

Left Versus Right Landmark-Guided Subclavian Cannulation in Cardiogenic Shock: A Retrospective Study in Myanmar

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ABSTRACT

Background

Rapid central venous access is essential in the management of cardiogenic shock. Although ultrasound-guided internal jugular vein cannulation is widely recommended, landmark-guided subclavian venous access remains necessary during emergency resuscitation when ultrasound guidance is not feasible. The optimal laterality for landmark-guided subclavian cannulation remains uncertain.

Objectives

Our Objectives are to compare the incidence of catheter malposition and complications between left- and right-sided landmark-guided subclavian venous cannulation in critically ill patients with cardiogenic shock in the coronary care unit.

Methods

We conducted a retrospective cohort study including 150 adult patients who underwent emergent landmark-guided subclavian venous catheterization in the coronary care unit. The primary outcome was catheter malposition confirmed by post-procedure chest radiography. Secondary outcomes included pneumothorax, arterial puncture, and hematoma formation.

Results

Among 150 patients, 72 underwent left-sided cannulation and 78 underwent right-sided cannulation. Catheter malposition occurred significantly more frequently following right-sided cannulation compared with left-sided cannulation (12.8% vs 2.8%; $p = 0.03$), corresponding to an approximately 4.6-fold higher risk of malposition. Mechanical complication rates were low and did not differ significantly between groups.

Conclusions

Right-sided landmark-guided subclavian cannulation was associated with a higher incidence of catheter malposition compared with the left-sided approach. The anatomical course of the left brachiocephalic vein may facilitate more reliable catheter placement during emergency central venous access.

KEYWORDS: Subclavian vein; Central venous catheterization; Cardiogenic shock; Catheter malposition; Coronary care unit

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INTRODUCTION

Cardiogenic shock represents the most severe form of acute heart failure and is characterized by systemic hypoperfusion resulting from profound cardiac dysfunction. Despite

advances in pharmacologic therapy and mechanical circulatory support, cardiogenic shock remains associated with substantial morbidity and mortality. [1, 2] Rapid establishment of central venous access is therefore a critical

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component of early management, allowing administration of vasoactive medications, fluid resuscitation, and invasive hemodynamic monitoring. [3]

Central venous catheterization is commonly performed using the internal jugular, subclavian, or femoral venous approaches. Ultrasound-guided internal jugular venous access has been widely recommended because it improves procedural success and reduces complications. [4, 5] However, ultrasound guidance may not always be feasible in emergency cardiovascular situations. During cardiopulmonary resuscitation, severe pulmonary edema, or when rapid access is required, clinicians frequently rely on landmark-guided techniques. [6] Under these circumstances, the subclavian vein remains an attractive access site because it provides stable catheter positioning and does not interfere with airway management or chest compressions. [7]

Catheter malposition represents one of the most frequent mechanical complications of central venous catheterization. [8] Malpositioned catheters may lead to inaccurate central venous pressure measurements, ineffective infusion of vasoactive medications, and delays in the initiation of advanced procedures such as pulmonary artery catheterization or temporary transvenous pacing. [9, 10] Previous studies evaluating complications of subclavian venous catheterization have reported that catheter malposition occurs in a notable proportion of cases, particularly when landmark-guided techniques are used. [6, 11, 12]

Several observational studies have suggested that the side of cannulation may influence catheter trajectory. An observational investigation by Shin KW reported higher malposition rates during right-sided subclavian venous catheterization compared with the left side. [13] These findings suggest that anatomical factors related to the brachiocephalic venous system may influence the direction of guidewire advancement during catheter placement. [14]

Anatomical considerations provide a plausible explanation for this phenomenon (Figure 1).

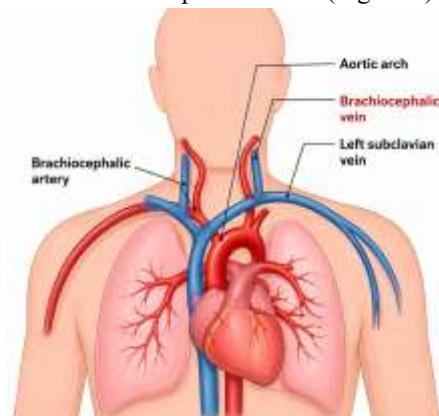


Figure 1: Anatomy of the central venous system.

Note the relatively acute angle formed by the junction of the right subclavian and internal jugular veins, compared to the

longer, gentler curvature of the left brachiocephalic vein as it courses toward the superior vena cava. This anatomical variation provides the mechanical basis for the higher rate of catheter malposition observed during right-sided landmark cannulation.

