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Treatment Optimization of Post-pneumonectomy Pleural Empyema

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Abstract

Introduction: Pleural empyema after pneumonectomy still poses a serious postoperative complication. A bronchopleural fistula is often detected. Despite various therapeutic options developed during the last five decades it remains a major surgical challenge.

Results: There is no widely accepted treatment for post-pneumonectomy pleural empyema (PPE) and the management depends mostly on the presence or absence of broncho-pleural fistula (BPF) and the patient's general condition. In the absence of BPF, the role of surgery is still not clear because of its high morbidity and impossibility to prevent recurrences. In the earlier period, the definitive treatment consisted of open window thoracostomy followed by obliteration of the pleural cavity with antibiotic solution at the time of chest wall closure. Subsequently, the proposed different methods and modifications improved the outcome. There is an association between hospital volume and operative mortality after the lung resection. Hospital volume and the surgeon's specialty have more influence on the outcome than the individual surgeon's volume.

Conclusions: Treatment management of PPE should be individualized. Definitive treatment options comprise aggressive surgery that is not possible in quite a high proportion of impaired patients. Hospital volume, surgeon's volume and surgeon's specialty may influence the prognosis.

Keywords

complications, post-pneumonectomy, pleural empyema, specific considerations, treatment

INTRODUCTION

Postoperative pleural empyema is the second most frequent form of empyema, accounting for up to 20% of all pleural empyemas. It occurs usually after surgery of the lungs, esophagus or mediastinum, but it may occur after abdominal, urologic, and pelvic operations as well.[1] The incidence is 1% to 3% after lobectomy and 2% to 12% after pneumonectomy.

Despite various therapeutic options developed during the last five decades, post-pneumonectomy pleural empyema (PPE) is still associated with 10-20% mortality rate, reaching up to 50% in case of broncho-pleural fistula (BPF), with high morbidity and prolonged hospitalization.[2]

AIM

The aim of this review is to summarize the treatment options and specific considerations of PPE. The etiology, epidemiology, and prevention are discussed elsewhere.

Treatment options

Conservative treatment

Emergency chest tube drainage is usually reported as the

first step in the acute phase of the empyema, with patients instructed to lie on their operative side in order to prevent spillage into the remaining lung, reported as a main cause of mortality.[3] Bronchoscopy is not always necessary but is mandatory in unclear situations in order to confirm or rule out BPF.

Chest tube drainage alone is considered as initial and, in fact, palliative procedure. If performed as a definitive option, it includes irrigation by an additional apical drain and endoscopic closure of small bronchial fistulas by fibrin glue, if necessary. The limitations and drawbacks of this method are prolonged treatment, discomfort, uncertain cavity obliteration, and chest deformity. Ben-Nun et al.[4] reported about eight patients with PPE, who were successfully treated by continuous soft chest tube thoracostomy, intrapleural fibrinolytics, and antibiotics.

Surgical treatment

This form of treatment follows the principles of surgical treatment of infected spaces and includes evacuation of pus and debridement of the infected tissue, combined with obliteration, marsupialization, or opening of the infected cavity. Debridement and closure of BPF (if present) and obliteration of pleural cavity (antibiotic plombage, muscle, omental flaps or thoracoplasty) take place after the first step, being usually the chest tube drainage of the pleural cavity.

In 1963, Clagett and Geraci[5] introduced a two-stage procedure that consisted of 1) open pleural drainage-open window thoracostomy (OWT) with pleural space cleansing and eventually obliteration by daily dressing changes through the thoracostomy (4-6 weeks) followed by 2) obliteration of the pleural cavity with debridement antibiotic solution at the time of chest wall closure. The procedure had been successful in 14 (88%) patients but was associated with prolonged hospitalization and significant morbidity. Failure was often the result of persistent or recurrent BPF.[6]

In an attempt to address these failures, Pairolero and Arnold modified the 'Clagett' procedure with initial bronchial stump reinforcement and had decreased the size of the pleural cavity by transposition of a well-vascularized extrathoracic muscle before obliteration of the pleural cavity with antibiotic solution.[7] The success rate of the Pairolero modification on 28 patients was 83.9%, but with many re-interventions and long hospital stay.

A similar modification was suggested by Gharagozloo et al.[8] for patients with early PPE associated with BPF, with 100% success rate, shorter hospitalization and decreased morbidity. Their 'Clagett' procedure modification was based on emergency tube drainage followed by thoracotomy, debridement, bronchial stump resuture, and immediate chest cavity closure, but is suitable only for a limited patient group.

