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Comparison of Doppler Guided Seldinger Technique Versus Classic Palpatory Seldinger Technique for Radial Artery Cannulation-an Open Label Randomized Controlled Trial

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Research Article

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Abstract

Objective: Radial artery cannulation is commonly performed by the conventional palpatory technique. However, in circumstances where the cannulation is difficult, other methods such as Doppler or ultrasound are used to guide the cannulation. Incorporating the Seldinger technique can further improve the successful cannulation. The aim of the study was to compare the first attempt success rate of radial artery cannulation between conventional palpatory Seldinger technique and Doppler guided Seldinger technique.

Methods: Ninety patients undergoing major open abdominal surgeries were divided into two groups -the Classic palpatory and the Doppler guided radial artery cannulation. The Seldinger Technique was used in both the groups. First attempt success rate of radial artery cannulation and time to cannulation were noted by both the techniques.

Results: The number of attempts and the time to cannulation were significantly less in the palpatory Seldinger group as compared with the Doppler Seldinger group. Complication rates were similar in both the groups but there were 4 failure in palpatory Seldinger group.

Conclusion: The classic palpatory technique along with the Seldinger technique for radial artery cannulation is better in terms of first attempt cannulation rate and duration of cannulation than the Doppler guided Seldinger technique in patients undergoing elective surgeries. However, Doppler method had no failures and can be a useful rescue method in failed cannulation.

Keywords: Radial Artery; Palpation; Doppler; Catheterization; Hematoma; Canula

Main Points

1. The classic Palpatory technique along with the Seldinger technique for radial artery cannulation is better in terms of first attempt cannulation rate than the Doppler guided Seldinger technique in patients undergoing elective surgeries.
2. The cannulation time is lesser in palpatory Seldinger

technique than doppler Seldinger technique.

3. Thus doppler technique along with Seldinger technique can be used as a rescue method to canulate radial artery in patients where cannulation is difficult with palpatory Seldinger technique.

Introduction

Radial arterial cannulation is commonly performed in the operation theatre for continuous monitoring of blood pressure, and arterial blood gas analysis in surgeries where major fluid shifts are expected [1,2]. Traditionally and most commonly, the radial artery cannulation is performed blindly using the palpatory technique. Many techniques have been described in the literature for easing cannulation in difficult cases [3,4]. Studies have demonstrated that cannulation becomes more difficult under general anaesthesia as the artery dilates and becomes collapsible leading to difficulty in passage of the arterial catheter or guidewire during diastole [5].

The Doppler has been used since 1976 for easing cannulation in patients with weak and thready pulse such as shock state, in pediatric age group, obesity and presence of vascular anomalies [4]. The Doppler helps to locate the artery by identification of maximum Doppler sound and by an increase or decrease in the pitch on compressing the artery by the needle, thus confirming the arterial puncture [4]. In an experienced hand, the success rate of radial arterial cannulation by Doppler has been reported to be as high as 86 % [4]. Appearance of bright red blood in the hub of the needle confirms the arterial puncture in both the palpatory and Doppler techniques. In recent years, ultrasound has been increasingly used to guide the radial artery Cannulation [3]. It has been shown to be better than the Doppler and palpatory methods of radial artery cannulation. This is due to the fact that the arterial puncture can be performed in real time under vision.

Direct technique of cannulation without guidewire can lead to failed attempts due to presence of arterial spasm, tortuosity of artery, tangential insertions or presence of atherosclerosis [6]. Use of the Seldinger technique has been shown to overcome these shortcomings and improve the success rate [6]. Thus we hypothesize that addition of Seldinger technique to Doppler may lead to better cannulation success rate than when added to the palpatory technique. To our knowledge, there are no studies comparing the Doppler Seldinger technique versus palpatory Seldinger technique for radial artery cannulation. Thus, we conducted a pilot study to compare the use of Seldinger technique in Doppler guided and the classic palpatory techniques for radial artery cannulation.

Methods

After approval from the institutional ethics committee, a randomized clinical trial was conducted at the Institute of Liver and Biliary sciences, New Delhi, India from July 2021 to December 2021. This trial was registered at the National Clinical Trail Registry of India (www.ctri.nic.in, REF/2021/06/044108). The inclusion criteria were all adult patients between 18-70 years of age scheduled to undergo elective major surgical procedures requiring continuous arterial pressure monitoring. Patients with negative modified Allens' test, patients not giving consent, known peripheral arterial disease, pediatric patients, infection at arterial insertion site and radial artery puncture in last 30 days, were excluded from the study. Patients were assigned to 2 groups of 45 each according to the computer generated block randomization method with a block size of 10 which was known only to the faculty member of the anaesthesia department involved in the care of the patient. The patients were allocated by sealed envelops prepared at the start of recruitment and the envelops were opened in the preoperative area just before taking the patient to the operation theatre.

All the procedures were performed by two qualified anesthetist's who have been regularly practicing radial artery cannulation for more than 7 years. Before starting the study, 50 arterial insertions by Doppler technique were performed by both the participating anesthetist's.

