Original Article

# Incidence and Risk Factors of Iatrogenic Pneumothorax after Thoracentesis in Medical Wards: A 1-year Prospective Single-center Study

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## Abstract

**Introduction:** Iatrogenic pneumothorax (IP) after thoracentesis can lead to life-threatening conditions and increased treatment costs. Understanding the associated risk factors is crucial for prevention.

**Objectives:** This study aims to investigate the incidence of IP and its contributing risk factors.

**Methods:** This one-year prospective consecutive study was conducted in a tertiary teaching hospital, documenting all thoracentesis procedures performed in the medical wards from July 2021 to June 2022.

**Results:** Data were collected from a total of 47 procedures involving 39 patients, with a mean age (SD) of 69.4 (13.9) years. Among the patients, 21 (53.9%) were male. The incidence of IP was 10.6% (5 events). Most incidents (80.0%) took place in the general ward, while the remaining 20.0% occurred in the intensive care units ($p = 0.136$). Notably, periprocedural events, particularly coughing, were reported in 80.0% of IP cases (IRR 8.40, 95% CI [3.00, 23.53], $p < 0.001$). No significant associations were found between IP and factors such as body mass index, use of mechanical ventilator, drainage volume, needle type, number of attempts, or the quarter of the training year in which the procedures were performed.

**Conclusions:** Over the course of the year, the incidence of IP following thoracentesis was found to be low. Although specific risk factors could not be identified, peri-procedural events warrant careful consideration, as they may indicate an increased likelihood of this complication.

**Keywords:** Iatrogenic pneumothorax, Thoracentesis, Incidence, Risk factors, Cough

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## Introduction

Thoracentesis is generally regarded as a safe procedure; however, it is not without complications.[1] This medical intervention is frequently utilized for both diagnostic and therapeutic purposes, particularly in the management of pleural effusions.[2] Iatrogenic pneumothorax (IP) is the most common complication associated with thoracentesis, potentially leading to life-threatening conditions and increased treatment costs.[2] IP occurs when a patient's lung is inadvertently perforated during an invasive medical or surgical procedure, allowing air to escape from the lung into the pleural space, which can result in partial or complete lung collapse.[3] Patients with IP often exhibit symptoms and require management comparable to that for spontaneous or traumatic closed pneumothorax.[4, 5]

The incidence of pneumothorax following thoracentesis varies among studies, ranging from 0% to 19%, reflecting differences in procedural techniques, patient populations, and institutional protocols.[1, 2, 6-9] A systematic review and meta-analysis of 24 studies, including a total of 6,605 cases that underwent thoracentesis, reported an overall 6% incidence of pneumothorax.[8]

Several factors may contribute to the development of IP, including operator inexperience, patient-related variables such as preexisting lung disease or anatomical abnormalities, use of mechanical ventilator,[9] and the use of larger needle gauges or catheters.[8] The implementation of ultrasound-guided interventions may reduce the incidence of IP.[9, 10] However, data regarding the incidence and risk factors associated with IP following thoracentesis remain limited, with most existing studies being retrospective in nature. Therefore, the objective of this study was to prospectively determine the incidence of IP within the medical ward of our institution and to identify associated risk factors.

## Methods

### Study design and population

This is a one-year, single-center prospective consecutive study. Ethical approval was obtained from the Human Research Ethics Committee of Thammasat University (Faculty of Medicine), Thailand (IRB No. MTU-EC-IM-0-074/64), and the study was conducted in accordance with the Declaration of Helsinki. Eligible patients were screened from the internal medicine ward at Thammasat University Hospital, a tertiary care university hospital in Thailand.

### Eligibility criteria

Patients aged 18 years or older who were hospitalized in the internal medicine ward and had indications for thoracentesis between July 2021 and June 2022 were consecutively included. Patients who underwent thoracentesis procedures performed by interventional radiologists or who had a history of pneumothorax were excluded (Figure 1).

