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ORIGINAL ARTICLE

To compare the frequency of first attempt successful ultrasound guided radial artery cannulation by modified short axis out-of-plane technique versus conventional long axis in-plane technique.

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ABSTRACT… Objective: To compare the frequency of first attempt successful ultrasound guided radial artery cannulation by modified short axis out-of-plane technique versus conventional long axis in-plane technique. **Study Design:** Quasi Experimental Study **Setting:** Jinnah Hospital, Lahore. **Study Period:** 1st January 2019 to 30th June 2019. **Material & Methods:** 180 patients fulfilling the selection criteria were divided in two groups using lottery method. Group modified SA-OOP (short axis out-of-plane) and group LA-IP (long axis in-plane). Modified Allen test was performed in all patients, if positive, procedure was carried out. In modified short axis out of plane approach, a suture was tied on the midpoint of ultrasound probe and perpendicular to the long axis as a guide and then radial artery was viewed by placing US probe on the wrist of patient transversely. The needle was inserted at 30^{O}-45^{O} angle into the skin. In long Axis In- Plane approach, radial artery was first viewed by placing US probe transversely on the wrist of patient and then probe was rotated to 90^{O} in clockwise direction to see the artery in longitudinal plane. Then cannula was inserted at 30^{O}-45^{O} angle into the skin. Success of first attempt was recorded. **Results:** The age range was 18-70 years. Mean age of the patients was 46.69 ± 17.35 and 43.68 ± 17.99 years in group LA-IP and SA-OOP, respectively (4). In group LA-IP, 57 patients (63.3%) were male and in group SA-OOP 45 patients (50%) were male while 33 patients (36.7%) of group LA-IP and 45 patients (50%) of group SA-OOP were female. Frequency of first attempt was 64.4% (58 patients) in group LA-IP and in group SA-OOP frequency of first attempt was 53.3% (48 patients). Statistically significant difference was not seen between two groups as p-value is 0.172. **Conclusion:** There is no difference in frequency of first attempt success in modified short axis out-of-plane ultrasound versus conventional long axis in-plane ultrasound to guide radial artery cannulation.

Key words: Arterial Cannulation, Modified SA-OOP, Ultrasound Guided Radial Artery Cannulation.

INTRODUCTION

Arterial cannulation is the gold standard procedure for blood pressure monitoring in critically ill patients.[1] It is an ideal alternative for non-invasive blood pressure monitoring specially in conditions such as burns and morbid obesity.[2] Arterial cannulation is indicated not only in procedures in which blood pressure changes rapidly moment to moment, but also when frequent arterial blood sampling is required. Major surgeries such as cardiac, thoracic, vascular and certain general surgeries such as pheochromocytoma requires invasive blood pressure monitoring with arterial cannulation.[3] The radial artery at the wrist is the most common site for an arterial catheter; alternatives included are femoral, axillary, brachial and dorsalis pedis arteries. Radial artery is safer than others because of alternate blood supply of hand from ulnar artery and its easy access due to its superficiality. Ultrasound-guided vascular access is becoming gold standard not only for venous access but also for arterial access particularly in patients with obesity, failed cannulation with conventional methods, low cardiac output, inconsistent anatomies etc.[1,4] Ultrasound made it possible to have fewer traumatic complications at puncture, irrespective of an adult or child is involved and irrespective of the site of insertion.[4]

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One recent study by Sarinya et al found that there was no significant difference in 1st attempt success rate in radial artery cannulation by Ultrasound guided approach vs conventional palpation technique ($P > 0.999$ and $P = 0.732$) in old patients undergoing cardiothoracic surgery. But they included only the patient above age 65 years. And the diameter of the artery was a little smaller in ultrasound guided group as compare to the palpation technique group. Which can be the reason for no difference in both technique, and it shows superiority of ultrasound technique in smaller diameter artery cannulation, but it needs further studies focusing on the diameter and distance of the artery from the skin.[5]

The approaches used for cannulation with ultrasound guidance can be described as Long axis in-plane (LA-IP) and Short axis out-of-plane (SA-OOP) technique. Sameer et al found that the first attempt success in SA-OOP group was 80% compared to 82.6% (p =0.67) in LA-IP group.[6] Derya at al found that the rate of cannula-insertion success in radial artery at the first attempt by SA-OOP approach is 51% as compared to 76% (p = 0.0131) in LA-IP approach.[8] Recently a new technique has been developed for radial artery cannulation by ZheFeng et al called Modified Short axis out of plane technique (Modified SA-OOP).[10] It showed statistically better result in the success rate of cannula insertion into the radial artery on first attempt by modified SA-OOP technique i.e. 88.9% when compared with the conventional LA-IP technique i.e. 73.2% (P = 0.0158).[10]

Rationale of this study is to find the best approach for ultrasound guided cannulation of radial artery that will have high success rate for first pass. Only one research has been done on modified SA-OOP technique, which shows very limited data to calculate its superiority over the LA-IP technique. In addition, no local study has ever been conducted to establish guidelines for our set-up.

