

## ARTERIAL LINE PLACEMENT, A COMPARISON OF ULTRASOUND GUIDED VS PALPATION TECHNIQUE

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### Abstract

**Objectives:** The main objective of the study is to compare arterial line placement via ultrasound-guided Seldinger with palpation technique.

**Study design and place of study:** Quasi experimental study, September 2024- February 2025, Tertiary care hospital. Lahore

**Methodology:** A total of 120 adult patients requiring arterial line placement were randomly assigned into two groups: ultrasound-guided Seldinger arterial line (n=60) and palpation technique (n=60). Patients with local infection, coagulopathy, or vascular disease were excluded. Arterial cannulation was performed under aseptic conditions using a 20G catheter. The primary outcome was first-attempt success rate, while secondary outcomes included overall success, number of attempts, procedure time, and complications. Data were analyzed using SPSS, with  $p < 0.05$  considered statistically significant.

**Results:** A total of 120 patients were analyzed, with comparable baseline characteristics between groups. The ultrasound group showed significantly higher first-attempt success (80% vs. 55%,  $p=0.003$ ) and overall success rates (96.7% vs. 85%,  $p=0.028$ ). The mean number of attempts was lower ( $1.3 \pm 0.6$  vs.  $2.1 \pm 1.0$ ,  $p < 0.001$ ), and procedure time was shorter ( $92.5 \pm 28.4$  vs.  $135.2 \pm 45.6$  seconds,  $p < 0.001$ ) in the ultrasound group. Complications such as hematoma were less frequent (5% vs. 16.7%,  $p=0.041$ ). No cases of thrombosis or infection were reported.

**Conclusion:** ultrasound-guided Seldinger arterial line placement is more effective and safe procedure as compared to conventional approach.

### Introduction:

The placement of arterial lines is an invasive procedure that is regularly undertaken in the critical care and perioperative units and enables constant monitoring of blood pressure and frequent arterial blood sampling. The most common site of cannulation is radial artery because it is superficial, easy to access and has minimal complication rate due to the ulnar artery supplying collateral circulation. Although it is a

routine procedure, arterial cannulation is technically difficult in some patient groups, such as patients with obesity, hypotension, edema, or weak peripheral pulses, which has prompted several attempts and consequently elevated the risks of complications, including hematoma, arterial spasm, thrombosis, and infection.[1]

From ancient times, the practice of arterial cannulation has been by palpation, in which the clinician palpates the artery and determines its

location and inserts the catheter according to anatomical landmarks. Although this technique is easy and does not need extra staff, it is very operator-sensitive and could have diminished success rates when used in patients whose pulses are poor or impalpable. Several unsuccessful cases do not only postpone clinical management, but also cause more patient suffering and complications during the procedure.[2]

Ultrasound guidance has been used as a substitute in recent years as a method of place arterial line. Such a way allows visualising the artery, structures around it and the path of a needle in real-time, which may increase the success rates of the first attempt and minimize complications. Vascular access using ultrasound guidance has already become the standard of practice in central venous catheter insertion, and is implemented in the insertion of arterial cannulations in an increasingly diverse range of locations such as emergency department, intensive care, and operating rooms.[3]

Some of the studies have provided comparisons between the ultrasound guided arterial cannulation and the traditional palpation technique with diverse results in the success rates, number of attempts, time to cannulation, and complications. There is evidence that high-risk or challenging populations of patients may need ultrasound guidance especially in pediatric patients, critically ill patients, and patients that are hemodynamically unstable. The common application of ultrasound is however controversial because of the availability of equipment, the training of the operators as well as length of time taken to perform the procedure.[4]

Considering the increasing importance of patient safety and the efficiency of the procedure, it is crucial to determine whether the application of ultrasound guidance is a strong benefit in comparison with the palpation method of placing arterial lines. The proposed research will provide the comparison of the ultrasound- guided technique and palpation technique on the ground of the first-attempt success rate, the overall success, the procedure time, and the complications associable with each method. The results can be used to inform clinical practice and direct

adoption of ultrasound as a routine practice in arterial cannulation.

