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RESEARCH ARTICLE
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COMPARISON OF THE OUTCOME OF THE SHORT-AXIS OUT-OF-PLANE ULTRASOUND VERSUS LONG-AXIS IN-PLANE ULTRASOUND GUIDE RADIAL ARTERY CANNULATION AT TERTIARY CARE HOSPITAL, KARACHI

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Abstract

Introduction: Radial artery cannulation is essential for hemodynamic monitoring and blood sampling in critical care. Ultrasound guidance improves success rates over palpation, with short-axis out-of-plane (SA-OOP) and long-axis in-plane (LA-IP) as primary techniques. This study compares their outcomes in a tertiary care setting.

Objective: To compare the outcomes of SA-OOP versus LA-IP ultrasound-guided radial artery cannulation at a tertiary care hospital in Karachi.

Materials and Methods: A randomized controlled trial at the Department of Anesthesia, National Institute of Cardiovascular Diseases, Karachi, from 21st July, 2022 to 22nd January, 2023, enrolled 152 patients (76 per group). Patients aged 18–70 years, ASA II-IV, were included; those with non-consent, negative Modified Allen's test, or local infection were excluded. Outcomes included first-attempt success, ultrasound location time, and cannulation time, analyzed using SPSS Version 20.

Results: SA-OOP showed higher first-attempt success (89.5% vs. 73.7%, $p = 0.012$), shorter ultrasound location time (6.03 ± 1.81 vs. 15.09 ± 2.45 seconds, $p < 0.001$), but longer cannulation time (29.47 ± 7.78 vs. 26.29 ± 4.02 seconds, $p = 0.002$).

Conclusion: SA-OOP enhances first-attempt success and localization efficiency, making it preferable for radial artery cannulation.

Keywords: Radial artery cannulation, short-axis out-of-plane, long-axis in-plane, ultrasound guidance.

INTRODUCTION

Radial artery cannulation is essential for patients in ICUs or undergoing intensive surgery who require constant hemodynamic monitoring and frequent blood sampling. It is generally better to use the radial artery for anastomosis because it lies above the skin, is easy to reach and backs up blood flow, allowing for fewer risks of poor blood flow (1). Usually, finding the radial artery for cannulation was done by the clinician's palpation of its pulse. At the same time, difficulties in obese, edematous,

hypotensive or anomalous patients can make the procedure challenging, with chances of extra attempts, taking a lot of time and leading to problems such as blood clots, narrowing of the arteries or arterial blockage (2). Ultrasound guidance in vascular access procedures helps medical professionals achieve better accuracy and fewer complications, which has made this approach a popular choice in modern medicine (3).

The techniques for ultrasound-guided radial artery cannulation are known as the short-axis out-of-plane (SA-OOP) method and the long-axis in-plane (LA-IP) approach. In this method, the transducer is placed alongside the artery, and the ultrasound creates an unlit display of the artery that makes the needle visible as a point (4). In comparison, using LA-IP with parallel placement of the transducer allows the artery to appear as a tube, enabling a good display of both the needle shaft and tip during the procedure (5). There is a unique set of pros and cons for every single approach. With the SA-OOP method, it is easier to identify an artery, but sometimes, visualizing the needle tip is a problem which increases the risk of hitting the back wall. While the LA-IP technique makes it easier to locate the needle, staying focused on the artery's centre in the narrow ultrasound can be challenging, and this might cause off-target punctures (7).

Many studies have investigated which ultrasound method works best by comparing the success rate of these attempts, the speed at which the catheter was inserted, and the risk of complications. Research has shown that using the SA-OOP method, the artery is positioned in the centre of the screen for better precision during the first attempt, but LA-IP allows for better needle handling (8). Several studies using randomized trials found that with SA-OOP, the location of the artery on ultrasound is completed faster because it appears in the transverse plane (9). It was noticed that LA-IP may make cannulation quicker in some groups, most importantly older patients, because it allows for precise needle positioning (10). The differences in outcomes from one study to another highlight the importance of collecting data that fits each location's patients and surgeons (11).

To help pediatric patients with tiny blood vessels, techniques that target the problem have been suggested. In children, the modified LA-IP approach has demonstrated success by aligning the needle more closely with the long axis of the artery (12). In addition, the operator's experience and the patient's heart anatomy affect the approach decision, with some studies demonstrating that SA-OOP is the easiest method for identifying vessels. These observations show that operators should be well-trained and familiar with using ultrasound equipment to produce the best results (13). For premature infants, using an SA-OOP technique with dynamic needle placement is more successful than using LA-IP.