Resuming the Mayo Clinic experience with 84 patients, Zaheer et al.[9] reported the decrease in the failure rate of the chest closure before hospital discharge from initial 19% to 12% after a second Clagett procedure. Healing of BPF was achieved in all 55 patients, whilst permanent chest wall defects persisted in 8 (9.5%) patients. However, the recurrence rate after the first and second attempt was 18%, and 5% respectively with 7.1% perioperative mortality.

Late onset of PPE and immediate thoracostomy creation, as well as the age under 65 years, were reported as significant predictors of OWT closure.[10] As the process of obliteration of pleural space after OWT alone may take up to 2 years, some authors have suggested the need for further surgery to obliterate the pleural space.[11] Different extrathoracic muscles or omental transposition were used to obliterate the pleural space and, at the same time, to close the associated BPF, if present.[12] Omentoplasty is suitable for low-risk patients, for patients with a history of radiation therapy and posterolateral thoracotomy, and especially in the presence of BPF.[13,14] The extrathoracic muscle flap advantages are their reliable blood supply, ability to reach almost any part of the pleural space and sufficient volume to fill the cavity, but is contraindicated in debilitated patients, following radiotherapy and posterolateral thoracotomy. Most of the authors recommend single-stage muscle flap reconstruction of the post-pneumonectomy empyema space.[15,16] The latissimus dorsi flap (rarely the reversed latissimus dorsi flap) is probably the most frequently used flap in thoracic surgery.[17]

Obliteration of the cavity should be postponed at least 3 months after an operation for benign disease. In patients operated for lung cancer, this interval is much longer, 1-2 years mostly because of the risk of recurrent disease.[18] However, there are some comments that a six-months interval between performing and closing the OWT could be acceptable.[19]

Disadvantages of the earlier procedures for PPE treatment are a prolonged and very expensive treatment. The accelerated Weder method can be considered an advancement of the 'Clagett' procedure, with a 97.3% reported success rate and mean postoperative hospital stay of 17-18 days.[20] The therapy consists of repeated open surgical debridement of the pleural cavity under general anesthesia, temporary closure of the chest cavity filled with povidone-iodine-soaked towels and negative pressure wound therapy.[21] If present, BPF is closed and reinforced either with a muscle flap or the omentum. The final step is filling the pleural space with an antibiotic solution and definitive closure. The procedure is repeated every 48 hours and usually, mean 3.5 procedures are enough until the chest cavity is macroscopically clean.

Petrov et al.[22] have reported a video-assisted modification of Weder procedure on three patients which was carried out through a 4 cm mini-thoracotomy, the first session being carried out under general anesthesia, in case a more extensive surgery is required and with subsequent sessions in high thoracic epidural with preserved self-ventilation. In all patients, PPE was successfully treated, with excellent long-term functional and cosmetic results and mean hospital stay of 10.3 days.

Particular aspects of different procedures for definitive PPE treatment are summarized in **Table 1**.

Some recent experimental works showed that the cells

within collagen matrices can survive in the thoracic cavity, leading to neovascularization and recipient cell infiltration. Both cellularized and acellularized matrices show bacterial clearance in vivo, suggesting a potential use of a novel tissue engineering approach for problems of the post-pneumonectomy space.[23]

VATS DEBRIDEMENT

One of the reasons for limited experience with VATS debridement in PPE treatment may be the fear to overlook infection in the regions that are difficult to reach by the thoracoscope. However, there is no evidence that treatment success relies on complete debridement of infected tissues. As pointed out by Wait et al.[24], although VATS does not accomplish as thorough a pleural cleaning as does thoracotomy, it is often successful owing to reduction of the bacterial load and of the amount of infected exudate below a critical level, allowing subsequent pleural space healing.

Several authors reported the use of VATS for debridement, either as an initial procedure or after previous irrigation with antibiotic solutions and fibrinolytics and both with and without postoperative irrigation.[25,26] All these reports were small case series with 3-9 patients, but the long-term results were good with an acceptable hospital stay.

