Financial Analysis of the Video Assisted Thoracoscopic Surgery versus Open Thoracotomy in Management of Pediatric Parapneumonic Empyema

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Abstract

Introduction: In this article we will evaluate the cost of these two techniques for management of parapneumonic empyema. Aim of this study is comparison of the Cost-benefit of the less invasive Thoracoscopic Approach (VATS) versus Open Thoracotomy in pediatric patients with.

Materials and Methods: A prospective study was done on 42 patients referred to Department of Pediatric Surgery, between 2015 and 2017.
Patients were divided randomly into two groups of open thoracotomy(group I) and VATS (group II). Both groups were similar by terms of age (mean 6 years), number of patients (22/20), sex (1.1 male/female)and comorbidities. Routine preliminary workups were ordered for all patients. Patients were followed up for a course of 90 days to evaluate the results of the treatment and the incidence of complications and death. To calculate the cost of each method we take into account the defined parameters.

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Results: The mean operative time (60versus45 minutes), the average of drainage time (7 versus 5 days), average length of hospital stay (23 versus 13 days) (p=0.007), and duration of pain–relief medications (10 versus 5 days) (p=0.004), were longer in group I. 27.3% of group I had surgical wound infection but no such case was seen in group II (p = .003). Redo thoracotomy due to lack of clinical improvement in group I and II, was observed in 9.1% versus 20%, respectively. Death due to pulmonary complications during the first 30 days after the surgery was seen in one case in the group I. The mean cost for VATS is about 1045.9$ versus 976,32$ for open thoracotomy technique.

Conclusion: Apart from other benefits of VATS technique such as less postoperative hospital stay, that has been shown in the previous article published by our team, now we can highly recommend this technique because of the lack of any significant cost difference between the VATS and open thoracotomy technique.

Keywords

- Empyema
- Video Assisted Thoracic Surgery (VATS)
- Thoracotomy
- Cost

Introduction

Pleural empyemais described as a pus-filled fluid collection in the pleural space. Some usual disorders which correlated with this disease include: pneumonic processes in patients with pulmonary and malignant disorders, heart disease, diabetes, drug and alcohol abuse, neurological disorders, post-thoracotomy complications, and immunological disorders.[1]

The key pathophysiology of the empyema is related to severe pneumonia and parapneumoniceffusions.[2]The mortality due to empyema is usually related to the severity of the disease. The incidence of this disorder is 0.6%, but the mortality rate of up to 8% is also stated.[3]

In the 1960s, the American Thoracic Society (ATS) announced three pathobiological stages that are related to existing conditions for empyema. The management differs according to the stages. Stage one, which is usually denoted as the "exudative stage and Parapneumonic discharge", occurs in the first 24 to 72 hours and can classically be treated by using a simple drainage (including Thoracentesis or placement of a chest tube), and administration of broad-spectrum antibiotics **Table 1**.

The second stage, also referred to as the "fibro-purulent stage", lasts 7 to 10 days and is characterized by fibrin and liquid fluids containing a large number of PMN cells[4] **Table 1**.

The third stage or the "organized stage" classically happens in 2 to 4 weeks following the beginning of the initial process.[5, 6]This stage is characterized by condensing of visceral & parietal pleura as an outcome of significant fibroblasts proliferation, causing a peel or organized pus which finally gets in contact with visceral pleura, causing lung parenchymal entrapment[7] **Table 1**.

Table 1: Three pathobiological stages that are announced by the American Thoracic Society (ATS) for existing conditions of empyema

	Title	Time of occurrence or duration	Characterized factor	treatment
Stage 1	Exudative stage	Happens in the first 24-72 hours	Parapneumonic discharge	Thoracentesis – chest tube - antibiotics
Stage 2	Fibro-purulent stage	Lasts 7-10 days	Fibrin and PMN cells	VAST
Stage 3	Organized stage	Happens in the first 2-4 weeks	Condense visceral and parietal pleura – lung parenchymal entrapment	Tube thoracotomy – thoracoscopic method

Tube Thoracotomy is seldom able to clear pleural space in a child who has gone to advanced stages of the disorder.[2]Pediatricians have developed Thoracoscopic technique for management of such pediatric patients. This less invasive technique allows comprehensive clearance and washes the debris off the pleural space.[8]

It's furthermore shown that there are other benefits to this method, such as decreasing the complications of the process and decreasing the extent of hospital stay.[3]

One of the limiting factors that usually decrease the interest of Health policy makers for expanding the use of VATS technique as the first choice for management of parapneumonic empyema is the cost of this technique versus open thoracotomy. In this article we will evaluate the cost of these two techniques for management of parapneumonic empyema.

