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# INCIDENCE OF PNEUMOTHORAX AFTER THORACENTESIS AND FACTORS ASSOCIATED WITH ITS OCCURRENCE

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## ABSTRACT

***Objectives*: We embarked on this observational study (a) to determine the rate of occurrence of pneumothorax after thoracentesis and (b) to identify patient-related and procedure-related risk factors that may be associated with the development of pneumothorax post-thoracentesis.**

***Methodology*: This observational study covered the period July 2005 – July 2006. We included patients 18 years old and above who underwent thoracentesis for a pleural effusion documented by an upright chest radiograph. The primary outcome was the occurrence of pneumothorax after thoracentesis. Data on potential patient-related and procedure-related risk factors for pneumothorax were also collected.**

***Results*: Fifty-seven patients with pleural effusion were included and they underwent a total of 62 thoracenteses. There were 3 incidents of pneumothorax, with a rate of 4.8% (Binomial exact 95% CI 1.0 - 13.5%). No associations can be made between patient-related and procedure-related risk factors and the occurrence of pneumothorax after thoracentesis because of the very small number of episodes of pneumothorax in this study.**

***Conclusion*: Thoracentesis is a low-risk procedure performed in a patient with pleural effusion, either for diagnostic or therapeutic indications or both.**

***Keywords*: Pneumothorax, thoracentesis, pleural effusion**

## INTRODUCTION

Thoracentesis is a bedside procedure valuable in the evaluation and management of pleural effusion. This procedure entails the insertion of a sterile needle into the pleural space. Technically, thoracentesis is relatively uncomplicated, well tolerated and quite safe.

However, various complications have been associated with this procedure, the most frequent of which is pneumothorax occurring in 3% to 20% of the patients in whom it is performed as shown by the studies of Bartter *et al.*[1] Studies conducted abroad report variable incidence rates. Several factors contributing to the occurrence of pneumothorax post-thoracentesis were identified in international studies, but findings were inconsistent. Locally, there are no formal studies that have documented the experience of institutions with regards to the incidence of pneumothorax and the possible factors associated with its development. Thus, this observational study was conducted to determine the rate of occurrence of pneumothorax after thoracentesis and to identify patient-related and procedure-related factors that may be associated with the development of pneumothorax. Identification of modifiable or preventable factors can lead to the formulation of recommendations that can minimize the risk and eventual development of pneumothorax after thoracentesis.

## MATERIALS AND METHODS

### *Study Sample*

The study was conducted from July 2005 to July 2006 in the Philippine General Hospital. Eligible patients were at least 18 years old and above, with pleural effusion documented by an upright chest radiograph. Patients should have undergone thoracentesis performed by a physician from the Department of Medicine, and had a post-procedure chest radiograph. Excluded were patients whose pleural effusion was drained by tube thoracostomy, and those whose post-thoracentesis radiograph was unavailable for review.

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*Data Gathering*

Medical records and chest radiographs of included patients were retrieved and reviewed for this study. Pertinent data collected from the patient's medical record included: age, sex, laterality of pleural effusion and thoracentesis, amount of the pleural effusion drained, type of pleural effusion based on Light's criteria,[2] use of mechanical ventilation, number of thoracentesis done, gauge of needle/catheter used, number of needle passes, use of a stop-cock during thoracentesis, occurrence of a dry tap, use of ultrasound marking or ultrasound guidance, use of lubricant jelly to seal the puncture wound after thoracentesis and the level of training of the physician performing the procedure. These were the patient- and procedure-related factors which we hypothesized to have a potential effect on the occurrence of pneumothorax post-thoracentesis.

*Outcomes Measured*

The primary outcome measured was the occurrence of pneumothorax after thoracentesis, documented by a post-procedure chest radiograph. We planned to do Fischer's exact test to identify patient-related and procedure-related factors that may be associated with an increased risk for pneumothorax.

## RESULTS

Fifty-seven patients with pleural effusion were included in the study and 62 thoracenteses were performed. This is because a patient could have undergone thoracentesis more than once. Majority of the procedures was done for diagnostic purposes (n=44). Fifteen procedures were performed for both diagnostic and therapeutic reasons. The male: female ratio was 1:1.2. Mean age was 48 years with a range of 18-78 years. Five of the patients were admitted at the intensive care unit and 4 patients were mechanically ventilated. Most of the pleural effusions were unilateral with majority being right-sided (see Table I).

