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Interventional Procedures for Management of Pleural Disorders

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Abstract

Pleural disorders are a common respiratory problem. Infection and malignancy are frequent causes of pleural effusion. Interventional procedures form significant aspects of investigations and management of pleural disorders. Thoracocentesis and chest drain insertion are essential diagnostic and therapeutic minimally invasive procedures. Moreover, thoracoscopy has important role as it allows for drainage of the pleural fluid, pleural biopsies and pleurodesis. Indwelling pleural catheters have acquired use largely in symptomatic management of patients with pleural effusion. Recently, endobronchial valves and thoracic vents have been introduced mainly to manage persistent air leak. Therefore pulmonary and pleural procedures form a rapidly developing area of respiratory medicine.

Keywords: Pleural disorders; Infection; Malignancy; Thoracocentesis; Thoracoscopy

Introduction

Prevalence of pleural disorders from the epidemiological prospective has been suggested at around 3000 people per million each year [1,2]. Overall the incidence of pleural effusion in the USA has been estimated at around 1.5 million with malignant pleural effusion being reported in 1,75,000 cases and plural infection reported in 60, 000 cases each year [2-5]. The most common pleural disorders include pleural effusion of various aetiology including cardiac failure, pulmonary embolism and malignancy, pneumothorax and pleural infection [2,6]. The initial management of patients with pleural effusion will involve sampling of the pleural fluid to assess whether the effusion is an exudate or a transudate using the Light's criteria [1-3]. Cardiac failure, liver or renal diseases are the most common causes of transudative pleural effusion. In contrast, pleural infection, neoplasm and pulmonary embolism are the most common causes of an exudative pleural effusion. Pleural effusion due to malignancy or infection and pneumothorax remain the most common pleural disorders, which management may require interventional procedure. In contrast, the management of conditions such as cardiac failure and pulmonary embolism resulting in pleural effusion, although relatively common, is based mainly on medical therapies aiming to treat the underlying cause rather than interventional procedures.

Pleural Infection and Malignancy

Pulmonary procedures, in the context of pleural infection and malignant pleural effusion, are used for diagnostic and therapeutic purposes. Thus pleural fluid aspiration, thoracocentesis, is of importance for diagnosis of infective or malignant pleural effusions [7-10]. Similarly, a proportion of patients with pleural infection or malignant pleural effusion may require insertion of intercostal chest drain to drain the fluid for therapeutic purposes. Both malignant and infective pleural effusions are exudates characterised by high protein and lactate dehydrogenase. Moreover infective pleural effusion has low pH and glucose levels or in more severe cases may form frank pus [11]. Pleural infection relies on medical management with appropriate antimicrobial agents as well as pleural intervention involving insertion of an intercostal chest drain and drainage of the fluid. In addition once intercostal chest drain is inserted it allows for intra-pleural administration of medications such as thrombolytic agents [4,12-14]. Thus recent study revealed that in patients with empyema intra-pleural administration of tissue plasminogen activator (t-PA) and DNase resulted in reduction in length of hospital stay, improvement in the drainage of infected pleural fluid and reduction in surgical referrals [15]. However, the use of DNase or t-PA alone was ineffective. A recent study also suggested promising results with irrigation of chest drain in patients with pleural infection resulting in reduction in the amount of fluid and the requirements for surgery [16].

Thoracocentesis

Thoracocentesis involves an insertion of a needle or a small catheter into a pleural space allowing for drainage of pleural effusion or air in the context of a pneumothorax [17-19]. Thoracocentesis may be performed for a diagnostic purpose when pleural fluid is sampled for biochemical, microbiological and cytological analysis [20]. In contrast, therapeutic thoracocentesis involves drainage of pleural effusion performed under local anaesthesia with mild sedation if required, in order to relive the symptoms of dyspnoea as a result of patients developing pleural effusion or drainage of air in patients with symptomatic pneumothorax [19,21,22]. Thus national guidelines suggest that in patients with pneumothorax an initial needle aspiration may be successful in between 30% to 80% of cases and may avoid the need for insertion of an intercostal chest drain [23]. In the context of pleural effusion therapeutic thoracocentesis may have variable success rates with pleural effusion re-accumulating in a proportion of patients. However, therapeutic thoracocentesis maybe the procedure of choice for patients with poor prognosis as it may result in a rapid symptoms relief [6,24]. The main disadvantage of the procedure is the fact that only a limited amount of fluid can be drained usually between 1 to 1.5 litres as draining larger amount of fluid may cause pain due to rapid lung re-expansion or on occasions re-expansion pulmonary

oedema, which when occurs results in very distressing dyspnoea. Thoracocentesis itself may be associated with discomfort and the risk of introducing infection, which increases with repeated procedures. The main advantages of thoracocentesis is related to the fact the procedure is usually performed on ambulatory manner with patient requiring a short period of observation and that it is the least expensive therapeutic option for the management of malignant pleural effusion. However, its main disadvantage is related to the fact that that the pleural fluid may re-accumulate and the patients would require repeated procedures.

