Original Article

Utility of a scoring system and indicative variables for assessing the need for pleural drainage in pediatric patients with parapneumonic pleural effusion*

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Background: The decision to drain parapneumonic pleural effusion in children is still controversial. An indicative scoring system to assess the need for chest-tube drainage arose from a partnership between pediatricians and surgeons.

Objective: To evaluate the utility of the score in indicating whether drainage should be performed in pediatric patients with parapneumonic effusion.

Method: A cross-sectional study involving 250 inpatients with parapneumonic effusion, treated in a tertiary-care hospital between 1994 and 1999. The following variables were analyzed: clinical presentation, chest X-rays, pleural fluid culture and biochemical analysis of the pleural fluid, as well as the score and treatment. The score was based on four categories: general appearance of the pleural fluid, chest X-rays, laboratory findings, and the second thoracentesis. Drainage was recommended for patients scoring higher than 5.5.

Results: Of 941 children with pneumonia, parapneumonic effusion occurred in 304 (32.2%), 250 of which were included in the study. Of those, 146 (58.4%) were male, with mean of age of 3 years (median, 2 years). The cutoff points (determined through receiver operating characteristic curve analysis) for suggesting pleural drainage were pH $\leq$ 7.29 (89.2% sensitivity and 76.5% specificity), score $\geq$ 5.0 (68.7% sensitivity and 81.7% specificity). These values were more strongly correlated with the need for drainage ($p = 0.001$), as were those reported in the literature (pH = 7.0 and glucose $\leq$ 40). The lactate dehydrogenase did not prove to be a good parameter for indicating a need for drainage.

Conclusion: In addition to the purulent aspect, pH = 7.29 and score were the best indicators of the need for chest-tube drainage in pediatric patients with parapneumonic effusion. However, we suggest that some score variables be readjusted to improve the usefulness of this particular scoring system

J Bras Pneumol 2005; 31(3): 205-11.

Key words: Empyema. Pleural effusion. Pneumonia.

*Study carried out in the Postgraduate Department of the Universidade Estadual de Campinas - UNICAMP, Campinas, SP
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Submitted: 18 December 2003. Accepted, after review: 21 March 2005.

INTRODUCTION

Pneumonia is the main cause of mortality among children of less than five years of age. Pneumonia causes from 10% to 30% of hospitalizations, and pleural effusion is the most prevalent complication. Mortality due to pneumonia is higher in children below the age of two years. Incidence is higher in developing countries. It has been reported in some studies that the mortality rate ranges from 10% to 12% in hospitalized children submitted to antibiotic therapy, and that the disease is responsible for 80% to 85% of deaths due to respiratory diseases[1-3].

In studies involving adult patients, pleural effusion has been found in approximately 40% of patients diagnosed with bacterial pneumonia, 10% of which later develop empyema[4-8]. It has been reported that the incidence of parapneumonic effusion in children ranges from 20% to 91%, with an increase in morbidity and mortality[9,10]. This incidence is alarming and calls for a better understanding of the appropriate approach to this condition, which is still responsible for a great number of complications. Complications due to parapneumonic effusion often require, in addition to antibiotic therapy, chest tube drainage. Some patients, if not submitted to drainage, may present spontaneous drainage through the chest wall (empyema necessitans) or lung entrapment[11,12].

By definition, parapneumonic effusion is pleural effusion related to pneumonia and may appear in either a complicated or uncomplicated form. Complicated parapneumonic effusion consists of an exudate that can be purulent, present germs in culture/Gram stain or (in the biochemical analysis) have a pH lower than 7.0, glucose levels lower than 40 mg/dL and lactate dehydrogenase (LDH) higher than 1000 IU/L. Uncomplicated parapneumonic effusion consists of an exudate that is reactive to the pulmonary infection, is not purulent, presents no germs in culture/Gram stain, and (in the biochemical analysis) has a pH higher than 7.2, glucose levels higher than 40 mg/dL and LDH lower than 1000 IU/L[6,10].

Surgical treatment of complicated parapneumonic effusion is controversial and, in pediatrics, is based on the personal experience of the pediatrician or on the limited number of studies available in the literature. Macroscopic analysis, as well as biochemical and bacteriological testing of the pleural fluid, may help professionals evaluate whether or not surgical drainage is necessary[6,10].