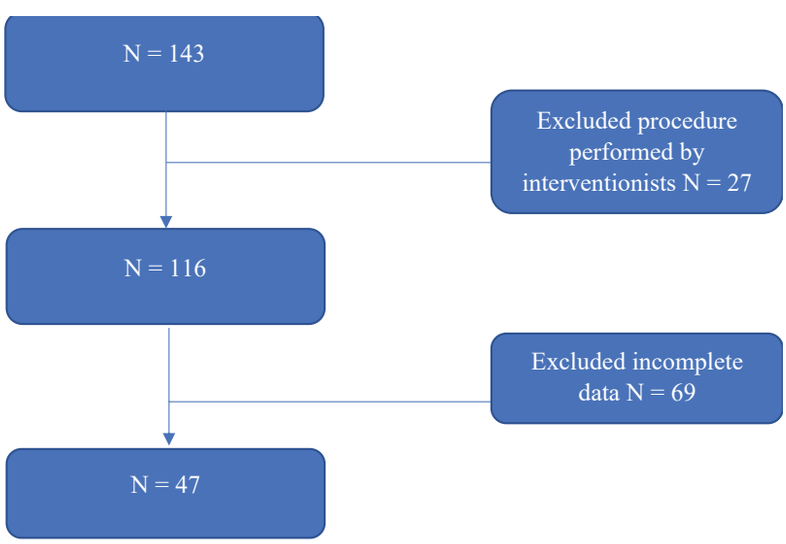


**Figure 1** Patient Flow Diagram

**Data collection**

The clinical characteristics were recorded, including age, sex, weight, height, body mass index (BMI), indications for thoracentesis, positioning, site of the procedure, and equipment used (e.g., type of needles-catheter or sharp needles; size of needles [No. 18-22]; syringe volume [5-50 mL]; ultrasound guidance). Periprocedural events such as coughing, dry tapping, and air tapping were also documented. Age was classified as extremely elderly (≥ 90 years), elderly (60-89 years), and adult (< 60 years). BMI was categorized as obese (≥ 25 kg/m²), normal (18-24.99 kg/m²), and underweight (< 18 kg/m²).

Pleural effusions were diagnosed using chest X-ray, computed tomography (CT) of the chest, or bedside thoracic ultrasound. The decision to perform the procedure and the method employed were made by the attending physicians. The physicians discussed the advantages and potential risks of the procedure with the patient and/or their family once the patient met the criteria for intervention. Prior to the procedure, the physician ensured that the patient or their legal representative provided informed consent. Diagnostic thoracentesis was defined as the drainage of less than 60 mL of fluid, while therapeutic thoracentesis was defined as the drainage of 60 ml or more. The volume of fluid drained was classified as large volume (≥ 500 mL), medium volume (200-499 mL), and small volume (< 200 mL). The diagnosis of pneumothorax was confirmed by chest X-ray or CT scan within 24 hours after the procedure, and the incidence of IP was recorded.

**Statistical analysis**

Descriptive statistics were presented as frequency and percentage for categorical data. For continuous data, the mean and corresponding standard deviation (SD) were calculated, assuming normal distribution. The incidence was determined by dividing the number of patients with IP by the total number of patients at risk. Comparative statistics of clinical characteristics between patients with pneumothorax and those without were analyzed using Fisher's exact test or Pearson's Chi-square test for categorical variables. Significant variables (p-value < 0.05) were reported as incidence rate ratios (IRR) with 95% confidence intervals (CI). Data analysis was performed using SPSS version 27.

## Results

During the one-year study period, a total of 47 thoracentesis procedures involving 39 participants were included. The mean (SD) age was 69.38 (13.85) years, the mean (SD) BMI was 21.61 (3.28) kg/m$^2$, and 21 (53.85%) participants were male. Other baseline characteristics are presented in Table 1. IP occurred in 5 events, resulting in an incidence rate of 10.64%.

