BLUNT THORACIC AND ABDOMINAL INJURIES

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I

Traumatic injuries are all caused by force. Newton's Second Law of Motion has force being equal to the mass times the acceleration of the mass (F=MA). The law states that a very large object moving very slowly such as a rolling truck can cause significant force or injuries. Alternatively, a small mass going very fast such as a bullet can be just as devastating. We can quickly understand how a very large object going extremely fast can result in utter catastrophe!

Traumatic injuries take many forms. Some are accidents and some are intentional. The major sources of blunt traumatic injuries are 1. motor vehicle accidents. 2. falls. 3. assaults. 4. sports injuries. It is self-evident how all these sources have the potential for both high mass and acceleration. Many accidents are oftentimes primed by other factors. Stupidity such as drinking and driving or using cell phones or texting while occupied with controlling a large vehicle going eighty miles per hour often is a precipitating event to accidents. Sleep deprivation; yes there are times when medics actually are up the whole 24 hours, can lead to accidents. Of course, accidents do occur and faulty equipment, bad weather and just bad luck can cause injuries.

Minimizing blunt trauma reverts back to Newton's Second Law. How can the force be diminished? Essentially, diminishing the force has to come from making the mass smaller and/or reducing the acceleration. Reduce these and you have reduced the force. In most cases, you can't change the size of the mass in blunt trauma. There is of course the exception to the rule and it would be prudent that if you plan on getting drunk and in a fight, choose the geek in the corner playing dungeons and dragons. Diverting the acceleration is what usually reduces the force. Seatbelts and airbags reduce and dissipate the acceleration. Harnesses prevent falls. Improved sports equipment can dissipate the impact and therefore the force.

Understanding how the force of injury occurs can now make it evident in almost all cases why certain circumstances are associated with greater trauma. Heights with increasing gravitational force, large crushing objects

such as cars or trucks, rapid moving objects such as bats or bullets will all result in an increase in force and therefore increasing trauma.

II

THORACIC TRAUMA runs the spectrum from minor nagging injuries to catastrophic lethal injuries. This is because the thoracic anatomy has so many layers. On the outside is the protective layer consisting of skin, muscle and ribs. Inside however are the lungs and pulmonary structures, great vessels and the heart. The diaphragm creates the inferior boundary of the thoracic cavity.

So how do the injuries occur? Essentially we are back to Newton's Second Law:
Force = Mass X Acceleration. The extent of the injury (force) is caused by the mass of the object coming in contact with the person times the speed at which the object impacts the person (acceleration).

Let's examine how the extent of an injury changes with where the impact occurs and how much force is used. A person is butted in the ribs with the end of a bat. It comes across the side glazing off the arm. In this example the arm softened the blow to the ribs and slowed the acceleration. It also changed the angle of the impact reducing the mass. Therefore, the soft tissue and ribs bow in, resulting in bruising to both but no fractures. Now let's increase the swing or the acceleration of the bat. Swinging for a home run, the assailant makes a direct impact on the chest wall. In this case, the acceleration and the mass to the ribs is increased resulting in more force. Two ribs crack, protrude into the chest cavity and stab the pleura. The ribs tear at the lung causing bleeding along with a pneumothorax resulting from the torn pleura. Now the injury has resulted in rib fractures and a hemopneumothorax. What if the location is changed and instead the same injury occurs over the left anterior chest wall? Depending on the exact location, those broken ribs could case a pulmonary contusion, hemopneumothorax, pericardial tamponade, cardiac contusion, or even a splenic laceration.....there's nothing like a 36 ounce Louisville Slugger!

III

As already stated, thoracic injuries can be singular or result in multiple organ involvement. Generally, the force causes injury from the outside, (chest wall and ribs) and works its way into the underlying organs. The exception to this is a deceleration injury.

CHEST WALL: The chest wall is made up of skin, vessels, nerves and ribs. It provides an outer protective encasement for the internal organs. Limited damage to this area may result in contusions and rib fractures. When the force is stronger or there is more penetration, underlying organs can be involved. Fractured ribs may tear the pleura resulting in a hemo/pneumothorax. The barometric changes that occurs when the chest wall is suddenly compressed can also cause a pneumothorax. Segmental rib fractures or a flail chest occur when 3 or more ribs are broken in two different places. This creates a paradox in breathing and the flailed segment moves in the opposite direction of the rest of the chest wall. Since the segment or flail is not connected to the other ribs, it gets sucked in when the chest wall expands on inhalation and pushed out when the person exhales.

