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Review Article

Surgical Management of Pneumothorax

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Abstract

Introduction: The term pneumothorax refers to the existence of air anywhere in the pleural cavity between the lungs and chest wall. The probability of developing a pneumothorax is higher in patients with existing lung conditions, and such cases are more endangering and difficult to treat. The treatment protocol for the management of pneumothorax was initially published in the year 1993 by the British Thoracic Society and was later modified in 2003 with a more conservative approach towards management and more focus on the conditions and consequences associated with it [7]. This review talks in detail about the surgical techniques for the management of pneumothorax.

Aim of Work: This review aims at highlighting an overview of the surgical management of pneumothorax.

Methodology: This review is a comprehensive research of PUBMED and Google Scholar from the years 1930 to 2020.

Conclusion: The management of pneumothorax mainly aims at reducing the chances of recurrences and complete evacuation of air. VATS is a more cost-effective and conservative surgical approach as compared to open thoracotomy, but the lack of clinical trials and evidence has not been standardized as the treatment approach for pneumothorax. In the limitation of this review, it is concluded that more extensive research should be done for surgical management techniques, and a paradigm shift towards conservative treatment approaches is required.

Keywords: *Spontaneous Pneumothorax; Thoracotomy; Pleurodesis; Pleural Abrasion; VATS*

Introduction

The term pneumothorax came into existence in the 1800s by Itard and Laennec and referred to the existence of air anywhere in the pleural cavity between the lungs and chest wall. The occurrence of pneumothorax is generally secondary to severe cases of tuberculosis or other lung diseases, and that variant of pneumothorax is called Secondary Pneumothorax. Pneumothorax occurring in healthy patients is called Primary spontaneous Pneumothorax [1].

The probability of developing a pneumothorax is higher in patients with existing lung conditions, and such cases are more endangering and difficult to treat. One of the most important etiological factors of pneumothorax is anatomical variations found in the lung in the

form of sub-pleural blebs and bullae, which are generally visible on CT scans and thoracoscopy at the lung apices [2]. These subpleural blebs are seen more frequently in patients who are taller as the alveoli in taller individuals are more prone to developing higher pressure, thereby increasing the formation of blebs [3]. Studies done in autofluorescent lighting have also revealed porosities in the pleural layer and obstruction of the airway by inflammatory cells influx [4].

Smoking has also been established as a reason for the development of pneumothorax. There is a 12% higher chance in healthy smoking individuals to develop pneumothorax compared to a 0.1% chance in nonsmoking individuals. The chances of pneumothorax recurrence also increase to more than 50% in patients who do not quit smoking after their first episode. A study concluded that more than 80% of the individuals continue to smoke after their first episode of pneumothorax, thereby increasing the chances of recurrence, which is generally high in the first four years of the first episode [5,6].

The treatment protocol for the management of pneumothorax was initially published in the year 1993 by the British Thoracic Society and was later modified in 2003 with a more conservative approach towards management and more focus on the conditions and consequences associated with it. This review talks in detail about the surgical techniques for the management of pneumothorax [7].

Diagnosis of pneumothorax

Spontaneous pneumothorax generally occurs during the resting phase of the patient. The symptoms and their severity depend on the size of the pneumothorax. In cases of a small pneumothorax, patients may develop a sharp chest pain that gradually becomes a steady dull ache and resolves in 24 hours without intervention. Patients generally complain of chest pain and breathlessness. On examination, the following signs are seen (Table 1) [8].

Physical signs in case of pneumothorax
1. Marked reduction in expansion of the lung
2. Increased heartbeat, which may go up to 135 beats per minute
3. Breath sounds are reduced on the side where pneumothorax is present
4. Hyper resonant percussion note
5. Inadequate oxygenation in the blood leading to cyanosis
6. Tension pneumothorax might also be associated with tachypnea and hypotension and signs of cardiorespiratory distress.

Table 1: *Clinical presentation of pneumothorax [8].*

Secondary Spontaneous Pneumothorax generally presents with more severe symptoms, and the severity of these symptoms is not associated with the size of the pneumothorax. A bigger primary pneumothorax may not be as severe as a small secondary pneumothorax, and hence symptoms of the disease will not always be a good indicator of the size of the lesion [9].

