Primary Operative Management for Pediatric Empyema

Decreases in Hospital Length of Stay and Charges in a National Sample

Su-Ting T. Li, MD, MPH; Robert L. Gates, MD

Objective: To determine whether primary operative management (decortication within the first 2 days of hospitalization) decreases hospital length of stay (LOS) and total charges in children with empyema.

Design: Retrospective cohort study.


Participants: Children and adolescents aged 0 to 18 years (hereinafter referred to as children) with empyema.

Main Outcome Measures: Hospital LOS and total charges.

Results: A total of 1173 children with empyema were identified. Compared with children treated with primary nonoperative management, children treated with primary operative management had a shorter hospital LOS by 4.3 (95% confidence interval [CI], 2.3-6.4) days and lower total hospital charges by $21 179.80 (95% CI, −$34 111.12 to −$8248.48) and were less likely to be transferred to another short-term hospital (0% vs 13.3%). In addition, children with primary operative management were less likely to have therapeutic failure (odds ratio, 0.08 [95% CI, 0.04-0.15]). There was no difference in complications between the 2 groups (odds ratio, 1.01 [95% CI, 0.59-1.74]).

Conclusion: Primary operative management is associated with decreased LOS, hospital charges, and likelihood of transfer to another short-term hospital, compared with nonoperative management.


The treatment of empyema in children remains controversial. Treatment options include antibiotic therapy, thoracentesis, chest tube placement, fibrinolytic therapy, video-assisted thoracoscopic surgery (VATS), and thoracotomy. The stage of the empyema may influence its response to therapy. Early empyemas (stage 1 [exudative]) may respond to antibiotics with or without chest tube drainage. However, as loculations develop (stage 2 [fibrinopurulent]) and a thick fibrinous peel forms (stage 3 [organizing]), decortication may be needed to allow adequate chest tube drainage.

Many authorities advocate nonoperative management (NM) as first-line therapy. Nonoperative management is defined as antibiotic therapy with or without thoracentesis/chest tube drainage. Other studies, including recent meta-analyses and systematic reviews, suggest that primary operative management (POM), defined as antibiotics plus early decortication with VATS or thoracotomy within the first 2 days of admission, may decrease the hospital length of stay (LOS) and the need for reintervention. However, most existing studies have been limited to single-center retrospective studies spanning multiple years. The single prospective randomized controlled trial in children comparing early VATS with chest tube placement showed a decreased LOS in children treated with early VATS. However, that study was limited because all 18 children had large effusions (>1.5 cm), and 16 of them (89%) had obvious loculations on the initial computed tomography study of the chest, which is consistent with at least a stage 2 empyema.

We designed this study to investigate whether POM improved outcomes compared with NM in children with empyema, regardless of stage, using a large national database of child hospitalizations and procedures in a single year (2003).

METHODS

DATA SOURCE

This retrospective cohort analysis used administrative data from the most recent release (2003) of the Kids’ Inpatient Database (KID). The KID is a national pediatric hospital dis-
charge database developed by the Agency for Healthcare Research and Quality as part of the Healthcare Cost and Utilization Project. Data from 36 states and 3438 hospitals are included in the database for 2003. The KID contains a random 10% sample of all uncomplicated births and 80% of all other hospitalizations for children, adolescents, and young adults 20 years and younger from each nonfederal, short-term care hospital located in the participating states, with up to 15 diagnoses and 15 procedures for each hospitalization. The KID contains discharge-level records, not patient-level records, so hospitalization records cannot be linked when a patient is transferred from one short-term care hospital to another or readmitted to the same hospital.

The KID includes patient demographic information, hospital characteristics, and diagnostic and procedure codes, including the hospital day the procedure was performed, payer, LOS, total charges, and discharge disposition. The KID contains no laboratory or physiological patient data.

The institutional review board at the University of California Davis approved this study.

### ELIGIBILITY

For this study, children and adolescents 18 years or younger (hereinafter referred to as children) with an International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) code for empyema (510.0 and 510.9) in any of the diagnoses on the discharge record were included in the analysis.25 Children with empyemas related to tuberculosis (ICD-9-CM codes 012.00-012.06) were not included. Exclusion criteria included (1) birth during the hospital admission; (2) comorbidities associated with empyema (valvular disease and congestive heart failure, chronic pulmonary disease and pulmonary circulation disorders, liver disease, cancer, paralysis, and renal failure as indicated by the Agency for Healthcare Research and Quality comorbidity measures); (3) transfer from another hospital; (4) transfer from another facility (including long-term care facilities); and (5) missing admission source. Patients with empyema who died during their hospitalization were included.