## **Methodology:**

This was a quassi experimental study, that was carried out in the operating rooms and the intensive care units of a tertiary care hospital Lahore ( Hameed Latif Hospital) in a six months period from September 2024- February 2025. The research was accepted by the Institutional Review Board (IRB), and informed consent was signed by all the patients or their legal guardians before participating. The study involved 120 patients who needed to have the arterial line inserted in them in order to monitor their hemodynamic conditions or take blood samples. Eligible patients were patients of both genders aged 18 years and above. The confidence level and power of sample size were determined as 95 and 80 respectively, using the first-attempt success rates that have already been reported. The inclusion of the patients was conducted through a consecutive sampling method, and a random selection of two groups was done based on a computer-generated randomization list.

## **Inclusion criteria:**

- Patients in need of clinical arterial cannulation.
- Age > 18 years
- Stable or unstable patients with the need of the invasive monitoring.

## **Exclusion criteria:**

- Local infection in the site of insertion.
- Peripheral vascular disease affecting upper limbs known.
- Past attempt of cannulation of the arteries (at the same site).
- Coagulopathy (INR>1.5 or platelet count less than 50,000/uL)
- Test by Negative Allen who showed poor collateral circulation.

**The respondents were separated into two equal groups (n=60 each):**

a. Group A (Ultrasound-guided, group, Seldinger method): Arterial cannulation was carried out under real time ultrasound guidance.

b. Group B (Palpation group): This involves cannulation of the arteries with the conventional palpation.

The probe was in high-frequency linear ultrasound (7-12 MHz) and sterile. It was discovered that the radial artery appeared in the transverse (short-axis) view. A 20G arterial catheter was placed with the dynamic needle tip positioning technique after antisepsis and local anesthesia of the skin and 1-2 mL of 2 percent lidocaine. The pulsatile blood flow and pulseform on the monitor were a positive indication of successful cannulation.

The palpation of the strongest skin pulsation at the wrist revealed the radial artery. A 20G arterial catheter was inserted over the maximal rate of pulsation at 30-45deg angle following the aseptic preparation and local anesthesia. Arterial waveform and free flow of blood were similarly observed to be successful placements. Everyone was carried out by the anesthesiologists with the experience of at least two years in the field of cannulation of the arteries. Operators who were working in ultrasound guided procedures had had prior formal training in vascular ultrasound.

- Primary outcome:
  - First-attempt success rate
- Secondary outcomes:
  - Overall success rate
  - Number of attempts required
  - Time to successful cannulation (skins to waveform)

### **Complications (hemorrhage, artery spasm, thrombosis, infection)**

The information was documented using a structured proforma, which included patient demographics (age, gender, BMI), the reason why the patient was admitted to the hospital to receive an arterial line, and his/her clinical condition. Immediately after cannulation, procedural variables and outcomes were recorded. The SPSS version 25 was used to analyze data. The continuous variables were reported as mean +

standard deviation, whereas the categorical ones were reported as frequencies and percentages. The independent t-test was employed in comparing continuous variables whereas the chi-square test was employed in comparing categorical variables. The p-value of 0.05 was taken as statistically significant.

### **Results:**

A total of 120 patients were enrolled in the study and equally randomized into two groups: ultrasound-guided Seldinger Technique (Group A, n=60) and palpation technique (Group B, n=60). All patients completed the study, and no data were excluded from the final analysis.

The demographic characteristics of patients in both groups were comparable. The mean age in Group A was  $52.3 \pm 14.1$  years, while in Group B it was  $50.8 \pm 13.6$  years ( $p=0.54$ ). The male-to-female ratio was similar in both groups. There was no statistically significant difference in body mass index (BMI) or indication for arterial cannulation between the two groups, ensuring baseline comparability.

The first-attempt success rate was significantly higher in the ultrasound-guided group compared to the palpation group. In Group A, 48 patients (80%) had successful cannulation on the first attempt, whereas only 33 patients (55%) in Group B achieved first-attempt success ( $p=0.003$ ).

The overall success rate was also higher in the ultrasound group (96.7%) compared to the palpation group (85%), which was statistically significant ( $p=0.028$ ). The mean number of attempts required for successful cannulation was significantly lower in Group A ( $1.3 \pm 0.6$ ) compared to Group B ( $2.1 \pm 1.0$ ;  $p<0.001$ ).

The mean time required for successful arterial line placement was shorter in the Seldinger ultrasound-guided group ( $92.5 \pm 28.4$  seconds) compared to the palpation group ( $135.2 \pm 45.6$  seconds), demonstrating a statistically significant difference ( $p<0.001$ ).

