Current trends in surgical treatment of parapneumonic effusions and empyema thoracis.

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ABSTRACT: Surgical treatment of complicated parapneumonic effusions and empyema thoracis consists of drainage and obliteration of the pleural space. Two scientific Societies have published guidelines concerning management of empyema thoracis in the near past. American College of Chest Physicians (2000) has defined criteria of high-risk for poor outcome. Parapneumonic effusions which met the criteria of high-risk for poor outcome should undergo at least chest tube drainage, that is however unsuccessful in 25-50% of cases. Intrapleural instillation of fibrinolytics, thoracoscopic drainage and thoracotomy were, according to ACCP experts, accepted modalities of management. According to British Thoracic Society guidelines (2003), surgical treatment should be offered after failure of conservative treatment with antibiotics and chest tube drainage.

We have nowadays enough evidence that early thoracoscopic drainage reduces hospitalization, chest tube drainage duration and that is successful initial treatment in 90% of cases. Minimally invasive thoracoscopic drainage can effectively drain loculations, inflammatory intrapleural fluid and gel, obliterate the pleural cavity and achieve strategic position of chest drains. Thoracoscopic drainage is unsuccessful management for organizing empyemas, where decortication is the treatment of choice. Early involvement of thoracic surgeons and early thoracoscopic drainage may effectively change the prognosis and outcome of complicated parapneumonic effusions and empyema thoracis.

Key Words: Parapneumonic effusion, Complicated parapneumonic effusion, Empyema thoracis, Thoracoscopy, Lung decortication.

INTRODUCTION

Surgical treatment for empyema thoracis is well known since the time of Hippocrates (460-377 BC), who has recognized the disease and he did drainage of the empyema through the intercostal space after resection of one rib[1]. Since the Hippocrates time, 2,400 years ago, intercostal drainage still remains the initial, widely-accepted treatment worldwide, with the addition of antibiotics from the middle of the last century.

The basic principles and main targets in the treatment of parapneumonic effusion and empyema thoracis are the following:[1,2].

a) treatment of underlying pulmonary parenchyma disease and sterilization of the empyema space by the use of antimicrobials
b) the support of the immune and nutritional status of the patient
c) drainage of the accumulated inflammatory pleural fluid or pus from the pleural space
d) the obliteration of the pleural space

Surgery is involved in the treatment of parapneumonic effusions and empyemas to accomplish drainage and obliteration of the pleural space. Surgical manipulation include intercostal chest tube drainage with or without the instillation of fibrinolytics (streptokinase, urokinase, deoxyribonuclease), transthoracic drainage of the effusion through small bore tubes which are inserted in the appropriate position under CT guidance, rib resection empyema drainage, drainage via thoracotomy or thoracoscopy, lung decortication and open window thoracostomy[1-3].

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Table 1. Categorization of parapneumonic effusions and empyema thoracis according to ACCP criteria of risk for poor outcome (CHEST, 2000).

Anatomy of the pleural space		Pleural fluid bacteriology		Pleural fluid chemistry	Category	Risk of poor outcome	Drainage procedure
Minimal, free-flowing pleural effusion (< 10mm in lateral decubitus chest X-ray)	**and**	Gram stain and culture results unknown	**and**	ph unknown	**1**	Very low	No
Small to moderate free-flowing pleural effusion (> 10mm and occupying less than half of the hemithorax	**and**	Negative culture and Gram stain	**and**	ph < 7,20 *(Glucose < 60 mg/dl)	**2**	Low	No
Large, free-flowing pleural effusion, occupying more than half of the hemithorax or loculated effusion or effusion with thickened parietal pleura on contrast-enhanced CT scan of the thorax	**or**	Positive culture and Gram stain	**or**	ph < 7,20 *(Glucose < 60 mg/dl)	**3**	Moderate	Yes
		pus		-	**4**	High	Yes

**If a blood gas analyzer is not available, pleural fluid glucose levels should be used.*

GUIDELINES ON SURGICAL TREATMENT OF PARAPNEUMONIC EFFUSIONS AND EMPYEMA THORACIS

In the current era of «evidence based medicine», the basic principles of treatment, which are described in the introduction, still remain unchanged. Two medical societies, the American College of Chest Physicians/ACCP (2000) and British Thoracic Society/BTS (2003) have published guidelines on the treatment of parapneumonic effusions and empyema thoracis[4,5].

