

## ORIGINAL ARTICLE

# A randomized comparison of ultrasound guided versus direct palpation method of radial artery cannulation techniques in adult patients undergoing open heart surgery

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## ABSTRACT

**Background & Objective:** The use of two dimensional ultrasound technique allows radial artery cannulation to take place under real time visualization and may increase the success rate of first time pass of the needle and reduce the complications of the invasive procedure compared to traditional palpation and trial method.

We aimed to compare the success rate of radial arterial catheter insertion at first attempt and average time for successful first attempt by traditional palpation method with ultrasound guided technique in adult patients undergoing open heart surgery.

**Methodology:** A randomized study was conducted at our hospital during a 12 months period from 1st January 2014 to 31st December 2014. After taking permission from hospital ethical committee, one hundred adult patients were enrolled in whom radial artery cannulation was required prior to open heart surgical procedures including CABG, valvular heart disease, atrial septal and ventricular septal defect repairs and total correction. Patients were divided in two equal groups. In Group I radial artery cannulation was performed by ultrasound guidance and in Group II it was done by palpation method; in both groups Seldinger technique was used.

Demographic and medical data were recorded in both groups. Heart rate, and invasive blood pressure monitoring was done in the arm in which the catheter was going to be inserted. Allen test with the help of pulse oximeter was also performed in all patients for detecting adequacy of ulnar artery flow. Time to first successful cannulation and the number of attempts were noted.

Computer software SPSS 19.0 was used for data statistical analysis, the Chi-square/Fisher's exact test used for the comparison of qualitative/categorical variable in between groups. Student's t-test used for comparison of quantitative / continuous variables in between groups.

**Results:** Average time to first successful attempt was  $72.4 \pm 23.0$  sec vs.  $94.6 \pm 13.7$  sec in Group I and II respectively ( $p=0.001$ ). Average number of attempts at same radial artery was significantly less in ultrasound group ( $1.4 \pm 1.0$ ) as compared to palpation group ( $2.0 \pm 0.7$ ) ( $p=0.001$ ). Ultrasound group (Group 1) had successful insertion at the first attempt in 36 (72%) patients, as compared to 32 (64%) patients in (Group II), but the difference was statistically not significant ( $p = 0.391$ ).

**Conclusion:** Average time for successful first attempt was significantly less for radial artery cannulation performed by two dimensional ultrasound guidance as compared to palpation method; however, it did not significantly increase the success rate of first time cannulation of radial artery.

**Key words:** Radial Artery; Radial artery cannulation; Two dimensional ultrasound technique; Real time visualization; open heart surgery.

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## INTRODUCTION

Arterial line placement is a routine procedure in patients undergoing open heart surgery, as it permits rapid recognition of blood pressure changes that is vital for patients on vasoactive drugs and it also allows for frequent arterial blood gas sampling.

In both adults and children, the most common site of cannulation is the radial artery because of its superficial location and easy maintenance of the site. An additional advantage is the presence of ulnar collateral blood flow and a low rate of complications.

The arterial catheter may not be passed successfully into the artery despite apparent good blood return on initial puncture, or the artery may develop spasm after a failed attempt, thus making any further attempts more difficult. Ultrasound guidance is being used with increasing frequency in vascular access. The hypothesis of our study was that radial artery cannulation can be more easily and rapidly performed with guidewire technique by ultrasound guidance as compared to the traditional palpation technique in open heart surgery procedures.

## METHODOLOGY

This prospective randomized study was conducted at our hospital during a 12 months period from 1st January 2014 to 31st December 2014 after approval by the hospital ethics committee. Informed consent was taken from all patients. The patients included in the study were between 18 – 70 years of age, of either sex, who were electively scheduled for open heart surgery. Exclusion criteria were: patients with previous attempt at radial arterial cannulation during the same hospital visit, unstable patients like emergency / urgent cardiac surgery and patients with inadequate ulnar collateral flow. The demographic data of all patients were recorded. The patients were randomly divided into two groups with 50 patients each. In Group I radial artery cannulation was performed by ultrasound guidance, while it was done by palpation method in Group II.

We cannulated the radial artery if color returned to the hand within 5 sec as documented by Robert J el al.<sup>1</sup> A modified Allen test has been described for use in unconscious or anesthetized patients who are unable to make a fist on demand. In this test Esmarch bandage is used to exsanguinate the hand.<sup>2,3</sup>

The main study measurements included the number of patients whose arterial catheter was successfully inserted at the first attempt, average elapsed time, number of attempts, number of catheters used and complications noted with the related technique. In both groups, radial artery cannulation was performed by a consultant anesthesiologist. A standard 20G arterial Leadercath™ (Vygon, 5-rue Adeline 95440 Ecouen, France) catheter was

used for all access procedures.