The right subclavian vein joins the internal jugular vein at a relatively acute angle before forming the right brachiocephalic vein and entering the superior vena cava. In contrast, the left subclavian vein forms the left brachiocephalic vein, which courses more horizontally across the mediastinum before entering the superior vena cava. This smoother anatomical pathway may facilitate guidewire advancement toward the central circulation and reduce the likelihood of catheter misdirection. [15] Anatomical studies of the thoracic inlet have demonstrated the close relationship between the subclavian vein and surrounding structures, including the pleural dome, emphasizing the importance of understanding venous geometry during catheter placement. [16]

Additional support for the anatomical advantage of left-sided access comes from cardiac electrophysiology practice. Electrophysiologists frequently prefer the left subclavian vein for implantation of permanent pacemakers and implantable cardioverter-defibrillators because the left brachiocephalic vein provides a relatively straight pathway toward the right atrium. [17, 18]

More recently, randomized clinical evidence has further examined the influence of cannulation laterality. A randomized controlled trial conducted by Shin KW demonstrated significantly lower malposition rates during left-sided infraclavicular subclavian venous catheterization compared with right-sided cannulation. [13]

Based on these anatomical and clinical observations, we hypothesized that landmark-guided cannulation of the left subclavian vein would be associated with a lower incidence of catheter malposition compared with right-sided cannulation. Therefore, the present study aimed to compare the incidence of catheter malposition between left- and right-sided landmark-guided subclavian venous cannulation in critically ill patients with cardiogenic shock in the coronary care unit.

METHODS

Study Design and Population

This retrospective cohort study included consecutive adult patients undergoing emergent landmark-guided subclavian venous catheterization in the coronary care unit between January 2024 and December 2025.

Procedural Technique

Subclavian venous access was performed using the landmark-guided infraclavicular technique and the Seldinger method (Figure 2).

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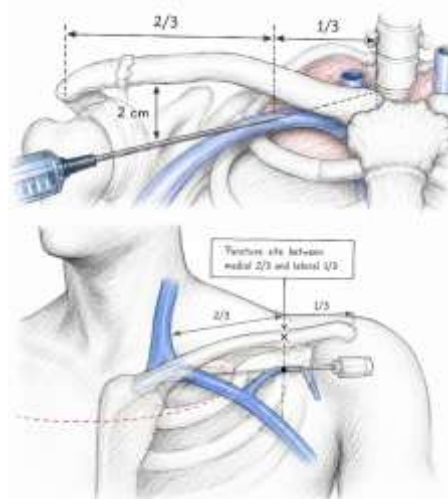


Figure 2: Anatomical landmarks and needle trajectory for landmark-guided infraclavicular subclavian vein (SCV) cannulation.

(Top) Schematic representation of the right-sided approach. The introducer needle is inserted approximately 1 to 2 cm inferior to the clavicle at the junction of the medial and lateral segments. The needle is kept strictly parallel to the chest wall and advanced medially beneath the posterior surface of the clavicle.

(Bottom) Anatomical overlay demonstrating the left-sided approach. The entry site is identified inferior to the clavicle (depicted here between the medial 2/3 and lateral 1/3). The needle is advanced along the trajectory indicated by the white arrow, aiming medially toward the suprasternal notch to safely access the left subclavian vein before it merges with the left internal jugular vein to form the left brachiocephalic vein.

Guidewire orientation may influence catheter trajectory during advancement. [19]

Outcome Measures

The primary outcome was catheter malposition identified on post-procedure chest radiography (Figure 4). Secondary outcomes included pneumothorax, arterial puncture, and localized hematoma.

Statistical Analysis

Continuous variables were expressed as mean $\pm$ standard deviation. Categorical variables were analyzed using chi-square or Fisher's exact tests. Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). A p value <0.05 was considered statistically significant.

RESULTS

Patient Characteristics

A total of 150 patients who underwent emergent landmark-guided subclavian venous catheterization in the coronary care unit met the inclusion criteria during the study

period. Of these, 72 patients underwent left-sided subclavian vein cannulation and 78 patients underwent right-sided cannulation.

Baseline demographic and clinical characteristics were comparable between the two groups (Table 1).

