Comparing failure rate and complications between Seldinger and conventional chest drainage techniques in pneumothorax: A retrospective cohort study

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ABSTRACT

Introduction: Chest drainage remains an important intervention for pneumothorax when conservative or ambulatory management is not suitable. Although chest drain techniques have been widely studied, contemporary real-world data from Southeast Asia remain limited, particularly in populations with a high burden of secondary pneumothorax related to infectious lung disease.

Materials and Methods: We conducted a retrospective cohort study of adult pneumothorax patients who underwent intercostal chest drain insertion at Sibu Hospital, Sarawak, Malaysia, between January 2021 and February 2024. Patients were managed with either conventional trocar chest tubes or Seldinger wire-guided drains. The primary outcome was chest drain–related complications. Secondary outcomes included chest drain duration, hospital length of stay, persistent air leak (PAL >5 days) and mortality. Continuous variables were analysed using independent t-tests and categorical variables using chi-square or Fisher's exact tests. Multivariate logistic regression was performed to identify predictors of subcutaneous emphysema, and multiple linear regression was used to evaluate factors associated with chest drain duration.

Results: A total of 123 patients were included (86 conventional and 37 Seldinger). Subcutaneous emphysema occurred significantly less frequently in the Seldinger group (5.4% vs 55.8%, p<0.001). Mean chest drain duration was shorter in the Seldinger group (8.86 ± 7.10 vs 10.34 ± 11.96 days, p=0.032). Differences in insertion failure (0% vs 8.1%, p=0.074), tube dislodgement (2.7% vs 11.6%, p=0.112), persistent air leak >5 days (67.6% vs 54.7%, p=0.182) and mortality (10.8% vs 15.1%, p=0.518) were not statistically significant. Multivariate logistic regression identified conventional chest drainage as an independent predictor of subcutaneous emphysema (OR 27.6, 95% CI 5.24–145.94; p<0.001). Multiple linear regression demonstrated that conventional drainage, non-tension pneumothorax, smoking and persistent air leak were independently associated with longer chest drain duration.

Conclusion: In this retrospective cohort, the Seldinger technique was associated with lower complication rates and shorter drainage duration compared with conventional chest drainage. Prospective multicentre studies are required to confirm these findings.

KEYWORDS:
Pneumothorax; chest tubes; thoracostomy; seldinger technique; subcutaneous emphysema; treatment outcome

INTRODUCTION

Pneumothorax occurs when air accumulates in the pleural space and impairs lung expansion, resulting in varying degrees of respiratory compromise. Management strategies depend on symptom severity, pneumothorax size and underlying lung disease, with chest drainage remaining an important intervention for patients who are symptomatic or unsuitable for conservative management. Contemporary guidance, including the 2023 British Thoracic Society (BTS) pleural disease guideline, supports conservative or ambulatory approaches in selected patients while recommending chest drainage for those who are symptomatic or at higher risk.[1]

Conventional trocar-based chest drain insertion has long been widely practiced but may be associated with greater tissue trauma and procedure-related complications.[2] The Seldinger technique allows placement of a small-bore catheter using a guidewire and is increasingly used as a less invasive alternative.[3] Previous studies have demonstrated comparable effectiveness between small-bore and large-bore chest drains in pneumothorax management, although real-world comparative data remain limited, particularly in Southeast Asia.[2-3]

In Malaysia and other parts of Asia, secondary pneumothorax related to infectious lung diseases such as tuberculosis remains common, and the optimal drainage approach in such populations is less well described.[4] Given these considerations, we conducted a retrospective cohort study to compare complications and clinical outcomes between conventional and Seldinger chest drainage techniques in a Malaysian secondary referral hospital.