Imaging

The most reliable method for diagnosis of pneumothorax is through imaging. Conventional and digital chest x-rays and other digital imaging methods have proven to be the gold standard for diagnosing pneumothorax. Various modalities used for the imaging of pneumothorax are mentioned below [8]:

1. Standard erect x-rays
2. CT scans
3. Ultrasound scanning
4. Lateral X-rays
5. Supine and lateral decubitus x-rays.

Standard erect x-rays

Standard X-rays are the mainstay for imaging in cases of pneumothorax. In the current times, the advent of digital imaging has left a lesser scope for erect imaging as the films are not as easily available. The other limitation of erect X-rays is their inability to tell the size of the pneumothorax. The x-ray reveals displacement in the pleural line and an air-fluid level in the costophrenic angle, which are the only two abnormalities seen on the x-ray (Figure 1) [10].

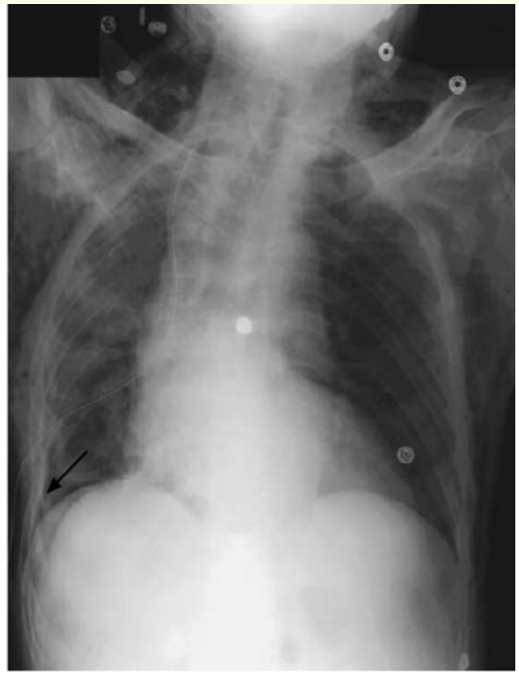

Figure 1: *The black arrow in this chest X-Ray indicated the presence of pneumothorax [10].*

Lateral x rays are not as accurate as erect x rays and hence are used less often for the diagnosis. Supine and lateral decubitus x-rays are generally used in cases of trauma where erect x-ray is not possible due to limitations in patient movement [11].

Digital imaging

The main advantages of using digital imaging is their ease of use and size calculation. Contrary to conventional X-rays, digital x-rays can be easily manipulated in terms of contrast adjustment, size adjustment, ease of storage and reproduction [12].

CT scanning

CT scans are considered the gold standard in the diagnosis of pneumothorax. They are the most precise in terms of size estimation, which helps in identifying even the smallest pneumothoraces. CT scans give us an accurate idea for the placement of chest drainage units and the presence of any other lung pathology. In Spite of the above facts, CT scans cannot be used as the first line of diagnosis due to increased exposure and other practical issues [13].

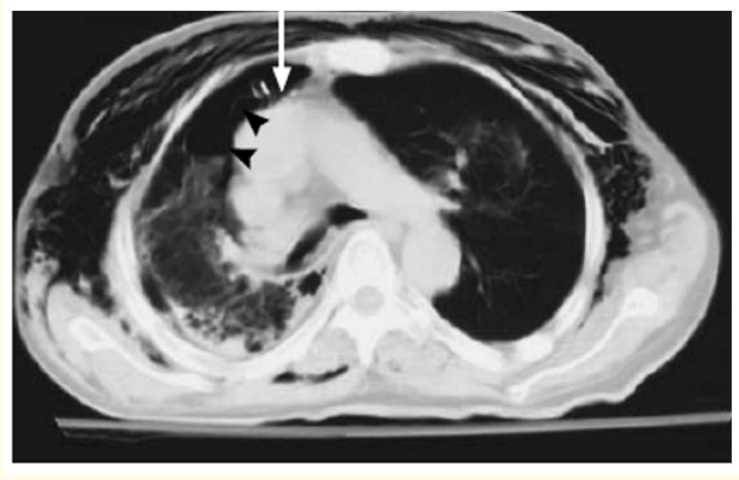

Figure 2: *Pneumothorax as seen in CT scan, the black arrow indicates the presence of multiple bullae [13].*