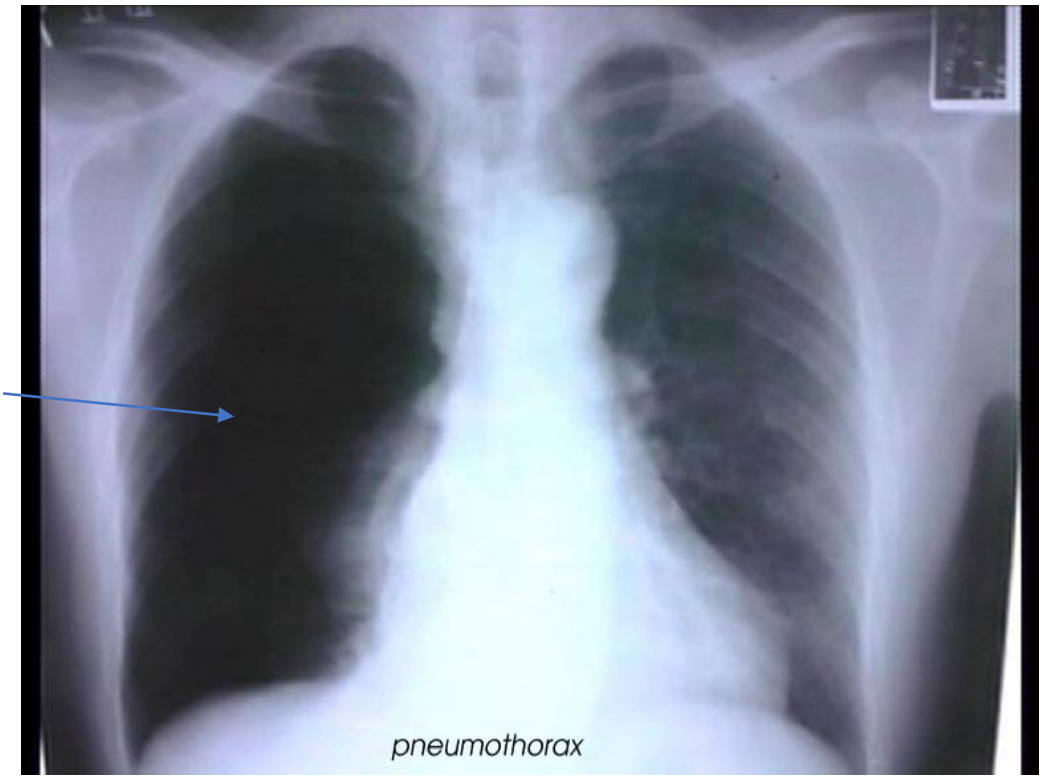
HEMO/PNEUMOTHORAX: When air or blood accumulates in the pleural space, there is compression on the adjacent lung. When part of the lung is filled with blood or compressed, it cannot work. This results in diminished function of the lung and increasing difficulty breathing. A hemothorax, or blood (hemo) in the chest (thorax) is when blood accumulates in the lung and pleural space. Having blood or any fluid in the lung is like trying to breath underwater in that section of the lung. The blood in the pleural space will compress the lung as well making that area inefficient or useless. An of course the injury can also cause significant blood loss.

DIAPHRAGMATIC INJURY OR PSEUDOPNEUMOTHORAX: DIAPHRAGMATIC INJURIES result in direct tears to the diaphragm such as a rib stabbing and tearing it. Pressure changes can also cause the diaphragm to “blow out”. This would occur when an outside force such as a high velocity impact to the chest wall occurs when the lungs are full of air. The immense force to abruptly expel the air can result in so much

intrathoracic pressure that the diaphragm tears. Alternatively, a blow to the abdomen can cause the diaphragm to “blow out” into the lungs.

PNEUMOTHORAX

All The Black Is Air. Note How The Other Side Is Hazy Which Is Lung That Is Not Compressed By The Pneumothorax

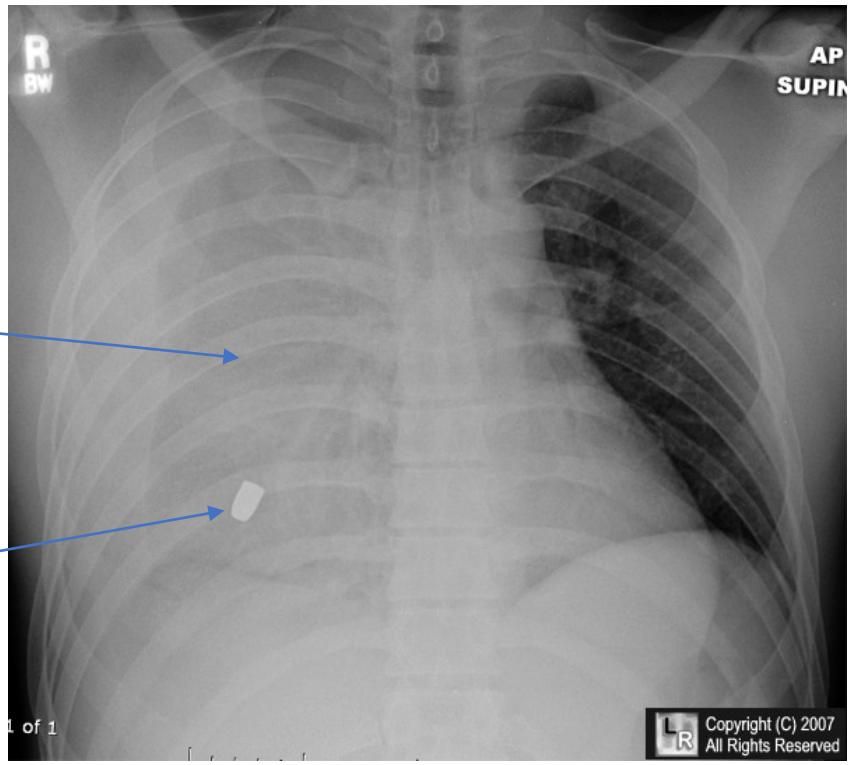


The pneumothorax is on the right. Since there is only air it shows up as black on the X ray.

The Right Lung Is Filled With Blood And Therefore Looks Dense And White. If You Look Closely At The Point Of The Arrow, You Can See A Greyish Portion Which Is The Outline Of The Collapsed Lung.