The Hospital das Clínicas of the Universidade Estadual de Campinas (State University at Campinas) is a tertiary-care hospital. In an attempt to reduce the morbidity and mortality related to parapneumonic effusion, as well as to reduce both hospital stay and complications related to this disease, the staff of the Pediatrics Department, together with the pediatric surgery team, devised a scoring system based on clinical, radiologic and laboratory data in the literature. The objective of this study was to evaluate the effectiveness of this scoring system and of the variables used in the literature as indicators of the need for pleural drainage in pediatric patients with parapneumonic effusion.

METHODS

This was a retrospective, cross-sectional study in which we reviewed the medical charts of 941 pediatric ward inpatients diagnosed with pneumonia between January 1994 and December 1999 at the State University at Campinas Hospital das Clínicas[13]. Of these 941 patients, 304 (32.3%) developed parapneumonic effusion. The medical charts of patients diagnosed with comorbidities (such as acquired immunodeficiency syndrome, sickle cell anemia, cystic fibrosis or postoperative complications of cardiac surgery) were excluded from the study, as were those that were incomplete or illegible. A total of 54 charts were excluded. Therefore, the medical charts of 250 patients diagnosed with parapneumonic effusion were included in the study.

Data were collected using a single protocol that was conducted exclusively by the author. The Ethics Research Committee of the Faculdade de Ciências Médicas of the Universidade Estadual de Campinas (State University at Campinas School for Medical Sciences) approved the study, in accordance with the recommendations regarding research on human beings made in Ministry of Health Resolution 196 (1996).

Using the above mentioned scoring system, closed pleural drainage is indicated if the score is higher than 5.5 (cutoff value). This scoring system was designed between 1984 and 1990, with an initial cutoff value of 4.5. However, when we observed that patients in whom the drains were left in place for only 24 to 48 hours presented rapid improvement (calling into question the real need for drainage), the scoring system was revaluated, and a cutoff value of 5.5 was adopted in 1990. The components of the scoring system used in this study are listed in Chart 1.

CHART 1

Score for the individual components of the scoring system used to assess the need for chest tube drainage. According to this classification system, patients scoring higher than 5.5 points should be submitted to drainage

Scoring system component	Score
1. Macroscopic aspect of pleural fluid:	
a) purulent	3.0
b) turbid	1.0
c) bright yellow	0.0
2. Chest X-ray presenting:	
a) minor or moderate parapneumonic effusion (less than half of the hemithorax)	1.0
b) major effusion (more than half of the hemithorax)	2.0
c) mediastinum deviation	3.5
3. Biochemical testing of pleural fluid:	
a) pH < 7.2	0.5
b) glucose < 50 mg/dL	0.5
c) positive smear microscopy	2.0
d) cytology: pus cells	2.0
neutrophil predominance	1.5
e) positive culture	1.0
f) pleural protein/serum protein ratio > 0.5	0.75
g) pleural LDH/serum LDH > 0.5	0.75
4. Second puncture (after 72 hours)	2.0

LDH: lactate dehydrogenase

We used either a pH meter or a gas blood analyzer in order to determine the pleural fluid pH. Due to their unreliability, we did not use pH strips to determine pleural fluid pH. The best method for this determination is using a blood gas analyzer, although a pH meter also seems to be reliable. Pleural fluid testing was carried out in the hospital emergency laboratory. Samples were tested immediately after collection[14].

We used the chi-square test to compare patients who had been submitted to drainage to those who had not. We used Fisher's exact test when the collected data were lower than 5. Since the results presented extreme discrepancies and did not follow normal distribution, we used the non-parametric Mann-Whitney (Wilcoxon) test for leukocyte counts. We accepted an alpha error of 5% for test interpretation. The Spearman correlation coefficient was used to determine the correlation between drainage and leukocyte count, between score and pH, between score and glucose, and between score and LDH. Receiver operator characteristic (ROC) curves were determined for pH, LDH, glucose and score (Chart 1) in order to establish a new cutoff point, with higher specificity and sensitivity for the discrimination between the groups of patients submitted or not submitted to drainage[15-19].

