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Outcomes of Primary Image-Guided Drainage of Parapneumonic Effusions in Children

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ABSTRACT. *Objective.* To assess the outcome of image-guided needle aspiration when compared with image-guided percutaneous catheter drainage in the management of parapneumonic effusions in children.

Methods. A retrospective chart review was conducted of the medical records, microbiology, and radiology reports of 67 children who presented with parapneumonic effusions and underwent primary image-guided drainage between April 1, 1995, and April 1, 2000.

Results. Thirty-four patients had aspiration only, and 33 patients had pigtail catheters placed. The 2 drainage methods had similar median length of stay and complication rates. The reintervention rate in this study was 27% (18 patients). Children who underwent primary aspiration without catheter placement had significantly higher rates of reintervention. Method of drainage, pH lower than 7.2, and loculation of the fluid collection were independent predictors of reintervention. A low glucose level was an additive predictor of reintervention when the pH was low.

Conclusions. Aspiration and catheter drainage of parapneumonic effusions had similar complication rates and lengths of stay, but children who underwent primary aspiration had significantly higher reintervention rates, particularly when pH and glucose levels were low. Therefore, primary catheter placement for parapneumonic effusions should be considered in children who undergo diagnostic thoracentesis. The decision regarding tube placement could be facilitated by the on-site availability of a pH meter and a glucometer. *Pediatrics* 2002; 110(3). URL: <http://www.pediatrics.org/cgi/content/full/110/3/e37>; pneumonia, pleural effusions, parapneumonic effusion, drainage, thoracentesis, simple aspiration, percutaneous catheter drainage.

ABBREVIATIONS. VATS, video assisted thoroscopic surgery; LDH, lactate dehydrogenase; WBC, white blood cell; OR, odds ratio; CI, confidence interval.

Pneumonia is the most common cause of the development of thoracic fluid collections in children. Evidence-based guidelines for the treatment of parapneumonic effusions in adults¹

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have recently become available, but the optimal treatment of children remains controversial. The reasons for draining parapneumonic pleural effusions include reliable diagnosis of the infectious agent, removal of infected fluid or pus, and, less frequently, alleviation of symptoms related to the volume effect of fluid accumulation.

Various procedures are available to drain pleural effusions. These include needle aspiration, tube thoracostomy, video-assisted thoracoscopy, and thoracotomy with or without decortication. Image-guided percutaneous procedures are precise and relatively noninvasive alternatives to surgical management.^{2,3} Two such image-guided techniques are aspiration and percutaneous catheter drainage.

Although it is standard practice to analyze the pleural fluid in children with parapneumonic effusions at our institution, the decision of whether to proceed to percutaneous catheter drainage after aspiration is not based on evidence-based data. This retrospective, nonrandomized, single-center study compares 2 primary image-guided drainage procedures: needle aspiration and percutaneous catheter drainage. The purpose of this study was to compare the outcomes of these 2 methods in the treatment of children with parapneumonic effusions and to develop criteria to determine which patients are at risk for developing a complicated course and should proceed directly to chest tube placement.

METHODS

All children who underwent chest drainage procedures between April 1, 1995, and April 1, 2000, were identified using the interventional radiology databases. With the use of charts and a laboratory database, a retrospective review of consecutive cases was completed after institutional review board approval. Patients who had noninfectious causes of their effusion, such as malignancy, nephrotic syndrome, or postsurgical fluid collections, were excluded from the analysis. Only patients who underwent primary image-guided drainage were included in this study. Patients who had effusions that were too small for thoracentesis or patients who had aspiration or catheter placement without image guidance were not included. Primary video assisted thoroscopic surgery (VATS) is not the routine practice of this hospital; nonetheless, it is possible that some patients underwent primary surgical thoracostomy without a preceding radiologic intervention. These patients were also not included. This method retrieved a total of 67 consecutive cases of primary image-guided drainage procedures that form the basis of this report. All 67 procedures were performed by ultrasound and/or fluoroscopic guidance by the interventional radiology staff at Children's Hospital, Boston.