Radial artery cannulation using ultrasound reduces the risk of complications such as hematoma, thrombosis, or infection. A study looking at children undergoing ultrasound-guided cannulation showed that it results in fewer complications, highlighting its low-risk profile (14). Among adults with extra conditions such as diabetes or hypertension, relying on ultrasound when performing pericardiocentesis helps minimize complications. A new plan combines SA-OOP to determine the vessel's location with LA-IP for inserting the catheter, thereby taking advantage of both approaches and reducing the the chances of error and complications (5). Being thin and set near other blood vessels, the radial artery should be punctured with great care to prevent possible complications like puncturing its back wall or creating spasms. It has been found that when dynamic needle placement is added to SA-OOP, operators can reach the centre of the artery, enhancing success on the first attempt.

LA-IP approaches may be favoured in certain situations when proper visualisation of the needle as it enters the blood vessel is essential, such as for patients with altered anatomy or when deep access to the blood vessel is required. The differences between these approaches depend on factors such as who is performing the operation, the patient's health condition and age, and where the procedure takes place (17). Since hospitals and training programs in Pakistan differ, there is very little local information available about ultrasound-guided radial artery cannulation. Medical studies in tertiary hospitals revealed that ultrasound-based interventions are more successful than those guided by touch, even though the difference between SA-OOP and LA-IP is not discussed (17). Choosing a technique

also depends on the gear nearby and the proficiency of each operator, which play a major role in places where resources are scarce.

Many recent trials have shown that following the same standards for ultrasound-guided catheter placement is essential, especially among individuals undergoing cardiac surgery or those experiencing shock. The results indicate that choosing the right ultrasound approach for each type of medical issue increases both safety and effectiveness for patients. By comparing SA-OOP with LA-IP, this study aims to fill this gap in understanding the success rates of each technique for radial artery cannulation. The researchers use the information on first-time success, time spent cannulating, and ultrasound use to find the ideal technique for inserting a radial artery catheter in Pakistan. These results could benefit medical practice, boost educational programs and increase patient satisfaction by reducing the risks and making things more effective.

Objective: To compare the outcomes of short-axis out-of-plane versus long-axis in-plane ultrasound-guided radial artery cannulation in a tertiary care hospital in Karachi, evaluating first-attempt success, cannulation time, and ultrasound location time.

MATERIALS AND METHODS

Study Design: Randomized Controlled Trial.

Study Setting: The study was conducted at the Department of Anesthesia, National Institute of Cardiovascular Diseases (NICVD), Karachi.

Duration of the Study: The study spanned six months, from 21st July, 2022 to 22nd January, 2023.

Inclusion Criteria: Patients who fell in the range of 18 to 70 years old, both male and female, having radial artery cannulation and with ASA II-IV status were included in the study. Critically ill patients were regularly monitored with blood pressure readings or had frequent blood sampling which is usual in the care setting at the National Institute of Cardiovascular Diseases.

Exclusion Criteria: Patients who did not give their consent, had a negative modified Allen's test, a history of ulnar artery blockage, an infection at the injection site or weakness or paralysis in the upper limb were excluded. They played an important role in guaranteeing both patient safety and the possibility of carrying out the procedures.

Methods

A total of 152 patients were randomized for the study, with 76 in each group (SA-OOP and LA-IP), based on WHO software and a power of 80% and a 95% confidence interval, using rates of success previously reported (88.9% vs 73.2%). The non-probability consecutive sampling method was used. Patients were divided at random using envelopes that were opaque and labelled with L for the LA-IP group or S for the SA-OOP group. The ultrasound probe was sterile, and it was inserted 2 cm deep into the skin at a frequency of 18 MHz for the procedure. The SA-OOP placed the artery in the\u0095centre and angled the needle at 30° to 45° when inserting. Soon after blood backflow, the doctor shifted the angle of the needle in the LA-IP probe to 15°.