THORACOPLASTY

This procedure represents an alternative to open thoracostomy in case a secondary closure seems doubtful, or in case of previous treatment failure. Advantages of this procedure are avoidance of multiple operative procedures and draw-backs of prolonged hospitalization in case of definitive open drainage.[27] About 75% of the patients returned to work again after thoracoplasty.[28]

Thoracopleuroplasty, as described by Andrews, allows good control of infection with a complete evacuation of the products of empyema under direct vision and immediate closure of any bronchial fistula, with a rapid and smooth postoperative recovery.[29]

BRONCHO-PLEURAL FISTULA CLOSURE

This is a key factor in PPE treatment. The choice of the technique depends on the type and size of the fistula.

Endoscopic treatment of BPF with various glues and sclerosing agents is suitable for fistulas <3 mm, especially in high-risk patients.[30]

Some non-surgical procedures for closure of BPF have been reported, including the use of ethanol silver nitrate, cyanoacrylate compounds, coils, lead plugs, balloons, fibrin or tissue glue, antibiotics, gel foam, spigots, and an autologous blood patch.[31] Okuda et al.[32] reported a case with BPF closure by using basic fibroblast growth factor (bFGF; up to 30 μg) and a film dressing following OWT and initial debridement of the empyema cavity.

Access to the bronchial stump fistula can be achieved through the same pleural cavity, through the contralateral pleural cavity in case of left bronchial stump fistula[33] and through transsternal transpericardial approach.

The advantages of transsternal transpericardial closure of BPF (Abruzzini technique) are avoidance of areas of infection, scarring in previous surgical fields, devascularized

Table 1. Main types of definitive surgical treatment

	Initial drainage	OWT	Immediate chest closure	BS reinforcement	PS obliteration		Success rate (%)	Prolonged hospital stay	High Mb
					Antibiotic solutions	Extra-thoracic muscles			
Clagett[5] (1963)	yes	yes	no	no	yes	no	88	yes	yes
Pairolero[7] (1990)	yes	yes	no	yes	no	yes	83.9	yes	no
Gharagozloo[8] (1998)	yes	no	yes	yes	no	no	100	no	no
Zaheer[9] (2006)	yes	yes	no	no	yes	no	81/88*	yes	yes
acc. Weder[20] method (2008)	yes	yes	no	yes	yes	yes	97.3	no	no
Petrov[22]** (2011)	yes	yes	no	yes	yes	yes	100	no	no

OWT: open window thoracostomy; BS: bronchial stump; PS: pleural space; Mb: morbidity; Acc: accelerated

* - success after the first/second procedure; ** - video-assisted modification of the accelerated Weder procedure

bronchus, and better cosmetic and functional results.[34] It is strongly recommended to completely excise the distal stump. This technique is also an alternative for persistent fistulas after repair by other techniques.[35] The disadvantage of this method is that the residual empyema space is not dealt with at the same time with the closure of BPF so that additional surgical procedures are needed. Some authors performed carinal resection by means of transsternal approach in patients with short, less than 5 mm bronchial stump.[36]

Spaggiari et al.[37] developed a mini-invasive Abruzzini-like technique using three simultaneous approaches: cervical videomediastinoscopy, right anterior mediastinotomy, and parasternal thoracoscopic port.

Recently, transmediastinal VATS was introduced as a minimally invasive approach for closure of BPF in selected cases. Azorin reported a successful re-closure by stapling of an early BPF after left pneumonectomy by mediastinoscopy followed by VATS debridement and irrigation of the infected pleural cavity.[2] Leschber et al. reported the first case of resection and re-closure BPF by video-mediastinoscopy.[38]

SPECIFIC CONSIDERATIONS

Influence of the hospital volume, surgeon's volume and surgeon's specialty on the complication rate after a lung resection

The existing evidence strongly supports the link between the hospital volume and operative mortality after the lung resection. However, limits for the volume definition are in general inconsistent and heterogeneous, varying, for example, between 7-8 lung resections a year as the lowest volume and 17-100 resections representing the high volume group in US studies.[39]

In a meta-analysis of studies published between 1990 and 2011, in 5/11 studies, in-hospital mortality was significantly lower in high vs. low volume hospitals.[40] However, a cut-off value for the volume of lung cancer resections that could help to classify hospitals according to the mortality rate, could not be identified.