Complication rates were lower in the ultrasound group. Hematoma formation occurred in 3 patients (5%) in Group A compared to 10 patients (16.7%) in Group B ( $p=0.041$ ). Arterial spasm was observed in 2 patients (3.3%) in Group A and 7

patients (11.7%) in Group B (p=0.08), which was not statistically significant. No cases of thrombosis or catheter-related infection were observed in either group during the study period.

Overall, ultrasound-guided Seldinger arterial line placement demonstrated superior outcomes

compared with the traditional palpation technique, including higher first-attempt and overall success rates, fewer attempts, shorter procedure time, and fewer complications

Table 1.1: Demographic Data of study groups

Variable	Group A (Ultrasound) (n=60)	Group B (Palpation) (n=60)
Age (years)	52.3 ± 14.1	50.8 ± 13.6
Gender (Male/Female)	34 / 26	36 / 24
BMI (kg/m <sup>2</sup> )	27.1 ± 3.8	26.7 ± 4.1

Table 1.2: 1<sup>st</sup> procedural attempt

Outcome	Group A (Ultrasound)	Group B (Palpation)
First-attempt success	48 (80%)	33 (55%)
Overall success	58 (96.7%)	51 (85%)
Failed cannulation	2 (3.3%)	9 (15%)

Table 1.3: Procedural efficacy in both groups

Variable	Group A (Ultrasound)	Group B (Palpation)
Number of attempts	1.3 ± 0.6	2.1 ± 1.0
Time to cannulation (seconds)	92.5 ± 28.4	135.2 ± 45.6

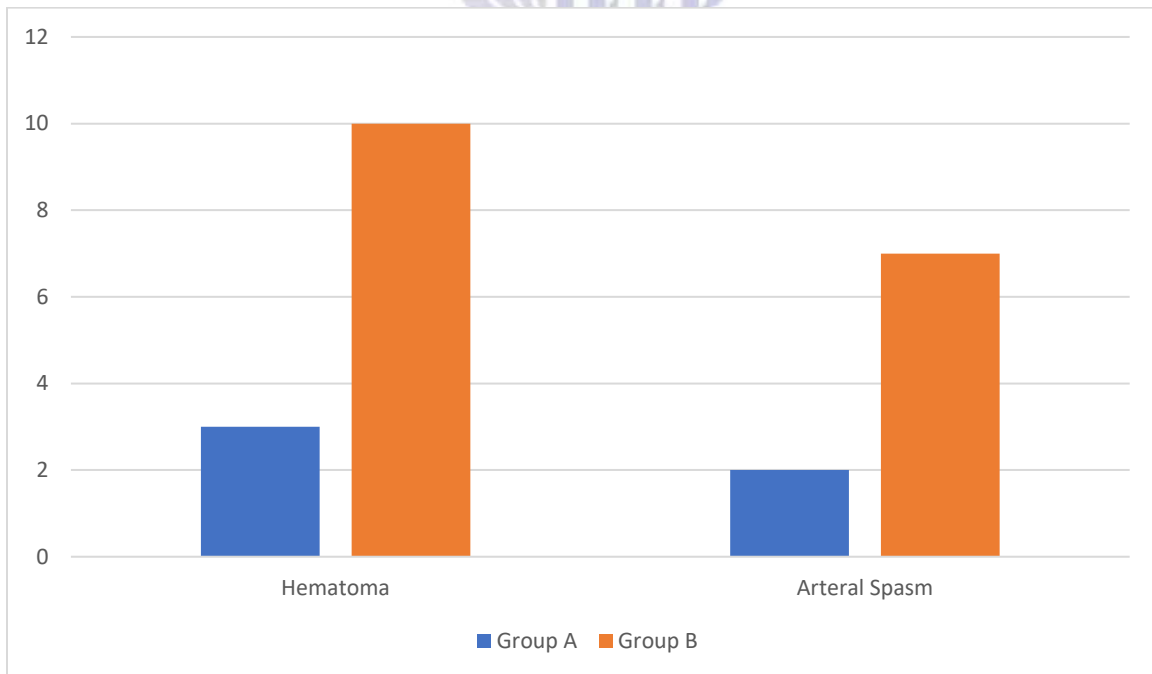


Figure 1.1: Complications comparison between groups

Table 1.4: Outcome comparison between two groups

Parameter	Ultrasound Group	Palpation Group
First-attempt success	Higher	Lower
Overall success	Higher	Lower
Number of attempts	Fewer	More
Procedure time	Shorter	Longer
Complications	Fewer	More

**Discussion:**

The current research proves that ultrasound-guided placement of arterial lines is superior to the conventional palpation-guided one regarding the first-attempt success rate, total success rate, the number of attempts, and the time required to complete the procedure and the complication rates. These results augment the increasing literature on the use of ultrasound guidance as a standard procedure of arterial cannulation, especially in difficult clinical settings.

