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Best evidence topic – Thoracic non-oncologic

Is video-assisted thoracoscopic surgery the best treatment for paediatric pleural empyema?

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Summary

A best evidence topic in thoracic surgery was written according to a structured protocol. The question addressed was whether video-assisted thoracic surgery (VATS) is the best treatment for paediatric pleural empyema. Altogether 274 papers were found using the reported search, of which 15 represented the best evidence to answer the clinical question. The authors, journal, date and country of publication, patient group studied, study type, relevant outcomes and results of these papers are tabulated. We conclude that early VATS (or thoracotomy if VATS not possible) leads to shorter hospitalisation. The duration of chest tube placement and antibiotic use is variable and does not correlate with treatment method. Patients who underwent primary operative therapy had a lower aggregate in-hospital mortality rate (0% vs. 3.3%), re-intervention rate (2.5% vs. 23.5%), length of stay (10.8 days vs. 20.0 days), duration of tube thoracostomy (4.4 days vs. 10.6 days), and duration of antibiotic therapy (12.8 days vs. 21.3 days), compared with patients who underwent non-operative therapy. Similar complication rates were observed for the two groups (5% vs. 5.6%). Moreover, median hospital charges for VATS were $36,320 [interquartile range (IQR), $24,814–$62,269]. The median pharmacy and radiological imaging charges were $5884 (IQR, $3142–$11,357) and $2875 (IQR, $1703–$4950), respectively, for VATS and tube drainage. Adjusting for propensity score matching, costs for primary VATS were equivalent to primary chest tube placement. Only one article found discordant results. Ninety-five children (52%) received antibiotics alone, and 87 (45%) underwent drainage procedures (21 chest tube alone, 57 VATS/thoracotomy, and eight chest tube followed by VATS/thoracotomy); only four received fibrinolytics. Mean (standard deviation) length of stay was significantly shorter in the antibiotics alone group, 7.0 (3.5) days vs. 11 (4.0) days. The strongest predictors of undergoing pleural drainage were admission to the intensive care unit and large effusion size (>1/2 thorax filled).

Keywords: Empyema; Pleural; Children

1. Introduction

A best evidence topic was constructed according to a structured protocol. This is fully described in the ICVTS [1].

2. Three-part question

In [children with empyema thoracis] is [video-assisted thoracoscopic surgery (VATS)] superior [to conservative management] in terms of [disease resolution, hospital stay, morbidity and mortality]?

3. Clinical scenario

You have been referred a five-year-old child with a large loculated pleural effusion. Blood tests and analysis of pleural fluid confirmed the presence of an empyema. He was treated conservatively for four weeks by the district hospital paediatricians without success. You wonder if an earlier referral for thoracoscopic surgery, considering its lower morbidity, would have been more appropriate to improve the resolution of the empyema. You resolve to check the literature yourself.

4. Search strategy

Medline 1948 to January 2011 using OVID interface
(exp Empyema/OR empyema.mp) AND (exp Child/OR exp Pediatrics/OR exp Infant/
OR pediatric.mp OR paediatric.mp) AND (exp Thoracic Surgery/OR Thoracoscop$.mp
OR VATS.mp OR Thoracotomy.mp)

5. Search outcome

Two hundred and seventy-four papers were found using the reported search. From these, 15 papers were identified that provided the best evidence to answer the question. These are presented in Table 1.

In addition, the reference list of each paper was searched.

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Table 1. Best evidence papers

