ORIGINAL ARTICLE
A PROSPECTIVE COMPARISON OF ULTRASOUND GUIDED VERSUS PALPATION METHOD FOR RADIAL ARTERY CATHETER PLACEMENT

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Objectives: The objective of this study was to assess the effectiveness of ultrasound guided vs. conventional palpation method for radial artery cannulation in the operating room for patients undergoing elective open-heart operations.

Methodology: This prospective observational study was carried at the National Institute of Cardiovascular Disease (NICVD) in Karachi and Sukkur. All cannulation procedures were performed by anesthesia residents (R-1). Two equal sized independent groups of patients based on radial artery cannulation technique, either ultrasound guided (USG) or conventional palpation method (CPM) were recruited. Artery cannulation success along with number of attempts, total duration, number of additional operators, need for change of site, and complications were recorded.

Results: A total of 70 patients were recruited in each of the group, mean patient age was 52.43±13.53 years vs. 50.71 ± 14.1 years; p=0.605 with proportion of male patients as 65.7% (46) vs. 77.1% (54); p=0.290, for USG and CPM, respectively. Artery cannulation success rate was 74.3% (52) vs. 80% (56); p=0.569, mean number of attempts was 1.71±1.05 vs. 1.51±0.89; p=0.391, mean total duration was 7.76±3.78 minutes vs. 5.42 ± 8.2 minutes; p=0.131, mean number of additional operators was 0.74±0.44 vs. 0.89±0.32; p=0.128, need for change of site was 11.4% (8) vs. 2.9% (2); p=0.356, and complications were observed in 8.6% (6) vs. 2.9% (2); p=0.614 for USG and CPM, respectively.

Conclusion: In this observational study, no significant differences were observed in the effectiveness of USG and CPM for radial artery cannulation when performed by newly inducted anesthesia residents.

Keywords: radial artery cannulation, ultrasound, palpation, vygon catheter

INTRODUCTION

In various hospital situations, including the emergency room (ER), intensive care unit (ICU), and operating room, a patient may need an indwelling arterial cannulation. However, arterial cannulation is essentially necessary for hemodynamics measurements during open-heart cardiac surgery, such as beat-to-beat blood pressure monitoring, fluid responsiveness assessment, and frequent blood sample collection for ACT, arterial blood gas (measurements), and other blood tests during the operation and in the intensive care unit.[1]

The best method for measuring blood pressure accurately is using arterial lines. The radial, brachial, femoral, posterior tibial, axillary, ulnar, and dorsalis pedis are some of the different locations that can be used for arterial cannulation. The adult radial artery, however, is the ideal location for arterial cannulation insertion because of its superficial accessibility, relatively low complication rate because most patients have redundant collateral blood flow to the hand via the ulnar artery, and compressibility for hemostasis.[1,2]

Unfortunately, anatomic landmarks may not detect the radial artery in up to 30% of patients, despite the fact that they have traditionally been recognized as the gold standard for inserting radial arterial catheters.[2] Despite the fact that arterial cannula placement by palpation method continues to pose a challenge to even the most experienced anesthetic in obese, tachycardia, edematous, awake, and hypotensive patients, anesthetics are expected to be very proficient

in placing arterial lines and they gain a lot of experience during training and practice.[3]

In open heart surgery arterial cannulation needs to be placed in awake patient before induction, this may lead to repeated unsuccessful attempts, potentially causing complication i.e. arterial hemorrhage, hematoma, spasm, which can compromise blood supply downstream. These complications become more likely with increased number of cannulation attempts.[4-6]

Ultrasound is increasingly being employed as a vascular access adjunct. The US Centers for Disease Control and Prevention advise ultrasonography for central venous catheter placement as it results in fewer tries and complications than the conventional landmark technique, which has been the standard of care for central line placement.[7-9]

Several systematic evaluations throughout the perioperative context have demonstrated the effectiveness of using ultrasonography for arterial line placement. Recent meta-analyses comparing TBP with ultrasonography for radial artery cannulation all indicate considerably improved ultrasound outcomes, including first-attempt success rate, failure rate, number of attempts, duration, and complications.[10-12]

Although ultrasonography guidance has been successful in central access, there is little information available regarding the use of us in peripheral access. The use of ultrasound guidance for the radial artery catheter placement has also received minimal attention in the literature. We are not aware of any locally published prospective studies comparing the placement of radial arterial cannulas using the palpation approach vs. ultrasound guidance. Our study's objective was to assess the use of ultrasound guidance by newly inducted anesthesia residents during radial artery cannulation to see if it has any advantages over the conventional palpation method in the operating room.