According to ACCP guidelines, all patients with parapneumonic effusions and empyema are classified in four categories, according to established criteria of risk for poor outcome (Table 1). ACCP criteria of risk for poor outcome are any parapneumonic effusion that occupies more than half of the hemithorax, the presence of loculations and/or thickening of parietal pleura, positive Gram stain or culture of the pleural fluid, ph of the pleural fluid less than 7.2 and/or glucose of the pleural fluid less than 60 mg/dl. Drainage of the parapneumonic effusion according to these guidelines is necessary only in categories 3 (complicated parapneumonic effusion) and 4 (empyema).

Chest tube drainage alone was concluded by the members of the ACCP panel to be inadequate treatment in 25% to 50% of patients with high risk for poor outcome parapneumonic effusion. Their conclusion was based on the reported higher mortality rates associated with this kind of drainage and the frequent need for a second or third intervention, when compared to chest tube drainage plus the intrapleural instillation of fibrinolytic agents, thoracoscopic drainage and drainage through standard thoracotomy incision. The members of the panel have agreed with the fact that intrapleural instillation of fibrinolytics and drainage by thoracoscopy or thoracotomy are all acceptable strate-

Table 2. The traditional classification of empyema in 3 stages (Chest Surgery Clinics of North America, 1996).

Stage	Pleural effusion characteristics	Biochemistry of the pleural fluid
Early stage - exudative	Free-flowing pleural effusion on lateral decubitus chest radiography and absence of any loculation on trans-thoracic ultraound and chest CT scan	ph > 7,3 Glucose > 60mg/dl LDH < 500U/L
Second stage - fibrinopurulent	Loculations visible on lateral decubitus chest radiography, trans-thoracic ultrasound or chest CT scan	ph < 7,1 γλυκόζη < 40mg/dl LDH > 1000U/L
Third stage - organizing	Trapping and immobilization of the lung from a thick, inelastic peel. Pleural fluid becomes a gelatinous material, that is impossible to drain through the chest tube	-

gies for the treatment of high risk for poor outcome parapneumonic effusions. However no consensus was obtained on which of the above mentioned acceptable strategies is the best to apply. A major point to underlie is that for the first time the problem of parapneumonic effusion was dealt with the described in Table 1 criteria of risk for poor outcome and not with the traditional classification of empyema thoracis in 3 stages (exudative, fibrinopurulent and organizing), which are presented in Table 2. The use of criteria of risk for poor outcome to classify a parapneumonic effusion is very important, because an accurate estimation of the stage of the disease at presentation of the patient or at any time later in the course of the disease is difficult to be made. Poor outcome of a complicated parapneumonic effusion or empyema was considered by the ACCP experts panel to be the prolonged toxic state of the patient or the need for surgical intervention in the acute phase of the disease or the chronic impairment of lung function (constrictive pattern) and the need to proceed with lung decortication to re-establish normal lung function. Surgical intervention was regarded as «primary» and «rescue», depending on the decision to perform it as initial maneuver or after failure of any other initial treatment[4].

Guidelines published by BTS are presented in Figure 1. According to these guidelines surgical intervention is always a «rescue» procedure, as the thoracic surgeon is involved after failure of the conservative treatment[5]. Thoracoscopic drainage and drainage via thoracotomy with or without lung decortication were considered to be acceptable strategies for the management of the disease. BTS experts state that the decision on which drainage method should be selected for the management of each patient individually, will be based on the availability of instrumentation for thoracoscopic surgery, on the age and comorbidities of the patient and on the preference of the responsible consultant thoracic surgeon.

