Pneumothorax

39

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Introduction

Pneumothorax is the presence of air in the pleural cavity between the parietal and visceral pleura, resulting in partial or total collapse of the lung.

The name *pneumothorax* was introduced in 1803 by Itard, and the first clinical description was delivered by Laennec in 1819. Kjaergaard in 1932 first used the term *spontaneous pneumothorax* to refer to disease without a detectable etiology (Kjaergaard 1932). Pneumothorax may affect patients of any age, but there are two peaks of incidence: at 20–30 years and 60–70 years. The first peak usually affects patients with lung pathology that is difficult to detect even during thoracoscopy, whereas the second peak is more directly accompanied by emphysema. Pneumothorax occurs four to five times more frequently in males, and the overall rate is estimated at 24–32 cases per 100,000 people. A specific type of this disease is *catamenial pneumothorax*, which occurs only in females, usually as a result of endometriosis in the pleura (Alifano 2010).

Although pneumothorax may occur as a complication of virtually any disease of the lung parenchyma or from chest trauma (both blunt and penetrating), most pneumothoraces are caused by the rupture of smaller or bigger blebs of the lung parenchyma. Iatrogenic pneumothorax most commonly is a complication of catheterization of the subclavian vein, pleural puncture, transthoracic needle aspiration biopsy, or ventilation with positive pressures.

The most typical clinical symptoms of pneumothorax are chest pain, dyspnea, and cough. Its manifestation varies; in younger people, the dominant symptom frequently is chest pain whereas older patients usually complain of dyspnea. About 12 % of patients do not report any symptoms, which delays the proper diagnosis. Typical symptoms revealed during physical examination are tympanic resonance and decreased breath sounds in the affected hemithorax. Asymmetric breath sounds between the left and right chest suggest pneumothorax, but the difference may be subtle; therefore, the diagnosis should be confirmed by a posteroanterior chest radiograph or, in selected cases, by chest CT. When in doubt, it is useful to obtain another chest radiograph in the expiration phase with less voltage and amperage of the x-ray lamp (i.e., "soft" radiograph). Sometimes it is difficult to differentiate a pneumothorax from a large emphysematous bulla on the chest radiograph; a CT scan is usually decisive. Proper differentiation between these two entities is important because drainage of an emphysematous bulla may result in major complications, including prolonged drainage, risk of infection, and respiratory insufficiency. Seventy percent of patients with left pneumothorax present with nonspecific electrocardiographic changes, which may lead to an improper diagnosis and delayed treatment.

Pneumothorax is classified according to etiology, mechanism and clinical appearance, and size (Table 39.1).

Some types of pneumothorax—namely, tension pneumothorax, hemopneumothorax, and simultaneous bilateral pneumothorax—may be life threatening. Tension pneumothorax is dangerous because the air freely enters the pleural space, but a valve effect created by the ruptured tissue (chest wall or lung parenchyma) prevents the air from escaping the pleural cavity, resulting in increasing pressure in the pleural cavity, total collapse of the affected lung, a shift of the mediastinum

Table 39.1 Classification of pneumothorax

Etiology	Clinical appearance	Size (British Medical Society)
Spontaneous	Closed pneumothorax (also called pneumothorax simplex)	Small (lung <2 cm from the chest wall)
Symptomatic	Open pneumothorax	Large (lung >2 cm from the chest wall)
Iatrogenic	Tension pneumothorax	—
Traumatic	Hemopneumothorax	—

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toward the opposite side, and compression of the opposite healthy lung. The return of blood to the right atrium is inhibited by the intrathoracic pressure, and without intervention the patient may die of *empty heart syndrome*. In these cases, patients have severe dyspnea, the affected hemithorax may look overinflated, and cyanosis of the upper part of the body may be visible. These patients often require immediate intervention via a needle puncture of the pleural space (Kelly et al. 2008).

Pneumothorax is a recurrent disease, with 53–75 % of cases recurring less than 5 years after the first episode (Devenand et al. 2004).

