Contents

Abbreviations

- 3D 3 dimensions
- ABCs Airway, Breathing, and Circulation
- ABG Arterial blood gas
- ALI Acute lung injury
- AP Anteroposterior View
- ARDS Acute Respiratory Distress Syndrome
- ATLS Advanced Trauma Life Support
- BAI Blunt aortic injury
- BCI Blunt cardiac injury
- BDI Blunt diaphragmatic injury
- BTAI Blunt thoracic aortic injury
- cm Centimeter
- CO2 Carbon dioxide
- COPD Chronic obstructive pulmonary disease
- CT Computerized tomography
- CXR Plain chest radiograph
- ECG Eelectrocardiogram
- ED Emergency department
- EGD Esophogastroduodenoscopy
- F French
- FAST Focused Assessment with Sonography for Trauma
- FiO2 Oxygen fraction in inspired air
- HU Hounsfield unit
- ICU Intensive care unit
- INR International Normalized ratio
- kPa Kilo Pascal

- MDCT Multidetector computed tomogram
- MIP Maximum Intensity Projection
- mL Millie Liter
- mm/Hg Millimeter Mercury
- MRI Magnetic Resonance Imaging
- MVAs Motor vehicle accidents
- NCEPOD National Confidential Enquiry into Patient Outcome and Death
- PaO2 Oxygen partial pressure in arterial blood
- PSV Pressure support ventilation
- PTX Pneumothorax
- RTAs Road traffic accidents
- RTC Road traffic crash
- SIMV synchronized intermittent mandatory ventilation
- TAI Thoracic aortic injury
- TDI Traumatic diaphragmatic injury
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- US Ultrasound
- VATS Video-Assisted Thoracic Surgery

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بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

قَالُوا سُبْحَانَكَ لاَ عِلْمَ لَنَا إِلاَّ مَا عَلَّمْتَنَا

إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ

صدق الله العظيم

سورة البقرة أية (32)

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Chest wall injuries

General concepts:

The understanding of pathophysiologic processes and the mechanisms of traumatic injury is crucial in the management of these patients. The thorax is the only area of the body where five separate mechanisms for early loss of life coexist:

1- Airway obstruction from tracheobronchial injuries, pulmonary secretions, or haemorrhage.
2- Loss of oxygenation and ventilation capability from pneumothorax, haemothorax, or pulmonary contusion.
3- Exsanguination.
4- Cardiac failure from cardiac contusion or valve rupture.
5- Cardiac tamponade.**(Khandhar et al,2009)**

A) Subcutaneous emphysema:

Subcutaneous emphysema refers to the presence of air in the extrathoracic soft tissues. This condition can result from chest wall blunt trauma with damage to the respiratory or gastrointestinal systems, and penetrating injuries that introduce external air into the soft tissues. Chest radiography shows air in the subcutaneous tissues, which may create radiolucent striations outlining the individual fibers of the pectoralis major muscles "ginkgo leaf" sign (Fig. 1).

Air can spread via fascial planes to the rest ofthe chest wall and abdomen and even to thehead, neck, and extremities. The condition isusually self-limiting, but severe cases maycompress the trachea and require intervention. Sources of persistent air leakage willrequire corrective surgery. (**Ho & Gutierrez,2009)**

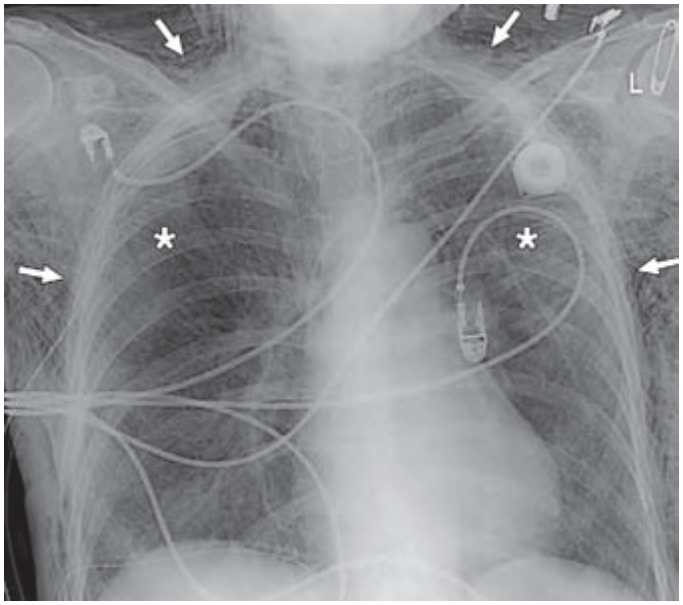

Fig. 1;Frontal chest radiograph shows extensivesubcutaneousemphysema (*arrows*) and air outliningfibers of pectoralismuscles bilaterally ("ginkgo leaf"sign) (*asterisks*).(**Ho& Gutierrez,2009).**

B)Soft tissue haematoma:

Subcutaneous haematomas are produced by accumulation of blood in the soft tissues. This condition may result from damage to thoracic vessels, muscles, or ribs during blunt or penetrating chest trauma.(**Ho & Gutierrez,2009)**