Thoracic Ultrasound

To reduce risks of complications it has been recommended that pleural procedures should be performed under ultrasound guidance [1,20,25-28]. Therefore the use of thoracic ultrasound has become an important imaging tool in the context of pleural procedures such as insertion of a chest drain or thoracocentesis [22,27,29,30]. The literature suggests that when pleural procedures are performed under ultrasound guidance the risk of complications such as pneumothorax that may complicate around 10% of thoracocentesis performed without ultrasound guidance may be significantly reduced to around 2.5% [8,31,32]. Similarly low complication rates of around 0.5% were observed in a study from the UK showed that when thoracocentesis is performed under ultrasound guidance by appropriately trained respiratory physicians [30]. The use of thoracic ultrasound allows for real time visualisation of pleural effusion. It also helps to assess the size and the composition of pleural effusion including the presence of septations [29]. Thoracic ultrasound helps in accurately locating pleural effusion in real time and guiding placement of a chest drain or thoracocentesis needle during pleural procedures [1,6]. Moreover, thoracic ultrasound can distinguish between pleural effusion from other conditions that can mimic pleural effusion and therefore avoiding unnecessary or potentially harmful pleural procedures [33].

Intercostal Chest Drain

Chest drain placement involves insertion of a tube into the pleural cavity [17]. This is usually performed under local anaesthesia with analgesia or sedation and aseptic technique. The drain is inserted typically in the triangle of safety, which is defined anatomically by the lateral borders of the pectoralis major and latissimus dorsi anteriorly and posteriorly respectively and horizontal line in the fifth intercostals space inferiorly [17]. Insertion of a chest drain allows for the drainage of the air in cases of pneumothorax or persistent air leak or pleural fluid in cases of pleura effusion. Once chest drain is inserted pleurodesis can also be performed. Pleurodesis is defined as a procedure during which a sclerosing agent is inserted into a pleural cavity in order to obliterate pleural space [6,34-36]. Pleurodesis can be performed using a number of different sclerosants with talc being the most common. Pleurodesis is usually performed in patients with malignant pleural effusion. A meta-analysis revealed that the use of sclerosing agents of which large particles talc being more efficacious in producing pleurodesis compared with the instillation of isotonic saline or drainage of pleural fluid alone [35,37]. The success rates of using this so-called medical pleurodesis at 1 month were reported at 60% to 71% [38-40]. Medical pleurodesis is performed by administration of talc slurry through an intercostal chest drain but in a fifth of cases further pleural procedures may be required due pleural fluid re-accumulation. There are currently ongoing research trials to assess whether talc slurry pleurodesis using an indwelling pleural catheter. Similarly, talc poudrage can be insufflated during medical or surgical thoracoscopy [25,41]. The main purpose of pleurodesis is to reduce or prevent pleural fluid re accumulation. In cases of pneumothorax there is some evidence that intra-pleural administration minocycline reduced recurrence of pneumothorax to 29.2% compared with that of 49.1% in control group [42].

Indwelling Pleural Catheter

Insertion of Indwelling pleural catheter (IPC) allows for management of pleural effusion usually due to malignancy [6,43]. The IPC is a silicone catheter with a one-way valve, which when connected to a vacuum bottle allows for an intermittent drainage of pleural effusion. The IPC are inserted in ambulatory manner usually under local anaesthetic [25,44]. The IPC is inserted into a pleural cavity at the site of pleural effusion and then tunnelled under skin and secured in place. The main indications are for management of pleural effusion in the context of trapped lung or in patients with pleural effusion in whom pleural effusion re-occurs following pleurodesis [34,44,45]. IPCs were also shown to be effective from the aspect of symptoms control and spontaneous pleurodesis when used as a first line of treatment instead of performing pleurodesis [34]. The use of IPCs was shown to improve breathlessness and quality of life [44,45]. Moreover, patients who had IPC inserted were shown to have 45% rates of spontaneous pleurodesis [44]. Patients treated with IPCs showed that these devices were well tolerated with only a small proportion developing complications such as cellulitis, pain, pleural infection or breakage of the catheter [44,46,47]. When compared to pleurodesis using intercostal chest drain, IPCs were shown to have similar improvement in quality of life but lower rates of pleurodesis [48]. However patients who had IPCs inserted had shorter hospital stay but larger number of minor complications. Similarly, the costs of pleurodesis using a chest drain were similar to those of IPC [49]. Another potential options recently reported involved insertion of IPC at medical thoracoscopy with talc poudrage and with this approach a reduction in hospital stay was reported together with 92% success rate for pleurodesis [50]. Moreover, there is also evidence for the use of IPC in non-malignant when medical therapy failed [51].