RESULTS

A total of 152 patients who were having radial artery cannulation were recruited during this study at the Department of Anesthesia, National Institute of Cardiovascular Diseases in Karachi from March 2024 to August 2024. The study included 76 patients who received short-axis out-of-plane (SA-OOP) ultrasound and 76 patients who got long-axis in-plane (LA-IP) ultrasound. The aim was to find out how the different techniques affected first-try success, how long it took to make an ultrasound and cannulation and the rate of complications in each case. To ensure that groups were the same, age, gender, having diabetes, hypertension, dyslipidemia, smoking status, ASA status and being obese were checked for all patients.

The participants in the SA-OOP group had an average age of 43.87 ± 15.58 years which was not significantly different from the 39.82 ± 14.42 years seen in the LA-IP group. Out of the SA-OOP group, 65.8% were males and 73.7% were males in the LA-IP group ($p = 0.289$). Among the SA-OOP

group, 9.2% had diabetes mellitus and the figure was 13.2% among the LA-IP group (p = 0.440). The study revealed that 6.6% of SA-OOP and 2.6% of LA-IP patients had hypertension (p = 0.246). Just 2.6% of SA-OOP and 1.3% of LA-IP patients had dyslipidemia and this difference was not statistically significant (p > 0.99). According to our analysis, SA-OOP patients smoked in, 35.5% of the cases, but it increased to 46.1% among LA-IP patients (p = 0.187). In the two groups, obesity was seen in 25% of SA-OOP and in 27.6% of LA-IP patients (p = 0.713). In most cases (86.8% in SA-OOP, 85.5% in LA-IP), ASA score was one and only a few were ASA II. According to Table 1, no group differed significantly at the study's start in regard to the characteristics measured.

Table 1: Distribution of Baseline Characteristics of Study Population

Variable	Short Axis (n=76)	Long Axis (n=76)	p-value
Age (Years)	43.87 (15.58)	39.82 (14.42)	0.098
Male	50 (65.8%)	56 (73.7%)	0.289
Female	26 (34.2%)	20 (26.3%)	
Diabetes Mellitus	7 (9.2%)	10 (13.2%)	0.440
Hypertension	5 (6.6%)	2 (2.6%)	0.246
Dyslipidemia	2 (2.6%)	1 (1.3%)	>0.99
Smoking	27 (35.5%)	35 (46.1%)	0.187
ASA I	66 (86.8%)	65 (85.5%)	>0.99
ASA II	10 (13.2%)	11 (14.5%)	
Obesity	19 (25%)	21 (27.6%)	0.713

There was a significant difference in the ultrasound location time and cannulation time between the groups. The SA-OOP group was able to locate the heart with ultrasound in 6.03 ± 1.81 seconds which was faster than the 15.09 ± 2.45 seconds in the LA-IP group (p < 0.001). Alternatively, the operation group took more time for cannulation (29.47 ± 7.78 seconds) than the level group (26.29 ± 4.02 seconds, p = 0.002). Table 2 shows the results obtained.

Table 2: Comparison of Ultrasound Location Time and Cannulation Time

Variable	Short Axis (Mean ± SD)	Long Axis (Mean ± SD)	p-value
Ultrasound Location Time (s)	6.03 (1.81)	15.09 (2.45)	<0.001
Cannulation Time (s)	29.47 (7.78)	26.29 (4.02)	0.002

