

Influence of the Method Used to Obtain Pleural Fluid on the Determination of the Acid-Base Balance

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OBJECTIVE: To analyze the methods used in our hospital for obtaining pleural fluid to determine the acid-base balance and to evaluate the clinical repercussions of each method.

METHODS: Initially we studied the methods used by physicians in our hospital to collect pleural fluid for determination of the acid-base balance. In a second phase, we performed a prospective, descriptive, comparative study with the participation of 71 patients with pleural effusions in order to compare the acid-base balance according to the technique used to obtain the fluid.

RESULTS: Pleural fluid was obtained using 3 methods: *a*) direct extraction using a heparinized syringe (group 1); *b*) extraction using a 20-mL syringe with subsequent aspiration from this syringe into a heparinized syringe (group 2); and *c*) filling a heparinized syringe from the 20-mL syringe (group 3). The only significant differences between group 1 and groups 2 and 3 were an increase in the pleural PO₂ and oxygen saturation. The difference in the mean pH between groups 1 and 2 was 0.009 (95% confidence interval: -0.39 to 0.02; *P*=.5) and between groups 1 and 3 was 0.007 (95% confidence interval: -0.38 to 0.023; *P*=.6). The correlations between findings for PO₂, pH, and PCO₂ obtained in the different groups were statistically significant, with values superior to .95 in the last 2 variables.

CONCLUSIONS: Physicians who perform thoracentesis in our hospital use different methods for obtaining fluid to determine the pleural acid-base balance. The 3 methods analyzed show no significant differences with regard to pH or PCO₂. Pleural fluid may be obtained by a single puncture with a large-volume syringe, subsequently transferring the fluid to a heparinized syringe without this significantly affecting the pH or PCO₂, thus reducing the number of manipulations and the risk of complications.

Key words: *Pleural effusion. pH. Thoracentesis.*

Importancia de la forma de obtención del líquido en la determinación del equilibrio ácido-base pleural

OBJETIVO: Analizar las formas de obtención del líquido para determinar el equilibrio ácido-base pleural en nuestro medio y su influencia o relevancia clínica.

MÉTODOS: En una primera fase se describieron las formas en que los médicos de nuestro hospital obtenían el líquido para determinar el equilibrio ácido-base pleural. En una segunda fase se realizó un estudio prospectivo, descriptivo y comparativo de 71 pacientes con derrame para comparar el equilibrio ácido-base pleural según las formas de obtención.

RESULTADOS: El líquido pleural se obtenía de 3 formas distintas: *a*) extracción directa con jeringa heparinizada (grupo I); *b*) extracción con jeringa de 20 ml, aspirando de esta jeringa con la jeringa heparinizada (grupo II), o *c*) llenando la jeringa heparinizada con la jeringa de 20 ml (grupo III). Se observó un aumento significativo sólo en los valores de la presión parcial (PO₂) y saturación de oxígeno entre el grupo I y los grupos II o III. La diferencia de las medias del pH entre los grupos I y II fue de 0,009 (intervalo de confianza del 95%, -0,039 a 0,02; *p* = 0,5), y entre los grupos I y III, de 0,007 (intervalo de confianza del 95%, -0,038 a 0,023; *p* = 0,6). Las correlaciones entre los distintos grupos de la PO₂, pH y presión parcial de anhídrido carbónico (PCO₂) fueron estadísticamente significativas y con valores superiores a 0,95 en las 2 últimas.

CONCLUSIONES: Los médicos que realizan las toracocentesis en nuestro hospital procesan de formas distintas el líquido para determinar el equilibrio ácido-base pleural. Las 3 formas analizadas no mostraron diferencias significativas en cuanto al pH y la PCO₂. La obtención del líquido puede realizarse con una única punción con jeringas de mayor capacidad, para posteriormente llenar la jeringa heparinizada, sin que se modifiquen de forma significativa los valores del pH y la PCO₂, y con una disminución del número de manipulaciones y el riesgo de complicaciones.