**Ultrasound-guided technique:** All procedures were performed on *Toshiba Nemio 20 ultrasound* machine with 7.5 MHz linear array transducer. Image display settings were set at a minimum of depth penetration (i.e., 2 cm). After disinfection radial artery was imaged in the axial plane by holding the ultrasound probe perpendicular to the course of the artery. The artery appeared as echolucent circle that pulsates on gentle compression. The artery was aligned with the centerline guide on the display by moving the probe. Inj. lignocaine 1 ml was injected above the radial artery; radial micropuncture needle was introduced into the skin directly underneath the center marking of the probe, as close to the probe as possible at about a 45° angle.

Short jabs (in/out) movements of the needle were used to see the approximate course of the needle; angulation was readjusted if needed to have the needle move towards the artery. Eventually needle compressed the artery wall, and subsequently pulsatile blood was seen in the needle at this point and guidewire was inserted in the artery followed by catheter insertion; the guidewire was withdrawn and catheter secured.

**Blind palpation technique:** It was performed as follows, after disinfection and local anesthesia, needle was inserted through the skin and directed at a 45° angle towards the anterior wall of the artery. After artery was punctured and confirmed by a flashback of blood, a guidewire was advanced into the arterial lumen. Then the needle was removed and arterial catheter was advanced over the guidewire. Following the access of the catheter, guidewire was removed and catheter was secured.

In the ultrasound group, time zero was defined as the time the ultrasound machine turned on (before gel applied to the transducer and before a sterile cover applied). For the blind palpation group time zero was defined as the time the operator's fingers were placed on the wrist to palpate the radial pulse to guide needle placement.

In addition, for both techniques, a second time record started at the point the needle entered the skin. The time of placement ended when the catheter had successfully been placed into the vessel with appropriate pulsatile blood return and waveform presence.

An observer with a stopwatch documented how long the anesthesiologist took to achieve successful placement of arterial catheter.

The number of attempts were restricted to three per patient (defined as purposeful penetration of the skin with the needle, but unlimited needle redirections in the skin). A new site was defined as moving to the other wrist or another location. If 3 attempts failed using either technique, the patient was excluded from the study.

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In both groups, successful insertion of the catheter was verified by observing a transduced arterial blood pressure waveform. Furthermore, in both groups, the time for each attempt at cannulation was recorded in addition to the total time taken.

**Statistical Analysis:** Computer software SPSS version 19.0 was used for data statistical analysis. The results are given in the text as mean  $\pm$  standard deviation (SD) for quantitative / continuous variables i.e. age, baseline heart rate, baseline systolic/diastolic blood pressure, number of attempts at same radial artery, time (sec) of successful attempt, etc. number and percentage for qualitative/categorical variables i.e. gender, diseases, radial artery pulses with palpation, arterial catheter successfully inserted at the first attempt, etc. The statistical analysis was performed using the Chi-square/Fisher's exact test for the comparison qualitative/categorical variable in between groups. Student's t-test was used for the comparison of quantitative /continuous variables in between groups.

P-value < 0.05 was considered significant.

## RESULTS

The mean age of the patients was  $43.0 \pm 14.8$  years in Group I and  $41.0 \pm 14.0$  years in Group II. Male to female ratio was 31:19 in Group I, and 29:21 in Group II. Demographic data of the patients are summarized in Table 1. There was no statistically significant difference between groups in demographic data.

Radial artery pulse was strong in 36 vs. 32, weak in 11 vs.

10 and absent in 3 vs. 2 patients in Group I as compared to Group II.

Insertion of arterial catheter at first attempt was successful in 36 (72%) vs. 32 (64%) patients in Group I and II respectively, but statistically the difference was not significant ( $p = 0.391$ ).

Average number of attempts at same radial artery was significantly less in ultrasound group ( $1.4 \pm 1.0$ ) as compared to palpation group ( $2.0 \pm 0.7$ ) ( $p=0.001$ ). Average time for successful first attempt was significantly less in Group I as compared to Group II ( $72.4 \pm 23.0$  sec vs.  $94.6 \pm 13.7$  sec) ( $p=0.001$ ), as shown in Table 2.

## DISCUSSION

Arterial catheterization for cardiac surgery is essential for the continuous invasive monitoring of arterial pressure and arterial blood sampling. The radial artery is most commonly used because of the low incidence of complications.<sup>4</sup> However, with palpation technique, cannulation of the radial artery can be challenging, even for experienced providers.

