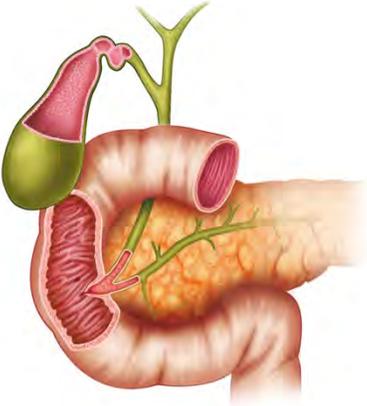
Over 90% of pancreatic injuries have an associated intra-abdominal injury.

GSW and stab wounds frequently include pancreatic injury, occurring in approximately 20-30% of all patients with penetrating traumas

Early deaths are secondary to hemorrhage. Late deaths result from infection.

Duodenum

- First part of small intestine
- Location of most digestion and absorption
- Divided into four sections with only the superior portion residing in the peritoneal cavity
- Rapid deceleration may lead to rupture
- Vulnerable to compression injuries




SOCIETY OF TRAUMA NURSES

Primarily a retroperitoneal organ and considered the first part of the small intestine. Significant portions of the duodenum lie directly over the spinal column, and it is bordered anteriorly by the liver, colon, and stomach. The duodenal sweep is bordered by the gallbladder laterally and the head of the pancreas medially.

The duodenum is the receiver of the highly acidic chyme from the stomach. Only the superior portion is located within the peritoneum. The descending, transverse, and ascending segments are located in the retroperitoneum.

Due to its location, rupture may occur between the anchored and free segments. Compression injuries are seen due to its location over the vertebral column.

Duodenal Injuries



Incidence

- Majority caused by penetrating trauma
- Blunt trauma is usually compression type
- Mortality is variable
- Multi-organ injuries



Its locations and proximity to other organs and vessels make multi-organ injury a frequent occurrence.

98% duodenal injuries have an associated intra-abdominal injury.

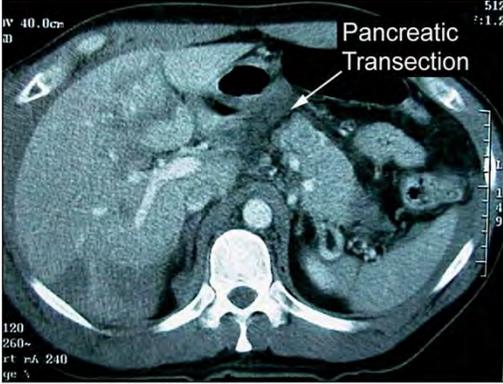
Due to the location of various segments of the duodenum, usually the second portion, vertebral column fractures are associated. Chance fracture, transverse process fractures, etc.

Image is from a compression injury (BMX rider vs. handlebars)

Pancreatic and Duodenal Injuries

Assessment

- Peritoneal symptoms not evident but appear later
- CT scan is the exam of choice
- Injury usually found intraoperatively



STN
SOCIETY OF TRAUMA NURSES

The pancreas is a retroperitoneal structure, and the duodenum is primarily a retroperitoneal structure so symptoms of the injury may not be evident for 24 to 72 hours.

Note pancreatic transection on image

If isolated, initial complaints are vague, however, within 6-24 hours after injury, the patient will complain of midepigastic or back pain with evolving peritoneal signs.

The head of the pancreas lies at the level of L2. This is why associated transverse process fractures or a Chance fracture may have an associated pancreatic injury.

Pancreas – Although CT scan is the exam of choice, and will identify contusions and hematomas of the pancreas early, it may not identify the actual pancreatic lacerations or transection initially.

Duodenal – CT scan findings include paraduodenal hemorrhage; air or oral contrast leak

Usually these injuries are found intraoperatively when other injuries are being repaired. Or, when peritoneal signs are apparent and CT scans are repeated.

Pancreatic and Duodenal Injuries



Assessment

- Blunt injury to duodenum can produce intramural hematoma
- Perforation causes contamination



Duodenal injuries are among the most commonly missed injury during exploratory laparotomy.

If diagnosis is made > 24h post injury, mortality is 40%. Complications occur in 64% of duodenal injuries.

Image is of a GSW to the pancreatoduodenal complex.

Pancreatic and Duodenal Injuries

Management

- Options depend on site and severity
- Primary closure
- Simple external closed drainage
- Distal pancreatectomy
- Pancreatic duodenectomy

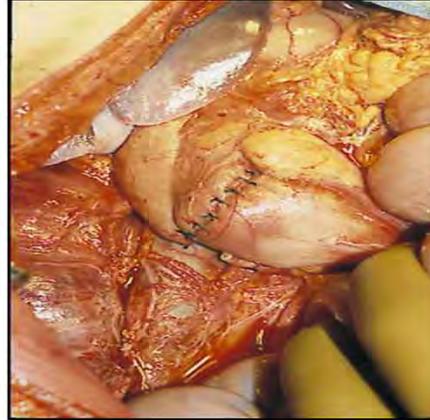


Photo after repair.

Goals are to control hemorrhage, debride devitalized tissue, and provide drainage. Various management options depending on the site of injury, severity, and whether or not there is ductal involvement.

Removal of 90 percent of the mass of the pancreas can be performed without resulting in diabetes.

Pancreatic and Duodenal Injuries

Duodenal Management	Pancreatic Management
<ul style="list-style-type: none">• Debridement and primary repair• Surgical procedure depends on hemodynamic stability and duct involvement• Nonoperative management requires close observation	<ul style="list-style-type: none">• Primary cause of death is hemorrhage• Late deaths are due to sepsis, ARDS, multiple organ failure• Observe for complications



Nonoperative management requires close observation for expanding or ruptured hematomas causing bleeding or peritoneal contamination.

Pancreatic injuries can be complex to manage. Complications include fistulas, pseudocyst formation, pancreatic abscess, recurrent hemorrhage and pancreatitis.



Image is of gunshot wound to the stomach

Stomach Injury

Incidence

- Rare; more common in children
- Commonly involves adjacent organs
- Protected by location and mobility
- Most common cause is penetrating injury





Sometimes referred to as a gastric injury.

Injuries to the stomach are very rare in blunt abdominal trauma. The stomach has very strong walls and these are not torn by blunt trauma unless it is very severe or the stomach is full, or both.

Occurs in 10-15% of penetrating trauma.

Image is of GSW to stomach.

Stomach Injury



Assessment

- Symptoms variable and nonspecific
- May include severe epigastric or abdominal pain, tenderness, signs of peritonitis
- Clouded by associated injuries
- Bloody output from gastric tube
- Free air on radiograph
- Findings on CT or DPL



The initial inflammatory response is due to chemical irritation rather than bacterial contamination. The stomach has a high acidic environment normally and is relatively free from bacteria

Bloody output from the gastric tube is seen in a third of patients with penetrating gastric wounds.

Free subdiaphragmatic air is seen in less than 50% of blunt gastric ruptures.

A presentation slide with a purple gradient background and a white cross in the top right corner. The title "Stomach Injury" is centered at the top in white. Below it, the word "Management" is written in black. A bulleted list follows, and the STN logo is in the bottom right corner.

Stomach Injury

Management

- Gastric decompression
- Surgical intervention
- If contamination exists, copious peritoneal irrigation and delayed primary closure
- Monitor for postoperative complications



STN
SOCIETY OF TRAUMA NURSES

The placement of a gastric tube is essential and should remain until gastric emptying returns to normal.

Surgery includes debridement, diligent irrigation to remove any contaminants, and primary closure. Obviously, appropriate timing and selection of antibiotics is important.

Complications are rare. Judicious irrigation is essential to prevent complications such as peritonitis intra-abdominal abscesses to include subphrenic, subhepatic, and pelvic as well as those of the lower sac, and formation of gastric fistulas.