Palabras clave: *Derrame pleural. pH. Toracocentesis.*

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Introduction

Consideration of the general characteristics of pleural fluid and its analysis are essential in the management of pleural effusions.¹⁻³ In the analysis of the acid-base balance, pleural pH is the most widely used parameter because of

its diagnostic, prognostic, and therapeutic implications.³⁻⁵ The utility of PCO₂, which is directly related to pH, and PO₂ is more debatable and they are not usually systematically measured in pleural fluid.^{3,6,7}

For the determination of the acid-base balance, fluid must be withdrawn directly from the pleural space using a separate heparinized syringe, avoiding mixing with the local anesthetic, and analyzed anaerobically.^{3,7,8} However, in our experience, physicians who perform thoracentesis do not always follow the same procedure. It is not uncommon to avoid transferring fluid between syringes and to perform 2 independent punctures (a heparinized syringe for the pH and another syringe for the other measurements); on other occasions, a single syringe is used and the sample is then divided, although the possible effects of these changes of syringe and manipulations on the acid-base balance are not accurately known.

The aims of the present study were both to identify the different methods used in our hospital to obtain pleural fluid for measurement of the acid-base balance and to evaluate the influence of these methods on the values measured, particularly with respect to differences in the pH, PO₂, and PCO₂, and their clinical relevance.

Methods

The study was performed in a tertiary hospital between January 2005 and March 2006, with 2 consecutive phases.

First Phase

Those physicians who habitually perform thoracentesis in our hospital participated in a cross-sectional, descriptive study to identify the methods used to obtain pleural fluid to determine the acid-base balance. The information was gathered by direct questioning or by observing the procedure. All specialist and resident physicians in chest medicine and thoracic surgery and more than half of those working in the emergency department, internal medicine, or intensive care medicine were interviewed.

Second Phase

A prospective, descriptive study was performed on a total of 71 patients admitted to our hospital with a pleural effusion not studied or investigated in the previous 30 days. Thoracentesis using all 3 of the methods detected in the first phase was performed in all these patients in order to collect pleural fluid in a heparinized syringe for analysis of the acid-base balance.

With the patient in a sitting position, thoracentesis was performed under local anesthesia (2% mepivacaine hydrochloride without vasoconstrictor, Scandinibsa, Inibsa SA, Barcelona, Spain) administered using a 10-mL syringe. Three different 20-mL syringes were then used to obtain a sample of 60 mL for biochemical (proteins, glucose, lactate dehydrogenase, amylase, cholesterol, and adenosine deaminase), microbiological (microscopy and culture), and cytologic studies. For the thoracentesis, 3- to 4-mL of local anesthetic were injected into the skin and intercostal space down to the parietal pleura, without entering or injecting into the pleural space at any time during the procedure and discarding the syringe in order to avoid interference of the anesthetic with the pH values.⁸ Those patients who did not sign the informed consent form, with contraindications for thoracentesis,⁹ traumatic puncture, with fluid that was purulent or contained clots, in whom insufficient

fluid was obtained for the measurements, or in whom the acid-base balance of the pleural fluid could not be analyzed within the first 10 minutes after extraction⁷ were excluded. The effusions were classified into transudates or exudates based on the Light criteria.³ Measurements in plasma were performed within 24 hours after the thoracentesis.

Determination of the Acid-Base Balance in the Pleural Fluid

Two-to-three mL of pleural fluid were passed slowly into each heparinized syringe (3-mL syringe for arterial blood samples with 200 units of heparin and a 22F needle, Quick ABG, Marquest, Englewood, Colorado, USA; ref. 4022) taking care to avoid the presence of residual air bubbles by elimination of part of the fluid loaded into the syringe before its subsequent closure. The syringes were opened and used once only at the time of processing the samples. The syringes loaded from each patient using the various techniques for obtaining the fluid were transported to the laboratory to determine the acid-base balance within 10 minutes of having performed the thoracentesis. The order in which the different syringes from a single patient were tested was altered each time (the first syringe tested from a patient became the last one tested in the following patient).