Aim of this study is comparison of the Cost- benefit of the less invasive Thoracoscopic Approach (VATS) versus Open Thoracotomy in pediatric patients with parapneumonicempyema.

Inclusion criteria: Pediatric patients with Pleural empyema whose course of disease is less than 3 weeks.

Exclusion criteria: Pediatric patients with Pleural empyema whose course of disease is more than 3 weeks.

Materials and Methods

This is a prospective study that was conducted over a 2-year period (2015-2017) on 42 empyema patients referred to the pediatric surgery department of Mofid children's Hospital, Shahid Beheshti University, Tehran, Iran. Patients entered the study following the consent taken from their parents. First, they were randomly allocated into two clusters; Thoracotomy (cluster I) versus VATS (cluster II). Twenty-two patients allocated in cluster I (13 males, 9 females) with an average age of 6.34 years, and twenty patients allocated in clusterII (12 males, 8 females) with an average age of 6 years. The mean clinical symptoms of patients were less than 15 days. The diagnosis of empyema was made according to:

1- Clinical symptoms, for example: cough, fever, chest pain, respiratory distress, and inspection of sputum or aspirated secretions from the lung.
2- Thoracocentesis(PH less than 7.2, glucose lower than 60 mg/dl, LDH more than 1000Unit/L).
3- Chest High resolution computerized tomography (HRCT) and diagnosing loculated complex.

Pre-operation workups included intravenous antibiotic prescription, laboratory exams, and chest high resolution computerized tomography (HRCT),which was performed to determine the status of lung, mediastinum and plural loculations.

Afterwards, intercostal drainage (ICD) was implanted for patients in case of respiratory distress and high fever before surgery.

Post-operation workups included the continuation of intravenous antibiotics and Paracetamol until the fever was resolved, removal of ICD and starting respiratory physiotherapy and chest x-ray on 2nd post-operative day.

Then Patients were followed up for a course of 90 days on certain intervals in order to assess the results of the treatment and incidence of the complications and death.

We have measured the costs in each patient’s case according to following parameters and compared the cost for each of these two clusters by statistical tools.

Parameters include:

1- Number of admission days
2- Number of VATS which had converted to thoracotomy
3- Number of VATS which needed open thoracotomy afterwards
4- Number of patients who had been treated with SK after the open surgery
5- Number of patients who had been treated with SK after the VATS
6- Number of Redo Surgeries needed
7- Cost of each surgery method

Surgical Technique: All 42 patients underwent general anesthesia, using Double-lumen endotracheal intubation.

Patients incluster I were approached through posterolateral thoracotomy by opening of the fifth intercostal space, proceeded down to parietal pleura. A blade was used between curved hemostats to open the parietal pleura and a Finochietto rib spreader was used for a clear access to the surgical field. Blunt manipulations was done to destroy plural thick septae and releasing all fissures, then a large bore chest tube was inserted following completed decortications and full expansion of the lungs.

In clusterII, inlateral decubitus position, first trocar was placed either from the fifth intercostal space along the mid-clavicular line or the entrance site of the previous chest tube insertion. Additional trocars (two or three)were inserted depending on the lung loculations. The gas pressure was adjusted to 5 mmHg at a rate of 1 L/ min. After dividing the adhesions by dissecting Forceps and by high pressure suctions to remove fibrin clots from all tissues and recesses, and ensuring complete lung expansion, a large bore chest tube was placed under endoscopic vision through the site of the first port entry. Then cases from both clusters were sent to pediatric intensive care unit (PICU) until the patient's clinical conditions have been stabilized.

