Original Article

# Comparison of outcome of surgery for tubercular and nontubercular empyema: An analysis of 285 consecutive cases

*Arvind Kumar[1], C Vijay Lingaraju[2], Mohan Venkatesh Pulle[1], Belal Bin Asaf[1], Harsh Vardhan Puri[1], Sukhram Bishnoi[1]*

*[1]Department of Thoracic Surgery, Institute of Chest Surgery, Medanta – The Medicity, Gurgaon, Haryana, India, [2]Department of Thoracic Surgery, Narayana Hrudayalaya, Bengaluru, Karnataka, India*

## ABSTRACT

**Background:** Few studies have compared the surgical outcomes between tubercular empyema (TE) and nontubercular empyema (NTE), which were limited by a small sample size. We conducted this study with the objective of comparing the surgical outcomes of patients with tuberculous and nontuberculous empyema. **Materials and Methods:** This is a retrospective analysis of 285 consecutively operated cases of TE and NTE over 5 years conducted in a tertiary care center in New Delhi, India. A comparative analysis of demography, intraoperative, and postoperative variables including mortality between the two groups was carried out. **Results:** Out of 285 patients, 166 were tubercular and 119 were nontubercular. Nontubercular group had significantly higher age (45.4 ± 17.2 vs. 31.2 ± 13.6 in years), more comorbidities. Procedure was started by thoracotomy in 25.9% of tubercular group and 41.1% of nontubercular group. In patients where procedure started by video-assisted thoracoscopic surgery (VATS), complete decortication could be achieved by VATS in 91.1% of TE patients, whereas it was possible in 77.2% of nontubercular group. Need for postoperative ventilation (10% vs. 1.2%, $P = 0.0011$) and intensive care unit (ICU) stay (25.2% vs. 3%, $P = 0.001$) was significantly higher in nontubercular group. Nontubercular group was found to have significantly higher number of complications (13.4% vs. 5.4%, $P = 0.02$) and postoperative mortality (10% vs. 0, $P = 0.001$). **Conclusions:** Higher percentage of TE cases were managed by VATS with reduced operative time, less blood loss, and lower conversions. Need for postoperative ventilation, ICU stay, and complications including mortality were more in NTE.

**KEY WORDS:** Empyema, nontubercular, surgical outcomes, tubercular

**Address for correspondence:** Dr. Arvind Kumar, Room No. 12, 4th Floor, OPD Block, Medanta, The Medicity, Gurgaon, Haryana, India.
E-mail: arvindreena@gmail.com

**Submitted:** 17-Jun-2021 **Revised:** 20-Jun-2021 **Accepted:** 24-Jun-2021 **Published:** 26-Oct-2021

## INTRODUCTION

Empyema thoracis continues to be a major public health problem across the world. Parapneumonic effusion and trauma are its major causes in developed countries,[1] whereas tuberculosis (TB) continues to be a major cause in developing countries like India.[2,3] No single procedure is ideal in the management of all stages of this complex clinical entity. Tubercular empyema (TE) and nontubercular empyema (NTE) not only have different

Access this article online

Quick Response Code:

Website: www.lungindia.com

DOI: 10.4103/lungindia.lungindia_33_21



**How to cite this article:** Kumar A, Lingaraju CV, Pulle MV, Asaf BB, Puri HV, Bishnoi S. Comparison of outcome of surgery for tubercular and nontubercular empyema: An analysis of 285 consecutive cases. Lung India 2021;38:514-9.

etiology and demographic features, but their treatment outcomes have also been variously reported. Very few studies have compared the surgical outcomes of TE and NTE and these were limited by a small sample size.[3,4] The present study aims at comparing the surgical outcomes between TE and NTE and analyze the factors predicting perioperative mortality.