Majority of the procedures were done by physicians-in training. Most of the patients underwent thoracentesis only once (n=47). None of the patients who underwent multiple thoracentesis had a pneumothorax. Other possible procedure-related factors compared were the laterality of thoracentesis, the amount of fluid drained, the diameter of needle used and the use of ultrasound guidance, stopcock and lubricant jelly. There were 9 cases of dry tap; none of which was associated with pneumothorax (see Table II).

Pneumothorax occurred in 3 out of the 62 procedures, with an incidence of 4.8% (binomial exact 95% CI 1.0 – 13.5%). None required subsequent chest tube drainage. There were no reported deaths, hemothoraces, inadvertent liver or splenic lacerations or cases of reexpansion edema.

**Table I. Occurrence of Pneumothorax in Relation to Patient-Related Factors**

| | No. of Procedures n = 62 | No. pneumothoraces n = 3 |
|---|---|---|
| Sex | | |
| Male | 28 | 1 |
| Female | 34 | 2 |
| Age (yrs) | | |
| 18-37 | 17 | 0 |
| 38-57 | 21 | 1 |
| 58-77 | 18 | 2 |
| ≥78 | 6 | 0 |
| Laterality of effusion | | |
| Right | 36 | 2 |
| Left | 10 | 0 |
| Bilateral | 15 | 1 |
| Undetermined | 1 | 0 |
| Amount of effusion (fraction of hemithorax) | | |
| ≤1/2 | 27 | 1 |
| > 1/2 | 29 | 2 |
| Undetermined | 6 | 0 |
| Type of effusion | | |
| Transudate | 14 | 1 |
| Exudate | 13 | 2 |
| Undetermined | 18 | 0 |
| Mechanically ventilated | 4 | 1 |
| Yes | 58 | 2 |
| No | | |
| Admitted to ICU | | |
| Yes | 5 | 1 |
| No | 57 | 2 |

**Table II. Occurrence of Pneumothorax with Respect to Procedure-Related Factors**

| | No. of Procedures n = 62 | No. pneumothoraces n = 3 |
|---|---|---|
| Laterality of thoracentesis | 45 | 3 |
| Right | 15 | 0 |
| Left | 2 | 0 |
| Undetermined | | |
| Amount of pleural fluid drained | | |
| ≤500 cc | 18 | 1 |
| >500 cc | 40 | 2 |
| Undetermined | 4 | 0 |
| Initial or repeated thoracentesis | | |
| Initial | 47 | 3 |

*(Table II continue next page)*

*(continuation of Table II . . . )*

| | No. of Procedures n = 62 | No. pneumothoraces n = 3 |
|---|---|---|
| Repeated | 11 | 0 |
| Undetermined | 4 | 0 |
| Diameter of needle/ catheter used | | |
| Gauge 16 | 46 | 3 |
| Gauge 18 | 7 | 0 |
| Gauge 20 | 1 | 0 |
| Undetermined | 8 | 0 |
| Number of needle passes | | |
| 1 | 43 | 3 |
| 2 or more | 12 | 0 |
| Undetermined | 7 | 0 |
| Use of stop- cock | | |
| Yes | 46 | 3 |
| No | 9 | 0 |
| Undetermined | 7 | 0 |
| Occurrence of dry tap | | |
| Yes | 9 | 0 |
| No | 47 | 3 |
| Undetermined | 6 | 0 |
| Use of ultrasound-marking or ultrasound guidance | | |
| Yes | 40 | 2 |
| No | 18 | 1 |
| Undetermined | 4 | 0 |
| Use of lubricant jelly | | |
| Yes | 11 | 1 |
| No | 43 | 2 |
| Undetermined | 8 | 0 |
| Level of physician training | | |
| Intern | 4 | 0 |
| Resident | 35 | 2 |
| Fellow | 21 | 1 |
| Consultant | 2 | 0 |

Using Fischer's exact test, no significant association was identified between any of the hypothesized patient- and procedure-related factors and the development of pneumothorax. Due to the low incidence of pneumothorax, no definitive conclusions can be made between the factors examined and the occurrence of pneumothorax post-thoracentesis.

## DISCUSSION

Our study is in agreement with the reports of previous studies that thoracentesis is a low-risk procedure. In the medical wards of our institution, pneumothorax occurred in 4.8% of procedures. Overall, our rate of pneumothorax compares favorably with the experience reported in the literature (see Table III). Since the frequency of this complication was similar to that which exists in the medical literature, it is possible that thoracentesis, like any invasive procedure, is associated with inherent complications and that our rate represents the best that one can expect.

