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Evaluation of The Diagnostic Potential of Sonography in Pleural Effusion in Supine and Erect Positions

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Abstract

Rationale and Objectives: Chest tube insertion in patients with pleural effusion necessitates a pre-procedural evaluation of the fluid amount. Ultrasound is currently the most efficient modality for this evaluation. In this study, we aimed to seek a simple diagnostic method to evaluate the volume of pleural effusion.

Materials (patients) and Methods: This study includes 38 ICU patients who were diagnosed with pleural effusion in their chest x-ray. We measured the maximum distance from the diaphragm to the pleura in the erect position and the maximum distance from the visceral pleura to the chest wall in the supine position to estimate the amount of pleural effusion. Then we used a simple regression model to compare the estimated values with the actual amount of fluid.

Result: There is a linear relationship between the estimated values of pleural effusion in the erect and supine positions and the actual amount of fluid.

Conclusion: Maximum distance between the diaphragm and pleura in the erect position and the maximum distance between visceral pleura and chest wall could be utilized to estimate the pleural effusion volume with high accuracy in ICU patients. This could be a cost-effective simple method for the management of pleural effusion in ICU patients.

Keywords: pleural effusion; erect position; supine position; sonography; thoracosynthesis.

Introduction

Evaluation of pleural effusion is considered crucial due to its chest tube insertion which is invasive. Complications due to a misplaced chest tube are possible Pneumothorax, Hemothorax, malfunctioning tube, infection, and wound scar. Furthermore, displacing an ICU patient could result in infection, hemodynamic instability, and disconnection of the patient's IV line. The patient's position during sonography is essential in the accurate estimation of pleural effusion.

Pleural effusion is rather prevalent in ICU patients thus timely diagnosis and management are considered vital in the outcome. Sonography is assumed to be a safe, available and economical method of diagnosis; furthermore, it is preferable to Chest X-ray [1]. The minimum fluid content identified via X-Ray is nearly 150 cc, whereas much lower pleural effusion volume (5 ccs) can be seen utilizing sonography [2]. In the sonography, the volume of pleural

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effusion can be obtained and reported qualitatively and quantitatively [1–7]; In a qualitative report, the estimations of the fluid content could be classified as low, medium, and high, however from a quantitative point of view, various formulas could be used according to different patient positions, such as supine and erect positions [3].

Multiple formulas have been evaluated for supine and erect positions to estimate the amount of pleural effusion content, which is a testament to finding a single unique formula and optimum patient position during sonography. Pleural effusion is often controlled using thoracocentesis, and the actual amount of effusion is usually varied from its clinical presentation. An accurate and simple formula should be used to estimate the pleural effusion's exact volume.

This study assists us in determining not only the precise amount of the volume but also the management methods, meaning if a patient requires thoracocentesis or not. Therefore, this study aims at determining the discrepancies between the supine and erect positions of the patient during sonography.

Methodology

This study is approved by the Shahid Beheshti Medical University ethics committee. (Code: IR.SBMU.RETECH.REC.1398.125)

Our study population includes all the patients who had been admitted in the six months from November 2018 to May 2019 to the Imam Hossein hospital. The main inclusion criteria for this study were as follows;

1. ages 18 and above,
2. patients with a SOFA score of 0,1 and 2 were considered as they could obey the given instruction,
3. patients with detected pleural effusion in their radiography.

The exclusion criteria of this study were;

1. Those incapable of being positioned (SOFA scores of 3 and 4),
2. Low amounts of pleural effusion lead to no need for drainage,
3. The presence of pus, blood, or loculation (>5 mm of separation of pleural layers) resulted in incomplete emptying, [8]
4. Chest deformity, previous thoracic surgery, diaphragmatic pathology, and adhesions due to previous chest tube implantation, caused the pleural effusion not to be extracted.

After recording the patients' demographic information, i.e., age, gender, and the history of any previous conditions, the objectives of this study were explained to the patients and/or their companions for consent. A board-certified radiologist performed sonography in erect and supine positions for the patient by a [3–5] MHz convex-array probe of SonoScape (E2 Model). The distance between the diaphragm to the pleura is obtained in the erect position and the distance between the pleura and chest wall in the supine position in the mid and posterior axillary lines (Fig 1) through the intercostal spaces. This process is implemented by positioning the convex transducer perpendicular to the chest wall without angling or tilting to avoid overestimation of the pleural effusion width [3]. While patients were holding their breath, measurements were taken at the maximum inspiration. The values in the erect and supine positions perpendicular to the axis of the chest wall were measured. The estimated pleural effusion volume was further calculated via different formulas [5,9–11]. The closest estimations to our measurements were related to Balik et al [12] formula in the supine position and Usta et al [9] formula in the erect position. Afterward, the 14-French pigtail catheter was planted by an ICU specialist through the midaxillary line, and the amount of the excreted flow was obtained and recorded. It should be noted that the performing radiologist was not aware of the actual amount of the measured volumes throughout the study.

Erect (Usta): Volume= 16D

Supine (Baltik): Volume=20X

Statistical Analysis

Eventually, all the acquired data was collected and imported to SPSS software for further Statistical Analysis. A simple regression model was used to determine the predictability of the actual pleural effusion volume via the mentioned formulas in supine and erect positions.

Results

A total of 38 cases aging between 21 to 79 with a mean of 50 and a Standard deviation (SD) of 16, were available for data analysis. Table 1 depicts the mean, standard deviation, and range of pleural effusion in each position.