The success rate of the first attempt was larger in this study in the ultrasound-guided group (80%), than in the palpation group (55%). This is in line with other studies, such as the meta-analysis by Gu et al., that indicated higher success in the first-pass when using ultrasound guidance during radial artery catheterization. On the same note, Shiloh et al. reported that ultrasound guidance is a factor that greatly improves the success rates of the first attempt, particularly in critically ill patients and with weak or impalpable pulses. This increased success is possibly due to the enhanced visualization of the artery and needle path eliminating the use of anatomical landmarks.[5]

Our study was also much more successful in the ultrasound group (96.7% vs. 85%). This conclusion is consistent with previous studies indicating that ultrasound guidance enhances the success of the procedures, despite having patients with challenging vascular access. This capability to visualize the anatomical variations, depths of the arteries and the structures around them enable clinicians to make real-time modifications thereby enhancing the chances of successful cannulation.[6]

The other significant result was a decrease in the number of attempts of successful cannulation. The number of attempts needed by the patients

was much lower in the ultrasound group (1.3 +/- 0.6) than in the palpation group (2.1 +/- 1.0). There are several attempts that are linked to high patient discomfort and complications such as the formation of a hematoma and arterial spasm. The same study by Peters et al. had fewer attempts using ultrasound guidance with specific attention to the fact that it enhances the efficiency of the procedure.[7]

The effective cannulation period was much less in the ultrasound-guided group. Even though other previous investigations proposed that ultrasound could increase procedure time because of equipment preparation, our results are in line with the more recent research findings that real-time visualization actually decreases the total time of cannulation. This applies especially to the emergency and critical care facilities where fast vascular access is needed.[8]

The rate of complications was much less in the ultrasound group, and the rates of hematoma occurrence were also significantly lower (5% vs. 16.7%). This is in agreement with the results of White et al., who indicated that ultrasound-guided intervention will help in reducing the incidence of complications since it reduces the occurrence of unwanted trauma to the artery wall and multiple puncture. Even though no statistical significant decrease was detected in the arterial spasm of our experiment, there was still a tendency towards the fewer spasms that occurred in the ultrasound group, and this may be of clinical use.[9]

The clinical implications of these findings are huge. Ultrasound guidance is beneficial in terms of patient safety as well as the rate of the procedure and is thus especially useful in high-risk groups like obese patients, patients with hypotension and critically ill patients. Arterial pulsations can be hard to feel in such patients, which makes the

conventional method less accurate. Ultrasound offers a graphical reassurance of arterial positioning and openness and thus eliminates these constraints.[9]

Although it has these benefits, actual application of ultrasound-guided cannulation of the arteries could be restricted by the availability of the equipment, its affordability, and the necessity of training the operator. Nonetheless, as more portable ultrasound devices are offered and training in the field of ultrasound is introduced in medical school curriculums, these obstacles are slowly falling. Troianos et al. have also indicated that training and standardization of ultrasound guided vascular access are crucial in maximizing the benefits of ultrasound guided vascular access.

The other factor is the learning curve of using ultrasound. Although both methods can be very successful in the hands of experienced operators, the ultrasound guidance seems to present more benefits to less experienced clinicians. This implies that ultrasound can be used to normalize procedural success across different levels of expertise ending up in the enhanced overall patient outcomes.[10]

Some of the advantages of this study are that it is randomized and standardized in terms of procedural approach. Nonetheless, there are some drawbacks that must be admitted. First, the research was done in one center and thus it might not be generalized. Second, operator experience though standardized to some degree, might have also affected results. Third, long term complications like arterial occlusion were not observed because of the short time of the follow up.

