

The role of medical thoracoscopy in the management of empyema

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Background Empyema thoracis is defined as accumulation of pus in the pleural space. Despite advanced medical diagnostic and therapeutic methods, thoracic empyema remains a common clinical entity and a serious problem all over the world with significant associated morbidity and mortality.

Aim The aim of this work was to study the efficacy and safety of medical thoracoscopy (MT) in the management of empyema.

Patients and methods This study included 30 inpatients with empyema. Included patients had frank pus on aspiration (turbid purulent fetid fluid) with or without positive Gram stain smear and microbiological culture findings or pH less than 7.20, with signs of sepsis. Patients were managed by MT. MT using rigid thoracoscopy was performed with evacuation of the purulent fluid, visualization of the pleural space, assessment of adhesions and purulent material, forceps adhesiolysis, and irrigation by normal saline with partial debridement of accessible parietal pleural surface.

Results The present study included 30 patients with empyema (17 men, 13 women with a mean age of 47.4 ± 14.5 years; range, 18–70 years); 19 (63.3%) patients had free-flowing empyema (by computed tomography/ultrasonography) and 11 (36.7%) patients had multiloculated empyema. The etiology of empyema included pneumonia

Introduction

Pleural empyema is defined as pus accumulation in the pleural space. Despite the advanced progress in antibiotic therapy during the last decades, empyema thoracis remains a widespread serious clinical problem with significant associated morbidity and mortality of 2–30%. The processes that lead to the formation of empyema include three phases: an exudative phase, fibrinopurulent phase, and organization phase [1].

The exudative phase is characterized by increased permeability of the visceral pleura leading to the accumulation of a sterile, exudative pleural fluid. Untreated exudative effusions become complicated during the subsequent fibrinopurulent phase and may develop into fibrinopurulent effusions (purulent and increasingly viscous fluid). Owing to the disequilibrium between coagulation and fibrinolysis processes within the pleural space during the fibrinopurulent phase, fibrin and fibrin strands coat the pleural surfaces, leading to adhesions and loculations within the pleural space. This phase often requires interventional procedure to break down the adhesions [2].

(parapneumonic effusion) (33.3%), malignancy (23.3%), tuberculosis (6.7%), lung abscess (6.7%), and no cause was identified in nine patients (spontaneous pleural infection) (30%). MT was considered successful without subsequent interventional procedures in 26 of 30 (86.7%) patients, including all patients with free-flowing empyema (19 patients), 63.6% of patients with multiloculated empyema (seven patients), and four (13.3%) patients required surgical intervention (surgical decortication). No procedure-related mortality or chronic morbidity occurred in this study.

Conclusion MT is a simple, safe, minimally invasive, and effective modality in the management of empyema.

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The treatment options for the management of empyema are variable and include observation and antibiotic therapy, therapeutic thoracentesis, tube thoracostomy, intrapleural fibrinolytics, thoracoscopy with breakdown of adhesions, thoracotomy with breakdown of adhesions and decortication, and open drainage procedures. The selection of appropriate methods to treat empyema depends on the category or phase of the disease and the patient's overall medical condition [3].

Medical thoracoscopy (MT) is minimally invasive video-assisted thoracoscopy that allows visualization of the pleural space and intrathoracic structures. It is done under local anesthesia and moderate sedation, and it has been used throughout Europe since 1910 for the diagnosis and treatment of pleural diseases including thoracic empyema. MT allows disruption of numerous loculations, aspiration of the purulent

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fluid, and removal of the fibrinous adhesions. Local treatment with fibrinolytic therapy can be administered during MT [4].

Aim

The aim was to study the efficacy and safety of MT in the management of empyema.