## MATERIALS AND METHODS

It is a retrospective analysis of a prospectively maintained database of 285 consecutively operated cases of Stage III pleural empyema from March 2012 to March 2017. Out of 285 patients, 166 (58.2%) were of tubercular (TE) origin and the rest 119 (41.8%) were nontubercular (NTE). Various causes of NTE are enlisted in Table 1. The demographic data, details of present illness, and treatment received including antitubercular treatment were recorded in detail. All patients underwent a detailed clinical examination along with routine preoperative investigations. Computed tomography of the chest was performed in all to assess the disease state. Indications for surgery were trapped lung, multiloculated collection, and incomplete drainage of empyema even after tube thoracostomy.

Patients were taken up for surgery after thorough preoperative evaluation and adequate physical and nutritional preparation. All patients were counseled by physiotherapist for pre- and postoperative physical training. The patients were taken up for video-assisted thoracoscopic surgery (VATS) or open approach as per the described criteria [Figure 1]. However, VATS was converted to thoracotomy if there was a need for lung resection with unclear hilar anatomy not considered safe to proceed by VATS, presence of ruptured cavitary lesion(s) in the lobe(s) with bronchopleural fistula, and excessive oozing/bleeding from lung surface or pleura altering patient's hemodynamics.

Intraoperatively, pleural fluid/pus as well as pleural tissue was sent for Gram's stain, routine aerobic bacterial culture, direct fluorescent staining for acid fast bacilli, mycobacterial culture, KOH staining for fungus, and fungal culture in all patients. Procedure was chosen according to the disease stage and patient`s fitness. Procedures performed included VATS or open debridement, decortication with or without lung resection, and window thoracostomy.

**Table 1: Nontubercular empyema: Causes (*n*=119)**

| Cause | Number of cases |
|---|---|
| Postpneumonic | 72 |
| CKD-associated empyema | 20 |
| Posttraumatic | 8 |
| Recurrent empyema | 6 |
| Postpneumothorax | 4 |
| Postesophageal perforation | 2 |
| Post-PCNL | 2 |
| Rheumatoid arthritis effusion | 2 |
| Subphrenic abscess | 1 |
| Postpancreatitis | 2 |

CKD: Chronic kidney disease, PCNL: Percutaneous nephrolithotomy

### Surgical details

All the procedures were performed under general anesthesia with single lung ventilation. Patients were placed in lateral decubitus position with the diseased side up. In the VATS group, three ports were used with one being a camera port and two working ports. Standard thoracoscopic instruments were used during the procedure. Open group had a classical posterolateral thoracotomy through either fifth or sixth intercostal space. Initial debridement and breaking of loculations was done followed by decortication of visceral pleura. A combination of sharp and blunt dissection techniques was adapted for visceral decortication. In areas with inseparable peel, the same was criss-crossed with electrocautery till the soft parenchyma was reached, thereby helping in expansion of the lung. Lung was mobilized completely till the hilum including division of inferior pulmonary ligament. Fissures were also freed whenever feasible. Parietal peel was removed completely starting from apex till the diaphragm and any diaphragmatic adhesions were released, thereby achieving complete mobilization of diaphragm. Lung expansion was checked and any sites of major air leak assessed and solved. Hemostasis was ensured with a combination of pressure packing, electrocautery, and argon plasma coagulation. Two chest drains were placed and connected to Thopaz™ digital negative suction device (Medela, Switzerland) with 20 cm of $H_2O$ negative pressure. Patients were extubated on the table whenever possible, monitored in the recovery