### INDEPENDENT VARIABLE

A patient was defined as undergoing POM if an ICD-9-CM procedure code of 34.51 (decortication of lung) was identified in any of the procedures listed in the discharge record with a time to the procedure of 2 or fewer days from arrival (days 0, 1, or 2).25 The KID uses ICD-9-CM procedure codes rather than Current Procedural Terminology codes. We excluded from analysis cases for which time to decortication was missing or the time to decortication was before admission. Decortications performed at day 3 or later were considered as attempted NM.

### OUTCOME VARIABLES

Primary outcomes were hospital LOS (in days) and charges (in US dollars). Secondary outcomes included patient disposition, therapeutic failure, and complications. Patient disposition included death, discharge home, or transfer to another short-term hospital. For children with POM, therapeutic failure was defined as chest tube placement after the date of the initial decortication or as a second decortication. For children with NM, therapeutic failure was defined as the placement of a second chest tube after the date of the initial chest tube placement or as operative decortication. Complications included mechanical complication due to an internal device (ICD-9-CM code 996.59), infectious complication due to an internal device (ICD-9-CM code 996.69), other complications due to an internal device (ICD-9-CM code 996.79), cardiac complication due to a thoracic procedure (ICD-9-CM code 997.1), respiratory complication due to a thoracic procedure (ICD-9-CM code 997.3), hemorrhage due to the procedure (ICD-9-CM code 998.11), hematoma due to the procedure (ICD-9-CM code 998.12), sepsis due to the procedure (ICD-9-CM code 998.13), wound dehiscence (ICD-9-CM codes 998.31 and 998.32), postoperative wound infection (ICD-9-CM code 998.5), iatrogenic pneumothorax (ICD-9-CM code 512.1), and postoperative pulmonary insufficiency (ICD-9-CM code 518.5).25

### POTENTIAL CONFOUNDING VARIABLES

A priori, we selected the following potential confounding variables for multivariable analysis: patient demographics (age, sex, insurance status [public insurance, private insurance, or other]), admission characteristics (admission source [emergency department vs routine] and day of admission [weekday vs weekend]), hospital characteristics (urban nonteaching, urban teaching, or rural), and hospital region (Northeast, South, Midwest, or West). By including the admission characteristics, day of admission, hospital characteristics, and hospital region as potential confounders, we minimized the true benefit of POM.

### DATA ANALYSIS

For descriptive statistics, we completed univariate and bivariate analyses using the unpaired t test with unequal variances for continuous variables and χ² tests for categorical variables. To identify associations between patient or hospital factors and POM for pediatric empyema, we used logistic regression with POM as the outcome variable and the potential confounders as explanatory variables as described. Explanatory variables are presented as odds ratios (ORs) and 95% confidence intervals (CIs). To determine whether POM for pediatric empyema resulted in decreased LOS or decreased hospital charges, we used linear regression with LOS or hospital charges as the outcome variable, POM as the independent variable, and the same potential confounders as listed in the preceding section. To examine the secondary outcomes of patient disposition (transfer to a short-term hospital), therapeutic failure, and complications, we used multivariate logistic regression and the Fisher exact test.

We performed a sensitivity analysis restricted to children with a primary diagnosis of empyema to minimize treatment misclassification by eliminating patients in whom empyema was not present at admission. We also looked at whether redefining POM as initial therapy with decortication and antibiotics (rather than timing of decortication within 2 days of admission) and NM as initial therapy with thoracentesis/chest tube placement and antibiotics affected our outcomes. Children who did not receive thoracentesis, chest tube placement, or decortication were excluded from this analysis.

In addition, we examined LOS and hospital charges in (1) children with VATS (ICD-9-CM procedure codes 34.51 [decortication of lung plus 34.21 [transpleural thoracoscopic]) compared with children with open decortication (ICD-9-CM procedure code 34.51 only) and (2) children with intrapleural fibrinolytic infusion (ICD-9-CM procedure code 99.10 [injection or infusion of thrombolytic agent]) compared with children with POM.