MATERIAL & METHODS

Quasi Experimental study done at Operation Theater and ICU Jinnah hospital for six months from January 2019 to June 2019, sample of 180 cases has been selected by nonprobability purposive sampling after taking informed consent. All sample cases met the inclusion and exclusion criteria.

Inclusion Criteria

1. Patients with status ASA I to IV (American Society for Anesthesiologists)
2. Age 18-70 years.
3. Patients in operation theaters or admitted in ICU, requiring invasive blood pressure monitoring or frequent arterial blood gas sampling such as in respiratory failure.

Exclusion Criteria

1. Refusal of patient to give informed consent
2. Pre-existing coagulation disorder. (PT/APTT) deranged > 4sec)
3. Local infection (skin redness, warmth)
4. Diagnosed case of peripheral vascular disease on history or medical record.

Data Collection Procedure

After taking approval from ethical committee (Reg: 55th/ERB, Dated: 15th Jan, 2020) and taking informed consent, 180 patients fulfilling the selection criteria were recruited for the study from operation theatres and ICU of Jinnah Hospital, Lahore. Demographic information like age, sex, height, weight was obtained. Then patients were divided in two groups by using lottery method. Group modified SA-OOP (short axis out-of-plane) and group LA-IP (long axis in-plane). Modified Allen test (Annexure IV) was performed in all the patients, if positive then the procedure was carried out. All the patients in both groups were positioned supine and ECG (continuous), SpO2 (continuous) and NIBP (every 3 minutes) was monitored. After aseptic measures and local infiltration (with 2% xylocaine 0.5 - 1 cc by insulin syringe), aseptic ultrasound probe was placed on the wrist and cannulation was attempted with 22-gauge IV line by either of the two approaches (as explained in operational definitions). If needle didn't pass first time, then needle was withdrawn and was passed again and it was noted. After confirming the entry into the artery, cannula was pushed 2-3mm more and stylet needle was removed and cannula was pushed completely in

the artery. Cannula was secured with adhesive tape and manometer line was connected and IBP was taken. Vitals, especially SpO2 were monitored after the cannulation. All the data was entered in the Proforma. Presence of first attempt success of cannulation was recorded (as per operational definition).

Data Analysis

The data was entered and analyzed in SPSS version 17.0. Quantitative variables like age and BMI were measured in the form of mean ± SD. Qualitative variables like first attempt success rate, gender and ASA status were measured in the form of frequency and percentages. Chi-square test was used to compare variables in the groups. Data was stratified for age, gender, first pass effect and BMI. Post stratification Chi-square test was applied taking p value < 0.05 as significant.

RESULTS

Patients ranged between 18-70 years of age. Mean age of the patients was 46.69 ± 17.35 and 43.68 ± 17.99 years in group LA-IP and SA-OOP, respectively. Table-I

Gender	LA-IP	Modified SA-OOP
	No. of Patients (%)	No. of Patients (%)
18-30 Years	25 (27.8%)	27 (30%)
Above 30 Years	65 (72.2%)	63 (70%)
Total	90 (100%)	90 (100%)
Mean ± SD	46.69 ± 17.35	43.68 ± 17.99

Table-I. Age distribution of cases

The t-test was applied and resulted in p-value = 0.14. This result is not significant at p < .05.

In group LA-IP 57 patients (63.3%) were male and in group SA-OOP 45 patients (50%) were male while 33 patients (36.7%) of group LA-IP and 45 patients (50%) of group SA-OOP were female (Table-II).

Gender	LA-IP	ModofieD SA-OOP
	No. of Patients (%)	No. of Patients (%)
Male	57 (63.3%)	45 (50%)
Female	33 (36.7%)	45 (50%)
Total	90 (100%)	90 (100%)

Table-II. Gender distribution of cases

The chi-square test was applied. The p-value is 1.0. This result is not significant at p < .05

Frequency of first attempt was 64.4% (58 patients) in group LA-IP and in group SA-OOP frequency of first attempt was 53.3% (48 patients). Statistically significant difference was not seen between two groups as p-value is 0.172 (Table-IV).