Small Intestine

Jejunum and Ileum

- Responsible for nutrient absorption and fluid and electrolyte shifts
- Jejunum lies in the umbilical region
- Ileum lies in the hypogastric and pelvic regions
- Vulnerable to seatbelt injury

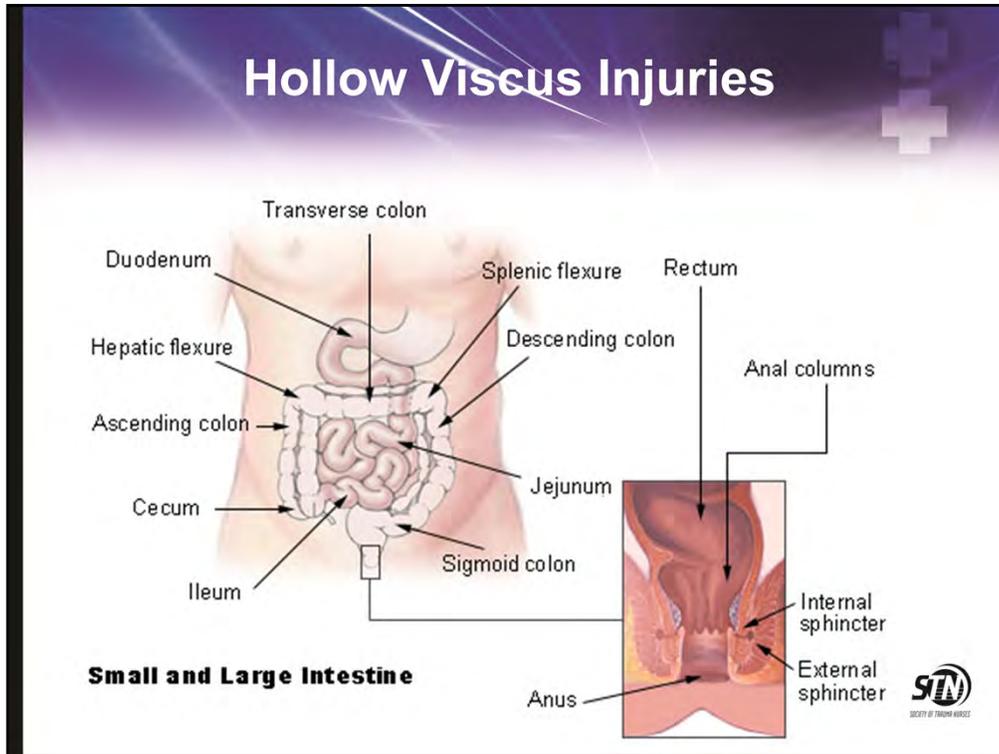


The small intestine is divided into three structural parts: the duodenum (already discussed) and the jejunum and ileum

The lap belt can cause the bowel to be crushed between the vertebrae and a solid object.

Note seat belt mark in the image.

Not always diagnosed on initial presentation, and this delay contributes to morbidity and mortality.



Review the anatomy of location of key structures.

Duodenum, Jejunum, Ileum



What is wrong with this picture.

Obviously, a seatbelt sign in an obese abdomen. However, more importantly, one can see the incorrect wearing of the seat belt, high across the abdomen, which increases the chance for injury.

Small Bowel Injury

Incidence	Assessment
<ul style="list-style-type: none">• Most frequently injured by penetrating trauma• Blunt injury is relatively uncommon• Presence of pancreatic and solid organ injury are predictive of increased risk for hollow viscus injury	<ul style="list-style-type: none">• Clinical signs may not be apparent initially• Signs of peritonitis develop• Any blow to the abdomen or penetrating injury to the lower chest or abdomen should increase suspicion of injury



Direct blows crush the intestine between the force and the vertebrae. Shearing forces occur in MVC.

It is the most commonly injured intra-abdominal organ in penetrating trauma. The lack of specific symptoms initially should challenge the nurse to carefully evaluate all information provided from the scene until admission. Spinal injury may occur with bowel trauma and may mask symptoms.

Small Bowel Injury



Management

- Bleeding should be controlled prior to exploration
- Debridement followed by primary closure and ligation of bleeders
- Bowel resection for multiple defects
- Gastric decompression and parenteral nutrition not usually required if isolated
- Antibiotics recommended
- Observe for complications such as wound infection and abscess


SOCIETY OF TRAUMA NURSES

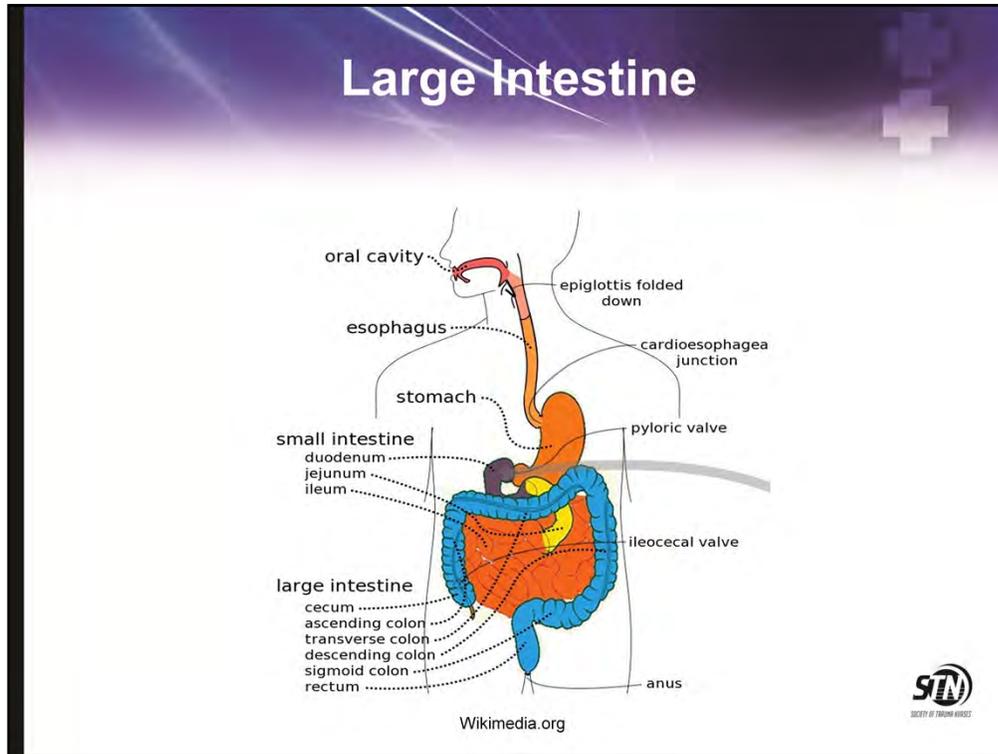
Hemoperitoneum can be associated with injuries to the mesentery and ligation of bleeders is necessary as they can bleed massively.

Bowel resection will be performed for larger or multiple injuries with end-to-end anastomosis as indicated.

Antibiotics are given postoperatively to reduce the incidence of postoperative infections after contamination.

Complications are related to the extent of contamination.

There is a possibility for an anastomotic leak that will show up as a enterocutaneous fistula, peritonitis, or intra-abdominal abscess.



Just completed review of the small intestines and now we will discuss the large intestines, comprised of the colon, cecum and rectum