MATERIALS AND METHODS

Study Design and Setting

This retrospective cohort study was conducted at Sibu Hospital, Sarawak, Malaysia, a secondary referral centre serving a population of approximately 760,000 people. Adult patients aged 18 years and above with radiologically confirmed pneumothorax who underwent intercostal chest

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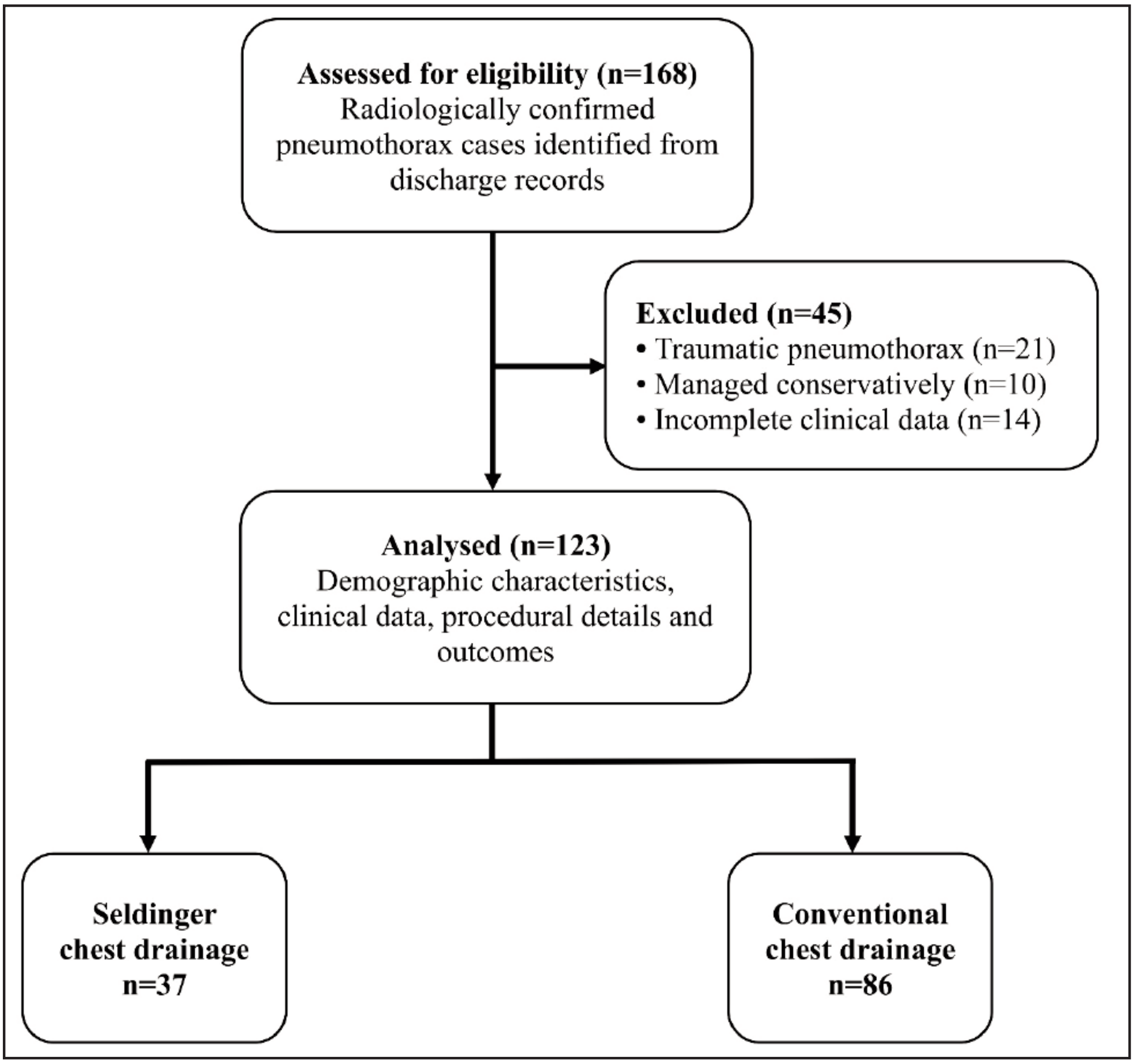

Fig. 1: Flow diagram of patient selection and analysis

drain insertion between January 2021 and February 2024 were included. Patients were identified through electronic discharge records using the keyword "pneumothorax" and verified using individual medical records. Consecutive sampling was applied. Patients with traumatic pneumothorax, those managed conservatively without drainage and those with incomplete clinical data were excluded. The process of patient selection is illustrated in Figure 1.