Author, journal, date and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
Mahant et al., (2010), Arch Pediatr Adolesc Med, USA, [2] Systematic review (level 1a)	Three randomised control trials One hundred and fourteen patients in total comparing VATS vs. chest drain±fibronolytics	LOS mean±S.D. (days)	St. Peter et al. 6.9±3.7 vs. 6.8±2.9; P=0.93 Sonnappa et al. 6 (range 3–16) vs. 6 (range 4–25); P=0.31	The findings in this review are different from previous one including only observational studies. The evidence suggest that VATS and conservative management are equally effective
		VATS vs. drain±fibrinolytics	Kurt et al. 5.8±2.8 vs. 13.2±7.2; P<0.01	
		Mortality	0 in each arm in each trial	
		Time of chest drain after intervention mean±S.D. (days)	St. Peter et al. not reported Sonnappa et al. one day less in VATS group; P=0.05 Kurt et al. 2.8±0.63 VATS vs. 9.6±5.4 drain; P=0.01	
		Cost of charges in US$ for VATS vs. drain, respectively	St. Peter et al. 11,700 vs. 7600 Sonnappa et al. 11,379 vs. 9127 Kurt et al. 19,714 vs. 21,947	
Sonnappa et al., (2006), Am J Resp Crit Care Med, UK, [3] Randomised control trial (level 1b)	Sixty patients randomised in two groups of 30 in each arm, VATS vs. drain±fibrinolytics	LOS (days)	Six (range 3–16) vs. six (range 4–25); P=0.31	From this trial it seems that VATS and conservative management are identical. Nevertheless, we need to point out that 16 patients were lost at follow-up in an already small trial and that the failure rate was not really VATS procedure related as the patients converted to thoracotomy had a more advanced stage
		Failure rate	VATS five, four conversion to minithoracotomy for thick peel which prevented lung expansion and one required VATS twice. Five in drain group	
		Adverse events	None in both groups	
		Cost analysis VATS vs. drain	US$11,379 vs. US$9127; P<0.001	
St. Peter et al., (2009), J Pediatr Surg, USA, [4] Randomised control trial (level 1b)	Thirty-six patients in two groups of 18 in each arm, VATS vs. drain±fibrinolysis	LOS (days)	VATS 6.9±3.7 vs. drain 6.8±2.9; P=0.93	No difference between VATS and conservative management. VATS has higher charges
		Post-therapy days of oxygen support	VATS 2.3±1.7 vs. drain 2.3±2.1; P=0.9	
		Days to a febrile after the intervention	VATS 3.1±2.7 vs. drain 3.8±2.9; P=0.46	
			VATS US$11,700±2900 vs. drain US$7600±5400; P=0.02	
Kurt et al., (2006), Pediatrics, USA, [5] Randomised control trial (level 1b)	Eighteen patients in total. Ten for VATS arm and eight for drain±fibrinolysis	LOS (days)	VATS 5.8±2.82 vs. drain 13.25±7.15; P=0.004	This study suggest that primary VATS is strongly superior to conservative management for stage I or II pleural empyema in children
		Days of tube drainage	VATS 2.8±0.63 vs. drain 9.63±5.45; P<0.001	
		Fever duration (days)	VATS 3.6±2.95 vs. drain 6.25±4.1; P=0.146	
		Total charges in US$	VATS 19,714 vs. drain 21,947; P=0.315	
Shah et al., (2010), Pediatr Pulmonol, USA, [6]	Seven hundred and sixty-four patients	Charges per procedure in US$	Median hospital charges for VATS were $36,320	Adjusting for propensity score matching, costs for

(Continued on next page)

Table 1. *(Continued)*

Author, journal, date and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
Retrospective cohort study (level 2b)	underwent pleural drainage by VATS (n=50) or chest tube placement (n=714)		(IQR, $24,814–$62,269). The median pharmacy and radiological imaging charges were $5884 (IQR, $3142–$11,357) and $2875 (IQR, $1703–$4950), respectively, for VATS and tube drainage	primary VATS were equivalent to primary chest tube placement
Avansino et al., (2005), Pediatrics, USA, [7] Systematic review (level 2a)	Sixty-seven studies including 3418 cases from 54 studies treated non-operatively and 343 patients from 25 studies treated by VATS	Mortality rate	VATS 0% vs. drain 3.3%	These aggregate results suggest that primary operative therapy is associated with a lower in-hospital mortality rate, re-intervention rate, length of stay, time with tube thoracostomy, and time of antibiotic therapy, compared with non-operative treatment
		Re-intervention rate	VATS 2.5% vs. drain 23.5%	
		LOS (days)	VATS 10.8 days vs. drain 20 days	
		Duration of drain insertion (days)	VATS 4.4 vs. drain 10.6	
		Complications rate	VATS 5% vs. drain 5.6%	
Li and Gates, (2008), Arch Pediatr Adolesc Med, USA, [8] Retrospective cohort study (level 2b)	One thousand one hundred and seventy-three children with empyema were identified from nationally representative Kids' Inpatient Database for 2003	Length of stay mean 95% CI	VATS 9.8 (8.8–10.7) vs. drain 13.6 (12.6–14.5)	Primary operative management is associated with decreased LOS, hospital charges, and likelihood of transfer to another short-term hospital, compared with non-operative management
		Hospital charges mean±S.D.	VATS $48,679.41 ($42,008.79) vs. drain $66,855.22 ($94,847.78)	
		Chances to be transferred to another short-term hospital	VATS 0% vs. drain 13.3%	
Shah et al., (2008), Arch Pediatr Adolesc Med, USA, [9] Retrospective cohort study (level 2b)	Nine hundred and sixty-one of 2862 patients (33.6%) with complicated pneumonia underwent early pleural fluid drainage. Initial procedures included chest tube placement (n=714), VATS (n=50), and thoracotomy (n=197)	Length of stay	The median LOS was 10 days (IQR, 7–14 days). In linear regression analysis, children undergoing primary VATS had a 24% (adjusted coefficient, –0.24; 95% CI, –0.41 to –0.07) shorter LOS than patients undergoing primary chest tube placement; this translated into a 2.8-day reduction in the LOS for those undergoing early primary VATS	Compared with primary chest tube placement, primary VATS is associated with shorter LOS and fewer additional procedural interventions
		Requirement for additional pleural drainage procedures	In logistic regression analysis, patients undergoing primary VATS had an 84% (adjusted odds ratio, 0.16; 95% CI, 0.06–0.42) reduction in the requirement for additional pleural fluid drainage procedures compared with patients undergoing primary chest tube placement	
Gates et al., (2004), J Pediatr Surg, USA, [10] Systematic review (level 2a)	Forty-four retrospective studies with a total of 1369 patients were available for analysis	LOS (days)	Patients undergoing early VATS (weighted mean LOS, 10.5 days) or thoracotomy (9.9 days) had a shorter length of stay (P=0.003) compared with chest tube alone (16.4 days) or fibrinolytic therapy (18.9 days)	Early VATS or thoracotomy leads to shorter hospitalisation. The duration of chest tube placement is variable and does not correlate with treatment method
		Fever resolution	Although patients undergoing VATS tended to have a shorter duration of fever after	