Sedation of children was administered directly by registered nurses from the department of radiology in accordance with the sedation guidelines and policies established by our department. Intravenous midazolam (0.05 mg/kg titrated to a maximum dose

of 0.15 mg/kg), fentanyl citrate (1 μ g titrated to a maximum dose of 3–4 μ g/kg/20 min), and pentobarbital (2–3 mg/kg titrated to a maximum dose of 6 mg/kg) were used routinely, and all children were monitored continuously by pulse oximetry and given “blow-by” oxygen. Efforts were made to minimize the sedative dosage administered to patients with compromised respiratory status. Six patients underwent general anesthesia because they were deemed inappropriate candidates for intravenous sedation. Fifty-eight patients received intravenous sedation, and 3 patients underwent their procedures with local anesthesia only.

Patients were placed in the recumbent position for the procedure. After initial localization of the pleural effusion with ultrasound, the overlying region of skin was prepared with Betadine solution and draped in sterile manner. After subcutaneous infiltration with 1% lidocaine buffered with bicarbonate, ultrasound guidance was used to gain initial access to the pleural space. Operators differed in their methods of initial access to the effusion, with preferences including 18-gauge angiographic needles or 5-French catheter needles consisting of a short 5-French catheter with side holes over a 19-gauge needle. Both of these methods allow introduction of a 0.035-inch Bentson wire. An initial sample was acquired and inspected; if the fluid was clear, then aspiration of a volume appropriate for laboratory analyses would be conducted. In some cases, the effusions were drained completely.

No specific protocol defining the indication for placement of the pigtail catheters was used. The decision to place a chest tube was made by the referring physician and interventional radiologist and was based on the clinical presentation, the radiographic features, and the appearance of the fluid. When deemed appropriate, a 10- or 12-French pigtail catheter was placed under fluoroscopic guidance using the Seldinger technique and appropriate dilation. The catheters were attached to Pleur-Evac chambers, and wall suction was applied.

All children had preprocedural and serial postprocedural documentation of their fluid collection by chest radiography. Preprocedural loculation of the fluid collection was determined by non-dependence of fluid on decubitus chest radiographs or computed tomographic examination when the latter was performed. The length of hospital stay was defined as the time between the intervention and discharge. The duration of symptoms was defined as the length of time between the onset of pneumonia-related symptom(s) and the intervention. The type of drainage, length of stay, duration of symptoms, age, any history of severe immunologic compromise, and pretreatment with antibiotics were recorded for all patients. Culture and Gram stains were done on all pleural fluid samples, and additional samples were sent for measurements of pH (fluid was sent on ice to the blood gas laboratory), lactate dehydrogenase (LDH), glucose, protein, and leukocyte count.

Complications directly related to the procedure and repeat interventions were recorded for all patients. Complications included both acute complications (eg, pneumothorax) and long-term complications (eg, repeat admission as a result of fever and fluid reaccumulation). Repeat interventions were defined as any subsequent procedures for the treatment of pleural fluid accumulation that required a repeat sedation or general anesthetic. These included radiologic interventions such as placing additional chest tubes, upsizing the catheter, or making adjustments to tube position when residual loculated pleural fluid accumulated away from the pigtail. Repeat interventions also included surgical thoracotomy or thoracotomy. The decision to reintervene was based on the presence of enlarging or persistent pleural effusion in the setting of continued dyspnea and/or fever. It was a common clinical decision between the attending pediatrician and interventional radiologist or surgeon and, similar to the primary intervention, was not based on an established protocol. Resolution of the pleural fluid collection (ie, satisfactory outcome) was confirmed by a reduction in pleural fluid collection (determined by reduced fluid drainage in conjunction with reduced size of the fluid collection as assessed by serial chest radiography or computed tomographic examination) with associated clinical improvements including resolution of fever.

Statistical Analysis

Aspiration and catheter drainage treatment groups were compared using the unpaired Student *t* test for continuous variables and Fisher exact test for categorical variables and proportion.

