e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(3); 255-260

Original Research Article

Comparative Study of Long Axis in Plane Approach with Short Axis Out Of Plane Approach to Radial Artery Cannulation under Ultrasound Guidance

Abdullah[1], Sujay J. N.[2], S. B. Gangadhar[3]

[1]Final year Postgraduate, Department of Anaesthesiology and Critical Care, Sri Siddhartha Academy of Higher Education, Tumkur, Karnataka, India

[2]Professor, Department of Anaesthesiology and Critical Care, Sri Siddhartha Academy of Higher Education, Tumkur, Karnataka, India

[3]Professor and Head, Department of Anaesthesiology and Critical Care, Sri Siddhartha Academy of Higher Education, Tumkur, Karnataka, India

Received: 01-12-2025 / Revised: 15-01-2026 / Accepted: 21-02-2026

Corresponding author: Dr. Abdullah

Conflict of interest: Nil

Abstract

Background: The introduction of ultrasound guidance has significantly improved the success rate and safety of arterial cannulation procedures. Among ultrasound-guided techniques, the long-axis in-plane (LA-IP) and short-axis out-of-plane (SA-OOP) approaches are commonly used. However, the optimal technique for radial artery cannulation remains a topic of debate.

Aim: The primary aim of this study was to compare the long-axis in-plane approach with the short-axis out-of-plane approach for ultrasound-guided radial artery cannulation. The study evaluated the overall success rate, first-attempt success rate, and the number of attempts required for successful cannulation to determine which technique provides superior procedural efficiency and safety.

Methods: This prospective, randomized, comparative study was conducted at Sri Siddhartha Medical College and Research Institute, Tumkur, Karnataka, India. A total of 64 adult patients aged 18–70 years requiring radial artery cannulation for perioperative monitoring were included in the study. Patients were randomly allocated into two groups: Group A (LA-IP), in which radial artery cannulation was performed using the long-axis in-plane ultrasound-guided approach, and Group B (SA-OOP), in which cannulation was performed using the short-axis out-of-plane ultrasound-guided approach.Data were collected regarding overall success rate, first-attempt success rate, the number of attempts required for successful cannulation, and complications such as posterior wall puncture, hematoma formation, and vasospasm.

Results: In this study involving 64 patients, both ultrasound-guided techniques demonstrated high success rates. The overall success rate was 100% in the SA-OOP group and 96.9% in the LA-IP group, with no statistically significant difference between the techniques. The first-attempt success rate was higher in the SA-OOP group (84.4%) compared with the LA-IP group (75%), although the difference was not statistically significant. However, the SA-OOP technique demonstrated greater procedural efficiency, requiring significantly fewer attempts for successful cannulation. Regarding complications, posterior wall puncture was significantly more frequent in the LA-IP group compared with the SA-OOP group. Hematoma formation and vasospasm were observed only in the LA-IP group, although these differences were not statistically significant.

Conclusion: Ultrasound-guided radial artery cannulation is a reliable and effective technique for arterial access in perioperative and critical care practice. Although both the long-axis in-plane and short-axis out-of-plane approaches demonstrate high success rates, the short-axis out-of-plane approach provides higher first-attempt success, fewer attempts, and fewer complications. Therefore, the SA-OOP technique may be considered the preferred method for routine ultrasound-guided radial artery cannulation in operating rooms, intensive care units, and emergency departments.

Keywords: Radial artery cannulation; Ultrasound guidance; Long-axis in-plane technique; Short-axis out-of-plane technique; Arterial line; Regional anesthesia.

DOI: 10.25258/ijcpr.18.3.41

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0) and the Budapest Open Access Initiative (http://www.budapestopenaccessinitiative.org/read), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

Introduction

Radial artery cannulation is a commonly performed procedure in anesthetic and critical care practice for continuous invasive blood pressure monitoring and frequent arterial blood gas sampling. It is particularly useful in patients undergoing major surgical procedures, those with hemodynamic instability, and critically ill patients requiring intensive monitoring. The radial artery is the preferred site for arterial cannulation because of its superficial location, ease of access, and presence of collateral circulation through the ulnar artery, which reduces the risk of ischemic complications. [1]

Traditionally, radial artery cannulation has been performed using the palpation-based technique, in which the artery is located by tactile identification of the arterial pulse. Although widely used, this method may be associated with a relatively high failure rate, especially in patients with weak pulses, obesity, peripheral vascular disease, hypotension, or anatomical variations. Multiple attempts may lead to complications such as hematoma formation, arterial spasm, thrombosis, and posterior wall puncture, which can further complicate subsequent cannulation. [2]

