Recognizing Pneumothorax—A Case Study

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Pneumothorax injuries are infrequent but can be life threatening. They are most often associated with blunt trauma of the chest. The trauma causes rib fracture, which in turn perforates the pleural wall. Thus, air or gas accumulates in the pleural cavity and causes the lung to collapse. It is critical to recognize the signs and symptoms of this condition in order to provide prompt and successful treatment in what can be a medical emergency.

Dynamics of Normal Breathing

Within the thoracic cage, each lung resides in a separate compartment, the pleural sac. Between the thoracic wall and the pleural sac is a thin layer of intrapleural fluid (Vander et al., 1985) (Figure 1).

In the normal chest the lungs remain expanded due to two counteracting pressures: alveolar (pressure within the lungs) and intrapleural (pressure of the fluid in the pleural cavity surrounding the lungs) (Vander et al., 1985). Between breaths, when no contraction of the diaphragm occurs, the pressure within the lungs is equal to atmospheric pressure while the intrapleural pressure is less than atmospheric pressure. This gradient creates a negative pressure situation that allows each lung to expand fully within its own pleural sac.

During inspiration, the diaphragm contracts and flattens while the ribs are lifted by contraction of the intercostal muscles. Thus, the negative pressure increases, resulting in air flow from the atmosphere into the increased area of the lungs.

When the muscles involved in respiration relax, the diaphragm returns to its dome-shaped resting position and air is expired from the lungs. The passive expiration process becomes active and is facilitated by contraction of abdominal and chest muscles during exercise.

Injury Changes in Respiration

When the chest wall is pierced, in either an open or closed chest injury, normal pressure gradients are altered. The normal pressure

PNEUMOTHORAX

(OPEN—THE CHEST WALL INJURY PERMITS AIR TO FLOW IN AND OUT OF THE PLEURAL SPACE ON THE AFFECTED SIDE)

PNEUMOTHORAX

TRACHEA AND MEDIASTINUM SHIFTED AWAY FROM PNEUMOTHORAX

TRAUMATIC RUPTURE OF THE CHEST WALL

AIR HAS ENTERED THE PLEURAL SPACE AND COLLABSED THE LUNG

HAIR AND VESSELS IN THE MEDIASTINUM

NORMAL PLEURAL SPACE

PLEURAL SPACE FILLED WITH AIR

INHALATION: AIR ENTERS THE INJURED SIDE, CAUSING COLLAPSE OF THE LUNG AND SHIFT OF THE MEDIASTINUM AND HEART TOWARD THE UNAFFECTED SIDE

EXHALATION: THE AIR IS PARTIALLY FORCED FROM THE AFFECTED SIDE PLEURAL SPACE AND THE MEDIASTINUM Shifts Toward the AFFECTED SIDE

difference between alveolar and intrapleural pressure is eliminated. The resultant air in the intrapleural space causes lung collapse and unilateral chest wall expansion. The presence of air within the pleural space, but outside the lung, reduces the air volume capacity of the lung and decreases its ability to accept and transport oxygen (Thomas, 1993) (Figure 2).

Types of Pneumothorax

Simple Pneumothorax

Most cases of pneumothorax are simple and closed. Generally caused by a blunt blow to the chest, 90% of all cases of traumatic closed pneumothorax observed in adults are the result of rib fractures (Zuidema et al., 1979), although closed pneumothorax following blunt chest trauma may occur without a rib fracture. The severity of pneumothorax is classified by the volume of pleural space occupied by air and the degree of pulmonary collapse (Table 1).

<table>
<thead>
<tr>
<th>Size</th>
<th>% Pleural cavity occupied by air</th>
<th>Degree of lung collapse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>15% or less</td>
<td>Minor</td>
</tr>
<tr>
<td>Medium</td>
<td>15-60%</td>
<td>Moderate</td>
</tr>
<tr>
<td>Large</td>
<td>60% or greater</td>
<td>Severe</td>
</tr>
</tbody>
</table>

Figure 2 Lung collapse caused by pneumothorax injury. From Thomas, C.L. (ed.): Taber’s Cyclopedic Medical Dictionary, ed. 17, F.A. Davis, Philadelphia, 1993. Reprinted with permission of F.A. Davis Company.
The increase in intrapleural pressure can cause a mediastinal shift toward the uninvolved side of the chest, adversely affecting cardiac output. The hypovolemic condition created by the decrease in cardiac output results in peripheral hypoxia and metabolic acidosis. If these conditions persist for any length of time, they can be fatal.

In simple pneumothorax, lung capacity may not be significantly altered. However, for cases in which pneumothorax is significant or complications arise, changes in normal respiration can affect the cardiorespiratory system. Increasing intrapleural pressure can compress the vena cavae, interfering with diastolic filling of the heart. This will decrease cardiac output.