Table 1. Baseline Demographic and Clinical Characteristics

Characteristic	Total (N=150)	Left SCV (n=72)	Right SCV (n=78)	p-value
Age, years (mean $\pm$ SD)	62.4 $\pm$ 14.1	62.1 $\pm$ 14.5	62.7 $\pm$ 13.8	0.82
Male sex, n (%)	88 (58.7)	42 (58.3)	46 (59.0)	0.94
BMI, kg/m ² (mean $\pm$ SD)	27.4 $\pm$ 5.8	27.2 $\pm$ 5.9	27.6 $\pm$ 5.7	0.68
Cardiogenic shock, n (%)	96 (64.0)	46 (63.9)	50 (64.1)	0.89
Cardiac arrest, n (%)	32 (21.3)	15 (20.8)	17 (21.8)	
Pulmonary edema/other, n (%)	22 (14.7)	11 (15.3)	11 (14.1)	
Mechanical ventilation, n (%)	6 (4.0)	3 (4.2)	3 (3.8)	>0.99
Operator: Fellow, n (%)	104 (69.3)	48 (66.7)	56 (71.8)	0.77
Operator: Attending, n (%)	46 (30.7)	24 (33.3)	22 (28.2)	

The overall mean age of the cohort was 62.4 $\pm$ 14.1 years, and 58.7% of patients were male. The mean body mass index was 27.4 $\pm$ 5.8 kg/m². There were no statistically significant differences in age, sex distribution, or body mass index between the left- and right-sided cannulation groups.

The most common indication for central venous access was cardiogenic shock requiring vasoactive or inotropic support, accounting for 64.0% of cases. Cardiac arrest was the second most frequent indication, occurring in 21.3% of patients. Severe pulmonary edema or other acute cardiovascular conditions accounted for the remaining 14.7% of procedures. Mechanical ventilation at the time of catheter insertion was documented in 4.0% of patients.

Procedures were primarily performed by fellows in cardiology or critical care (69.3%), with the remainder performed by attending physicians (30.7%). The distribution of operator experience did not differ significantly between the left and right cannulation groups.

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Primary Outcome: Catheter Malposition

Across the entire cohort, catheter malposition occurred in 12 patients, corresponding to an overall incidence of 8.0%.

A significant difference in malposition rates was observed between the two cannulation sites (Table 2).

Table 2. Primary Outcome: Catheter Malposition

Outcome	Total (N=150)	Left SCV (n=72)	Right SCV (n=78)	p-value
Catheter malposition, n (%)	12 (8.0)	2 (2.8)	10 (12.8)	0.03

Location of Malposition

Location	Total	Left SCV	Right SCV
Ipsilateral internal jugular vein	9	1	8
Contralateral brachiocephalic vein	2	1	1
Looped within subclavian vein	1	0	1

Catheter malposition occurred in 10 of 78 patients (12.8%) undergoing right-sided cannulation, compared with 2 of 72 patients (2.8%) undergoing left-sided cannulation (p = 0.03). This corresponds to an approximately 4.6-fold higher risk of catheter malposition associated with right-sided cannulation.

Analysis of the anatomical locations of malposition revealed a consistent pattern. The majority of malpositioned catheters (9 of 12 cases, 75%) were directed cephalad into the ipsilateral internal jugular vein (Figure 3).



Figure 3. Catheter Malposition on Chest Radiography

Malposition of a central venous catheter following right-sided subclavian cannulation.

An anteroposterior chest radiograph demonstrating cephalad migration of the catheter into the ipsilateral internal jugular vein following right subclavian vein cannulation. The catheter tip is directed upward rather than toward the superior vena cava.

Two catheters were located within the contralateral brachiocephalic vein, and one catheter formed a loop within the ipsilateral subclavian vein. Among the right-sided cannulation group, internal jugular vein malposition accounted for 8 of the 10 malposition events.

These findings suggest that the anatomical junction between the right subclavian vein and internal jugular vein may predispose guidewire advancement toward the cervical venous system during right-sided cannulation.

Secondary Outcomes: Mechanical Complications

Immediate mechanical complications were uncommon in the study cohort and were similar between the two groups (Table 3).

Table 3. Mechanical Complications

Complication	Total (N=150)	Left SCV (n=72)	Right SCV (n=78)	p-value
Pneumothorax	4 (2.7%)	2 (2.8%)	2 (2.6%)	>0.99
Arterial puncture	5 (3.3%)	2 (2.8%)	3 (3.8%)	0.72
Localized hematoma	6 (4.0%)	3 (4.2%)	3 (3.8%)	>0.99

Radiographically confirmed pneumothorax occurred in four patients (2.7%). Two cases occurred following right-sided cannulation (2.6%), while two occurred following left-sided cannulation (2.8%). The difference between groups was not statistically significant (p > 0.99).

Arterial puncture occurred in five procedures (3.3%) and was distributed similarly between the groups, occurring in three patients in the right-sided group (3.8%) and two patients in the left-sided group (2.8%).