Results

Parapneumonic effusion was the main cause of empyema in group I. The average duration of clinical symptoms in this group was 12 days **Table 2**. 14 patients had involvement on the right side, 7 cases had involvement on the left side, and 1 had bilateral involvement **Table 2.** The average duration of surgery was 60 minutes. The median drainage time was 7 days. The average length of hospital stay was 23 days **Table 2**.

Similarly, in group II, the main causes of empyema were parapneumonic effusion in 18 cases, and infection secondary to trauma related to thoracic surgeries in 2 cases. The average duration of clinical symptoms in this group was 11 days. The empyema in 12 patients was on the right side, in 7 cases on the left side, and in one case it was bilateral **Table 2.**

In four cases ICD was inserted prior to the surgery. The average duration of surgery was 45 minutes. On average the drainage time was 5 days. The average length of hospital stays in group II was 13 days **Table 2.**

Table 2: Detailed characteristics of each surgical approach group

	Group 1	Group 2
Average duration of clinical symptoms	12 days	11 days
Number of patients with the right-side involvement	14	12
Number of patients with the left side involvement	7	7
Number of patients with bilateral side involvement	1	0
Average duration of surgery	60 mins	45 mins

Median drainage time	7 days	5 days
Average time of hospitalization	23 days	13 days
Number of cases with redo surgery	2	4
Number of cases with incidence of pneumothorax immediately after pulling ICD	4	1
Number of patients with intra-operative bleeding	5	0
Number of deaths due to pulmonary complications	1	0

In the follow up of patients in two groups, 27.3% of patients undergoing Thoracotomy had a surgical wound infection, while no such case was seen in group II (p = 0.003)**Table 3.**Redo surgery due to lack of clinical improvement, in groups I and II was observed in 2 cases (9.1%) and 4 cases (20%), respectively **Table 2**. The incidence of pneumothorax immediately after removingICD was seen in 4 cases (18.2%) and 1 case (5%), respectively **Table 2**, and the problem was resolved by re-insertion of ICD.

Subcutaneous emphysema was seen in only one person in group I. The duration of admission in PICU was 5 days for group I and 2 days for group II (p=0.005)**Table 3**.

The duration of medicine use to relieve the pain was 10 days versus 5 days in the first and second groups, respectively (p=0.004)**Table 3.**

Intra-operative bleeding necessitated blood transfusion in 5 patients in group I but none in group II. Death due to pulmonary complications during the first 30 days after the surgery was seen in one case in group I **Table 2**.

Table 3: Detailed characteristics and statistical analysis results of each surgical approach group

	Group 1	**Group 2**	**P value**
Cause of empyema	Parapneumonic effusion	Parapneumonic effusion	
Average duration of admission in PICU	5 days	2 days	0.005
Percentage of patients with a follow-up surgical wound infection	27.3%	0%	0.003
Average duration of medication	10 days	5 days	0.004

For calculating the cost of each surgical technique, we needed these data:

(1) The cost of each surgical technique itself which is consisted of:

(a) The cost of surgical instruments, such as trocars, chest tube, chest bottle, surgical threads and etc., which estimated to be about 31.4$ for open thoracotomy and about 209$ for VATS.

(b) The Interest Rate of the cost of an Endovision instrument is an important aspect of the cost of VATS technique. If we consider an average of 66000$ for an endovision instrument, and consider that we use this instrument for an average of 6 different surgeries such as VATS per month, by Interest rate of 4%, it will be about 36,66$

(c) charge for each operation, and we also take this value in our account.

(2) The cost of each day of Hospital admission including: hoteling, the cost of each day vacation for patient's companion, which was estimated at least about 16,66$ for a simple worker. All these were about 38,16$ for each day of admission according to our estimation.

(3) Another amount is the cost of Streptokinase(SK) administration for each patient, that was estimated about 72,2$.

By calculating all of these amounts, the mean cost for VATS technique is about 1045.9$ versus 976,32$ for open thoracotomy technique **Figure 1**.

