

Tension Pneumothorax- Pathophysiology and Emergency Care

Tension pneumothorax is the progressive build-up of air within the pleural space, usually due to a lung laceration which allows air to escape into the pleural space but not move out. As more air leaks out filling the pleural space with each breath, the patient will find it progressively more difficult to breathe.

As emergency care providers become aware of the respiratory distress and decreased ability to expand the chest, the obvious choice would be to initiate positive pressure ventilation. Unfortunately, Positive pressure ventilation may exacerbate the rate of pleural space filling. Progressive build-up of pressure in the pleural space pushes the mediastinum in the opposite direction to the injured lung, and obstructs venous return to the heart. This ultimately leads to circulatory instability and may result in traumatic cardiac arrest.

Anatomy of the Chest

The lungs occupy almost the entire chest cavity. Each lung is surrounded by a thin serous membrane called the Visceral Pleura. The inner chest wall and Diaphragm is surrounded by the Parietal Pleura.

In between the Visceral and Parietal Pleura is a “potential” space called the Pleural Space. A small amount of Serous Fluid is found in the Pleural Space and acts as a lubricant and prevents friction between the Visceral and Parietal Pleura.

In between the two lungs is an area called the Mediastinum, where the heart and great vessels are located.

Any air and/or fluid accumulating in the Pleural Space physically separates the Visceral Pleura from the Parietal Pleura and has a direct impact on lung expansion and ultimately ventilation and oxygenation.

Pathophysiology of Tension Pneumothorax

As mentioned in the introduction, Tension Pneumothorax develops when air accumulates in the Pleural Space and causes the affected lung to collapse. Several mechanisms can lead to the development of a Tension Pneumothorax. In blunt chest trauma, the force can cause a rib fracture and the fractured rib end may puncture the lung. With each breath the patient takes, more and more air accumulates in the Pleural Space and ultimately leads to Tensioning.

In open chest trauma, a flap may form at the injury site, causing air to rush into the Pleural Space during inspiration and due to a one-way valve effect, not allow air to exit during expiration. As such, air will once again accumulate in the Pleural Space, once again leading to Tension Pneumothorax.

In both instances, as more and more air accumulates in the Pleural Space, there is a dramatic rise in intrapleural pressure. If the pressure continues to rise, it will eventually force the injured lung towards the Mediastinum, compressing the great vessels and uninjured lung. This results in a decrease in venous return to the heart and decrease in cardiac output. If the pressure is not relieved, the dramatic decrease in cardiac output will ultimately cause death.

Clinical Presentation

Tension Pneumothorax can present with a range of signs and symptoms, however from personal experience, the one that truly stands out for me is progressive dyspnoea. In other words, the patient's breathing becomes more laboured with each breath he/she takes as intrapleural pressure in the affected hemithorax increases.

In several studies conducted on awake patients, a range of signs and symptoms were found with varying degrees of reliability. Let's take a look at some of these...

Universal findings:

- Chest pain
- Respiratory distress

Common Findings (50% - 75% of cases):

- Tachycardia
- Ipsilateral decreased air entry

Inconsistent Findings (<25% of cases):

- Low SP02
- Tracheal deviation
- Hypotension

Rare findings (about 10%)

- Cyanosis
- Hyper-resonance on percussion
- Decreasing level of consciousness
- Ipsilateral chest
 - Hyper-expansion
 - Hyper-mobility
- Acute epigastric pain
- Sternal resonance

So the point is, the regular EMS teaching of diagnosing Tension Pneumothorax by means of tracheal deviation, distended neck veins, hyper-resonance and decreased breath sounds may very well be absent or present in a smaller percentage of patients. Ultimately one should be guided by the mechanism of injury and the presence of significant progressive respiratory distress. A very rigid approach may very well be to the detriment of the patient.

Emergency Medical Care

In an open chest injury, treatment consists of covering the wound with an occlusive dressing taped down on 3-sides, or better still by making use of purpose designed chest wound seal such as the CriteSeal (developed and manufactured by Be Safe Paramedical). This effectively stops air from been 'sucked' in during inspiration and therefore dramatically reduces the potential for the development of tension pneumothorax.