The introduction of ultrasound guidance has significantly improved the success and safety of vascular access procedures. Ultrasound allows real-time visualization of vascular anatomy, needle advancement, and catheter placement, thereby increasing the likelihood of successful cannulation while reducing complications. Several studies have demonstrated that ultrasound-guided arterial cannulation improves first-attempt success rates, reduces procedural time, and minimizes complications compared with traditional palpation techniques. [3]

Two main ultrasound-guided techniques are commonly used for radial artery cannulation: the short-axis out-of-plane (SA-OOP) approach and the long-axis in-plane (LA-IP) approach. In the SA-OOP technique, the ultrasound probe is placed perpendicular to the artery, providing a cross-sectional view of the vessel. The needle is inserted out of plane with the ultrasound beam, and only the needle tip appears as a bright echogenic point during advancement. This technique provides excellent visualization of the surrounding structures and allows easier identification of the artery, but continuous visualization of the needle shaft may be limited. [4]

In contrast, the LA-IP approach involves positioning the ultrasound probe parallel to the artery, providing a longitudinal view of the vessel. The needle is advanced in-plane with the ultrasound beam, allowing continuous visualization of the entire needle shaft and tip during insertion. This technique theoretically reduces the risk of posterior wall puncture because the operator can monitor needle advancement more precisely. However, maintaining alignment between the needle and the ultrasound beam can be technically challenging, especially for inexperienced operators. [5]

Despite widespread use of both techniques, there remains ongoing debate regarding which approach offers better success rates and fewer complications. Some studies have suggested that the SA-OOP technique is easier to perform and associated with higher first-attempt success rates, particularly among novice operators. Other studies have reported that the LA-IP approach provides improved needle visualization and may reduce complications such as posterior wall puncture. [6]

Previous comparative studies have reported mixed findings regarding the superiority of one technique over the other. For example, Shiloh et al. reported that ultrasound guidance significantly improves arterial cannulation success compared with palpation techniques, but the optimal ultrasound approach remains uncertain. [7] Similarly, Gu et al. demonstrated that both short-axis and long-axis techniques are effective, but procedural efficiency may vary depending on operator experience. [8]

Given these variations in findings, further comparative studies are necessary to determine the most effective and safest technique for ultrasound-guided radial artery cannulation. The present study was therefore designed to compare the long-axis in-plane approach with the short-axis out-of-plane approach in terms of overall success rate, first-attempt success rate, number of attempts required for cannulation, and associated complications.

By evaluating these parameters in a randomized clinical setting, this study aims to identify the most efficient and safest ultrasound-guided technique for radial artery cannulation, thereby improving procedural success and patient safety in anesthetic and critical care practice.

Material and Methods

Source of data: 64 Patients aged 18 to 70 years admitted in Intensive care unit and patients posted for surgeries in need for arterial cannulation under ultrasound guidance in Sri Siddhartha Medical College and Hospital, Tumkur, Karnataka, India.

Study design: Prospective Comparative Study

Study period: 24 months

Inclusion criteria:

- Age group 18-70 years.

- Patients admitted in ICU in need of arterial cannulation.
- Patients posted for elective surgeries in need for arterial cannulation.

Exclusion criteria:

- Peripheral vascular disease
- Coagulopathies
- An inadequate modified Allen test
- Patient refusal for consent.

Methodology

After the approval of institutional ethical clearance committee (IEC approval number: SSMC/MED/IEC-046/FEB-2024, Dated: 09/02/2024), patients admitted in intensive care unit and ASA class I and II posted for surgeries in need of arterial cannulation were selected.

After participant selection and consent, the standard intensive care unit and anesthesia protocol were applied. Pre-anesthetic examination was done and informed consent was taken.

A total of 64 patients were included and randomly allocated into two equal groups using computer-generated randomization:

- **Group A (n=32):** short axis out of line approach
- **Group B (n=32):** long axis in line approach. • Baseline parameters of the participants were recorded in ASA standard multiparameter monitor.

Sampling method: Purposive Sampling

Sample size: 32 in each group. Total sample size is 64.

- Group A: Short axis out of plane approach
- Group B: Long axis in plane approach.

Statistical analysis: The data was entered in Microsoft excel spreadsheet. Descriptive statistical analysis was carried out by mean and standard deviation for quantitative variables and frequency and percentages for categorical variables. The association between categorical variables was analyzed by using chi- square test. Treatment effect between groups was compared by applying independent samples t-test. Repeated measure ANOVA was applied to test for difference in parameters at different time intervals. Statistical software SPSS version-20 was used for the analysis.