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Table 1. *(Continued)*

Author, journal, date and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
			intervention (mean, 3.5 days) compared with chest tube alone (9.7 days), fibrinolytic therapy (8.8 days), and thoracotomy (5.7 days), did not reach statistical significance (P=0.055)	
		Chest tube duration	No difference among the treatments	
Bishay et al., (2009), J Pediatr Surg, UK, [11] Retrospective cohort study (level 2b)	One hundred and fourteen children younger than 16 who presented with pleural empyema irrespective of the stage from February 2004 to February 2008	Median pleural cavity drainage (days)	Four (2–13) days	VATS has a better outcome in childhood empyema than reported in a randomised trial [3] and an important role in the management of this condition. All patients in this study received operative management as the authors felt it was impossible to discriminate between operative and conservative management on the basis of the preoperative imaging
		Median postoperative hospital stay	Seven (4–36) days	
		Treatment failures	There were eight (7%) treatment failures: five conversions to thoracotomy and three recurrent empyemas	
		Complications	There were seven complications (6%): air leak (n=6) and lung injury (n=1). 104 (91%) children had full resolution of symptoms	
		Mortality	There were no deaths	
Cohen et al., (2003), J Thorac Cardiovasc Surg, UK, [12] Retrospective cohort study (level 2b)	The clinical course of 54 patients treated conventionally between 1989 and 1997 was compared with that of 21 patients treated by means of thoracoscopic drainage and decortication between September 2000 and September 2001	Number of invasive interventions	The drainage-decortication group had fewer invasive interventions per patient than those in the conventional management group (1.0 vs. 1.26)	This study supports the use of thoracoscopic surgery as the primary therapeutic modality in children presenting with pleural empyema. This strategy appears to offer significant benefits over conventional treatment in terms of duration of treatment and the need for more invasive surgery
		Intravenous antibiotic therapy	VATS 7.6±1.2 days vs. drain 18.2±7.5 days	
		Chest tube drainage	VATS 4.0±0.5 days vs. drain 10.2±6.1 days	
		LOS (days)	VATS 7.4±0.8 vs. drain 15.4±7.4	
Carter et al., (2010), Pediatr Pulmonol, USA, [13] Retrospective cohort study (level 2b)	One hundred and eighty-two previously healthy children, 1–18 years old, hospitalised with empyema from December 1996 through December 2008 Ninety-five (52%) received antibiotics alone, and 87 (45%) underwent drainage procedures (21 chest tube alone, 57 VATS/thoracotomy, and eight chest tube followed by VATS/thoracotomy); only four received fibrinolytics	LOS (days)	Mean±S.D. LOS was significantly shorter in the antibiotics alone group, 7.0±3.5 days vs. 11±4.0 days	Some children with empyema can be treated with intravenous antibiotics alone and have reasonably short LOS. Those that required intensive care or had large effusions with mediastinal shift were more likely to require pleural drainage
		Predictors of need for pleural drainage	Admission to the ICU and large effusion size (>1/2 thorax filled)	
Aziz et al., (2008), Surg Infect, USA, [14]	Forty-nine paediatric patients with pneumonia complicated by	LOS (days)	Patients undergoing primary VATS demonstrated a significantly shorter total	Patients treated by primary VATS had a shorter stay and lower

