Comparison of success rates of different methods of Ultrasound guided radial artery cannulation (short axis and long axis methods) against traditional palpatory method in adult patients- a prospective randomised study.

Short Title: Short axis out of plane ultrasound guided radial artery cannulation method has higher first attempt success rate than palpatory and Ultrasound long axis method.

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Key-words: Radial Artery, cannulation, Ultrasound, crossover, blood pressure

Key Messages:

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Abstract:

Objectives: Recent meta-analysis comparing the success rates of various methods of arterial cannulation in adult patients found heterogeneity in the available data. Hence an interest to evaluate the success rates of palpatory and the ultrasound guided methods of radial artery cannulation. The aim is to compare the first attempt success rate of palpatory method with that of ultrasound guided radial artery cannulation techniques- short axis-out of plane and long axis-in plane method.

Methods: This is a Prospective, Randomized parallel arm study. 90 patients of age 18 to 50 years coming for various surgeries requiring radial artery cannulation for invasive blood pressure monitoring or frequent arterial blood gas analysis were divided into three groups. Each group had one of the three techniques of radial arterial cannulation namely palpatory, short axis ultrasound method and long axis ultrasound method. The parameters analysed were first attempt success rate, number of attempts needed, cannulation time, need for cross-over of technique and incidence of complications. Multivariate analysis was done with one-way ANOVA with Tukey’s Post-Hoc test was used to compare the groups.

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used. For Categorical data Chi-Square test was used. The probability value .05 was considered as significant level.

**Results:** The first attempt success rate was 76.7% in Long axis method, 86.7% in short axis method and 56.7% in palpatory method. The short axis method has shown to have lesser cannulation time, number of attempts for successful cannulation and lesser need for crossover of techniques when the first two attempts failed.

**Conclusion:** We conclude that ultrasound guided short axis method of radial artery cannulation is associated with higher first attempt success rate compared to traditional palpatory method.

**Introduction:**

Intra-arterial cannulation for continuous beat to beat blood pressure monitoring and frequent arterial blood gas analysis have become essential component for physiological optimization and anesthetic management of patients with significant perioperative morbidity and/or in patients undergoing surgery with major blood loss. Radial artery is the most preferred site for arterial cannulation.(1) This invasive procedure is generally safe, but in approximately 1%(2) of patients, it is associated with thrombotic, infective, and mechanical complications. Recent literature review have shown that ultrasound guidance provides ability to overcome the factors that cause cannulation failure through real time visualization of the artery and thus increasing the success rates of

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cannulation. (3) Two different techniques are available for vascular visualization which includes Long axis-IN plane (LA-IP) approach and short axis-out of plane (SA-OOP) approach. (4) Recent literature review (5) has shown that there are lot of heterogeneity in the data in studies which has compared the traditional palpatory method together with that of the two ultrasound guided approaches of radial artery cannulation in terms of the first attempt success rate of cannulation.

We hypothesized that the short axis- out of plane technique of ultrasound guided radial artery cannulation will be more successful at first attempt than other two methods of radial artery cannulation. Hence, this study was conducted to compare the success rates of different methods of ultrasound guided radial artery cannulation- short axis and long axis method against the traditional palpatory method. Furthermore the time taken for cannulation, number of attempts, complication rate are also assessed between the groups as secondary outcomes of the study.

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Methods:

After Institutional Ethical Committee approval, clinical trial registry (CTRI/2019/02/017749) and informed patient consent, this Prospective, Randomized study was conducted on 90 adult patients of age 18 to 50 years coming for various surgeries requiring radial artery cannulation for invasive blood pressure monitoring or frequent arterial blood gas analysis in the course of the preoperative management. The need for radial artery cannulation was assessed during routine preoperative assessment and the procedure was explained to the patients. The exclusion criteria are the following: any signs of infection near the puncture site, recent arterial cannulation at the same site during this hospital admission, hemodynamically unstable patients, history or evidence of peripheral vascular disease and coagulopathies. The expected dropouts are patient refusal after recruiting and negative Modified Allen’s test if the hand doesn’t flush within 15 seconds after release of ulnar occlusive pressure taken as inadequate collateral flow.