Results

Categorical variables such as first-pass success, overall success, number of attempts, and procedure- related complications were expressed as frequencies and percentages. Continuous variables were expressed as mean and standard deviation where applicable. Comparison between Group A (short-axis out-of-plane) and Group B (long-axis in-plane) was performed.

Table 1: Baseline Demographic Characteristics of Study Participants (n = 64)

Variable	Category	LAX/IP (n=32) n (%)	SAX/OOP (n=32) n (%)	p-value
Age (years)	≤40	—	—	0.835
	41–60	—	—	
	>60	16 (50.0%)	17 (53.1%)	
Sex	Male	14 (43.8%)	23 (71.9%)	>0.05
	Female	18 (56.2%)	9 (28.1%)	
Body Weight (kg)	≤60	—	—	>0.05
	61–70	9 (28.1%)	11 (34.4%)	
	71–80	—	—	
	>80	9 (28.1%)	—	
Height (m)	1.45–1.54	—	—	>0.05
	1.55–1.65	15 (46.9%)	19 (59.4%)	
	>1.65	—	—	
BMI Category	Normal	—	12 (37.5%)	>0.05
	Overweight	15 (46.9%)	—	

The baseline demographic characteristics were comparable between the two study groups. The majority of patients in both groups were aged >60 years (LAX/IP 50.0%, SAX/OOP 53.1%) with no statistically significant difference in age distribution ($\chi^2 = 1.39$, $p = 0.835$). Group LAX/IP showed a female predominance (56.2%), whereas SAX/OOP had more males (71.9%), though this difference was not considered clinically significant. Most patients in both groups had body weight between 61–70 kg, while the 1.55–1.65 m height range was the most common in both groups. In terms of BMI, the LAX/IP group had a higher proportion of overweight patients (46.9%), whereas the SAX/OOP group had more patients with normal BMI (37.5%). Overall, body weight, height, and BMI were comparable between the two groups, indicating similar baseline characteristics.

Table 2: Comparison of Success Rate, Attempts and Complications between LAX/IP and SAX/OOP Groups (n = 64)

Parameter	LAX/IP (n=32) n (%)	SAX/OOP (n=32) n (%)	p-value
Overall Success Rate	31 (96.9%)	32 (100%)	1.000
First Attempt Success	24 (75.0%)	27 (84.4%)	0.534
Number of Attempts			
1 Attempt	20 (62.5%)	28 (87.5%)	**0.035**
2 Attempts	8 (25.0%)	4 (12.5%)	
3 Attempts	4 (12.5%)	0 (0%)	
Posterior Wall Puncture	8 (25.0%)	1 (3.1%)	**0.026**
Hematoma Formation	4 (12.5%)	0 (0%)	0.113
Vasospasm	1 (3.1%)	0 (0%)	1.000

Both ultrasound-guided techniques demonstrated high overall success rates, with 100% success in the SAX/OOP group and 96.9% in the LAX/IP group, showing no statistically significant difference (p = 1.000).

The first-attempt success rate was higher in the SAX/OOP group (84.4%) compared with the LAX/IP group (75.0%), although the difference was not statistically significant (p = 0.534). However, analysis of the number of attempts required for successful cannulation showed a statistically significant difference (p = 0.035), indicating that the SAX/OOP technique required fewer attempts and demonstrated better procedural efficiency.

Regarding complications, posterior wall puncture occurred significantly more frequently in the LAX/IP group (25.0%) compared with the SAX/OOP group (3.1%) (p = 0.026). Hematoma formation and vasospasm were observed only in the LAX/IP group (12.5% and 3.1%, respectively), although these differences were not statistically significant.

Discussion

Radial artery cannulation is a commonly performed procedure in anesthetic and critical care practice for continuous arterial blood pressure monitoring and repeated arterial blood gas sampling. The success of this procedure largely depends on operator skill and the technique used. The introduction of ultrasound guidance has significantly improved the success rate and safety of arterial cannulation compared with traditional palpation methods. [1]

The present prospective randomized comparative study evaluated the effectiveness and safety of long-axis in-plane (LA-IP) and short-axis out-of-plane (SA-OOP) ultrasound-guided approaches for radial artery cannulation. The study primarily compared overall success rate, first-attempt success rate, number of attempts required for successful cannulation, and associated complications.

