

Risk Factors for Bleeding in Patients Undergoing Ultrasound-guided Tube Thoracostomy: A Retrospective Study of 4073 Patients

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Background: US-guided tube thoracostomy (US-TT) is widely employed for pleural effusion management, however bleeding complications remain a clinical concern.

Objective: To identify risk factors for bleeding during US-TT, focusing on doctor experience, coagulation status, malignancy, and anticoagulant/antiplatelet medication use.

Methods: In this retrospective cohort study, we analyzed 4,073 patients undergoing US-TT between January 2019 and January 2024. Using univariate analysis and multivariate binary logistic regression, we evaluated associations between post-procedural bleeding and the following factors: coagulation parameters (PLT, INR, APTT), inflammatory markers, use of anticoagulant/antiplatelet medications, malignancy status, and doctor experience (junior vs. senior). Demographic and clinical data were extracted from electronic medical records.

Results: Bleeding occurred in 24 patients (0.6%). Univariate analysis identified procedure performance by junior physicians and presence of malignancy as significant risk factors ($P < 0.05$). No significant associations were found with coagulation parameters, inflammatory markers, or medication use. Factors with $P < 0.1$ (junior doctor, malignancy, $\text{INR} > 2.0$, elevated leukocyte count) were included in multivariate analysis. This confirmed junior doctor status ($\text{OR}, 3.333; P = 0.033$) and malignancy ($\text{OR}, 3.960; P = 0.016$) as independent predictors of bleeding.

Conclusions: US-TT carries a low overall bleeding risk (0.6%). In this study, bleeding was associated with malignancy and less experienced doctors, but not significantly with routine coagulation indices. A trend toward increased risk with $\text{INR} > 2.0$ warrants caution.

Key words: Tube thoracostomy; Bleeding; Experience; Ultrasound; Malignancy

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Pleural effusion is a common clinical manifestation, with an estimated incidence of 350 to 360 cases per 100,000 people [1]. Its etiology is diverse, though malignancy, heart failure, pneumonia, and tuberculosis collectively account for approximately 75% of cases [2]. Patients with pleural effusion frequently experience dyspnea and cough. Critically, intensive care unit (ICU) patients with moderate effusions (defined by a maximum pleural fluid depth ≥ 3.0 cm) are

at risk for clinically significant complications, including respiratory compromise and increased mortality [3]. Early therapeutic intervention is essential to mitigate these adverse outcomes.

Tube thoracostomy is a common procedure that alleviates compression symptoms, improves pulmonary function, and facilitates ventilator weaning in critically ill patients [4]. US-TT is currently recommended for pleural effusion drainage due to its ability to improve

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procedural safety through real-time imaging [5]. Despite this advantage, complications-including hemorrhage, pneumothorax, subcutaneous emphysema, and pulmonary edema may still occur [6]. Bleeding, a common complication, is receiving increasing clinical attention. One study reported bleeding in 15 of 1,124 patients undergoing thoracic drainage, with two experiencing serious hemorrhagic complications [7]. Critically, a reliable evidence-based method to assess bleeding risk remains elusive.

Coagulopathy is a significant risk factor for procedural bleeding. Clinical guidelines frequently cite derangements in the International Normalized Ratio (INR) or Platelet count (PLT) as key determinants of bleeding risk. For instance, the British Thoracic Society guidelines advise avoiding elective pleural procedures in patients with an INR > 2 and a PLT < $50 \times 10^9/L$ [8]. Similarly, the Society of Interventional Radiology recommends transfusion for INR > 3.0 or the PLT < $20 \times 10^9/L$ when managing perioperative bleeding risks [9]. However, in clinical practice, correcting coagulopathy is often unfeasible or may cause life-threatening treatment delays in critically ill patients [10,11]. Crucially, existing guidelines lack specific recommendations regarding the safety and necessity of tube thoracostomy in this high-risk population.

Clinician proficiency critically influences complication rates during ultrasound-guided tube thoracostomy (US-TT). Key technical determinants include sonographic interpretation (fluid characterization, needle trajectory visualization), procedural execution (vessel avoidance, first-pass success), and operational efficiency [4]. Notably, scant published evidence addresses two critical knowledge gaps: whether operator seniority independently predicts bleeding risk, and how patient-specific factors (comorbidities, disease phenotypes) modulate hemorrhage susceptibility during thoracostomy.

Therefore, we assessed bleeding risk factors using a large clinical cohort to provide evidence-based guidance for precise risk stratification and procedural optimization.

Methods

Patients

We retrospectively analyzed 4,519 consecutive patients undergoing US-TT at our institution between January 1, 2019, and January 31, 2024. After applying exclusion criteria, 4,073 patients were included in the final cohort. All procedures were performed by board-certified interventional US doctors using real-time ultra-

sound guidance. Written informed consent was obtained from all patients prior to the procedure. The institutional review board waived approval requirements due to the retrospective study design.

