Article Review

Persistent Air Leak

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Abstract

In cases of pneumothorax on chest tube, the presence of air in the pleural cavity which lasts more than 5 to 7 days can be suspected as a persistent air leak (PAL), especially if an increased amount of air is obtained. This condition can be caused by an alveolar-pleural fistula (APF) or a broncho-pleural fistula (BPF) characterized by a bubble that appears at the end of the chest tube hose in the water seal drainage (WSD) system. One of the conditions that often causes difficulties in PAL therapy is the presence of infection due to direct connection to the fistula. The presence of PAL is associated with higher morbidity and mortality, prolonged chest tube use, and prolonged hospital stay. Observations of air production in PAL are expected to occur spontaneously within 4 days, if the leak still persists, pleurodesis is recommended. If possible do surgery to close the leak. Bronchoscopy treatment is only recommended in special circumstances where surgery is contraindicated or the patient refuses the surgical procedure.

Keywords: *Persistent air leak (PAL), alveolar-pleural fistula (APF), bronchopleural fistula (BPF)*

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Submitted: February 27th, 2023
Accepted:, 2023
Published:, 2023

J Respirol Indones. 2023
Vol. 1 No. 2: 150-160
https://doi.org/10.36497/respirsci.v1i2.20

INTRODUCTION

Any air leak that continues for more than 5 to 7 days is considered persistent. APFs or BPFs may be the root of this issue. The most typical PAL is postoperative, although it can also happen after spontaneous pneumothorax brought on by an underlying lung condition such a lung infection, difficulties with mechanical ventilation, chest injury, or following lung surgery.(1,2)

Alveolar-pleural fistula refers to the junction between the pleural space and the alveoli. As air leaks from the lungs into the pleural space as a result of this interaction, a pneumothorax will form. The pneumothorax will become worse if this association persists because airflow from the lung parenchyma into the pleural space will occur. Following the insertion of the chest tube, bubbles in the. If the air leak is prolonged and lasts more than 5 to 7 days, then there is a persistent air leak.(2)

Having a direct connection between the bronchi and the pleural cavity is known as a BPF. BPF is split into two main groups, namely central and peripheral BPF, based on where it is located.(3) Peripheral BPF is defined as the connection between the pleura and the airways distal to the segmental bronchi or lung parenchyma, whereas central BPF is defined as the connection between the pleura and the tracheobronchial tract. BPF is also referred to as APF in certain literature.(4)

The complications of PAL arise from contamination of the pleural space through direct communication with an unsterile tracheobronchial tree. Additionally, it occurs in a mismatch between ventilation and perfusion and makes it difficult to sustain positive end-expiratory pressures during mechanical ventilation. A prolonged use of the chest tube, a longer hospital stay, and greater morbidity and death are all associated with PAL.(1)

CLASSIFICATION

The most popular classification, the Cerfolio classification, which rates PAL according to the volume of air leak and whether the leak is expiratory or continuous, is one of several proposed classifications that take the opportunity to quantify the severity of PAL in the postoperative condition.(2)

Table 1. Cerfolio Classification[2]

Grade	Manuver
Grade 1, FE	During forced expiration only, typically when asking the patient to cough
Grade 2, E	Expiration only
Grade 3, I	Inspiration only
Grade 4, C	Continous bubbling present in the air leak chamber during both inspiration and expiration

Observing the water seal area in the three-chamber drainage system allows for further classifications. The patient's fluids or blood are collected in the first room. The water room is the second space. This forces air to leave the pleural space during exhalation and prevents air from entering during inhalation. Air leaks are indicated by the presence of bubbles in the WSD system. When using three-chamber drainage, the amount of air leakage is usually indicated by the presence of bubbles in the air leak control, which measures it in a column from 1 to 7. The size of the air leak is seen by the extent of the bubbles in the column. The larger the size of the leak, the larger the column the bubbles reach. In general, if the air leak is less than 20 ml/min, the chest tube can be removed safely.[2]

RISK FACTORS

Risk factors that depend on the underlying etiology such as PAL in spontaneous pneumothorax are underlying lung disease, and older age and presence of a large diameter bulla are risk factors for disease severity.[5] Pleural adhesion and diffuse emphysema predominate in the upper lobe, test Pulmonary function and pulmonary diffusion predispose to the occurrence of PAL.[6]