After transferring the patient to the operation theatre, general anesthesia was administered using propofol 1.5 mg/ kg, fentanyl 2 µg/ kg and atracurium 0.5 mg/kg body weight following which, the patient's trachea was intubated. In all the patients, left radial artery was chosen arbitrarily and right radial artery was canulated only if the left radial cannulation failed or the pulsations on the left side were feeble. The transducer assembly along with heparin flush solution was kept in readiness before the cannulation was attempted.

In both the groups, radial artery was canulated using the Seldinger technique. The patient's hand was supinated with 50-60 degrees dorsiflexion using a roll under the wrist during cannulation. The skin was cleaned with 2 % chlorhexidine and draped.

Doppler guided Seldinger technique: The radial artery identification and cannulation was performed under the Doppler guidance. After applying the ultrasound jelly, the linear ultrasound probe with a foot print of 4.6 cm (HFL38, 13-6Mhz, Fujiform Sonosite, Japan) was covered with a sterile transparent sleeve. The probe was held by the

operator in the non-dominant hand and placed in transverse plane over the wrist. After identifying the radial artery, it was positioned at the centre of the ultrasound screen and then, the pulse-wave Doppler was applied by placing the sample volume over the middle of the artery. The arterial waveform on the spectral Doppler confirmed the artery. Then a 20 G, 3.8 cm needle (Leader flex, Vygon Group, France) was inserted at an angle of 30-400, at a point corresponding to the midpoint of the probe and gradually advanced towards the artery. An increased pitch or the loss of Doppler volume indicated the needle compressing or puncturing the artery.

The needle was advanced until the blood appeared in the hub and the Doppler tone returned to baseline. The guidewire was threaded in the needle and inserted sufficiently to lie freely in the artery lumen. The needle was removed keeping the guidewire in place and the arterial catheter was rail-roaded over the guide wire. Classic palpatory technique: In this group, the radial artery was palpated by the operator with the fingers of non-dominant hand and then the needle was inserted at an angle of 30 to 40 0 at a point where maximum pulsations were felt. Once blood appeared in the hub, the guidewire was inserted and then the catheter was advanced over the guidewire.

The primary objective was to study the first attempt success rate of radial artery cannulation. The number of attempts was quantified as the number of times the needle was advanced through a new skin puncture or the number of times the needle tip was withdrawn and redirected after entering through the same skin puncture. If the artery was not punctured after 3 attempts, the technique was switched from blind to Doppler or vice versa.

The time taken to canulate was the time from the insertion of the needle into the skin to the appearance of waveform on the screen. The time taken to canulate, number of times required to change the technique (failure of technique), complications related to the procedure (haematoma, infection, thrombosis at the site of insertion) were also noted at 48 hours following the procedure by an anaesthetist not involved in the patient care. All the readings were recorded by an anaesthetist not involved in the study.

Statistical analysis

The categorical variables are presented in the form of number and percentage (%). The quantitative data are presented as the means ± SD and as median with 25th and 75th percentiles (interquartile range) whichever is applicable. The comparison of the variables which were quantitative in nature was performed using Independent 't' test or Mann Whitney Test (when the data sets were not normally distributed). The qualitative data was analyzed using Chi-Square test or Fisher's exact test. If any cell had an expected value of less than 5, then the Fisher's exact test was used. The data were entered in the Microsoft EXCEL spreadsheet and the final analysis was performed with the use of SPSS version 21.0.A P value less than 0.05 was considered statistically significant.

Sample size estimation

No study has compared the first attempt cannulation rate of radial artery using palpatory Seldinger technique and Doppler guided Seldinger technique. Thus, 30 patients were enrolled in each group on pilot bases.

Results

The demographic parameters were comparable in both the groups (Table 1). In the Palpatory group, successful cannulation in first attempt was achieved in 34 patients as against 19 patients in the Doppler group (Table 2). The cannulation time was significantly longer in the Doppler group as compared with the palpatory group [median (IQR) 48s (42-58s) versus 38s (30-37s), P<0.0001, table 2].

Parameter	Doppler Group (n=45)	Palpatory Group (n=45)	P Value
Age (years)	39.38 ± 10.14 *	44.44 ± 12.61*	0.358
Sex (Male/ Female)	28/17	29/16	0.827
Weight (kg)	68± 7.84*	73.13± 9.79 *	0.007
Height (centimeters)	164.7± 12.9*	166.8± 13.5 *	0.54

Table 1: Demographic parameters.
*Data presented as mean± SD

	Palpatory Group (n=45)	Doppler Group (n=45)	P value
Number of attempts 1/2/3	34 /7/0	19 /17/9	0.0002#
Cannulation time (seconds)	38* (30-47)	48* (42-58)	<.0001#
Number of patients requiring change in technique	4	0	0.117

Table 2: Number of attempts for successful cannulation in the two groups.
P< 0.05 is considered statistically significant. * Data presented as Median (IQR)

Failure to canulate was encountered in 4 patients in the palpatory group, who required change over to the Doppler technique. (P<0.117) There were no failures in the Doppler group. Hematoma occurred in four patients in the Palpatory group, while no complications occurred in the Doppler group (Table 3).