Soft tissue haematomas may occur during direct compression trauma when rib fractures cause laceration of veins or arteries. Soft tissue haematoma may become lifethreatening if the patient is under anticoagulant therapy. If it is arterial in origin, embolisation is indicated. Breast haematomas can be serious in direct impact or compression injuries**. (Sangster et al, 2007).**

C) Ribs:

Rib fractures are the most common injury in blunt chest trauma, occurring in 50% of cases. A single rib fracture isusually not clinically significant, whereas multiple ribfractures indicate severe injury**.(Oikonomou&Prassopoulos,2011)**

Fractures of the first threeribs imply high-energy trauma that may be associated withinjury of the brachial plexus or subclavian vessels.Although upper rib fractures are not associatedwith an increased incidence of traumaticaortic injury , injury to the brachial plexusand subclavian vessels can be seen in 3% to 15%of patients who have upper rib fractures .**(Miller,2008)**

Fractures of the fourth up to the eighth ribs are the mostcommon, while fractures of the last four ribs are usuallyassociated with intra-abdominal injury. **(Oikonomou&Prassopoulos,2011)**

Promptcareful evaluation is needed for upper abdominal organ injuries associated withfractures of the last four ribs.Patients who have right-sided rib fractures atthese levels have a 19% to 56% probability of liverinjury, whereas those who have left-sided fractureshave a 22% to 28% probability of splenic injury. In the elderly population, overall morbidityand mortality increases with an increasing numberof ribs fractured. **(Miller,2008)**

Fractured rib ends can laceratethe pleura or lung, leading to the formationof pulmonary hematomas, haemothorax,or pneumothorax. Most fractures can be visualisedon chest radiographs, and a radiodensefracture callus develops after several weeks ofatelectasis, subpulmonic effusion, subphrenicabscess, colonic interposition "Chilaiditisyndrome" (pain occurs due to transposition of a loop of large intestine usually transverse colon in between the diaphragm and the liver), diaphragmatic eventration, congenitaldiaphragmatic hernia, andphrenicnerve injury can have a similar appearanceon chest radiographs, and CT is required fordiagnosis.(**Ho & Gutierrez,2009)**

Pain from ribs fractures adversely affect pulmonary function andmortality. It is believed that “chest wall splinting” from pain leadsto increased atelectasis, inability to clear secretions andhypoventilation. Pulmonary contusion can further impair gasexchange resulting in hypoxemia. **(O’Connor &Adamski, 2011)**

Late complications may develop such as bowel incarcerationor strangulation, thoracic organcompression, and diaphragmatic paralysis.Splenosis is a rare complication of left-sidedthoracoabdominal trauma in which thoracicautotransplantation of splenic tissue results inthe formation of left-sided chest wall masses.(**Ho& Gutierrez,2009)**

D) Flail Chest:

Flail chest is defined as the fracture of four or more consecutive ribs in at least two places (Fig. 2). This is accompanied by paradoxical motion of the affected chest wall segment during respiration such that the flail segment collapses during inspiration and expands during expiration.**(Pettiford et al, 2009)**

Flail chest is rare, but it is the most serious of the blunt chest wall injuries. The prevalence of flail chest among patients with chest wall injury is estimatedbetween 5% and 13%however, the patient's comorbidities and age greatly influence the clinical effect.Beyond the age of 55, the likelihood of death in cases of flail chest increases 32%for every 10-year increase in age and 30% for each unit increase in injury severityscore. **(Wanek& Mayberry, 2004)**

In flailchest, a free-floating segment of ribs results, andcauses focal chest wall instability. The paradoxicmotion of the fracture segment alters normal pulmonarydynamics and promotes atelectasis, stasis of secretions, and pneumonia it may requireearly intubation for ventilatory support.**(Miller,2008)**

In the presence of a flail chest, CO2 retention has commonlybeen attributed to the "pendelluft phenomenon", where to-and-fro flow of gas has been postulated to exist between the two hemithoracesin the presence of a unilateral flail segment. This concept isintuitively appealing, and the re-breathing of airway gas does createa pathologic dead space. In practice, elevatedshunt fractions and hypoxemia

are more common in flail chestand in trauma in general than is hypercarbia. Moreover, pendelluftoccurs in acute lung injury even without chest wall instability.This results from the heterogeneous viscoelastic properties of theinjured lung itself, which leads to gas movements between lungsegments of differing compliance. Clearly though, flail segmentsdo make ventilation both painful and increasingly inefficient.(**Hauser& Livingston, 2009)**

Flail chest is amarker of significant intrathoracic injury with increased morbidity. The diagnosis isclinically based on the paradoxical motion during respiration,which may result in ventilatory compromise. More than 50% of cases require surgical treatment and prolonged mechanical ventilation.**(Oikonomou&Prassopoulos,2011)**