Figure 39.1

Chest tube drainage remains the most common treatment for pneumothorax. The most frequent location for drain placement is the fifth to sixth intercostal space in the midaxillary line, although some surgeons use the second intercostal space in the midclavicular line. Several types of drains are commercially available, but most surgeons prefer relatively large (24F–32F), nonirritating (silicone or soft rubber), easy-to-install drains. Before the procedure, the patient should receive an explanation of the planned treatment, as well as a sedative and analgesic. The patient is placed in a semi-sitting position (i.e. with the chest elevated ~30°). The surgeon marks the incision site; the incision should be 1–2 cm long in the second intercostal space in the midclavicular line or slightly lateral to this line (not medial because of the risk of internal mammary artery laceration). It is advisable to make the incision slightly lower on the third rib (not on the second intercostals space) to provide an oblique channel for the drain directed toward apex, which is the preferred direction for the drain. The incision site should be anesthetized by instillation of 5–8 ml of 1 % lidocaine. The needle should penetrate the pleural space on the upper rim of the third rib (not the lower rim, to avoid intercostal vessel damage) and air must be aspirated, finally confirming the diagnosis of pneumothorax

The differential diagnosis for pneumothorax should include the following:

- Myocardial infarction
- Pulmonary artery embolism
- Exacerbation of chronic obstructive pulmonary disease
- Pneumonia
- Hydrothorax or hemothorax

There are three basic treatments for pneumothorax (Kelly 2009):