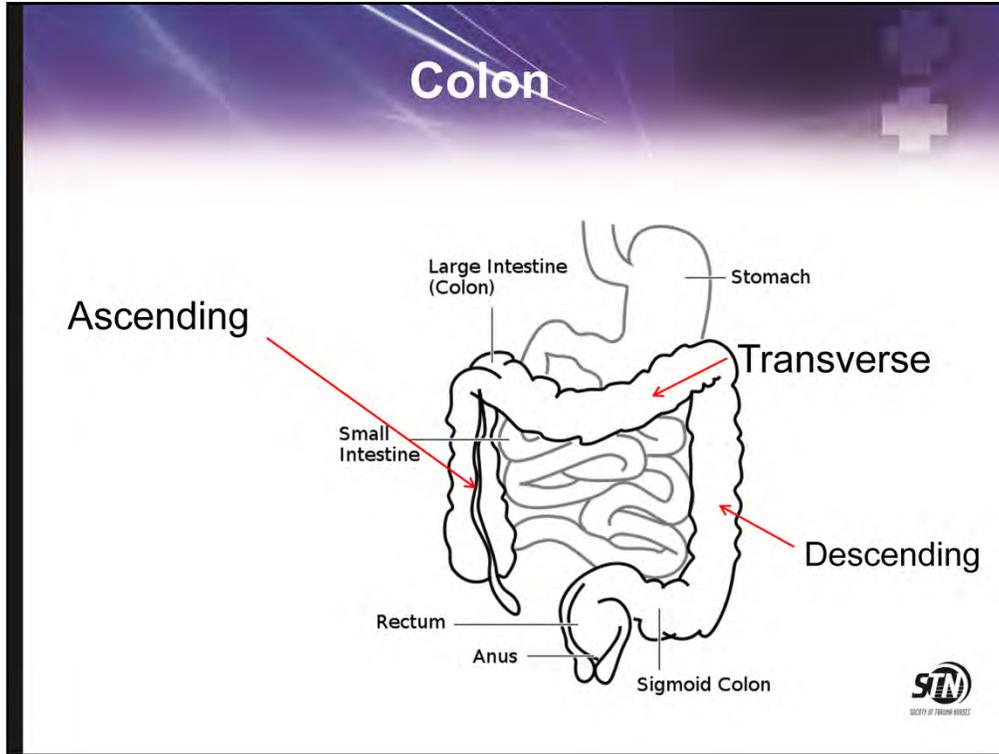
Digestive functions

- Absorption of water and electrolytes
- Synthesis of certain vitamins
- Temporary storage of intestinal waste
- Elimination of body waste

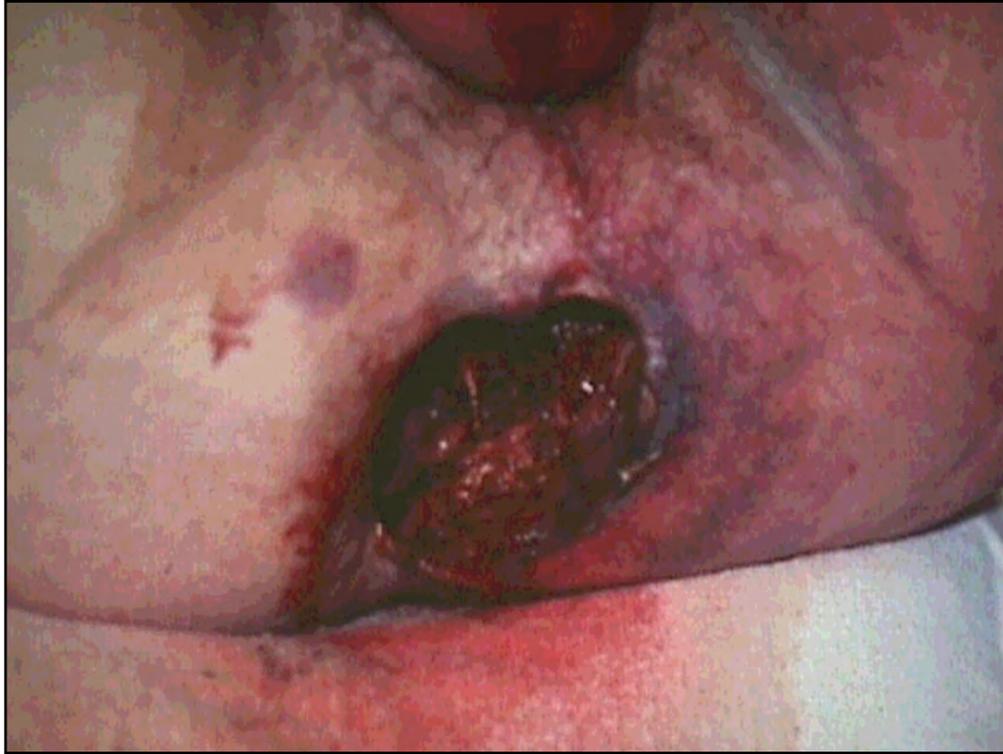
Blood supply from superior and inferior mesenteric arteries

Bacteria such as *E coli* in the intestinal tract is natural and are important in the synthesis of vitamins K and B complex but it causes significant problems in the bloodstream and urinary system.

Rectal injuries may be associated with severe pelvic fractures.



The colon is made up of three sections: ascending, transverse and descending



Severe pelvic fractures with destroyed rectum.

Large Bowel Injury

Incidence	Management
<ul style="list-style-type: none">• One of the most lethal abdominal injuries• Mortality affected by associated injuries• Penetrating injury is the most common	<ul style="list-style-type: none">• Early recognition and control of contamination• Exploratory laparotomy with primary repair and colostomy• Preoperative antibiotics• Observe for complications



Lethal due to the probability of sepsis related to fecal contamination.

96% of injuries to the colon and rectum are due to penetrating trauma. The transverse colon is most often injured.

Blunt trauma affects the sigmoid and transverse colon. Most injuries are contusions.

A laparotomy is performed when perforation to the colon or rectum is suspected. Operative management includes hemorrhage control, fecal contamination, and irrigation. If primary repair cannot be done, a colostomy may be needed.

Complications include incisional infection. Delayed skin closure is advocated in patients with major contamination. Intra-abdominal abscess is the most frequent complication.

Abscesses can be percutaneously drained.



Largest intra-abdominal organ in the body. It weighs approximately 3-4 pounds and lies in the RUQ. It is the most vulnerable to blunt injury because of its size and location

75% of blood to the liver is delivered by the portal vein

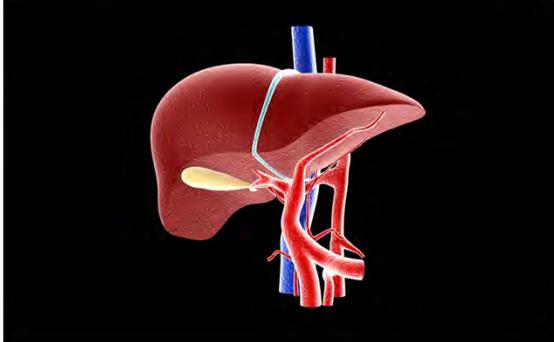
- The porta hepatis is located between the two lobes and provides the entry and exit points of all vessels and nerves as well as bile ducts.
- The majority of nutrient rich blood is delivered via the portal vein.
- Additional nutrient rich arterial blood enters through the hepatic artery.
- The right and left hepatic veins dump into the IVC. The mixture of blood occurs in the central vein of each lobule and is then channeled to the lobular veins which empty into the inferior vena cava.

The liver may be lacerated or contused, and it may leak bile without serious consequence. One can appreciate this rich vascular supply and the complicated surgical repair.

Uncontrolled hemorrhage is the primary cause of death

Liver Functions

- Detoxification
- Synthesis of plasma proteins
- Storage of iron and vitamins
- Metabolism of carbohydrates, protein, and fats
- Phagocytization of bacteria




SOCIETY OF TRAVEL NURSES

The liver performs many vital functions.

It is responsible for detoxifying various substances to include alcohol and drugs. By synthesizing plasma protein, the liver plays an important role in maintaining blood volume and controlling coagulation.

The liver provides storage of iron as well as certain vitamins, ADEK and vitamin B12.

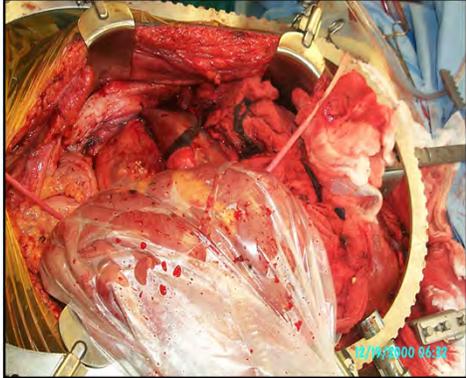
It also serves as the site for metabolism of carbohydrates, fats, and proteins.

This results in regulation of blood glucose, synthesis of amino acids and conversion of nitrogen to urea for excretion, and synthesis of cholesterol and phospholipids as well as conversion of excess dietary protein and carbohydrates to fat.

Lastly, the Kupffer cells perform phagocytosis of bacteria.

Point out anatomical areas and the liver's relationship to other abdominal organs.