Management of pneumothorax

The first and foremost aim for the management of pneumothorax is to cease the recurrence of the disease, which generally increases after the first episode of recurrence. In a randomized control trial conducted by Kelly., et al. where they compared the recurrence rate of pneumothorax as treated with drainage or drainage with tetracycline and concluded that cases treated with tetracycline during drainage had a lowered rate of recurrence (around 13%) as compared to 36% in cases with the only drainage [14]. Various treatment options for pneumothorax have been stated below in table 2. In this review, we discuss the surgical approach for the treatment of pneumothorax in detail [14].

Conservative Treatment	Intermediate Treatment	Invasive Treatment
1. Observation	1. Pleural Abrasion	1. Pleurectomy
2. Aspiration	2. Pluerodesis	2. Bullectomy
3. Drainage	3. Cauterisation	3. Thoracotomy
4. Medical thoracoscopy		4. Video-assisted thoracoscopic surgery (VATS)

Table 2: *Various management options for pneumothorax [15].*

Surgical management of pneumothorax

Surgical treatment is indicated in severe cases of pneumothorax where the recurrence rate is high, or the size of the pneumothorax is more. Patients with professional exposure to a high recurrence rate of pneumothorax like pilots, submarine, and scuba diving personnel, cases where there is consistent air leak even after conservative treatment generally tend to be taken for surgical approach. A study concluded that the recurrence rate after surgical management in a 20-year follow-up study was 3 - 4% [16]. The advent of VATS increased the shift towards the surgical management approach for pneumothorax as it provided all the benefits of a thoracotomy without actually opening the thorax. Apical lesions can be resected more comfortably with the help of endoscopic staplers, thereby making the whole surgery easier (Figure 3) [15]. However, due to the lack of literature and clinical evidence, the first choice of surgical treatment for pneumothorax still remains thoracotomy and pleurectomy [8].

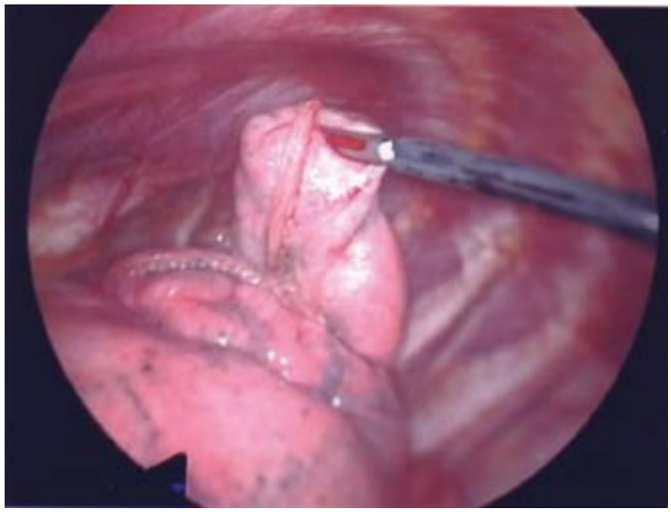

Figure 3: *Endoscopic stapler being used for resection of apical bullae [15].*

Surgical management by thoracotomy

The standard posterolateral thoracotomy technique is the most common surgical approach for surgical management pneumothorax. Other smaller incisions like axillary, interior, muscle-sparing approaches can also be used [17]. The surgical procedure involves excising the blebs and bullae or electrocoagulation of the smaller lesions. In order to avoid the recurrence rate, pleural procedures like abrasion of the parietal and visceral pleura with dry gauze or chemical pleurodesis with tetracycline on the surface of the visceral pleura are also done. Most common post-surgical complications include wound infection, fever, pneumonia, persistent air leak. Chances of death are very rare, only up to 1% cases, and are mostly associated with an underlying lung disorder [18].