Recent study indicates that many risk factors, particularly BPF, have been linked to the onset of PAL. Three categories of risk factors are distinguished: those relating to the patient, those relating to surgery, and those relating to the patient's anatomy. Age (over 60 years), gender (male), neoadjuvant radiation therapy, diabetes mellitus, malnutrition, smoking, chronic steroid/ immunosuppressive use, underlying lung disease like chronic obstructive pulmonary disease (COPD), and the requirement for postoperative mechanical ventilation are a few examples of patient-related risk factors.[4,7]

The use of mechanical ventilation following pneumonectomy surgery is frequently linked to surgical risk factors. Despite advancements in surgical methods, pulmonary surgery procedures continue to be a major source of air leakage.[8] Therefore, to prevent bronchial leaks, extubation should be performed as early as possible after surgery.[4] Fever, steroid use, H. influenzae in sputum, an elevated erythrocyte sedimentation rate, and anemia are preoperative risk factors. The postoperative risk factors involved were fever, steroid use, leukocytosis, tracheostomy, and bronchoscopy for suctioning of sputum or mucous blockage.[9]

Risk factors associated with defined anatomical weakness for right-sided pneumonectomy include:[4]

1. According to cadaveric research, the two left-sided and one right-sided bronchial artery supplies are the most typical configuration.
2. In contrast to the right main bronchus, which is not covered by mediastinal tissue, the left main bronchus is shielded by the aortic arch.
3. Compared to the left main bronchus, the right main bronchus is wider and more vertical. This condition facilitates the retention of secretions in the right main bronchus.

CLINICAL PRESENTATION

The acute stage, clinical presentation of PAL can be a life-threatening condition due to a tension pneumothorax or shortness of breath due to lung compression. Sudden onset of dyspnea, hypotension, subcutaneous emphysema, cough with purulent sputum expectoration, tracheal and mediastinal displacement, ongoing air leaks, and diminished or absent pleural effusion on chest radiographs are symptoms for the postoperative cases of PAL.[10]

The subacute presentation is characterized by fever and a minimally productive cough.[9] The chronic presentation is associated with an infected pleural space and manifests as cough, fever, and malaise with varying degrees of respiratory distress.[8]

The patient often coughs up purulent sputum. A tension pneumothorax or a big fistula may cause acute respiratory distress. Empyema commonly develops in a number of chronic PAL cases. The most crucial indicator of a continuous air leak on a chest X-ray is a change in the height of the air-fluid. PAL should be considered if there is a persistent postoperative air leak, fresh airfluid, or if the pleural effusion vanishes on the chest radiograph.[10]

DIAGNOSIS

The approach to the diagnosis of PAL is not only to establish the diagnosis but also to estimate the exact size and location of the air leak, understand its relationship to adjacent mediastinal structures, and identify secondary complications. The diagnosis of PAL may be made via bronchoscopy, chest X-rays, or chest CT scans, among other techniques.[11]

Chest X-ray

The simplest test to detect for air leaks is a chest X-ray. Specific signs for the diagnosis of PAL include the existence of a tension pneumothorax, an increase in intrapleural air, and the appearance of a new level of air-fluid. The appearance of subcutaneous emphysema, a new pneumothorax, a pneumothorax that is larger or displays a lower air-fluid level in the hydropneumothorax, a transfer of the mediastinum to the contralateral side, and any of these symptoms may be indicators of PAL. Therefore, if this image is discovered on a chest X-ray, more testing is required to confirm the diagnosis. The diagnosis of postoperative PAL usually shows a shift in the pleural fluid margin, whereas a decreased air-fluid level in the pleural cavity is.[11]

Bronchoscopy

The bronchoscopy technique is very important for the diagnosis of air leaks and can determine the location and size of air leaks. The bronchoscopy will show a fistula in the bronchi if the lesion is more centrally located.[12] Bronchoscopy should be done to evaluate the terminals of the bronchial branches if clinical suspicion is discovered or if radiological markers appear that suggest to PAL. Pathognomonic for PAL include air bubbles at the bronchial ends or a pleural fluid leak.[4]

Figure 1. Fistula on bronchoscopy [11]