Liver Injury



- Commonly injured organ
- MVC most common cause
- Mortality 10% to 15%



Size and location make it susceptible to injury from both blunt and penetrating trauma.

Either liver or spleen, depending on the reference.

Factors affecting mortality include associated injuries, the length of time from injury to treatment, and overall pre-morbid condition. The greatest risk following injury to the liver is severe hemorrhage.

Liver Injury

Assessment

- Suspect in any patient with blunt injury to right side
- Penetrating trauma produces a range of injuries
- FAST, CT scan
- Grading system





MVCs cause crushing of the liver between the ribs and vertebrae. Blunt injuries range from stellate lacerations or major fractures and are more lethal. Death results from exsanguination, and in later stages, sepsis.

Stab wounds and low velocity gunshots produce minor lacerations, but high velocity gunshot wounds produce more widespread damage that creates massive hemorrhage.

Obviously, the signs and symptoms are those associated with pain to the affected area and shock like symptoms if injury is serious.

FAST is commonly used initially to rule out free fluid.

CT scan is the preferred modality of choice in hemodynamically stable patients with blunt trauma and suspected injuries. Injuries can be graded from I to VI. Helical CT scanners offer better imaging and provide clinicians more information when determining operative vs. nonoperative management.

Many centers have established care guidelines for certain grades of injury. Reference www.aast.org for information on grading.

Note liver injury on CT.



Liver Injury

Management

- Nonoperative management in select patients
- OR for complex lacerations; arterial blush
- Angioembolization
- Aggressive intraoperative resuscitation
- Possible damage control


SOCIETY OF TRAUMA NURSES

The trend in blunt hepatic trauma is nonoperative management for hemodynamically stable patients. Historically, liver trauma was explored and packed, however, the nontherapeutic laparotomy rate reached as high as 67%. The presence of hemoperitoneum does not mandate exploratory laparotomy in the stable patient. The selection of patients for nonoperative management involves those who are usually neurologically intact and hemodynamically stable. These patients can be managed nonoperatively with high success.

Arterial blush or contrast pooling indicates a more significant injury that requires further evaluation and potentially operative intervention and/or angioembolization. If operative intervention is indicated, packing may be required if bleeding persists, and the patient is not stable enough for additional surgical intervention. The patient is taken to the ICU for continued resuscitation and stabilization and will be taken back to the OR in 24 to 36 hours for removal of packing, definitive management of the liver, and possible closure.

Aggressive resuscitation with hemorrhage control is required to prevent hypothermia, coagulopathy, and maintain hemodynamic stability. The risk for abdominal compartment syndrome must be considered.

The nurse's role is key in resuscitation and ongoing monitoring.

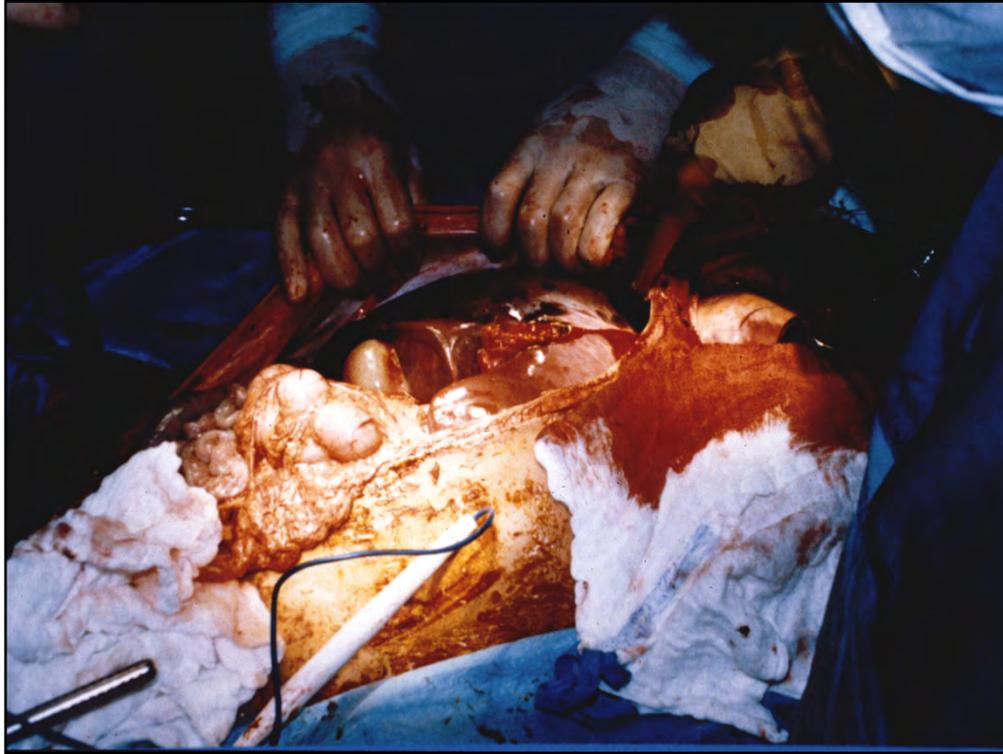


Image shows a hemorrhagic liver injury intraoperatively.



Liver Injury

Observe for complications

- Recurrent bleeding
- Hemobilia
- Abscess
- Biliary fistula
- Arterial-portal venous fistula
- Sepsis
- Liver failure



Occasionally, the patient must be returned to the OR for recurrent bleeding, usually as a result of inadequate hemostasis initially.

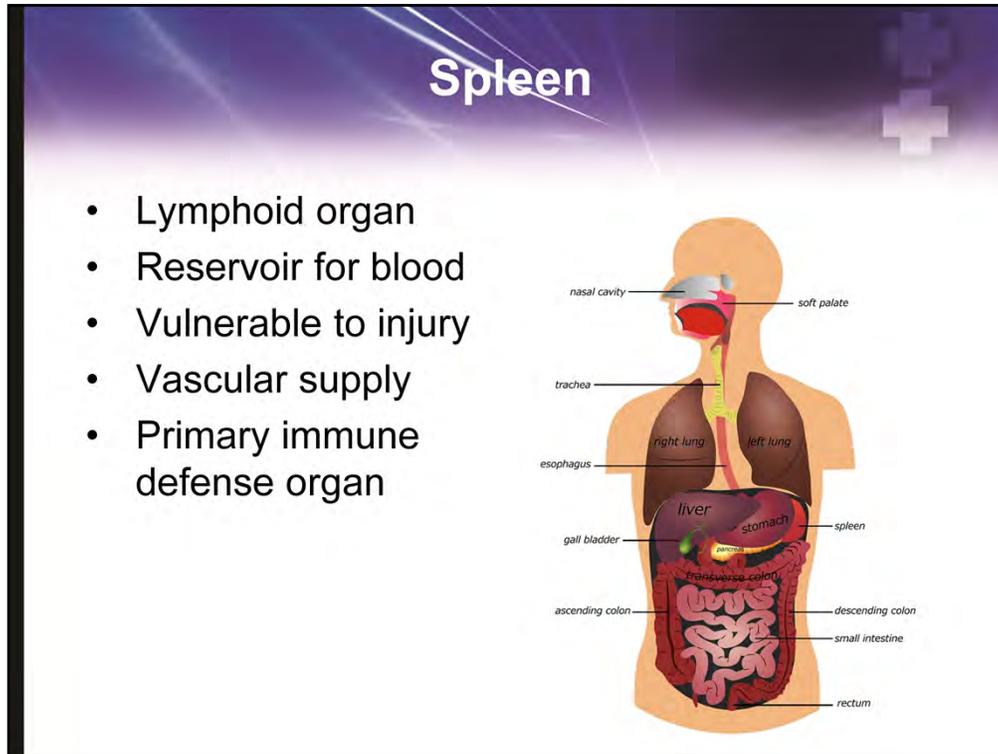
Hemobilia – RUQ pain with jaundice; may present days and weeks post injury so follow-up care is important.

Abscess – intrahepatic, perihepatic or biloma occur up between 7%-40% in the literature. Treated by percutaneous drain.