Chest Drain Insertion Procedures
Chest drainage was performed using either conventional trocar-based chest tubes (16–36 Fr) or wire-guided Seldinger chest drains (Rocket Medical plc, Watford, United Kingdom; 12 Fr and 18 Fr kits). The choice of technique was determined by the availability of Seldinger chest drains, operator preference and clinical judgement. Procedures were performed under local anaesthesia using sterile techniques in the emergency department, medical wards or intensive care unit as appropriate. Operator experience was not standardised, and procedures were performed by clinicians of varying seniority as part of routine clinical practice.

Definitions and Outcomes
The primary outcome was chest drain–related complications, defined as clinical subcutaneous emphysema, tube dislodgement, failed insertion, local infection or haematoma, haemothorax, tube malfunction, organ injury and mortality attributable to chest drainage. Failed insertion was defined as inability to successfully place a functioning chest drain requiring reinsertion or alternative technique. Intention-to-treat analysis was done, where any crossover was retained in the initial group during analysis.

Secondary outcomes included chest drain duration (days), hospital length of stay (days), persistent air leak (PAL >5 days) and mortality. Subcutaneous emphysema and other complications were confirmed based on clinical documentation and radiographic findings recorded in patient charts.

Table I: Baseline demographic and clinical characteristics of patients undergoing chest drainage for pneumothorax

Parameters	Total (n=123)	Seldinger group (n=37)	Conventional group (n=86)	p-value
Gender, n (%)				
Male	82 (66.7)	21 (56.8)	61 (70.9)	0.119†
Female	41 (33.3)	16 (43.2)	25 (29.1)	
Smoker, n (%)	76 (61.8)	20 (54.1)	56 (65.1)	0.243†
History of pneumothorax, n (%)	13 (10.6)	4 (10.8)	9 (10.5)	0.953†
Tension pneumothorax, n (%)	26 (21.1)	6 (16.2)	20 (23.3)	0.382†
Comorbidities, n (%)				
Hypertension	47 (38.2)	15 (40.5)	32 (37.2)	0.728†
Diabetes mellitus	27 (22.0)	11 (29.7)	16 (18.6)	0.180†
Dyslipidaemia	32 (26.0)	8 (21.6)	24 (27.9)	0.464†
CKD/ESRF	4 (3.3)	3 (8.1)	1 (1.2)	0.079‡
Autoimmune disease	6 (4.9)	3 (8.1)	3 (3.5)	0.358‡
Thyroid disease	3 (2.4)	0 (0)	3 (3.5)	0.550‡
COPD/asthma	16 (13.0)	3 (8.1)	13 (15.1)	0.296†
Stroke	1 (0.8)	1 (2.7)	0 (0)	0.304‡
IHD/heart failure	2 (1.6)	1 (2.7)	1 (1.2)	0.538‡
Gout	4 (3.3)	1 (2.7)	3 (3.5)	1.000‡
RVD	3 (2.4)	2 (5.4)	1 (1.2)	0.206‡
Aetiology, n (%)				
Primary spontaneous	6 (4.9)	1 (2.7)	5 (5.8)	0.668‡
Active tuberculosis	43 (35.0)	16 (43.2)	27 (31.4)	0.218†
Old tuberculosis	10 (8.1)	4 (10.8)	6 (7.0)	0.496‡
Pneumonia	27 (22.0)	5 (13.5)	22 (25.6)	0.139†
Malignancy	5 (4.1)	3 (8.1)	2 (2.3)	0.151‡
Emphysema/bullous	13 (10.6)	2 (5.4)	11 (12.8)	0.206‡
Iatrogenic	17 (13.8)	6 (16.2)	11 (12.8)	0.622†
Catamenial	1 (0.8)	0 (0)	1 (1.2)	1.000‡
ILD	1 (0.8)	0 (0)	1 (1.2)	1.000‡

Data are presented as n (%), or mean (SD). *, statistically significant. † , Pearson chi-squared; ‡ , Fisher's exact test. CKD, chronic kidney disease; ESRF, end stage renal failure; COPD, chronic obstructive pulmonary disease; IHD, ischemic heart disease; RVD, retroviral disease; ILD, interstitial lung disease.