Regarding procedure-related factors, as shown in Table 2, all procedures were performed using ultrasound guidance. The majority of the procedures (37, 78.72%) were conducted with therapeutic intent. A total of 41 procedures (87.23%) were performed while the patients were in an upright position, and 39 procedures (82.97%) were conducted on the right hemithorax. A catheter-over-needle No. 18 was the most frequently used, comprising 30 procedures (63.82%). Eighteen procedures (38.30%) involved multiple needle passes within a single procedure. Periprocedural events were noted in 5 procedures (10.64%), which included 3 cases of coughing, 1 case of air tapping, and 1 case of dry tapping, and were found to be associated with the development of IP in 4 of these procedures [IRR 8.40, 95% CI [3.00, 23.53], $p < 0.001$].

In relation to patient-related factors, as shown in Table 3, IP was not found to be associated with age, sex, BMI, amount of fluid removed, mechanical ventilator use, or type of effusion.

In terms of the operator-related factors, as shown in Table 4, the majority of the thoracentesis procedures were performed by internal medicine residents (70.21%). Six procedures were conducted by medical students under supervision, all of which resulted in no incidents of IP. Most of the IP occurred in general wards (80%), followed by intensive care units (20%). The occurrence of IP was not associated with the quarter of the year in which the residents were in-training.

**Table 1** Baseline Characteristics

| Characteristics | N = 39 |
|---|---|
| Male, n (%) | 21 (53.85) |
| Age years, mean ± SD | 69.38 ± 13.85 |
| Weight (kg), mean ± SD | 55.28 ± 8.85 |
| Height (m), mean ± SD | 1.60 ± 0.08 |
| BMI (kg/m$^2$), mean ± SD | 21.61 ± 3.28 |

BMI; body mass index, SD; standard deviation

**Table 2** Procedure-Related Factors: Comparison Between Pneumothorax and No-Pneumothorax Groups

| Procedure data N = 47 | Pneumothorax N = 5 | No pneumothorax N = 42 | IRR (95% CI) | *p*-value |
|---|---|---|---|---|
| Ultrasound-guided, n (%) | | | | N/A |
| Yes | 5 (100) | 42 (100) | N/A | |
| Indication for thoracentesis, n (%) | | | | 0.941 |
| For diagnosis* | 1 (20.0) | 9 (21.4) | 0.93 (0.12, 7.38) | |
| For therapeutic** | 4 (80.0) | 33 (87.6) | 1.08 (0.14, 8.63) | |
| Patient position, n (%) | | | | 0.366 |
| Upright | 5 (100) | 36 (85.7) | N/A | |
| Supine | 0 (0) | 6 (14.3) | N/A | |
| Side of procedure, n (%) | | | | 0.284 |
| Right | 5 (100) | 34 (81.0) | N/A | |
| Left | 0 (0) | 8 (19.0) | N/A | |
| Needle types, n (%) | | | | 0.926 |
| Catheter over needle 18 | 4 (80.0) | 26 (61.9) | 2.27 (0.28, 18.68) | |
| Catheter over needle 20 | 1 (20.0) | 11 (26.2) | 0.73 (0.09, 5.90) | |
| Catheter over needle 22 | 0 (0) | 3 (7.1) | N/A | |
| Needle 18 | 0 (0) | 1 (2.4) | N/A | |
| Needle 21 | 0 (0) | 1 (2.4) | N/A | |
| Number of attempts, n (%) | | | | 0.934 |
| 1 attempt | 3 (60.0) | 26 (61.9) | 0.93 (0.17, 5.04) | |
| ⩾ 2 attempts | 2 (40.0) | 16 (38.1) | 1.07 (0.20, 5.82) | |
| Size of syringes, n (%) | | | | 0.754 |
| 50 ml | 0 (0) | 3 (7.1) | N/A | |
| 20 ml | 3 (60.0) | 27 (64.3) | 0.85 (0.16, 4.59) | |
| Small syringes (5,10 ml) | 2 (20.0) | 12 (28.6) | 1.57 (0.29, 8.40) | |
| Periprocedural events, n (%) | | | | < 0.001 |
| Yes | 4 (80.0) | 1 (2.4) | 8.4 (3, 23.53) | |
| No | 1 (20.0) | 41 (97.6) | 0.22 (0.04, 1.28) | |