SURGICAL TREATMENT

A) *Thoracoscopic (VATS) drainage*

Thoracoscopic drainage has certain advantages over chest tube or CT guided single or multi-catheter drainage procedures. Break-down of all the adhesions results in obliteration of the pleural cavity. Drainage of gel, debris and contaminated pleural fluid or pus is complete. Lavage of the pleural cavity with sterile saline eliminates the concentration of microorganisms within the pleural cavity and the positioning of chest tubes under view through the camera is «strategic» and consequently effective. Early thoracoscopy gives also the possibility to remove the thin fibrous film that covers visceral pleura, avoiding that way lung entrapment. The technique is minimally invasive, resulting in minimal surgical trauma and fast patient's recovery[6-9]. Thoracoscopic drainage in simple cases and experienced hands can also be performed through the one port technique (uniportal VATS) with good results.

Despite all the above mentioned advantages, the

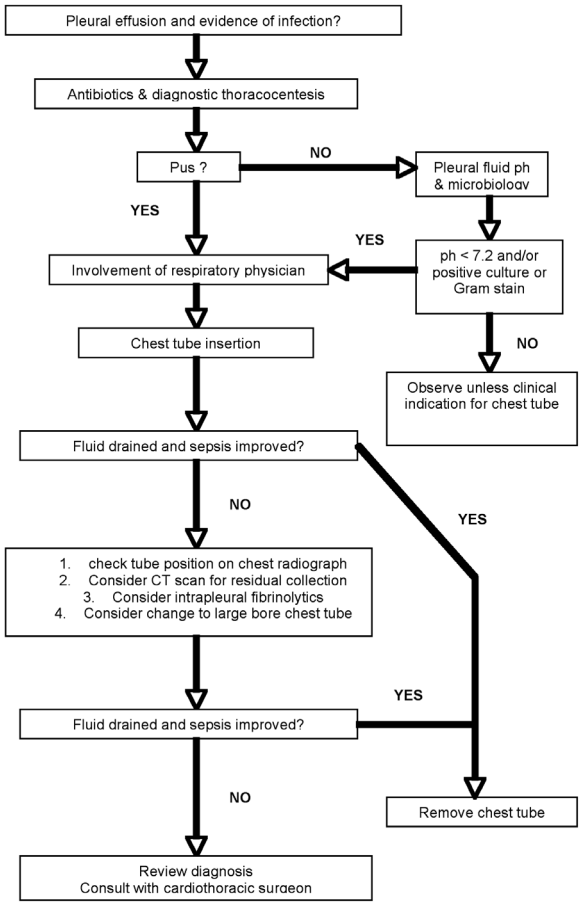

Figure 1. British Thoracic Society guidelines for the management of pleural infection (2003).

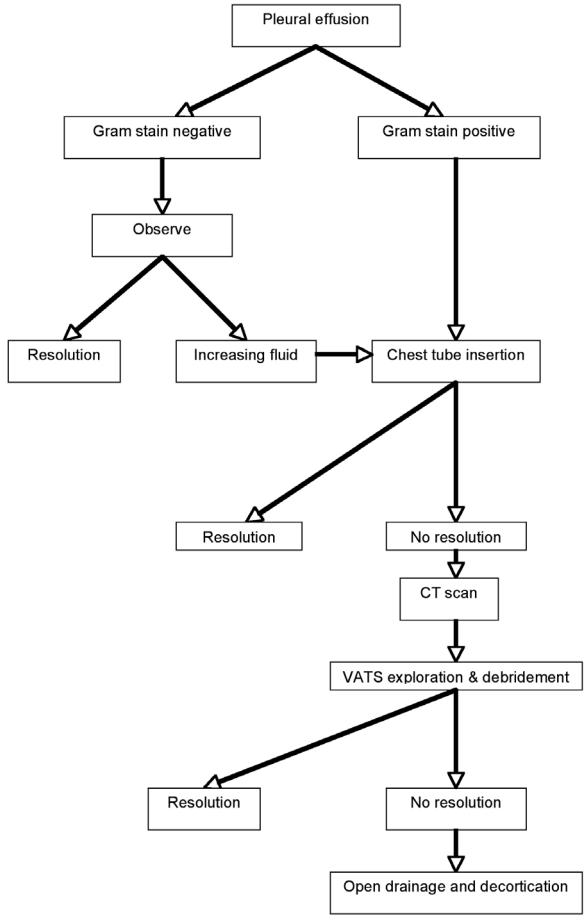

Figure 2. Algorithm proposed by Landreneau and coworkers for the management of empyema thoracis (1996). Thoracoscopy is a «bridge» between conservative management and aggressive surgical treatment.