Table II: Clinical outcomes and procedure-related complications

Parameters	Total (n=123)	Seldinger group (n=37)	Conventional group (n=86)	p-value
Subcutaneous emphysema, n (%)	50 (40.7)	2 (5.4)	48 (55.8)	<0.001*,†
Chest drain duration (days)	9.87 (10.63)	8.86 (7.10)	10.34 (11.96)	0.032*,§
Hospital length of stay (days)	16.46 (15.12)	15.54 (12.60)	16.84 (16.26)	0.648§
Persistent air leak >5 days, n (%)	72 (58.5)	25 (67.6)	47 (54.7)	0.182†
Insertion failure, n (%)	7 (5.7)	0 (0)	7 (8.1)	0.074‡
Tube dislodgement, n (%)	11 (8.9)	1 (2.7)	10 (11.6)	0.112‡
Local infection/haematoma, n (%)	6 (4.9)	1 (2.7)	5 (5.8)	0.670‡
Haemothorax, n (%)	4 (3.3)	1 (2.7)	3 (3.5)	1.000‡
Mortality, n (%)	17 (13.8)	4 (10.8)	13 (15.1)	0.518†

Data are presented as n (%), or mean (SD). * , statistically significant. † , Pearson chi-squared; ‡ , Fisher's exact test; § , Independent samples t-test.

Table III: Multivariate logistic regression analysis for predictors of subcutaneous emphysema

Variables	Adjusted OR	95% CI	p-value
Conventional chest drainage (vs Seldinger)	27.60	5.24–145.94	<0.001*
Smoking (smoker vs non-smoker)	1.42	0.63–3.19	0.397
Tension pneumothorax (yes vs no)	0.88	0.31–2.51	0.811
Chest drain duration (per day increase)	1.02	0.98–1.06	0.331
Underlying aetiologies†	—	—	NS

Model adjusted for smoking status, tension pneumothorax, chest drain duration, hospital length of stay and underlying aetiologies. Nagelkerke $R^2 = 0.62$. * , statistically significant. † , Included primary spontaneous, active tuberculosis, old tuberculosis, pneumonia, malignancy, emphysema/bullous lung disease, iatrogenic, catamenial, and interstitial lung disease. NS = not significant.

Table IV: Multiple linear regression analysis for predictors of chest drain duration

Variables	Adjusted β coefficient	95% CI	p-value
Conventional chest drainage (vs Seldinger)	1.68	1.45–1.94	<0.001*
Non-tension pneumothorax (vs tension)	1.21	1.03–1.43	0.021*
Smoking (smoker vs non-smoker)	1.17	1.02–1.35	0.028*
Persistent air leak >5 days (yes vs no)	1.52	1.29–1.78	<0.001*
Underlying aetiologies†	—	—	NS

Model adjusted for pneumothorax type, smoking status, persistent air leak and underlying aetiologies. $R^2 = 0.41$; adjusted $R^2 = 0.38$. * , statistically significant. † , Included primary spontaneous, active tuberculosis, old tuberculosis, pneumonia, malignancy, emphysema/bullous lung disease, iatrogenic, catamenial, and interstitial lung disease. NS = not significant.

Data Collection

Data were extracted using a standardised case record form and included demographic characteristics, smoking status, pneumothorax type (primary vs secondary; tension vs non-tension), underlying aetiology (including tuberculosis, pneumonia, emphysema/bullous lung disease and iatrogenic causes), procedural details and clinical outcomes. No patient identifiers such as names, initials or hospital numbers were recorded.