Inclusion criteria: US-TT performed at our institution; Sonographic confirmation of pleural effusion ≥ 3.0 cm in both anterior-posterior dimensions [4]; Real-time ultrasound guidance during catheter placement.

Exclusion criteria: Incomplete clinical documentation; Inadequate sonographic visualization of pleural effusion; Diagnostic thoracentesis without catheter insertion; Patient non-cooperation compromising procedural safety.

Clinical information

We collected clinical data including patient age, sex, pleural effusion etiology, comorbidities and puncture laterality, and doctor experience. Preoperative laboratory parameters-PLT, INR, Activated Partial Thromboplastin Time (APTT), C-reactive protein (CRP), and Leukocyte count-were measured within 48 hours preceding the procedure. Table 1 details medication regimens for anticoagulants (dabigatran, rivaroxaban) and antiplatelet agents (aspirin, clopidogrel) [12].

Table 1 Inclusion criteria for medications

Antiplatelet	Dosage regimen ^a	Anticoagulated	Dosage regimen ^a
Aspirin ^b	5 days	Rivaroxaban ^d	1 days
Clopidogrel ^c	5 days	Dabigatran ^c	1 days

^a The patient took the drug within a limited period of time before the operation was placed. ^b Aspirin: 75 mg/ tablet/ day. ^c Clopidogrel: 75 mg/ tablet/ day. ^d Rivaroxaban: 10 mg/ tablet/ day. ^e Dabigatran: 150 mg/ capsule/ day

Doctor's experience

US-guided catheterization was performed using established techniques [13]. Adapting competency standards from the American College of Emergency Physicians-which requires > 150 emergency ultrasound examinations for proficiency [14]. We defined senior doctors as physicians with > 2 years of interventional experience who had performed ≥ 150 US-TT procedures. All other practitioners were classified as junior doctors.

Complications

All complications were prospectively documented. Pneumothorax was confirmed by chest radiography within 48 hours post-procedure. Pleural reaction was defined as an adverse systemic response to pleural cavity puncture, manifesting as ≥ 2 of the following: persistent cough, dizziness, chest tightness, pallor, diaphoresis, or syncope. Subcutaneous emphysema was clinically diagnosed within 48 hours.

Bleeding complications required meeting ≥ 1 criteri-

on [15]:

Post-procedural hemoglobin decline > 2 g/dL within 48 hours (excluding alternative explanations).

Clinician-documented puncture-related hemorrhage in medical records.

Substantial increase in drainage fluid hematocrit (from non-bloody baseline).

Hemorrhage requiring emergent transfusion, intervention, or causing mortality.

Exclusions: Pre/postoperative transfusion unrelated to procedure; Baseline bloody drainage at initial puncture.

Statistical analysis

Continuous variables, all non-normally distributed, are expressed as the medians with interquartile ranges (IQR) and analyzed using the Mann-Whitney U test. Categorical variables are presented as percentages (%) and compared with Chi-square tests. Bleeding risk factors were evaluated through multivariate binary logistic regression analysis. All analyses were performed using SPSS 26.0 (IBM Corp, Armonk, NY), with figures generated in GraphPad Prism 8.0 (GraphPad Software, La Jolla, CA).

Results

Among 4,519 patients who underwent thoracentesis, 4,073 met inclusion criteria for final analysis (Fig. 1). The overall complication rate for US-TT was 0.9% (35/4,073), with bleeding complications accounting for 0.6% (24/4073). Bleeding represented 69% (24/35) of all complications. Other complications included pneumothorax (11%;4/35), pleural reactions (11%;4/35), and subcutaneous emphysema (9%;3/35) (Fig. 2). Figure 3 demonstrates representative imaging of a hemorrhagic complication.

Patient baseline characteristics are presented in table 2. The cohort had a median age of 69 years, with males comprising 62.3% ($n = 2,539$). Malignant disease accounted for 47.1% ($n = 1918$) of cases, yet represented 70.8% (17/24) of bleeding events. Conversely, non-malignant conditions (nephritis, pneumonia, cardiac disease, chest trauma, others) accounted for only 29.2% (7/24) of bleeding complications. Based on this distribution, we stratified disease types as malignant versus non-malignant for subsequent univariate analysis. Most patients (62%, $n = 2,524$) underwent unilateral drainage. Preoperative laboratory assessment revealed normal coagulation parameters in most cases. Anticoagulant or antiplatelet medication use was documented in 10.0% ($n = 407$) of patients, with combination therapies detailed in table 3.