Bronchoscopy cannot provide a clear view of the fistula if the lesion is more peripheral. The localization method for PAL related to bronchoscopy is by administering anterograde methylene blue (MB) through a surgical wound and a chest tube. An alternate method for identifying the location of the source of the air leak is to insert the MB into the pleural drainage catheter after some time has passed while carefully monitoring all of the bronchial trees via bronchoscopy.[1,12] This is carried out in conjunction with bronchoscopy-based bronchial visualization. The diagnosis will be confirmed by careful examination of the dye entering the tracheobronchial tree from the afflicted airway. This approach has the special benefit of not requiring the observation of chest drainage system bubbles.[1]

The approach is to dilute MB to the necessary volume in either 5% dextrose or norml saline in water. Because the dye will follow the largest leak to the smallest leak and only identify one fistula at a time, this method considers that the injection of methylene blue may not be able to localize multiple air leaks individually.[1]

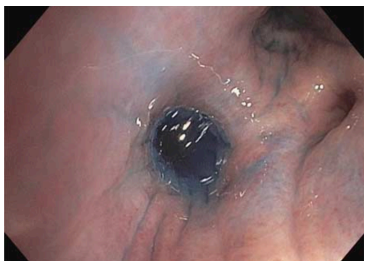

Figure 2. Methylene blue was seen in the anterior segment of the right upper lobe [12]

Computed tomography scan thorax

Bronchoscopy and thoracic computed tomography (CT) are helpful in determining the diagnosis, identifying the cause of the problem, and locating the fistula tract. For improved healing, patients with centrally located fistulas larger than 5 mm must undergo surgery. Many bronchoscopy procedures have been developed to treat PAL in addition to determining the diagnosis and location of the fistula. According to some research, peripheral air leaks with a size of 5 mm can be treated using bronchoscopy, particularly in patients who are frail and at high risk for surgery.[13]

There is significant debate surrounding the diagnosis made via a chest CT scan. Mediastinal emphysema, parenchymal infiltration, and expansion of the pleural cavity can all be seen on a CT scan. A fistula can be definitively diagnosed by periodic imaging of the bronchi or lung parenchyma into the pleural space (Figure 3).[4]

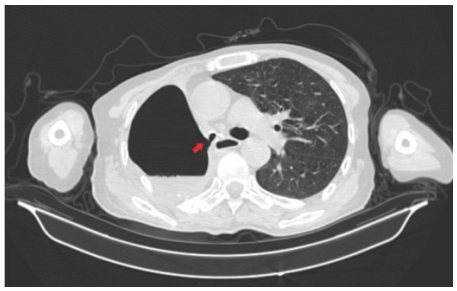

Figure 3. Bronchopleural fistula on the right hemithorax[4]

MANAGEMENT

While analyzing an air leak, the amount, duration, and trend of the leak should all be considered. A larger, longer-lasting air leak, for example, has a reduced chance of resolution, whereas a smaller air leak that gets better every day is more likely to mend spontaneously. Most postoperative air leaks might go disappear with their own, even if it takes weeks, assuming there isn't a fistula.[2]

The treatment of PAL frequently necessitates a prolonged hospital stay, difficult surgical procedures, and extensive follow-up. The management of life-threatening illnesses like sepsis, tension pneumothorax, and respiratory failure is the first stage of treatment. To minimize the danger of pneumonia and respiratory failure, it's important to protect the contralateral lung against pleural fluid aspiration. Thus, it is necessary to insert a chest tube to guarantee that the pleural area is drained. Broad-spectrum antibiotic therapy is depending on the results of the culture. In 16 of 17 effective cases of BPF, investigations using conservative therapy, such as pleural irrigation, drainage and reduction of the pleural cavity, antibiotics, and nutritional supplementation, have been documented.[4]

In patients with PAL, 4 days of observation are recommended for spontaneous closure of the defect. Pleurodesis surgery is advised if the air leak lasts for longer than 4 days. Bronchoscopy is only advised as a therapeutic option when surgery is not an option or when the patient declines the operation. Similar recommendations were made in the 2010 British Thoracic Society (BTS) guidelines, which state that in situations of PAL or failure of the lung to re-inflate after 3-5 days, a surgical opinion should be sought. Regarding situations in which surgery is not an option, there are no specific recommendations.[1,2]

There are a variety of minimally invasive PAL care strategies available for people who are inoperable or who choose not to have surgery. Since the first documented successful management of endobronchial fistulas, numerous alternative materials have been tested. Each has its own setbacks, and reported success rates are quite variable. It is crucial to emphasize that there have been no randomized controlled studies to identify the most safe and effective treatment approach. As a result, there are currently no recommendations, algorithms for treatment, or consensus among experts regarding the optimal kind of therapy. The preferred course of treatment is frequently conservative management with continuous chest tube drainage, and if further intervention is necessary, it should be based on the individual clinical signs of each patient.[1]