Patients and methods

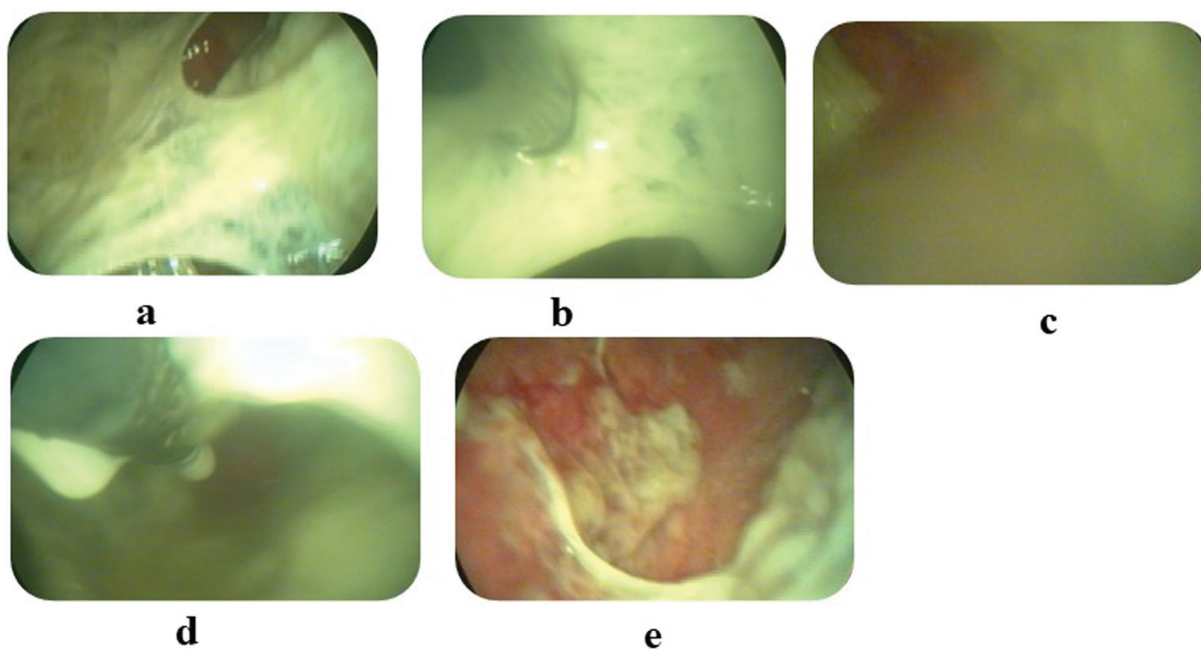
This study included 30 patients with empyema who were admitted to Chest Department, Benha University Hospital from July 2014 to September 2016. Informed consent was obtained from all patients. All patients had documented empyema following physical appearance, biochemical, bacteriological, and cytological analysis of the pleural fluid. The study was approved by the local institute ethics committee.

Full laboratory workup was done: plain chest radiography, transthoracic chest ultrasound (US) to detect loculations, and computed tomography (CT) chest were done. Pleural fluid aspiration was done and sent for biochemical analysis including pH, lactate dehydrogenase (LDH), protein content, and cellular pattern. Also Gram stain and culture were done. The included patients in this study had frank pus on aspiration (turbid purulent fetid fluid) with or without positive Gram stain smear and microbiological culture findings or pH less than 7.20, with signs of sepsis.

Patients with one or more of the following were excluded from the study: patients with unstable cardiovascular or hemodynamic status, patients with coagulation defects (prothrombin concentration should be $>60\%$, and the platelets count should be $>60\ 000/\text{mm}^3$) [5], with liver cell failure, renal failure, and patients with extensive pleural fibrosis and adhesions. Patients in whom the pleural space was judged radiologically (by transthoracic US and CT chest) to be inaccessible easily [5].

MT was done to all patients in a specially equipped endoscopy room in the Chest Department, Benha University. MT was performed under local anesthesia and conscious sedation (midazolam 5 mg). It was performed with the patient in the lateral decubitus position with the involved side facing upwards. The site for the introduction of the trocar was chosen by US to identify the point where there was adequate amount of pus collection. An 11-mm rigid rod lens telescope (STORZ, KARL STORZ-ENDOSKOPE, Mittelstrasse 8, D-78532 Tuttingen, Germany) was introduced in the pleural cavity, suction of all fluids was done, cutting and removal of adhesions and thickened pleura and opening of multiple loculations were done by using forceps through the forceps channel, lastly the pleural cavity was irrigated by normal saline and intercostal tube was inserted in the pleural cavity (Fig. 1).

Figure 1



After a thoracoscope is entered: (a) shows multiple adhesions, (b) shows cutting of adhesions by forceps, pus is drained (c), the pleura is attempted to be converted into a single space by opening pouches (d), a single space is formed for the insertion of the tube (e).