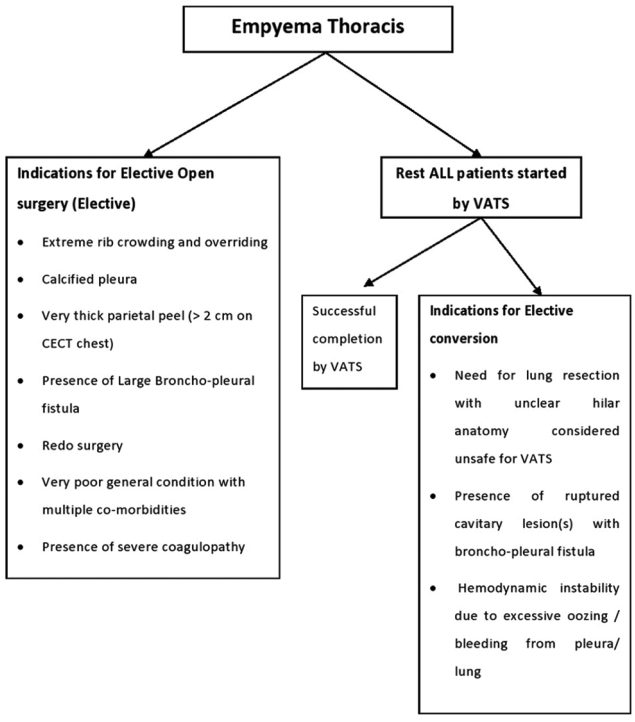


**Figure 1:** Institutional protocol of management of empyema thoracis

room overnight, and shifted to the floor the next morning. Patients who required ventilation were kept in intensive care unit (ICU) till they were extubated and then shifted to high dependency unit for further observation and transferred to the ward once stabilized.

### Postoperative care and follow-up

Supervised, vigorous chest physiotherapy along with adequate nutritional support was continued to maintain good lung expansion. Antibiotics were modified if intraoperative cultures showed sensitivity different from the drugs already being given. If patients were not on Anti-tuberculosis therapy (ATT) at the time of surgery, the same was started postoperatively if there was evidence of TB on pleural fluid, pus, or tissue studies. The chest drains were removed when there was no air leak, the drainage was not purulent/hemorrhagic and was <100 ml in 24 h. Patients were discharged from the hospital either after drain removal or with drains if they had prolonged drainage or air leak. Duration of postoperative air leak and chest tube, hospital stay, wound infection, recurrence of disease, and mortality during hospital stay were monitored and recorded. After discharge, patients were monitored for status of lung expansion and any other complication. Follow-up was done in the outpatient clinic, first 1 week after discharge and every month thereafter for 6 months. All patients had a chest X-ray at 6 months to assess the status of lung expansion and for any recurrence of collection.

### Statistical analysis

Statistical testing was conducted with the statistical package for the social science system version SPSS 22.0 (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp.). Continuous variables were presented as mean ± standard deviation or median (interquartile range). Categorical variables were expressed as frequencies and percentages. The comparison of normally distributed continuous variables between the groups was performed using Student's *t*-test. Nominal categorical data between the groups were compared using Chi-squared test or Fisher's exact test as appropriate. Nonnormal distribution continuous variables were compared using Mann–Whitney *U*-test. For all statistical tests, $P < 0.05$ was considered statistically significant.

## RESULTS

### Demography and preoperative variables

The study group consisted of 285 patients who were operated on for empyema thoracis during the period, i.e. March 2012 to March 2017. There were 166 patients in TE group and 119 in the NTE group. NTE patients had significantly higher age, and more comorbidities compared to TE group. However, patients in TE group had significantly lower body mass index, longer duration of symptoms, and also had undergone significantly more preoperative interventions, i.e., pleural tapping and Intercostal Drain (ICD) insertion compared to NTE group. Fever was the most frequent complaint in TE, whereas dyspnea on exertion was the most common presenting symptom in NTE. Detailed demographics are presented in Table 2.

### Intraoperative variables

Procedure was started by thoracotomy in 25.9% of TE group and 41.1% of NTE group. In the rest of patients where procedure was started by VATS, complete decortication could be achieved by this minimally invasive approach in 91.1% of TE patients, whereas it was 77.2% in NTE group. This difference was statistically significant. The mean operative time along with mean intraoperative blood loss was also significantly higher in NTE group [Table 3].