METHODOLOGY

This study was a prospective observational conducted at the National Institute of Cardiovascular Disease (NICVD), Karachi and Sukkur, Pakistan between September 2021 and February 2022. All cannulation procedures were performed by newly inducted anesthesia residents under the supervision of senior consultant. For this study, two equal sized independent groups of patients based on radial artery cannulation technique, either ultrasound guided (USG) or conventional palpation method (CPM) were recruited. A written consent was taken from all the patients who participated in this study and allow the publication of

the results while keeping their identity secrete. Study was approved by the ethical review board of the institution (ERC-93/2021).

At an 80 percent power of test and a 5 percent level of significance, a minim needed sample size of n=25 patients in each group was calculated based on the expected success rate of the first attempt as 91.6 percent for the ultrasound-guided method and 57.7 percent for the palpation method.[13] Forty five patients in each group were added to increase statistical precision and in account for non-systematic errors.

Study population consisted of patients who underwent elective open-heart surgery and had an the American Society of Anesthesiologists (ASA) class of 3 or 4 met the study inclusion criteria. While patients having age < 18 or >75 years, ASA class V, arterial cannula passed after induction, international normalization ratio (INR) > 1.5, previously angiography done via radial artery access in last 7 days, emergency surgery, patient on continuous heparin infusion, or body mass index (BMI) > 30 were excluded from the study.

Every patient received lorazepam 4 mg one hour prior to surgery in the pre-operative area. Standard monitoring (ECG and SpO2) and an intravenous line were then applied in the operating room. The skin close to the insertion site was cleansed with chlorhexidine per normal protocol for all patients. To preserve wrist extension, the wrist was extended and taped to an arm board. The radial artery was percutaneously punctured with an 18G vygon needle.

The radial artery was imaged in short axis for the USG-guided artery cannulation technique. Real-time out of plane technique was used to place the needle. The evaluation time (T1) is defined as "Time between the skin-applied probes of the portable ultrasonography equipment used to pinpoint the radial artery to skin punctured by needle." Additionally, cannulation time (T2) is defined as "the interval of time between the first penetrations of the needle through the skin to the successful cannulation of the artery."

While in the CPM, the radial artery was located using the palpation technique, and the vygon needle was guided by continuous or sporadic palpation of arterial pulse. The evaluation time (T1) is defined as "Time between the operator's initial placement of fingers on the patient's wrist and the needle puncture of skin." Furthermore, cannulation time (T2) is defined as "the interval of time between the first penetration of the needle through the skin to the successful cannulation of the artery."

When necessary, the second operator was the consulting anesthesiologist overseeing the operator. Before transitioning to a different approach, crossover with technique was tried in both situations one more time.

The primary outcome of the study was the successful of arterial cannulation. Secondary outcomes included number of attempts done, the duration of screening and cannulation, need to change the operator and site, and the frequency of problems (hand ischemia, and hematoma formation, arterial spasm).

The successful arterial cannulation served as the endpoint for both approaches. The success rate was calculated using the technique that had been randomly allocated to that patient and was defined as "successful cannulation of the radial artery in two attempts or fewer". "Removal of the guide wire and continuation of an arterial blood flash" was the definitions of a successful arterial cannulation. Failure was described as "the inability to cannulate successfully after two attempts". The number of needle tips entirely extracted from the skin were used to quantify cannulation attempts.

The IBM SPSS version 21 was used to evaluate the collected data, summary statistics like mean, SD, or frequency (percent) were computed. The USG and CPM groups were compared with the help of independent sample t-test or Mann-Whitney U test for continuous response variables, and the Chi-square test or Fisher's exact test to compare categorical response variables. P-value of 0.05 or less was taken as criteria for statistical significance.

RESULTS

A total of 70 patients were recruited in each of the group, mean patient age was 52.43±13.53 years vs. 50.71 ± 14.1 years; p=0.605 with proportion of male patients as 65.7% (46) vs. 77.1% (54); p=0.290, for USG and CPM, respectively (Table 1).

Table 1: Comparison of demographic and clinical characteristics of patients in ultrasound guided and palpation method

	Radial Arterial Cannulation		P-value
	USG	CPM	
Total (N)	70	70	-
Gender			
Male	65.7% (46)	77.1% (54)	0.290c
Female	34.3% (24)	22.9% (16)	
Age (year)	52.43 ± 13.53	50.71 ± 14.1	0.605t
Weight (kg)	65.49 ± 12.96	67.77 ± 13.23	0.468t
Height (cm)	162.66 ± 9.2	161.17 ± 12.45	0.572t
BMI (kg/m^2)	1.75 ± 0.31	1.85 ± 0.42	0.261t
ASA Class			
III	2.9% (2)	2.9% (2)	>0.999f