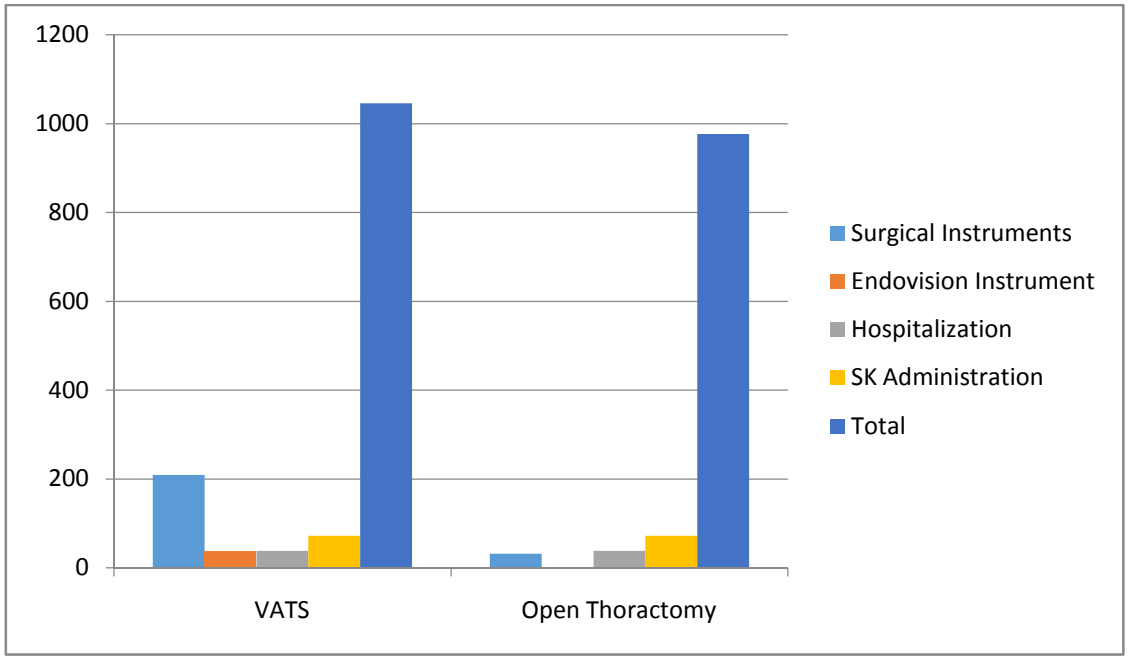

Figure 1: Columnar diagram of "Subgroup" and "Total" cost analysis of each surgical approach (US $)

Discussion

The Pleural empyema is described as an infected fluid collection in the pleural space. The main pathophysiology of the empyema is correlated with severe pneumonia and para-pneumonic discharge. Additional predisposing situations include the extent of infection through mediastinal, retropharyngeal or paravertebral infectious processes. Empyema can also be initiated by a direct trauma to chest wall.[1]

Mortality due to empyema is usually correlated with the severity of the disorder rand is stated to be fewer than 1% to more than 40% in immune compromised patients.[9]In the 1960s, the American Thoracic Society (ATS) announced three pathobiological steps that are related with present situations forempyema. Step 1, usually referred to as the Exudative phase. The second step, also referred to as the Fibro-purulent phase, continues for 7 to 10 days and is characterized by fibrin and liquid fluids encompassing a large number of PMN cells. In this step, the fluid is somewhat acidic compared to the Exudative phase.[10, 11]

The key difference among this step and the earlier one is that the fluid is often compartmentalized because of several septations. The last step, or the organized step classically occurs within 2 to 4 weeks after the onset of the initial process.[5] This phase is characterized by condensing of visceral & parietal pleura, because of a significant fibroblast proliferation, resulting in a peel or organized pus which finally gets contact with visceral pleural, causing lung parenchymal entrapment.[1, 7]

Video-assisted Thoracoscopic Surgery is a semi-invasive method that provides a wide-range vision for the surgeon rather than conventional thoracotomy to examine pathologic processes of the mediastinum, lungs and pleura, in less time with less morbidity in order to proper diagnosis and treatment.[12, 13]