Complications	Palpatory Group (n=45)	Doppler Group (n=45)	P value
Hematoma	4 (8%)	1 (2%)	0.361
Infection	0	0	
Thrombus of artery	0	0	

Table 3: Complications observed in the two groups.

Discussion

The study demonstrates that the cannulation was quicker with a higher first attempt success rate by the palpatory Seldinger method than the Doppler guided Seldinger method. But there were 4 failures in the palpatory group and none in the Doppler group. The reason for the difference in first attempt success rate could be because the participating anaesthetist had a 7 years experience in radial artery cannulation by conventional palpatory method, while the experience with the Doppler technique was limited to 50 patients. Also, the authors used a linear probe with a wide foot-print of 4.6 cm to perform the Doppler technique, which could have led to inaccuracy in the needle insertion point. A few case series have used a smaller doppler flow probe and reported a much higher success rate of more than 80 % (42% in our study) [7-9]. In contrast, the results of randomized trials are variable with reported success rates ranging from 39% to 81 % [10,11]. This variability seems to be related to non-standardization of the procedure as well as differences in the patient population and the expertise of the operators.

Various techniques of using Doppler for vascular cannulation have been described in the literature. For instance, the Doppler can be used for locating the position of artery and marking its course, which is used as a guide to needle insertion. In this technique real time visualization of the arterial pulse waveform is not used [10,12]. Another technique is by using a pencil style or small Doppler flow probe which detects the flow in the artery by auditory method. By using the Doppler flow probe, the point of loudest pulsation is identified and needle is inserted at this point. An increase or loss of pitch indicates that the needle is compressing the artery. Appearance of blood in the hub or return of pitch indicates the re-expansion of artery and then the catheter is advanced in the artery [11-13]. In the present study the ultrasound machine was used and artery was first visualized by the ultrasound using a linear probe and was positioned in the centre of the screen and then Doppler was applied to guide the needle insertion.

The present study was conducted as there are no earlier reports of Doppler in combination with Seldinger Technique. However due to non-availability of smaller Doppler probe (used in stand- alone Doppler machines) in our institution, we used conventional ultrasound machine with a wider footprint probe on an experimental basis. In the present study, there was no improvement in the first attempt success rate with Doppler in combination with Seldinger technique. However, there were no failures in this group. This indicates that the benefit of combining the Doppler with Seldinger technique is perhaps limited to its use as a bail out procedure in patients where there is failure of cannulation by the conventional palpatory technique. Further studies are necessary.

The application of Doppler has been earlier shown to be of benefit during cannulation of the radial artery in shock conditions, but not in patients with normal blood pressure [4,10,12]. Tada et al reported no benefit of the Doppler assisted arterial puncture (83.3%) over conventional palpatory technique (81.9%) in patients with normal pulse [10]. The benefit of Doppler technique has been shown in infants less than 6 months of age but not in children more than 6 months of age. The reason for this could be the diminutive artery size in infants which is better identified by the Doppler than by palpation [9].

Ueda and colleges reported a first attempt success rate of only 39 % in each of the Doppler and palpatory methods. In the present study, the first attempt success rate was much higher (75% in palpatory and 42 % in the Doppler technique). Likewise, the cannulation time in the present study was significantly improved as compared with the report by Ueda and colleges. (91 seconds by palpatory and 118 seconds by the Doppler methods in the study by Ueda's, and 38 and 48 seconds respectively in the present study). These differences from the Ueda's study are possibly related to greater experience of the anaesthetist (Ueda enrolled trainees with experience of 1-4 years and minimum of only 5 cannulation by each technique before enrolling for the study) and addition of Seldinger technique for cannulation in the present study. Also, in the present study, getting the transducer system ready before the start of procedure could have saved the time. The Ueda's study does not mention about the method of calculating the cannulation time [11].

The literature on the subject is scarce. The present study shows that addition of Seldinger technique to the palpatory method improves the first attempt success rate and shortens

the duration of cannulation. However, there were four failures by this method and successful cannulation was achieved in these 4 patients by Doppler method in collaboration with Seldinger technique. Although the time to canulate was significantly less in the palpatory method (38 vs 48 seconds), it does not appear clinically significant as spending 10 extra seconds to achieve successful cannulation is immaterial, especially in difficult scenarios. Therefore, it seems that Doppler can be a useful bail- out procedure in patient with failed cannulation using the conventional palpatory method with or without Seldinger technique

There are a few limitations to our study. Sample size is small to say the superiority of one procedure over the other. The authors used 2 D image to locate the artery before application of the Doppler, hence the results may not be strictly extrapolated to the stand-alone Doppler machines with a smaller probe. All the patients were listed for elective surgery but the results cannot be interpreted for emergency situations and in patients with feeble pulsations.

Conclusion

In conclusion, the classic palpatory technique along with the Seldinger technique for radial artery cannulation is better in terms of first attempt cannulation rate and duration of cannulation than the Doppler guided Seldinger technique in patients undergoing elective surgeries. However, Doppler method had no failures and can be a useful rescue method in failed cannulation.

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