ASA Status	No. of Patients (%)	LA-IP	Modified SA-OOP
			No. of Patients (%)
ASA I	1 (1.1%)		0 (0.0%)
ASA II	10 (11.1%)		7 (7.8%)
ASA III	15 (16.7%)		21 (23.3%)
ASA IV	64 (71.7%)		62 (68.9%)
TOTAL	90 (100%)		90 (100%)

Table-III. ASA status distribution of cases

The chi-square test was applied and the p-value = 0.039. This result is significant at p< .05

First Attempt	LA-IP	Modified SA-OOP	
	(%)	(%)	P-Value
Yes	58 (64.4%)	48 (53.3%)	0.172
No	32 (35.6%)	42 (46.7%)	
Total	90 (100%)	90 (100%)	

Table-IV

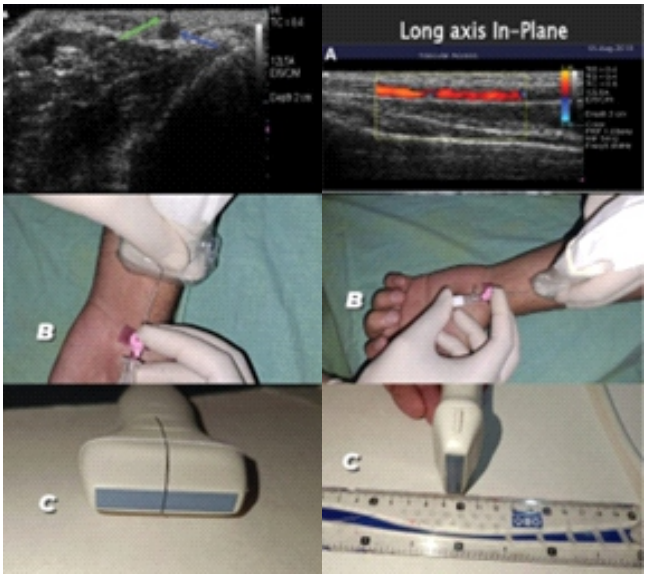
This result is not significant at p < .05

Mean BMI in group LA-IP was 25.86 ± 4.81 kg/m2 and in group SA-OOP mean BMI was 24.74 ± 4.34 kg/m2. It is shown in Table-V. Age, gender, ASA status, BMI are stratified in Table 6,7,8 & 9 respectively. Comparison of frequency of first attempt between groups with respect to Age, Gender, BMI and ASA status are shown in Table 6, 7,8, and 9 respectively.

First Attempt	LA-IP	Modified SA-OOP	
	No. of Patients (%)	No. of Patients (%)	P-Value
Yes	79 (87.8%)	65 (72.2%)	0.009
No	11 (12.2%)	25 (28.8%)	
Total	90 (100%)	90 (100%)	

Table-V. Frequency of success after second attempt

This result is significant at p < .05. Pearson chi-square test was applied.



DISCUSSION

Our current study revealed that there is no significant difference of first attempt success in between the Long axis in plane and Modified short axis out of plane approach for ultrasound guided radial artery cannulation i.e. 64.4% and 53.3% respectively (p-value=0.172) Table-iv. This result is different from the conclusion of Quan Zhefeng et al study.[10] When first and second radial artery cannulation attempts are combined then Long axis in plane approach came out to be more successful than the modified short axis out of plane i.e. 87.8% vs 72.2% respectively with p value 0.009 (<.05) as mentioned in Table-V. Mainly, there are two approaches when it comes to US-guided arterial cannulation; Long axis in plane (LA-IP), Short Axis Out of Plane (SA-OOP). Many studies have been done to compare both approaches for vascular cannulation. Quan zhefeng et al described a third approach i.e. Modified SA-OOP[10], which we have used in our study with comparison to Long axis approach. They compared the success rate of first attempt of Modified short axis out of plane with Long axis in plane approach for radial artery cannulation. They found modified SA-OOP approach to be better than the LA-IP technique for the first attempt success. They also found that there is no significant difference in success rates between the two groups when first and second attempts are combined.[10]

The result variation can be due to many factors such as user skills of ultrasonography, expertise, patient factors and ultrasound machine itself. One possible reason for result variation is ASA status of the patient. The patients in Quan Zheng's study were mostly ASA I-III, and in our study, we had mostly ASA IV class patients. In male patients, first attempt was successful in 42 (46.67%) and 30 patients (33.33%) in LA-IP and Modified SA-OOP groups respectively, and in 17 (18.89%) and 27 (30%) patients first attempt failed in LA-IP and Modified SA-OP groups respectively; P-value 0.03 (<0.05). In ASA class IV patients, first attempt was successful in 40 (44.44%) and 26 (28.89%) patients in LA-IP and Modified SA-OOP groups respectively, and in 24 (26.67%) and 36 (40%) patients first attempt failed in LA-IP and Modified SA-OP groups respectively; P-value 0.02 (<0.05). We found a significant difference in male patients and in ASA IV class patients in first attempt success rate. There was no significant difference noted in ASA II and III class; (P-value 0.55). It may be due to the non-probability sampling. In parent study we could not find any stratification so we cannot be sure whether such difference really exists or not.