The enrolled 90 patients were block randomized into one of the three groups (30 in each group) using computer generated randomization numbers and concealed by sealed enveloped technique. On arrival of the patient in the operating room, monitors like ECG, NIBP and Pulse Oximetry was connected and baseline values were recorded. The left median cubital vein was used to establish venous access in all the patients. Hockeystick probe of bedside USG machine (sonosite R ultrasound system, sonosite INC, Bothell, WA, USA) was used with strict aseptic precautions. All the
radial artery cannulations were done by the same experienced anesthesiologist who had prior experience in ultrasound guided vascular cannulation. All the arterial cannulations were done prior to the induction of anesthesia i.e., in an awake patient with local anesthetic skin infiltration at the puncture site. In all patient, the non-dominant wrist was extended at an angle of 30 degree on a splint to keep the angle of the wrist unchanged. In all patients, hand hygiene was done before gloving and a sterile barrier was placed. Skin preparation was done with alcohol-based chlorhexidine antiseptic. 20G intravenous access cannula (Jelco®, Smiths Medical international Ltd kent, UK) was used to cannulate the artery in all the patients.

Radial artery cannulation technique:

**Group A: Long axis- in-plane Ultrasound technique:**

Transducer was placed along the axis of the radial artery in the radial aspect of the distal forearm. Radial artery was identified by the lack of compressibility and visible pulsations. Skin was infiltrated with 1 ml of 2% lignocaine. After identifying the radial artery in the long axis, 20G cannula was used to cannulate the radial artery. Entry into the artery was confirmed by visualizing the backflow of blood into the hub of the cannula. The cannula was then slowly advanced over the stylet by rotating movements. The cannula is connected to the kept ready pressure transducer and placement was confirmed after visualizing arterial waveform on the monitor.

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Group B: Short axis- out of plane Ultrasound technique:

With the initial preparation as the long axis technique, in this patients the transducer was placed in the radial aspect of the distal forearm in an axis transverse to the radial artery. Skin was infiltrated with 1 ml of 2% lignocaine. After identifying the radial artery in the short axis, 20G cannula was used to cannulate the radial artery. The cannula was then slowly advanced over the stylet by rotating movements.

Group C: Traditional palpatory method:

In this method, the radial artery was cannulated by the traditional palpatory method. To eliminate the influence of other factors in palpatory method on the success rate and the procedure time, the use of guide-wire or transfixation was not allowed in the study population. Once the cannulation was done, the extension was connected immediately to obtain the arterial waveform on the monitor.

The Parameters observed were:

First attempt success rate of radial artery cannulation between the three groups as the primary outcome measure. The secondary outcome measures being: Number of attempts needed for successful cannulation,, time taken for cannulation, need for cross over between techniques, and complications if any.

The definitions of the various outcome measures are:

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Successful cannulation: defined as an attempt at arterial cannulation by any of the three methods and achieving an endpoint of arterial waveform on the monitor.

One attempt at cannulation: defined as skin puncture leading to successful cannulation or removal of the cannula from the skin after an unsuccessful attempt. (Redirection is taken as a same single attempt).

Time taken for cannulation: Time taken from the starting of skin puncture to the appearance of arterial waveform on the monitor after transducing the cannula.

Need for cross over: After two unsuccessful attempts, crossover between the three techniques or personnel is allowed and noted.

The following procedure-related complications are: Hematoma: Appearance of a visible swelling at the site of cannulation during the attempt. Vasospasm: Inability to feel the pulse clinically by the anesthesiologist following unsuccessful attempts at and distal to the site of cannulation.

Statistical Analysis:

All the data were collected by the same anesthesiologist in all the patients. All the patients were successfully cannulated according to the study protocol. No dropouts from the study occurred.

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The statistician analyzing the data was unaware about the type of cannulation technique utilized in the three groups. The collected data were analysed with IBM.SPSS statistics software 23.0 Version. To describe about the data descriptive statistics frequency analysis, percentage analysis was used for categorical variables and the mean & S.D were used for continuous variables. Distribution was tested using the Shapiro–Wilk normality test. To find the significant difference in the multivariate analysis the one-way ANOVA with Tukey’s Post-Hoc test was used. To find the significance in categorical data Chi-Square test was used. In all the above statistical tools the probability value .05 is considered as significant level.