Biliary fistula – usually resolve nonoperatively. If output is high, >300ml per day, further investigation with a fistulogram, ERCP or transhepatic cholangiogram may be necessary. Ductal injury can be repair with stenting if necessary.



Image is a spleen in a bucket!



The spleen is a lymphoid organ functioning in defense, hematopoiesis, and RBC and platelet destruction. Macrophages break apart the hemoglobin molecule from the destroyed RBCs and salvages the iron and globin and returns it to the bloodstream for storage in the bone marrow and liver. Approximately 90% of the splenic blood flow participates in the filtering process.

The spleen is a functionally complex organ occupying the left upper quadrant (LUQ) and is vulnerable to injury due to its proximity to left ribs 7-10. The spleen is the most vascular organ of the body, and approximately 350 L of blood passes through it per day. The spleen contains approximately 1 unit of blood at a given time, and injury poses a potentially life-threatening situation.

The blood supply is from the splenic artery which enters the spleen at the hilum and the splenic vein which originates outside the hilum. It joins the superior mesenteric vein to form the portal vein. It is extremely vascular and a source for profuse bleeding after injury.

Splenic Injury

- Incidence
 - Commonly injured abdominal organ
 - Mortality depends on the type of trauma and associated injuries
 - Mortality related to uncontrolled hemorrhage, delayed rupture, and sepsis



Stated to be the most commonly injured intra-abdominal organ in most resources. However, depending on the resource, the spleen is either the most commonly injured organ or second most commonly injured organ, the liver being the other. Splenic injuries represent approximately 25% of all blunt injuries to the abdominal viscera.

The location of the spleen makes it vulnerable to penetrating trauma of the LUQ. The lower ribs in the LUQ provide some protection, however, can also cause injury due to penetration from fractures. Penetrating injuries also frequently involve the spleen along with other abdominal organs.

The diagnosis of penetrating splenic injury is made easily because patients will most likely go to surgery for a penetrating injury to the abdomen.

Splenic Injury

Assessment

- Suspect in any patient with blunt injury to left side
- Penetrating trauma can produce a range of injuries
- FAST, CT scan, Angio
- Grading system



The most common finding associated with splenic injury is left lower rib fractures signifying adequate force has been transmitted to the LUQ . Left lower rib fractures are present in 44% of patients with splenic rupture.

As with other types of abdominal trauma, the signs and symptoms are those associated with pain to the affected area and shock like symptoms if injury is serious. In splenic injury, one may have referred pain to the left shoulder caused by the blood irritation to the phrenic nerve. This is called Kehr's sign.

Initial evaluation of abdominal trauma is done with FAST to rule out free fluid. If positive, free fluid will usually be seen around the spleen or in Morrison's pouch.

Nonoperative management should be considered for patients with splenic injury who are hemodynamically stable and who have no associated abdominal or CNS injuries that may preclude an accurate assessment of the abdomen by physical examination. CT scan is the preferred imaging modality of choice in hemodynamically stable blunt trauma. Injuries can be graded from I to VI. Helical CT scanners offer better imaging and provide clinicians more information when determining operative vs. nonoperative management. Active extravasation of contrast indicates ongoing bleeding and the need for urgent intervention.

The classic triad indicative of acute splenic rupture (i.e., left hemidiaphragm elevation, left lower lobe atelectasis, and pleural effusion) is not commonly present and should not be regarded as a reliable sign. However, any patient with apparent left hemidiaphragm elevation following blunt abdominal trauma should be considered to have splenic injury until proven otherwise.

More reliable signs of LUQ injury are medial displacement of the gastric bubble and inferior displacement of the splenic flexure gas pattern on radiology images.

Angioembolization may be utilized in select patients.

Many centers have established care guidelines for certain grades of injury. Reference www.aast.org for information on grading.

Splenic Injury

Management

- Nonoperative in select patients
- Splenorrhaphy and partial splenectomy
- Splenectomy
- Aggressive intraoperative resuscitation
- Possible damage control





The traditional treatment of blunt splenic trauma was splenectomy. However, more trauma surgeons are performing splenic salvage through nonoperative management as they recognize the important role the spleen plays in preventing overwhelming sepsis. When making nonoperative management decisions, the patient's age, stability, associated injuries and type of splenic injury are evaluated.

If operative intervention is necessary, repair of the spleen or partial splenectomy is recommended when possible due to the role of the spleen in maintaining immunocompetence. Removal of the spleen is indicated for the patient with associated life-threatening injuries and shock. In cases of severe hemorrhage, resuscitation is aggressively performed with possible damage control procedure depending on patient's stability.

Splenic Injury

Management

- Monitor for failed observation
- Observe for postoperative complications
 - Bleeding
 - Thrombocytosis
 - Gastric distention
 - Pancreatitis
 - Infection
- Ensure vaccines are given prior to discharge



The nurse's role is key to patient assessment. When observing a patient with known splenic injury, monitor signs and symptoms of increasing pain, shock like state, etc. This may indicate a failed attempt at nonoperative management. In the postoperative period, the nurse should observe for any complications and notify the appropriate surgeon as indicated.

Studies have shown that as many as 70% of patients may be treated nonoperatively, with success rates of up to 97%. Nonoperative management of splenic injuries is effective in more than 95% of children.

Again, the nurse's role involves close observation for any complications, resuscitation, and after the acute period, ensuring vaccines are administered prior to discharge. Vaccinations include pneumococcal vaccine, H. influenza and meningococcal vaccines.

There is not a lot of good evidence regarding vaccine administration and few studies. The CDC still recommends all three vaccines to be given day 14 post splenectomy or just prior to discharge due to issues in follow-up. Current recommendations include repeated pneumococcal vaccine at 5 years.

Discharge instructions related to activity will need to be provided to patients who have had nonoperative management and are discharged home for continued recovery.

Overwhelming Postsplenectomy Sepsis (OPSI)

- Rare
- Can occur from 1 to 5 years after surgery
- Illness presents with flu like symptoms, shock from sepsis, and DIC followed by death
- Mortality is 50%
- Preventative measures include vaccinations and education



Rare; Few cases documented; less than 0.5%
More common in children

Retroperitoneal Hemorrhage

- Management depends on the location
- Penetrating trauma requires exploration
- Blunt trauma –pelvic fractures
- Hematoma – explore vs. leave alone

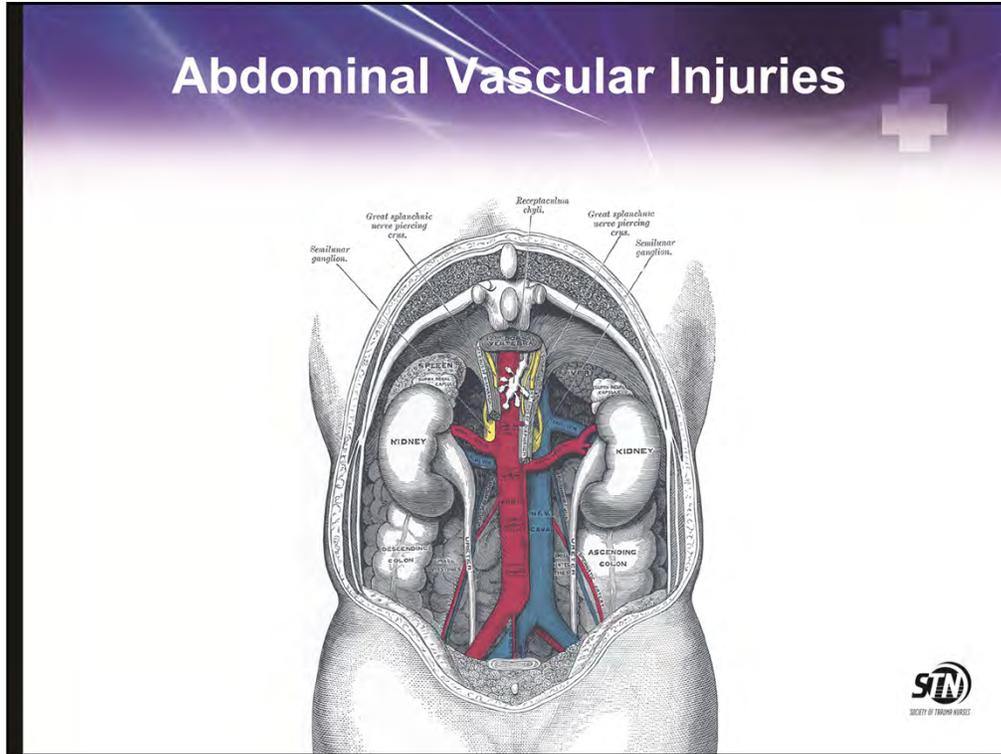


70-80% retroperitoneal hemorrhage is due from blunt trauma involving pelvic fractures.