### Postoperative variables

Need for postoperative ventilation and ICU stay was observed to be significantly higher in NTE group. Nevertheless, there was no difference in the incidence of prolonged postoperative air leak and mean intercostal ICD duration between the two groups. However, the duration of hospital stay along with mean time to return to full work was significantly shorter in TE group. This may due to the younger age group of TE patients with lesser comorbidities [Table 4].

### Postsurgical complications and mortality

Nontubercular group was found to have a significantly higher number of complications compared to TE group. Detailed complications are discussed in Table 5. In total, 12 postoperative deaths were noted in the study population, all in the NTE group. Sepsis with septic shock was the major cause of mortality in 6 patients, respiratory failure in 3 patients, and acute renal failure, aspiration pneumonitis, and massive intraoperative bleeding in one patient each. On subgroup analysis, age >40 years, presence of comorbidities, and open surgery were the significant predictors of perioperative mortality [Table 6].

## DISCUSSION

Empyema thoracis continues to be a menace worldwide, causing significant morbidity and mortality. In the western world, empyema secondary to pneumonia and trauma constitutes the major burden,[5] whereas TB is the leading cause in developing countries like India.[6,7] The treatment of this complex clinical condition includes pleural drainage and complete decortication to aid lung expansion, apart from antibiotics and supportive therapy. While traditionally it has been achieved by thoracotomy, VATS decortication is now being increasingly applied in all stages due to shorter hospital stay, less postoperative pain, and reduced morbidity and mortality.[8] There is a general belief that TE patients have poor surgical outcomes compared to NTE.[9] However, till date, there are no large series comparing the surgical outcomes among both the groups. In our study, tubercular versus nontubercular

**Table 2: Demographic details tubercular versus nontubercular empyema**

| Characteristics | TE, *n* (%) | NTE, *n* (%) | *P* |
|---|---|---|---|
| Number of patients | 166 | 119 | - |
| Male:female | 123:43 (74.1: 25.9) | 91:28 (76.5: 23.5) | 0.68 |
| Age (years) | 31.2±13.6 | 45.4±17.2 | <0.001 |
| Body mass index (kg/m$^2$) | 21.4±2.8 | 24.2±3.1 | <0.001 |
| Number of comorbidities | | | |
| No comorbidity | 133 (80.1) | 57 (48) | <0.001 |
| 1 comorbidity | 23 (13.9) | 31 (26) | 0.01 |
| ≥2 comorbidity | 10 (6) | 31 (26) | <0.001 |
| Comorbidities | | | |
| Hypertension | 14 (8.4) | 52 (43) | |
| Diabetes mellitus | 11 (6.6) | 43 (36) | |
| Coronary artery disease | 9 (5.4) | 20 (16.8) | |
| CKD | 10 (6) | 20 (16.8) | |
| COPD | 8 (4.8) | 9 (7.5) | |
| Rheumatoid arthritis | 1 (0.6) | 0 | |
| Symptoms | | | |
| Fever | 102 (61.4) | 102 (85.7) | |
| Cough | 63 (37.9) | 56 (47) | |
| Chest pain | 51 (30.7) | 90 (75.6) | |
| Dyspnea on exertion | 30 (18) | 109 (91.5) | |
| Mean duration of symptoms (months) | 5.2±4.8 | 2.1±1.9 | <0.001 |
| Side of disease | | | |
| Right | 89 (53. 6) | 62 (52.1) | - |
| Left | 75 (45.2) | 52 (43.6) | |
| Bilateral | 2 (1.2) | 5 (4.3) | |
| Preoperative interventions | | | |
| Needle aspiration | 149 (89.7) | 92 (77.3) | 0.005 |
| Multiple (≥2) aspirations | 38 (22.9) | 36 (30.2) | 0.17 |
| ICD placement | 85 (51.2) | 34 (28.5) | 0.005 |

TE: Tubercular empyema, NTE: Nontubercular empyema, COPD: Chronic obstructive pulmonary disease, CKD: Chronic kidney disease, ICD: Intercostal drain