Numerous techniques have been described for insertion of catheters such as direct cannulation with an over the needle approach, modified Seldinger technique, the liquid stylet technique, pressure curve directed technique etc.<sup>5</sup> Utilizing a Doppler to aid in radial artery cannulation has been well described.<sup>6</sup>

In Doppler guided radial artery cannulation technique

**Table 1: Demographic data**

Parameters	Group I (n=50)	Group II (n=50)	P value
Age in years (Mean $\pm$ S.D)	43.0 $\pm$ 14.8	41.0 $\pm$ 14.0	0.516
<b>Gender</b>			
Male	31 (62%)	29 (58%)	0.683
Female	19 (38%)	21 (42%)	
<b>Pathology / disease</b>			
CABG	29 (58%)	25 (50%)	0.422
ASD	7 (14%)	8 (16%)	0.779
VSD	2 (4%)	5 (10%)	0.436
VHD	9 (18%)	10 (20%)	0.798
TC	3 (6%)	2 (4%)	0.999
<b>Baseline heart rate (bpm)</b>	74.6 $\pm$ 15.8	73.8 $\pm$ 17.2	0.819
<b>Baseline systolic BP (mmHg)</b>	116.7 $\pm$ 16.1	119.7 $\pm$ 14.7	0.336
<b>Baseline diastolic BP (mmHg)</b>	71.9 $\pm$ 6.6	71.1 $\pm$ 7.3	0.567

CABG: Coronary Artery Bypass Grafting, ASD: Atrial Septal Defect, VSD: Ventricular Septal Defect, VHD: Valvular Heart Disease, TC: Total Correction

**Table 2: Comparison of results of arterial cannulation**

Parameter	Group I (n=50)	Group II (n=50)	P value
Number of patients whose arterial catheter successfully inserted at the first attempt	36 (72%)	32 (64%)	0.391
Number of attempt at same radial artery (Mean $\pm$ SD)	1.4 $\pm$ 1.0	2.0 $\pm$ 0.7	0.001
Time for successful first attempt (sec) (Mean $\pm$ SD)	72.4 $\pm$ 23.0	94.6 $\pm$ 13.7	0.001

the location of the artery is identified by a change to a higher pitch or loss of Doppler tones as the tip of the cannula contacts and compresses the artery. Success rates of using this technique have been shown to be around 90% for experienced anesthesiologists. Recent studies have also suggested the efficacy of real-time, ultrasound image-guided vascular access techniques in the pediatric population.<sup>7-9</sup>

Radial artery cannulation is generally accepted to be a low risk procedure.<sup>10</sup> One of the most important factor for failure of cannulation with direct technique was inability to advance the catheter even the needle appeared to be inside the artery, this problem may result from a tangential approach to the artery, tortuosity of the artery, or radial artery spasm. Another important cause is the impingement of the tip of the needle on the posterior wall. In this position a free flashback of blood will be obtained although the catheter is unable to pass the needle tip. However the guidewire catheter can be advanced into the artery even if the posterior wall impingement occurs.<sup>11</sup>

Our study demonstrated that radial artery catheters may be inserted by ultrasound guidance and that this device significantly decreased the total number of attempts required to insert the catheter and the average elapsed time for successful cannulation. The performance of fewer attempts in the ultrasound group also explained the decrease in the number of used catheters; however, it did not significantly increased the rate of successful catheter insertion on the first attempt.

Hematoma around the artery may compress the distal artery and cause thrombosis, which may propagate to the proximal section of the artery. When the length of the catheter is small, it may be surrounded by the thrombosis, which is a common cause of catheter failure for pressure monitoring and sampling. In our study hematoma was seen only in two cases in the palpation group.

A meta-analysis on radial artery cannulation included 4 prospective, randomized controlled trials on 311 total patients, comparing real-time ultrasound guidance with palpation, and demonstrated an increased likelihood of successful cannulation on first attempt of 71% over

palpation (relative risk, 1.17; 95% confidence interval 1.25-2.32).

Of these 311 total patients, 69 were adult surgical patients. Therefore, only 69 (22%) of the patients in this meta-analysis are relevant to the practice of adult anesthesia and intensive care, and the inclusion of both adult and pediatric populations in different clinical scenarios weakens the outcome measures in the meta-analysis due to heterogeneity of trials and the relatively small number of patients available for total analysis.<sup>12</sup>

The first-attempt success rate during arterial cannulation is higher when using ultrasound-guided approach compared with palpation alone. In either the emergency room or the operating theatre setting, the success rate for the ultrasound-guided approach is in the range of 62% to 87% in adults (compared with 34%–50% for palpation)<sup>13-15</sup> and 14% to 67% in the pediatric population (compared with 14%–20% for palpation).<sup>16</sup> In our study, the differences in successful first attempt were statistically not significant. It may be due to small sample size or relatively limited experienced with ultrasound. It is probable that with more experience, the results will become more conclusive.

## CONCLUSION

In our study the average time for successful first attempt with ultrasound-guided radial cannulation was significantly less and has reduced the time required to establish the arterial line as compared with the palpation method. However, it did not have significant effect on the number of successful first attempts. Further randomized controlled studies are needed to compare the efficacy and complications.

### Authors' contribution:

AN: Collection of data and conducted the study

AMK: Helped in conducting the study and compiling the results

PA: Arranged ultrasound machine and linear probe and helped in the procedure

NA: Manuscript writing

ZAR: Helped in statistical analysis and revised the manuscript.

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