Much debate has occurred over the years as to how to intraoperatively manage a retroperitoneal hematoma. Most will advise to leave intact unless expanding, pulsatile, etc. The challenge is to gain control prior to exploring



Note Yellow line – extravasation of contrast from artery in retroperitoneum



Abdominal Vascular Injury

Arterial injury

- Can stop bleeding spontaneously
- Usually occur with pelvic, thoracic, or visceral injury
- Vascular signs may be obscured initially
- Symptoms may include abdominal pain, back pain, hypoactive bowel sounds, tender abdominal mass



More patients are surviving vascular injuries that previously caused them to exsanguinate before transport or in the ED. Injuries occur as a result of penetrating trauma primarily, however, blunt injury can also occur.

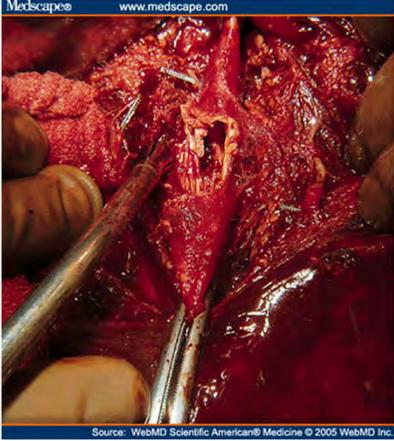
After a clean transection, arterial injuries secondary to penetrating injury can stop bleeding spontaneously.

Retroperitoneal hematoma in conjunction with pelvic or spine trauma may cause up to 4 liters of blood to collect.

Abdominal Vascular Injury

Arterial Injury Management

- Volume replacement
- Immediate surgery
- End to end anastomosis or graft
- Monitor for adequate volume status postoperatively



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GSW to Infrarenal Aorta

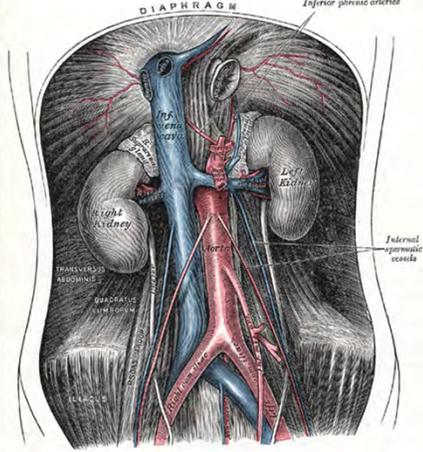


Restoration of volume may be impossible without surgical control.

The repair depends on the type and extent of injury.

Autogenous graft is preferred because many wounds are contaminated. Many injuries may require ligation if the site is contaminated.

Abdominal Vascular Injury



The diagram illustrates the abdominal cavity with the diaphragm at the top. The inferior phrenic arteries are shown crossing the diaphragm. The right and left kidneys are depicted on either side of the spine. The internal spermatic veins are shown descending from the kidneys. The diagram is labeled with 'DIAPHRAGM', 'Inferior phrenic arteries', 'Right Kidney', 'Left Kidney', and 'Internal spermatic veins'.

Venous Injury

- Low pressure system capable of tamponade effect
- Emergent operative repair for instability
- Diagnostic tests for stable patients to determine extent of injury



Shock unresponsive to fluid administration should cause one to suspect major injury.

Abdominal Vascular Injury

Venous Injury Management

- Quick assessment
- Massive fluid resuscitation
- Pressure and packing
- Operative repair to include ligation and grafting
- Monitor for complications



Some complicated repairs lead to stenosis of the vessel and increased risk of thrombosis or embolism. Others include dehiscence of the suture line and infection as well as bleeding.

Abdominal compartment syndrome can develop.



Damage Control

- Abbreviated laparotomy
- Containment of bleeding and contamination
- Temporary intra-abdominal packing
- ICU for physiologic restoration
- Definitive repair



Damage control in a difference sense. This term was first coined in the early 90s to describe a “salvage” philosophy for patients with exsanguinating hemorrhage.

The approach arose out of the need to stop hemorrhage within the abdominal cavity, stage resuscitation, and correct coagulopathy, acidosis, and hypothermia....The Triad of Death. A move away from the traditional approach in which the surgeon “completed” the laparotomy which often led to the triad of death.

Note open abdomen with VacPak

Damage Control

Three phases

- Control hemorrhage and contamination
- Continued resuscitation in ICU
- Planned reoperation for removal of packing; definitive repair with attempted closure

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In the ICU: Optimization of hemodynamics and oxygen delivery/consumption, clearance of lactate, core rewarming, correction of coagulopathy, ventilatory support, monitoring for abdominal compartment syndrome, and identification of additional injuries.

Key points:

- Involves the placement of multiple laparotomy pads within the abdominal cavities.
- OR reports in the chart should reflect that “the sponge count was incorrect.”
- Any dressing changes and re-packing that occur in the Operating Room or in the ICU, must include lap sponges removed and replaced; all notes should indicate “sponges were left in the abdomen.”

Did you know?

- A retained sponge at any time during the period which the abdomen is “open” with a VacPak™ or Whitman patch™ is not considered an adverse event and is simply part of the management of “Damage Control” and the open abdomen.



- At the time of definitive abdominal closure, a series of x-rays must be obtained in the OR prior to closure showing the entire body cavity
- The dictated sponge count is “incorrect” must be included in the operative reports

Surgical Counts

- X-ray detectable sponges
- Count “incorrect” on operative record
- Obtain an x-ray at end of permanent closure
- Document when x-ray is done in lieu of count



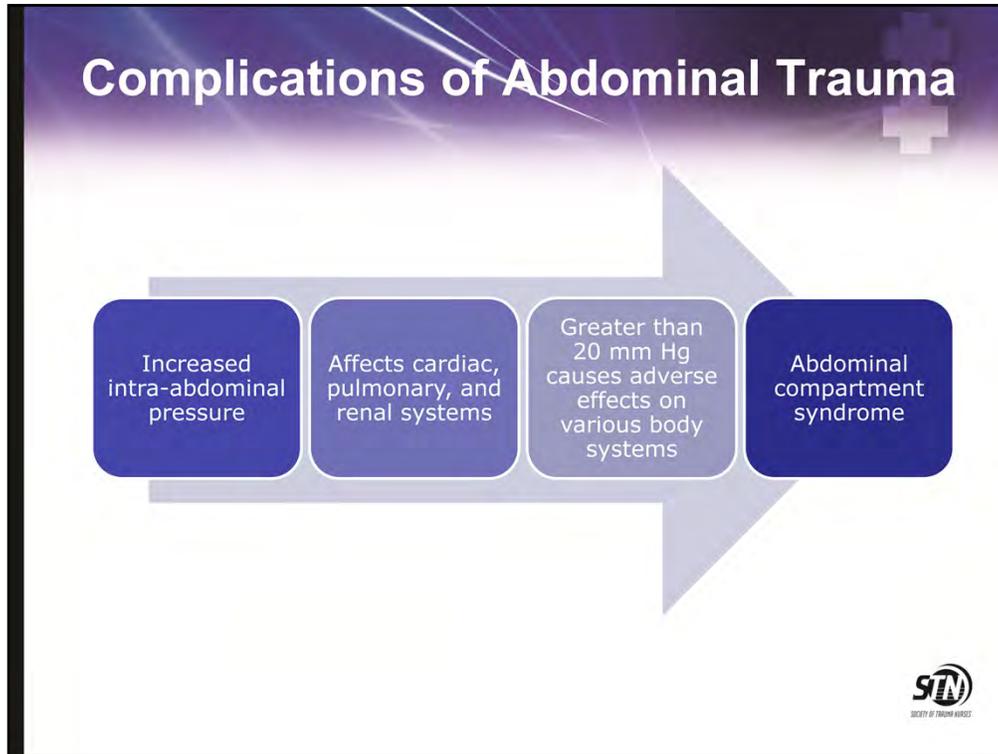
What is Your Policy?