- Bed rest
- Chest tube drainage
- Pleurectomy

Figure 39.1

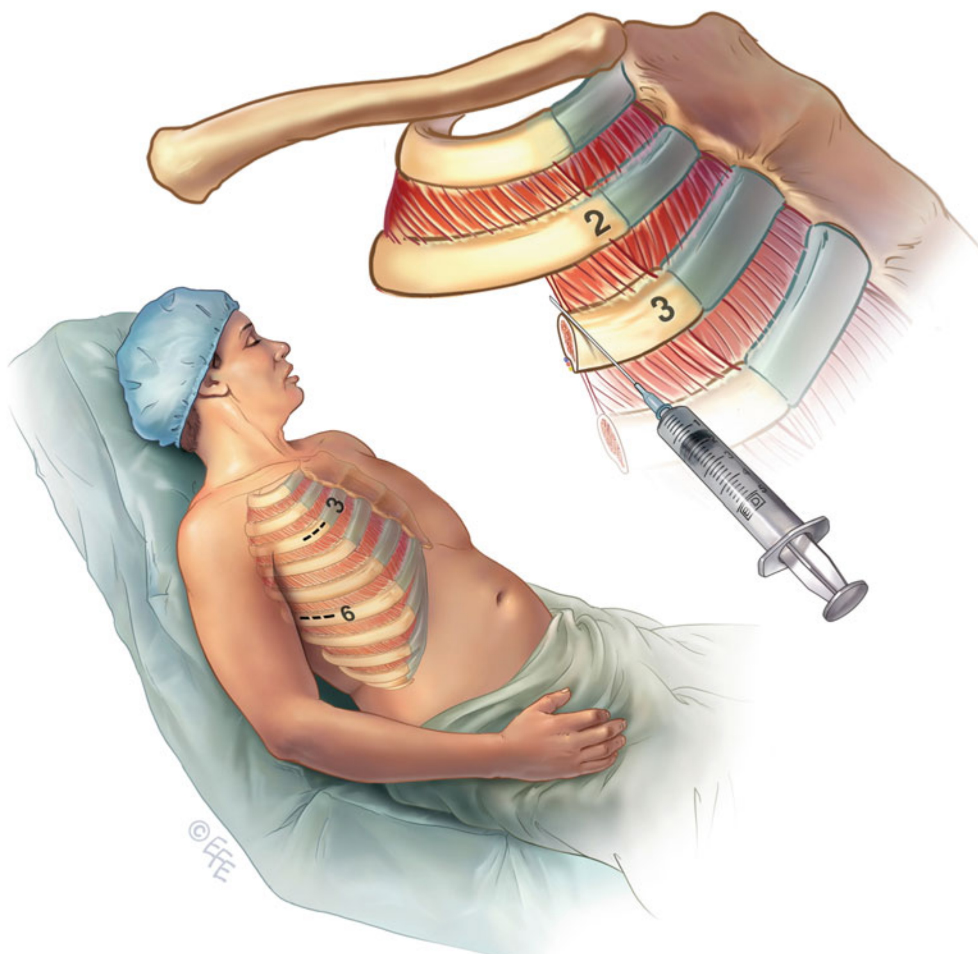


Figure 39.2

After the skin and subcutaneous tissue are incised, a suture may be placed across the incision and left untied; after the tube is removed, the suture may be tied to close the drain channel and prevent air from entering the pleura. Afterward, the surgeon should continue blunt dissection of the tissues with a clamp or trocar (delivered with some drain types) until it reaches the pleural space. A wheezing sound of evacuating air typically is heard after the pleural space is reached. The patient may experience dyspnea at this moment and become fearful of the reexpanding lung, but this usually resolves within a few minutes. (**a**) It is important to insert the instruments close to the upper margin of the lower rib. Inserting instrument close to the lower margin of the upper rib increases the risk of the intercostal vessels injury. (**b**) The chest drain should be placed upwards. It is essential to fix it to the skin by suture

Figure 39.2

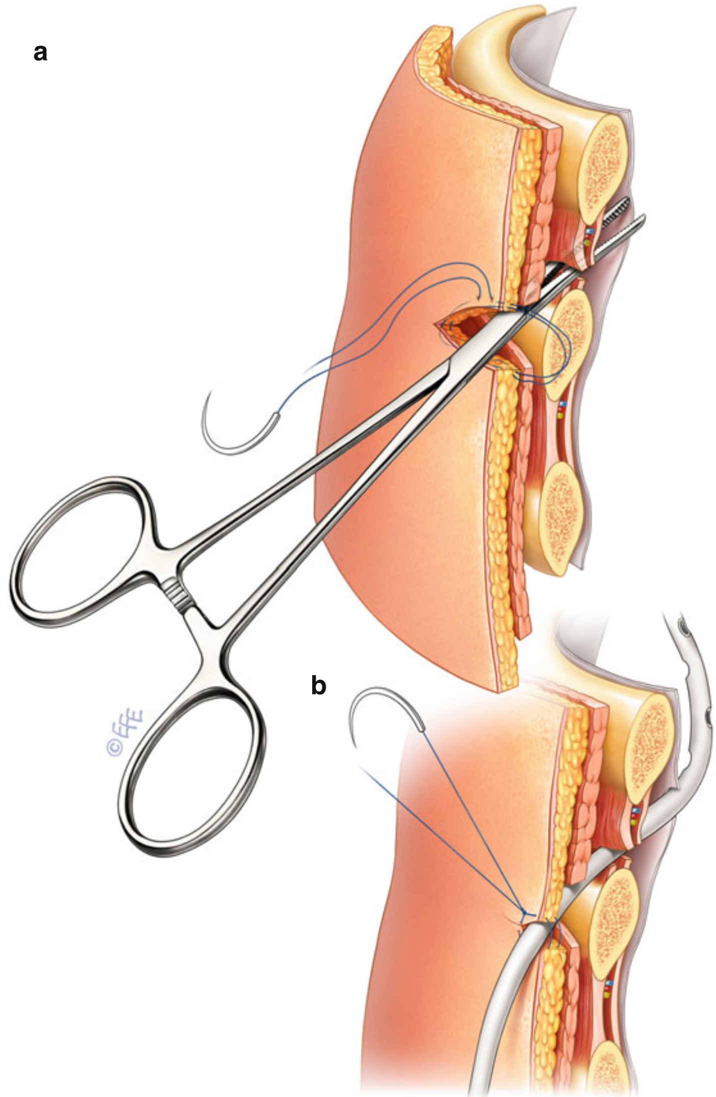


Figure 39.3

The drain is installed with the help of the long clamp or commercially available trocar. The tip of the drain must be directed toward the apex (this is easier if the drain is placed in the second intercostal space and more difficult if it passes through the sixth intercostal space). All lateral drain holes should remain in the pleural space. Sometimes it is necessary to make additional holes; however, the last one should not be closer to the chest wall than 2 cm, otherwise a false air leak might be observed. The installed drain should be connected to the drainage system; all connections must be airtight. The drain must be fixed to the skin with additional suture. There is an ongoing controversy regarding suction. Clinical practice indicates that most centers prefer active suction, but some papers suggest it seems more important after upper lobectomy than lower lobectomy. In cases of prolonged air leakage or fluid output, many centers discharge patients home with portable non-suction devices, which are removed subsequently when air leakage stops. Although a variety of these devices are commercially available and commonly used, the thoracic surgeon should be able to construct an ad hoc drainage system in case of emergency. The simplest and easiest method is to place the chest drain into the plastic bottle used for intravenous infusions. The bottle must be placed lower than chest level (practically speaking, on the floor). Widely accepted indications for chest tube removal are as follows:

- absence of air leakage
- full reexpansion of the affected lung (confirmed radiologically)
- volume of drained clear fluid less than 200–400 mL/d

Some surgeons clamp the drain for 6–48 h before removal. If the chest radiograph confirms there is no pneumothorax recurrence and there is no air leakage after the drain is reopened, the tube is removed. The aforementioned rules have been questioned with the advent of devices that provide a quantitative measure of an air leak, as well as with the trend over time. The decision-making process is easier and more evidence based with the use of such devices (Mattioli et al. 2008)

Figure 39.3

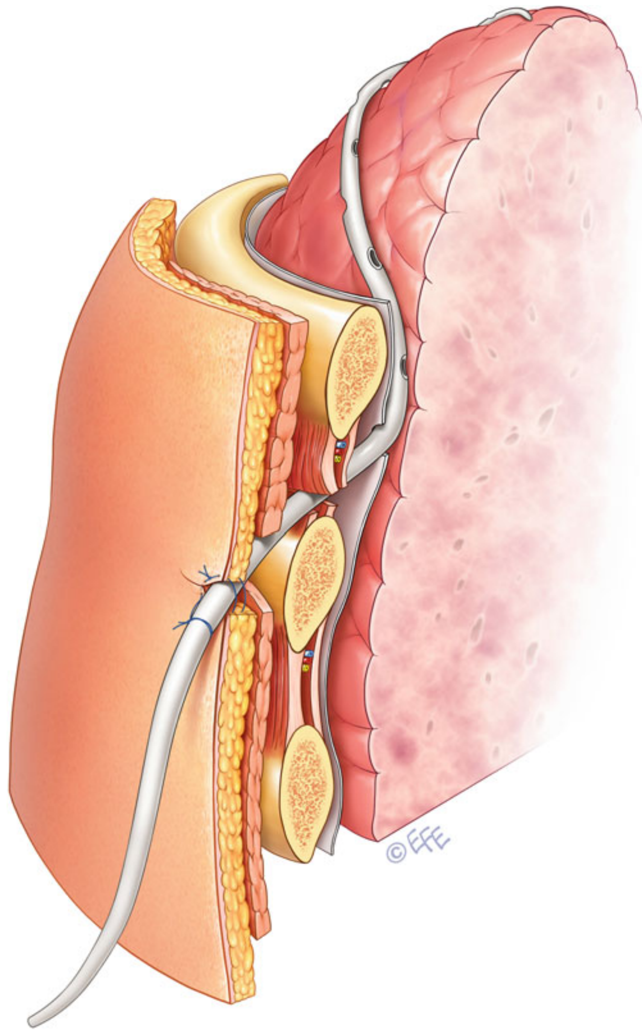


Figure 39.4

Partial or complete pleurectomy—surgical removal of part (the first to fifth ribs) or all of the parietal pleura, except mediastinal part—is the method of choice for recurrent pneumothorax or for treating the first episode in patients working in occupations that place them at high risk for recurrence (e.g., sailors, airline or military pilots, truck drivers, open sea fishermen, divers, trumpeters) or in those at risk for a recurrent episode occurring in an environment with limited access to medical treatment (e.g., open sea, transcontinental flight). In such cases, patients are offered surgical treatment at the time of the first episode. Pleurectomy creates strong adhesions between the visceral pleura and intrathoracic fascia (the next layer under the removed parietal pleura), providing protection against new episodes of pneumothorax because the pleural space is irreversibly obliterated. The first to describe this effect of pleurectomy was Gaensler in 1956. Pleurodesis is based on pleural abrasion to create the aforementioned adhesion, but it provides slightly worse protection against recurrence. In the past, pleurectomy usually was performed through thoracotomy, but now most cases are performed by VATS. The patient is placed in the lateral position, and three ports are installed as shown