**Table 3: Comparison of intraoperative variables between tubercular empyema and nontubercular empyema group**

| Characteristics | TE (*n*=166), *n* (%) | NTE (*n*=119), *n* (%) | *P* |
|---|---|---|---|
| Method of surgery | | | |
| Started by VATS | 123 (74.1) | 70 (58.8) | 0.007 |
| Successful | 112/123 (91.1) | 54/70 (77.2) | 0.01 |
| Converted to thoracotomy | 11/123 (8.9) | 16/70 (22.8) | <0.001 |
| Started by thoracotomy | 43 (25.9) | 49 (41.2) | 0.39 |
| Surgery | | | |
| Decortication only | 157 (94.5) | 109 (91.5) | |
| Decortication wedge or lobectomy | 6 (3.6) | 7 (5.8) | |
| Window thoracostomy | 3 (1.8) | 3 (2.5) | |
| Operative time (min) | 218±38.4 | 248.4±62.8 | <0.001 |
| Intra operative blood loss (ml) | 288.7±37.3 | 301.7±42.3 | 0.006 |

TE: Tubercular empyema, NTE: Nontubercular empyema, VATS: Video-assisted thoracoscopic surgery

group constituted a ratio of approximately 3:2. As per the World Health Organization TB Statistics for 2016, the estimated incidence of TB burden in India is 2.79 million cases, making India the country with the highest burden of TB.[10] This figure explains the high proportion of tubercular cases in our series. A similar ratio of TE and NTE cases has been reported by other studies from India.[11,12] In contrast, few Indian studies have also shown the predominance of NTE.[2,13,14]

Young males were affected more in TE group which could be explained by the fact that TB affects a similar age group. A similar experience was reported in other studies also.[3,15] Lower body mass index observed in TE could be due to a prolonged clinical course as the process of inflammation in TB may go on for months without much clinical symptoms. Formation of thick peel practically isolates the tubercular bacilli from pleural space which leads to relatively long asymptomatic course in comparison to NTE.[16,17] Similar findings, i.e. prolonged duration of symptoms with significant malnutrition were reflected in our study also. More than half of NTE group had comorbidities, out of which 50% had more than one comorbidity. Hypertension, diabetes mellitus, and chronic kidney disease were predominant comorbidities in descending order. Similar observations were reported by Tong *et al*.[18] in 420 patients of NTE. Patients in TE group had undergone frequent preoperative interventions, i.e. pleural aspiration and ICD placement. These observations represent the practice of physicians and pulmonologists, where patients were managed with repeat aspirations/ICD insertions without offering early surgical reference. Waller *et al*.[19] reported that the probability of success of VATS decreases in delayed referrals, thus indirectly altering postoperative outcomes.

A significantly higher proportion of patients in NTE group (41.2% vs. 25.9%) underwent open decortication per primum in view of comorbidities and altered preoperative coagulation profile. Cardillo *et al*.[20] also reported similar (40%) open decortication rates in their group. Efficacy of VATS was questioned in chronic Stage III empyema[21] in view of extremely narrowed intercostal spaces and thickened parietal peel which may

**Table 4: Comparison of postoperative variables between tubercular empyema and nontubercular empyema group**

| | TE (*n*=166), *n* (%) | NTE (*n*=119), *n* (%) | *P* |
|---|---|---|---|
| Need for postoperative ventilation | 2 (1.2) | 12 (10.08) | 0.001 |
| Need for postoperative ICU stay | 5 (3) | 30 (25.2) | <0.001 |
| Prolonged air leak (>7 days) | 35 (21) | 25 (21) | 0.76 |
| Postoperative ICD duration (days) | 7.4±2.3 | 7.9±3.1 | 0.12 |
| Hospital stay (days) | 7.1±3.2 | 9.7±3.0 | <0.001 |
| Mean time to return to full work (days) | 24.5±3.8 | 32.8±5.9 | <0.001 |