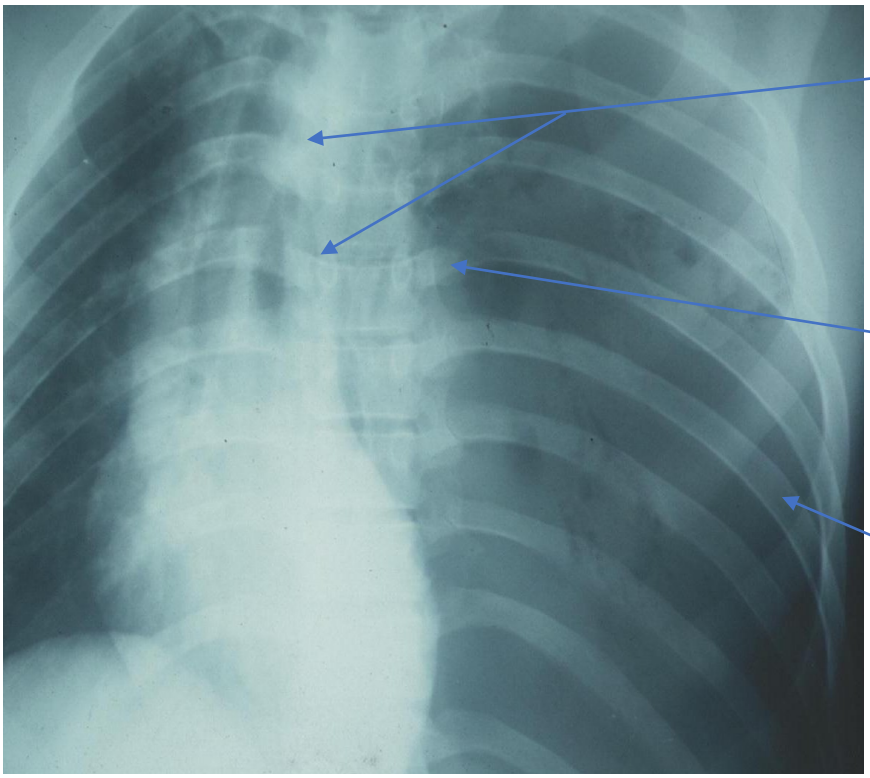
The Cause Of The Hemothorax.

HEMOTHORAX



Caused by blood in the chest cavity. Note the bullet. Blood shows up white on an xray because it is denser than air due to the hemoglobin in the

TENSION PNEUMOTHORAX



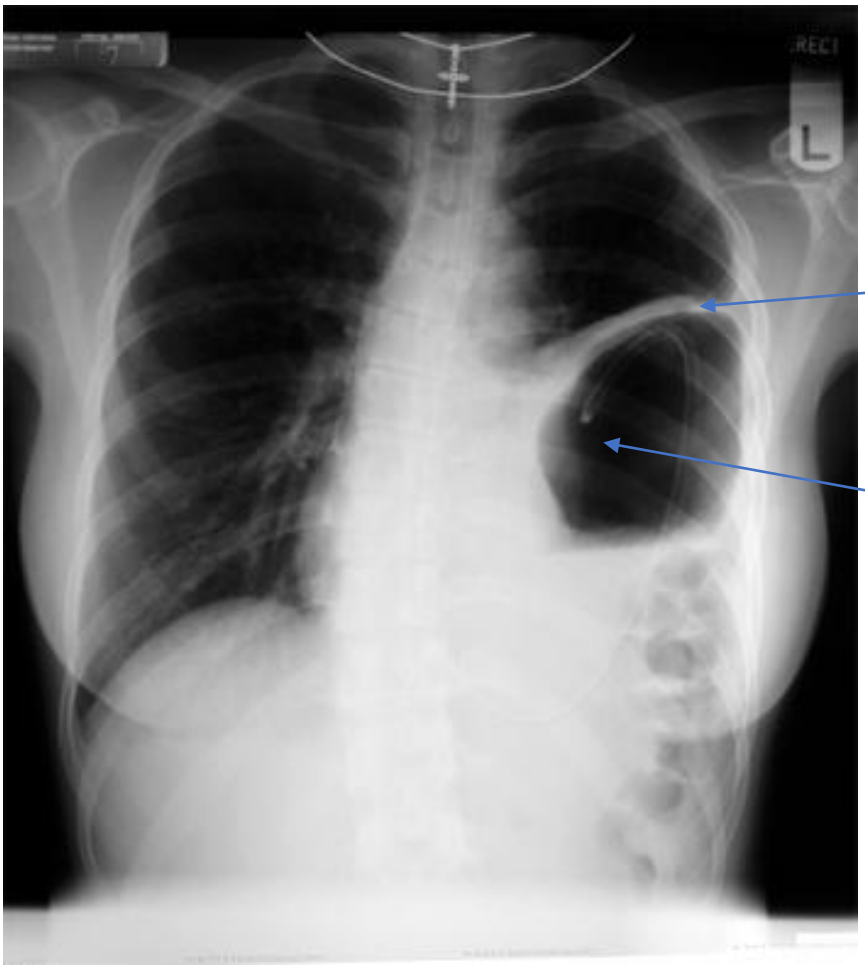
The Top Arrow Points To The Trachea And The Bottom To The Two Bronchi That Are Compressed And Pushed To The

Small White Area Is Compressed Lung. Looks White Because No Air Is In The Lung

All Air Caused By The Collapsed Lung

A tension pneumothorax results in complete collapse of the lung and compression of the heart and vessels. This as we know is a life-threatening event and needs to be immediately reversed with a needle thoracentesis. The tension pneumothorax is on the left pushing