### RESULTS

We identified a total of 2078 pediatric empyema hospitalizations among children aged 0 to 18 years. After excluding from analysis 10 patients born during the hospit...
talization that included treatment for an empyema, 264 patients with comorbidities that might cause empyema, 440 patients who were transferred to the treating hospital from another hospital, 62 patients who were transferred to the treating hospital from another facility, 15 patients with a missing admission source, 113 patients who were missing decortication procedure days, and 1 patient with decortication recorded as the day before admission, 1173 patients with empyema remained for analysis.

During their initial hospitalization for empyema, 792 of the 1173 children received a chest tube (67.5%). Decortication was performed in 505 children (43.1%), and 944 (80.5%) received a chest tube or a decortication. Of the 505 decortications performed during these hospitalizations, 220 (43.6%) were performed on days 0, 1, or 2 and were considered as POM in this study. Ten patients died during their empyema hospitalization, all in the NM arm. None of the patients who died had empyema as the primary diagnosis.

Table 1 presents the relative frequencies of patient and hospital characteristics and their relationships with POM vs NM. Children in both groups were similar in age, sex, and day of admission.

After controlling for potential confounders, we found that children with POM were more likely to have private than public insurance (OR, 1.44 [95% CI, 1.02-2.03]), more likely to be admitted routinely than through the emergency department (OR, 1.39 [95% CI, 1.02-1.90]), more likely to be admitted to an urban teaching hospital than an urban nonteaching hospital (OR, 2.02 [95% CI, 1.32-3.10]), and less likely to be from the South than the Northeast (OR, 0.59 [95% CI, 0.33-1.05]) (Table 1).

Compared with children with NM, children with POM had a shorter LOS by 4.3 days (95% CI, −2.3 to −6.4 days) and lower total hospital charges by $21 179.80 (95% CI, −$34 111.12 to −$8248.48) (Table 2). In addition, children with POM were much less likely to be transferred to another hospital (0% vs 13.3%; P < .01).

THERAPEUTIC FAILURE AND COMPlications

Children who had POM were less likely to have therapeutic failure compared with children with NM (5.5% vs 39.3% [P < .001]; OR, 0.08 [95% CI, 0.04-0.15]). There was no statistically significant difference in complications in children with POM compared with children with NM (8.6% vs 8.9%; OR, 1.01 [95% CI, 0.59-1.74]).

SENSITIVITY ANALYSIS RESTRICTED TO PATIENTS WITH EMPYEMA AS THE PRIMARY DIAGNOSIS

Of the 1173 patients with empyema, 362 (30.9%) had empyema identified as their primary diagnosis. Results were similar to those obtained by looking at children with empyema as any diagnosis. After controlling for patient and hospital characteristics, children with POM had a
shorter LOS by 1.7 days (8.9 vs 10.3 days [95% CI, −0.4 to −3.0 days; \( P = .02 \)) compared with children with NM. Despite additional operative costs, children with POM tended to have decreased hospital charges compared with children with NM, although this difference was not statistically significant (−$1298.13 [95% CI, −$10 646.11 to $8049.85]; $44 378.62 vs $44 910.83 [\( P = .90 \)]).

After redefining POM and NM as the initial therapy attempted, results were similar. Children with POM (decortication and antibiotics as initial therapy) had a shorter LOS by 1.3 days (10.1 vs 11.1 [95% CI, −0.03 to −2.6] days) compared with children with NM (thoracentesis/chest tube placement and antibiotics as initial therapy). There was no difference in hospital charges (−$657.55 [95% CI, −$9816.77 to $48 301.66]; $48 131.97 vs $48 433.92).

**VATS VS OPEN DECORTICATION**

Based on ICD-9-CM coding, a total of 121 children received a VATS procedure, with 48 children (39.7%) receiving an early VATS procedure on day 0, 1, or 2. After adjusting for potential patient and hospital confounders, although the hospital LOS and total charges trended toward being decreased in children who received a VATS, there was no statistically significant difference in LOS (−1.0 [95% CI, −3.6 to 1.5] days; 13.2 vs 14.1 days [\( P = .43 \)]) or total charges (−$13 440.54 [95% CI, −$28 278.51 to −$1227.43]; $59 001.61 vs $71 903.93 [\( P = .06 \)]) between children who received a VATS and children who received an open decortication. There was no difference in therapeutic failure (OR, 0.90 [95% CI, 0.58−1.40]) or complications (OR, 1.18 [95% CI, 0.58−2.40]) between the 2 groups.

