Pneumothorax and chest drain insertion

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Abstract

A pneumothorax is caused by air or gas in the pleural space. This causes lung collapse and a variable degree of impairment of both oxygenation and ventilation. Depending on the degree of lung collapse (determined by the size of the pneumothorax) and the underlying respiratory reserve and co-morbidities of the patient the clinical picture can vary from asymptomatic to life-threatening. The initial management varies with the clinical picture as well as the aetiology and size of the pneumothorax. It ranges from observation only (for small primary spontaneous pneumothorax), to needle aspiration or chest drain insertion. Chest drain insertion is a common procedure used routinely to not only drain the chest cavity of air as is the case with a pneumothorax but is also used to drain blood (haemothorax), chyle (chylothorax), pleural fluid or pus (empyema) from the chest cavity. It is the most common procedure in thoracic trauma and both Seldinger and open surgical chest drain insertion are discussed.

Keywords Chest drain; pneumothorax; tension pneumothorax; thoracocentesis

Pneumothorax

Definition

The presence of air or gas in the pleural cavity, resulting in partial or total collapse of the lung.

The pleural cavity is the compartment within each chest cavity formed by the space between the lung and the chest wall. The pleural space is lined by visceral (covering the lung) and parietal (covering the chest wall) pleura and normally has a negative intra-pleural pressure throughout the respiratory cycle (i.e. less than atmospheric pressure) due to the inward recoil of the lung and outward chest wall recoil. A pneumothorax occurs when air enters the pleural space, either from a penetrating injury to the chest wall or from the lung itself via a breach in the visceral pleura. Once air enters the chest cavity it causes the intra-pleural pressure to increase collapsing the ipsilateral lung.

Classification

A pneumothorax can be classified as spontaneous, traumatic or iatrogenic (Box 1). In spontaneous pneumothoraces the source of the air within the pleural space is from the lung parenchyma itself due to a breach in the visceral pleura allowing air to enter from the lung parenchyma. Spontaneous pneumothoraces are sub-classified as either primary or secondary. In traumatic pneumothoraces the source of the air may be from damaged airways or more commonly from a breach in the visceral pleural allowing air to leak from the lung parenchyma, or it may be the result of air entering through a defect in the chest wall (open pneumothorax). Alternative classification includes simple versus tension pneumothorax to differentiate the majority of 'simple' pneumothoraces from the immediately life-threatening tension pneumothorax discussed below.

Classification of pneumothorax

- Primary spontaneous pneumothorax
- Secondary spontaneous pneumothorax
- Traumatic
- Iatrogenic

Box 1

Primary spontaneous pneumothorax (PSP): a PSP is a pneumothorax occurring in a patient who has otherwise normal lungs. These are classically described as occurring more frequently in young, tall males. PSP are usually caused by the rupture of small subpleural bleb(s) or bullae on the surface of the lung which, when ruptured, allow air to leak from the lung parenchyma into the pleural space compressing the lung. In 90% of patients with secondary spontaneous pneumothorax (SSP) a subpleural bleb or bullae is present. Blebs are small (<1–2 cm) subpleural air spaces, they have thin walls and are most commonly found at the apex of the upper lobe but also occur on the apex of the lower lobe or along the fissure between the lobes. Patients with PSP tend to be taller than controls. There is a gradient within the pleural cavity of negative pleural pressure increasing from the lung base to the apex. This means that alveoli at the lung apex in tall individuals are subject to significantly higher distending pressures than those at the base of the lung and this is thought to predispose them to forming subpleural blebs. The incidence of PSP increases significantly with smoking (tobacco or cannabis). There is, however, no evidence for an association between physical activity and the occurrence of pneumothoraces.[1]

Secondary spontaneous pneumothorax (SSP) (Table 1)**:** SSPs occur in patients with abnormal lungs. Due to the underlying lung disease and poor respiratory reserve these patients are usually quite symptomatic even when the pneumothorax is relatively small and usually require intervention even for small pneumothoraces. The morbidity and mortality is higher for SSP than it is for PSP. SSPs are most commonly seen in patients with bullous disease due to chronic obstructive pulmonary disease (COPD) and emphysema. Bullae like blebs are cystic air-filled spaces that have a thin wall less than 1 mm; however bullae are larger than blebs (>2 cm) and commonly occur in diseased lung. The rupture of one of the bullae causes air to leak from the parenchyma and results in a pneumothorax and lung collapse.