DIAPHRAGMATIC TEAR

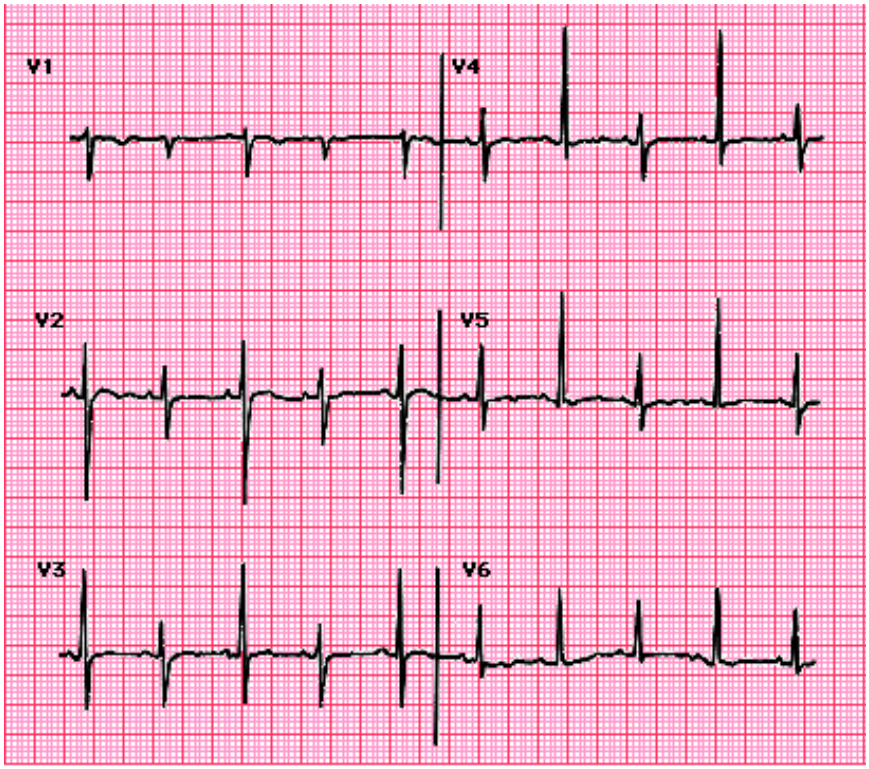


White Area Is Collapsed Lung Pushed Together By The Intestines

Intestines Pushed Into The Chest Cavity By A Tear In The Diaphragm

The intestines can enter the chest cavity through a tear to the diaphragm. This takes on the appearance of air since the intestines have air inside them. The intestines push the lung aside and cause the look of a pneumothorax.

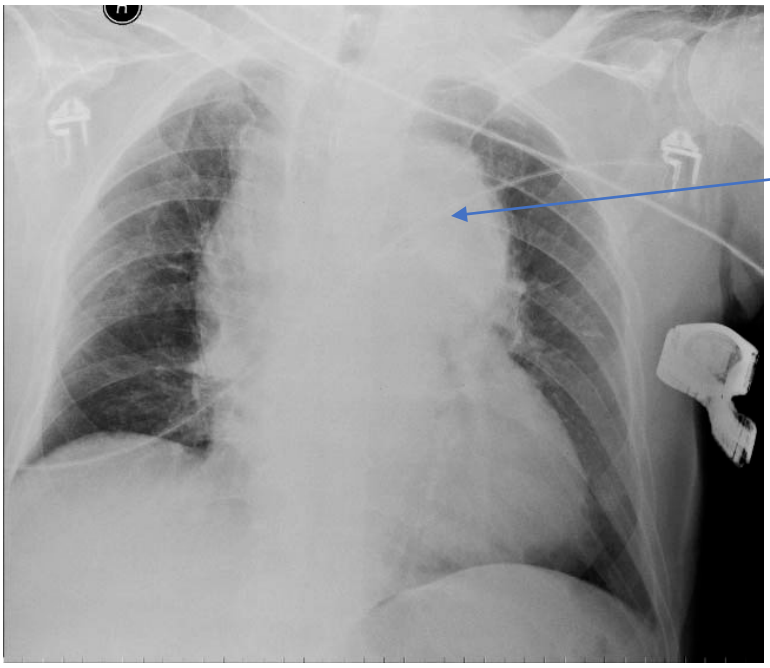
CARDIAC AND AORTIC INJURIES: Traumatic aortic injuries are one of the major causes of death in blunt trauma. The aorta is tethered in place allowing for it to be susceptible to rapid deceleration. In these cases, the rapid deceleration causes the organs to continue forward while the body has stopped because it hit another object like a steering wheel or pavement. As well wearing a seatbelt does not always prevent a tear. If the person hits a tree going 120 MPH wearing a seatbelt. The rapid deceleration may still be enough to tear the aorta. A shearing occurs where the aorta is tied in place resulting in the tear. For those who do live, the tear usually shows up as blood around the arch (top) of the aorta on X-ray. This is referred to as a widened mediastinum.



Electrical alternans Sinus tachycardia with electrical alternans which is characterized by beat-to-beat alternation in the QRS appearance (best seen in leads V2 to V4). These findings are strongly suggestive of pericardial effusion, usually with tamponade. The alternating ECG pattern is related to back-and-forth swinging motion of the heart in the pericardial fluid. Courtesy of Ary Goldberger, MD.

Bleeding can also extend into the space between the heart and the pericardium (the outer fibrinous covering around the heart). When the bleeding occurs in this area, the pericardium becomes restrictive causing the outside pressure to impinge on the heart. This in turn causes the heart chambers to collapse and restricts the ability of the chambers to fill and contract. Beck's triad which is seen with severe pericardial tamponade. It is muffled heart sounds, JVD and hypotension. Pulses or electrical alternans may be seen on the EKG.