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Table 1. *(Continued)*

Author, journal, date and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
Retrospective cohort study (level 2b)	parapneumonic effusion or empyema treated at the Children's Hospital of Pittsburgh (1997–2003) were divided into three groups according to the therapy instituted: primary chest tube, chest tube followed by VATS, or primary VATS		stay and lower hospital charges than the other groups. Forty percent of children started on chest tube therapy failed even with subsequent VATS, necessitating a significantly longer hospital course (18±3 days vs. 11±0.8 days; $P<0.05$)	hospital charges than patients treated by chest tube and antibiotic therapy alone. There were no demographic, physiological, laboratory, or chest radiographic data that predicted the selection of VATS as an initial treatment. These data suggest a strategy of primary VATS as first-line treatment in the management of empyema or parapneumonic effusion as a complication of pneumonia in paediatric patients
		Hospital charges	Higher hospital charges for other groups ($50,000±7000 vs. $29,000±1000) than those having primary VATS	
Schneider et al., (2010), Am Surg, USA, [15] Retrospective cohort study (level 2b)	Review of all paediatric (age younger than 17 years) patients with a diagnosis of pneumonia admitted between July 1998 and June 2008 Patients were divided into groups: those who only had thoracocentesis or thoracostomy (Group A), those who underwent a procedure and then required VATS (Group B), and those who went directly to VATS (Group C). Three hundred and eighty-two patients admitted with pneumonia identified. Of these, 79 (21%) required a thoracic drainage procedure	LOS (days)	LOS for Group C (10.5 days) was significantly ($P<0.05$) shorter than for both Group A (14.8 days) and Group B (15 days). Only two (6%) patients required conversion to open thoracotomy. A high percentage of children initially treated by tube thoracostomy eventually require additional interventions, leading to increased LOS	As a result of its simplicity, safety, and efficacy, VATS pleural evacuation can be recommended as the initial intervention in paediatric parapneumonic effusions and empyema in patients who do not require emergent drainage
Meier et al., (2010), Pediatr Surg Int, USA, [16] Retrospective cohort study (level 2b)	One hundred and fifty-one patients, 107 (70.1%) underwent VATS primarily, 44 (29.1%) following another procedure	Overall complications rate	13.8% (prolonged air leak four, blood loss/hemorrhage four, severe pain one, pneumatocele one, persistent pneumothorax one, readmission two, reintubation one, treatment failure seven, death two)	VATS provided effective treatment for paediatric empyema. Complications were mostly minor, occurring more frequently in older patients and those with a lower admission hematocrit. Early VATD decreased the length of hospitalisation
		LOS (days)	Mean LOS 10.1 days, but was significantly longer if VATS followed another procedure or if a complication occurred. The risk for complications correlated with older age (6.2 years vs. 8.8 years, $P=0.023$) and lower hematocrit on admission (31.1% vs. 27.9%, $P=0.006$)	

CI, confidence interval; IQR, interquartile range; LOS, length of hospital stay; S.D., standard deviation; VATD, video-assisted thoracoscopic decortication; VATS, video-assisted thoracic surgery; ICU, intensive care unit.

6. Results

Firstly, we must acknowledge that the treatment of pleural empyema in children differs considerably from that in adults due to the superior healing potential of paediatric patients.

Empyema in children usually develops as a complication in 0.6% of bacterial pneumonias.

Parapneumonic effusions have been described to encompass three stages progressing from sterile effusion, fibrin deposition leading to formation of a thick cortex with lung entrapment. Mahant et al. [2] reviewed three randomised controlled trials [3–5] comparing VATS with chest drain and fibrinolytics. Sonnappa et al. [3] and St. Peter et al. [4] used small (8–12-F) chest drains, and fibrinolytics were administered as a standing order. Kurt et al. [5], however, used larger chest drains (16–24-F) and administered fibrinolytics as a rescue therapy based on imaging and drainage. The study by Kurt et al. [5] was stopped early owing to an observed benefit in mean hospital stay (5.8±2.8 days vs. 13.2±7.2 days, $P<0.01$) with VATS compared to chest drain with fibrinolytics. Hospital stays were equivalent between VATS and chest drain with fibrinolytics in two other studies (St. Peter et al.: 6.9±3.7 days vs. 6.8±2.9 days; Sonnappa et al.: 6 days vs. 6 days). Chest drain with fibrinolytics was associated with lower costs in both studies (St. Peter et al.: $11,700 vs. $7600; Sonnappa et al.: $11,379 vs. $9127, respectively).