For statistical analysis purposes, our sample of 250 patients was subdivided into 5 groups. Group I comprised 121 patients submitted to drainage who presented at least one of the following characteristics: positive pleural fluid smear microscopy, positive pleural fluid culture, purulent pleural fluid, worsened condition or no improvement after conservative treatment during the first 5 days of hospitalization and subsequent drainage, requiring a second puncture due to reaccumulation of pleural fluid within 24 hours, and prolonged chest-tube drainage (for more than 7 days). Group II consisted of 18 patients submitted to drainage and pleural fluid collection but not presenting any of the characteristics of Group I. Group III comprised 72 patients not submitted to drainage from whom pleural fluid was collected and who presented none of the characteristics of Group I. Group IV comprised 10 patients not submitted to drainage but presenting any of the characteristics described for Group I; Group V, consisted of 29 patients not submitted to drainage and from whom pleural fluid could not be obtained during thoracentesis.

Groups I and III were considered reliable since

TABLE 1

Pleural fluid pH values, correlated with the need for chest tube drainage in patients hospitalized due to parapneumonic effusion on the Pediatric Ward of the *Universidade Estadual de Campinas Hospital das Clínicas* between 1994 and 1999

pH values	*n*	No drainage	Closed drainage	Open drainage*
d" 7.0	25	2 (8%)	23 (92%)	11(68.8%)
7.1 to 7.2	12	3 (25%)	9 (75%)	5(31.3%)
> 7.2	28	17(60.7%)	11 (39.3%)	-
Total	65	22	43	16

*Patients submitted to open drainage had previously been submitted to closed drainage.

they were selected in accordance with data in the literature describing indicators of the need for drainage, taking into account neither biochemical testing of pleural fluid nor score. The analyses were carried out both within these groups and among those formed according to other variables, such as pH determination, score, glucose, LDH, and patients submitted or not submitted to drainage.

RESULTS

Patients ranged from one month to fourteen years of age (median, two years), and 146 (58.4%) of the patients were male.

Of the patients included in the study, 130 (52%) presented parapneumonic effusion in the right hemithorax, 113 (45.8%) in the left hemithorax, and only 4 (1.6%) presented bilateral parapneumonic effusion.

Of 227 (90.8%) patients submitted to thoracentesis, pleural fluid was removed in the first puncture from 213 (85.2%), and 40 (16%) had to be resubmitted to the procedure after 24 to 48 hours.

TABLE 2

Glucose levels in pleural fluid, correlated with the need for chest tube drainage in patients hospitalized due to parapneumonic effusion on the Pediatric Ward of the *Universidade Estadual de Campinas Hospital das Clínicas* between 1994 and 1999

Glucose values	*n*	No drainage	Drainage
d" 40	80	14 (17.5%)	66 (82.5%)
41 to 50	13	6 (46.2%)	7 (53.8%)
> 50	84	46 (54.8%)	38(45.2%)

Chest tube drainage was indicated for patients scoring = 5.5 and for those presenting purulent pleural fluid, as well as for those with more severe clinical characteristics such as toxemia and intense dyspnea, which are not assessed in the scoring system but were taken into consideration by the physicians who evaluated the patients. In the present study, biochemical variables were analyzed in isolation and compared to patient scores, incidence of drainage and occurrence of complications.

Pleural fluid pH values were available in 65 medical charts. Lower pH, especially pH of less than 7.2, correlated with more complicated evolution and a greater need for chest tube drainage, including open drainage, for the resolution of the disease (Table 1).

Pleural fluid glucose levels were available in 177 medical charts. When glucose levels were lower, especially if lower than 50 mg/dL, the need for chest tube drainage was higher, (Table 2). However, these differences were less significant than those observed for pH values.

In the present study, 139 children were submitted to closed drainage, and it was maintained, on average, for 9 ± 5 days (median, 8 days; range, 1 to 30 days), whereas 56 patients (40.6%) were submitted to open drainage for a mean of 7 ± 5 days (median, 6 days; range, 2 to 25 days).