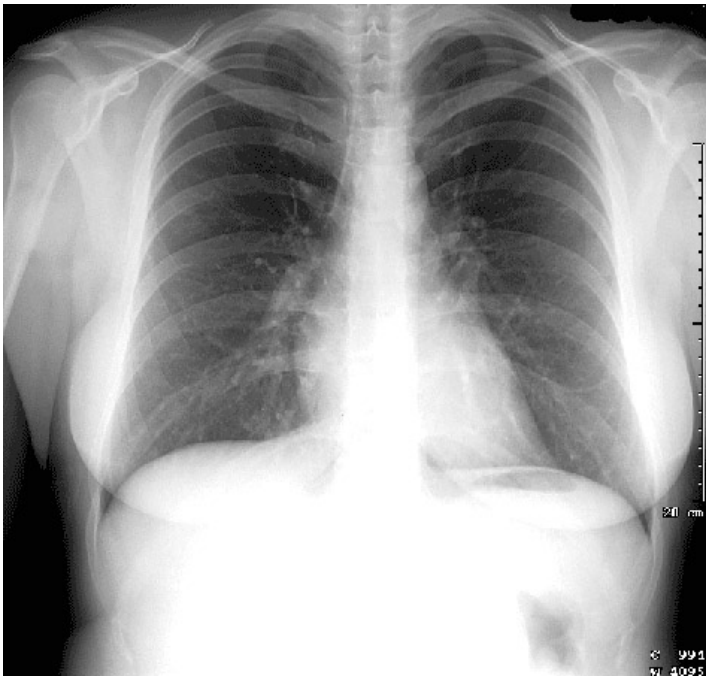
ENLARGED MEDIASTINUM DUE TO TORN AORTA



This Large Area Is Blood Caused By The Widen Mediastinum

Note The Size Of The Middle Of The Chest Compared To The Normal Chest X-Ray

NORMAL CHEST X RAY

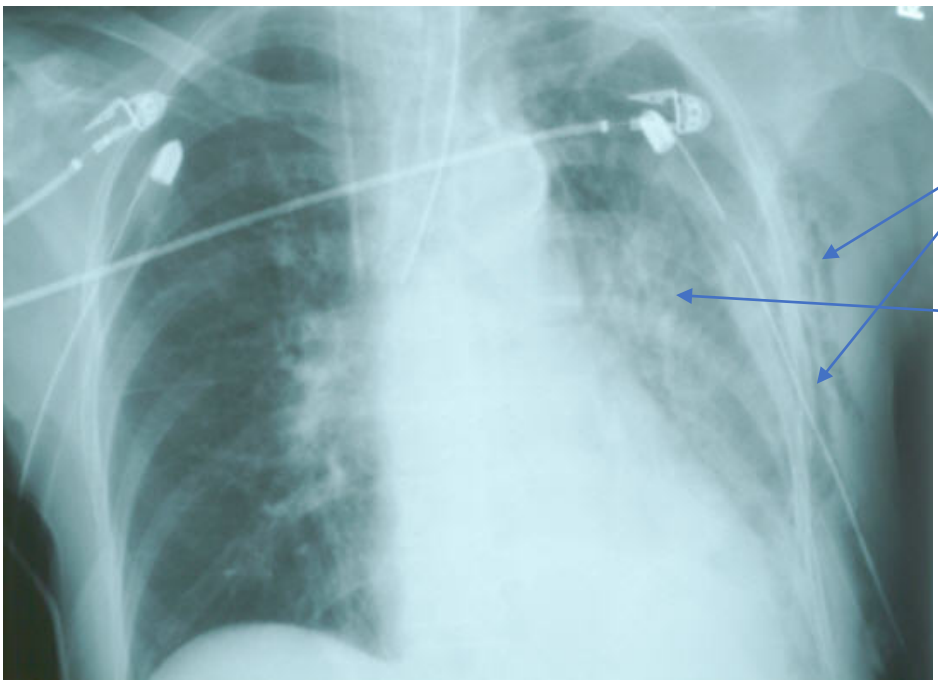


IV

CONTUSIONS can occur to any of the organs that exist on the thorax or within the thoracic cavity. Muscle contusions, boney contusions can result in direct impact to the chest wall. Deeper seeded contusions can occur to the lungs and heart. Of these the worse is to the lungs. Bruised lung cannot function and this results in difficulty breathing. If the area is large enough, the person can become hypoxic. A secondary consequence is the development of ARDS or Adult Respiratory Distress Syndrome. When ARDS occurs, large segments of the lung can be incapacitated by fluid leaching in to the lungs.

Debate exists over the significance of cardiac contusions. The concern is that a bruised heart will result in arrhythmias and potential death. Sinus tachycardia is the usual finding along with bruising of the chest, or tenderness of the chest wall over the region of the heart.

PULMONARY CONTUSION



The arrows point to air that is in the soft tissue. This is probably due to a pneumothorax that is not seen on the xray

The Whitish Area Is The Bruise. Small Vessels Break Just As They Would Underneath The Skin.

The bruised lung is the dense white area on the left lung. Note the air in the soft tissue on the left. When palpated, this is crepitus.

V

BLUNT ABDOMINAL TRAUMA in many ways is a continuation of the thoracic trauma. Force of injury will play a major role in the extent of the injuries. Motor vehicle accidents cause the majority of injuries, with blows to the abdomen and falls a distant second and third. Different types of forces can result in varying types of injuries. Because there are several hollow organs such as the bladder and intestines, changes of intraabdominal pressure can result in “blow outs” of the organs. Think of the person who is on the mass pike and misses the exit for the rest stop. He already has a full bladder which is continuing to fill. The sign states next rest stop is 25 miles! He speeds up because of the full bladder. The road is slippery and he loses control and hits a guard rail head on. The seatbelt holds him in place but rapidly compresses on an already over distended bladder. The “blow out” ensues with urine pouring into the pelvis.