Power analysis indicated that the sample size of 67 patients ($n = 34$ aspiration, $n = 33$ catheter drainage) provided 80% statistical power for comparing complication and reintervention rates and 90% power for comparing hospital length of stay between the 2 treatment groups (version 4.0, nQuery Advisor, Statistical Solutions, Boston, MA). The Kolmogorov-Smirnov test was used to assess normality (Gaussian distribution) for continuous variables.⁴ Variables—including duration of symptoms, LDH and WBC count, and length of hospital stay—showed significant departure from normality as a result of skewness and were therefore evaluated using the nonparametric Mann-Whitney *U* test for medians and ranges. Multiple logistic regression was performed to identify variables independently predictive of each outcome (complications and reinterventions), and the likelihood ratio χ^2 test using a backward elimination procedure was used to determine predictors. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for significant multivariate predictors.⁵ Eleven variables were tested for their impact on complication and reintervention: aspiration versus catheter drainage treatment, age, gender, duration of symptoms, loculation, pretreatment with antibiotics, pH, LDH, glucose, protein, and WBC. A 2-tailed $P < .05$ was considered statistically significant for all tests. Statistical analysis was conducted using the SPSS software package (version 11.0, SPSS Inc, Chicago, IL).

RESULTS

During the 5-year period between April 1, 1995, and April 1, 2000, 34 children underwent primary image-guided aspiration and 33 had primary percutaneous catheter drainage for management of their parapneumonic effusions. The characteristics and outcomes of both patient groups are presented in Table 1. Both groups were similar with respect to preprocedural duration of symptoms, loculation of the fluid collection, and pretreatment with antibiotics. There was a statistically significant difference in age between the 2 groups: older children were more likely to undergo aspiration, and younger children were more likely to undergo pigtail chest tube placement. Both treatment methods had similar median length of stay and complication rates, but children who underwent only primary aspiration had significantly higher reintervention rates. The pleural fluid analysis revealed comparable levels of pH, glucose, protein, and leukocytes, but the median LDH level was >3 times higher in the percutaneous catheter drainage group.

The complication rate in this study was 16% (11 of 67 patients). Complications included pneumothorax ($n = 5$), readmission with fever ($n = 4$), and recurrence of the fluid collection ($n = 2$). Table 2 compares the characteristics in each group according to whether a complication occurred. No significant differences in the number and severity of complications were found between the aspiration and catheter groups: 6 (18%) of the 34 patients who underwent aspiration and 5 (15%) of the 33 patients who underwent catheter drainage developed a complication. The method of drainage, age, gender, duration of symptoms, pretreatment with antibiotics, loculation, pH, LDH, glucose, protein, and WBC counts all were not significantly associated with complication in the univariate or multivariate analysis.

The reintervention rate in this study was 27% (18 of 67 patients). Table 3 compares the characteristics in each group according to whether a reintervention was required. Children who underwent primary aspiration had significantly higher reintervention rates:

TABLE 1. Characteristics of Patients According to Drainage Method Group

Variable	Aspiration (N = 34)	Thoracentesis and CT Placement (N = 33)	P Value*
Male gender (n [%])	15 (44)	19 (58)	.33
Mean age (y)	9.2 ± 6.5	5.5 ± 4.5	<.01
Duration of symptoms (d)	10 (3–120)	9 (1–45)	.35
Pretreatment with antibiotics (%)	30 (88)	31 (94)	.99
Loculation (%)	12 (35)	17 (42)	.22
Pleural fluid chemistry			
PH	7.1 ± 0.4	7.1 ± 0.4	.80
LDH (U/L)	402 (104–8710)	1276 (172–39 888)	<.01
Glucose (mg/dL)	69 ± 41	50 ± 37	.10
Protein (mg/dL)	4.6 ± 1.0	4.5 ± 1.4	.91
WBC count (per mm ³)	5085 (138–94 675)	5378 (11–204 500)	.97
Median drainage time (d)	—	5 (2–28)	—
Median LOS (d)	6 (1–57)	7 (3–41)	.16
Complications (%)	6 (18)	5 (15)	.98
Reinterventions (%)	13 (38)	5 (15)	.05

CT, chest tube; LOS, length of stay.

Continuous variables are mean ± SD or median with the range in parentheses.

* P values (2 tailed) are based on the unpaired Student *t* test for comparing means, Mann-Whitney *U* test for comparing medians, and Fisher exact test for comparing proportions.