Figure 39.4

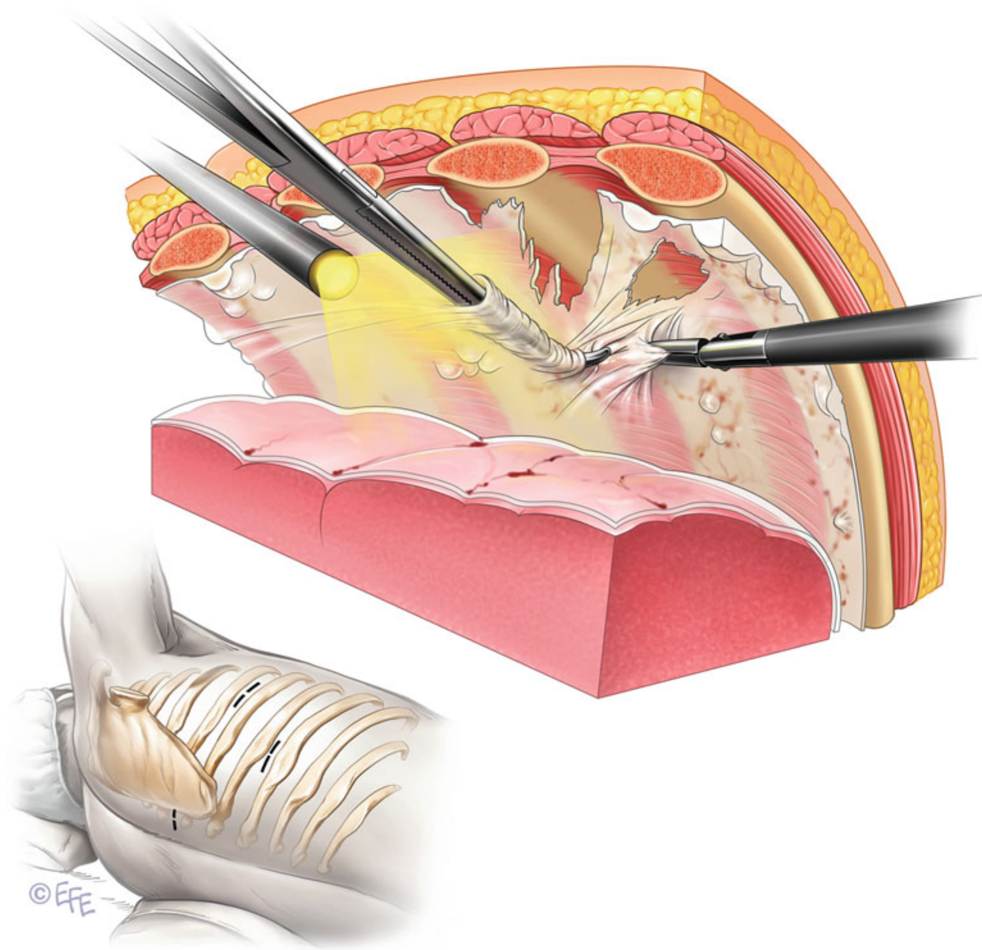


Figure 39.5

After the camera is inserted, the surgeon should try to locate the air leak; however, in about 50 % of cases, this is not possible. Blebs suspicious for air leakage should be resected using endostaplers. If no other pathology responsible for the pneumothorax is visible (the diaphragm should be checked for potential foci of endometriosis), pleurectomy should be started by blunt dissection of the parietal pleura close to one of the ports. This may be done using a curved clamp or even the surgeon's finger. Afterward, the preparation should be directed upward to the pleural cupula. It is particularly important to remove the pleura above the fifth rib, because potential recurrence affects the upper lobes more frequently. The margins of the pleural dissection should be the level of the azygos vein and mediastinum. Preparation then should be directed downward, and the parietal pleura must excised in the largest sections possible. Diaphragmatic pleura usually is impossible to dissect; therefore, this structure must be abraded by any kind of abrasive material (e.g., hard sponge, sandpaper). Puncture bleeding indicates proper abrasion