Outward forces can also cause injuries. Handlebars, bats, steering wheels and other objects that compress on the abdominal cavity can all result in injuries to the abdominal organs. This is one reason why outward trauma to the abdominal wall such as lap belt bruising should raise concern for other injuries. If the force was great enough to cause injury to the abdominal wall, there is a higher chance for intraabdominal injury. Remember that the abdomen does not have the shield like protection that ribs afford.

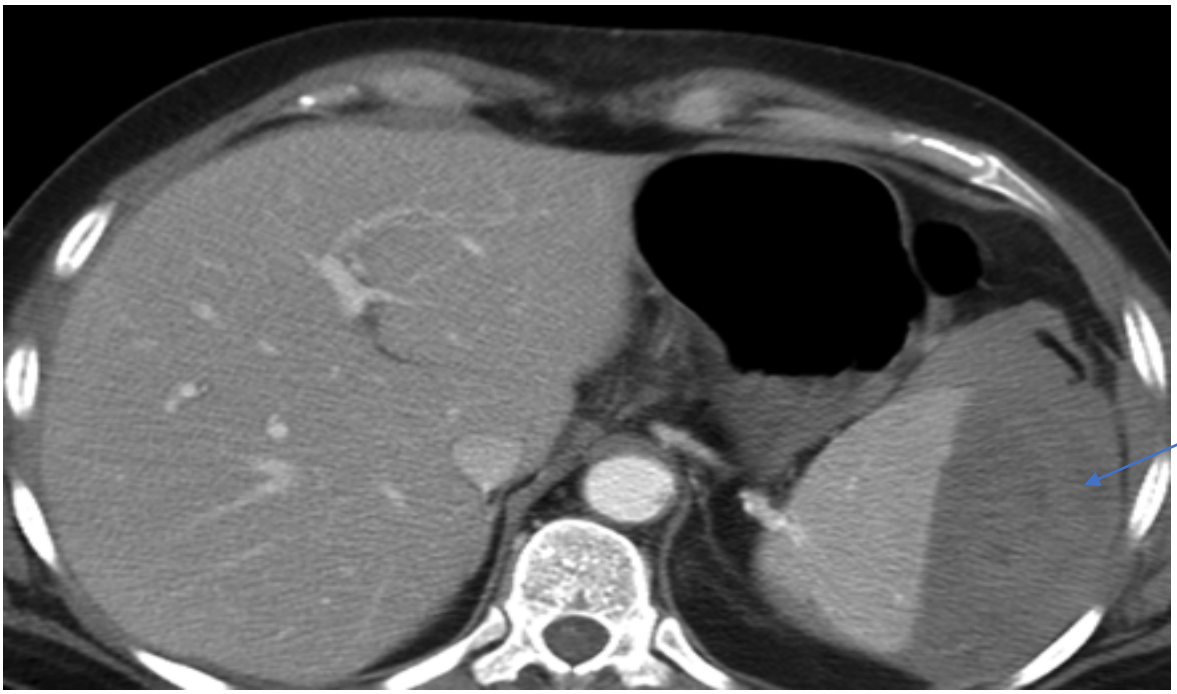
Rapid deceleration also can play havoc on the abdomen. The shearing force has the ability of tearing away the large vessels in the abdomen as well as the intestines. The renal vessels are most susceptible to this.

VI

SPLENIC INJURIES: The spleen, located in the left upper quadrant under the ribs, is a large spongy organ covered in a fibrous sack which acts as a filtration system for the blood. Because of this it is extremely vascular and susceptible to injury. The fibrous covering does help prevent many catastrophic injuries by containing the bleeding within the sack. The classic example of a splenic injury is the handlebar injury from a bicycle. A person goes up over the handlebar and he or she lands on the handlebar which

protrudes into the upper abdomen causing blunt trauma against the spleen. In reality, anything that can get up under the ribs can result in a splenic injury. In one case I had, kids were playing tackle whiffle ball. After hitting the ball, the kids would try to tackle the batter who was going to first base. At one point, the batter got a shoulder up under his ribs resulting in a splenic tear. Another source of injury is when the person is hit from behind on the left side. The ribs get pushed in and either the direct impact pushes up against the spleen or a broken rib pierces the spleen causing it to bleed. Commonly, the person will complain of shoulder pain with a splenic injury. This is actually the blood irritating the phrenic nerve which innervates the diaphragm. The pain is referred to the shoulder because the nerve originates from C3-5.

SPLENIC BLEED
The bleeding is the dark area on the patients left. Remember that when you read a cat scan, you are standing at the patient's feet. Their right is your left and visa versa.



Black Area Is the Spleenic Bleed.