We calculated the sample size based on a pilot case with 10 cases in each group and with first attempt success rate of 51% and 86% between the two methods, an effect size of 35% and with a power of 80% and type-I error 0.05 a sample of size of 28 and an expected drop rate of 10% sample size for each arm was calculated as 30 in each group.

All the patients recruited completed the study protocol and there were no dropouts at the end of the study as shown in the figure 1.
Results:

The analysis of the study population showed that there was no statistical difference in terms of mean age, sex distribution and BMI among the three groups as shown in Table 1. The difference in the distribution of study population between the various age groups are also statistically insignificant. The baseline parameters like heart rate, the systolic and diastolic blood pressure are comparable between the three groups and there is no statistically significant difference among the three groups since in the Table 2. The first attempt success rate of radial artery cannulation was higher with ultrasound guided short axis method when compared to that of the palpatory method and the values were statistically significant as shown in Table 3. Also, the first attempt success rate of radial artery cannulation was higher with ultrasound guided long axis method when compared to the palpatory method, the values were statistically significant.

Though the first attempt success rate is more with ultrasound guided short axis method (86.7) when compared to the long axis method (76.7%), the values were not statistically significant. The mean values of cannulation time in the palpatory, long axis and short axis approach were 52.33, 45.07 and 35.07 secs respectively which is statistically significant among the three groups as shown in table 4. Hence, the short axis method takes less time for successful cannulation at first attempt than compared to the other two methods. When comparing the need for third attempt or the need
for cross over between the techniques the short axis method requires less need for cross over when compared to the other two methods as shown in Table 4. There is no statistically significant difference with respect to complications (hematoma formation, vasospasm) among the three groups as shown in Table 4.

Discussion:

The primary finding of this study is that short axis USG method has significantly more first attempt success rate than the traditional palpatory method. The short axis method was also found to have more first attempt success rate than that of long axis method though statistically insignificant. This ultrasound guidance is particularly so helpful that it has shown benefit in subjects with variable diagnosis approaching the emergency department in the hands of trainee physicians. (6) Ultrasound guidance also has been shown to reduce the number of attempts and also increases the first attempt success rate for radial artery cannulation. (7,8) The ultrasound was shown not only handy in adult patients but also in varied group of patients for successful radial arterial cannulation with different expertise in the performer. (6,9,10) There are two basic needling approaches using ultrasound- the short axis out of plane approach and the long axis in plane...
approach both of which have their own merits and demerits. Our study was unique in the way that all the three methods namely palpatory, short axis and long axis ultrasound method of radial arterial cannulation were compared together in the same study. The meta-analysis also consistently showed heterogeneity in the data collected and none of the analysis could infer a consistent conclusion except that USG helps in achieving more first attempt success rate. Most of the earlier studies have been attempted in the patients under general anesthesia which the authors realized could be confounding the outcome because of the effect of general anesthetic on the radial artery diameter. Hence we conducted our study in the awake patients under local anesthetic infiltration.

A recent meta-analysis involving 10 studies of ultrasound guided radial artery cannulation has shown improved overall success rate of radial artery cannulation, decrease time to successful cannulation or mean number of cannulation attempt over digital palpation technique. Similar to our study, they have inferred that there is no significant clear cut advantage of short axis method over the long axis method in terms of successful cannulation.

The other uniqueness about our study: Aging is associated with alterations in a number of structural and functional properties of arteries, including diameter, wall thickness, wall stiffness, and endothelial function. Hence, in our study we grouped the participants according to age group intervals and analysed the distribution of patients in various age intervals between the groups which

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was found to be statistically insignificant. The earlier studies have included patients of varied age groups which will be a confounding factor because the agewise changes in the artery structure.

The other uniqueness in our study was that we have defined cannulation failure as need for more than three attempts to achieve successful cannulation. Also our study gave the scope for the anesthesiologist to cross over to the alternate method in case of failure of the initial two attempts. The authors felt that it will be unethical to try more than two attempts at the same site and hence given the scope for changing the technique at the third attempt at the discretion of the anesthesiologist. The authors also felt that because of this design the study has achieved successful attempts in all the participants.

The other uniqueness about our study is that we have taken the appearance of arterial waveform on the monitor as the end point for successful cannulation unlike in the earlier studies. The authors felt that simple aspiration of a gush of blood won't be sufficient to confirm a successful arterial cannulation and invasive monitoring. Earlier studies have not stated the precise endpoint of successful arterial cannulation.