Arterial line placement remains a fundamental procedure in perioperative and critical care practice, yet its success is often influenced by patient factors and operator skill. The present study highlights the clear advantage of ultrasound-guided arterial cannulation over the conventional palpation technique, demonstrating improved success rates, enhanced procedural efficiency, and reduced complication rates. These findings provide further evidence supporting the integration of ultrasound into routine vascular access practices.[11]

A key observation in this study was the significantly higher first-attempt success rate in the ultrasound-guided Seldinger method group. First-pass success is clinically important as it minimizes patient discomfort, reduces procedure-related anxiety, and limits vascular trauma. The improved outcomes seen with ultrasound guidance can be attributed to direct visualization of the artery, allowing accurate needle placement even in patients with difficult anatomy. In contrast, the palpation technique relies heavily on tactile feedback, which may be unreliable in cases of hypotension, obesity, or edema.[12]

The higher overall success rate observed with ultrasound guidance further reinforces its effectiveness. Failed arterial cannulation not only delays critical interventions but may also necessitate alternative access sites, which could carry higher risks. Ultrasound facilitates identification of the most suitable insertion point by providing information about arterial size, depth, and patency. This ability to tailor the approach to individual patient anatomy likely contributed to the near-complete success rate observed in the ultrasound group in this study.[13] Another important finding was the reduction in the number of attempts required for successful cannulation. Each additional attempt increases the risk of complications, including hematoma formation and arterial spasm. By enabling real-time needle tracking, ultrasound guidance reduces the likelihood of unsuccessful punctures. This is particularly relevant in clinical scenarios where repeated attempts may compromise arterial integrity or lead to patient instability.[14]

The study also demonstrated a significant reduction in the time required for successful cannulation in the ultrasound group. While the setup of ultrasound equipment may initially appear time-consuming, the overall procedure becomes more efficient due to fewer failed attempts and more precise needle placement. This finding underscores the importance of considering total procedural time rather than focusing solely on preparation time. In time-sensitive environments such as emergency departments and intensive care units, this

efficiency can have a meaningful impact on patient outcomes.[15]

Complication rates were lower in the ultrasound-guided (Seldinger) group, with a notable reduction in hematoma formation. This can be explained by the improved accuracy of needle insertion, which minimizes unintended arterial wall injury and reduces the number of punctures. Although arterial spasm was less frequent in the ultrasound group, the difference did not reach statistical significance. Nevertheless, the trend toward fewer complications suggests that ultrasound guidance (Seldinger) enhances procedural safety.[16]

An important consideration in interpreting these findings is the role of operator experience. While all procedures in this study were performed by trained clinicians, ultrasound guidance (Seldinger method) may offer particular benefits for less experienced operators. By providing visual feedback, ultrasound reduces reliance on subjective assessment and allows for more consistent performance. This has implications for training programs, as early incorporation of ultrasound techniques may help standardize competency in arterial cannulation.[17]

Despite its advantages, the widespread adoption of ultrasound-guided arterial cannulation may be influenced by practical factors such as equipment availability and training requirements. In resource-limited settings, access to ultrasound machines may be restricted, and clinicians may lack formal training in their use. However, the increasing availability of portable and cost-effective ultrasound devices is gradually addressing these barriers. Additionally, structured training programs and simulation-based education can facilitate skill acquisition and improve confidence among healthcare providers.[18]

Another aspect worth considering is patient selection. While ultrasound guidance appears beneficial across a broad range of patients, its advantages are particularly pronounced in those with difficult vascular access. In such cases, the use of ultrasound may not only improve success rates but also prevent complications associated with repeated failed attempts. Therefore, even in settings where routine use is not feasible, selective

application in high-risk patients may provide significant clinical benefits.

Further studies should be conducted on the multicenter trials using larger sample sizes to confirm these results in different patient populations. The other areas in which the research could be further improved are assessing the cost-effectiveness and long-term consequences of ultrasound-guided arterial cannulation to give a better overview of its application in everyday clinical practice.

**Limitation of Study:** it is single center study, with limited population size, hence its results cannot be generalized on population sample. To get better results, a larger study with more sample size is required.

#### **Conclusion:**

In conclusion, ultrasound-guided Seldinger arterial line placement method is a more effective and safer technique compared to the traditional palpation method. It significantly improves success rates, reduces procedural time and attempts, and minimizes complications. These findings support the incorporation of ultrasound guidance as a standard practice in arterial cannulation.

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