Localized hematoma formation occurred in six cases (4.0%), with no significant difference between left-sided (4.2%) and right-sided (3.8%) cannulation.

Importantly, no cases of clinically suspected or radiographically confirmed chylothorax were identified during the study period.

DISCUSSION

The present study evaluated the influence of cannulation laterality on catheter positioning during landmark-guided subclavian venous catheterization in critically ill patients with cardiogenic shock. The principal finding of this investigation was that right-sided cannulation was associated with a significantly higher incidence of catheter malposition compared with the left-sided approach. Importantly, this difference occurred without an increase in

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mechanical complications such as pneumothorax, arterial puncture, or hematoma formation. These findings suggest that anatomical characteristics of the thoracic venous system may play a key role in determining catheter trajectory during subclavian venous access. [16]

Central venous catheterization remains an essential procedure in the management of critically ill cardiovascular patients. In cardiogenic shock, central venous access allows the administration of vasoactive medications, monitoring of central venous pressure, and performance of advanced procedures such as pulmonary artery catheterization or temporary pacing. [1-3] Although ultrasound guidance has improved the safety of vascular access, landmark-guided techniques remain necessary in certain emergency settings where imaging equipment may not be readily available. [6]

One of the most notable observations in the present study was the predominance of internal jugular vein malposition among right-sided catheterizations. This pattern can be explained by the anatomical relationship between the right subclavian vein and the internal jugular vein. These vessels converge at an acute angle before forming the right brachiocephalic vein. [14] During advancement of the guidewire using the Seldinger technique, the guidewire may encounter the vessel wall at this junction and deflect cephalad into the internal jugular vein rather than progressing toward the superior vena cava. [15] Previous procedural studies have described similar patterns of catheter misdirection during subclavian venous catheterization. [20]

In contrast, the venous anatomy on the left side provides a different configuration. The left subclavian vein joins the internal jugular vein to form the left brachiocephalic vein, which travels horizontally across the mediastinum before entering the superior vena cava. This longer and smoother pathway may facilitate guidewire advancement toward the central circulation and reduce the likelihood of catheter malposition. [15] Anatomical studies of the thoracic venous system support the concept that variations in venous geometry can significantly influence catheter trajectory during subclavian venous access. [16]

Our findings are consistent with previously published investigations examining the influence of cannulation laterality. The observational study by Shin KW demonstrated that catheter malposition occurred more frequently during right-sided subclavian catheterization compared with left-sided access. [14] They reported lower malposition rates with left-sided infraclavicular subclavian venous catheterization. [13] The results of the present study align with these observations and further support the hypothesis that anatomical differences between the left and right brachiocephalic venous pathways influence catheter trajectory.

Guidewire mechanics may also contribute to catheter misdirection. During the Seldinger technique, the orientation

of the J-tip guidewire may influence the direction of guidewire advancement. A randomized study by Tripathi M demonstrated that the direction of the guidewire tip significantly affects the likelihood of catheter misplacement during subclavian venous catheterization. [15] Although guidewire orientation was not systematically documented in our study, the predominance of internal jugular vein malposition in the right-sided group suggests that both anatomical configuration and guidewire mechanics may contribute to this phenomenon.

Catheter malposition has important clinical implications in critically ill patients. Accurate positioning of the catheter tip within the distal superior vena cava or cavo-atrial junction is essential for reliable hemodynamic monitoring and safe administration of vasoactive medications (Figure 4). [7]

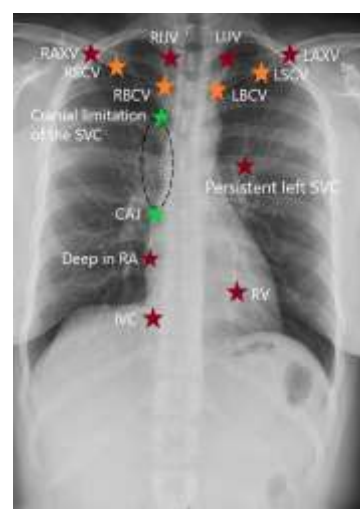


Figure 4. AP chest radiography illustrating different tip placements.

Green stars: correct tip position. Orange stars: minor tip misplacements. Red stars: major tip misplacements. IVC, inferior vena cava; LAXV, left axillary vein; LBCV, left brachiocephalic vein; LIJIV, left internal jugular vein; LSCV, left subclavian vein; RA, right atrium; RAXV, right axillary vein; RBCV, right brachiocephalic vein; RIJIV, right internal jugular vein; RSCV, right subclavian vein; RV, right ventricle; SVC, superior vena cava.