One of the other uses of VATS is in the management of second phase of empyema, which is more effective than conservative management with antibiotic and drainage, and has fewer complications than more invasive treatments such as Thoracotomy.[7]The first comparative studies among the two techniques of VATS and Thoracotomy could be related to the 1990s, when Angelillo Mackinlay T*et al*, studied these two techniques in patients with empyema following a fibrino-purulent phase of pneumonia. In this study, they determined that two methods had the same level of success but VATS had some advantages in the extent of disease, hospitalization, and cosmetic issues.[14]

In the current study, the rate of wound infection was significantly higher in the group I than in the group II ($p = .003$), and complications such as pneumothorax after removing the ICD, was higher in the group I than in group II.

In an article published in 2004 by Minchev T *et al*, they reviewed 359 empyema patients that had undergone thoracotomy or VATS during the years 1996-2003. In this study, shorter duration of chest tube drainage and a shorter duration of hospitalization were reported

for VATS method compared to Thoracotomy.[15]

In the current study, the ICD duration and hospital stay in the group II were shorter thangroup I (p=0.007).

In a study by Goldschlager T *et al* in 2005, a retrospective study was conducted among children who underwent drainage and decortication using two methods of VATS and Thoracotomy between 2000 and 2002. The study also revealed that drainage by VATS was a successful method for the management of empyema in pediatric patients.[16]

In another study by Stefani A in 2013, the investigator assessed pre-operative states for selecting either of the two methods of VATS or Thoracotomy. The researcher concluded that delays in surgery, fever and pleural thickness, were the factors that could be used to forecast the necessity to Thoracotomy.[17]

In the recent study also, re-operation due to absence of improvement of clinical symptoms caused by thickening of the pleural membranes and absence of complete lung expansion, was higher in group II.

Another study by Samira Shojaee*et al* at Virginia University in 2015 on comparing medical and surgical management for the treatment of pleural disorders, introduced VATS as a more effective technique than Thoracotomy. Specially in intubated patients, in which reduced time of surgery and decreased other complications of open surgery could increase their survival rate.[3]

In the recent study, the mortality rate after surgical complications were higher in Thoracotomy group.

Inasmuch as the duration of hospital stay, admission in the intensive care units, use of narcotics, and rate of complications such as infection and anxiety of the patients are lower in the group I. It seems that VATS is a safe and efficient procedure for management of the patients with empyema. In 2009, Marco Scarci*et al* reviewed 9 papers to compare VATS and tube thoracostomy in terms of many factors including cost of each method in patients with primary spontaneous pneumothorax. They concluded that even if VATS is associated with an average increased cost of $408, this is mitigated by the reduced length of stay and decreased pneumothorax recurrence, both resulting in a reduction of cost to 42% compared to conservative approach .

In 2011, Marco Scarci*et al* reviewed 15 papers to compare VATS and chest tube drainage in terms of many factors, including cost of each methods in pediatric patients with pleural empyema. They concluded that costs for primary VATS were equivalent to primary chest tube placement.

In 1997, Wait MA *et al* conducted a study to determine the optimal treatment of empyema thoracis (within the fibrino-purulent phase of the illness) comparing pleural drainage and fibrinolytic therapy vs video-assisted thoracoscopic surgery (VATS).They concluded that there is a clinically relevant but not statistically significant difference in hospital costs ($16,642±2,841 vs $24,052±3,466, p=0.ll) favoring the VATS group.

In our study, by taking in account the cost of each surgery method itself, and the cost

of hospital stay and being out of work and all the parameters that had been mentioned, the mean cost for VATS technique is about 1045.9$ and for open thoracotomy technique about 976,32$.

Conclusion

Regarding the comparison of the advantages and disadvantages of the mentioned approaches to the treatment of the empyema, it seems that the less invasive Video-assisted Thoracoscopic Surgery procedure can be highly recommended as a suitable technique for management of the patients with empyema especially in the early stages.

Ethical Consideration

This study was approved by Research Institute of Children Health, Shahid Beheshti University of Medical Sciences, Biomedical Research Ethics Committee with approval number: IR.SBMU.RICH.REC.1400.014

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Conflict of interests

There is no conflict of interest

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