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Original Research Article

Comparison of ultrasound guided long axis and short axis approach for radial artery cannulation in adult patients undergoing elective surgery under general anaesthesia

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ABSTRACT

Background: There can be two techniques for radial artery cannulation under ultrasound guidance, one being the short axis out-of-plane (SA-OOP) approach and the other being long axis in-plane (LA-IP) approach. We are conducting this study because there are incongruous opinions regarding the recommended approach for ultrasound guided radial artery cannulation.
Aim & Objective: To compare ultrasound guided long axis and short axis approach for radial artery cannulation in adult patients undergoing elective surgery under general anaesthesia. Primary objective of our study was to compare the first attempt success rate. Secondary objective was to compare successful cannulation time, number of attempts and complications.
Materials and Methods: 110 patients of ASA1 and ASA2 class of age 18-70 years, scheduled for elective surgery under general anaesthesia requiring radial artery cannulation were randomized into group I (long axis view) and group II (short axis view) using sealed envelope method. Statistical package for social Sciences (SPSS) version 21.0 was used for statistical analysis after entering data into Microsoft excel spreadsheet.
Results: The first attempt success rate was comparable between long axis and short axis, 81.82% vs 78.18% with a p value=0.634. Mean ± SD of time taken in seconds for successful cannulation in short axis group was 35.11 ± 19.79 which was significantly higher as compared to long axis group 25.51 ± 21.89 with p value=0.018.
Conclusion: Ultrasound guided long axis technique was analogous to ultrasound guided short axis technique with regard to overall and first attempt success rate, number of attempts and complications. However time taken for cannulation of the radial artery in long axis approach is lesser.

1. Introduction

In the current clinical era, Arterial Cannulation is a commonly performed procedure. It is mostly performed for continuous blood pressure monitoring and blood gas analysis in critical care setup, in emergency department and in operation theatre. A number of sites, including the radial, femoral, axillary, brachial, ulnar, dorsal pedis and posterior tibial artery can be used for arterial cannulation.[1] The radial artery being more superficial is preferred site for cannulation. The dual blood supply of hand provides added advantage offering lower rate of complications. Nowadays ultrasound guidance is frequently used for vascular access for example arterial cannulation, central venous catheterization. In 1976, Nagabhushan et al.[2] was the one of the first few pioneers to compare landmark technique with radial artery catheterization under ultrasound guidance. His study indicated better radial artery

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cannulation and a decreased requirement for arterial cut-down in patients with hypotension or barely palpable pulses. In last two decades multiple studies have been conducted, demonstrating superiority of ultrasound guided radial artery cannulation over palpatory method, especially in difficult cases.[2–7] Ultrasound guided radial artery cannulation can be done by two techniques, either the short axis out-of-plane (SA-OOP) technique or the long axis in-plane (LA-IP) technique. Each approach is accompanied by its own advantages and disadvantages. We are conducting this study because there are incongruous opinions regarding the recommended approach for ultrasound guided radial artery cannulation and comparing ultrasound guided long axis and short axis approach for radial artery cannulation is very limited.[1,8,9] This randomised study was designed to compare ultrasound guided long axis and short axis technique for radial artery cannulation in adult patients undergoing elective surgery under general anaesthesia.

2. Materials and Methods

This randomised comparative study was conducted in the Department of Anaesthesia, after approval from institutional review board and institutional ethical committee; F. No. TP (MD/MS) (38/2020)/IEC/ABVIMS/RMLH/325 from 1st January 2021 – 31st May 2022. Derya Berk et al.[1] in 2013 observed that the arterial cannulation by LA approach enhanced the rate of catheter-insertion success at the first attempt (76%) as compared to SA approach (51%). Taking these values as reference the minimum required sample size with 80% power of study and 5% level of significance is 55 patients in each study group. So total sample size taken is 110 (55 patients per group). Formula used:-

$$N \geq = \frac{(p_c\ x\ (1-p_c) + p_e\ x\ (1-p_e))\ x\ (Z_\alpha + Z_\beta)^2}{(p_c - p_e)^2}$$

p = catheter-insertion success rate at the first attempt in LA approach pe=catheter-insertion success rate at the first attempt in SA approach. Where Z_α is value of Z at two sided alpha error of 5% and Z_β is value of Z at power of 80%.