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Causes of secondary spontaneous pneumothorax (SSP)

Aetiology

Underlying lung condition	COPD/emphysema, interstitial lung disease, cystic fibrosis, asthma
Pulmonary infection	Leading to cavitatory lesions with rupture into the pleural space; mycobacterial (tuberculosis (TB) used to be the commonest cause of SSP), pneumocystis pneumonia (caused by *Pneumocystis jirovecii* occurring in immunocompromised patients) parasitic and mycotic infections
Malignancy	Bronchogenic carcinoma, pulmonary metastasis
Catamenial pneumothorax	Rare although likely under-diagnosed. It is seen in women within 48 hours of onset of menstruation due to intrathoracic endometriosis
Connective tissue disorders	Ehlers—Danlos syndrome, Marfan's syndrome
Others	Histiocytosis X, lymphangioleiomyomatosis, oesophageal rupture

Table 1

Tension pneumothorax: tension pneumothorax is the term used when the positive pressure produced by the air within the pleural cavity is so high that it causes not only collapse of the lung but also compression and shift of the mediastinum to the contralateral side. Impaired venous return to the heart results from compression of the superior vena cava (SVC), inferior vena cava (IVC) and right atrium. As air continues to enter the pleural space but cannot escape (caused by a one-way valve effect) the degree of compromise and haemodynamic instability increases. The compromised venous return leads to decreased cardiac output and systemic hypotension this coupled with severe hypoxia will lead to respiratory and cardiac arrest (pulseless electrical activity) within minutes if untreated. This most commonly occurs in patients receiving positive pressure ventilation or as a complication of a traumatic pneumothorax with 'sucking' chest wounds. In both cases air is pushed into the pleural cavity increasing intra-pleural pressure and the defect acts like a one-way valve allowing air in but preventing it escaping. This life-threatening complication requires a high index of suspicion and immediate treatment. Life-saving treatment should not be delayed and diagnosis should be made on clinical grounds without delaying treatment. Emergency thoracic decompression is performed via a large-bore needle inserted in the second intercostal space, mid-clavicular line prior to definitive chest drain insertion. Urgent diagnosis and immediate management are required.

Traumatic pneumothorax: a traumatic pneumothorax can result from either penetrating or blunt (non-penetrating) chest trauma. With penetrating chest trauma, the wound allows air to enter the pleural space through the chest wall or through a breach in the visceral pleura or tracheobronchial tree (bronchopleural fistula). With blunt trauma a pneumothorax may result from a direct laceration to the lung parenchyma from a broken rib (dislocated rib fracture). Alternatively the severity of chest compression sustained during blunt trauma may result in a sudden and dramatic rise in alveolar pressure leading to direct rupture of the alveoli or even rupture of the airway itself, allowing air to enter the pleural cavity leading to a pneumothorax (air may also enter the mediastinum producing a pneumomediastinum).

Pneumothorax and altitude: as per Boyle's law the volume of a given mass of gas is inversely proportional to its pressure (assuming a constant temperature). This means that a given volume of air at sea level will expand by 1.5 times if placed at an altitude of 3050 m, therefore the increased risk of a bleb or bullae rupturing at high altitude.[2] Similarly in deep sea divers barotrauma leading to a pneumothorax can occur during ascent.[3]

Pneumothorax, signs and symptoms

Signs and symptoms vary with the degree of lung collapse and the respiratory reserve of the patient. Patients with a pneumothorax may present with shortness of breath, chest pain, cough and rarely surgical emphysema (subcutaneous swelling from air within the tissues). On examination they may have tachypnoea, and on the side of the pneumothorax they may have reduced air entry, hyper-resonance on percussion and absent or decreased breath sounds on auscultation.

Investigations

An erect postero-anterior chest radiograph ideally on inspiration is usually diagnostic. Sizing of a pneumothorax in an adult is usually estimated based on a chest X-ray (CXR). A rim of roughly 2 cm from the lateral lung edge to the thoracic cage corresponds roughly to a large 50% pneumothorax.

A CT scan gives an accurate estimate of size and assessment of lung parenchyma but is not required for immediate management. It is recommended for uncertain or complex cases.

Pneumothorax management

Management depends on the clinical setting, degree of compromise (related also to underlying lung disease and associated comorbid condition), the size of the pneumothorax, and the aetiology.

Initial management in a trauma case: airway, breathing and circulation should be addressed first. Patency of the airway and adequacy of ventilation should be evaluated along with an assessment of the chest wall and circulation. Pericardial tamponade and tension pneumothorax are both life-threatening complications and can produce similar signs and symptoms. Upright positioning maybe helpful if spinal injury can be excluded. Any penetrating ('sucking') chest wounds need immediate coverage with occlusive air-tight dressings. If a tension pneumothorax is suspected needle thoracocentesis should be performed through the second intercostal space in the mid-clavicular line as described previously.

Initial management of spontaneous pneumothorax: depending on the size and degree of compromise the pneumothorax causes

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