IV	97.1% (68)	97.1% (68)	
Planned Procedure			
CABG	62.9% (44)	82.9% (58)	0.060c
CABG and Others	37.1% (26)	17.1% (12)	
Systolic blood pressure (mmHg)	128.6 ± 17.36	125.2 ± 18.47	0.430t
Diastolic blood pressure (mmHg)	76.14 ± 12.85	77.29 ± 22.4	0.794t
Mean atrial pressure (mmHg)	93.57 ± 12.86	93.26 ± 18.83	0.935t
Heart rate (bpm)	81.66 ± 11.9	82.34 ± 11.11	0.804t
Co-morbid conditions			
Hypertension	20% (14)	22.9% (16)	0.125c
Diabetes	20% (14)	14.3% (10)	
Both hypertension and diabetes	17.1% (12)	40% (28)	
Others	42.9% (30)	22.9% (16)	

USG: ultrasound guided, CPM: conventional palpation method, ASA: American Society of Anesthesiologists, CABG: coronary artery bypass grafting
c=Chi-square test, f=Fisher's Exact test, t=independent sample t-test

Table 2: Comparison of effectiveness of ultrasound guided vs. conventional palpation method for radial artery cannulation

	Radial Arterial Cannulation		P-value
	USG	CPM	
Total (N)	70	70	-
Arterial cannulation			
Unsuccessful	25.7% (18)	20% (14)	0.569c
Successful	74.3% (52)	80% (56)	
Site			
Left radial	55.6% (10)	85.7% (12)	0.308f
Left brachial	44.4% (8)	14.3% (2)	
Assessment time T1	3.17 ± 1.2	1.87 ± 1.01	0.804t
Cannulation time T2	4.58 ± 3.42	2.07 ± 1.93	<0.001t
Total Time	7.76 ± 3.78	5.42 ± 8.2	0.131t
Total no of attempts	1.71 ± 1.05	1.51 ± 0.89	0.391t
Total no of operators	0.74 ± 0.44	0.89 ± 0.32	0.128t
Need to change the position			
Yes	11.4% (8)	2.9% (2)	0.356f
No	88.6% (62)	97.1% (68)	
Complications			
Hematoma or other complication	8.6% (6)	2.9% (2)	0.614f
None	91.4% (64)	97.1% (68)	

USG: ultrasound guided, CPM: conventional palpation method
c=Chi-square test, f=Fisher's Exact test, t=independent sample t-test

Artery cannulation success rate was 74.3% (52) vs. 80% (56); p=0.569, mean number of attempts was 1.71±1.05 vs. 1.51±0.89; p=0.391, mean total duration was 7.76±3.78 minutes vs. 5.42 ± 8.2 minutes; p=0.131, mean number of additional operators was 0.74±0.44 vs. 0.89±0.32; p=0.128, need for change of site was 11.4% (8) vs. 2.9% (2); p=0.356, and complications were observed in 8.6% (6) vs. 2.9% (2); p=0.614 for USG and CPM, respectively (Table 2).

DISCUSSION

The use of ultrasound guidance has recently replaced the conventional palpation method in general procedures like arterial line cannulation because of the development of technology resources and their widespread accessibility in healthcare settings. In this study, we examined the long-running controversy over the use of ultrasound against the more traditional palpation approach for radial artery cannulation. In the past, not many studies have been done specifically involving novel anesthesia residents only.[14] Our study is amongst the few in the world and first in our department which basically involved practices of our anesthesia residents only.

Our work disproved the initial claim by demonstrating that there is little difference between ultrasound guided radial artery cannulation and conventional palpation approaches. The results of both groups show that USG requires twice as much time than palpation. Additionally, although though it was often less than 10%, the complication rate linked with USG cannulation was higher than the palpation approach. Both groups showed no significant difference in BMI (1.75 ± 0.31 in USG group vs. 1.85 ± 0.42 in CPM group).

According to a meta-analysis by Gu W-J et al.[12], USG is preferable to the palpation approach. Our investigation showed that USG takes longer and requires more skill to perform artery cannulation than palpation. We have noticed an increase in time with the use of USG (7.76 ± 3.78 in USG group vs. 5.42 ± 8.2 in CPM group). Bhattacharjee S et al.[10] found no significant time difference between USG and digital palpation for Radial Artery Cannulation, which is opposite to the finding of our trial. This can be put down to fact that the residents, at the end of day were learning new skill in form of ultrasound guided arterial line cannulation and are more comfortable in palpatory method as mentioned earlier.