Malpositioned catheters may lead to inaccurate pressure measurements and may delay the initiation of advanced cardiovascular procedures. Previous clinical investigations have identified catheter malposition as one of the most frequent complications associated with subclavian venous catheterization. [8-12]

In the present study, despite the difference in malposition rates, mechanical complications were uncommon and occurred at similar rates in both groups. Historical analyses of subclavian venous catheterization have reported overall complication rates ranging from 5% to 15%, highlighting the importance of procedural expertise and anatomical awareness. [12] In addition, anatomical

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investigations of the thoracic inlet have demonstrated the close relationship between the subclavian vein and the pleural dome, which may influence the risk of pneumothorax during infraclavicular cannulation. [16] Although uncommon, procedural complications related to guidewire handling, including guidewire loss, have been reported and emphasize the importance of meticulous adherence to the Seldinger technique during central venous catheterization. [12]

Clinical Implications

The findings of this study have practical implications for cardiovascular critical care. When ultrasound guidance is unavailable or impractical during emergency resuscitation, clinicians often rely on landmark-guided techniques to obtain central venous access rapidly. Our results suggest that selecting the left subclavian vein may improve the likelihood of correct catheter placement without increasing the risk of procedural complications. However, the choice of laterality in emergency settings must also account for patient-specific structural alterations, such as the presence of clavicular orthopedic hardware, which may preclude the preferred left-sided access and necessitate the contralateral approach (Figure 5).

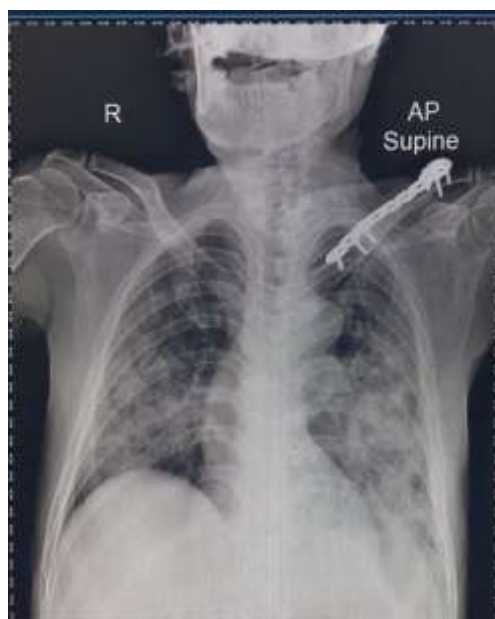


Figure 5. Altered Anatomical Landmarks due to Orthopedic Hardware

Anteroposterior supine chest radiograph demonstrating prior surgical fixation of the left clavicle with a plate and screws. In the setting of emergent central venous catheterization, the presence of such orthopedic hardware distorts the normal topography required for landmark-guided infraclavicular access. Such structural alterations often serve as a relative contraindication to cannulation on the affected side, necessitating either the use of the contralateral (right-sided)

approach—which carries a higher baseline risk of catheter malposition—or an alternative venous access site.

Limitations

Several limitations should be acknowledged. First, the retrospective design may introduce selection bias because the cannulation site was determined by operator preference rather than random allocation. Second, the study was conducted at a single center and included a relatively limited number of malposition events. Third, procedural variables such as guidewire orientation and number of insertion attempts were not consistently documented and therefore could not be analyzed.

Future Research Directions

Future prospective multicenter studies involving larger patient populations may help further clarify the relationship between cannulation laterality and catheter trajectory during subclavian venous access.

CONCLUSION

In conclusion, this retrospective cohort study demonstrates that right-sided landmark-guided subclavian cannulation in critically ill patients with cardiogenic shock is associated with a significantly higher incidence of catheter malposition compared with the left-sided approach. This increased risk of misdirection, which primarily involves guidewire deflection into the ipsilateral internal jugular vein, is likely driven by the more acute anatomical angle formed by the right brachiocephalic venous system. In contrast, the longer and more horizontal pathway of the left brachiocephalic vein appears to facilitate more reliable guidewire advancement and correct catheter placement into the superior vena cava. Importantly, both approaches demonstrated similarly low rates of immediate mechanical complications, such as pneumothorax and arterial puncture. Therefore, when ultrasound guidance is not feasible during emergency cardiovascular resuscitation, the left subclavian vein may be the preferred anatomical site for landmark-guided access to ensure accurate catheter positioning, provided there are no patient-specific structural contraindications.

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Conflicts of interests

The authors declare no conflict of interest.

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