exact role of the technique in the management of the disease is not well defined until today. There are two unanswered questions:

1) Should thoracoscopic drainage be the initial therapeutic maneuver or should be offered as «rescue» treatment?
2) Does thoracoscopic treatment is a bridge between failure of conservative management and before aggressive surgical manipulation, as Landreneau and coworkers have proposed in the middle of the past decade (1996)? (Figure 2).

We have evidence from just one prospective randomized trial (Wailt et al, 1997) and some retrospective studies, that early thoracoscopic drainage could lead to a favorable outcome if applied early in the course of the disease[6,10-12]. In these studies, where early thoracoscopic drainage was compared with chest tube drainage and intrapleural instillation of fibrinolytic agents, the common findings supporting early thoracoscopic drainage were the shorter hospital stay, the shorter time of chest tube drainage and administration of antimicrobials and less requirement for aggressive drainage via thoracotomy. Early thoracoscopic drainage was effective and definitive treatment in 90% of cases[10-12]. In the recent published systematic review (Cohrane Review) from Coote and Kay (2005), the authors conclude that early thoracoscopy seems to be the most effective treatment of parapneumonic effusions and empyemas. It is important however to point out that thoracoscopic drainage is effective before the

development of the organizing stage of empyema, where the thick fibrous peel over visceral pleura entraps the lung and limits lung expansion. The trapped lung will not expand despite adequate thoracoscopic drainage at this stage[2,7-9]. Indeed, during thoracoscopic exploration, one's can converse the thoracoscopic procedure to a standard thoracotomy and proceed with lung decortication, if lung entrapment is detected[2,9].

RIB RESECTION EMPYEMA DRAINAGE

Rib resection empyema drainage is a salvage procedure in debilitated patients or in ICU patients, where double-lumen ventilation (necessary for thoracoscopy) is contraindicated or a major procedure will add significant risk for the patient. The goal of the procedure is to move the patient out of the toxic state, without adding the risk of thoracotomy[2,9,14]. There are some concerns to proceed with rib resection empyema drainage. First at all the technique is suitable only for patients who have a limited (< 500ml), solitary empyema space, which is well detected on chest CT scan or plain chest radiography. The visceral pleura that cover the empyema cavity should be thick enough and fixed well to surrounding structures, to prevent further lung collapse after drainage of the cavity[14]. Rib resection drainage offers complete clearance of the empyema cavity from pus, gelatinous material and debris, while the cavity is at the end of the procedure drained with a large bore chest tube, through which is also possible to daily irrigate the cavity with sterile saline. Chest tube is connected with underwater seal bottle. The drainage technique of open thoracostomy window, which was performed in the past, is that way almost always avoided.

Meticulous study of chest CT scan and plain films is very important to identify the appropriate rib to resect to enter the empyema cavity. The rib to be resected should be the inferior rib of the empyema cavity. Drainage of the cavity is accomplished by using a small rib spreader and by taking special care to avoid any lung injury and consequently air leak, especially during the initial application of the rib spreader[14].

THORACOTOMY AND LUNG DECORTICATION

Any inflammatory process within the pleural cavity leads within a few days in the formation of a thin layer of fibrin and red cells that covers both pleural surfaces, parietal and visceral. Within seven days from the initiation of the inflammatory process evidence of fibroblastic ingrowth is noted, which causes a peel to develop over the pleural surfaces. The peel progressively increases in thickness and neo-capillaries are formed and extent into the peel. The parietal portion of the peel is usually thicker than the visceral portion of the peel. In some instances the pleural peel is absorbed spontaneously. In most of the cases the scenario is the formation of a thick, inelastic pleural cortex that limits lung expansion and leads finally to lung entrapment («trapped» lung). However, the underlying parietal and visceral pleura remain thin and this fact is the physiologic basis and «philosophy» of lung decortication. When the peel covering the visceral pleura is removed by a «lege artis» decortication procedure, the underlying visceral pleura can be left largely intact[1].

