Open Pneumothorax

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Injury Demographics

- While the incidence of pneumothorax (PTX) in all trauma admissions has been estimated to be as high as 8%, the incidence of open pneumothorax is unknown.
- Open PTX is a common combat injury with blast effect as a frequent etiology.
- The most common causes of an open PTX in the civilian population are firearms, stab wounds, or impalements.

Clinical Presentation

- An open PTX is a PTX with an associated chest wall defect; the pleural cavity is in direct communication with atmospheric air.
- If the chest wall wound is greater than approximately two-thirds of the size of the trachea, air will preferentially communicate with the atmosphere rather than allowing gas exchange through the tracheobronchial tree.
- If the soft tissue defect results in a ball-valve communication with the atmosphere, a tension PTX may result.
- An open PTX can have a characteristic "sucking" sound (thus the name "sucking chest wound").
- Bubbling may be seen in the wound and is pathognomonic.

Evaluation/Diagnostics/Imaging

- Physical exam findings are frequently diagnostic:
    - Bubbling from the chest wall wound
    - Open wound of the chest wall with visualization of the lung
- A chest radiograph should be performed after chest tube insertion to assess for residual hemothorax and lung expansion.

Role of Conservative Management and Associated Considerations

- Pre-hospital management has historically been to tape an airtight dressing over the wound and tape it on three sides to allow egress of pleural air, preventing a tension PTX.
- Commercially available dressings are also available which have built-in valves.
- Management in the Emergency Department includes tube thoracostomy placement followed by an occlusive dressing over the soft tissue defect.
- Positive pressure ventilation may be needed when the open pneumothorax leads to respiratory failure manifested by unacceptable tachypnea or hypoxia. However, it is paramount to ensure that the respiratory failure is not actually due to conversion of the open pneumothorax to a tension pneumothorax, as pleural decompression is required in the latter case.

Indications for Operative Intervention

- The size and severity of the soft tissue and bony defect is the best predictor of the need for surgical repair.
    - Stab wounds and small caliber gunshot wounds generally leave soft tissue defects that can be repaired at the bedside.
    - Shotgun wounds, blast injuries, impalements, and larger caliber gunshot wounds are more likely to need operative repair.
- Significant amounts of devitalized skin, subcutaneous tissue, and muscle should be debrided operatively.
- Chest wall defects that result in lung herniation require reconstruction/closure in the OR.
- While occasionally gripping in their physical appearance, the soft tissue defect is an injury that can wait until the patient is not in a damage control situation; the wound should optimally be dealt with urgently if simple and semi-electively if complex reconstruction is necessary.

Pre-operative Preparation/Associated Injuries

- In a stable patient, if surgical intervention is planned, a CT scan of the chest should be performed to assess rib fracture anatomy, presence/size of a residual hemothorax, and extent of internal soft tissue disruption. This information will be important in deciding whether concomitant rib fracture fixation, hemothorax evacuation or chest wall reconstruction should be performed.
- If interventions for hemorrhage control are needed for other parts of the body and oxygenation/ventilation are acceptable after placement of an occlusive dressing and a chest tube, these associated injuries should take priority over surgical repair of the open pneumothorax
- Multiple rib fractures are commonly seen in conjunction with open pneumothorax, and consideration should be given for simultaneous rib fixation when operation is required for treatment of the soft tissue defect.
- If rib fracture fixation is contemplated in a dirty wound, a staged approach should be considered in which the first operation consists of debridement to viable soft tissue and bony margins to be followed by hardware placement at a second operation once the wound bed is acceptable.

Operative Techniques

- The principles of surgery for open pneumothorax are debridement of all devitalized tissue and restoration of pleural integrity.
- Options range from as simple as a single operation with debridement and primary closure to as complex as multiple staged operations with placement of synthetic materials for re-establishment of chest wall integrity and/or rotational/free flaps.
- Up to three contiguous rib resections with primary chest wall closure are feasible with acceptable postoperative morbidity.

- The frequency of intrapleural and extrapleural infectious complications are high enough that biologics should be considered the reconstructive matrix of choice when a synthetic material is deemed necessary due to an inability to reapproximate the ribs.

Intraoperative Considerations

- Placement of a dual lumen tube is advisable to facilitate lung deflation should it be needed.
- Alternatively, a bronchial blocker may be utilized for lung deflation if the patient is intubated and not a candidate for tube exchange to a dual lumen tube.

Postoperative Management

- Barring contraindications, an epidural should be placed for postoperative analgesia if thoracotomy is needed to effect repair of the soft tissue and chest wall defects.

Complications

- Lung herniation can occur when the musculoskeletal integrity of the chest wall is not re-established, but is surprisingly well tolerated.
- Infection, both intrapleural and extrapleural, is a risk.
- Flap failure can occur for a variety of reasons, among them technical and infectious.
- Functional limitations can be seen in patients with massive chest wall and axillary injuries, so consultation with rehabilitation specialists is helpful.
- Chronic pain from rib fracture malunion and intercostal nerve injuries can be seen, and are sometimes amenable to nerve blocks.

Considerations for Special Populations

- The morbidity and mortality of chest wall injuries is higher for geriatric trauma patients than their younger peers
    - A discussion about the goals of care should be had with the geriatric trauma patient or (more commonly) their surrogate when a high injury burden that includes an open pneumothorax is present
    - This discussion about goals of care for the injured elderly should include data from a prognosis calculator such as those promulgated by the PALLIATE consortium and available free of charge at www.palliateconsortium.com.

Suggested Readings

- Kong VY, Liu M, Sartorius B, Clarke DL. Open pneumothorax: the spectrum and outcome of management based on Advanced Trauma Life Support recommendations. Eur J Trauma Emerg Surg. 2015 Aug;41(4):401-4.

- Butler FK, Dubose JJ, Otten EJ, et al. Management of Open Pneumothorax in Tactical Combat Casualty Care: TCCC Guidelines Change 13-02. J Spec Oper Med. 2013 Fall;13(3):81-6.

- Kheirabadi BS, Terrazas IB, Koller A, et al. Vented versus unvented chest seals for treatment of pneumothorax and prevention of tensionpneumothorax in a swine model. J Trauma Acute Care Surg. 2013 Jul;75(1):150-6.