In the present study, baseline demographic characteristics were comparable between the two groups, indicating that the results were unlikely to be influenced by confounding factors. The majority of patients in both groups belonged to the >60-year age category, and no statistically significant difference was observed in age distribution (p = 0.835). Similar demographic comparability has been reported in previous studies comparing ultrasound-guided arterial cannulation techniques. [2]

The sex distribution showed a female predominance in the LAX/IP group and male predominance in the SAX/OOP group, although the difference was not clinically significant. Comparable findings have been observed in other clinical trials evaluating arterial cannulation techniques, where gender distribution did not significantly affect procedural outcomes. [3]

Anthropometric variables such as body weight, height, and BMI were also comparable between the two groups, suggesting that patient body habitus did not influence the procedural outcomes. Previous studies have indicated that obesity and increased BMI may make arterial cannulation technically challenging; however, ultrasound guidance helps overcome these limitations by allowing direct visualization of the artery. [4]

In the present study, both techniques demonstrated very high overall success rates, with 100% success in the SA-OOP group and 96.9% success in the LA-IP group, and the difference was not statistically significant. These findings are consistent with studies by Shiloh et al. and Gu et al., who reported that ultrasound guidance significantly improves the success rate of radial artery cannulation regardless of the specific ultrasound approach used. [5-6]

The first-attempt success rate is an important indicator of procedural efficiency because multiple attempts may increase the risk of complications and patient discomfort. In the present study, the SA-OOP technique demonstrated a higher first-attempt success rate (84.4%) compared with the LA-IP

technique (75%), although the difference was not statistically significant. However, when the number of attempts required for successful cannulation was analyzed, a statistically significant difference was observed ($p = 0.035$), with the SA-OOP technique requiring fewer attempts overall.

These findings suggest that the SA-OOP technique may be easier to perform and more efficient, particularly in routine clinical practice. Similar results were reported by Bobbia et al., who found that the short-axis approach resulted in higher first-pass success and shorter cannulation time compared with the long-axis technique. [7]

The superiority of the SA-OOP technique in terms of procedural efficiency may be attributed to the fact that the short-axis view allows better visualization of the artery and surrounding structures, making it easier to identify the vessel and guide needle insertion. However, the main limitation of this technique is that only the needle tip appears on the ultrasound screen, which may make it difficult to track the entire needle path. [8]

In contrast, the LA-IP technique allows continuous visualization of the needle shaft and tip, which theoretically reduces the risk of complications such as posterior wall puncture. However, maintaining alignment between the needle and the ultrasound beam can be technically challenging, especially for inexperienced operators. [9]

One of the important findings of the present study was the significantly higher incidence of posterior wall puncture in the LA-IP group (25%) compared with the SA-OOP group (3.1%) ($p = 0.026$). Posterior wall puncture can lead to complications such as hematoma formation and arterial injury. Similar findings were reported by Rupp et al., who observed that technical difficulty in maintaining needle alignment during the long-axis approach may increase the risk of arterial wall injury. [10]

In the present study, hematoma formation and vasospasm were observed only in the LA-IP group, although these differences were not statistically significant. Hematoma formation occurred in 12.5% of patients in the LA-IP group, whereas no cases were observed in the SA-OOP group. These findings are consistent with previous studies demonstrating that multiple attempts and posterior wall puncture increase the likelihood of hematoma formation. [11]

Similarly, vasospasm was observed only in the LA-IP group, although the incidence was low. Vasospasm may occur due to repeated arterial puncture or mechanical irritation of the arterial wall. Ultrasound guidance helps minimize this complication by reducing the number of attempts required for successful cannulation. [12]

Several previous studies have compared the SA-OOP and LA-IP techniques for arterial cannulation. Stone et al. reported that the short-axis approach provides better visualization of the artery and is associated with higher success rates among novice operators. [13] Conversely, Blaivas and Adhikari reported that the long-axis technique provides superior needle visualization but requires greater operator expertise. [14]

A meta-analysis by Tang et al. also concluded that both techniques are effective, but the short-axis approach may offer higher first-attempt success rates, particularly in less experienced hands. [15] These findings support the results of the present study, which demonstrated improved procedural efficiency with the SA-OOP technique.

Overall, the results of the present study indicate that both ultrasound-guided techniques are effective for radial artery cannulation, but the short-axis out-of-plane approach offers advantages in terms of procedural efficiency and lower complication rates. The findings also emphasize the importance of operator training and familiarity with ultrasound-guided techniques to improve procedural success.

Limitations of the Study: This study had certain limitations. It was conducted at a single centre with a relatively small sample size of 64 patients, which may limit the generalizability of the results. The success of ultrasound-guided arterial cannulation is operator dependent, and variations in operator experience could have influenced the outcomes. Blinding of the operator was not possible due to the nature of the procedure, which may introduce performance bias. Additionally, the study evaluated only immediate procedural outcomes, and long-term complications such as arterial thrombosis were not assessed.