Of the patients from whom pleural fluid was collected, all data related to the scoring system were recorded in the charts of 46. However, 200 patients whose charts were incomplete were also submitted to the scoring system. A total of 88 patients presented scores = 5.5 and consequently were candidates for chest tube drainage. Of all the patients submitted to closed drainage, 49 (43.8%) scored less than 5.5, and 10 (9%) had to be submitted to open drainage and thoracoscopy in order to clear the pleural cavity.

TABLE 3

Cutoff points obtained from the Receiver Operator Characteristic curve, showing the sensitivity and specificity of each parameter analyzed in pleural fluid samples of patients hospitalized due to parapneumonic effusion on the Pediatric Ward of the *Universidade Estadual de Campinas Hospital das Clínicas* between 1994 and 1999, compared to parameters found in the literature

Variables	Cutoff point	Sensitivity (%)	Specificity (%)
pH	**7.29**	**89.2**	**76.5**
pH	7.00	40.5 - 67.6	41
Glucose	**45 mg/dL**	**68.7**	**81.7**
Glucose	40 mg/dL	65.7	81.7
LDH	**4772.5 mg/dL**	**40.3**	**35**
LDH	1000 mg/dL	81.8	30.4

Values in bold correspond to those obtained in the present study; other values are those reported in the literature.

In 50 patients (56.8%) whose scores were > 5.5, the pleural fluid was not purulent. In this group of patients, either the score or biochemical testing would be more useful indicators.

A statistically significant correlation was found between pleural fluid pH < 7.0 and pleural fluid glucose < 40 mg/dL, although this correlation was stronger in Group I than in Group III (p = 0.001 in both groups, according to chi-square test). The Spearman correlation coefficient showed the lowest pH values and lowest glucose values to correlate with the highest scores (r = -0.61 in both cases).

In the present study, LDH values < 1000 and > 1000, respectively, presented no statistically significant difference when analyzed and compared between Groups I and III (p = 0.117). Values of LDH > 1000 were more frequently found in most patients, whether or not they had been submitted to drainage.

Scores > 5.5 were more common in Group I (p = 0.001).

Using the ROC curve, we determined the cutoff points with the highest sensitivity and specificity for the indication of chest tube drainage. The cutoff points were: 7.29 for pH (89.2% sensitivity; 76.5% specificity); 45 mg/dL for glucose (68.7% sensitivity; 81.7% specificity); 4772 for LDH (40.3% sensitivity; 35 % specificity) (Table 3); and 5.4 for the score (70.4% sensitivity; 100% specificity) (Table 4).

In addition to the analysis based on the groups described above, we also analyzed the group of 46 patients for whom all elements of the score were assessed. The statistical evaluation of the scoring system failures demonstrated that the results were less than significant (p = 0.497 using the chi-square test), although 43.8% of the patients with scores < 5.5 had been submitted to drainage. The ROC curve of this group showed a cutoff point of 4.87, with 78.1% sensitivity and 64.3% specificity (Table 4).

DISCUSSION

In developed countries, the incidence of empyema in pediatric inpatients ranges from 0.11% to 0.5%, and, in select groups in Brazil, this

TABLE 4

Comparison between drainage parameters and their respective sensitivity and specificity values in patients hospitalized due to parapneumonic effusion on the Pediatric Ward of the *Universidade Estadual de Campinas Hospital das Clínicas* between 1994 and 1999

Parameters	Values	Sensitivity (%)	Specificity (%)	
Score (Groups I and III)		5.4	70.4	100
Score (group of 46 patients with complete score)		4.87	78.1	64.3
Pleural fluid pH		7.29	89.2	76.5
Glucose level in pleural fluid		45	68.7	81.7

incidence ranges from 5% to 46%[2,20,21]. The mortality rate among children hospitalized with pneumonia and submitted to antibiotic therapy in Brazil has been reported to be as high as 12%[1]. In the present study, the incidence of parapneumonic effusion in pediatric inpatients with pneumonia was 32.3%. This is probably due to the fact that the patients were hospitalized in a tertiary-care hospital, which receives (by referral) patients with more severe diseases or complications.