Univariate analysis showed no significant differences in age, gender distribution, or puncture laterality between patients with and without bleeding complications ($P > 0.05$). The bleeding incidence was significantly higher in malignant disease patients (0.9%, 17/1918), than in non-malignant cases (0.3%, 7/2155; OR, 2.744; $P = 0.025$). Operator experience significantly influenced bleeding risk: junior physicians accounted for 79.2% (19/24) of bleeding events versus 20.8% (5/24) for senior physicians, corresponding to a 3.346-fold increased odds of bleeding with junior operators ($P = 0.016$) (Table 4).

The bleeding rate was comparable between patients with coagulation parameters (0.6%, 14/2,093) and those with any abnormal coagulation value (defined as abnormality in ≥ 1 parameter: PLT, INR, or APTT) (0.5%, 10/1,980). Univariate analysis revealed no statistically significant associations between laboratory parameters and bleeding, as categories with zero bleeding events were excluded from analysis. However, two parameters

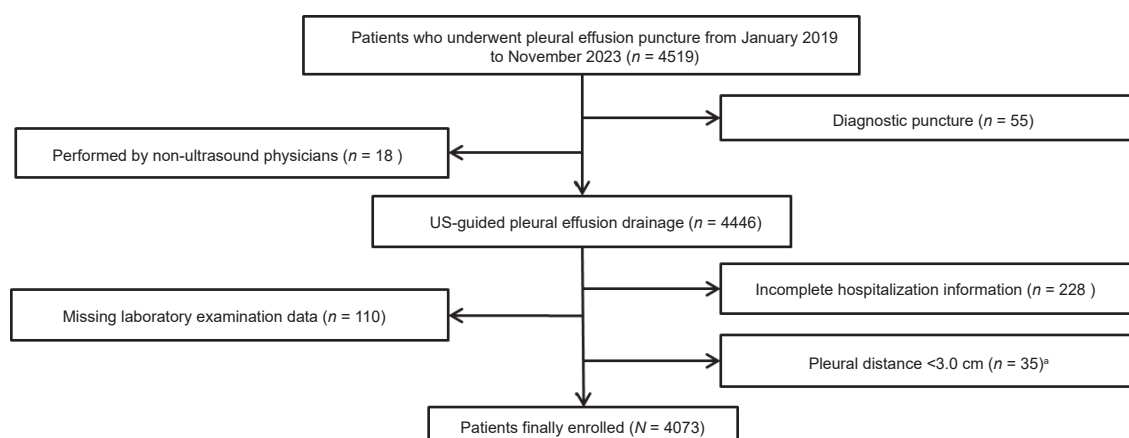


Figure 1 Flow chart of inclusion and exclusion. The final cohort comprised 4,049 patients without bleeding complications and 24 with hemorrhagic events. ^a Consistent with institutional protocol, procedures were not performed for effusion volumes < 500 mL—a threshold aligning with our sonographic inclusion criterion of < 3.0 cm maximal depth.

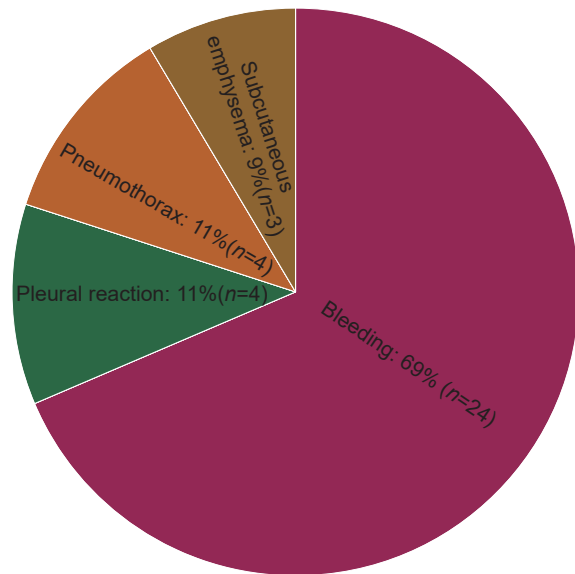


Figure 2 Complications of US-TT. The overall complication rate was 0.9% (35/4,073), including bleeding in 69% (24/35).

showed trends toward significance: patients with INR > 2.0 had 2.085-fold higher bleeding odds than those with normal INR ($P = 0.052$), while leukocyte counts > $10 \times 10^9/L$ was associated with a 2.172-fold increased odds ($P = 0.059$). Both values approached but did not reach statistical significance (Table 4).

Medication use did not significantly increase bleeding risk. Among 407 patients receiving anticoagulant/antiplatelet therapy and 3,795 untreated patients, bleeding incidence showed no significant difference (0.7% [3/407] vs. 0.6% [21/3,795]; $P = 0.946$). Subgroup analyses of individual agents—aspirin ($P = 0.786$) and clopidogrel ($P = 0.121$)—similarly demonstrated no statistically significant associations with bleeding (Table 4). Combination drug regimens also showed no elevated risk ($P = 0.332 - 1.00$, Table 3).