The acid-base balance was determined throughout the study using the same machine (model 248 gas analyzer, Ciba Corning Diagnostics, Medfield, Massachusetts, USA) with hourly calibration of the system. The determinations were performed using samples of 60 to 85 μ L at 37°C \pm 0.15°C in less than 60 seconds, with a wash out every 30 minutes to prevent obstruction. The pH, PO₂, and PCO₂ were measured and the system calculated the base excess, true or plasma bicarbonate, standard bicarbonate, estimated oxygen saturation, and total carbon dioxide.

Statistical Analysis

A descriptive analysis of the techniques used by the staff in our hospital to obtain the pleural fluid in order to determine the acid-base balance was performed for the overall sample of physicians and by specialty. For the second phase of the study, the descriptive data were compiled for the principal characteristics of the patients included in the study and the type of pleural effusion and its etiology. An independent analysis of the acid-base balance was performed for each of the techniques used to obtain the pleural fluid. These values were compared using as reference the values recorded after obtaining the fluid directly from the pleural space. Comparisons were performed using the *t* test and the Pearson correlation coefficient. All analyses were performed using the SPSS 11.0 program (SPSS Inc, Chicago, Illinois, USA). Statistical significance was taken as a *P* value less than or equal to .05.

Results

Table 1 shows the different methods used to obtain pleural fluid to determine the acid-base balance and the distribution of these methods among the staff in our hospital. The 3 forms used were *a*) direct aspiration from the pleural cavity using a heparinized syringe (group 1), *b*) aspiration of the sample using a 20-mL syringe, subsequently aspirating fluid from this syringe into a heparinized syringe (group 2), and *c*) using the fluid from the 20-mL syringe to fill the heparinized syringe (group 3).

Table 2 shows the principal characteristics of the patients studied in the second phase of the study. The group of patients with pleural tumors included 26 patients with

TABLE 1
Methods for Obtaining Pleural Fluid for Determination of the Acid-Base Balance and Their Distribution Among the Physicians of Our Hospital^a

Department	Number of Physicians Studied	Age, y	Men	Groups		
				1	2	3
Pulmonology	10	44 (12)	8 (80%)	4 (40%)	3 (30%)	3 (30%)
Thoracic surgery	4	38 (12)	2 (50%)	1 (25%)	3 (75%)	0
Internal medicine	21	38 (13)	8 (38%)	6 (29%)	11 (52%)	4 (19%)
Emergency department	12	31 (4)	3 (25%)	0	6 (50%)	6 (50%)
Intensive care	13	35 (9)	3 (23%)	1 (8%)	9 (69%)	3 (23%)
Overall	60	37 (11)	25 (42%)	12 (20%)	32 (53%)	16 (27%)
Residents	27	28 (3)	4 (15%)	5 (18%)	10 (37%)	12 (44%)

^aData are given as mean (SD) or number (percentage). Group 1: direct aspiration of the fluid from the pleural cavity using the heparinized syringe; group 2: aspiration into a heparinized syringe from a 20-mL syringe used to obtain the pleural fluid directly; group 3: filling of the heparinized syringe with the liquid obtained using the 20-mL syringe.

adenocarcinomas (15 of pulmonary origin, 5 from the breast, 4 from the stomach, and 2 from the ovary), 4 malignant mesotheliomas, and 1 lymphoma. The important conditions among the nonneoplastic lesions were 7 parapneumonic effusions, 4 cases of tuberculous pleuritis, 6 cases of heart failure, 3 cases of chronic liver

TABLE 2
Principal Characteristics of the Patients in the Second Phase of the Study (n=71)^a

Age, y	67 (12)
Men	47 (66%)
Smokers	37 (52%)
Right-sided effusion	31 (44%)
Unilateral effusion	61 (86%)
Massive effusion	34 (48%)
Effusion 1/3 of hemithorax	19 (27%)
Transudate	4 (6%)
Lymphocytic exudate	51 (72%)
Neutrophilic exudate	13 (18%)
Malignant etiology	31 (44%)
Glucose in pleural fluid, mg/dL	96 (59)
Proteins in pleural fluid, g/dL	4.9 (6)
Lactate dehydrogenase in pleural fluid, U/L	707 (688)
Cholesterol in pleural fluid, mg/dL	82 (30)
Red blood cells/ μ L in pleural fluid	57 812 (152 000)
White cells/ μ L in pleural fluid	57 812 (152 000)
Percentage of lymphocytes in pleural fluid	68 (22)

^aData are given as mean (SD) or number of patients (percentage).