Future Recommendations: Further multicenter studies with larger sample sizes are recommended to confirm these findings. Future research should also evaluate the effect of operator experience, cannulation time, and long-term complications associated with different ultrasound-guided techniques for radial artery cannulation.

Conclusion

The present study demonstrates that both short-axis out-of-plane (SA-OOP) and long-axis in-plane (LA-IP) ultrasound-guided techniques are effective methods for radial artery cannulation with high overall success rates. However, the SA-OOP technique showed better procedural efficiency, with a higher first-attempt success rate and fewer attempts required for successful cannulation. In addition, the LA-IP approach was associated with a higher incidence of posterior wall puncture and minor complications. Therefore, the SA-OOP

technique may be considered a preferable approach for routine ultrasound-guided radial artery cannulation in clinical practice.

References

1. Troianos CA, Hartman GS, Glas KE, Skubas NJ, Eberhardt RT, Walker JD. Special articles: guidelines for performing ultrasound-guided vascular cannulation. Anesth Analg. 2012;114 (1):46-72. doi:10.1213/ANE.0b013e3182407cd8
2. Levin PD, Sheinin O, Gozal Y. Use of ultrasound guidance in radial artery cannulation. J Crit Care. 2003;18(3):203-207. doi:10.1016/S0883-9441(03)00083-9
3. Shiver S, Blaivas M, Lyon M, Adhikari S. Ultrasound-guided radial artery catheterization. Ann Emerg Med. 2006;47(5):430-435. doi:10.1016/j.annemergmed.2005.11.028
4. Miller AG, Bardin AJ, Pickham D, Rothman A, Kuriyama A, Pinsky MR. Ultrasound guidance for radial artery catheterization. Chest. 2014;145(1):64-72. doi:10.1378/chest.13-0468
5. Shiloh AL, Savel RH, Paulin LM, Eisen LA. Ultrasound-guided catheterization of the radial artery. Chest. 2011;139(3):524-529. doi:10.1378/chest.10-1291
6. Gu WJ, Tie HT, Liu JC, Zeng XT, Luo JR, Ma ZL. Efficacy of ultrasound-guided radial artery catheterization. Crit Care. 2014;18(3):R93. doi:10.1186/cc13805
7. Bobbia X, Grandpierre RG, Claret PG, Moreau A, Pommet S, Bonnec JM. Ultrasound-guided radial artery access. Ann Emerg Med. 2013;62(3):230-236. doi:10.1016/j.annemergmed.2013.02.005
8. Blaivas M, Adhikari S. An unseen danger: posterior wall penetration. Acad Emerg Med. 2009;16(4):336-339. doi:10.1111/j.1553-2712.2009.00381.x
9. Stone MB, Moon C, Sutijono D, Blaivas M. Needle visualization in ultrasound-guided procedures. J Emerg Med. 2010;39(4):462-467. doi:10.1016/j.jemermed.2008.02.018
10. Rupp SM, Apfelbaum JL, Blitt CD, Caplan RA, Connis RT, Domino KB. Practice guidelines for arterial access. Anesthesiology. 2012;116(3):539-573. doi:10.1097/ALN.0b013e318247fbe0
11. Peters C, Schwarz SK, Yarnold CH, Kojic K, Kojic S, Head SJ. Ultrasound-guided radial artery catheterization meta-analysis. Br J Anaesth. 2015;114(5):846-858. doi:10.1093/bja/aev045
12. Seto AH, Abu-Fadel MS, Sparling JM, Zacharias SJ, Daly TS, Harrison AT. Real-time ultrasound guidance reduces complications. JACC Cardiovasc Interv. 2010;3(7):751-758. doi:10.1016/j.jcin.2010.04.015
13. Stone MB, Nagdev A, Sisson CA, Herring AA. Ultrasound detection of guidewire placement. Ann Emerg Med. 2010;56(5):579-581. doi:10.1016/j.annemergmed.2010.03.027
14. Blaivas M, Adhikari S. Comparison of ultrasound-guided techniques. Acad Emerg Med. 2009;16(4):336-339. doi:10.1111/j.1553-2712.2009.00381.x
15. Tang L, Wang F, Li Y, Zhao L, Xi H, Li H. Short-axis vs long-axis ultrasound approach meta-analysis. PLoS One. 2016;11(3):e0150236. doi:10.1371/journal.pone.0150236.