TE: Tubercular empyema, NTE: Nontubercular empyema, ICU: Intensive care unit, ICD: Intercostal drain

**Table 5: Comparison of complications and mortality between tubercular empyema and nontubercular empyema group**

| | TE (*n*=166), *n* (%) | NTE (*n*=119), *n* (%) | *P* |
|---|---|---|---|
| Number of complications (overall) | 9 (5.4) | 16 (13.4) | 0.02 |
| Bleeding | 0 | 2 (1.6) | 0.17 |
| Wound infection | 4 (2.4) | 9 (7.5) | 0.04 |
| Atelectasis and pneumonia | 2 (1.2) | 3 (2.5) | 0.65 |
| Cardiac arrhythmias | 1 (0.6) | 0 | 1.0 |
| Renal complications | 2 (1.2) | 2 (1.6) | 1.0 |
| Recurrence | 5 (3.01) | 5 (4.2) | 0.33 |
| Perioperative mortality (<30 days) | 0 | 12 (10) | <0.001 |

TE: Tubercular empyema, NTE: Nontubercular empyema

**Table 6: Predictors of perioperative mortality**

| Variables | Characteristics | Mortality | *P* |
|---|---|---|---|
| Age (years) | ≤40 (*n*=29) | 0 | 0.03 |
| | >40 (*n*=90) | 12 | |
| Comorbidities | Present (*n*=62) | 12 | 0.03 |
| | Absent (*n*=57) | 0 | |
| Duration of symptoms (months) | <2 (*n*=84) | 6 | 0.18 |
| | ≥2 (*n*=35) | 6 | |
| Method of surgery | VATS (*n*=70) | 3 | 0.02 |
| | Open (*n*=49) | 9 | |
| Culture positivity | Yes (*n*=47) | 7 | 0.21 |
| | No (*n*=72) | 5 | |

VATS: Video-assisted thoracoscopic surgery

make introduction and manipulation of the endoscopic instruments very difficult. By further studies, researchers proved the efficacy of VATS even in Stage III NTE[4,19,21,22] as well as TE.[9,23] In our series, more conversions were seen in NTE group than TE group (22.8% vs. 8.9%) which can be explained by higher coagulation abnormalities in old frail patients of NTE group. Few series also reported conversion rates as high as up to 40%–44% where the probability of conversion increases in Stage III empyema.[24,25] We, in our own series, earlier reported a 10% conversion rate among one hundred chronic TE cases.[26]

No differences between these two groups were found in postoperative air leak and total ICD duration. Not surprisingly, the total duration of hospital stay along with time to return to normal activity was significantly shorter in TE group which could be explained by the mean age of patients and comorbidities. These observations were contrary to other studies. In a prospective comparative analysis of 75 cases of TE and NTE by Kundu *et al*.,[3] the authors reported that tubercular group required prolonged intercostal tube drainage and complicated surgery and had a poorer outcome. Another similar study by Malhotra *et al*.[2] also reported poorer outcomes with longer pleural drainage and longer duration for resolution of symptoms.

The complication rates were found comparable to previously published literature in both TE and NTE groups.[9,22,23] On overall comparison, the postoperative complication rate was observed significantly more in NTE group compared to TE group (13.4% vs. 5.4%). This could be due to presence of significantly more comorbidities with relatively severe sepsis in NTE group. On analysis of individual complications, surgical site wound infection was found common in NTE group. This finding could be due to the 40% culture positivity in the pus.