As a matter of process, one should check their hospital policy to ensure Damage Control is included.

X-ray detectable sponges may be used as packing to facilitate removal at a later date e.g. “Damage Control.”

Count- When counted sponges are used as packing, they should be documented/dictated as incorrect.

An x-ray should always be done at the end of the permanent closure to fully evaluate cavity and validate that all sponges have been removed.



The extent of organ involvement, level of injury, and time of injury until treatment affect the morbidity.

Increased intra-abd pressure prevents venous return (preload reduction) and impedes arterial outflow (increase in afterload). Transmitted backpressure from the abdominal cavity falsely elevates CVP, PAP, PCWP, PVR, and SVR.

Due to decreased preload and venous stasis, patients may develop DVTs; once IAH resolved, pulmonary emboli may occur.

Renal parenchyma is compressed reducing blood flow and urinary output.

Increased intrathoracic pressure (sec to abd) limits diaphragmatic excursion resulting in hypoventilation and hypoxia. Increased PIP; decreases tidal volume

It also impedes venous outflow from the brain increasing cerebral congestion so there is increased ICP but decreased CPP.

Decreased perfusion to gut exhibited by decreased intramucosal pH (pHi)

Occurs when the pressure within a closed anatomic space increases to the point that vascular flow into the area is compromised and the function and viability of the tissues within the compartment are threatened

How? Within any closed body cavity when the size of the compartment is restricted; when the volume of the contents in the compartment is increased

What you see:

Tense distended abdomen

Failure of ventilation: high PIP, high pCO₂

Oliguria

Abdominal Compartment Syndrome

Primary Causes

- Resuscitation edema
- Bowel edema
- Postoperative hemorrhage
- Bowel obstruction
- Closure of abdomen under tension
- Abdominal packing



Abdominal compartment syndrome (ACS), also referred to as intra-abdominal hypertension, is a clinical condition in which elevated intra-abdominal pressure leads to impaired end-organ perfusion.

Causes... It can be caused primarily by the above. Fluid resuscitation is a known risk factor.

Intra-abdominal hypertension (IAH) is when the abdominal pressure is sustained at 12 mm Hg or greater

Abdominal compartment syndrome (ACS) pressure greater than 20 mm Hg produces physiological effects.

There are two types of ACS, primary and secondary, as defined by a consensus statement from the World Congress of ACS.

- Primary ACS is caused by a condition associated with injury in the abdominopelvic region requiring early surgical or radiological intervention, or a condition that develops following abdominal surgery e.g. surgical repair of abdominal organs, damage control surgery, bleeding pelvic fractures. It may also result from continuing hemorrhage from either a missed injury (surgical hemorrhage) or hypothermia/coagulopathy (non-surgical). Visceral edema from third spacing is also a consideration.
- Secondary ACS is caused from other conditions that do not originate in the abdomen and appear to be fluid sequestered in the viscera due to a reperfusion injury and increased capillary permeability.

Patient with open abdomen.

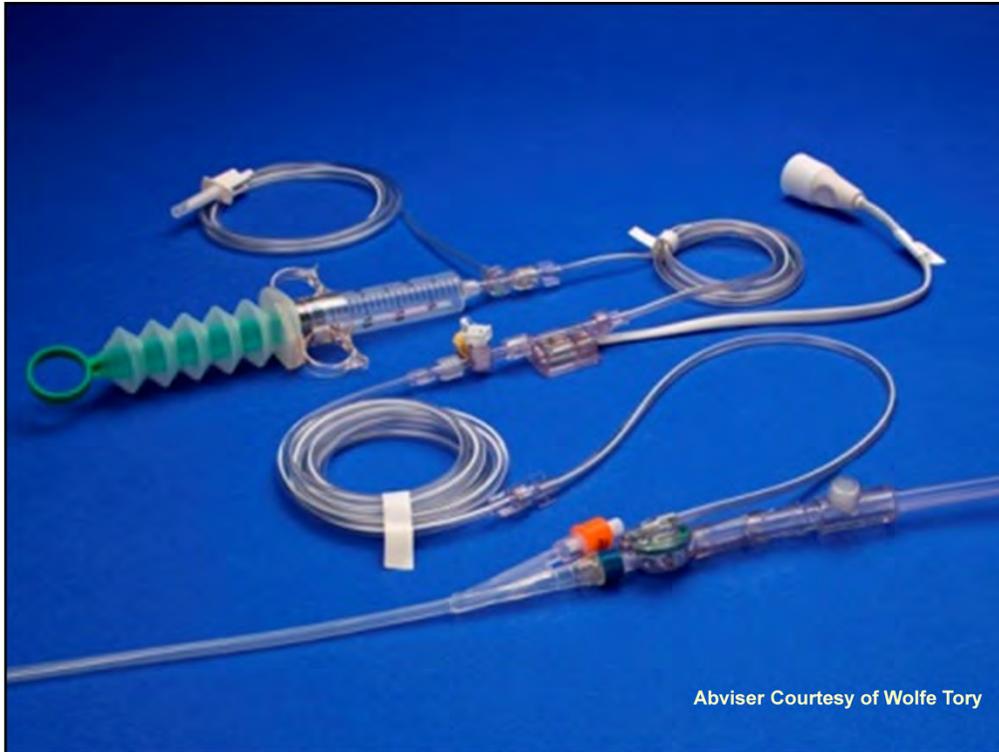
Abdominal Compartment Syndrome

Secondary Causes

- Intra-abdominal
- infection
- Ascites
- Ileus
- Pancreatitis
- Sepsis
- Major burns



Some of the secondary causes are listed above.



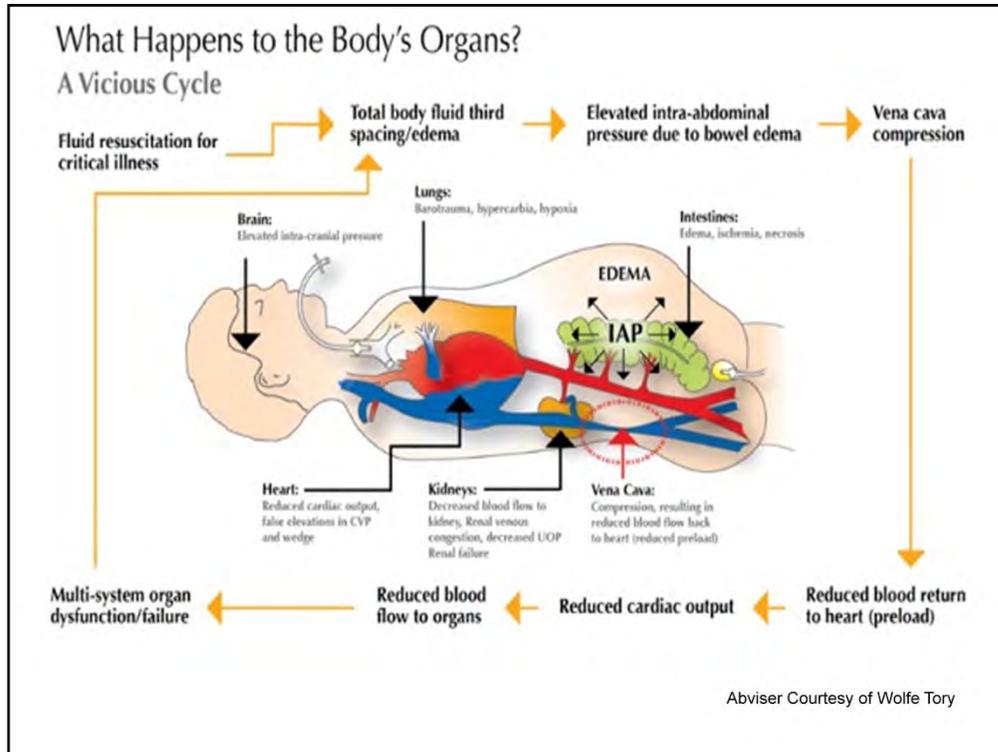
Discuss values for Intra-Abdominal Hypertension: Sustained 12 mm Hg or more

Abdominal Compartment Syndrome: Sustained pressures > 20 mm Hg; clearly an indication for decompression; Consideration should be given for pressures between 15 and 20 with signs of organ failure

. When pressure increases above 20 mm Hg and oliguria is present, the abdomen should be re-explored.