Unfortunately circumstances do sometimes develop where the only means of reducing intrapleural pressure and improving patient cardiac output is to perform needle thoracostomy. It is not a skill to be taken lightly as its invasive nature can be associated with several dangerous complications.

Let's say that you have diagnosed a left-sided Tension Pneumothorax and you have opted to perform needle thoracostomy, let's take a quick refresher on how to perform the procedure safely.

Equipment

- Sterile gloves
- At least 4 x Disinfectants pads
- 14 gauge over the needle IV catheter (Please note I will be using an 18G needle to puncture the Trainer for obvious reasons)
- 20cc syringe pre-filled with 5ml of sterile water or Saline



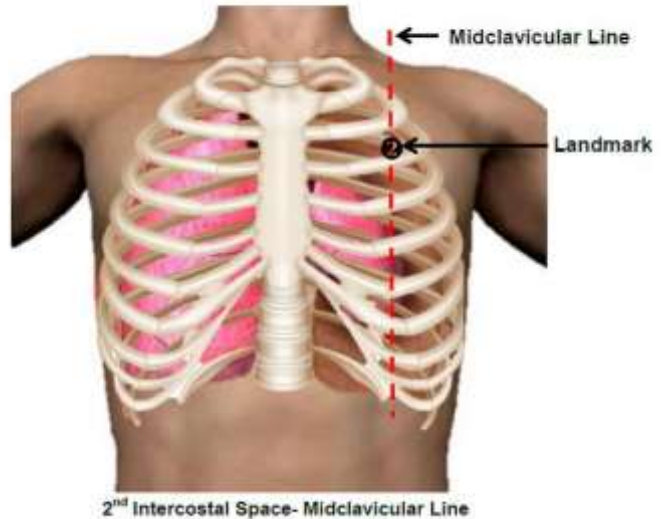
- One-way valve (I used CriteValve with Luer Lock available from Be Safe Paramedical)
- Securing tape

Landmark

With reference to the above patient scenario, the current preferred site for performing Needle Thoracostomy is the 2nd Intercostal Space Midclavicular Line. The needle should be placed just above the 3rd Rib to avoid hitting the neurovascular bundle.

Recent studies suggest that the 5th Intercostal Space in the Anterior Axillary Line is significantly thinner than the 2nd Intercostal Space in the Midclavicular Line, thus increasing the likelihood of needle decompression having a higher success rate.

In line with current ATLS teaching, I will continue using the 2nd Intercostal Space until such time as changes are made to the programme.



Procedure

Step 1

Provide the patient with high-flow oxygen. Position patient supine and expose the chest. Don sterile gloves and lay out a sterile drape on which to place your equipment. Prefill your 20ml syringe with 5ml of sterile water or normal saline and attach the syringe to the 14G IV Catheter.



Step 2



<-- Locate the landmark (in this case Left 2nd Intercostal Space Midclavicular Line)

Clean the area thoroughly with the disinfectant pads. Don't be shy to use a few pads to make sure the area is as clean as possible.



Step 3

Take your needle and insert it just above the 3rd rib perpendicular to the chest wall while gently drawing back on the syringe. Once you have penetrated into the Pleural Space, any air being drawn into the syringe will cause the sterile water/ saline to bubble. Once air is drawn back into the syringe, advance the needle a further 5mm or thereabouts, hold the stylette stationary and advance the Catheter into the Pleural Space.



Step 4

Place your stylette into a sharps container and attach a one-way valve to your IV Catheter. Secure Catheter and valve with strapping (I like to use goal-post strapping as it creates a little flexibility and is less likely to kink Catheter).



Step 5

Reassess the chest for improvement. I have seen quite dramatic improvement in a very short space of time with many patients over the years (provided it is a genuine Tension Pneumothorax). If no improvement following reassessment, consider inserting another needle next to the first one.

Needle Thoracostomy may seem simple enough, however as mentioned, it is associated with numerous complications.

Complications Include:

- Creating a pneumothorax where none existed
- Laceration of lung wall
- Haemothorax
- Injury to heart or great vessels
- Laceration of the spleen
- Laceration of the liver
- Infection

And that's it... Relatively simple to perform, quite a number of complications to consider, however when performing the procedure is weighed up against a severely compromised patient with confirmed Tension Pneumothorax, it can be life-saving

Written by: Gavin Sutton

www.be-safe.co.za