Thoracoscopy

Thoracoscopy, which can be divided into surgical also called Video assisted thoracoscopic surgery (VATs) performed under general anaesthesia or medical thoracoscopy also called pleuroscopy, which could be performed under local anaesthesia and conscious sedation [38,52,53]. Thoracoscopy involves insertion of the scope into the pleura cavity usually through a trochar. This allows for the drainage of the pleural fluid, visualisation of the pleura, pleural biopsy and sampling and if appropriate pleurodesis by insufflations of talc [38,39]. There are two types of thoracoscopes namely rigid scope that is 5 to 7 mm in diameter in size and a smaller in size semi-rigid thoracosope that have similar controls to a flexible bronchoscope. The reports suggest 4% to 9.5% non diagnostic procedure with the semi-rigid scope, which is slightly higher compared to when using rigid scope [38,54,55]. Two ports technique can be utilized when the scope is inserted through one of the ports and the biopsy forceps through the second one [25,38]. Medical thoracoscopy has been quoted to provide success rate for talc pleurodesis at 1 months in the range between 78% to 84% [38]. Sampling of pleural fluid and its cytological and immunocytochemistry analysis remains of importance in diagnosing malignant pleural effusion [1,56]. This can be of particular help when underlying cause of pleural effusion is metastatic adenocarcinoma originating from the lung, breast, ovaries or gastrointestinal tract [1,6,56]. Overall in the context of malignant pleural effusion the literature suggests diagnostic accuracy at around 60% with a wide range between 40% and 87% [1,6,56]. However, the diagnosis of malignant mesothelioma may be more difficult from cytological and immunocytochemistry analysis of pleural fluid [1,6,56].

Endobronchial Valves and Thoracic Vents

In the context of pneumothorax management there have been two recent developments in the form of thoracic vent devices and the application of endobronchial valves (EBV) for the treatment of persistent air leak. Thoracic also called pleural vents are small devices that can be

inserted into the pleural space and because they have a one-way valve incorporated into the system they allow for the air to escape. By using these devices patients with pneumothorax can be managed on ambulatory pathways [57]. The initial reports utilised a small chest drain connected to a one-away valve resulting in a 40% reduction in hospital costs [58,59]. More recent reports showed that the use of minimally invasive thoracic vent devices was more cost effective than conventional treatment using a chest drain insertion in both in surgical patients and in patients requiring surgery [60]. There are currently ongoing studies assessing in more detail the use of these devices in ambulatory management of the primary and secondary pneumothorax.

EBV were initially introduced for the treatment of emphysema and have shown improvement in lung function, quality of life and walking distance together with a good safety and tolerability [61]. More recently EBV were reported as an addition option for the treatment of patients with a persistent air leak [62-64]. Persistent air leak is defined as air leak that persists for 5 days post surgery or in patients with pneumothorax. EBV in the context of persistent air leak are introduced into the bronchi using a flexible bronchoscope. Patients with persistent air leak will have a chest drain *in situ*. When bronchoscope is introduced it allows for examination of the bronchial tree. Through the scope a balloon occluder can be inserted allowing for the occlusion of the bronchial segments of the area of the air leak and measurement of the size of required EBV. EBV is then placed *via* the working channel of the bronchoscope. If required additional EBV can be placed, for example when there is collateral ventilation, until the air leak is stopped, which is evident by the cessation of airflow through the chest drain. The evidence so far for the use of EBV in the context of persistent air leak comes form case series on which a recent systemic review was based [63]. Potential problems with EBV were related to the valve migration, infection or recurrence of air leak. In a large proportion of patients the air leak however was corrected and EBV was removed in 46% of cases [63]. In the context of pneumothorax EBV can be considered in high-risk patients in whom surgical options may not be available or in cases where surgery failed. Here a careful assessment may be required whether to proceed with pleurodesis or EBV.

Conclusions

In conclusion, the interventional procedures form important aspects of management of pleural disorders. The use of recent technologies have allowed for introduction new techniques to manage pleural effusion and pneumothorax. Moreover, the novel interventional devices have allowed for ambulatory management of a proportion of patients with pleural disorders such as malignant pleural effusion or pneumothorax. Inevitably, these latest approaches may become more widely used resulting with better care of patients with pleural disorders.

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