Lung decortication is a well established procedure, which is performed through a thoracotomy incision, usually via the 6th intercostal rib, with or without rib resection. Rib resection to access the pleural space may be necessary in chronic empyemas, because of the shrinking of the hemithorax and serious narrowing of the intercostal spaces. Break-down of any loculations and open drainage of debris, pus and gelatinous material is the next step. After complete mobilization of the lung, the visceral pleural cortex is removed and the lung re-expands. Special attention has to be made to avoid visceral pleura tears during removal of the peel (decortication) and consequently to air leak creation. Serious air leak may lead to the development of residual pleural space, which predispose to decortication failure, empyema recurrence and to the need for reintervention[1,15].

The main complications of lung decortication are air leak from the lung surface, incomplete lung expansion and recurrence of empyema, suppuration of the thoracotomy wound, postoperative bleeding and rarely injury of the phrenic nerve. Postoperative bleeding may be a serious problem, especially when the parietal pleura is going to stripped-off. Mortality rates with the appropriate selection of patients for decortication is very low (< 2%)[1,15].

Lung decortication is a major procedure. The procedure is relatively safe with the appropriate selection

of patients. Any temptation to employ lung decortication non-critically should be avoided. Lung decortication is indicated in patients without high-risk for thoracotomy comorbidities, who have multiloculated empyema and lung entrapment, where thoracoscopy or rib resection drainage or open window thoracostomy are of limited value[1,15]. Very careful selection is mandatory in aged and debilitated patients, where simpler drainage procedures will give satisfactory results without the mortality and morbidity associated with thoracotomy. However, recovery is expected to be delayed by using simple drainage procedures[1].

Improvement of pulmonary function after lung decortication depends on the state of the underlying pulmonary parenchyma and the extent of the underlying parenchymal disease[1,5]. The situation of the underlying lung is very important, as complete lung re-expansion is necessary for the obliteration of the pleural space. Preoperative chest CT scan gives a lot important of information for the situation of the underlying lung parenchyma and it is an important examination to be done before the decision to proceed with decortication. It should be stated at this point that a restrictive pattern of some degree is expected after decortication, because diaphragmatic and chest wall function never will reach normal, because of the loss of their elasticity. For this reason, stripping-off the thickening and inelastic parietal pleura is not so important to be done and should be avoided, as stripping of parietal pleura may result in serious bleeding.

Lung decortication performed with the proper indications results in serious improvement of the respiratory function. In two published series, serious increase of FEV_1 and FVC values, percent of the predicted FEV_1 and FVC, oxygen saturation of the arterial blood and perfusion of the decorticated lung were well detected after lung decortication[16,17].

COMMENTS

The management of parapneumonic effusions and empyemas still remain a point of debate and heavy disagreement. Disagreement concerning the use of intrapleural instillation of fibrinolytics still exists. The results of three published prospective randomized trials are confusing regarding figures of mortality rate, time of hospitalization and the need for surgical intervention[20-22]. It is well recognized from these series that the intrapleural instillation of fibrinolytics increases the amount of fluid drained from chest tubes and improves the radiographic image. However, in the larger of these studies (Maskell et al, 2005) no certain clinical benefit was detected[22]. The authors of the above mentioned study conclude that increasing the amount of drained pleural fluid has little importance in the era of modern antibiotics[22]. In the other hand, the study has received heavy criticism from the supporters of the use of intapleural instillation of fibrinolytics through multiple letters[23-26].

Early thoracoscopic drainage tend to become the standard initial procedure in high risk for poor outcome parpaneumonic effusions according to the ACCP criteria, because of the doubtful benefit from intrapleural instillation of fibrinolytics and the high failure rate of conservative therapy by chest tube drainage alone. Enthusiasm for early thoracoscopic drainage of complicated parapneumonic effusions is supported from one randomized trial (Wait et al, 1997) and some large retrospective studies[8,10-12,27]. The growing experience of thoracic surgeons to perform thoracoscopy within a pleural cavity with inflammatory conditions and full of adhesions as in empyema and complicated parapneumonic effusion, will further enhance its use as initial therapeutic maneuver. The role of thoracoscopic drainage as «salvage» treatment after failure of the conservative treatment is an established knowledge that is included in the recent published guidelines.