Calculations:

$$n \geq = \frac{(0.76 \times (1-.76) + 0.51 \times (1-.51)) \times (1.96+.84)^2}{(0.76-.051)^2} = 54.23 = 55(approx.)$$

Adults of age 18-70 years of age with ASA Grade I and II, posted for elective surgery under general anaesthesia requiring radial artery cannulation were included in the study. Patients with negative Allen's test, atherosclerotic vascular diseases, morbid obesity (BMI >35), raynaud's disease, peripheral vascular disease and coagulopathy were excluded from the study. Randomization was done with sealed opaque envelopes, in a series of blocks of 10 and divided into two groups, group I and group II. Ten randomly generated treatment allocations were prepared within sealed opaque envelopes assigning I and II group 5 envelopes each, where group I represents long axis group and group II represents short axis group. When a patient entered a trial, an envelope was opened, revealing the group allocated. Patients were randomized using this method in a series of blocks of ten. After explaining the procedure, written informed consent from the patient or their relatives was obtained. The standard monitors were attached. All patients underwent induction of general anesthesia (GA) as per protocol. Post induction and intubation radial artery was cannulated. The left hand was designated for the puncture. The hand was fixed in dorsiflexion using a 10 cm roll under the wrist for extension. Sterile preparation was performed over the skin insertion site. The ultrasonic probe of 6-13 MHz frequency (Sonosite M Turbo) with sterile cover was used to recognize radial artery. The real time ultrasound guidance was used to cannulate the radial artery using Seldinger's technique with vygon arterial leadercath (20G size; 80mm length; 0.9mm outer diameter; 24 ml/ min flow rate).

2.1. *Long axis in plane approach*

In this technique the ultrasound probe was kept parallel to the radial artery (Figure 2 A). The artery was visualised as a tubular anechoic structure on ultrasound screen (Figure 2 B). After locating the artery in the long axis view, the arterial cannula needle (18G) was inserted steeply downward (30 to 45 degrees) at the midpoint of the short axis of the ultrasonic probe. The needle was seen entering the screen from either the left or right, depending on the probe's orientation. The backflow of blood into the needle confirmed entry into the artery. The guidewire was inserted through the needle. The needle was then removed and catheter was threaded over guide wire. Guide wire was then removed. The arterial transducer with the extension, which has been flushed with heparinized saline was kept ready and was connected immediately post the arterial cannulation and the waveform was then observed.

2.2. *Short axis out of plane approach*

In this approach the ultrasound probe was placed transverse to the radial artery at the wrist (Figure 1 A). The radial artery was visualized as a circular anechoic structure on the screen (Figure 1 B). After locating the radial artery in short axis view, arterial cannula (18G) was placed on the midpoint of long axis of ultrasound probe and inserted steeply downward at an angle of 30 to 45 degree. The needle was seen entering the screen from the center. The backflow of blood into the needle confirmed entry into the artery. The guidewire was inserted through the needle. The needle was then removed and catheter was threaded over guide wire. Guide wire was then removed. The arterial transducer with the extension was flushed with heparin saline and kept ready. Once the artery was cannulated, we connected it immediately to the extension tubing and the wave form was observed.

3. Results

The study was conducted in the Department of Anaesthesia. 110 patients aged 18-70 years, of either sex with ASA grade I and II who were undergoing elective surgery under general anaesthesia requiring radial artery cannulation were included in the study. Patients were randomly divided into two groups by sealed envelope technique: -Long axis group (n=55) and Short axis group (n=55). The two groups were comparable on demographic profile including gender, age and body mass index as depicted in (Tables 1, 2 and 3). The first attempt success rate was comparable between long axis and short axis, 81.82% vs 78.18% with a p value=0.634, which is statistically not significant (Table 4). Success rate was 100% in both groups (Table 5). Mean ± SD of time taken in seconds for successful cannulation in short axis group was 35.11 ± 19.79 which was significantly higher as compared to long axis group 25.51 ± 21.89 with p value=0.018 (Table 6). Distribution of vasospasm was comparable between long axis and short axis was 14.55% vs 12.73% respectively and p value is 0.781, which is not significant, as depicted in (Table 7). Distribution of hematoma was comparable between long axis and short axis, 3.64% vs 10.91% respectively. p value is 0.271, which is not significant statistically (Table 8). Distribution of posterior wall puncture was comparable between long axis and short axis 7.27% vs 5.45% respectively with p value of 1.