Further studies focusing on solely ASA IV class patients may reveal if there exist any difference in it or not. A newer approach i.e. Oblique approach for ultrasound guided radial artery cannulation was used in comparison to Short axis and Long axis approach by Usama Elsayed, Abdalla, Alaa , AlRefaey.[7] They found that overall success rate of radial artery cannulation was higher in Oblique approach up to 90% as compare to Short axis 60% and Long axis 70% respectively. But their 1st attempt success rate of Oblique approach was 63%, Short axis approach; 50% and long axis approach 27%, which is actually quiet low. They faced some limitations for long axis approach, which might be the cause of low 1st attempt success rate. In our study, 1st attempt success rate of Long axis in plane approach was 64.4%, and overall success rate was 87.8%. So, if we compare Oblique approach from Usama Elsayed's study with Long axis in plane approach of our study, we can see, that both have almost same results, i.e. first attempt success and overall

success for Oblique vs Long axis approach is 63% vs 64.4% and 90% vs 87.8% respectively.

Study by Derya et al also compared both approaches, SA-OOP and LA-IP for ultrasound guided radial artery cannulation, he found that LA-IP approach has better first pass success rate as compare to SA-OOP i.e. 76% and 51% respectively. (p-value = 0.0131).[8] Our study also showed that first attempt success rate in LA-IP approach is 64.4% and in Modified SA-OOP 53.3%. So, we can say that there is no significant difference in first attempt success rate of SA-OOP as compare to Modified SA-OOP approach i.e. 51% and 53.3% respectively. It still needs further research by adding other factors like, ASA status, diameter of the artery and distance of artery from skin.

There has been a long debate, trials and meta-analysis for comparison between the long axis in plane vs short axis out of plane approaches for vascular cannulation. Chao et al in his meta analysis showed that there was no significant difference in total success rate between the SA-OOP and LA-IP approaches for US-guided vascular catheterization. (RR, 1.01; 95% CI, 0.99–1.04; P=0.35; I2=48%.[8] Further in subgroup analyses it was found that the total success rate was no different between the SA-OOP and LA-IP approaches for the ultrasound guided radial artery cannulation. (RR, 1.00; 95% CI, 0.96–1.05; P=0.88; I2=49%).[9]

The most recent meta-analysis and systemic review by Lei Cao et al compared the ultrasound guided radial artery cannulation by two approaches, SA-OOP and LA-IP. They analyzed the 1st attempt success rate and total success rate as primary outcome, cannulation time and complications as secondary outcome. A total of 13 RCTs and 1377 patients were included. They also found that there was no significant difference in 1st attempt success rate in both approaches. (RR 0.93; 95% CI, 0.78-1.12; P = 0.45; I^2 = 84%) and overall success rate (RR, 0.99; 95% CI, 0.95-1.02; P = 0.48; I^2 = 57%). But they found that there was an increased incidence of posterior wall puncture (RR, 3.01; 95% CI, 1.27-7.14; P = 0.01; I^2 = 79%) and hematoma (RR, 2.15; 95% CI, 1.05-4.37; P = 0.04; I^2 = 63%) with SA-OOP approach.[11]

There were few limitations in our study which require further studies and RCTs: We did not account for the diameter of radial artery in different patients which may be related to success of first pass effect. We also did not note the distance of artery from the skin which can also make difference for passing arterial line in first attempt. The success rate of First attempt of US-guided radial artery cannulation might depend upon the patient's ASA class, his clinical condition, edema, hypotension and requirement of vasopressors. At the end, we would say that it may vary and depend upon user, different situations that certain approach may be superior than other, or there might be no significant difference for passing arterial line successfully in first attempt. This needs further research and study, keeping in accounts the above mentioned limitations.

CONCLUSION

There is no difference in frequency of first attempt success in modified short axis out-of-plane ultrasound versus conventional long axis in-plane ultrasound to guide radial artery cannulation.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

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1	Bilal Mahmood Bhandari	Conception & design acquisiton of data, Analysis and interpretation of data.	
2	Hajra Shuja	Literature review, References, Drafting readingand revising it critically.	
3	Syed Mehmood Ali	Drafting the article revising it critically for important intellectual content.	
4	Sadaf Bokhari	Drafting, Proof reading and revising it critically.	
5	Liaqat Ali	Conception, drafting revising critically for important intellectual content.	