We encountered 10% ($n = 12$) mortality all in NTE group. Various studies reported mortality ranging from 0% to 11.4% in NTE.[19,27] In our study, severe sepsis with septic shock and postoperative respiratory failure were the predominant causes of mortality, whereas renal failure was the etiology in 12% of cases. Analysis of perioperative variables revealed that higher age (>40 years), presence of comorbidities, and open approach for surgery were associated with postoperative mortality. No mortality was present in TE group. Various other published series also demonstrated the mortality rates ranging from 0% to 3.1%.[28,29] Late referral could be another factor to consider in the mortality group. A study by Cham *et al*.[30] showed that total hospital stay, postoperative morbidity, and mortality were higher in late referrals. In our own study of TE, we have reported that the probability of conversion and postoperative air leaks increases with an increase in the time before referral for surgical treatment.[28]

Retrospective nature is one of the major limitations of this study. The second most significant limitation is the heterogeneity of the cohort that is being studied. Third, the method/policy of surgical management was also heterogeneous, i.e. VATS/open and decortication with/without lung resection and window thoracostomy. Therefore, this analysis is prone to a number of biases, including selection, detection, and performance bias. However, it is the first and the largest study from a TB endemic country comparing the surgical outcomes in two major causes of empyema.

## CONCLUSIONS

Our study reveals that a higher percentage of TE cases

could be managed by VATS with reduced operative time, less blood loss, and lesser conversion rate as compared to NTE cases. Postoperative ventilation, ICU stay, and complications including mortality were more in NTE cases. Further prospective, multicenter, randomized studies with standardized treatment protocols are required to confirm these findings.