All Univariate factors were entered into binary logistics regression analysis (Table 4). Variables meeting the

$P < 0.10$ threshold (malignancy, junior doctor, INR > 2.0, leukocyte count > $10 \times 10^9/L$) were included in multivariate modeling. Multivariate analysis identified malignancy (OR, 3.960; $P = 0.016$) and junior doctor experience (OR, 3.333; $P = 0.033$) as independent predictors of bleeding during US-guided catheterization (Table 4). Drainage catheter size analysis revealed 11 bleeding events with 7F tubes and 6 with 8F tubes. However, no significant association was observed between catheter size and bleeding risk when compared to non-bleeding procedures ($P = 0.467$, Table 5).

Discussion

This retrospective study identifies junior operator experience and malignant disease status as significant factors associated with bleeding events during US-TT. Postprocedural hemorrhage typically results from intercostal artery injury during puncture, as these vessels are normally protected within the superior rib's intercostal groove [16,17]. In our cohort, real-time ultrasound guidance contributed to a low overall bleeding complication rate of 0.6% and total complication rate of 0.9%. These findings align with reported bleeding risks ranging from 0.0% to 1.2% in the literature [18–20].

While pneumothorax historically represented the most frequent complication of thoracic puncture (reported incidence: 19%), ultrasound guidance has markedly reduced this risk to 0%–3%, a finding consistent with our results [21,22]. Although US-TT bleeding complications remain uncommon, they carry significant clinical consequences, including potential mortality. In our cohort, two fatal hemorrhagic events occurred, both in patients with advanced-stage malignancies. We attribute these outcomes to disease severity and diminished physiological reserve rather than procedural factors per se.

While coagulation assessment PLT, INR, and APTT remains standard for invasive procedure risk stratifica-

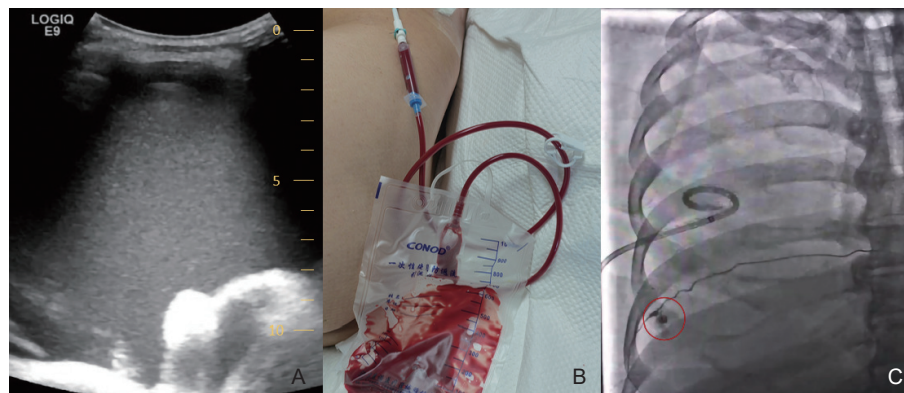


Figure 3 Representative case. A 55-year-old male with stage IV lung adenocarcinoma (diagnosed > 24 months prior) presented with malignant pleural effusion following intermittent targeted therapy and chemotherapy. During ultrasound-guided tube thoracostomy performed by a junior operator: (A) Pre-procedural sonography revealed massive pleural effusion; (B) Immediate postprocedural drainage demonstrated frank hemothorax; (C) Emergency digital subtraction angiography (DSA) confirmed intercostal artery injury requiring coil embolization. The red circle indicates the site of bleeding.

Table 2 Patient clinical and demographic characteristics of US-TT

Variable	All procedures (n = 4073)
Age (y), median (IQR)	69 (57,81)
Male, n (%)	2539 (62.3)
Type diseases, n (%)	
Malignant	1918 (47.1)
Nephritis	524 (12.9)
Pneumonia	442 (10.9)
Cardiopathy	365 (9)
Chest trauma	61 (1.5)
Others ^a	761 (18.7)
Unilateral puncture, n (%)	2524 (62)
PLT category, n (%), (10 ⁹ /L)	
≤ 30	64 (1.6)
31-60	119 (2.9)
61-100	479 (11.8)
> 100 (normal)	3411 (83.7)
INR category ^b , n (%)	
< 0.8	2 (0.05)
0.8-1.2 (normal)	2603 (63.9)
1.21-2.0	1285 (31.5)
> 2.0	72 (1.8)
APTT category ^c , n (%), s	
< 30	417 (10.2)
30-45 (normal)	2443 (60)
46-55	826 (20.3)
> 55	277 (6.8)
Leukocyte category, n (%), (10 ⁹ /L)	
≤ 10 (normal)	2926 (71.8)
> 10	1147 (28.2)
CRP category ^d , n (%), (mg/dl)	
≤ 0.8 (normal)	813 (25.6)
> 0.8	2360 (74.4)
Medications, n (%) ^e	
No medication	3795 (90)
Clopidogrel	262 (6.4)
Aspirin	237 (5.8)
Dabigatran	30 (0.7)
Rivaroxaban	6 (0.1)