Patients received routine empirical antibiotic therapy covering most of the likely possible organisms, modified later according to the results of culture and sensitivity. Patients with tuberculous empyema received antituberculosis medications. Follow-up of all the patients was carried out by clinical, laboratory, and radiological follow-up. Follow-up was done by plain chest radiography till the amount of effusion drained is less than 50 ml per day and fluid became clear and after 1 month from the procedure. Successful treatment was defined as presence of successful pleural drainage (that was confirmed radiologically, and did not need any further treatment as insertion of another chest tube or surgical procedures), and by objective evidence of resolution of sepsis (improved temperature and clinical condition and decreased inflammatory laboratory markers).

Statistical analysis

The gathered data were tabulated and analyzed using the statistical package for social sciences, version 16 (SPSS Inc, Chicago, ILL Company and MedCalc software version 16 (1993-2016) MedCalc software bvba), software. Qualitative data were presented as number and percent while quantitative data were presented as mean±SD, median, and range. Fisher's exact test was used to analyze categorical variables. Quantitative data were tested for normality using Shapiro–Wilks test, assuming normality at *P* value more than 0.05, using Mann–Whitney *U* test for not normally distributed. The accepted level of significance in this work was stated at 0.05 ($P < 0.05$ was considered significant) [6].

Results

The present study included 30 patients with empyema. Table 1 shows the characteristics of 30 patients included in the study. Their mean age was 47.4 ±14.5. They included 17 (56.7%) men and 13 (43.3%) women. Twelve (40.0%) patients were smokers, 17 (56.7%) patients were nonsmokers, and one (3.3%) patient was an ex-smoker. Hypertension was present in two (6.7%) patients, whereas diabetes mellitus was present in 10 (33.3%) patients.

In this study, 19 (63.3%) patients had free-flowing empyema (by CT/US), and 11 (36.7%) patients had multiloculated empyema. Nine (63.3%) patients had right-sided empyema while 11 (36.7%) patients had left-sided empyema (in the chest radiograph). For the amount of pleural effusion in the chest radiograph, one (3.3%) patient had mild pleural collection (defined as just obliteration of the costophrenic angle), 13 patients had moderate pleural collection (defined as pleural

Table 1 Sociodemographic data of the studied patients

Variables	<i>n</i> (%) (<i>N</i> =30)
Sex	
Male	17 (56.7)
Female	13 (43.3)
Age (years)	
Mean±SD	47.4±14.5
Range	18–70
Smoking	
Nonsmoker	17 (56.7)
Smoker	12 (40.0)
Ex-smoker	1 (3.3)
DM	
Absent	20 (66.7)
Present	10 (33.3)
HTN	
Absent	28 (93.3)
Present	2 (6.7)

DM, diabetes mellitus; HTN, hypertension.

Table 2 Radiological findings among the studied patients

Variables	<i>n</i> (%) (<i>N</i> =30)
Chest radiography)side)	
Right side	19 (63.3)
Left side	11 (36.7)
Chest radiography)size(
Mild	1 (3.3)
Moderate	13 (43.3)
Massive	16 (53.3)
CT chest/pleural US	
Free	19 (63.3)
Multiloculated/ loculated	11 (36.7)

CT, computed tomography; US, ultrasonography.

effusion that occupies less than 2/3 of the hemithorax), and 16 patients had massive pleural collection (defined as pleural effusion that occupies more than 2/3 of the hemithorax up to total opacification of the whole hemithorax) (Table 2).

Concerning pleural fluid analysis, in the present study, the mean value for pleural fluid pH was 7.09±2.1; the mean value for pleural fluid protein was 4.8±0.82; the mean value for pleural fluid LDH was 1223.16±964; and the mean value for pleural fluid glucose was 29.67±17.02 (Table 3).

In the present study, a positive result of Gram stain was only in six (20%) patients. Gram-negative organisms were more common to be isolated than Gram-positive organisms (Table 4).

In the present study, full laboratory workup and tuberculin skin test (TST) were done. Table 5 shows the laboratory investigations done to the studied patients [the mean hemoglobin value was 11.3±2.2;

Table 3 Chemical examination of pleural fluid among the studied patients

Variables	Mean±SD	Range
pH	7.09±2.1	6.5–7.5
Glucose	29.67±17.02	5–65
Protein	4.8±0.82	3.4–6.6
LDH	1223.16±964	233–3443

LDH, lactate dehydrogenase; pH, negative logarithm hydrogen ion concentration.