Other signs that the nurse should monitor include increasing abdominal girth, increasing tenseness, decreased I & O, increased peak inspiratory pressures, and worsening lung compliance.

- Any patient that has had massive fluid/blood resuscitation within a 24-hour period should have bladder pressure monitoring.
- Recommendation: Check bladder pressures when volumes approach 10 liters of fluid or 10 units of packed cells
- There are a few ways this can be done, however, the most simple and user friendly method is to use a commercially available kit called the ABVISOR.



Review the slide and all the changes that affect each body system as a result of abdominal compartment syndrome.

CV - Decreased cardiac output; Decreased preload; Increased afterload (SVR); Increased CVP and PCWP

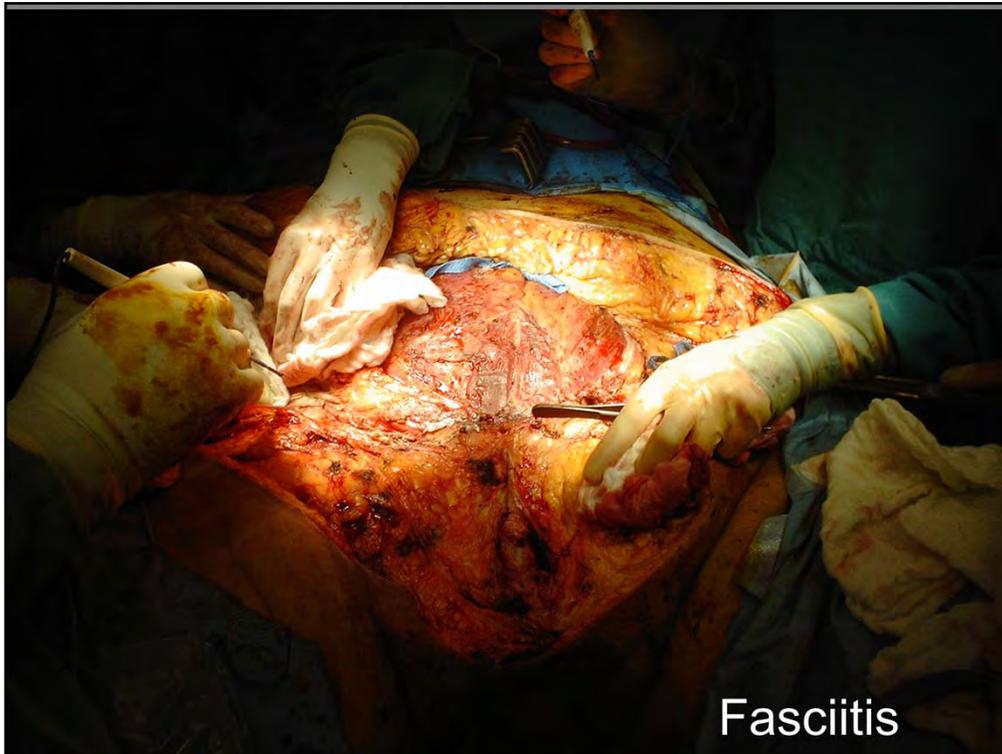
Pulmonary - Increased peak inspiratory pressures; Increased airway pressure; Hypoxemia, hypercarbia; Decreased compliance

Renal - Decreased renal plasma flow; Decreased GFR; Oliguria, anuria

Neurologic - Increased ICP; Decreased CPP

Intestinal and Mucosa - Decreased blood flow to all abdominal organs; Decreased mesenteric and mucosal blood flow

Abdominal wall abnormalities - Actual defects; Large, open wound; Repair
 Increased pressure; Reduces blood flow to abdominal wall; Leads to local ischemia and edema; Ischemia of muscle and fascia; Contributes to wound complications such as infection, dehiscence, herniation, and necrotizing fasciitis; Wall becomes less compliant and less capable of stretching to accommodate additional increases in pressure



Fasciitis as mentioned in previous slide

Reperfusion Phenomenon

- **Decompression**
 - Release of accumulated acids, metabolites (byproducts of anaerobic metabolism)
 - Profound cardiac depression and hypotension
- **To blunt effects**
 - 50 mEq Bicarb – may give 2-4 amps
 - Volume resuscitation



Review with the surgeon and staff the need for volume loading before abdominal decompression advocated as a means of controlling hypotension after acute reduction in SVR caused by a decrease in IAP or from ischemia-reperfusion phenomenon after decompression.

Some advocate giving the patient Bicarb to counter the influx of acids.

Complications of Abdominal Trauma

Acute acalculous cholecystitis (AAC)

- Acute inflammation of gallbladder
- Masked by concomitant injuries and interventions
- Contributing factors include decreased oral intake, TPN, use of narcotics and gallbladder ischemia may occur due to hypotension
- Diagnosis assisted by US, elevated WBC
- Requires surgical intervention



Cause of ACC is uncertain and most likely multifactorial.

Does not differ from calculous type except there is a higher rate of gangrene and perforation.

It is a diagnostic challenge because it can be masked by many things to include narcotic administration, incisional abdominal pain, other injuries or disease processes.

US is helpful in the diagnosis and an elevated WBC is found in 70% of cases.

The gallbladder can be removed by cholecystectomy or laparoscopic cholecystectomy.

Common Pitfalls

- Failure to suspect intra-abdominal injury from the mechanism of injury
- Failure to fully evaluate abdominal pain after sustaining blunt abdominal injury
- Failure to perform timely operative intervention
- Failure to recognize hemodynamic compromise and delay surgery for additional diagnostic testing



There are some common pitfalls in evaluating the patient with abdominal trauma.

General Nursing Considerations

- Preparation of patient
- Current knowledge of resuscitation
- Administer blood and blood products
- Prevent hypothermia
- Ongoing monitoring of patients
- Monitor intake and output
- Evidenced based practice



Throughout all procedures, nursing staff must closely monitor the patient, continuously re-evaluating the ABCs.

- The potential for bleeding and fluid volume deficit exists in patients with abdominal trauma.
- A thorough understanding of shock and resuscitation is essential in managing the critically injured trauma patient.
- Continuous monitoring is essential in minimizing the effects of hypovolemic shock.
- Blood and blood products should be administered as indicated.
- Warming measures to prevent hypothermia are essential and include the use of warm fluids/blood, warm blankets, warming lights, and heated respiratory gas applications.

Note: Preventing hypothermia is important to continue in the radiology suites as most are kept at a cool temperature due to the machinery operational requirements.

Frequent evaluations and the detection of changes in patients admitted for nonoperative management of solid organ injuries are essential. These patients may require serial exams and possible surgical intervention should nonoperative management fail.

The level of monitoring depends on the physiological and clinical needs of the patient. The use of cardiac monitoring, pulse oximetry, and arterial monitoring are usually sufficient for the uncomplicated patient, however, more complex patients may require the insertion of special monitoring devices utilizing advances in fluid monitoring and hemodynamic status.

Once the patient has been stabilized, the nurse's focus transitions to continued resuscitation as indicated and prevention of complications.

Nutrition, mobility, pain control, and wound care are just a few of the responsibilities throughout the continuum of care.

Due to the potential effects of multiple tests requiring contrast on the renal system, monitoring of intake, output, creatinine levels is essential, especially in the elderly patient.

Summary

- Abdominal trauma presents challenges
- Not all injuries are easy to diagnose
- Not all diagnostic modalities are useful in certain injuries
- Nursing staff must be astute in assessment skills and injury management
- Teamwork is essential
- Optimizing outcomes is important