**Financial support and sponsorship**
Nil.

**Conflicts of interest**
There are no conflicts of interest.

## REFERENCES

1. Light RW. Parapneumonic effusions and empyema. In: Rhyner S, Winter N, Koleth J, editors. Pleural Diseases. 5th ed. Philadelphia: Lippincott Williams and Wilkins; 2007. p. 179-210.
2. Malhotra P, Aggarwal AN, Agarwal R, Ray P, Gupta D, Jindal SK. Clinical characteristics and outcome of empyema thoracis in 117 patients: A comparative analysis of tubercular vs. non tubercular aetiologies. Respir Med 2007;101:423-30.
3. Kundu S, Mitra S, Mukherjee S, Das S. Adult thoracic empyema: A comparative analysis of tuberculous and non-tuberculous aetiology in 75 patients. Lung India 2010;27:196-201.
4. Chan DT, Sihoe AD, Chan S, Tsang DS, Fang B, Lee TW, *et al*. Surgical treatment for empyema thoracis: Is video-assisted thoracic surgery "better" than thoracotomy? Ann Thorac Surg 2007;84:225-31.
5. Light RW. Parapneumonic effusions and empyema. In: Light RW, editor. Pleural Diseases. 3rd ed. Baltimore: Williams and Wilkins; 1995. p. 129-53.
6. Sharma TN, Jain NK, Madan A, Sarkar SK, Durlabhji P. Tubercular empyema thoracis: A diagnostic and therapeutic problem. Indian J Chest Dis Allied Sci 1983;25:127-31.
7. Goyal SP, Tandon RK, Patney NL, Mishra OP. Management of tubercular empyema thoracis: A review of 53 cases. Ind J Tub 1976;23:103-9.
8. Pan H, He J, Shen J, Jiang L, Liang W, He J. A meta-analysis of video-assisted thoracoscopic decortication versus open thoracotomy decortication for patients with empyema. J Thorac Dis 2017;9:2006-14.
9. Chen B, Zhang J, Ye Z, Ye M, Ma D, Wang C, *et al*. Outcomes of video-assisted thoracic surgical decortication in 274 patients with tuberculous empyema. Ann Thorac Cardiovasc Surg 2015;21:223-8.
10. World Health Organization. Global Tuberculosis Report 2016. Geneva: World Health Organization (WHO); 2016.
11. Singh RP, Katiyar SK, Singh KP. Conservative management of empyema thoracis and bronchopleural fistula. Ind J Chest Dis Allied Sci 1994;36:15-9.
12. Agarwal SK, Roy DC, Jha N. Empyema thoracis: A review of 70 cases. Indian J Chest Dis Allied Sci 1985;27:17-22.
13. Gupta SK, Kishan J, Singh SP. Review of 100 cases of empyema thoracis. Ind J Chest Dis Allied Sci 1989;31:15-20.
14. Banga A, Khilnani GC, Sharma SK, Dey AB, Wig N, Banga N. A study of empyema thoracis and role of intrapleural streptokinase in its management. BMC Infect Dis 2004;4:19.
15. Al-Kattan KM. Management of tuberculous empyema. Eur J Cardiothorac Surg 2000;17:251-4.
16. Bai KJ, Wu IH, Yu MC, Chiang IH, Chiang CY, Lin TP, *et al*. Tuberculous empyema. Respirology 1998;3:261-6.
17. Prakash B, Khare P, Bhatnagar AK. Tuberculous empyema thoracis: Clinical, bacteriological features and its medical management. Int J Sci Stud 2015;3:120-5.
18. Tong BC, Hanna J, Toloza EM, Onaitis MW, D'Amico TA, Harpole DH, *et al*. Outcomes of video-assisted thoracoscopic decortication. Ann Thorac Surg 2010;89:220-5.
19. Waller DA, Rengarajan A, Nicholson FH, Rajesh PB. Delayed referral reduces the success of video-assisted thoracoscopic debridement for post-pneumonic empyema. Respir Med 2001;95:836-40.
20. Cardillo G, Carleo F, Carbone L, Di Martino M, Salvadori L, Petrella L, *et al*. Chronic postpneumonic pleural empyema: Comparative merits of thoracoscopic versus open decortication. Eur J Cardiothorac Surg 2009;36:914-8.
21. Barbetakis N, Paliouras D, Asteriou C, Tsilikas C. eComment: The role of video-assisted thoracoscopic surgery in the management of tuberculous empyemas. Interact Cardiovasc Thorac Surg 2009;8:337-8.
22. Luh SP, Chou MC, Wang LS, Chen JY, Tsai TP. Video-assisted thoracoscopic surgery in the treatment of complicated parapneumonic effusions or empyemas: Outcome of 234 patients. Chest 2005;127:1427-32.
23. Liu Z, Cao S, Zhu C, Wei L, Zhang H, Li Q. Application of thoracoscopic hybrid surgery in the treatment of Stage III tuberculous empyema. Ann Thorac Cardiovasc Surg 2015;21:523-8.
24. Solaini L, Prusciano F, Bagioni P. Video-assisted thoracic surgery in the treatment of pleural empyema. Surg Endosc 2007;21:280-4.
25. Lardinois D, Gock M, Pezzetta E, Buchli C, Rousson V, Furrer M, *et al*. Delayed referral and gram-negative organisms increase the conversion thoracotomy rate in patients undergoing video-assisted thoracoscopic surgery for empyema. Ann Thorac Surg 2005;79:1851-6.
26. Kumar A, Asaf BB, Lingaraju VC, Yendamuri S, Pulle MV, Sood J. Thoracoscopic decortication of Stage III tuberculous empyema is effective and safe in selected cases. Ann Thorac Surg 2017;104:1688-94.
27. Yamaguchi M, Takeo S, Suemitsu R, Matsuzawa H, Okazaki H. Video-assisted thoracic surgery for fibropurulent thoracic empyema: A bridge to open thoracic surgery. Ann Thorac Cardiovasc Surg 2009;15:368-72.
28. Naidoo R. Active pulmonary tuberculosis: Experience with resection in 106 cases. Asian Cardiovasc Thorac Ann 2007;15:134-8.
29. Furák J, Troján I, Szöke T, Tiszlavicz L, Morvay Z, Csada E, *et al*. Surgical intervention for pulmonary tuberculosis: Analysis of indications and perioperative data relating to diagnostic and therapeutic resections. Eur J Cardiothorac Surg 2001;20:722-7.
30. Cham CW, Haq SM, Rahamim J. Empyema thoracis: A problem with late referral? Thorax1993;48:925-7.