^a Other diseases included autoimmune diseases, gastrointestinal diseases, skeletal diseases. ^b 111 cases have missing data. ^c 110 cases have missing data. ^d 900 cases have missing data. ^e Among 407 patients receiving anticoagulant/antiplatelet therapy, 128 were on combination regimens

tion, growing evidence challenges its predictive value for thoracic interventions [19,23–25]. Notably, a study of 41 patients with malignancies and severe thrombocytopenia (PLT < 30 × 10⁹/L) undergoing US-TT reported only minor bleeding events (3/41, 7.3%) without major hemorrhage [26]. APTT—an indicator of intrinsic pathway dysfunction—has been notably absent from prior thoracic drainage complication literature. Both univari-

Table 3 Drug combination

Medication ^a	Non-bleeding (n)	Bleeding (n)	P value
C+A	117	2	0.332
A+D	1	0	1.000
A+R	2	0	1.000
C+D	4	0	1.000
C+R	2	0	1.000
D+R	1	0	1.000

^a Clopidogrel = C, Aspirin = A, Dabigatran = D, Rivaroxaban = R.

ate and multivariate analyses confirmed no statistically significant association between conventional coagulation parameters (PLT, INR, APTT) and catheterization-related bleeding in our cohort [27]. However, it is worth noting that in the univariate analysis, an INR > 2.0 showed an odds ratio (OR) of 2.085 for bleeding risk compared to the normal INR group, approaching statistical significance. While this finding did not reach the conventional threshold for significance and was not confirmed in multivariate analysis, it suggests a potential trend that warrants consideration in clinical risk assessment. The absolute bleeding risk in the INR > 2.0 group was 0.8%, compared to 0.6% overall. Clinicians might still exercise heightened vigilance or consider individualized risk-benefit discussions in patients with markedly elevated INR, particularly in conjunction with other risk factors, acknowledging that the absolute risk increase in this cohort was small.

In our study, coagulation parameters (INR and APTT) were central to the primary analysis, while CRP, as an inflammatory marker, was a secondary and exploratory variable. Therefore, we focused our missing data analysis on the core variables of interest: INR and APTT. Using the Expectation-Maximization (EM) algorithm in SPSS, we tested the pattern of missingness for INR and APTT. The result of Little's MCAR test was not significant ($P = 0.085$), providing evidence that the data for these coagulation parameters are likely Missing at Random (MAR). This suggests that while the missing data reduces the sample size and power for analyses involving INR/APTT, it is unlikely to have introduced substantial selection bias into our core findings related to coagulation.

Patients requiring tube thoracostomy frequently present with complex comorbidities—including coronary artery disease, myocardial infarction, cerebrovascular accidents, and renal impairment—necessitating uninterrupted anticoagulant or antiplatelet therapy [28]. Discontinuation of agents like clopidogrel in stent-implanted patients elevates coronary thrombosis risk, a concern substantiated by multiple studies showing no increased bleeding risk during thoracentesis with continued clopidogrel use [18,29,30,31]. Given its pharmacokinetic pro-