Table 4 Culture results of pleural fluid among the studied patients

Culture results	n (%)
No growth	24 (80.0)
<i>Staphylococcus aureus</i>	2 (6.7)
Gram-negative bacilli	4 (13.3)
Total	30 (100.0)

Table 5 Laboratory investigations among the studied patients

Variables	Mean±SD	Range
Hb%	11.3±2.2	8–17
WBCs	13.7±5.6	2.9–24.0
ESR	91.3±36.7	5–150
Tuberculin skin test [n (%)]		
Negative	26	86.7
Positive	4	13.3

ESR, erythrocyte sedimentation rate; Hb, hemoglobin; WBCs, white blood cells.

Table 6 Etiology of empyema among the studied patients

Causes	n (%) (N=30)
Pneumonia	10 (33.3)
Lung abscess	2 (6.7)
TB	2 (6.7)
Spontaneous (no cause identified)	9 (30.0)
Malignant	7 (23.3)
Total	30 (100.0)

the mean leukocytic count was 13.7±5.6; erythrocyte sedimentation rate was 91.3±36.7; and TST was positive in four (13.3%) patients].

Table 6 shows the etiology of pleural empyema, of the 30 patients evaluated, 10 (33.3%) were diagnosed as pneumonia, seven as malignancy, two as tuberculosis, and two as lung abscess. The cause was not identified in nine patients (spontaneous pleural infection).

Table 7 shows the histopathology of pleural biopsies taken during MT [nonspecific inflammation in 21 (70%) patients, malignancy in seven (23.3%) patients, and caseating granuloma in two (6.7%) patients].

The mean duration of intercostal chest tube (ICT) inserted in the studied patient was 6.3±1.2 (range, 4–9 days) (Table 8).

Table 7 Histopathology of pleural biopsies among the studied patients

Histopathology	n (%)
Nonspecific inflammation	21 (70.0)
Caseating granuloma	2 (6.7)
Malignant	7 (23.3)
Total	30 (100.0)

Table 8 Duration of ICT insertion among the studied patients

Variable	Mean±SD	Range
Duration of ICT insertion (days)	6.3±1.2	4–9

Table 9 Outcome after medical thoracoscopy among the studied patients

Outcomes	n (%) (N=30)
Complete resolution (treatment success)	26 (86.7)
Surgery (decortication)	4 (13.3)
Total	30 (100.0)

MT was considered successful with no need for any subsequent interventional procedures in 26 of 30 (86.7%) patients. Four (13.3%) patients required a surgical procedure (Table 9).

All patients were with free-flowing empyema, 63.6% of patients with multiloculated empyema were successfully treated by MT. Four (13.3%) patients required surgical interventional procedure (surgical decortication). There was a statistically significant correlation between the outcome of treatment of empyema by MT and the type of empyema (complete resolution more with free-flowing empyema) (Table 10).

In the present study, complications related to MT were encountered in three patients (subcutaneous emphysema that was resolved on supplemental oxygen and follow-up). No empyema or procedure-related mortality or chronic morbidity were observed in this study (Table 11).

There was a statistically significant correlation between the type of empyema and occurrence of complications (complications occurred with multiloculated empyema) (Table 12).

Discussion

There has been increasing interest in the use of MT for patients with empyema. The BTS Local Anesthetic Thoracoscopy Guideline Report acknowledged that the procedure may be useful for breakdown of septations and adhesions, thus creating a single pleural cavity and improving drainage [7].

Table 10 Outcome after medical thoracoscopy according to the type of empyema

	Outcome		Total	Test of significance	P
	Complete resolution (treatment success)	Surgery (decortication)			
Free-flowing					
Count	19	0	19		
% within CT chest–pleural US	100.0	0.0	100.0		
Multiloculated/loculated					
Count	7	4	11	FET	0.012 (S)
% within CT chest–pleural US	63.6	36.4	100.0		
Total					
Count	26	4	30		
% within CT chest–pleural US	86.7	13.3	100.0		

CT, computed tomography; FET, Fisher’s exact test; S, significant; US, ultrasonography. P value 0.012 ($P < 0.05$ was considered significant).

Table 11 Complications after medical thoracoscopy among the studied patients

Complications	n(%) (N=30)
No	27 (90.0)
Yes (subcutaneous emphysema)	3 (10.0)
Total	30 (100.0)

The exact role and timing of thoracoscopy in the management of empyema has been debated in the literature. Loddenkemper [8] recommended the use of thoracoscopy before chest tube placement; others have suggested its use after failure of the tubal drainage to control the sepsis or when loculations need to be disrupted [9].