In accordance with the results of other studies, the prevalence of parapneumonic effusion was found to be higher among male patients younger than two years of age. It has been suggested that the condition is more frequently seen in the right hemithorax[11,12,20,21]. However, the discrete difference demonstrated in the present study does not seem to be significant.

Since other biochemical parameters - although correlated with the difference between exudate and transudate - have not been correlated with the therapeutic decision, they were not analyzed in the present study. Positive smear microscopy, positive culture and purulent pleural fluid, without being evaluated separately, were considered indicators of the need for drainage. This is in accordance with the findings of other studies in the literature[6,7,11,12,21-26].

Regarding the biochemical aspects, more recent studies involving adults[4,7,25,27,28] and children[12,14,21,29,30] have shown that drainage is indicated for parapneumonic effusion patients who present a pH < 7.0 - 7.2 or a glucose level < 40 mg/dL. In the present study, there were statistically significant correlations between the need for drainage and each of these values as reported in the literature. However, in relation to the ROC curve, cutoff points of 7.29 for pH and of 45 mg/dL for glucose levels showed greater sensitivity and specificity in the indication for chest tube drainage (Table 3).

The use of the Spearman correlation coefficient revealed no correlation that would allow any conclusions to be drawn regarding the relationship between the leukocyte count in pleural fluid and the frequency of the use of drainage (r = 0.145).

It has been reported that pleural fluid must be appropriately sampled and, in order to obtain reliable results, pH tests must be carried out using a blood gas analyzer rather than pH strips[14,21,30]. In the laboratory of the State University at Campinas Hospital das Clínicas, pH determinations were initially carried out using a blood gas analyzer but are currently conducted using a pH meter adapted for organic fluid testing, the latter method having been seldom reported in the literature.

In the analysis of biochemical variables, we found a great variation in the sample size for each variable. However, since these data were tested in isolation, we believe there was no methodological interference in the results.

The ROC curve cutoff point for the score differed between the two groups in which it was tested (the group with all scores and the group with complete scores). If we consider the group with complete scores as the most reliable one, the cutoff point for the need for drainage would be 4.87, which, by approximation, would be rounded up to 5. However, various serum and pleural fluid tests are necessary in order to determine the score (Chart 1), including the study of unreliable parameters used as indicators for drainage, such as the serum protein/pleural fluid protein ratio and serum LDH/pleural fluid LDH ratio, which could be excluded from the scoring system. The scoring system gives little importance to parameters such as pH and glucose (the cutoff point for the latter is too high for the indication for drainage). These data suggest that the pH value and glucose level could be increased, establishing new cutoff points such as those determined from the ROC curve (7.2 for pH and 45 mg/dL for glucose). The length of time required to obtain the results of pleural fluid culture makes it a test that is impractical for use in the initial evaluation and consequent therapeutic decision. Therefore, its inclusion in the scoring system should be reevaluated. The predominance of neutrophils component is not very useful and should simply be excluded since laboratory professionals have reported that the samples collected are either unusable or insufficient for its determination. Therefore, since it is known that the scoring system is a good parameter for indicating the need for drainage, changing some of its components and values could make it even more efficient as a predictor of the need for chest tube drainage. When such modifications have been adopted, a new prospective study should be carried out in order to validate the new scoring system.

A (ROC curve-determined) pH value of 7.29 is higher than that typically found in the literature. However, according to Wheeler et al.[3], the few studies that have evaluated the application of Light's criteria

in pediatric patients have suggested that this criterion for glucose would be appropriate for use in children. However, regarding pH values, the cutoff point for the indication of drainage should be higher for children than for adults. This difference might be related to the fact that pneumonia is the principal cause of the pleural exudative process in children, whereas most adult cases result from congestive heart failure or cancer. The most common cause of adult empyema is pneumonia.

Comparing biochemical values in isolation, as well as those of the scoring system, in terms of sensitivity and specificity, the present study showed that pH is the best indicator of the need for drainage, followed by the score and the glucose level in pleural fluid (Table 4).

ACKNOWLEDGMENTS

I would like to thank my family, friends and workers at the Hospital das Clínicas and at the Faculdade de Medicina of the Universidade Estadual de Campinas.

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