The chances of recurrence after surgery may vary between 1 to 5%. In a study conducted by Nkere., et al. 2 out of the 60 patients who had undergone apical parietal pleurectomy and 1 out 93 patients treated with mechanical abrasion reported recurrence [19].

Video-assisted thoracoscopic surgery

Surgical preparations for VATS are the same as that of thoracotomy, where the patient is kept under general anesthesia in a lateral decubitus position. General anesthesia can be replaced by epidural anesthesia or sedation in older patients and patients who have underlying lung disease. The main advantage of VATS over a limited thoracotomy is the increased visibility. The management of blebs and bullae can be carried out by various means like stapled resection, and pedicled bullae can be clipped, laser ablation of blebs can be done. The parietal pleura can be abraded with dry gauze in order to reduce recurrences (Figure 4) [20,21]. Postoperative complications are the same as those in thoracotomy, although less seen in VATS. Persistent air leak, if seen as a complication, requires reintervention. In certain cases where the patients are kept on external ventilation machines, there are chances of myocardial infarction and respiratory failure [21]. Interestingly, the recurrence rate is inversely proportional to the treatment intensity and cases with a more intense treatment plan involving lung and pleural procedures. In order to avoid the recurrence rates, the more preferred treatment plan is resection of the lung tip and complete pleurodesis [22].

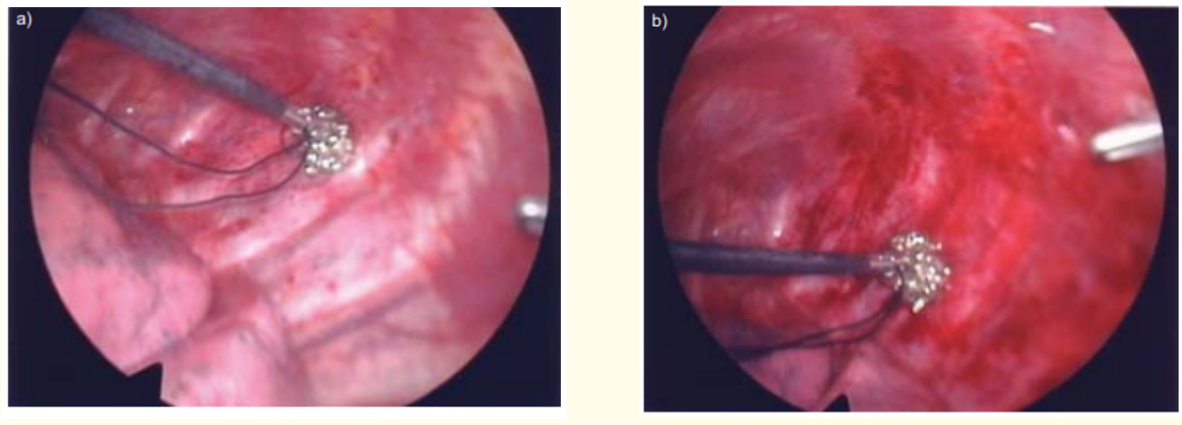

Figure 4: *Mechanical abrasion of parietal pleura [15].*

Simultaneous surgical treatment of both lungs

Cases where both the lungs are involved or contralateral recurrence, occurs which indicates surgery for both lungs at the same time. Such cases can be handled via bilateral thoracotomy or VATS. After treating one side, access to the other lung is gained via mediastinum present between the esophagus and first thoracic vertebral bodies. Graspers are used to get the contralateral apex in the pleural cavity and drained from the ipsilateral chest, which is opened. The same procedure can be done using VATS, where the passage for the adjacent lung can be done via space between the sternum and pericardium. Bilateral thoracotomy has proven to be more successful than VATS, where the patient may be subjected to a prolonged hospital stay in complicated cases where adhesion is seen [23].

Conclusion

The management of pneumothorax mainly aims at reducing the chances of recurrences and complete evacuation of air. VATS is a more cost-effective and conservative surgical approach as compared to open thoracotomy, but the lack of clinical trials and evidence has not been standardized as the treatment approach for pneumothorax. In the limitation of this review, it is concluded that more extensive research should be done for surgical management techniques, and a paradigm shift towards conservative treatment approaches is required.

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