Spontaneous Pneumothorax

Occasionally pneumothorax occurs without an associated injury. This spontaneous accumulation of gas within the pleural space without a portal of entry through the chest wall (Simoneaux et al., 1990) is most common in young people between the ages of 15 and 30 and is reported more often in men than in women (Booher & Thibodeau, 1994).

Spontaneous pneumothorax is often associated with pulmonary disease (asthma, emphysema, chronic bronchitis) that results in rupture of the alveoli in the lungs (Griffith, 1986). However, it has also been associated with heavy exertion in healthy individuals. Diving, scuba diving, high altitude flying, or other activities that unduly stretch the chest and rib cage (e.g., track and field or throwing sports) can all cause spontaneous pneumothorax.

Hemothorax and Hemopneumothorax

Hemothorax, a condition in which blood but no air is present in the pleural cavity, also often occurs with blunt chest trauma. The incidence of hemothorax in patients with nonpenetrating chest wounds varies between 25 and 75% (Kirsh...
The source of the bleeding may be the lung, the heart, the great vessels and their branches, an intercostal artery or vein, mediastinal veins, or vessels of the chest wall or diaphragm. Broken ribs may also cause this condition if the blow forces them inward to puncture the lung.

If both blood and air are present in the pleural cavity following injury, it is termed hemopneumothorax. Both hemothorax and hemopneumothorax cause cardiorespiratory distress. The systemic result is similar to that observed with severe pneumothorax.

Complications of Pneumothorax

Several complications can occur with pneumothorax injury. Tension pneumothorax is a common complication of pneumothorax in which the air that enters the pleural space and cannot escape will accumulate, causing the affected lung to press on the heart and the unaffected lung. The increase of pressure in the pleural space results in lung collapse (Thomas, 1993). Each breath aggravates the collapse since air cannot be exhaled.

Negative pressure of the collapsed lung continues to rise and can exceed the normal pressure of venous blood, thus reducing venous return to the heart (Heckman, 1992). The result is an inability to pump blood to the lungs for oxygen. Arterial blood flow also decreases, resulting in hypoxia. Tension pneumothorax is life threatening, exhibiting a rapid onset of symptoms of respiratory distress and dyspnea (Booher & Thibodeau, 1994).

Other possible complications of pneumothorax include hemopneumothorax, which often accompanies both open and closed chest wounds, and hydropneumothorax (fluid in addition to air in the pleural cavity); these often develop within 48 hours of the injury (AAOS, 1991).

Diagnosis

With mild pneumothorax there may be no signs or symptoms. Damage to the pleural wall may be limited to minor injury and the resultant pulmonary collapse will seal the wound. A small pneumothorax will usually resolve itself without intervention.
Only in moderate and severe pneumothorax injury will symptoms usually present, the most common ones being marked chest pain and shortness of breath. These symptoms are seen in about half of all cases (Kirsh & Sloan, 1977).

The chest pain may extend to a shoulder or across the chest and abdomen, and breathing may be rapid and shallow. The athlete may have a dry, hacking cough, occasionally coughing blood. These symptoms usually appear soon after injury.

If the pneumothorax has a tension component, respiratory distress progresses rapidly. The pulse is weak and rapid and blood pressure decreases rapidly. In moderate and severe cases, there is a mediastinal and tracheal shift to the uninjured side and a bulging of the tissues of the chest wall between the ribs and above the clavicle (Vinger & Hoerner, 1986). There is visible distention of the neck veins and cyanosis.

Physical examination reveals tympanic hyperresonance to percussion. Distant or absent breath sounds occur on the involved side. These sounds may be difficult to interpret since the patient cannot breathe normally.

The definitive diagnosis of pneumothorax is made from the physical findings and chest X-rays, which will show a separation of the two layers of pleura by an accumulation of air (or fluid in the case of hemothorax or hemopneumothorax) in the pleural cavity. A small pneumothorax may be difficult to detect with X-rays.

### Treatment

Immediate attention to suspected pneumothorax injuries involves making the athlete comfortable and monitoring vital signs: pulse, blood pressure, and respiration. The athlete will usually breathe more easily if he or she lays on the affected side, as this may seal the pleural perforation.

Emergency treatment of the athlete with pneumothorax requires immediate administration of oxygen and transport to a hospital. Moderate and severe traumatic pneumothorax will be drained by intercostal intubation (tube thoracostomy) (Hughes, 1983). Some advocate needle aspiration and/or observation of "minor" pneumothorax, particularly spontaneous pneumothorax. If the condition is caused by trauma, however, Zuidema et al. state, "This so-called conservative approach is associated with a much lower success rate than when used for spontaneous pneumothorax" (1979, pp. 394-395).

### Conclusion

Pneumothorax can be life threatening. Trauma-induced pneumothorax may be overlooked in blunt trauma, such as that resulting in rib fracture. Successful treatment includes close monitoring of symptoms and medical intervention. With careful and consistent monitoring, adequate recuperation time, rehabilitation, and proper postinjury protection, the patient can expect full recovery from pneumothorax injury.

### References


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