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Ultrasound-Guided Versus Palpation-Based Femoral Arterial Cannulation: A Randomized Comparative Study

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Abstract

Objectives

The study aimed to compare palpation-guided and ultrasound-guided femoral arterial line placement in hemodynamically unstable patients on vasopressors, with respect to cannulation time, number of attempts, procedure-related complications, and the need for conversion from palpation to ultrasound guidance.

Methods

This prospective randomized comparative study was conducted in the Intensive Care Unit of Santosh Medical College Hospital, Ghaziabad. A total of 110 adult patients (≥18 years) requiring femoral arterial access were enrolled and randomized into two groups: palpation-guided (n=55) and ultrasound-guided (n=55) femoral arterial catheterization. Primary outcomes included time to successful cannulation and number of attempts. Secondary outcomes assessed procedure-related complications and conversion rates. Data were analyzed using IBM SPSS Statistics version 25.0, with a p-value <0.05 considered statistically significant.

Results

The mean age was 39.22 ± 12.11 years, with no significant difference between palpation-guided and ultrasound-guided groups (39.35 ± 12.57 vs. 39.09 ± 11.75 years; P=0.913). Gender distribution (P=0.565), mean BMI (26.03 ± 1.52 kg/m²; P=0.801), and comorbidities including diabetes (P=0.68), hypertension (P=0.825), and coronary artery disease (P=0.742) were comparable between groups. Technical success was 100% in the ultrasound-guided group and 94.55% in the palpation-guided group (P=0.243). The mean number of attempts was significantly lower with ultrasound guidance (1.07 vs. 1.6; P=0.0001), and mean cannulation time was significantly shorter (72.65 ± 18.71 vs. 95.54 ± 21.62 seconds; P<0.0001). Complications were infrequent, with four femoral vein punctures and three hematomas, predominantly in the palpation-guided group (P>0.05).

Conclusion

Ultrasound-guided femoral arterial catheterization is a more efficient and reliable technique than palpation-guided catheterization in critically ill patients, supporting its routine use in intensive care practice.

Keywords: Catheterization, Critical Care, Femoral Artery, Interventional, Ultrasonography

Introduction

Femoral artery catheterization plays a vital role in the management of critically ill patients in the intensive care unit (ICU), particularly those who are hemodynamically unstable and require vasopressor support.[1] Reliable arterial access is essential for continuous blood pressure monitoring, frequent blood sampling, and advanced cardiovascular interventions.[1] Traditionally, femoral artery

cannulation has been performed using the palpation-based anatomical landmark technique; however, technological advances have led to increasing use of ultrasound-guided approaches.[2]

The palpatory anatomical method relies on manual identification of surface landmarks and arterial pulsations to guide needle insertion, most commonly using the Seldinger technique.[3] This method is widely practiced due to its simplicity, minimal equipment requirements, and familiarity among clinicians. It can be performed rapidly, making it useful in emergency situations and low-resource settings.[3] Despite these advantages, the success of the palpatory method is highly operator dependent and can be compromised in critically ill patients, particularly those receiving vasopressors, in whom arterial pulsations may be weak or absent. Anatomical variations further increase the risk of failed cannulation and access-related complications such as hematoma, pseudoaneurysm, and inadvertent vascular injury.[3,4]

Ultrasound-guided femoral artery catheterization has emerged as a safer and more precise alternative. Real-time ultrasound imaging allows direct visualization of the femoral artery, surrounding veins, nerves, and bifurcation anatomy, enabling accurate needle placement.[3-6] It has been seen that ultrasound guidance improves first-pass success rates, reduces the number of attempts, shortens time to successful cannulation, and significantly lowers complication rates compared with palpation-based techniques.[4] Importantly, ultrasound guidance reduces dependence on operator experience, leading to more consistent outcomes across clinicians.[5,6]

Despite growing evidence supporting ultrasound guidance, comparative data in unstable ICU patients remain limited. Therefore, the present study aims to compare ultrasound-guided and palpation-based femoral artery catheterization in patients on vasopressors, focusing on procedural success, time to cannulation, number of attempts, complications, and the need for conversion to ultrasound guidance.

Methods

This prospective randomized study was conducted in the Intensive Care Unit (ICU) of Santosh Medical College Hospital, Ghaziabad, Uttar Pradesh, India, after obtaining approval from the Institutional Clearance Committee. Adult patients admitted to the ICU who required vasopressor support for hemodynamic instability were screened for eligibility. Patients aged more than 18 years were included in the study. Exclusion criteria comprised refusal to provide informed consent, local infection at the catheterization site, morbid obesity, and age below 18 years. Written informed consent was obtained from all participants or their legally authorized representatives prior to enrollment.