**FIBRINOLYSIS VS POM**

Based on ICD-9-CM coding, a total of 27 children received intrapleural fibrinolytic infusion. After adjusting for potential patient and hospital confounders, there was no statistically significant difference in LOS (−2.9 [95% CI, −6.1 to 0.3] days; 9.8 vs 12.4 days [\( P = .07 \)]) or total charges (−$9137.81 [95% CI, −$28 313.85 to $10 038.23]; $48 679.41 vs $51 597.88 [\( P = .69 \)]) between children who received POM and children who received intrapleural fibrinolytic infusion, although the hospital LOS and total charges trended toward being decreased in children who received POM. Children who received POM were less likely to have therapeutic failure (OR, 0.06 [95% CI, 0.02−0.19]). There was no difference in complications (OR, 3.28 [95% CI, 0.36−29.42]) between the 2 groups.

We found that children with empyema who underwent POM had a decreased LOS by 4 days, decreased hospital charges by $21 000, and decreased likelihood of transfer to another hospital.

This study confirms the results of previous studies that showed decreased LOS with POM in children with empyema.\(^{13,14}\) Our LOS data for POM (mean LOS, 9.8 days) are similar to those of recent retrospective studies and meta-analyses, in which LOS was found to range from 10.8 to 11.5 days, reflecting the recent practice of POM.\(^{14,19}\) Our LOS data for NM (mean LOS, 13.6 days) are shorter than those of recent retrospective studies and meta-analyses, in which LOS was found to range from 15.2 to 20.0 days.\(^{14,19}\) Our study has less temporal bias because our data were collected for 1 year rather than multiple years and therefore reflect modern modalities of treatment and current microbiological causes of empyema.\(^{15}\) In addition, this study adds to the literature by showing decreased hospital charges and decreased likelihood of transfer to another hospital.

Fibrolysis also trended toward a 1-day decrease in LOS compared with children who underwent open decortication, and children who received POM trended toward a 3-day decrease in LOS compared with children who received intrapleural fibrinolytic infusion. However, this decrease in LOS was not statistically significant, possibly secondary to our small sample size of children with codes for VATS or intrapleural fibrinolytic infusion. In addition, it is possible that some children received incorrect codes, causing us to underestimate the benefit of VATS and POM.

There are several limitations to our study. We could not stage the empyema using administrative data. However, despite being unable to stage the empyema, it is reasonable to assume that children who had stage 1 empyema are overrepresented in the NM group. If this hypothesis is correct, we are underestimating the actual benefit of POM. In addition, we could not determine severity of illness using administrative data. If it is reasonable to assume that sicker children are more likely to receive decortication, we are further underestimating the actual benefit of POM.

We could not determine whether the patient had empyema on hospital admission or developed the empy-
This study suggests that POM of empyema in children is associated with decreased LOS and decreased hospital charges compared with NM. Although decortication was not necessary in all children with empyema, most of the children (80.5%) had a chest tube inserted or underwent decortication during their initial hospital stay.

The advantages of an early VATS include the ability to stage the empyema accurately, to direct chest tube placement appropriately under optimal anesthesia and airway control, and then to decorticate operatively if needed. In addition, a recent randomized controlled trial comparing VATS and chest tube placement alone showed fewer days of narcotic use among children with VATS. Therefore, because early VATS is associated with decreased LOS and hospital charges, children with empyema may benefit from early VATS.

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Correspondence: Su-Ting T. Li, MD, MPH, Department of Pediatrics, University of California Davis, 2516 Stockton Blvd, Sacramento, CA 95817 (su-ting.li@ucdmc.ucdavis.edu).

Author Contributions: Dr Li had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Li. Analysis and interpretation of data: Li and Gates. Drafting of the manuscript: Li and Gates. Critical revision of the manuscript for important intellectual content: Li and Gates. Statistical analysis: Li.

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REFERENCES


23. Kurt BA, Winterhalter KM, Connors RH, Betz BW, Winters JW. Therapy of empyema after admission to the hospital. However, our sensitivity analyses restricted to children with empyema as the primary diagnosis yielded similar results. Complications may be incompletely coded or under-reported. We did not look at the external cause of injury codes (E codes) because the collection and reporting of E codes varies greatly across states.

Because the KID contains only discharge-level records, not patient-level records, we cannot directly link data from patients who were transferred to another hospital with the data from their initial hospitalization.