Hence in this study we found that short axis ultrasound method has higher first attempt success rate, lesser number of attempts, less cannulation time than the traditional palpatory method. When compared to Long axis USG method, short axis ultrasound method approach has higher first attempt success rate clinically, lesser number of attempts and cannulation time.

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The limitations of our study are: firstly, blinding was not possible in our study. Secondly, the ultrasound evaluation of the distal flow would have added much more information to the secondary outcomes. Morbidly obese and those with acute hemodynamic changes were excluded from the study. If those patients were included the effectiveness of ultrasound could have been more widely evaluated.

Technically, author’s felt that the arterial cannulation procedure requires two steps: initially, locating the artery with the stilleted cannula and once it enters the artery and sufficiently inside, the cannula sheath is moved over the stationed stillette. Ultrasound short axis view should help more in locating the artery which will be the initial part of the cannulation procedure and the long axis view is more useful in visualizing the path of the cannula moving inside the artery.

Our study has shown the scope for further research in this area of interest- studies have to specifically evaluate the use of ultrasound guidance in difficult radial artery catheterization like patients with severe hypotension or morbid obesity and also, the integrated use of both methods of ultrasound for effective arterial cannulation.

CONCLUSION:

We conclude that ultrasound guided short axis method of radial artery cannulation is associated with higher first attempt success rate compared to traditional palpatory method. The ultrasound
guided short axis method has more first attempt success rate than long axis method though statistically insignificant. The short axis method tend to have less cannulation time and number of attempts needed for successful cannulation.

Main Points:

- Short axis out of plane ultrasound guided radial artery cannulation method has higher first attempt success rate than palpatory and Ultrasound long axis method in adult patients.
- It has also lesser cannulation time and number of attempts needed for successful cannulation.
- Bedside ultrasound is an effective tool for successful cannulation of radial artery.

Acknowledgement: Nil

Conflict of Interest: Nil

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Figure 1: Consort flow diagram

Assessed for eligibility (n=90)
- Excluded (n=0)
  - Not meeting inclusion criteria (n=0)
  - Declined to participate (n=0)
  - Other reasons (n=0)

Randomized (n=90)

Allocated to intervention (n=30)
- Received allocated intervention (n=30)
- Did not receive allocated intervention (n=0)

Allocated to intervention (n=30)
- Each of group B
  - Received allocated intervention (n=30)
  - Did not receive allocated intervention (n=0)

Allocated to intervention (n=30)
- Each of group C
  - Received allocated intervention (n=30)
  - Did not receive allocated intervention (n=0)

Lost to follow-up (n=0)
- Discontinued intervention (n=0)

Lost to follow-up (n=0)
- Discontinued intervention (n=0)

Lost to follow-up (n=0)
- Discontinued intervention (n=0)

Analysed (n=30)
- Excluded from analysis (n=0)

Analysed (n=30)
- Excluded from analysis (n=0)

Analysed (n=30)
- Excluded from analysis (n=0)
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Table 2: Comparison of hemodynamic parameters between the three groups

<table>
<thead>
<tr>
<th></th>
<th>Palpatory</th>
<th>US long axis</th>
<th>US short axis</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (beats/min)</td>
<td>72.13</td>
<td>71.87</td>
<td>72.67</td>
<td>0.639</td>
</tr>
<tr>
<td>Systolic BP (mm Hg)</td>
<td>150.77</td>
<td>147.47</td>
<td>146.90</td>
<td>0.597</td>
</tr>
<tr>
<td>Diastolic BP (mm Hg)</td>
<td>90.70</td>
<td>89.07</td>
<td>90.43</td>
<td>0.421</td>
</tr>
</tbody>
</table>

No statistical significance at p value > 0.05

Table 3 Comparison of first attempt success rate between groups:

<table>
<thead>
<tr>
<th>GROUPS</th>
<th>No. of attempts</th>
<th>Long axis method</th>
<th>Short axis method</th>
<th>Palpatory Method</th>
<th>Long axis vs short axis</th>
<th>Long axis vs palpatory</th>
<th>Short axis vs palpatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23 (76.7%)</td>
<td>26 (86.7%)</td>
<td>17 (56.7%)</td>
<td>0.052</td>
<td>0.037</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>

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