TABLE 3
Values of the Acid-Base Balance in the Pleural Fluid and Its Comparison Between the 3 Methods for Obtaining the Fluid to Be Analyzed^a

Group	1	2	3
pH	7.337 (0.09)	7.344 (0.09)	7.346 (0.09)
PCO ₂ , mm Hg	54.9 (10)	53.7 (10)	53.7 (10)
PO ₂ , mm Hg	42.4 (15)	49.5 (18) ^b	49.3 (16) ^b
True HCO ₃ ⁻ , mmol/L	28.8 (6)	28.6 (5)	28.7 (5)
Std HCO ₃ ⁻ , mmol/L	25.5 (6)	25.7 (5)	25.5 (6)
BE, mmol/L	4.5 (4)	4.5 (4)	5.7 (10)
SaO ₂ , %	67.5 (22)	74.8 (22) ^b	74.4 (21) ^b
CtCO ₂ , mmol/L	30.5 (6)	30 (5)	30 (7)

^aData are shown as mean (SD). Abbreviations: BE, base excess; CtCO₂, total carbon dioxide; SaO₂, oxygen saturation; Std, standard.

^bP<.05 on comparison with the values in group 1.

disease, 2 pulmonary emboli, and 2 postcardiac-surgery effusions; the remainder were nonspecific pleural effusions.

Table 3 shows the values of the pleural acid-base balance using the 3 different methods for obtaining this fluid. The results for groups 2 and 3 were compared with those of group 1. Only the PO₂ and oxygen saturation were significantly higher in the patients from groups 2 and 3. The intergroup differences in the mean pH were 0.009 (95% confidence interval [CI], -0.039-0.02; P=.5) for groups 1 and 2, 0.007 (95% CI, -0.038-0.023; P=.6) for groups 1 and 3, and 0.001 (95% CI, -0.032-0.03; P=.9) for groups 2 and 3. The correlations between results from groups 1 and 2 for pH, PCO₂, and PO₂ were 0.98, 0.96, and 0.90, respectively; between results for groups 1 and 3, the correlations were 0.98, 0.97, and 0.85; and between groups 2 and 3 they were 0.98, 0.95, and 0.85. The level of significance for all these correlations was P<.05. The correlations between the different methods used to determine the pH are shown graphically in the Figure.

Discussion

Our study shows that the physicians who perform thoracentesis in our hospital use different methods to obtain pleural fluid to determine the acid-base balance. Of the 3 methods studied, the majority of physicians avoided using the system considered to be the gold standard, namely direct aspiration of the fluid from the pleural space using a heparinized syringe.³ However, the pH and PCO₂ did not vary significantly between the different methods of extraction. With the exception of the PO₂ and oxygen saturation, the 3 methods used to extract the pleural fluid to determine the acid-base balance showed no significant or clinically relevant differences, and presented good correlations, particularly with respect to pH.

Only 1 previous study has evaluated differences in pH according to the method used to obtain the pleural fluid (MEDLINE search, 1996-2007). In that study, Goldstein et al¹⁰ analyzed 20 pleural effusions, mainly of lymphocytic exudates of nonspecific etiology, without observing significant differences in the pH values between the 2 methods used to extract the fluid. They included a smaller number of patients than we did, only compared direct extraction of the fluid from the pleural space with the filling of the heparinized syringe from the fluid obtained