TABLE 2. Comparison of Patients According to the Presence of Complications

Variable	Complications (N = 11)	No Complications (N = 56)	P Value*
Method of drainage (n [%])			.99
Aspiration	6 (54)	28 (50)	
CT placement	5 (46)	28 (50)	
Male gender (n [%])	5 (46)	29 (52)	.75
Mean age (y)	5.5 ± 4.1	7.7 ± 6.1	.26
Duration of symptoms (d)	12 (7–120)	8 (1–90)	.07
Pretreatment with antibiotics (%)	10 (91)	51 (91)	1.00
Loculation (%)	4 (36)	25 (45)	.75
Pleural fluid chemistry			
PH	7.1 ± 0.3	7.1 ± 0.4	.57
LDH (U/L)	503 (238–39,888)	824 (104–29,870)	.89
Glucose (mg/dL)	61 ± 39	60 ± 40	.94
Protein (mg/dL)	4.6 ± 1.4	4.5 ± 1.1	.89
WBC count (per mm ³)	7135 (120–86,533)	5058 (11–204,500)	.86

Continuous variables are mean ± SD or median with the range in parentheses.

* P values (2 tailed) are based on the unpaired Student *t* test for comparing means, Mann-Whitney *U* test for comparing medians, and Fisher exact test for comparing proportions.

TABLE 3. Comparison of Patients According to the Need for Reintervention

Variable	Reintervention (N = 18)	No Reintervention (N = 49)	P Value*
Method of drainage (n [%])			
Aspiration	13 (72)	21 (43)	.05
CT placement	5 (28)	28 (57)	
Male gender (n [%])	8 (44)	26 (53)	.59
Mean age (y)	7.3 ± 6.4	7.4 ± 5.8	.96
Duration of symptoms (d)	7 (1–14)	10 (4–120)	.006
Loculation (%)	11 (61)	18 (37)	.10
Pleural fluid chemistry			
PH	6.8 ± 0.3	7.2 ± 0.3	<.001
LDH (U/L)	1766 (111–22,870)	650 (104–39,888)	.07
Glucose (mg/dL)†	37 ± 40	70 ± 36	.007
Protein (mg/dL)	4.5 ± 1.1	4.6 ± 1.2	.77
WBC count (per mm ³)	12,385 (11–143,500)	4810 (16–204,500)	.33

Continuous variables are mean ± SD or median with the range in parentheses.

* P values (2 tailed) are based on the unpaired Student *t* test for comparing means, Mann-Whitney *U* test for comparing medians, and Fisher exact test for comparing proportions.

† Glucose was not available for 2 patients who had reintervention and 6 who did not.

13 (38%) of the 34 patients who underwent aspiration and 5 (15%) of the 33 patients who underwent catheter drainage required a reintervention (*P* = .05). Of

the 18 patients who underwent reintervention, 7 (39%) underwent surgical chest tube placement; 6 (86%) of 7 of these patients had previously under-

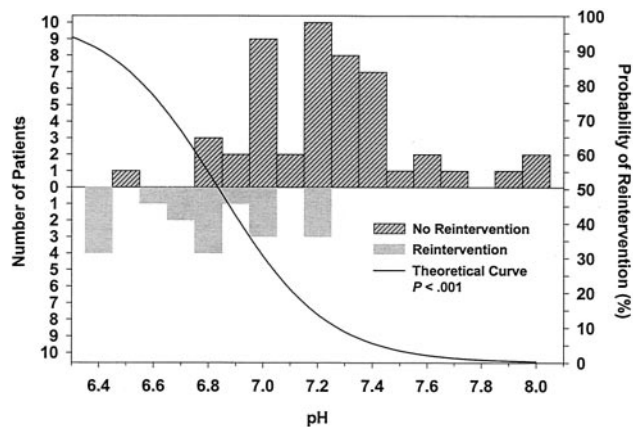


Fig 1. Empirical frequency distributions of pH for children according to the need for reintervention after drainage of parapneumonic fluid (left axis). Theoretical curve, derived from logistic regression, demonstrated a significant inverse relationship between pH and the need for reintervention (likelihood ratio χ^2 test: 18.92; $P < .001$). The graph shows that the probability (right axis) of reintervention is significantly higher in patients with lower values of pH.