The exact time to proceed with surgical intervention in complicated parapneumonic effusions and empyemas is not well defined until today. However, it is well recognized that poor outcome is connected with prolonged conservative treatment and delay to refer the patient for consultation to the thoracic surgeon[2,4,8,9,18,19,28]. Any delay to refer to the thoracic surgeon the patient who did not respond to conservative treatment has as result prolong hospitalization and increase rate of need for major surgery, as is drainage through thoracotomy with or without lung decortication[9]. A week of conservative treatment with chest tube drainage and the appropriate antibiotics is enough time to judge if should continue with conservative treatment or proceed with surgical intervention[2,5,29].

Moreover, at the moment it is impossible to predict with certainty who is the patient who will benefit from conservative management or from early surgi-

cal intervention[2]. Early thoracoscopic intervention is an attractive method to manage patients with complicated parapneumonic effusions and empyemas from experienced in thoracoscopy thoracic surgeons[30] and future well conducted prospective randomized studies are awaited to establish the technique as initial therapeutic maneuver in these patients. One's should however keep in mind that the conduction of randomized studies concerning a surgical technique is extremely difficult to be made, if not impossible.

Thoracotomy and lung decortication is the appropriate management for patients with lung entrapment in the organizing stage of empyema. Strict selection of patients who will undergo decortication should be made to achieve good results. Thoracoscopic decortication is recently reported in some small retrospective studies[31,32]. However, experience with the procedure is at the moment limited and the conversion rate to standard thoracotomy is high (40%)[31]. Thoracoscopic decortication is at the moment inferior to the decortication performed through the standard thoracotomy incision for the management of organizing empyema associated with trapped lung[29].

CONCLUSIONS

The intrapleural instillation of fibrinolytics in high risk for poor outcome parapneumonic effusions is under serious concern. Failure of the conservative treatment with chest tube drainage and antibiotics for a reasonable period up to one week should alert the physician to refer the patient for consultation from a thoracic surgeon. Any delay to offer surgical intervention results in prolonged hospitalization and increasing need for major surgery. The exact role of thoracoscopic drainage, as initial therapeutic maneuver or as «salvage» therapy after failure of the initial conservative management, in high risk for poor outcome parapneumonic effusions is not well clarified until today. Decortication through a standard thoracotomy incision is the procedure of choice for good risk patients with trapped lung and underlying lung parenchyma not seriously involved from a chronic disease. Stripping of the parietal pleura during surgery for empyema do not offer major benefit and should be avoided.

Σύγχρονες απόψεις στη χειρουργική αντιμετώπιση των παραπνευμονικών συλλόγων και του εμπυήματος θώρακα.

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Χειρουργική Κλινική Θώρακος - Καρδιάς και Μεγάλων Αγγείων, Πανεπιστημιακό Νοσοκομείο Θεσσαλονίκης ΑΧΕΠΑ

ΠΕΡΙΛΗΨΗ: Η χειρουργική θεραπεία των επιπλεγμένων παραπνευμονικών συλλογών και του εμπυήματος θώρακα αποσκοπεί στην επαρκή παροχέτευση της υπεζωκοτικής κοιλότητας και την εξάλειψη της κοιλότητας του εμπυήματος. Δύο Επιστημονικές Εταιρείες έχουν δημοσιεύσει κατευθυντήριες οδηγίες. Το American College of Chest Physicians όρισε κριτήρια κινδύνου για κακή έκβαση. Οι παραπνευμονικές συλλογές που πληρούν τα κριτήρια αυτά χρήζουν παροχέτευσης με σωλήνα, η οποία όμως κρίθηκε ανεπαρκής στο 25-50% των περιπτώσεων. Ενδοπλεύρια έγχυση ινωδολυτικών, θωρακοσκοπική παροχέτευση και θωρακοτομή θεωρήθηκαν αποδεκτές στρατηγικές, αλλά δεν υπήρξε ομοφωνία. Στις κατευθυντήριες οδηγίες της British Thoracic Society (2003) η χειρουργική εφαρμόζεται μετά την αποτυχία των αντιβιοτικών και της παροχέτευσης με σωλήνα να ελέγξουν τη νόσο.