Table 4 Logistic regression for the bleeding patients vs Non-Bleeding patients

Variable	Univariate analysis		Multivariate analysis ^a	
	OR (95%CI)	P value	OR (95%CI)	P value
Age, y				
≤ 69	1 [Reference]			
> 69	0.934 (0.417-2.089)	.867	NA	NA
Gender				
Male	1 [Reference]			
Female	1.470 (0.608-3.554)	.392	NA	NA
Type diseases ^b				
Others	1 [Reference]			
Malignant	2.744 (1.136-6.631)	.025	3.960 (1.293-12.130)	.016
Puncture side				
Unilateral	1 [Reference]			
Bilateral	1.847 (0.732-4.663)	.194	NA	NA
Coagulation function				
Normal	1 [Reference]			
Abnormal	0.754 (0.334-1.701)	.496	NA	NA
PLT category				
≤ 30	NA	NA		
31-60	0.834 (0.304-2.287)	.725		
61-100	0.936 (0.277-3.161)	.915	NA	NA
> 100 (normal)	1 [Reference]			
INR category				
< 0.8	NA	NA		
0.8-1.2 (normal)	1 [Reference]		NA	NA
1.21-2.0	0.594 (0.219-1.614)	.307		
> 2.0	2.085 (0.993-4.379)	.052	2.138 (0.981-4.659)	.056
APTT category				
< 30	0.638 (0.211-1.931)	.426		
30-45 (normal)	1 [Reference]			
46-55	0.393 (0.090-1.722)	.215	NA	NA
> 55	1.331 (0.714-2.482)	.368		
Leukocyte category				
≤ 10 (normal)	1 [Reference]			
> 10	2.172 (0.970-4.863)	.059	2.019 (0.788-5.177)	.143
CRP category				
≤ 0.8 (normal)	1 [Reference]			
> 0.8	1.497 (0.426-5.268)	.529	NA	NA
Medications				
No medication	1 [Reference]			
Clopidogrel	1.150 (0.420-3.146)	.786		
Aspirin	3.181 (0.737-13.729)	.121	NA	NA
Dabigatran	NA	NA		
Rivaroxaban	NA	NA		
Medical experience				
Senior doctor	1 [Reference]			
Junior doctor	3.346 (1.247-8.979)	.016	3.333 (1.099-10.109)	.033

^a $P < 0.1$ in univariate logistics regression analysis were included in multi-factor analysis. ^b The proportion of malignant patients was close to 50, so we divided the disease types into two categories

Table 5 Drainage tube model

Model, <i>n</i> (%)	Non-bleeding	Bleeding	P value
5F	355 (9.5)	3 (13.0)	0.467
6F	193 (5.1)	3 (13.0)	
7F	1635 (43.6)	11 (47.8)	
8F	1205 (32.1)	6 (26.1)	
10F	273 (7.3)	0 (0)	
12F	47 (1.3)	0 (0)	
14F	41 (1.1)	0 (0)	

file (half-life comparable to aspirin), the thrombotic risks of clopidogrel withdrawal may outweigh potential bleeding benefits [32]. Our data corroborate this clinical calculus: patients receiving preoperative anticoagulant/antiplatelet therapy exhibited a bleeding rate of 0.7%, statistically indistinguishable from the overall cohort's 0.6%. This supports the conclusion that perioperative continuation of these agents does not significantly increase hemorrhage risk during US-TT.

Operator proficiency critically influences procedural outcomes and complication profiles in interventional radiology [33]. Operator expertise critically determines US-TT success, with procedural outcomes dependent on: Patient positioning feasibility; Optimal puncture site selection; Intercostal vessel navigation; Real-time needle tip visualization; Precise insertion trajectory [5]. We hypothesize that multiple puncture attempts by inexperienced operators—frequently necessitated by suboptimal needle tip visualization—represent key modifiable risk factors for hemorrhagic complications. While the impact of operator seniority on US-TT bleeding risk remains unquantified in existing literature, our analysis demonstrates a 3.333-fold reduction in hemorrhage incidence with experienced practitioners.

Malignancy-associated coagulopathy predisposes patients to hemorrhagic manifestations, with literature reporting clinically significant bleeding in approximately 10% of this population. Our analysis revealed a three-fold higher incidence of procedure-related bleeding in malignant cases (0.9% [17/1,918]) versus non-malignant counterparts (0.3% [7/2,155]). This differential risk profile likely stems from tumor-mediated vascular invasion, cytotoxic therapy effects [34], hemorrhagic effusions, and cancer cachexia-related coagulopathies [35]. Regarding technical considerations, our statistical evaluation of drainage catheter calibers (5F–14F) demonstrated no significant association with bleeding risk ($P = 0.467$). The predominant clinical utilization of smaller-bore catheters ($\leq 8F$: 90% of cases) versus limited application of larger devices ($\geq 10F$: 10%) may introduce selection bias. The pathophysiological relationship between catheter diameter and vascular injury warrants further mechanistic investigation.

This research has several important constraints: Single-center retrospective design introduces potential selection bias, particularly regarding bleeding determination which relied solely on clinician documentation in medical records; this may result in underreporting, as some cases of bleeding that were promptly and effectively controlled may not have been captured. Furthermore, the high missing rate of inflammatory markers such as CRP precludes definitive conclusions regarding their association with outcomes. Rare outcome limitation: The low overall bleeding incidence (0.6%) and small absolute number of events ($n = 24$) preclude development of robust predictive models. These methodological constraints necessitate validation through multicenter prospective studies with standardized bleeding criteria. In light of these limitations, particularly the retrospective nature and potential for bias in event ascertainment, the conclusion that bleeding risk is unrelated to laboratory tests should be interpreted with caution. Our findings suggest that within the context of this study and its inherent constraints, routine coagulation parameters (PLT, INR, APTT) did not demonstrate a statistically significant independent association with bleeding risk. However, the potential signal observed with elevated INR (> 2.0) merits attention and highlights the need for larger, prospective studies to definitively evaluate the role of coagulopathy and refine risk stratification strategies. The association with doctor experience and malignant status appears more robust based on our data, but also requires prospective validation.