Chest Tube

Chest tubes can be used to treat air leaks, but there are also potential risks. Chest tubes can have adverse effects, including tidal volume loss, irregular gas exchange, and the development of ventilator cycles, particularly when mechanical ventilation is employed. Moreover, applying negative pressure to a chest tube may increase flow through the fistula tract and delay healing and closure.[9]

Patients with high-flow air leakage and empyema drainage require a chest tube. A chest tube can also be used to occlude during the inspiratory phase or enhance positive intrapleural pressure during the expiratory phase in patients who are undergoing mechanical ventilation. In order to maintain positive end-expiratory pressure (PEEP), this intervention aims to both decrease air leakage during expiration and to decrease airflow near the leak during the last inspiration. This method has also been used in conjunction, and it might be especially important for patients with ARDS or other disorders where PEEP is required to keep oxygen levels up. Any air leaks must be able to drain through a chest tube that is large enough. A sclerosing agent can be applied through a chest tube to perform pleurodesis.[9]

Heimlich Valve

Heimlich valve is another alternative to shorten the hospital stay if the insertion of a chest tube to the water drainage system is unsuccessful in stopping the air leak. The tiny one-way valve gives the patient more flexibility. Every patient with PAL receives a Heimlich valve to allow early hospital discharge, regardless of the size of the air leak.Each patient got daily chest tube therapy and pulmonary rehabilitation. Chest tubes can be removed from PAL patients using the Heimlich valve as long as they do not exhibit subcutaneous emphysema symptoms and the pneumothorax does not enlarge, according to another study.[14]

Heimlich valve is one-way flutter valve permits fluid and air to leave the pleural region without returning. The collection device that is connected to the other end of the Heimlich valve allows air to pass while collecting pleural fluid. A chest X-ray was taken after 24 hours, and the patient was sent home if there were no new or expanded pneumothoraxes or subcutaneous emphysemas. Patient should be returned to suction or water seal if there is an issue with the chest X-ray. This method must be repeated every one to two days. Alternatives to more long-term treatment must be considered if relapses do occur.[1]

After being discharged with the Heimlich valve, chest radiographs are taken every week. By immersing the Heimlich valve tip in water and having the patient practice passive or forced breathing techniques, the existence of PAL can be checked on a weekly. When there are no bubbles, PAL has resolved, allowing the chest tube to be withdrawn. Regardless of the magnitude of the leak or the occurrence of a pneumothorax, the chest tube can be safely removed 2 weeks after discharge. Even though there was still an air leak, numerous pleural space adhesions that had formed by this point would have prevented the growth of a growing pneumothorax.[1]

This method provides a number of benefits, including as simple placement, quick hospital discharge for patients, and no introduction of foreign materials into the pleural space. The inconvenience of leaving the patient with the chest tube in place (which frequently necessitates home care services and onsite care supplies), the discomfort and pain related to the chest tube, the risk of pleural infection secondary to the chest tube, and having to bring the patient back frequently are all limitations of this approach.[1]

Figure 4. Heimlich valve (left) and use of a chest tube in the left hemithorax (right) [15]

Chemical Pleurodesis

In order to prevent repeated pleural effusion or pneumothorax, a procedure known as pleurodesis is used to create adhesion between the visceral and parietal pleura. Inflammation, fibrosis, and adhesions between the two pleural layers are made on by chemical irritation (chemical pleurodesis) or mechanical abrasion (mechanical pleurodesis). Chemical pleurodesis is frequently used in clinical settings to control air leaking or stop a pneumothorax from recurring. Via a chest tube, a thoracoscopic procedure, or during surgery, chemical pleurodesis can be applied. Several sclerosants, such as talc, bleomycin, autologous blood patches, iodopovidone, and a number of other chemical substances, have been utilized in clinical practice. Tetracyclines and their derivatives, such as doxycycline and minocycline, have also been employed.[16]