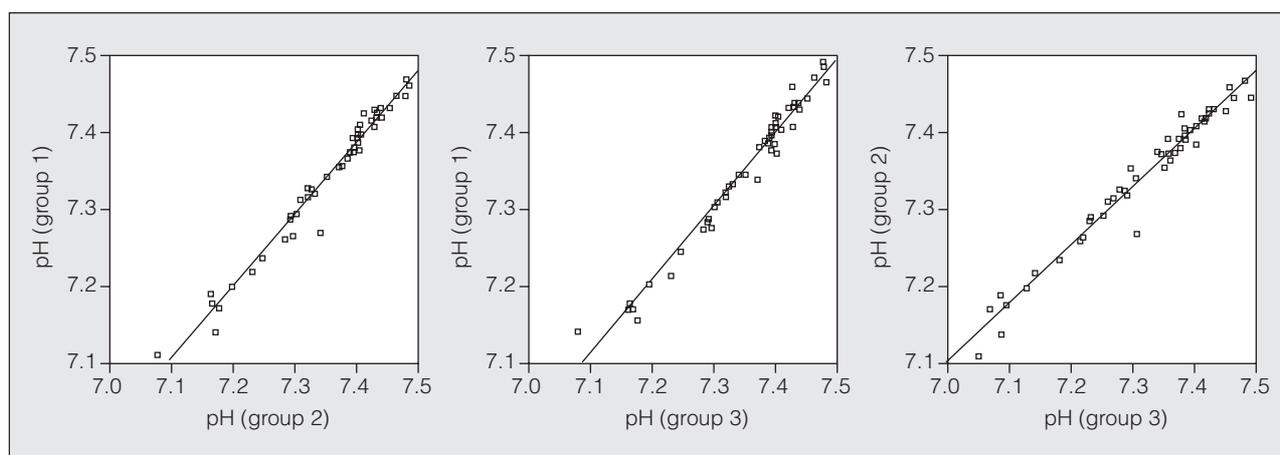


Figure. Graphs of the relationship between the pH values obtained with the different methods for collecting pleural fluid to determine the acid-base balance.

using a 30-to-60-mL syringe, and did not analyze the other parameters of the acid-base balance. Our study, with a larger number of patients and etiologies, is the only one to have analyzed the changes suffered by all the components of the acid-base balance on using 3 distinct methods to obtain the fluid, after studying the techniques used by the physicians who perform thoracentesis in our hospital. We did not find significant differences in the pH or PCO_2 values.

The absence of between-method differences in the pH and PCO_2 of the pleural fluid indicates that the method used to obtain the fluid does not affect these values. Variations in PCO_2 are usually attributed to changes in its intrapleural production or in its diffusion from the blood.^{11,12} The importance of measuring this parameter derives from its ability to alter the pH and from the fact that it increases in patients with greater metabolic activity, inflammation, or infiltration of the pleura, which would not be modified and would be independent of the method used to obtain the fluid.¹³⁻¹⁵ The pleural PO_2 was the only component that was significantly higher when techniques other than direct aspiration of the fluid were used. This parameter is the least used in the study of the pleural acid-base balance and the most susceptible to variation during handling of the fluid samples.^{7,11-13} The higher PO_2 and the stability of the other parameters analyzed in this study, despite following the current recommendations on the processing of pleural fluid and the use of gas analyzers, indicate that this technique does not prevent the entry of small bubbles of oxygen when the heparinized syringe is being filled.^{3,7,16-19} However, this increase is of little importance given the unknown clinical utility of pleural PO_2 compared to the better-known importance of the pH and PCO_2 ; nevertheless, these results are sufficient to recommend against evaluation of the PO_2 when the pleural fluid is not obtained by direct aspiration.

The absence of significant differences in the values of the pH and PCO_2 confirms that the method used to obtain pleural fluid for study of the acid-base balance does not affect the management of these patients and provides clinically useful information for the general management

of patients with pleural effusions.^{3,20-23} In daily practice, the use of a single syringe reduces the duration of thoracentesis and the risk associated with an increase in the number of manipulations or changes of syringe during the procedure. It is likely that this will reduce the risk of pneumothorax due to entry of air into the pleural space through the needles or to an accidental lesion to the lung parenchyma during the changes of syringe.^{3,10} Our study indicates that, in this type of patient, pleural fluid may be obtained with a single puncture using a larger syringe and that this fluid may be introduced into a heparinized syringe to determine the acid-base balance without risk that its values will be significantly affected.

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