gone primary simple aspiration, and 1 child had undergone primary percutaneous drainage. In addition, patients who required a reintervention had significantly lower pH ($P < .001$) and glucose levels ($P = .007$). We used multiple logistic regression to control for confounding in an effort to identify independent predictors of reintervention. We found 3 significant multivariate predictors of reintervention: aspiration versus catheter drainage treatment ($P < .001$), fluid pH ($P < .001$), and loculation of the fluid collection ($P = .03$). Glucose was nearly significant in the final multivariate model ($P = .06$) and did not reach significance because of its positive correlation with pH (Pearson $r = 0.55$, $P < .001$). Additional analyses of these 3 predictors revealed that children who underwent aspiration had 8 times the estimated risk of reintervention compared with children who had catheter drainage (OR: 8.0; 95% CI: 2.5–33.5).

We tested pH as a continuous variable, and it was found to be highly significant. Figure 1 illustrates that the probability of reintervention increases with decreasing pH. When a pH of 7.0 was used as a cutoff value, patients with pH < 7.0 were found to be 14 times more likely to require reintervention than those with pH > 7.0 (OR: 14.3; 95% CI: 4.8–42.6). Figure 1 also presents the empirical data for pH for each individual patient according to reintervention status. The 18 patients who had a reintervention had pH levels 7.2 or below, whereas 34 (70%) of the 49 patients who did not have a reintervention had pH levels above 7.0. Loculation of fluid collection was associated with an increased risk > 3 times higher (OR: 3.6; 95% CI: 1.4–11.2).

Although the multivariate analysis did not find glucose level to be an independent predictor of reintervention, the univariate analysis based on an unpaired Student t test revealed that glucose levels were significantly lower in patients who required reintervention (37 ± 40 mg/dL vs 70 ± 36 mg/dL; $P = .007$; Table 3). Logistic regression also indicated that glucose is an important predictor of reinter-

vention. Figure 2 illustrates the inverse relationship between glucose level and probability of intervention and includes individual patient data points. The reason that glucose, in contrast to pH, was not retained in the final multivariate model as an independent predictor for reintervention was because of the positive correlation between pH and glucose (Pearson $r = 0.55$; $P < .001$). Nonetheless, additional analysis did reveal that taking both glucose and pH into account improves the clinical utility over pH alone. We therefore determined the probability of reintervention on the basis of the combination of pH and glucose (Table 4). The probabilities shown suggest that when pH is > 7.2 , the predicted probability of reintervention is very low and glucose level does not provide additional information; however, at lower pH values, glucose does influence the probability of reintervention. None of the other variables was found to be associated with reintervention in the multivariate analysis.

Median hospital length of stay (range) was not significantly different between the aspiration and catheter drainage groups: 7 days (3–41 days) for aspiration compared with 6 days (1–57 days) for catheter drainage ($P = .14$, Mann-Whitney U test). However, patients who underwent reintervention had significantly longer median length of stay compared with those who did not require reintervention (12 and 6 days, respectively; $P < .001$, Mann-Whitney U test). We therefore used 2-way analysis of variance to test whether hospital length of stay indeed differed between the treatment groups after adjusting for the differences in the rates of reintervention. After the higher rate of reintervention in the aspiration group was controlled for, hospital length of stay remained comparable between the 2 groups ($P = .32$).

Gram-stain and culture and sensitivity data were available for all pleural fluid samples. Positive Gram stains were obtained in 3 of 67 samples, and 5 of 67 samples were culture positive. Sixty-one (91%) of 67