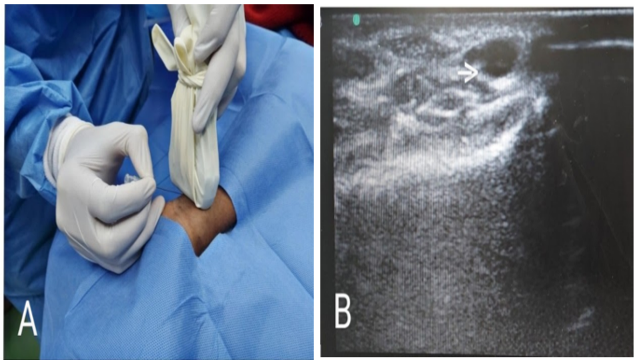

Figure 1: (A): Short axis view showing probe and needle position; **(B):** Ultrasound-guided view showing artery in cross section

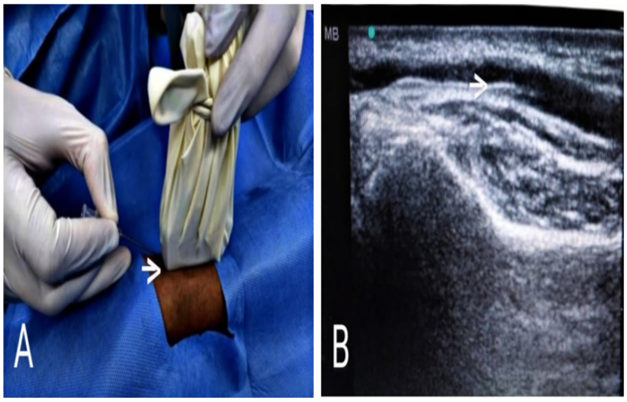

Figure 2: (A): Long axis view showing probe and needle position; **(B):** Ultrasound guided view showing artery

4. Discussion

In clinical setting, radial artery cannulation under ultrasound guidance has demonstrated enhanced needle placement accuracy with decreased complication.[8–10] In our study, 110 patients were enrolled and randomly divided into group 1 (Long axis, n=55) and group 2 (Short axis, n=55) using Block Randomization with Sealed envelope technique. We compared the use of ultrasound guided long axis and short axis for radial artery cannulation in patients undergoing elective surgery under general anaesthesia. Primary objective of this study was to compare first attempt success rates (both overall as well as first attempt). Secondary Objective was to compare number of attempts, successful cannulation time and complications. The difference between the two groups of this study in terms of baseline vital signs (blood pressure and pulse) and the demographic profile (age, body mass index and sex) was not statistically significant. Our primary objective, the first attempt success rate in group 1(LA) was 81.2% and in group 2(SA) was 78.18%. This difference was not statistically significant. A prospective study Sethi et al.[11] conducted in150 adult patients in 2016 first attempt success rate was similar between the two groups (p > 0.05). Ultrasound-guided radial artery cannulation is divided into three steps: arterial image localization, artery puncture, and cannula insertion into the artery. These steps are impacted by various factors. Puncturing accurately becomes challenging if the radial artery has a small diameter. It might take several attempts, if the artery is deeper. In atherosclerosed artery, cannulation of the artery is difficult. Catheter advancement fails when the needle is only inserted partially inside the vessel or on the vessel wall.

In ultrasound guided short axis approach it allows better visualization of surrounding structures and their relation to the vessel simultaneously. In ultrasound guided long axis approach it permits better visualisation of the needle shaft and needle tip throughout the advancement of the needle. The number of attempts were also comparable between group long axis and short axis (1:81.82% vs 78.18%, 2:18.18% vs 21.82%, p=0.634). The overall success rate between group 1 (LA) and 2 (SA) was 100% and 100% respectively. Liu C et al.[12] conducted an RCT comprising 1210 patients in 2017, and found no statistically significant difference in first attempt success rate and the number of attempts in between two approaches. The meta-analysis