Figure 39.5

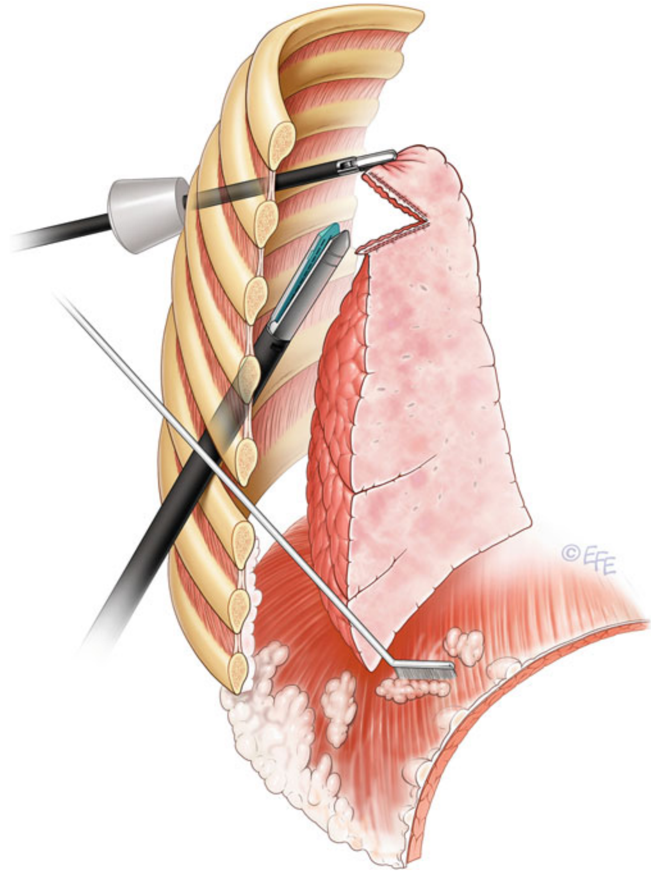
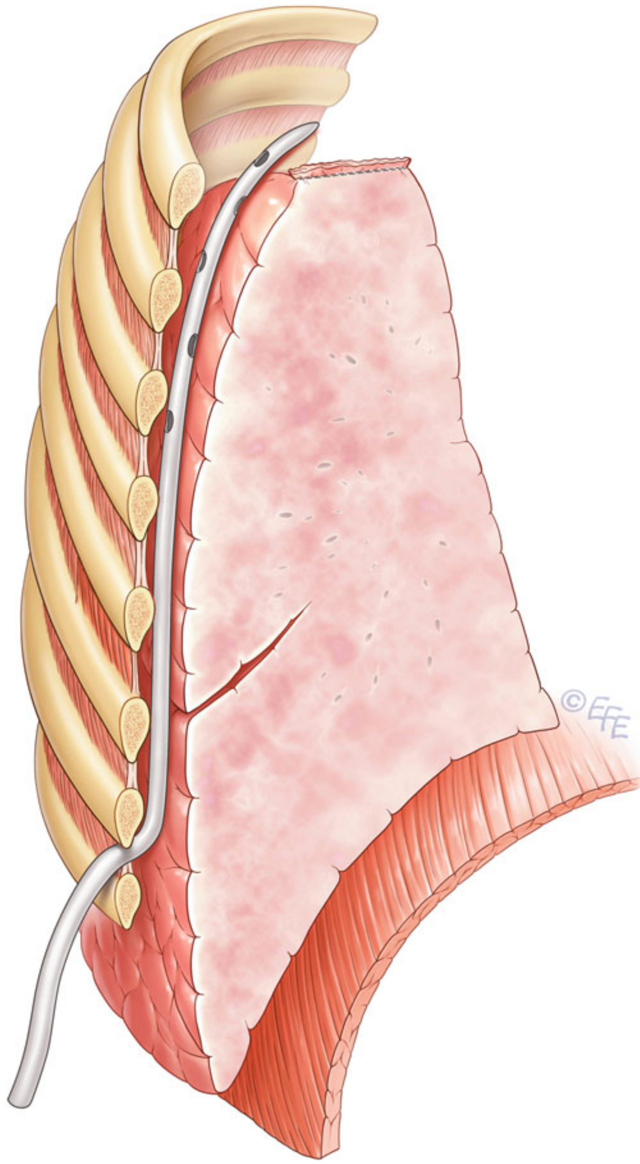