Conclusions

Ultrasound-guided tube thoracostomy is associated with a low overall incidence of bleeding (0.6% in this study). Within the limitations of this retrospective analysis, routine coagulation parameters (PLT, INR, APTT) did not demonstrate a statistically significant independent association with bleeding risk. However, the presence of malignant disease and procedures performed by less experienced doctors were identified as significant factors associated with increased bleeding risk. Therefore, to minimize bleeding risk, special attention should be paid during preoperative preparation and procedural execution for patients with malignancies, and whenever feasible, the procedure should be performed by experienced clinicians. Although not statistically significant in our multivariate model, the trend observed for elevated INR (> 2.0) warrants attention and should be considered to represent an elevated risk category when planning invasive procedures. These findings, particularly regarding the role of coagulation tests, require prospective val-

itation in larger, multicenter studies.

References

- [1] Mumtaz SR, Stoller JK, Lopez R, Kailasam K, Gillespie CT, Hahn PY. Epidemiology of adult pleural disease in the United States. *Chest* 2021;160:1534-1551.
- [2] Porcel JM, Esquerda A, Vives M, Bielsa S. Etiology of pleural effusions: analysis of more than 3,000 consecutive thoracenteses. *Arch Bronconeumol* 2014;50:161-165.
- [3] Razazi K, Boissier F, Neuville M, Jochmans S, Tchir M, May F, et al. Pleural effusion during weaning from mechanical ventilation: a prospective observational multicenter study. *Ann Intensive Care* 2018;8:103.
- [4] Brogi E, Gargani L, Bignami E, Barbariol F, Marra A, Forfori F, et al. Thoracic ultrasound for pleural effusion in the intensive care unit: a narrative review from diagnosis to treatment. *Crit Care* 2017;21:325.
- [5] Keng LT, Hsieh MY. Ultrasound guidance for pleural-catheter placement. *N Engl J Med* 2018;379:401-402.
- [6] Gordon CE, Feller-Kopman D, Balk EM, Smetana GW. Pneumothorax following thoracentesis: a systematic review and meta-analysis. *Arch Intern Med* 2010;170:332-339.
- [7] Dangers L, Giovannelli J, Mangiapan G, Alves M, Bigé N, Messika J, et al. Antiplatelet drugs and risk of bleeding after bedside pleural procedures: a national multicenter cohort study. *Chest* 2021;159:1621-1629.
- [8] Roberts ME, Rahman NM, Maskell NA, Bibby AC, Blyth KG, Corcoran JP, et al. British thoracic society guideline for pleural disease. *Thorax* 2023;78:1143-1156.
- [9] Patel IJ, Rahim S, Davidson JC, Hanks SE, Tam AL, Walker TG, et al. Society of interventional radiology consensus guidelines for the periprocedural management of thrombotic and bleeding risk in patients undergoing percutaneous image-guided interventions-part ii: recommendations endorsed by the canadian association for interventional radiology and the cardiovascular and interventional radiological society of Europe. *J Vasc Interv Radiol* 2019;30:1168-1184.e1.
- [10] Douketis JD, Spyropoulos AC, Murad MH, Arcelus JJ, Dager WE, Dunn AS, et al. Perioperative management of antithrombotic therapy: an american college of chest physicians clinical practice guideline. *Chest* 2022;162:e207-207e243.
- [11] Herman DD, Thomson CC, Brosnhan S, Patel R, Trosini-Desert V, Bilaceroglu S, et al. Risk of bleeding in patients undergoing pulmonary procedures on antiplatelet or anticoagulants: A systematic review. *Respir Med* 2019;153:76-84.
- [12] Zalt MB, Bechara RI, Parks C, Berkowitz DM. Effect of routine clopidogrel use on bleeding complications after ultrasound-guided thoracentesis. *J Bronchology Interv Pulmonol* 2012;19:284-287.
- [13] Vetrugno L, Guadagnin GM, Orso D, Boero E, Bignami E, Bove T. An easier and safe affair, pleural drainage with ultrasound in critical patient: a technical note. *Crit Ultrasound J* 2018;10:18.
- [14] American College of Emergency Physicians. Emergency ultrasound guidelines. *Ann Emerg Med* 2009;53:550-570.