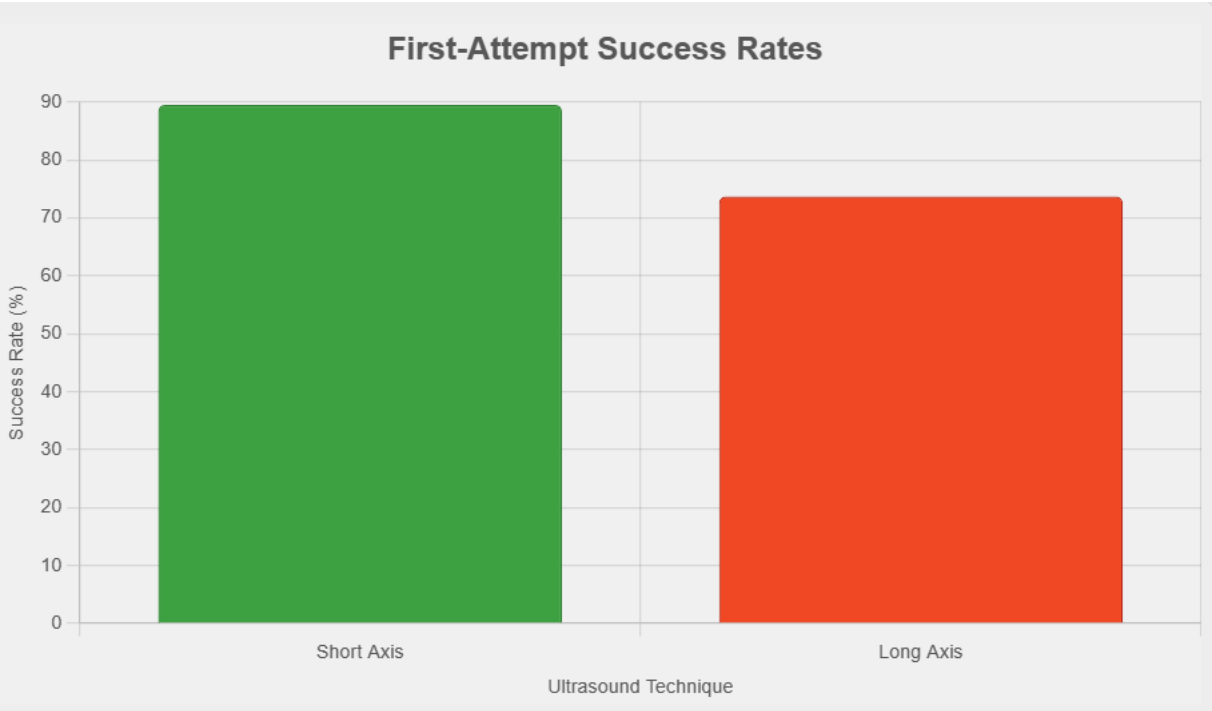
First-attempt success rates were higher in the SA-OOP group, with 68 patients (89.5%) achieving successful cannulation compared to 56 patients (73.7%) in the LA-IP group (p = 0.012). This is detailed in Table 3.

Table 3: Comparison of Success of Cannulation

Group	Success: No	Success: Yes	p-value
Short Axis	8 (10.5%)	68 (89.5%)	0.012
Long Axis	20 (26.3%)	56 (73.7%)	

The analyses, which covered many variables at the beginning of the study, yielded consistent results. Patients younger than 50 years had higher SA-OOP success rates, while those aged 50 or older showed no significant differences (p = 0.003 and p > 0.99, respectively). There was a larger success rate among males in the SA-OOP group than in the LA-IP group (88% vs. 71.4%, with p = 0.036). All groups experienced a quicker location of the ultrasound needle in SA-OOP procedures (p < 0.001). However, for those with hypertension, the time it took to insert the catheter was not significantly

different (p = 0.164). The table on the following page demonstrates the percentage of success for each group.



They reveal that SA-OOP improves the chance of success on the first try and lowers the time spent locating the IV site, even though it takes longer to put in the cannula than with LA-IP. By having alike baseline characteristics, the effects recognized can be credited to ultrasound rather than any medical condition in the patients.

DISCUSSION

Radial artery cannulation is crucial in critical care and surgery, as it enables real-time monitoring of the patient's blood pressure and facilitates the collection of blood samples for patients with illnesses or undergoing surgery. Being located on the surface and the hand using two arteries for blood supply, the radial artery is an excellent option that reduces the risk of serious ischemia (1). Still, palpation-based cannulation by the traditional method is not successful in many patients with obesity, swelling (oedema), low blood pressure or abnormal body structures, leading to several attempts with possible results like hematoma, blood clots or artery narrowing (2). Ultrasound guidance has helped reduce mistakes, make treatments safer, decrease complications, and improve the effectiveness of these treatments. The study between SA-OOP and LA-IP radial artery cannulation at NICVD, Karachi, revealed clear differences in first-attempt success rates, time used for locating the artery through ultrasound and the time taken to insert the catheter.

In SA-OOP, if the ultrasound transducer is placed straight perpendicular to the artery, the image shows the artery as a circular white area and the needle as a dot once it passes through (3). Unlike the other methods, the LA-IP has the transducer positioned parallel to the artery. This way, the needle shaft and tip can be seen continuously moving into the artery as one tube (4). According to our findings, the first-attempt success rate was found to be greater with SA-OOP (89.5%) compared to manual CLS (73.7%; p = 0.012), matching previous research that showed SA-OOP helped by placing the vessel on the screen (5). Since SA-OOP provides a wider angle, identifying vessels is simpler in patients with narrow or twisted arteries, which is often the case in areas like the NICVD (6).