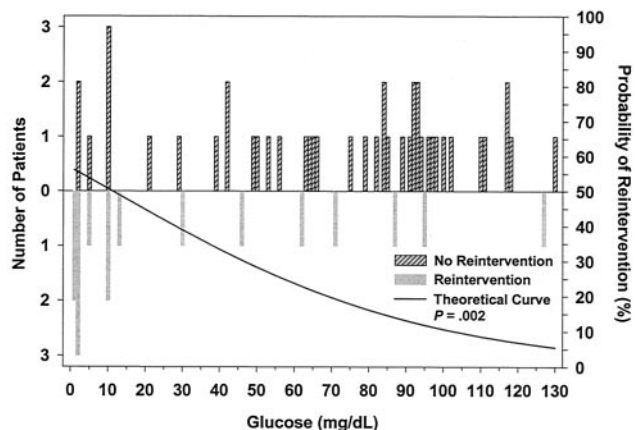


Fig 2. Empirical frequency distributions of glucose for children according to the need for reintervention after drainage of parapneumonic fluid (left axis). Theoretical curve, derived from logistic regression, demonstrated a significant inverse relationship between glucose and the need for reintervention (likelihood ratio χ^2 test: 9.20; $P < .001$). The graph shows that the probability (right axis) of reintervention is significantly higher in patients with lower values of glucose.

TABLE 4. Predicted Probability of Reintervention for Combination of pH and Glucose*

pH/Glucose	<20 mg/dL	20–75 mg/dL	>75 mg/dL
<7.0	75%	58%	40%
7.1–7.2	33%	20%	10%
>7.2	<1%	<1%	<1%

* Predicted probabilities were determined by multiple logistic regression analysis.

patients were pretreated with antibiotics. Of the 3 Gram-positive patients, 1 was pretreated with antibiotics; of the 5 culture-positive patients, 3 had such treatment. Because of the paucity of microbiologic data, no additional statistical analyses were done.

DISCUSSION

Few reports on the management of parapneumonic effusions in children are evidence based.^{6–8} The range of recommended interventions varies substantially, and some interventions are not without risk.⁹ Older literature is in favor of a conservative approach, emphasizing that treatment with intravenous antibiotics alone results in successful resolution of the fluid collection in 65% to 82% of patients.^{6,7} More recent, after the emergence of new surgical techniques, a more aggressive approach in the form of primary VATS has been advocated by Doski et al⁸ and Grewel et al,¹⁰ who cited shorter procedures and shorter lengths of stay. In our study, we attempted to compare the results of 2 less-invasive procedures: image-guided aspiration and image-guided catheter drainage of pleural effusion.

Image-guided fluid aspiration has emerged as a safe and effective method of sampling pleural fluid and frequently seems to suffice as the drainage method.^{2,3} Aspiration alone without catheter placement avoids the discomfort related to the presence of an indwelling catheter, the risk of potential catheter-related complications, and the cost of the catheter. The decision-making process of the interventional radiologists and physicians was not standardized and therefore could not be analyzed retrospectively. We cannot explain the significant difference between the mean age in the 2 treatment groups (mean of 9.2 years in the aspiration group vs 5.5 years in the catheter drainage group) with certainty. Possibly, either younger children present with more severe symptoms or a more aggressive therapeutic bias is held by referring physicians and interventional radiologists toward the younger patients. Nonetheless, our study seems to support primary image-guided placement of a percutaneous catheter because it reduces the need for repeat intervention and thus reduces the number of painful procedures requiring sedation, with its own inherent complications. Our study suggests that primary percutaneous catheter drainage may prevent fluid reaccumulation and progression to loculated fluid collections. Although our study did not assess patient discomfort, our results demonstrate no significant difference between the complication rates of aspiration and those of percutaneous catheter drainage. Thus, our study offers a practical approach to parapneumonic effusions: ra-

diologic chest tube placement allows early drainage of potentially harmful pleural fluid until the laboratory results become available or until the clinical course of the process becomes more obvious.

It is widely accepted that empyema (essentially defined as purulent pleural fluid) needs to be drained. In our series, no frankly purulent effusions were encountered. Such presentations, the minority of cases, would warrant aggressive removal either by the traditional large bore chest drain or by early VATS, as has recently been advocated.^{8,10} Our article deals with the more common clinical dilemma of discerning the characteristics that differentiate fluid that is predictive of a complicated course from fluid that is not. A study by Freij et al¹¹ elegantly demonstrated that the appearance of the pleural fluid is misleading and that visual assessment of color and appearance is not reflective of the cellular components of the fluid. In fact, the cellular components may not be a good predictor of outcome at all,^{11,12} and the cell count may be high in the uninflamed pleural space. Yamada¹³ demonstrated as many as 6200 cells/mm³ in the pleural fluids drawn from normal subjects, although a more recent study suggested that the numbers are not as high.¹⁴ The limited predictive value of the cellular count is also noted by Freij et al¹¹ and shown to be an unreliable predictor for a complicated course.¹² Our data support the limited value of cell count in that it showed no significant difference between the patients who required reintervention and those who did not.