When injected into the pleural space, a sclerosant triggers an inflammatory response that permits the pleural space to close, eliminates air leaking, and prevents recurrent pneumothoraxes. In a retrospective analysis, talc pleurodesis was successful in treating 40 of 41 postlobectomy patients who had PAL.[17] Therefore, chemical pleurodesis should be performed only if there is no or only a small pneumothorax remaining when the chest tube is in the aqueous drainage system. Alternatively, chemical pleurodesis need to be avoided since it can make it difficult for the lung to re-inflate. Chest pain, fever, acute lung damage, and empyema are all side effects of chemical pleurodesis.[2]

Bronchoscopy

Flexible bronchoscopy is a recognized diagnostic and treatment option for BPF patients. Broncholeurocutaneous fistula traces have been successfully viewed using fiberoptic bronchoscopy. However, distal BPF has to occlude bronchial segments using a balloon in order to find one that leads to a fistula. Via bronchoscopy, a number of sealants have been placed directly to the fistula, including ethanol, lead plugs, fibrin, antibiotics, gel foams, and a number of other substances. The majority of leakage happens in peripheral situations, which increases the possibility of this strategy's effectiveness. For individuals who are unable to tolerate large thoracic surgical operations, it also provides an option.[2]

Endobronchial (EBV)/Intrabronchial (IBV) Valves

A flexible bronchoscope is used to insert the one-way EBV and IBV valves into the lobar, segmental, or subsegmental airways. This procedure aims to maintain normal distal secretion flow while preventing air from passing through the fistula. Using an airway gauge, the bronchi are measured after the airway leading to the abnormality has been identified. The airway lumen is measured using the balloon catheter and calibrated to determine the size of the valve. The chest tube drainage chamber needs to be watched for 4-5 ventilation cycles after the valve is installed in order to detect any changes in the air leakage rate. Past research has indicated that each PAL is typically controlled by 1–10 valves (on average: 2-3 valves).[2]

This valve is simply removed with forceps and is well tolerated. Rarely may air leaks stop right away once a valve is installed. The usual duration from valve installation to resolution of the air leak is 4-7 days, with a mean of 5 days, so spontaneous responses to remove the valve should be avoided in cases where the air leak persists for 1-2 days following placement.[1] For some patients whose conservative treatment has failed or who are poor surgical candidates, the insertion of EBV and IBV for PAL has been successful.[2]

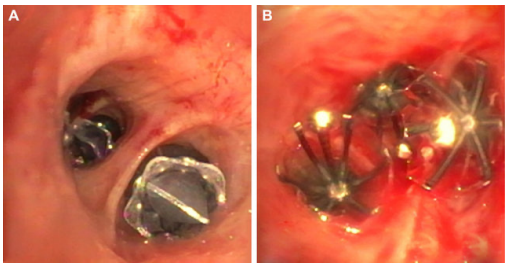

Figure 5. The endobronchial valve (right) has been placed in lower left lobe. Intrabronchial valve (left) in the left upper lobe [18]

Surgery

Although conducting a thoracotomy has a risk, the reported low mortality has been low, and the success rate of surgical closure of the BPF has been

reported to be almost 95% of the cases. Omental flaps, transsternal bronchial closure, direct leak closure with intercostal muscle strengthening, thoracoplasty with or without extrathoracic chest wall muscle transposition, and open drainage are some surgical closure options. This method has also been applied in attempts to cure BPF since the development of video-assisted thoracoscopy (VATS).[9]

It is advised to close the BPF in steps. The Eloesser treatment for drainage the chest cavity, which involved a muscle flap operation with minimum morbidity in a chronically ill patient, was performed on the patient in the initial stage. After that, the patients endured intensive nutritional and physical therapy until they were able to tolerate a second thoracic obliteration with an omental flap operation.[9]

CONCLUSION

Long hospital stays and significant morbidity are related to persistent air leaks caused on by BPF and APF. As the gold standard of care, recent guidelines advise conservative waiting with chest tube drainage followed by surgical repair. In contrast to a big or central BPF, which is best treated through surgery or stent implantation, a minor distal BPF is better treated through bronchoscopy. If PAL develops soon after surgery, re-closure is required. Multiple air leaks can be controlled with proper chest tube management, and switching to an outpatient drainage device (such as the Heimlich valve) can allow the leak to heal while avoiding the morbidity linked to prolonged hospitalization. Several case series have demonstrated that pleurodesis and IBV are effective treatments for PAL.[2,9]

ACKNOWLEDGMENTS

None.

CONFLICT OF INTEREST

None.

FUNDING

None.

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