This study included 30 patients with documented empyema. MT using rigid thoracoscopy was performed with evacuation of the purulent fluid, visualization of the pleural space, assessment of adhesions and purulent material, forceps adhesiolysis, irrigation by normal saline with partial debridement of accessible parietal pleural surface.

In the present study, chest radiography, chest CT scan, and chest US (when needed) were done to the studied patients. Chest US prior to MT can make the procedure easier and more successful as it improves point of access to the pleural cavity, lower the risk for complications, and decreases the duration of the procedure [10].

According to radiological findings by radiography, US, or CT, 19 (63.3%) patients had free-flowing empyema and 11 (36.7%) patients had multiloculated empyema. Nineteen (63.3%) patients had right-sided empyema while 11 (36.7%) patients had left-sided empyema.

Table 12 Complications after medical thoracoscopy according to the type of empyema

Type	Complications		Total	Test of significance	P
	No	Yes			
Free-flowing					
Count	19	0	19		
%	100.0	0.0	100.0		
Multiloculated/loculated					
Count	8	3	11	FET	0.041 (S)
%	72.7	27.3	100.0		
Total					
Count	27	3	30		
%	90.0	10.0	100.0		

FET, Fisher’s exact test; S, significant. P value 0.041 ($P < 0.05$ was considered significant).

This study shows that pleural empyema (free-flowing and multiloculated) can be safely and successfully managed by MT. All patients were with free-flowing empyema, 63.6% of patients with multiloculated empyema were successfully managed by MT. Four (13.3%) patients received surgical intervention (surgical decortication).

Ravaglia *et al.* [11] assessed the safety and efficacy of MT in 41 patients with empyema; nine (22%) patients had free-flowing empyema, 24 (58.5%) patients had multiloculated empyema, and eight (19.5%) patients had organized disease.

Concerning pleural fluid analysis, in the present study, the biochemical analysis of the pleural fluid showed that the pleural fluid protein ranged from 3.4 to 6.6 g/dl with a mean value of 4.8 ± 0.82 g/dl, and the pleural LDH ranged from 233 to 3443 IU/l with a mean value of 1223.2 ± 964.2 IU/l confirming cases as an exudative

pleural effusion. In the present study, the pleural fluid pH was consistently low among patients, with a mean pH of 7.09 ± 2.1 . Glucose concentration was, as would be expected, low in all the studied patients with a mean glucose concentration of 29.7 ± 17.0 mg/dl.

The pleural fluid analysis results in this study are in agreement with that done by Reda *et al.* [12] and with that done by Hewidy and Elshafey [13].

In the present study, a positive result of Gram stain was only in six (20%) patients. Gram-negative organisms were more common to be isolated than Gram-positive organisms.

These results are in agreement with that done by Jiménez *et al.* [14], who showed that the results of the culture and sensitivity of the pleural fluid is of low yield in suspected cases of empyema. This is due to the use of antibiotics before thoracentesis; additionally the pleural fluid is a relatively poor specimen from a microbiological point of view. However, continuous taking of pleural liquid for cultures can probably be explained by identification of unusual or resistant organisms in small subgroups of patients.

In the present study, full laboratory workup and TST were done. The laboratory investigations done to the studied patients showed that the mean hemoglobin value was 11.3 ± 2.2 ; the mean leukocytic count was 13.7 ± 5.6 , erythrocyte sedimentation rate 91.3 ± 36.7 ; and TST was positive in four (13.3%) patients.

Etiology of empyema was based on the history, physical examination, radiology, pleural fluid analysis, histopathology of pleural biopsy taken during MT as well as other clinically relevant investigations. In the present study, of the 30 patients evaluated, 10 (33.3%) patients were diagnosed as having pneumonia, seven as malignancy (three cases mesothelioma and four cases adenocarcinoma), two as tuberculosis, and two as lung abscess. Etiology was not identified in nine patients (spontaneous pleural infection).

Histopathology of pleural biopsies taken during MT in this study was nonspecific pleuritis, accounting for 21 (70%) cases, seven cases showed malignancy (three cases mesothelioma and four cases adenocarcinoma). Two biopsies revealed caseating granuloma (tuberculous).