The sample size was calculated based on a previous study by Kumar K et al.[7], which reported mean cannulation times of 4.58 ± 3.42 minutes for ultrasound-guided femoral artery catheterization and 2.07 ± 1.93 minutes for the palpation-based method. With a confidence level of 95% and a power of 90%, the minimum required sample size was estimated to be 48 patients per group. After accounting for a potential non-response rate of 15%, a final sample size of 55 patients per group was determined. Consecutive sampling was employed after applying the inclusion and exclusion criteria.

Baseline demographic and clinical data, including age, sex, body mass index, and comorbidities, were recorded using a predefined study proforma. Randomization was performed using computer-generated random numbers generated through the RANDBETWEEN function. Patients were allocated to Group A (palpatory anatomical method) or Group B (ultrasound-guided method), with equal distribution maintained between the two groups.

All catheterizations were performed under strict aseptic precautions using the Seldinger technique. In conscious patients, local anesthesia was administered prior to the procedure. In Group A, femoral artery cannulation was performed using anatomical landmarks and palpation of the arterial pulse. If successful cannulation was not achieved within five attempts, ultrasound guidance was employed as a rescue technique. In Group B, real-time ultrasound guidance was used with a 10–18 MHz linear vascular probe covered with a sterile sheath. Vessels were visualized in the short-axis view, and puncture was performed using the out-of-plane technique. Following successful guidewire placement, the arterial catheter was advanced, secured, and dressed in both groups.

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The primary outcomes assessed were successful catheterization and the number of attempts required for success. Secondary outcomes included time to vascular access and the incidence of complications such as hematoma, arterial puncture, and pseudoaneurysm formation.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics, Chicago, USA version 25.0. Data distribution was assessed using the Shapiro–Wilk test. Non-parametric methods were applied when normality assumptions were not met. Comparisons between non-normally distributed continuous variables were performed using the Mann–Whitney U test, while normally distributed variables were analyzed using the independent t-test. Associations between categorical variables were evaluated using the Chi-square test, with Fisher's exact test employed when expected cell counts were less than five. A p-value of less than 0.05 was considered statistically significant.

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Results

A total of 110 participants were included in the final analysis, with 55 patients each in the palpation-guided and ultrasound-guided groups. The baseline demographic characteristics of the two groups were comparable. The mean age of the overall study population was 39.22 ± 12.11 years. Patients in the palpation-guided group had a mean age of 39.35 ± 12.57 years, while those in the ultrasound-guided group had a mean age of 39.09 ± 11.75 years. There was no statistically significant difference in age between the two groups (P = 0.913), indicating adequate baseline comparability.

With respect to gender distribution, males constituted 55.45% of the study population, while females accounted for 44.55%. The distribution of gender was similar between the two groups, with males comprising 58.18% in the palpation-guided group and 52.73% in the ultrasound-guided group, and females comprising 41.82% and 47.27%, respectively. This difference was not statistically significant (P = 0.565), suggesting that gender did not influence group allocation or outcomes.

Body mass index (BMI) was also comparable between the two groups. The mean BMI of the entire cohort was 26.03 ± 1.52 kg/m². The palpation-guided group had a mean BMI of 25.99 ± 1.46 kg/m², while the ultrasound-guided group had a mean BMI of 26.06 ± 1.60 kg/m². No statistically significant difference was observed between the two approaches (P = 0.801), confirming similar anthropometric profiles across groups.

Analysis of comorbid conditions demonstrated a similar distribution between the two groups. Diabetes mellitus was present in 30.91% of patients, hypertension in 24.55%, and coronary artery disease (CAD) in 9.09% of the study population. The prevalence of diabetes (29.09% in palpation-guided vs. 32.73% in ultrasound-guided; P = 0.68), hypertension (25.45% vs. 23.64%; P = 0.825), and CAD (10.91% vs. 7.27%; P = 0.742) did not differ significantly between groups. Table 1 outlines the baseline demographic and clinical characteristics of study patients.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants

Variable	Palpation-guided (n = 55)	Ultrasound-guided (n = 55)	Total (n = 110)	*P* value
Age (years)				
Mean ± SD	39.35 ± 12.57	39.09 ± 11.75	39.22 ± 12.11	0.913‡
Gender				
Female	23 (41.82%)	26 (47.27%)	49 (44.55%)	0.565†
Male	32 (58.18%)	29 (52.73%)	61 (55.45%)	
Body Mass Index (kg/m²)				
Mean ± SD	25.99 ± 1.46	26.06 ± 1.60	26.03 ± 1.52	0.801‡
Comorbidities				
Diabetes mellitus	16 (29.09%)	18 (32.73%)	34 (30.91%)	0.68†
Hypertension	14 (25.45%)	13 (23.64%)	27 (24.55%)	0.825†
Coronary artery disease	6 (10.91%)	4 (7.27%)	10 (9.09%)	0.742*

‡ Independent samples *t*-test; † Chi-square test; * Fisher's exact test

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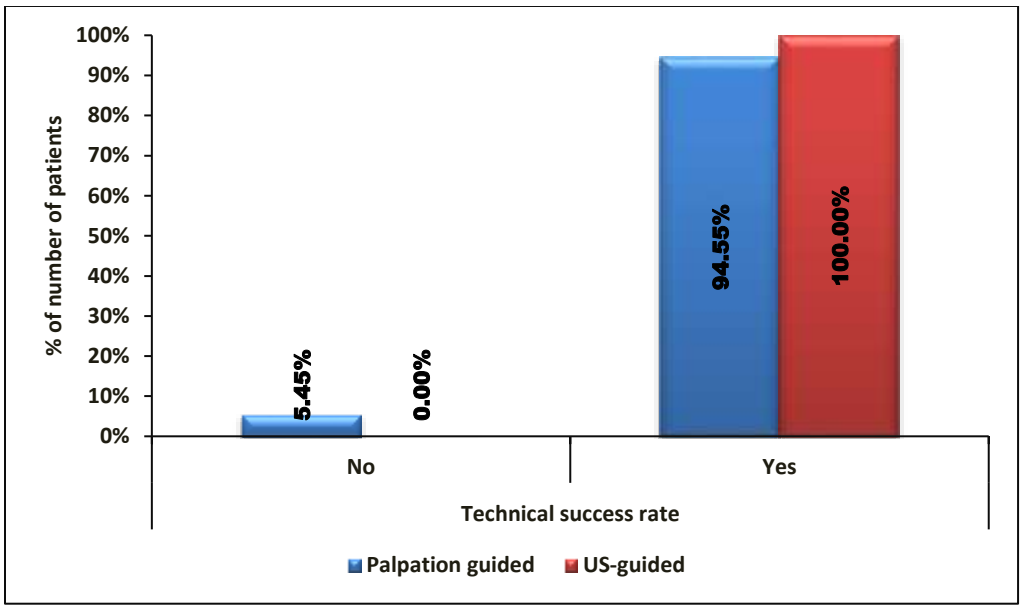
Regarding procedural outcomes, the ultrasound-guided group achieved a technical success rate of 100%, whereas the palpation-guided group demonstrated a success rate of 94.55%. Although the ultrasound-guided approach showed a numerically higher success rate, the difference was not statistically significant (P = 0.243). (Figure 1)

Figure 1:-Comparison of technical success rate between Palpation guided and US-guided.



The mean number of attempts required for successful cannulation was significantly lower in the ultrasound-guided group compared to the palpation-guided group (1.07 vs. 1.60 attempts; P = 0.0001). (Table 2)

Table 2:-Comparison of number of attempts between Palpation guided and US-guided.

Number of attempts	Palpation guided(n=55)	US-guided(n=55)	Total	P value
1	36 (65.45%)	52 (94.55%)	88 (80%)	0.001*
2	10 (18.18%)	2 (3.64%)	12 (10.91%)	
3	6 (10.91%)	1 (1.82%)	7 (6.36%)	
4	1 (1.82%)	0 (0%)	1 (0.91%)	
5	2 (3.64%)	0 (0%)	2 (1.82%)	
Mean ± SD	1.6 ± 1.01	1.07 ± 0.33	1.34 ± 0.79	0.0001§
Median(25th-75th percentile)	1 (1-2)	1 (1-1)	1 (1-1)	
Range	1-5	1-3	1-5	