R LIVER SPLEEN WITH BLOOD **L**

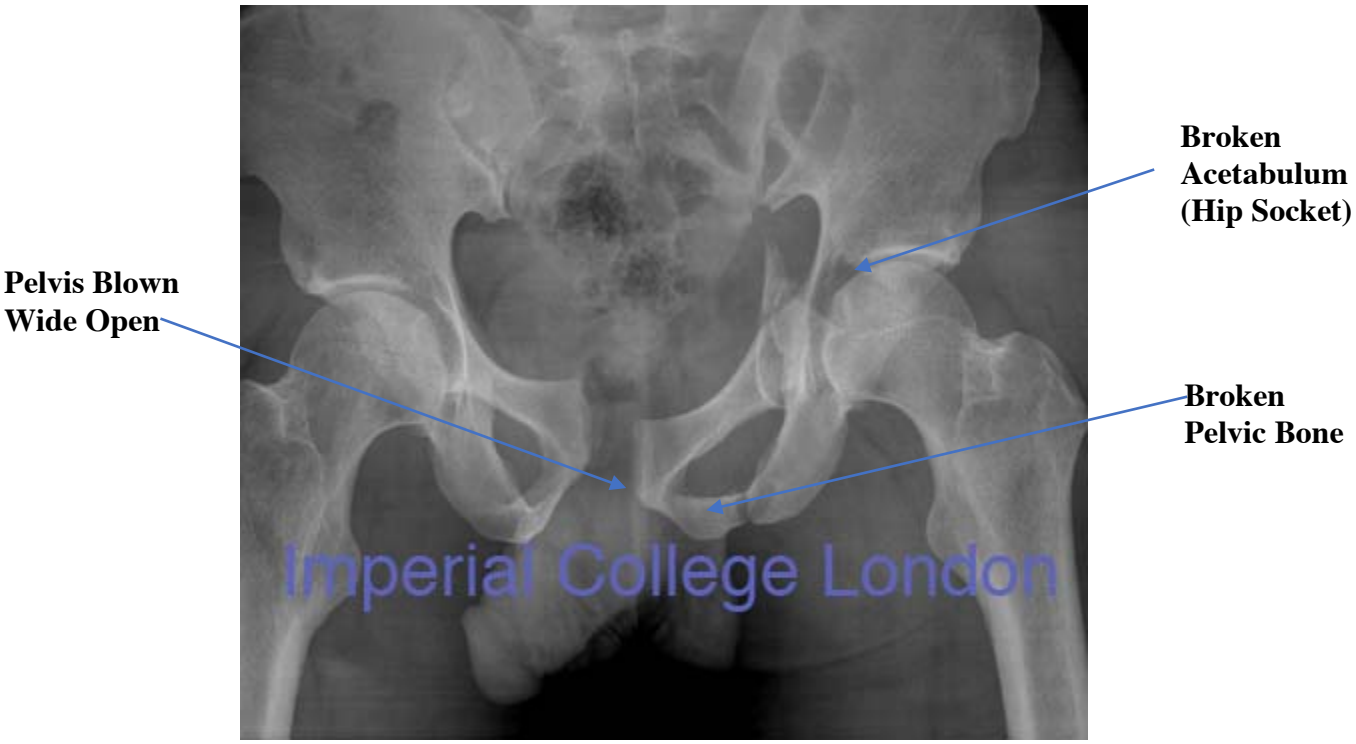
KIDNEY INJURIES: The kidneys sit behind the ribs toward the back. Their location makes them susceptible to direct impact and the shearing effect of decelerating injuries.
The old Louisville Slugger to the flank can mangle a kidney directly or with the help of broken ribs. Deceleration can tear the vessels off of its pedicle. Either way, bleeding can be catastrophic.

PELVIC FRACTURES: The pelvis is an extremely vascular area which can result is immense bleeding. With unstable fractures, the constant movement of the pelvis breaks down any clotting that may have occurred. Stabilization needs to be established and those old mast trousers work well in this capacity.

HOLLOW VISCOUS INJURIES: The abdomen is full of hollow viscous such as the intestines and bladder. Both can tear open from impact. The intestines can also shear open from deceleration injuries. The bladder is very prone to “bursting” when it is full at the time of impact.

PELVIC FRACTURE

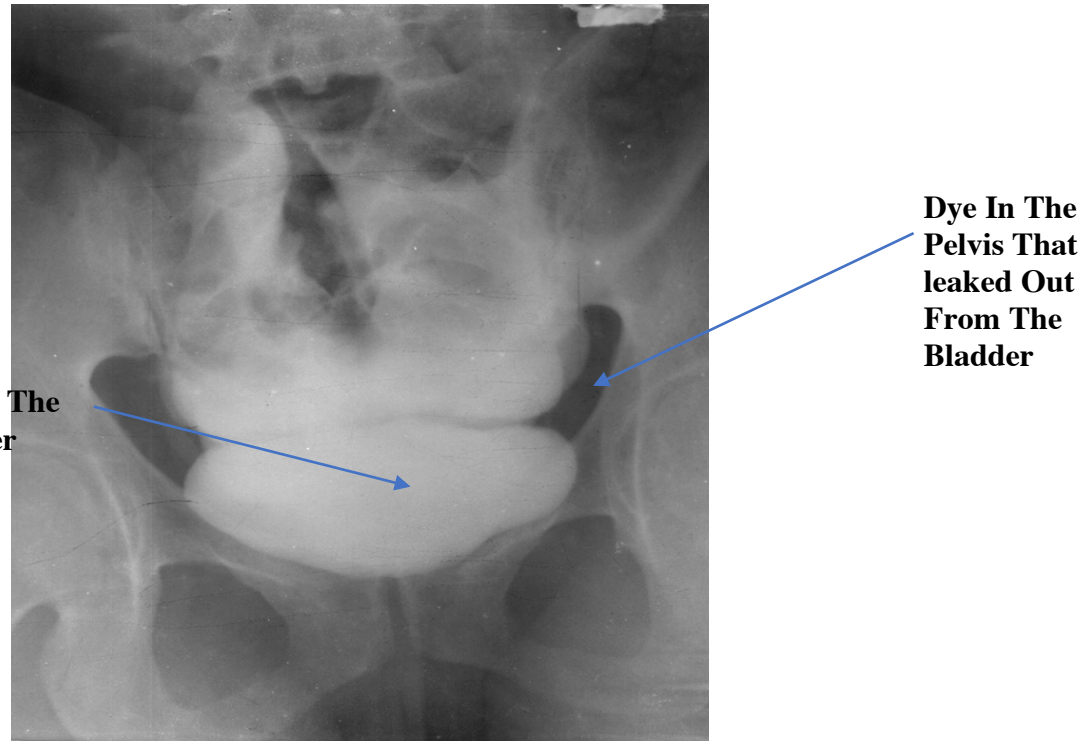
The pelvis is split open and fragmented along the left sacrum and the front of the left side of the pelvis. The left hip also blew open the acetabulum