The ultrasound time took much less for the SA-OOP group (6.03 seconds) than for the MP plane group (15.09 seconds, p < 0.001), supporting what is reported in studies about how the best performance is in the transverse plane (7). Lateral ultrasound imaging makes it possible to easily

locate the radial artery's cross-section, especially when it is hard to feel with palpation during shock or obesity (8). Nevertheless, it took patients in the SA-OOP group longer to undergo cannulation (29.47 ± 7.78 seconds) than those in the ESO group (26.29 ± 4.02 seconds, p = 0.002). The difficulty visualizing the needle made it necessary to adjust the distance to the skin for precise puncture (9). By comparison, LA-IP enables better placement of the needle and speeds up cannulation when it is needed for precise placement, as often occurs in patients of older age with calcified arteries (10).

Having a diameter of about 2.4 mm makes the radial artery tricky, because even the smallest deviation could cause the needle to puncture part of the vessel or harm its back wall (11). By modifying our technique to use dynamic needle placement, we increased the chance of successfully targeting the center of the artery which agrees with studies showing this improvement in accuracy for children (12). Because cardiac surgery patients often have altered anatomy, the ease of identifying vessels in SA-OOP makes it especially beneficial, based on results from adult-based studies (13). Being experienced and confident with ultrasound is very notable in studies on ultrasound-guided techniques, since it can affect the outcomes (14).

In newborns and children with smaller blood vessels, SA-OOP has been shown to achieve better outcomes than LA-IP (15). According to our findings, the benefits of SA-OOP appear to be useful in cardiovascular patients with additional conditions, such as diabetes and hypertension, which are represented in 9.2% and 6.6% of the SA-OOP cohort, respectively. Using ultrasound while inserting a line is connected to less hematoma and thrombosis in children, and the study suggests that this benefit also applies to adults with the same risk factors (16). Since our study did not reveal any cases of serious complications, it demonstrates that ultrasound-guided SA-OOP is a safe method for minimising the number of punctures.

Researchers have suggested merging SA-OOP for vessel tracking and LA-IP for placement of the catheter so the benefits of both methods are achieved (18). Using SA-OOP allowed us to reduce the time for ultrasound location, which could be further optimized with a hybrid method. Observing no posterior wall damage in both groups is promising; however, we were unable to confirm it definitively without further imaging, a problem also mentioned in previous studies (6). Studies could be done on live dual-plane imaging to better represent the needle location during the SA-OOP cannulation procedure. In Pakistan, since there is not the same level of resources and training everywhere, what we found is particularly important. Research from local studies shows that ultrasound is more effective than simply feeling the spot. There is little data available on how SA-OOP and LA-IP compare (5). Because procedures in tertiary care hospitals like the NICVD are busy, the ability to do shortened ultrasound procedures matters a lot.

However, the extra time required for cannulation in SA-OOP highlights that better training is needed to enhance one's ability to see the needle tip (7). Using standard operating procedures using a modified form of SA-OOP may help improve the results in areas without many resources, agreeing with worldwide trends toward supported evidence (8). Regardless of the patient's age, gender or if they had various disorders, the results suggested that SA-OOP provided more benefits than OOP. Because they are more likely to succeed in one go, SA-OOP is often preferred where patients turn over quickly, and procedures are frequently delayed, which can cause problems. Still, the shorter cannulation time with LA-IP for patients with high blood pressure may guide it as the preferred choice in some circumstances (9). The research indicates that tailoring ultrasound approaches to each patient and operator's skills enhances the success rate in tertiary care hospitals in Karachi.

CONCLUSION

A total of 152 patients were involved in the trial that took place between March 2024 and August 2024 at the National Institute of Cardiovascular Diseases, Karachi. Applying the SA-OOP technique, there were more first-time successes (89.5%), cannulations took less time (29.47 seconds), and the ultrasound procedure took less time (6.03 seconds) compared to LA-IP. Therefore, it can be concluded that the modified SA-OOP approach increases the efficiency and success of procedures, mainly in swiftly locating vessels, which is important for busy tertiary centres. No dangerous events were

noticed, confirming that ultrasound tracts are safe to use. SA-OOP is highly suggested as the way to cannulate the radial artery, and training can help enhance visualization for better outcomes in Pakistan's medical situations.

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