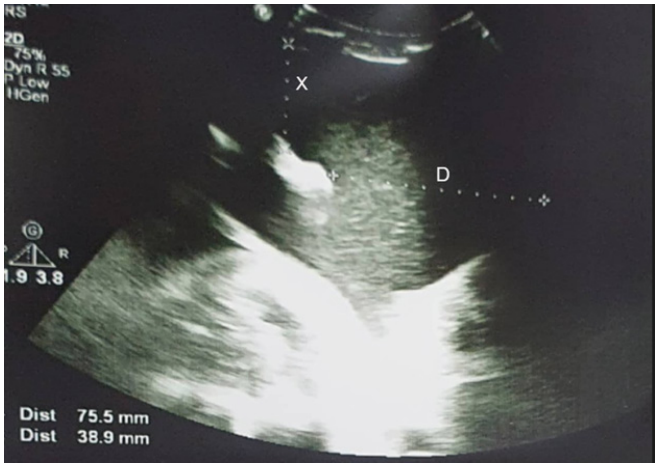

Figure 1: mid-axillary view with the convex probe for measurement of D (distance between the diaphragm and collapsed lung) and X (the distance between the chest wall and collapsed lung)

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In the first row of table 2, the relationship between erect pleural effusion versus the real amount is compared, depicting a linear relationship with a correlation factor of 99 percent with a P-value of less than 0.001. in the second row, the supine pleural effusion volume versus the actual amount is compared, which shows a statistically meaningful relationship with a correlation factor of 99 percent and a P-value of less than 0.001.

Figure 2 and 3 depict a simple linear regression to show the dependent and independent variable relationships alongside each other. Of note, the relationship between supine and erect pleural effusions has been investigated, which shows a meaningful linear relation with a correlation factor of 99 percent and a P-value of less than 0.001.

Table 1: Average, Standard deviation, and range of each variable

	Mean ± SD	Range (min-Max)
Drained Effusion	1564.47±445.53	800-2500
Erect (Usta)	1531.79±426.54	784-2500
Supine (Baltik)	1565.26±420.31	780-2500

Table 2: Results from two different positions and the actual amount of pleural effusion

	Effusion	P-value
Erect	0.99	<0.001
Supine	0.994	<0.001

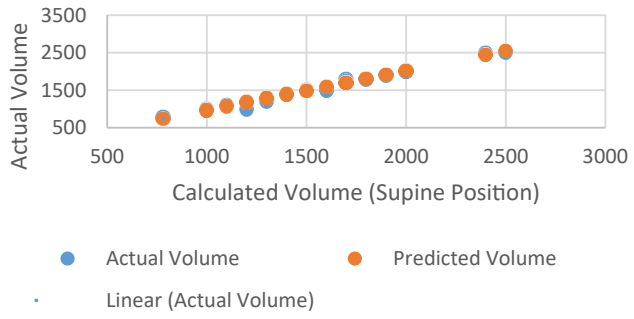

Figure 2: Volume (Supine Poisiton) Line Fit Plot

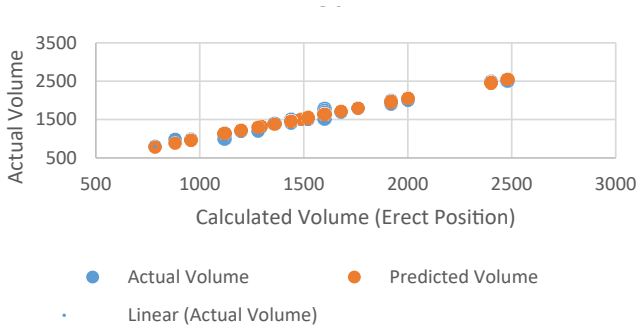

Figure 3: Volume (Erect Poisiton) Line Fit Plot

Due to the linear relationship between the volume of pleural effusion obtained from the two positions and an apparent interaction between the two variables, they could not have been inserted simultaneously in a regression model to obtain a linear model regarding their relationship with the real pleural effusion amount.

The results implicate that measuring the distance between the lung and diaphragm, and the distance between a collapsed lung and the chest wall could be used to estimate the pleural effusion in the erect and supine positions, respectively. (P value<0.001)

Discussion

The earliest case study regarding the patients in supine position was conducted by Schwerk et al. in 1990 [6]. In another study by Mathis et al. in 2011, it is deduced that the effusion estimation in the erect position is more precise than in supine [4]. Bolanle et al. implemented a study in 2018 consisting of 32 cases with pleural effusion and compared the four formulas used to estimate pleural effusion volume. Their study suggests that the erect position was preferred versus the supine position [1]. in 1994, Eibenberger et al. concluded that based on their study, the supine position was preferable to the erect position [3]. In another study that Balik et al. implemented in 2006, it is stated that the supine position estimation of the pleural effusion is more precise than that of the erect. However, different formulas were used in their study [5]. Maged Hassan et al. have compared and investigated a variety of formulas and deduced that the formula presented by Schwerk et al. was more precise and exact [2]. In a study by Roch et al., 44 patients with mechanical ventilation were considered. The relationship between the distance of the parietal and visceral pleura in the supine position and the volume of the drained effusion was found [10]. Usta et al. detected a robust relationship between the distance of the mid-diaphragm to the visceral pleura in the erect position and the volume of the effusion in cases that had undergone heart surgery [9].

Conclusion

The calculation of the pleural effusion using simple sonographic parameters in the ICU setting, in the erect and supine positions, could estimate the actual amount of fluid in patients with pleural effusion volume of 500-3000 cc. Furthermore, the obtained volume could be utilized in consequent management.

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