Two studies addressed the relationship between surgeon volume and complication rate.[41,42] Although some difference was found in favour of high volume surgeons, in the meta-analysis it was not statistically significant. In some studies, low-volume surgeons had significantly higher operative mortality compared with both medium- or high-volume surgeons (2.3% vs. 1.0% and 2.3% vs. 0.6%), with 46, 47-131 and 132 or more cases referred as low-, medium and high-volume surgeons, respectively.[42]

The third point relates to the surgeon's specialty. Currently, lung cancer resections are performed by general thoracic, cardiothoracic or general surgeons. Three studies analyzed the relationship between surgeon specialty and postoperative mortality.[43-45] In one study a significant difference was found in favour of general thoracic and cardiothoracic vs. general surgeons; in another study, the difference was significant only for lobectomies, but not for

pneumonectomies. The third study did not show a significant difference.

In brief, it seems that hospital volume and surgeon's specialty have more influence on the outcome than the individual surgeon's volume. It is also likely that some kind of concentration of lung cancer surgery could contribute to a decrease of operative mortality and morbidity, but it is still not possible to suggest the cut-off values for the annual volume.

PNEUMONECTOMY AFTER PREVIOUS PLEURAL EMPYEMA

This is an extremely unfavourable situation that significantly increases the risk of postoperative complications. Literature data are scarce, after 1995 only two patient series have been published with nine and four operated patients, suggesting that such type of surgery is justified from the oncological standpoint.[46,47] Before 1995, such an association treated surgically, has been reported only 10 times. Mortality of empyema associated with a malignant disease is 60 to 80% independently on pathogenesis.[48]

Subotic et al. recently summarized a two-institutional experience on 15 patients (12 with a pneumonectomy), representing the biggest patient series dealing with this problem.[49] In patients with pneumonectomy, empyema without bronchopleural fistula occurred in two patients, while in one patient, empyema was associated with fistula. The operative morbidity after pneumonectomy was 33.3%, thus confirming the results of the second biggest series of Riquet, with 2/9 (22.2%) empyemas after pneumonectomy.[46] The fact that we had four long-term survivors with N1 lesions (unlike the Riquet's report with long-term survivors only in case of N0 lesions) justifies such an extensive surgery in well-selected patients. However, it should be pointed out that patients operated after a previous empyema may not tolerate a full dose of adjuvant treatment. Even without preoperative empyema, impossibility to receive a full dose of adjuvant treatment after pneumonectomy is not to be neglected.

All the reports underline that full control of infection before surgery, achieved either by chest tube drainage or by repeated needle-aspirations, is a key point for the successful treatment outcome and that these patients should not be automatically rejected from surgery.

CONCLUSIONS

There is no widely accepted treatment for PPE and the management depends mostly on the presence or absence of BPF and the patient's general condition. In the absence of BPF, the role of surgery is still not clear because of its high morbidity and impossibility to prevent recurrences. Therapeutic procedures can be temporary or definitive. Initial treatment frequently remains the definitive therapeutic option, having in mind many patients with a bad general condition. There is an association between hospital volume and operative mortality after the lung resection. However,

the cut-off value for the volume of lung cancer resections is unclear. Hospital volume and surgeon's specialty have more influence on the outcome than the individual surgeon's volume.

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Терапевтическая оптимизация постпневмонэктомической эмпиемы плевры

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Абстракт

Введение: Эмпиема плевры после пневмонэктомии всё ещё является серьёзным послеоперационным осложнением. Часто обнаруживается бронхоплевральный свищ. Несмотря на различные варианты лечения, разработанные за последние пять десятилетий, она остаётся серьёзной хирургической проблемой.

Результаты: Не существует широко распространённого лечения ППЭ, а лечение в основном зависит от наличия или отсутствия бронхоплеврального свища (БПС) и общего состояния пациента. В отсутствие БПС роль хирургии ещё не ясна из-за высокой заболеваемости и невозможности предотвратить рецидив. В прошлом окончательное лечение состояло из открытой торакотомии с последующей облитерацией плевральной полости раствором антибиотика при закрытии стенки грудной клетки. Впоследствии предложенные различные методы и модификации значительно улучшают результат. Существует связь между объёмом медицинской помощи больницы и оперативной смертностью после резекции лёгких. Объём медицинской помощи больницы и специализация хирурга оказывают большее влияние на результат, чем опыт отдельного хирурга.

Выводы: Терапевтическое лечение ППЭ должно быть индивидуальным. Определённые варианты лечения включают агрессивную хирургию, которая невозможна у довольно большой части больных пациентов. Объём медицинской помощи больницы, опыт и специальность хирурга могут повлиять на прогноз

Ключевые слова

постпневмоэктомия, эмпиема плевры, лечение, осложнения, специфические соображения

Folia Medica