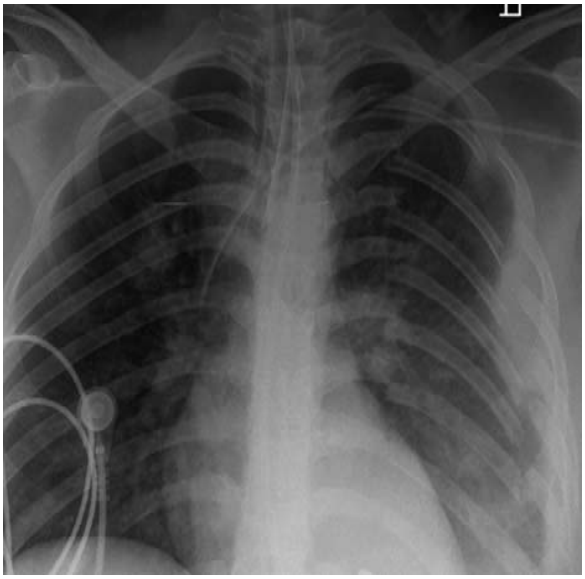

Fig. 2;Frontal chest radiograph shows fractures at two locations in the left posteriorthird through to the eighth ribs. Patient required treatment for a flail chest.**(Miller,2008)**

E)Sternum:

Sternal fractures have a prevalence of 3–8% in blunt chest trauma. The main mechanism is deceleration injury or adirect blow to the anterior chest wall. It is considered amarker of cardiac contusion (1.5%–6%).**(Miller,2008)**

Sternal fractures typically occur at the body or manubrium. It is almost always accompanied by anteriormediastinalhaemorrhage, which has a preserved fat planewith the aorta (Fig.3), as opposed to an anteriormediastinalhaemorrhage secondary to aortic injury, which will present with a lost fat plane with the aorta.**(Oikonomou&Prassopoulos,2011)**

Fig.3;Sternal fracture. Sagittal reconstructed CT image shows multiple fractures of the manubrium and the body of the sternum (white arrows) accompanied by extensive retrosternal haematoma (black ball arrows). Note also fracture of a thoracic vertebra (black arrow)**(Oikonomou&Prassopoulos, 2011)**

Sternoclavicular dislocation is rare and occurs in 1–3% of all types of dislocation. Anterior sternoclavicular dislocation is more common and easily detectable, as it is palpable. It usually has a benign course, but it implies a high-energy trauma and may be associated with haemopneumothorax, rib fractures or

pulmonary contusion.Posterior sternoclavicular dislocation is clinically andradiographically silent and carries serious morbidity, as it isassociated with injuries of the mediastinal vessels, nerves,trachea and oesophagus.(**Ho& Gutierrez,2009)**

Clavicle fractures are common in traumapatients and are generally of minor clinicalsignificance. **(Oikonomou&Prassopoulos,2011)**

F)Scapula:

It is easily detected on initial radiographs and may be masked clinically by other Scapular fracture is uncommon; occurring in 3.7% of cases of blunt chest traumaassociated serious injuries. It indicates a highenergy force trauma with a direct blow to the scapula or force transmitted through the humerus. Associated injuries are pneumothorax, haemothorax, clavicular fracture and injuries of the lung parenchyma, subclavian vessels, brachial plexus or spine.**(Miller,2008)**

J) Spine:

Thoracic spine fractures account for up to 30% of all spinefractures. 62% percent of spine fractures will result inneurological deficits. The most vulnerable site is betweenthe ninth and twelfth vertebra. The main mechanism ishyperflexion and axial loading. Plain radiographs may missfractures of the spine and therefore may be unnecessary inthose patients scheduled for CT. (**Ho & Gutierrez,2009)**

Pleural injuries

A) Pneumothorax:

Trauma-related pneumothorax occurs in 30–40% of cases, and it is most commonly associated with rib fractures than lacerate the lung. Less commonly, pneumothorax may be caused by a disruption of closed airway spaces, such as the alveoli, due to a sudden increase in intrathoracic pressure or to a direct impact or deceleration force to the chest wall. Tracheobronchial injuries are also always associated with pneumothorax. **(Peters et al, 2010)**

There are three types of pneumothaces associated with blunt chest trauma:
The first is a simple pneumothorax where the intra-pleural pressure becomes slightly more positive, but still below the pressure of the air inside the lungs. There is little impact on lung function with a simple pneumothorax, although it becomes of greater concern in patients with low respiratory reserve (chronic obstructive pulmonary disease COPD, severe asthma, pregnant) or those who are or will be on mechanical ventilation.**(Yiadom et al,2008)**

Tension pneumothorax is a second type of pneumothorax where the intra-pleural pressure exceeds atmospheric pressure, particularly in expiration when the pressure inside the lungs is more negative. This is often from a "check valve" mechanism (air moves into the pleural space during inspiration but cannot move out during expiration), which causes a progressive build-up of pleural pressure that can lead to respiratory failure when it exceeds that inside the lungs (greater than atmospheric pressure). **(Yiadom et al,2008)**

The intrapleural pressure rises and mediastinal structures begin to shift away from the injured haemithorax, resulting in diminished venous return as the superior vena cava and inferior vena cava begin to occlude resulting in fatal hypotension.