Υπάρχουν σήμερα ενδείξεις που υποστηρίζουν ότι η πρώιμη εφαρμογή της θωρακοσκόπησης μειώνει το χρόνο νοσηλείας, το χρόνο παραμονής του θωρακικού σωλήνα και αποτελεί οριστική αρχική αντιμετώπιση στο 90% των περιπτώσεων. Ο ρόλος της θωρακοσκόπησης συνίσταται σε διάλυση των εγκυστώσεων, ενοποίηση της υπεζωκοτικής κοιλότητας, παροχέτευση της γέλης και του φλεγμονώδους υγρού και «στρατηγική» τοποθέτηση των σωλήνων παροχέτευσης. Η θωρακοσκόπηση είναι αναποτελεσματική στο εμπύημα που βρίσκεται στο στάδιο της οργάνωσης, όπου η ενδεδειγμένη επέμβαση είναι η αποφλοίωση. Γρήγορη εμπλοκή του θωρακοχειρουργού και πρώιμη εφαρμογή θωρακοσκόπησης μπορεί να αλλάξουν την πρόγνωση της επιπλεγμένης παραπνευμονικής συλλογής και του εμπυήματος θώρακα.

Λέξεις Κλειδιά: Παραπνευμονική συλλογή, Επιπλεγμένη παραπνευμονική συλλογή, Εμπύημα θώρακα, Θωρακοσκόπηση, Αποφλοίωση πνεύμονα.