**Table III. Summary of Prospective Studies Reporting Thoracentesis-Related Pneumothorax**

| Author Year of Study | No. of patients | No. of procedures | No. of pneumothoraces (%) |
|---|---|---|---|
| Bartter 1993 (1) | 33 | 50 | 2 (4) |
| Colt 1999 (3) | 205 | 255 | 14 (5.1) |
| Collins 1987 (4) | 86 | 129 | 15 (12) |
| Grodzin 1997 (5) | 23 | 57 | 2 (3.5) |
| Grogan 1990 (6) | 52 | 52 | 10 (19) |
| Seneff 1986 (7) | 91 | 125 | 14 (11) |

Several reasons for the development of pneumothorax during thoracentesis exist. First, the decrease in pleural pressure can lead to a rupture of the visceral pleura. Second, the needle for thoracentesis may lacerate the lung and allow entry of air to the pleural space from the alveoli. And lastly, air may flow from the atmosphere in the pleural space, as occurs when the negative pressure on the pleural space communicates freely with the atmosphere. This most often happens as the syringe is removed from a needle or catheter, particularly in the inexperienced hands.[8]

Past studies have yielded conflicting data concerning the impact of the operator on the development of complications. Grogan *et al* have demonstrated that the incidence of pneumothorax is reduced if experienced individuals perform the procedure.[6] In the study by Petersen *et al*, more than 90% of procedures were performed by physicians in training, a factor that has been shown to strongly influence complication rates.[9] However, Swinburne *et al* reported that the risk of pneumothorax was the same for thoracentesis performed by medical residents and pulmonary specialists. In our study, all the procedures leading to pneumothorax were performed by physicians in training - two medical residents and one pulmonary fellow. No definite association could be made because there were only two procedures performed by a consultant and no pneumothorax occurred for both procedures.

In our experience, the use of ultrasonography did not seem to confer an advantage to prevent the occurrence of pneumothorax. We reported two incidents of pneumothorax among those who had ultrasound marking prior to the procedure versus

one occurrence in a patient who did not have ultrasound guidance. Theoretically, ultrasound guidance would confer an advantage in reducing the risk of complications, however studies are conflicting. A retrospective survey by Raptopoulus *et al* [10] involving 343 thoracenteses showed that the ultrasound-guided technique was the most significant single risk factor affecting the development of pneumothorax. The incidence rates were as follows: 18% among those without image guidance and 3% for those with ultrasonography. This study was also supported by Jones *et al* [8] who reported a low incidence rate of pneumothorax (<3%) in his large prospective study on ultrasound-guided thoracentesis performed by experienced interventional radiologists. The reason why the direct sonography-guided method is the safest is because the exact location as well as depth of the fluid to be sample can be seen by sonography while the procedure is being performed. Additionally, dry tap, inadequate yield and pneumothorax should be minimized if not eliminated as complications.[6] However, Peterson[9] in a small series of 36 thoracentesis procedures reported that the ultrasound guidance did not appear to offer protection, as 13.9% procedures performed with ultrasound guidance led to a pneumothorax.

We also observed that all the incidents of pneumothorax in our study occurred during the initial thoracentesis, using gauge 16 catheter and a stop cock and had a one-time needle pass. Two of the incidents of pneumothorax occurred in spontaneously breathing patients and the pleural fluid drained was more than 500 cc. A previous study by Raptopoulus *et al*[10] showed that the incidence of pneumothorax decreased when a smaller amount of pleural fluid was aspirated and when thin needles were used. These findings were in contrast with the report of Gervais *et al*[11] who revealed that neither the volume removed nor needle size used was a statistically significant predictor for the occurrence of pneumothorax. Gervais *et al*[11] also demonstrated a five-fold higher risk of pneumothorax in mechanically ventilated compared with spontaneously breathing patient.

This study is limited by the low incidence of the primary outcome which precludes us from concluding that no significant associations between the development of pneumothorax and the potential patient and procedure-related factors exist. A Type 2 error is likely due to the very small number of episodes of pneumothorax. Extending the study period to include more procedures can increase the sample size, as well as a thorough search for all thoracenteses performed during the study period for possible inclusion in the study. Some of the potential procedure-related factors, such as ultrasound guidance and the expertise of the physician performing the thoracentesis, have already been the subject of previous studies and they can be the topic of future randomized trials so that a direct association between these variables can be established.

## CONCLUSION

Thoracentesis is a low-risk procedure. We were not able to establish any associations between various patient- or procedure-related factors and the occurrence of pneumothorax post-thoracentesis because of the small sample size. Studies with adequate sample size are needed to determine whether there are factors that can predict this complication and whether this factors can be prevented or modified.

## CONFLICT OF INTEREST

None

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