*For diagnosis means release pleural fluid < 60 ml
**For therapeutic means release pleural ⩾ fluid 60 ml

**Table 3** Patient-Related Factors: Comparison Between Pneumothorax and No-Pneumothorax Groups

| Procedure data N = 47 | Pneumothorax N = 5 | No pneumothorax N = 42 | IRR (95% CI) | *p*-value |
|---|---|---|---|---|
| Age (years), n (%) | | | | 0.838 |
| ≥ 90 | 0 (0) | 2 (4.8) | N/A | |
| 60-89 | 3 (60.0) | 27 (64.3) | 0.85 (0.16, 4.59) | |
| < 60 | 2 (40.0) | 13 (30.9) | 1.42 (0.26, 7.64) | |
| BMI (kg/m$^2$), n (%) | | | | 0.843 |
| ≥ 25 | 1 (20.0) | 5 (11.9) | 1.71 (0.23, 12.84) | |
| 18-24.99 | 3 (60.0) | 30 (71.4) | 0.64 (0.12, 3.40) | |
| < 18 | 1 (20.0) | 7 (16.7) | 1.22 (0.16, 9.51) | |
| Amount of fluid, mL, n (%) | | | | 0.560 |
| ≥ 500 | 3 (60.0) | 15 (35.7) | 2.42 (0.45, 13.09) | |
| 200-499 | 1 (20.0) | 11 (26.2) | 0.73 (0.09, 5.90) | |
| < 200 | 1 (20.0) | 16 (38.1) | 0.44 (0.05, 3.64) | |
| Mechanical ventilator, n (%) | | | | 0.764 |
| Yes | 1 (20.0) | 11 (26.2) | 0.73 (0.09, 5.90) | |
| No | 4 (80.0) | 31 (73.8) | 1.37 (0.17, 11.1) | |
| Effusion type, n (%) | | | | 0.158 |
| Exudative MN | 1 (20.0) | 23 (54.8) | 0.24 (0.03, 1.99) | |
| Exudative PMN | 3 (60.0) | 9 (21.4) | 4.38 (0.83, 23.12) | |
| Transudate | 1 (20.0) | 10 (23.8) | 0.82 (0.10, 6.58) | |

BMI; body mass index, PMN; polymorphonuclear cell, MN; mononuclear cell

**Table 4** Operator-Related Factors: Comparison Between Pneumothorax and No-Pneumothorax Groups

| Procedure data N = 47 | Pneumothorax N = 5 | No pneumothorax N = 42 | IRR (95% CI) | *p*-value |
|---|---|---|---|---|
| Operator, n (%) | | | | 0.499 |
| Medical student | 0 (0) | 6 (14.3) | N/A | |
| Intern | 0 (0) | 7 (16.7) | N/A | |
| Resident | 5 (100) | 28 (66.7) | N/A | |
| Fellow | 0 (0) | 1 (2.4) | N/A | |
| Supervisor, n (%) | | | | 0.345 |
| Yes | 2 (40.0) | 26 (61.9) | 0.45 (0.08, 2.46) | |
| No | 3 (60.0) | 16 (38.1) | 2.21 (0.41, 12) | |
| Ward, n (%) | | | | 0.136 |
| Intensive care units | 1 (20.0) | 8 (19.0) | 1.05 (0.16, 6.75) | |
| General wards | 4 (80.0) | 16 (38.1) | 2.10 (1.17, 3.76) | |
| Private wards | 0 (0) | 18 (42.9) | N/A | |
| Quarter of the training year, n (%) | | | | 0.674 |
| 1$^{st}$ quarter (6/21-8/21) | 1 (20.0) | 8 (19.0) | 1.06 (0.13, 8.34) | |
| 2$^{nd}$ quarter (9/21-11/21) | 0 (0) | 5 (11.9) | N/A | |
| 3$^{rd}$ quarter (12/21-2/22) | 3 (60.0) | 15 (35.7) | 2.42 (0.45, 13.09) | |
| 4$^{th}$ quarter (3/22-5/22) | 1 (20.0) | 14 (33.30) | 0.53 (0.07, 4.37) | |