REFERENCES

1. Lee-Chiong TL, Matthay RA. Current diagnostic methods and medical management of thoracic empyemas. Chest Surg Clin North Am 1996; 6: 419-438.
2. Chapman SJ, Davies RJO. The management of pleural space infections. Respirology 2004; 9: 4-11.
3. Simpson G, Roomes D, Reeves B. Successful treatment of empyema thoracis with human recombinant deoxyribonuclease. Thorax 2003; 58: 365-366.
4. Medical and surgical treatment of parapneumonic effusions. An evidence-based guideline. Colice GL, Curtis A, Deslauriers J, Heffner J, Light R, Littenberg B, et al, for the American College of Chest Physicians Parapneumonic effusion panel. Chest 2000; 18: 1158-1171.
5. BTS guidelines for the management of pleural effusion. Davies CWH, Gleeson FV, Davies RJO, on behalf of the BTS Pleural Diseases Group, a subgroup of the BTS Standards of Care Committee. Thorax 2003; 58 (Suppl II): 18-28.
6. Ferguson MK. Thoracoscopy for empyema, bronchopleural fistula and chylothorax. Ann Thorac Surg 1993; 56: 644-645.
7. Silen ML, Naunheim KS. Thoracoscopic approach to the management of empyema thoracis. Indications and results. Chest Surg Clin North Am 1996; 6: 491-499.
8. Luh A-P, Ghou M-C, Wang L-S, Chen J-Y, Tsai T-P. Video-Assisted thoracocscopic surgery in the treatment of complicated parapneumonic effusions or empyemas. Outcome of 234 patients. Chest 2005; 127: 1427-1432.
9. Landreneau RJ, Keenan RJ, Hazelrigg SR, Mack MJ, Naunheim KS. Thoracoscopy for empyema and hemothorax. Chest 1996; 109: 18-24.
10. Wait MA, Sharma S, Hohn J, Dal Nogare A. A randomized trial on empyema therapy. Chest 1997; 111: 1548-1551.
11. Petrakis IE, Kogerakis NE, Drositis IE, Lasithiotakis KG, Bouros D, Chalkiadakis GE. Video-assisted thoracoscopic surgery for thoracic empyema: primarily or after fibrinolytic therapy failure? Am J Surg 2004; 187: 471-474.
12. Cohen G, Hjortdal V, Ricci M, Jaffe A, Wallis C, Dinwiddie R, Elliott MJ, de Leval MR. Primary thoracoscopic treatment of empyema in children. J Thorac Cardiovasc Surg 2003; 125: 79-84.
13. Coote N, Kay E. Surgical versus non-surgical management of pleural empyema. The Cochrane Database of Systematic Reviews 2005, Issue 4, Art. No.: CD001956.pub2.DOI10.1002/14651858.CD0011956.pub2.
14. Smolle-Juettner F. Pleural empyema. In Moghissi K, Thorpe JAC, Ciulli F, eds, Moghissi's Essentials in Thoracic and Cardiovascular Surgery, 2nd Edition. Elsevier Science BV: The Netherlands, 2003: 195-203.
15. Rice TW. Fibrothorax and decortication of the lung. In: Shields TW, LoCicero J, Ponn RB, eds. General Thoracic Surgery, 5th Edition. Lippincott Williams and Willkins: Philadelphia, 2000: 729-737.
16. Rzyman W, Shokowski J, Romanowicz G, Lass P, Dziadziuszko R. Decortication in chronic pleural empyema - effect on lung function. Eur J Cardiothorac Surg 2002; 21: 502-507.
17. Choi S-S, Kim D-J, Chung K-Y. Change in pulmonary function following empyemectomy and decortication in tuberculous and non-tuberculous empyema thoracis. Yonsei Med J 2004; 45: 643-648.
18. Spencer D. Empyema thoracis: not time to put the knife down. Arch Dis Child 2003; 0: 842-843.
19. Anstadt MP, Guill CK, Ferguson ER, Gordon HS, Soltero ER, Beall AC, Musher DM. Surgical versus non-surgical treatment of empyema thoracis: an outcome analysis. Am J Med Sci 2003; 326: 9-14.
20. Bouros D, Schiza S, Tzanakis N, Chalkiadakis G, Drositis J, Siafacas N. Intrapleural urokinase versus normal saline in the treatment of complicated parapneumonic effusions and empyema. Am J Resp Crit Care Med 1999; 159: 37-42.
21. Misthos P, Sepsas E, Konstantinou M, Athanassiadi K, Skottis I, Lioulias A. Early use of intrapleural fibrinolytics in the management of post-pneumoic empyema. A prospective study. Eur J Cardiothorac Surg 2005; 28: 599-603.
22. Maskell NA, Davies CWH, Nunn AJ, Hedley EL, Gleeson FV, Miller R, et al, for the first Multicenter Intrapleural Sepsis Trial (MIST1) group. N Engl J Med 2005; 352: 865-874.
23. Katikireddy CK, Dube DS. A trial of intrapleural streptokinase. N Engl J Med 2005; 352: 2243.
24. Diacon AH, Koegelenberg CFN, Bolliger CT. A trial of intrapleural streptokinase. N Engl J Med 2005; 352: 2243.
25. Rosa UW. A trial of intrapleural streptokinase. N Engl J Med 2005; 352: 2244.
26. Bouros D. A trial of intrapleural streptokinase. N Engl J Med 2005; 352: 2244.
27. Cheng G, Vintch JRE. A retrospective analysis of the management of parapneumonic empyemas in a County Teaching facility from 1992 to 2004. Chest 2005; 128: 3284-3290.
28. Ozol D, Oktem S, Erdinc E. Complicated parapneumonic effusion and empyema thoracis: microbiologic and therapeutic aspects. Resp Med 2006; 100: 286-291.
29. Na MJ, Dikensoy O, Light RW. New trends in the di-

agnosis and treatment in parapneumonic effusion and empyema. Tuberk Toraks 2008; 56: 113-120.
30. Solaini L, Prusciano F, Bagioni P. Video Assisted Thoracic Surgery in the treatment of empyema. Surg Endosc 2007; 21: 280-284.
31. Waller D, Rengarajan A. Thoracoscopic decortication: a role for video-assisted thoracic surgery in chronic postpneumonic pleural empyema. Ann Thorac Surg 2001; 71: 1813-1816.
32. Olgac G, Fazlioglu M, Kutlu CA. VATS decortication in stage 3 empyema. Thorac Cardiovasc Surg 2005; 53: 318-320.