These results are in agreement with that done by Bhatt *et al.* [15], who studied the diagnostic role of MT in empyema and reported that MT is a simple, safe, minimally invasive, less painful, and efficient

diagnostic procedure. It decreases the morbidity and length of hospitalization in loculated empyema.

This study shows that pleural empyema (free-flowing and multiloculated) can be safely and successfully managed by MT. All patients were with free-flowing empyema, 63.6% of patients with multiloculated empyema were successfully managed by MT. Four (13.3%) patients received surgical intervention (surgical decortication).

These results are in agreement with Akhan *et al.* [16], who showed that nonloculated anechoic effusion without septae is effectively treated with catheter drainage.

Also, these results are in agreement with Reynard *et al.* [17], who reported five cases of pleural empyema successfully treated with simple MT.

Also, Brutsche *et al.* [18] assessed the beneficial role of using MT in the treatment of multiloculated pleural effusion stratified by chest US in a series of 127 patients with empyema. The pleural space of 116 (91%) patients was successfully drained by MT with no procedure-related complications. However, four (3%) patients required either an additional chest tube or a second thoracoscopy and 62 (49%) patients required postprocedure intrapleural fibrinolytic over 3–5 days.

Ravaglia *et al.* [11] reported that MT was successful without any additional interventional procedures in 35 of 41 (85.4%) patients with empyema.

Soler *et al.* [19] also reported on 16 patients with complicated parapneumonic effusion or empyema, in whom after a failure of tube drainage attempt, MT was performed for debridement and insertion of a chest tube. MT was successful in the treatment of 12 of 16 (75.0%) patients included in the study.

Furthermore, in another study of 29 patients, the majority (79%) were successfully managed with single-trocar thoracoscopy (MT) [20].

The results in this study are also in agreement with that done by Hewidy and Elshafey [13] and that done by Reda *et al.* [12].

Hewidy and Elshafey [13] reported that MT was successful without further intervention in 19 of 20 (95%) patients with complicated parapneumonic effusion and empyema and reported that MT is better than streptokinase fibrinolysis in complicated

parapneumonic effusions and empyema as regards safety and efficacy.

Reda *et al.* [12] reported that MT is efficient and safe in treating patients with empyema regardless of the use of fibrinolytics post-thoracoscopy.

In this study, follow-up after MT was done by plain chest radiography till the amount of effusion drained is less than 50 ml per day and the fluid became clear and after 1 month from the procedure. The mean duration of ICT inserted in the studied patient was 6.3 ± 1.2 days. These results were close to that done by Hewidy and Elshafey [13] and that done by Reda *et al.* [12].

In other studies, however, MT is not considered as an alternative method to surgical procedures in the presence of loculations [21–23].

Tassi *et al.* [23] concluded that MT is a draining procedure intermediate between tube thoracotomy and thoracoscopic surgery. It is essential that it is performed early in the course of empyema and it is particularly advisable for patients at high surgical risk. Thoracoscopic examination results in better anatomical details about the stage and extent of the empyema, and guides about the management plans. MT allows breakdown of the adhesions and loculations, removal of fibrinous debris in the pleural cavity, creating a single pleural cavity, and chest tube insertion under vision, in addition to the pleural biopsy taken for histopathological and microbiological examination.

Regarding complications after MT, complications were strictly related to the difficulty of the cases treated and were represented mainly by subcutaneous emphysema occurred in only three (10%) patients. No procedure-related mortality or chronic morbidity related to empyema occurred in this study.

Overall, the complications of thoracoscopy appear to be less, and it is very safe. These results are in agreement with that done by Brutsche *et al.* [18], who showed that MT is safe, minimally invasive, and an efficient treatment approach for patients with multiloculated empyema, who was stratified by US and treated with MT.

Thoracoscopy remains a treatment option for the patient with an incompletely drained loculated parapneumonic effusion, provided that it is performed early in the course of the disease and that the pleural anatomy is defined by means of either US or CT scan. Loculations can be broken down, the visible pleural space completely evacuated with optimal insertion of an intercostal

chest tube. Furthermore, visual inspection of the pleura may guide decisions as regards the need for any open surgical intervention [2].

MT is effective to help to control the pleural infection and prevent the need for thoracotomy especially in patients with bad general health condition and high surgical risk [24].

Conclusion

MT is a simple, safe, minimally invasive, and effective modality in the management of empyema.

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Conflicts of interest

There are no conflicts of interest.

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