§ Mann Whitney test, * Fisher's exact test

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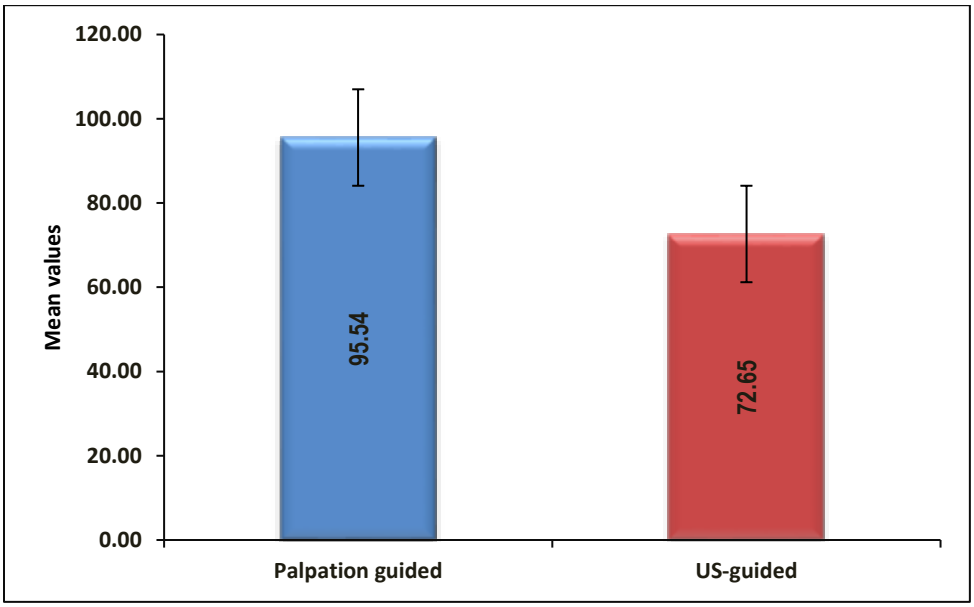
Similarly, the mean time to vascular access was significantly shorter in the ultrasound-guided group (72.65 ± 18.71 seconds) compared to the palpation-guided group (95.54 ± 21.62 seconds), with a highly significant difference (P < 0.0001).(Figure 2)

Figure 2:-Comparison of mean time to access between Palpation guided and US-guided.



Complications were infrequent in both groups. A total of four femoral vein punctures and three hematomas were documented. One femoral vein puncture occurred in the ultrasound-guided group, while the remaining punctures and all hematomas were observed in the palpation-guided group. Despite a higher number of complications in the palpation-guided group, this difference did not reach statistical significance (P > 0.05). (Table 3)

Table 3:-Comparison of complications between Palpation guided and US-guided.

Complications	Palpation guided(n=55)	US-guided(n=55)	Total	P value
Femoral vein puncture	3 (5.45%)	1 (1.82%)	4 (3.64%)	0.618*
Hematoma	3 (5.45%)	0 (0%)	3 (2.73%)	0.243*

*** Fisher's exact test**

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Discussion

The present study compared ultrasound-guided and palpation-guided femoral artery catheterization in critically ill patients and demonstrated that ultrasound guidance offers clear procedural advantages across several clinically relevant outcomes. As both groups were well matched with respect to baseline demographic and clinical variables, differences observed in procedural success, number of attempts, access time, and complications can be primarily attributed to the catheterization technique itself.

Although the overall technical success rate was high in both groups, ultrasound-guided catheterization achieved a 100% success rate compared to 94.55% in the palpation-guided group. While this difference was not statistically significant, it reflects the greater consistency and reliability of ultrasound guidance. Gedikoglu M et al[8] reported similar findings, with technical success rates of 100% in the ultrasound-guided group versus 96% in the palpation group (P = 0.052). Likewise, Lazaar S et al[9] demonstrated a significantly higher technical success rate with ultrasound guidance (96%) compared to the landmark-based technique (74%, P = 0.0005), underscoring the benefit of real-time vessel visualization.

A key strength of ultrasound guidance observed in the present study was the markedly higher first-pass success rate. Ultrasound guidance achieved first-pass success in 94.55% of cases compared to only 65.45% in the palpation-guided group, highlighting its superiority in facilitating accurate initial needle placement. First-pass success is clinically important as it minimizes tissue trauma, reduces patient discomfort, and lowers the risk of complications. Comparable results have been reported in earlier studies. Singhal MK et al[10] found significantly higher first-attempt success with ultrasound guidance than with the conventional technique (64% vs. 42%, P < 0.028). Gutte S et al[11] also reported superior first-attempt success in the ultrasound group (83.3%) compared to palpation (55.6%, P = 0.02). In a meta-analysis, Guan et al[12] reported that ultrasound guidance significantly improved first-attempt success rates, with a relative risk of 1.42 (P = 0.04), reinforcing the consistency of this advantage across diverse clinical settings.