Table 1: Comparison of age (Years) between long axis and short axis

Age(years)	Long axis group(n=55)	Short axis group(n=55)	Total	P value
18-30	14 (25.45%)	17 (30.91%)	31 (28.18%)	
31-40	14 (25.45%)	19 (34.55%)	33 (30%)	
41-50	20 (36.36%)	10 (18.18%)	30 (27.27%)	0.316*
51-60	5 (9.09%)	7 (12.73%)	12 (10.91%)	
61-70	2 (3.64%)	2 (3.64%)	4 (3.64%)	
Mean ± SD	39.2 ± 10.82	36.76 ± 11.53	37.98 ± 11.2	
Median(25th- 75th percentile)	38(30.5-45)	34(29-43.5)	36(30-45)	0.256‡
Range	18-65	18-61	18-65	

‡Independent t test, * Fisher's exact test

Table 2: Comparison of gender between long axis and short axis

Gender	Long axis group(n=55)	Short axis group(n=55)	Total	P value
Female	29 (52.73%)	35 (63.64%)	64 (58.18%)	
Male	26 (47.27%)	20 (36.36%)	46 (41.82%)	0.246†
Total	55 (100%)	55 (100%)	110 (100%)	

†Chi square Test

Table 3: Comparison of Anthropometric parametric parameters

Anthropometric Parameters	Long axis group(n=55)	Short axis group(n=55)	Total	P value
Body mass index(kg/m^2)				
<18.5 kg/m^2	0 (0%)	1 (1.82%)	1 (0.91%)	
18.5 to 24.99 kg/m^2	21 (38.18%)	23 (41.82%)	44 (40%)	0.605*
25 to 29.99 kg/m^2	30 (54.55%)	25 (45.45%)	55 (50%)	
>=30 kg/m^2	4 (7.27%)	6 (10.91%)	10 (9.09%)	
Mean ± SD	25.86 ± 3.28	25.79 ± 3.01	25.82 ± 3.13	
Median(25th-75th centile)	25.96(23.73- 28.575)	26.03(23.54- 28.215)	25.96(23.655-28.39)	0.905‡
Range	18.51-32.04	18.01-31.21	18.01-32.04	
Height(cm)				
Mean ± SD	155.4 ± 5.55	155.02 ± 5.37	155.21 ± 5.44	
Median (25th-75th centile)	155(152-159)	155(151-158)	155(151-158)	0.715‡
Range	145-171	146-171	145-171	
Weight(kg)				
Mean ± SD	62.31 ± 8.9	61.98 ± 7.61	62.15 ± 8.25	
Median (25th-75th centile)	60(58-70)	60(58-65.5)	60(58-68)	0.836‡
Range	40-80	40-75	40-80	

‡Independent t test, * Fisher's exact test

Table 4: Comparison of first attempt success rate between long axis and short axis

Number of Attempts	Long axis group(n=55)	Short axis group(n=55)	Total	P value
1	45 (81.82%)	43 (78.18%)	88 (80%)	
2	10 (18.18%)	12 (21.82%)	22 (20%)	0.634†
Total	55 (100%)	55 (100%)	110 (100%)	

Table 5: Comparison of success/failure between long axis and short axis

Success/failure	Long axis group(n=55)	Short axis group(n=55)	Total	P value
Success	55 (100%)	55 (100%)	110 (100%)	NA
Total	55 (100%)	55 (100%)	110 (100%)	

Table 6: Comparison of time taken for successful cannulation (seconds) between long axis and short axis

Time taken for successful cannulation (seconds)	Long axis group(n=55)	Short axis group(n=55)	Total	P value
Mean ± SD	25.51 ± 21.89	35.11 ± 19.79	30.31 ± 21.32	
Median (25th- 75th percentile)	18(15-21)	26(24-30)	22.5 (18-28)	0.018‡
Range	9-144	18-83	9-144	

Table 7: Comparison of vasospasm between long axis and short axis

Vasospasm	Long axis group(n=55)	Short axis group(n=55)	Total	P value
No	47 (85.45%)	48 (87.27%)	95 (86.36%)	
Yes	8 (14.55%)	7 (12.73%)	15 (13.64%)	0.781†
Total	55 (100%)	55 (100%)	110 (100%)	

Table 8: Comparison of haematoma between long axis and short axis

Haematoma	Long axis group(n=55)	Short axis group(n=55)	Total	P value
No	53 (96.36%)	49 (89.09%)	102 (92.73%)	
Yes	2 (3.64%)	6 (10.91%)	8 (7.27%)	0.271*
Total	55 (100%)	55 (100%)	110 (100%)	

done by Wang H H et al.[9] in 2022 comprising of 6 studies, indicated that the difference between the two groups, in terms of first attempt success rate (p =0.90) and number of attempts, was not statistically significant. Rajsekar M et al.[13] conducted a randomized prospective study in 2022 and found no statistically significant difference in first attempt success rate in two approaches (76.7% in the long-axis method, 86.7% in the short-axis method) . The findings of all these studies support our results. These authors observed that first attempt success rate was similar in both the techniques of ultrasound guided radial artery cannulation.