In accordance with Bhattacharjee S et al.[10], we also discovered a slightly better rate of attempts with USG in comparison to palpation. However, the difference was not a significant one. Tariq S et al. in their study also mentioned more successful attempts while using USG in placing radial arterial line.[15]

Ammar A et al.[16] in their randomized trial highlighted the fact of significant decreased amount complications when Ultrasound was used in terms of cannulating radial artery when compared to blind technique. We, in our study had, although insignificant in terms of P-value had opposite results in terms of complications (8.6% in USG group vs. 2.9% CPM group). Again the same reason of residents being more prone to the blind technique of arterial cannulation can be put down as justified reason.

A single center coverage with relatively small sample size remained the main limitation of this study. Secondly, due to observational nature of the study, operators' experience and method adopted for arterial cannulation were not controlled, which are likely to induce non-random bias in the study findings. However, if performed in a control environment with sufficient training ultrasound guided arterial cannulation can result in better results with better success rate, lesser complications, and lesser number of attempts.

CONCLUSION

In conclusion, no significant differences were observed in the effectiveness of USG and CPM for radial artery cannulation when performed by newly inducted anesthesia residents. Although it is constrained by the small sample size and single center. For this reason, a bigger sample size and multi-centric research are advised.

AUTHORS' CONTRIBUTION

KK and MAK: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. SAK, MT, SZ, and SA: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

REFERENCES

1. Wilson C, Rose D, Kelen GD, Billioux V, Bright L. Comparison of ultrasound-guided vs traditional arterial cannulation by emergency medicine residents. West J Emerg Med. 2020;21(2):353.

2. Brzezinski M, Luisetti T, London MJ. Radial artery cannulation: a comprehensive review of recent anatomic and physiologic investigations. Anesth Analg. 2009;109(6):1763-81.

3. Peters C, Schwarz SK, Yarnold CH, Kojic K, Kojic S, Head SJ. Ultrasound guidance versus direct palpation for radial artery catheterization by expert operators: a randomized trial among Canadian cardiac anesthesiologists. Can J Anaesth. 2015;62(11):1161-8.

4. Fisher N, Mutimer D. Central venous cannulation in patients with liver disease and coagulopathy–a prospective audit. Intensive Care Med. 1999;25(5):481-5.

5. Paisley CB, Thomas S. Ultrasonic locating devices for central venous. BMJ. 2003;327(361).

6. Froehlich CD, Rigby MR, Rosenberg ES, Li R, Roerig P-LJ, Easley KA, et al. Ultrasound-guided central venous catheter placement decreases complications and decreases placement attempts compared with the landmark technique in patients in a pediatric intensive care unit. Crit Care Med. 2009;37(3):1090-6.

7. White L, Halpin A, Turner M, Wallace L. Ultrasound-guided radial artery cannulation in adult and paediatric populations: a systematic review and meta-analysis. Br J Anaesth. 2016;116(5):610-7.

8. Shiloh AL, Savel RH, Paulin LM, Eisen LA. Ultrasound-guided catheterization of the radial artery: a systematic review and meta-analysis of randomized controlled trials. Chest. 2011;139(3):524-9.

9. Gu W-J, Tie H-T, Liu J-C, Zeng X-T. Efficacy of ultrasound-guided radial artery catheterization: a systematic review and meta-analysis of randomized controlled trials. Crit Care. 2014;18(3):1-7.

10. Bhattacharjee S, Maitra S, Baidya DK. Comparison between ultrasound guided technique and digital palpation technique for radial artery cannulation in adult patients: an updated meta-analysis of randomized controlled trials. J Clin Anesth. 2018;47:54-9.

11. Gao Y-B, Yan J-H, Gao F-Q, Pan L, Wang X-Z, Lv C-J. Effects of ultrasound-guided radial artery catheterization: an updated meta-analysis. Am J Emerg Med. 2015;33(1):50-5.

12. Gu W-J, Wu X-D, Wang F, Ma Z-L, Gu X-P. Ultrasound guidance facilitates radial artery catheterization: a meta-analysis with trial sequential analysis of randomized controlled trials. Chest. 2016;149(1):166-79.

13. Wang J, Lai Z, Weng X, Lin Y, Wu G, Su J, et al. Modified long-axis in-plane ultrasound technique versus conventional palpation technique for radial arterial cannulation: A prospective randomized controlled trial. Medicine. 2020;99(2).

14. Yeap YL, Wolfe JW, Stewart J, Backfish KM. Prospective Comparison of Ultrasound-Guided Versus Palpation Techniques for Arterial Line Placement by Residents in a Teaching Institution. J Grad Med Educ. 2019;11(2):177-81.

15. Tariq S, Afzal MO. Comparison between ultrasound guided and palpatory method for radial artery Catheterization. Professional Med J. 2022;29(11):1637-43.

16. Ammar A, Ali L, Furqan A. A randomized comparison of ultrasound guided versus blindly placed radial arterial catheters. J Postgrad Med Inst. 2017;31(1):8-11.

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