The number of attempts required for successful catheterization was significantly lower in the ultrasound-guided group in the present study. Ultrasound-guided procedures required a mean of 1.07 attempts compared to 1.6 attempts in the palpation-guided group (P = 0.0001). Fewer attempts reduce the likelihood of arterial wall injury, venous puncture, and hematoma formation. Similar findings have been reported by Katırcıbaşı MT et al,[13] who observed fewer attempts with ultrasound guidance compared to manual techniques (1.06 ± 0.26 vs. 1.32 ± 0.74; P < 0.001). Marquis-Gravel G et al[14] also demonstrated a reduction in median puncture attempts with ultrasound guidance (1 vs. 2; P = 0.04). Sorrentino S et al[15] further confirmed this benefit, reporting a standardized mean difference of −0.40 in the number of attempts in favor of ultrasound guidance.

Time to successful arterial access was another outcome where ultrasound guidance demonstrated significant superiority. In the present study, mean access time was significantly shorter in the ultrasound-guided group (72.65 ± 18.71 seconds) compared to the palpation-guided group (95.54 ± 21.62 seconds, P < 0.0001). Rapid arterial access is particularly crucial in critically ill patients requiring prompt hemodynamic monitoring and vasoactive support. Singhal MK et al[10] reported similar reductions in cannulation time with ultrasound guidance (78.16 seconds vs. 100.90 seconds, P < 0.001). Gedikoglu M et al[8] also found significantly shorter access times with ultrasound guidance (68.6 ± 45.1 seconds vs. 94.3 ± 66.4 seconds, P = 0.001). These findings collectively suggest that ultrasound guidance enhances procedural efficiency.

With respect to complications, the overall incidence in the present study was low in both groups. However, femoral vein puncture and hematoma were observed more frequently in the palpation-guided group. Although these differences did not reach statistical significance, likely due to the small number of events, the trend favors ultrasound guidance. Singhal MK et al[10] reported a significantly lower incidence of femoral vein puncture with ultrasound guidance (4% vs. 28%, P = 0.02) and fewer hematomas (12% vs. 28%, P = 0.046). Similarly, Sorrentino S et al[15] demonstrated significantly reduced rates of access-site hematoma (1.2% vs. 3.3%) and venepuncture events (3.6% vs. 12.1%) with ultrasound guidance.

Overall, the findings of the present study support the routine use of ultrasound guidance for femoral artery catheterization. Ultrasound guidance was associated

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with higher first-pass success, fewer attempts, reduced access time, and a trend toward fewer complications. While factors such as equipment availability, cost, and operator training must be considered, the consistent procedural benefits observed in this and previous studies suggest that ultrasound guidance should be regarded as the preferred technique for femoral artery catheterization, particularly in critically ill patients.

Limitations Of The Study

This study has certain limitations that should be acknowledged. Being a single-center study, the findings may have limited external validity and may not be fully generalizable to other institutions with different patient populations, operator expertise, and procedural protocols. Operator experience and technical proficiency were not stratified or separately analyzed, which could have influenced outcomes such as cannulation success rates, number of attempts, procedural time, and complication rates. Blinding of the operator was not feasible due to the nature of the intervention, thereby introducing the possibility of procedural and performance bias. Femoral nerve injury was not specifically evaluated, as distinguishing nerve damage attributable to arterial catheterization from that related to underlying pelvic pathology or critical illness can be challenging in this patient population. Additionally, long-term vascular and infectious complications could not be assessed because of the limited duration of follow-up, which may have led to an underestimation of delayed adverse events.

Conclusion

Ultrasound-guided femoral arterial catheterization demonstrated slightly higher procedural success rate compared to the palpatory anatomical technique in hemodynamically unstable patients receiving vasopressor support. The ultrasound-guided approach was associated with a significantly shorter cannulation time and fewer attempts while maintaining a high first pass success rate. Although overall complication rates were low and comparable between groups, complications such as hematoma and inadvertent venous puncture occurred more frequently with the palpatory method. These findings suggest that ultrasound guidance provides a safer and more effective alternative for femoral arterial line placement in critically ill patients and supports its routine use to improve procedural outcomes in intensive care settings.

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