## Discussion

The overall incidence of IP following thoracentesis in our medicine ward was 10.64%, consistent with findings from a previous meta-analysis conducted in 2010.[8] Although, ultrasound-guided thoracentesis has been found to reduce the incidence of IP, with an odds ratio (OR) of 0.3 (95% CI 0.2, 0.7).[8] Our cohort, which exclusively employed this technique, still experienced a notable occurrence of this complication. This indicates that further investigation into the specific procedural and patient-related factors contributing to this outcome is warranted, and that additional training in ultrasound-guided procedures may be essential for minimizing the risk of IP.

There were no significant associations between IP and the demographic characteristics of the patients, in contrast to previous studies,[6, 9] which identified being underweight and the use of mechanical ventilator as increased risk factors for IP. A recent study also demonstrated that a greater volume of pleural fluid drained is significantly associated with an increased risk of developing pneumothorax.[7] In our study, we observed a non-significant trend in this direction, with 60% of patients with IP undergoing drainage of more than 500 mL. These factors contribute to an increase in transpulmonary pressure (the difference between alveolar and pleural pressure), a key component in the pathophysiology of pneumothorax.[11] Specifically, being underweight[12] and draining a larger volume of pleural fluid[13] are associated with lower pleural pressure, while mechanical ventilator is linked to elevated alveolar pressure.

We identified that factors associated with the occurrence of pneumothorax following thoracentesis were primarily periprocedural events, particularly coughing. This finding aligns with a previous study that reported periprocedural symptoms as an increased risk factor for IP, with an OR of 26.6 (95% CI 2.7-262.5).[8] Coughing during thoracentesis may occur due to a decrease in pleural pressure resulting from the removal of pleural fluid, which facilitates the expansion of collapsed alveoli and can induce coughing.[14] In this context, coughing may serve as a protective mechanism by preventing excessive reductions in pleural pressure and mitigating increases in transpulmonary pressure.[15] While such elevation can be beneficial, it is essential to recognize that coughing may also lead to movements that could potentially result in lung injury during the procedure.

There were no incidents of IP in the six thoracentesis procedures performed by the medical students. Furthermore, only one case of IP occurred during the first quarter of the academic year, representing a rate lower than anticipated. This reduction in incidence may be attributed to the close supervision provided to the operators by their instructors.

This study benefits from its design as a prospective consecutive study conducted within the context of real-life practice at a referral teaching hospital. However, the limitations include a relatively low number of participants and a significant amount of incomplete data, which precluded the identification of potential risk factors. Future research should consider extending this study or conducting a multicenter investigation to validate these findings and explore additional potential risk factors.

## Conclusion

Over the course of one year, the incidence of IP following thoracentesis in our cohort was lower than anticipated, which limited the identification of significant risk factors. However, it is important to emphasize that peri-procedural symptoms, such as coughing, air tapping, or dry tapping, should be closely monitored to facilitate the early recognition of this complication. To further reduce the incidence of this serious complication, we recommend that senior physicians provide supervision during the procedure and that workshops be conducted for new residents to enhance their skills and minimize the risk of complications.

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**Compliance with Ethics Requirements**

Ethical approval was obtained from the Human Research Ethics Committee of Thammasat University (Faculty of Medicine), Thailand (IRB No. MTU-EC-IM-0-074/64), and the study was conducted in accordance with the Declaration of Helsinki.

**Conflicts of interest**

All authors report no conflicts of interest relevant to this article.

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**Author Contributions**

The authors involved in the study are as follows; Limsakul P: Conceptualization, Methodology, Investigation and data collection, Formal analysis, Writing-Original draft. Phuangsombut N: Formal analysis, Writing-Review and editing. Pirompanich P: Conceptualization, Methodology, Investigation, Formal analysis, Writing-Review and editing. All authors approved the final article.

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