Sample Size

The sample size was estimated based on the expected difference in complication rates between conventional and small-bore chest drainage techniques reported in previous studies. Prior comparative studies have demonstrated complication rates ranging from approximately 45%–60% with conventional large-bore chest tubes and 10%–20% with small-bore or Seldinger drains in pneumothorax management.[2,3] Assuming a conservative absolute difference in complication rates of 35% between groups, with a two-sided α of 0.05 and statistical power of 80%, the minimum required sample size was calculated to be 102 patients, comprising 68 in the conventional group and 34 in the Seldinger group. The unequal group sizes reflect routine clinical practice during the study period, in which conventional trocar-based drainage remained more commonly performed owing to greater operator familiarity and earlier adoption, whereas the Seldinger technique was introduced later and used less frequently.

Statistical Analysis

Statistical analysis was performed using SPSS version 22.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean and standard deviation (SD) and compared using independent t-tests. Categorical variables were presented as frequencies and percentages and analysed using chi-square or Fisher's exact tests as appropriate. Additionally, we performed exploratory binary logistic regression to identify independent predictors of subcutaneous emphysema. Multiple linear regression was used to evaluate factors associated with chest drain duration. Variables included in multivariate models were selected based on clinical relevance and univariate analysis results. A two-sided p-value <0.05 was considered statistically significant.

Ethical Considerations

This study was approved by the Medical Research and Ethics Committee, Ministry of Health, Malaysia (NMRR ID-24-01329-54S (IIR) dated June 27, 2024). The requirement for informed consent was waived due to the retrospective study design.

RESULTS

During the study period, 168 patients with radiologically confirmed pneumothorax were screened. After exclusion of patients with traumatic pneumothorax (n=21), those managed conservatively without drainage (n=10) and those with incomplete clinical data (n=14), a total of 123 patients were included in the final analysis. Of these, 37 underwent Seldinger chest drainage and 86 underwent conventional chest drainage. Three failed conventional insertions were subsequently salvaged using Seldinger drains but were analysed within the conventional group according to intention-to-treat principles.

The overall mean (SD) age was 49.7 (17.1) years old, with no significant difference between the conventional and Seldinger groups (p=0.376). There were no significant differences in gender distribution, clinical characteristics or underlying aetiology between the two groups, as summarised in Table I.

Clinical outcomes and procedure-related complications are summarised in Table II. Subcutaneous emphysema was significantly more frequent in the conventional drainage group. Although other complications were also more common with conventional drainage, these differences did not reach statistical significance. Chest drain duration was shorter in the Seldinger group, while hospital length of stay was comparable between groups. There were likewise no significant differences in persistent air leak or in-hospital mortality.

Multivariate logistic regression analysis demonstrated that conventional chest drainage remained an independent predictor of subcutaneous emphysema after adjustment for potential confounders, including smoking status, tension pneumothorax, chest drain duration and underlying aetiologies (Table III).

Multiple linear regression analysis identified several independent predictors of chest drain duration. Conventional chest drainage was independently associated with longer drainage duration. In addition, non-tension pneumothorax, smoking status and persistent air leak lasting more than five days were independently associated with prolonged chest drainage (Table IV).

Subgroup analyses comparing pneumothorax types and tube sizes did not demonstrate statistically significant differences in all outcomes. These analyses were exploratory and limited by the smaller number of patients in the Seldinger group.

DISCUSSION

This study shows that the Seldinger technique for chest drainage in pneumothorax is associated with lower rates of subcutaneous emphysema and shorter drainage duration compared with conventional trocar-based drainage in routine clinical practice. These findings remained consistent after multivariate adjustment and highlight the potential procedural advantages of wire-guided small-bore chest drains in contemporary pneumothorax management.

The lower incidence of subcutaneous emphysema observed with the Seldinger technique is biologically plausible. Guidewire-assisted insertion typically requires a smaller incision and less blunt dissection than conventional trocar techniques, which may reduce tissue disruption and air leakage along the insertion tract. Previous comparative studies have similarly reported favourable safety profiles with small-bore chest drains and comparable effectiveness to larger chest tubes in pneumothorax management.[1-3] These findings support the continued shift toward minimally invasive drainage approaches in selected patients.