Figure 39.6

Hemostatic control at the end of the procedure is essential. Pleurectomy creates a relatively large wound; therefore, bleeding after this procedure requires meticulous observation. If the pleura is prepared without touching the chest wall by gently pressing on the dissected pleura, the bleeding usually is minor. Larger vessels must be coagulated. Some surgeons use the so-called spray function of diathermy, others use argon beam cautery. If the procedure is performed through open thoracotomy, it may be possible to use hot sponges pressed toward the denuded intrathoracic fascia, which stops minor bleeding very effectively. One large drain from the cupula to the seventh intercostal space in the midaxillary line usually is sufficient; there is no need to use two drains. The complication rate following pleurectomy is low; the predominant complications are prolonged air leakage and bleeding, rarely requiring reintervention. The mortality rate also is low (<5 % in the current era) and predominantly involves older patients with severe concomitant diseases. For patients younger than 40 years without severe disorders, the mortality rate is less than 1 %. We must keep in mind that much less invasive procedures such as chest drainage also may result in life-threatening complications

Figure 39.6



Conclusion

The treatment strategy of limiting physical activity without evacuating the pneumothorax should be reserved for small pneumothoraces, usually closed (or simplex), with minor or no clinical symptoms. In some countries, such patients are hospitalized, but close ambulatory monitoring by family doctors (general practitioners) seems sufficient. Patients should be advised to avoid physical exercise; in some countries, patients are even asked to stay in bed most of the time, preferably lying on the affected side. It is useful for the patient to have a control chest radiograph 7 days after disease onset to confirm the disappearance of the pneumothorax. This type of treatment does not provide any protection against recurrence. The complications are minor, but if prolonged bed rest is prescribed, consideration should be given to anticoagulant prophylaxis against venous thrombosis. Prolongation of bed rest beyond 1 week is not justified. If the pneumothorax is still present, more aggressive treatment should be offered to the patient.

Chest drainage sometimes is replaced by repeated needle aspirations; this method was popular in the last century but is less effective than continuous drainage. The Heimlich one-way valve is used as a portable nonsuction device for ambulatory patients without large amounts of fluid evacuating the pleural space. Some centers prefer to instill irritating substances such as talc, silver nitrate, the patient's own blood tetracycline, or fibrin glue into the pleural cavity to cause pleurodesis and decrease the risk of recurrence; however, this is not a commonly accepted approach, particularly for a first episode. Some authors suggest the chest drain may be removed safely even if the nonchylous fluid output is as high as 450 ml/d after pulmonary resection (Shen et al. 2009). They also state that removal of the chest drain may be safe in the presence of an air leak or small pneumothorax if the patient is asymptomatic and the pleural space deficit has not increased. Nevertheless, such an approach is not widely accepted and requires further, larger randomized studies.

To avoid prolonged air leakage after lobectomy, particularly bilobectomy, if the remaining lung seems too small to fulfill the pleural space, it is possible to create a pleural tent to decrease the volume of the pleural space. A simple method to temporarily reduce the volume of the pleural space is to create a pneumoperitoneum that elevates the diaphragm (Okur et al. 2009).

Although the recurrence rate is slightly higher after pleurodesis than pleurectomy (particularly total and open), it is low for both methods, ranging from 0 to 4 %. Pleurectomy does not affect lung function as measured by spirometry. Postoperative care is similar to that after any video-assisted thoracoscopic surgery (VATS) or open thoracotomy and includes monitoring vital signs, early ambulation, coughing, and good pain control.

Young patients undergoing pleurectomy sometimes require another thoracic surgical procedure 20–30 years later for other pulmonary pathology, including lung cancer. Thoracic surgical procedures in such patients are usually difficult because of strong, massive adhesions between the lung and chest wall. VATS is difficult and often impossible to perform in these cases.

There is no specific prophylaxis against pneumothorax. Studies (including nationwide population-based studies) evaluating the effect of air pressure found no significant differences between seasons or particular weather conditions and the incidence of pneumothorax. This disease may occur during any condition, including sleeping; however, patients not treated by pleurectomy after a prior episode should refrain from risk situations such as diving, traveling to remote areas, or sailing far away from shore.

In summary, pneumothorax remains a potentially dangerous and life-threatening disease with a frequent tendency to recur; however, quick and proper diagnosis followed by more or less aggressive treatment tailored to the patient and immediate rehabilitation provide excellent results and a full recovery.

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