Previous studies suggested that a low pH of the pleural fluid was associated with a complicated course.^{12,15,16} This was confirmed by our observations, and Fig 1 depicts that the lower the pH, the higher the probability of reintervention. A finding of low glucose was also associated with a significantly higher rate of reintervention (Fig 2), similar to previous findings.^{12,15} Of particular interest is the observation that, when compared with pH, glucose is a lesser independent predictor of reintervention, but when used in combination with low pH (<7.2), glucose seems to add predictive value (Table 4). In our study, similar to Heffner et al,¹² a high LDH was associated with a complicated course (reintervention in our case). This effect is dampened in our study, however, because the group with primary chest tube drainage had a significantly higher mean value than the aspiration group, an unintentional random selection bias.

It is our experience that most patients come to pleural tap after having had antibiotic treatment. In the present study, 91% of the patients had been on varying courses of antibiotic therapy before the procedure. The number of patients who had either a positive Gram stain or a positive culture was too small to draw any meaningful conclusions but seems to suggest that even short courses of antibiotic treatment are sufficient to limit the therapeutic significance of the microbiologic studies obtained from the pleural tap. This study and many others suggest that the continuing presence of bacteria in the fluid does not underlie the persistent damage seen in some parapneumonic effusions. Indeed, most studies fail

to show viable organisms early in the course of treatment. The pernicious course of some pleural effusions seems to be uncoupled from the original bacterial agent, and it seems as well that the physical removal of the effusion has the therapeutic effect. This study reinforces previous findings by others that low pH and low glucose are associated with harmful pleural effusions. These indices are likely only surrogate markers of the presence of other noxious chemicals in the fluid, which are not currently directly assessed. Such factors may include tissue irritants, products of inflammatory cells such as proteases, or proinflammatory agents such as cytokines. Thus, it stands to reason that the availability of instrumentation to measure pH and glucose on the acquired fluid in the radiologic suite could be very helpful in the decision regarding the need for the catheter placement.

It is widely accepted that the diagnostic approach of sampling the pleural fluid is appropriate in significant pleural effusion. The identification of the cytologic and chemical components of the effusion are helpful in deciding on the therapeutic modalities, and if performed early enough (a rare occurrence in our experience), a microbiologic identification with appropriate sensitivities can be of great assistance. We, therefore, ascribe to the notion that "the sun should never set on a pleural effusion."¹⁵

The techniques used for drainage of pleural effusion have not changed during the 5 years of this study, but its major limitation is the nonrandomized, retrospective design. This study did not address the question of whether early addition of thrombolytic agents such as urokinase or streptokinase^{17,18} would further benefit patients by shortening the course of the effusion and reducing complications. Finally, we could not exclude referral bias to our tertiary center, and the population of children who had primary image-guided drainage may not be representative of all parapneumonic effusions in children.

The uncomplicated course of the patients who received pigtail placement in our study seems to suggest that this minimally invasive intervention will suffice in providing a beneficial outcome in most cases of pleural effusion and that the liberal use of primary VATS^{8,10} should therefore be reserved to those cases in which empyema is unequivocal. Nonetheless, it is evident that the advantage of VATS over chest drain and the role of fibrinolytic agents require separate prospective, controlled, and preferably multicenter studies to be evaluated fully.

CONCLUSION

Primary image-guided catheter placement significantly reduces the need for reintervention without

increasing the complication rate or length of hospital stay when compared with aspiration alone in children with parapneumonic fluid collections. Because there are strong correlations between fluid pH and glucose level and subsequent need for multiple interventions, immediate availability of these chemistry measurements could be used to determine the need for catheter drainage. When the fluid cannot be analyzed in the procedure room, we recommend primary catheter drainage of significant parapneumonic fluid collections.

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