- [15] Freitas-Martinez A, Santana N, Arias-Santiago S, Viera A. Using the common terminology criteria for adverse events (ctcae - version 5.0) to evaluate the severity of adverse events of anticancer therapies. *Actas Dermosifiliogr (Engl Ed)* 2021;112:90-92.
- [16] Helm EJ, Rahman NM, Talakoub O, Fox DL, Gleeson FV. Course and variation of the intercostal artery by CT scan. *Chest* 2013;143:634-639.
- [17] Yacovone ML, Kartan R, Bautista M. Intercostal artery laceration following thoracentesis. *Respir Care* 2010;55:1495-1498.
- [18] Aljundi L, Chaar A, Boshara P, Shiari A, Gennaoui G, Noori Z, et al. Incidence of bleeding in patients on different anticoagulants and antiplatelet therapies undergoing thoracentesis. *BMJ Open Respir Res* 2021;8:e000874.
- [19] Feller-Kopman D, Light R. Pleural disease. *N Engl J Med* 2018;378:740-751.
- [20] Fong C, Tan C, Tan D, See KC. Safety of thoracentesis and tube thoracostomy in patients with uncorrected coagulopathy: a systematic review and meta-analysis. *Chest* 2021;160:1875-1889.
- [21] Grogan DR, Irwin RS, Channick R, Raptopoulos V, Curley FJ, Bartter T, et al. complications associated with thoracentesis. a prospective, randomized study comparing three different methods. *Arch Intern Med* 1990;150:873-877.
- [22] Cavanna L, Mordenti P, Bertè R, Palladino MA, Biasini C, Anselmi E, et al. Ultrasound guidance reduces pneumothorax rate and improves safety of thoracentesis in malignant pleural effusion: report on 445 consecutive patients with advanced cancer. *World J Surg Oncol* 2014;12:139.
- [23] Puchalski J. Thoracentesis and the risks for bleeding: a new era. *Curr Opin Pulm Med* 2014;20:377-384.
- [24] Ault MJ, Rosen BT, Scher J, Feinglass J, Barsuk JH. Thoracentesis outcomes: a 12-year experience. *Thorax* 2015;70:127-132.
- [25] Patel MD, Joshi SD. Abnormal preprocedural international normalized ratio and platelet counts are not associated with increased bleeding complications after ultrasound-guided thoracentesis. *AJR Am J Roentgenol* 2011;197:W164-W168.
- [26] Orlandi E, Citterio C, Seghini P, Di Nunzio C, Mordenti P, Cavana L. Thoracentesis in advanced cancer patients with severe thrombocytopenia: ultrasound guide improves safety and reduces bleeding risk. *Clin Respir J* 2018;12:1747-1752.
- [27] Kamal AH, Tefferi A, Pruthi RK. How to interpret and pursue an abnormal prothrombin time, activated partial thromboplastin time, and bleeding time in adults. *Mayo Clin Proc* 2007;82:864-873.
- [28] Puchalski JT, Argento AC, Murphy TE, Araujo KL, Pisani MA. The safety of thoracentesis in patients with uncorrected bleeding risk. *Ann Am Thorac Soc* 2013;10:336-341.
- [29] Iakovou I, Schmidt T, Bonizzoni E, Ge L, Sangiorgi GM, Stankovic G, et al. Incidence, predictors, and outcome of thrombosis after successful implantation of drug-eluting stents. *JAMA* 2005;293:2126-2130.
- [30] Patel PP, Singh S, Atwell TD, Kashyap R, Kern RM, Mullon JJ, et al. The safety of ultrasound-guided thoracentesis in patients on novel oral anticoagulants and clopidogrel: a single-center experience. *Mayo Clin Proc* 2019;94:1535-1541.
- [31] Perl S, Bondarenko M, Natif N, Shpirer Y, Enghelberg S, Fox B. Thoracentesis under clopidogrel is not associated with excessive bleeding events: a cohort study. *Respir Res* 2020;21:281.
- [32] Armstrong PC, Hoefer T, Knowles RB, Tucker AT, Hayman MA, Ferreira PM, et al. Newly formed reticulated platelets undermine pharmacokinetically short-lived antiplatelet therapies. *Arterioscler Thromb Vasc Biol* 2017;37:949-956.
- [33] Jin S, Fu Q, Wuyun G, Wuyun T. Management of post-hepatectomy complications. *World J Gastroenterol* 2013;19:7983-7991.
- [34] Patel IJ, Davidson JC, Nikolic B, Salazar GM, Schwartzberg MS, Walker TG, Saad WA, Standards of Practice Committee, with Cardiovascular and Interventional Radiological Society of Europe (CIRSE) Endorsement. Consensus guidelines for periprocedural management of coagulation status and hemostasis risk in percutaneous image-guided interventions. *J Vasc Interv Radiol* 2012;23:727-736.
- [35] Nishikawa H, Goto M, Fukunishi S, Asai A, Nishiguchi S, Higuchi K. Cancer cachexia: its mechanism and clinical significance. *Int J Mol Sci* 2021;22:8491.