The shorter chest drain duration observed in the Seldinger group may reflect improved tube positioning, reduced insertion-related trauma and fewer complications requiring prolonged drainage. Earlier studies have reported similar findings, suggesting that small-bore catheters achieve comparable clinical success while potentially improving patient comfort and reducing healthcare utilisation.[2,4] Contemporary international guidance, including the 2023 British Thoracic Society pleural disease guideline, also supports minimally invasive drainage strategies when intervention is required.[5] In many resource-limited settings where ambulatory pneumothorax devices are not widely available, wire-guided small-bore chest drains may represent a practical alternative.

In addition to procedural factors, patient-related variables influenced drainage duration. Smoking was independently associated with longer chest drainage, which is consistent with prior studies demonstrating delayed pleural healing and increased risk of persistent air leak among smokers.[6] Persistent air leak itself was also strongly associated with prolonged drainage, which is expected given its central role in determining chest tube removal timing.

Interestingly, non-tension pneumothorax was associated with longer drainage duration in our cohort. This may reflect differences in underlying pathology rather than severity at presentation, as secondary pneumothorax, particularly tuberculosis-related disease was common in our population and often requires longer drainage due to structural lung damage and bronchopleural fistula formation.[7] Taken together, these findings reinforce the importance of minimally invasive chest drainage strategies in contemporary practice and highlight the multifactorial determinants of drainage duration beyond procedural technique alone.

An important epidemiological observation in our cohort was the predominance of secondary pneumothorax, with active tuberculosis representing the most frequent underlying condition. This differs from many western cohorts in which primary spontaneous pneumothorax predominates and underscores the importance of evaluating pneumothorax management strategies in diverse clinical settings.[7,8] Our findings therefore contribute regionally relevant data that may better reflect practice patterns in southeast Asia.

Other outcomes, including insertion failure, tube dislodgement, persistent air leak and mortality, did not differ significantly between groups and should not be overinterpreted. Subgroup analyses comparing pneumothorax types and tube sizes were exploratory and likely underpowered given the smaller Seldinger cohort.

Despite the potential advantages of the Seldinger technique, several procedure-related risks have been described in previous studies. Guidewire-assisted catheter insertion may be associated with complications such as guidewire kinking or loss, catheter malposition, inadequate drainage due to small catheter diameter and rare visceral injury during insertion. Previous reports evaluating small-bore catheter drainage have also noted occasional tube blockage, kinking and the need for repositioning or reinsertion in a minority of cases.[2-4] However, in the present study, we did not observe any major guidewire-related complications or procedure-related organ injury among patients managed with the Seldinger technique. These findings suggest that, when performed using appropriate technique and operator experience, Seldinger chest drainage may have a favourable safety profile in routine clinical practice. Nevertheless, prospective randomised controlled trials would be required to more definitively evaluate the comparative safety and clinical effectiveness of Seldinger technique.

Several limitations should be considered when interpreting the findings of this study. First, the retrospective design introduces potential selection bias and residual confounding, and is subject to incomplete or inconsistently documented data. Second, the unequal group sizes reflect real-world practice patterns but may reduce statistical precision, particularly for subgroup analyses. Third, the multivariable analyses were exploratory in nature and not powered to establish causal relationships.

Despite these limitations, this study provides contemporary real-world data from a Southeast Asian population with a high prevalence of secondary pneumothorax. These findings demonstrate the feasibility and safety of minimally invasive chest drainage techniques in routine clinical practice. Prospective multicentre randomised controlled trials would further clarify the role of the Seldinger technique in pneumothorax management.

CONCLUSION

The Seldinger technique for chest drainage in pneumothorax has lower rates of subcutaneous emphysema and shorter chest drain duration compared with conventional trocar-based drainage. These findings support wire-guided small-bore chest drains as a safe and effective alternative in routine clinical settings.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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ETHICAL APPROVAL

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