PELVIC FRACTURE WITH FIXATION

The creation in the 1970s of the *Belfast Fixator* (an external fixation device for limb fractures), allowed for the treatment of muscular or vascular complications to proceed, whilst repair of the fracture and skin tissue continued.

BLADDER RUPTURE
The lower area of white just above the pelvis is the bladder. The white above it is contrast that has poured out into the pelvis through the tear in the bladder.



ANOTHER REASON NOT TO DRINK AND DRIVE!

VII

MANAGEMENT OF THE TRAUMA PATIENT: Consider the chest and abdomen as one large unit when assessing for injuries. By now it should be clear that injuries to one area can result in trauma to the other area. As well large moving vehicles do not distinguish what parts of the body it is going to hit. Always take time to LOOK AT THE WHOLE PATIENT. It is easy to forget that other injuries may be present when fixating on the most severe injury. As well, the most severe injury may be hidden within a cavity. Vital signs will always keep you from straying too far away from

how the patient is doing. Consider the Glascow Coma Score a fifth vital. Also, remember that people with intraabdominal trauma may have a bradycardia because of a vagal response on the heart. After using your eyes to assess the patient, evaluate the patient with your stethoscope and hands. Listen for breath sounds and heart tones. Feel for broken ribs, crepitus and abdominal tenderness.

Now having stated the above, the reality is that the exam is not very sensitive to traumatic injuries. Small but growing pneumothoricies may not be heard. Abdominal tenderness makes an injury more likely but is still not very predictive of intraabdominal pathology. Distracting injuries or closed head injuries may impair the patient's abdominal exam. Abdominal ecchymosis or a lap belt sign does correlate with abdominal injuries in a third of the cases.

SEATBELT SIGN

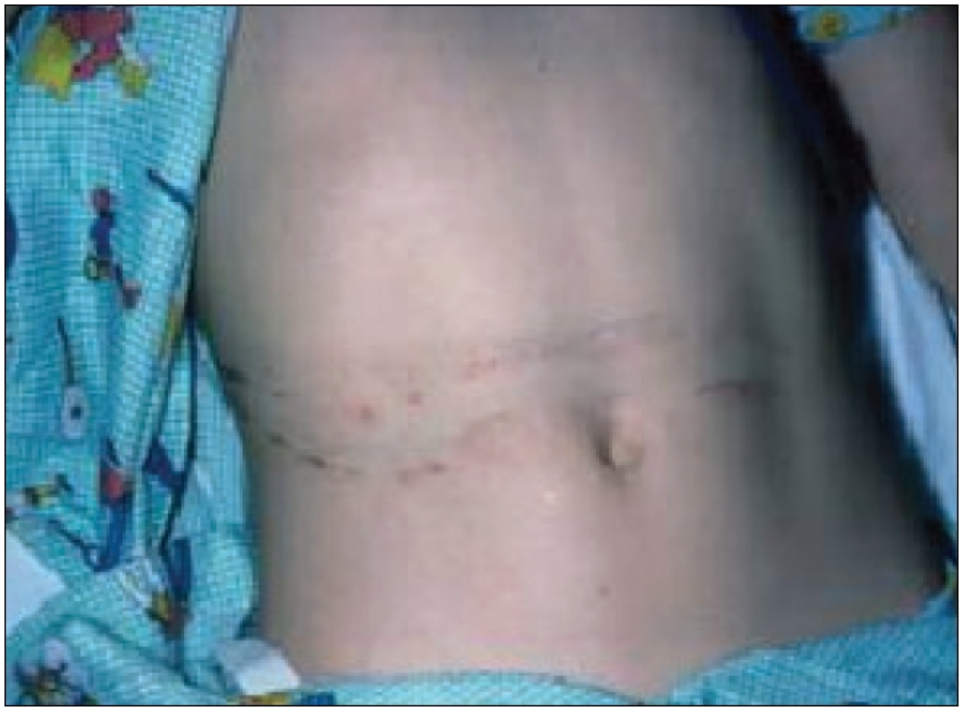


Figure 2: Telltale seatbelt sign of bruising across the abdomen

What does this all mean? Trauma is a dynamic process that will constantly change. You must constantly reassess the patient and look for changes. Care has to be expeditious...DON'T WASTE TIME. When changes occur, reassess your management and make the appropriate adjustments. DO

NO HARM.....Be appropriately aggressive and don't hold back when you feel a patient needs a procedure such as a needle thoracentesis or and IO if you can't get a line. Don't forget...you can't kill a dead person.

AND REMEMBER.....WE SHOOT FOR PERMISSIVE HYPOTENSION. A PRESSURE OF 80-90 AND NORMAL MENTATION IS GREAT. WE DON'T WANT TO BLOW OFF THE FORMED CLOTS AND CAUSE MORE BLEEDING.

.....OH YEAH. AND GOOD LUCK. SOMEONE'S LIFE DEPENDS ON IT!