A prospective randomized trial conducted by Berk et al. 1 in 2013, in 108 patients scheduled for elective surgery under general anaesthesia and a prospective randomised study conducted by Arora et al.[14] comprising 84 adult patients undergoing cardiac surgeries in 2021 showed first attempt success rate was better in long axis as compared to short axis (p<0.05) and number of attempts lesser in long axis. In Berk et al.[1] ASA III patients were included and in Arora et al. 14 cardiac patients were included. They could have difficult cannulation, thus long axis approach showing better visualization of the needle tip and the lumen of artery helped them with cannulation.

A prospective RCT done by Cao et al.[15] in 2021 showed the rate of success of first-attempt in the short axis group was significantly higher than those in both the long axis (69.7% vs 24.2%; P <0.05). They included operators were novice with no previous ultrasound usage experience. In long axis, it requires a higher level of hand-eye coordination by the operator to cannulate the artery thus explaining the result.

In our study the mean access time (seconds) in group 1 (LA) was 25.51 ± 21.89 and group 2 (SA) was 35.11 ± 19.79 which was significantly higher in short axis group (p=0.018). In long axis approach whole length of the artery is seen which helped us in taking lesser time than short axis approach. The results were Similar to a prospective randomized trial conducted by Berk D et al.[1] in which 108 patients scheduled for elective surgery under general anaesthesia, in 2013 showed shorter cannulation time (26.7 ± 17 s vs 46.8 ± 34 s) in long axis group compared to short axis group (p=0.05).

The meta analysis done by Gao YB et al.[16] in 2016 comprising 5 RCT showed no statistically significant difference between successful cannulation time in both groups. Liu C et al.[12] conducted a RCT comprising 1210 patients in 2017 concluding that the difference between two approaches was not statistically significant.

The metanalysis done by Wang H H et al.[9] in 2022,comprising 6 studies, indicated that the difference between the two groups in time taken for successful cannulation was not statistically significant.

Quite a lot of authors have found statistically insignificant difference between cannulation times of both the approaches. This can be explained by the fact they had different expertise of using ultrasound, different subset of patients, different types of ultrasound probe. That is why the result have been variable.

Preventing complications is as important as successful cannulation. So, we also compared the complications between two approaches. The complications were comparable between group 1 (LA) and group 2 (SA): hematoma (3.64% vs 10.91%), vasospasm (14.55% vs 12.75%), and posterior wall puncture (7.27% vs 5.45%) (P>0.05). Haematoma formation was less in long axis as compared to short axis, though it was statistically insignificant. This is because the advancement of needle and the catheter can be seen in long axis approach, but not in short axis approach.

The meta analysis done by Gao YB et al.[16] in 2016 comprising 5 RCT showed no statistically significant difference in complication during cannulation in both groups, which was similar to our study (P<0.05).

The metanalysis done by Wang H H et al.[9] in 2022 comprising 6 studies indicated that the difference between the groups was not statistically significant in terms of number of complications (p =0.24).

A prospective randomized trial conducted by Berk et al.[1] in 108 patients scheduled for elective surgery under general anaesthesia in 2013 showed significantly lesser number of haematoma formation in long axis as compared to short axis (20% vs 56%). This can be explained due to visibility of needle tip and shaft into the artery in long axis.

5. Limitation

This study was conducted only in ASA I and II patients with BMI<35kg/m2, undergoing elective surgery under general anaesthesia. So these results cannot be extrapolated for patients undergoing radial artery cannulation in ICU settings, general wards and emergency settings.

6. Conclusion

Ultrasound guided long axis technique was comparable to ultrasound guided short axis technique with regard to overall and first attempt success rate, number of attempts and complications. However, access time was more in short axis approach compared to long axis approach in radial artery cannulation under ultrasound guidance in elective surgery patients undergoing general anaesthesia.

7. Source of Funding

None.

8. Conflict of Interest

None.

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