In contrast, Shah et al. [6] found that median hospital charges for VATS were $36,320 [interquartile range (IQR), $24,814–$62,269]. The median pharmacy and radiological imaging charges were $5884 (IQR, $3142–$11,357) and $2875 (IQR, $1703–$4950), respectively, for VATS and tube drainage. Adjusting for propensity score matching, costs for primary VATS were equivalent to primary chest tube placement.

This is, in contrast, to a meta-analysis of 67 studies conducted by Avansino et al. [7] who compared children initially treated non-operatively (3418 cases from 54 studies) to children treated with a primary operative approach (363 cases from 25 studies). Patients who underwent primary operative therapy had lower in-patient mortality rate (0% vs. 3.3%), re-intervention rate (2.5% vs. 23.5%), hospital stay (10.8 days vs. 20.0 days), duration of tube thoracostomy (4.4 days vs. 10.6 days) and duration of antibiotic therapy (12.8 days vs. 21.3 days), compared with patients who underwent non-operative therapy. Similar complication rates were observed for the two groups (5% vs. 5.6%).

Li and Gates [8] analysed 1173 patients from a national hospital database and found that children who had primary operative management were less likely to have therapeutic failure compared with children with non-operative management (NM) (5.5% vs. 39.3% [$P<0.001$]; odds ratio (OR), 0.08 [95% confidence interval (CI), 0.04–0.15]). Complication rates were equivalent between the two groups [8.6% vs. 8.9%; OR, 1.01 (95% CI, 0.59–1.74)].

Shah et al. [9] analysed 961 patients that had complicated pneumonia and underwent early pleural fluid drainage. Initial procedures included chest tube placement ($n=714$), VATS ($n=50$), and thoracotomy ($n=197$). In linear regression analysis, children undergoing primary VATS had a 24% (adjusted coefficient, –0.24; 95% CI, –0.41 to –0.07) shorter hospital stay than those undergoing primary chest tube placement, which translates into a 2.8-day shorter stay. In logistic regression analysis, patients undergoing primary VATS had an 84% (adjusted OR, 0.16; 95% CI, 0.06–0.42) reduced requirement for additional pleural fluid drainage procedures compared with patients undergoing primary chest tube placement.

Gates et al. [10] reviewed 44 retrospective studies involving 1369 patients. Four treatment strategies were compared: chest tube drainage alone (16 studies, 611 patients), chest tube drainage with fibrinolytic instillation (10 studies, 83 patients), thoracotomy (13 studies, 226 patients), and video-assisted thoracoscopic decortication (VATD; 22 studies, 449 patients). Patients undergoing early VATS or thoracotomy had shorter hospital stay ($P=0.003$). There was a trend for shorter duration of postoperative fever compared with chest tube alone or with fibrinolytic therapy ($P=0.055$). There was no statistical difference in chest tube duration between methods. There was no trend correlating antibiotic use with treatment methods, length of hospital stay, duration of fever, or length of chest tube requirement.

Bishay et al. [11] analysed 114 children who underwent VATS for empyema and reported median pleural cavity drainage time of four (2–13) days. Median postoperative hospital stay was seven (4–36) days. There were seven complications (6%): air leak ($n=6$) and lung injury ($n=1$). One hundred and four (91%) children had full resolution of symptoms. There were eight (7%) treatment failures: five conversions to thoracotomy and three recurrent empyemas. This contrasts with Sonnappa et al. [3] who reported a failure rate for VATS of 16.6%.

Similarly, Cohen et al. [12] found that patients undergoing thoracoscopic drainage and decortication also had significantly shorter durations of intravenous antibiotic therapy (7.6±1.2 days vs. 18.2±7.5 days), chest tube drainage (4.0±0.5 days vs. 10.2±6.1 days), and hospital stay (7.4±0.8 days vs. 15.4±7.4 days).

In contrast, Carter et al. [13] reviewed 182 children who received antibiotics alone ($n=95$) or underwent drainage procedures ($n=87$) (21 chest tube alone, 57 VATS/thoracotomy, and eight chest tube followed by VATS/thoracotomy) and reported shorter mean±standard deviation hospital stay in the antibiotics alone group (7.0±3.5 days vs. 11±4.0 days). Intensive care unit admission and large effusion size (>1/2 thorax filled) are strong predictors for pleural drainage requirement.

Similar finding in children with parapneumonic empyemas were reported by another four studies [14–16].

7. Clinical bottom line

On the basis of the reported studies, we conclude that early VATS (or thoracotomy if VATS is not possible) leads to shorter hospitalisation.

The duration of chest tube placement and antibiotic use is variable and does not correlate with treatment method.

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