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Arterial Cannulation in Neonates: A Comparison Between Real-Time Ultrasound-Guidance and Palpation Technique

Azmat Riaz, Kaukab Majeed, Amran Hafiz, Usman Ejaz Malik, Syed Ali Mazhar Rizvi, Nabeel Tahir Butt

Department of Anaesthesia, Pak Emirates Military Hospital/National University of Medical Sciences (NUMS), Rawalpindi Pakistan

ABSTRACT

Objective: Arterial cannulation is a useful skill for doctors working in anaesthesiology and critical care. In paediatrics, arterial cannulation is arduous due to the small calibre of artery. In neonates, it becomes even more challenging. In this study, we compared the success of real-time ultrasound guided arterial cannulation with that of traditional palpation technique.

Study Design: Prospective Comparative Study.

Place and Duration of Study: Pak Emirates Military Hospital, Rawalpindi Pakistan, from Jul 2020 to Oct 2021.

Methodology: We included eighty neonates scheduled for major surgery under general anaesthesia. They were divided randomly into two Groups, each Group comprising 40 patients. In 'Group A' arterial cannulation was performed using real-time ultrasound guidance while in 'Group B' palpation technique was used. The primary outcome of our study was number of attempts until successful arterial cannulation. Secondary outcome of study was number of complications (thrombosis, haematoma).

Results: In this study, a total of 80 neonates were enrolled. There was no difference in demographic data comparison. First attempt success rate in imaging Group was considerably higher 33(82.5%) versus 21(52.5%) with *p*-value of <0.001. Neonates in ultrasound Group required a smaller number of attempts (1.38±1.005) than in palpation Group (4.00±1.396) for successful cannulation (*p*-value<0.001).

Conclusion: We concluded that real-time ultrasonography guidance is more successful than palpation technique for arterial cannulation.

Keywords: Arterial Cannulation, Neonates, Ultrasonography.

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INTRODUCTION

Arterial cannulation is considered an important skill for anaesthetists and critical care specialists.[1] Anaesthetists are frequently challenged by difficult arterial cannulations, and they trouble shoot such challenges during routine and emergency circumstances. Anaesthesiologists providing anaesthesia to paediatric patients especially neonates have frequent exposure to difficult cannulations. In neonates inserting an arterial cannula, is considered very perplexing due to small and mobile artery[2] and this problem is increased manifold when neonate is premature, small for dates or critically ill. In modern anaesthesia practice, arterial cannulation is frequently performed in neonates undergoing major surgeries. It is of great importance in hemodynamic management and a gold standard for blood pressure measurement. It offers beat to beat blood pressure measurement and helps in getting samples for performing arterial blood gas analysis.[3] It also helps in assessment of circulatory status by pulse wave contour analysis which cannot be achieved with non-invasive blood pressure measurement. There are various ways to achieve arterial access in neonates including umbilical artery, radial artery, brachial artery, femoral artery, and even axillary artery but all the routes are not easy and there is conflicting evidence regarding their safety. Radial artery is usually the first for cannulation in a surgical neonate presenting for elective surgery. Due to its extremely small calibre, its cannulation is always a challenge even for the most experienced anaesthetists.[4] Success on first attempt is important because unsuccessful attempt leads to vasospasm or haematoma formation in the successive attempts.[5,6]

In our department, we have been using real-time ultrasound guidance for central venous access in adults as well as in children. Ultrasound guidance is used to visualize target vessel and surrounding structures, increase success rate and reduce complications during vascular cannulation.[7] For arterial cannulation, palpation technique is used traditionally but multiple studies have shown effectiveness of real-time ultrasound guidance for

Correspondence: Dr Kaukab Majeed, Department of Anaesthesia, Pak Emirates Military Hospital, Rawalpindi Pakistan
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central venous and arterial cannulation in terms of success on first attempt. Use of ultrasonography has limited complication rate in adults. However, there are a very few studies on usefulness of ultrasound for arterial cannulation in neonates. The rationale of our study is to find a superior technique for arterial cannulation in neonates in terms of success on first attempt.

METHODOLOGY

This prospective comparative study was conducted by department of Anaesthesiology main operation theatre Pak Emirates Military Hospital, Rawalpindi Pakistan, from June 2020 to October 2021. We got approval from hospital ethics committee with IERB#A/28/EC/370/2021. The sample size was calculated by WHO sample size calculator with 95% confidence interval, margin of error 5% and expected patient proportion to be 4.7%8. The sample size came out to be 69. We included 80 neonates in our study. **Inclusion Criteria**: Neonates of both genders who presented to Pak Emirates Military Hospital, Rawalpindi for major surgery were included in the study. The requirement of arterial line placement which was determined by the attending anaesthetist.

Exclusion Criteria: Neonates with deranged coagulation profile (PT/INR > two times of normal) and skin infections overlying radial artery were excluded from the study.

Written informed permission was obtained from parent/guardian of every neonate included in the study. After computer generated randomization we divided them into 2 Groups; Group A and Group B containing 40 patients each. Neonates were anaesthetised by using standard anaesthetic agents. Left radial artery was selected for cannulation. Wrist was kept in extended position by placing a small roll of gauze underneath it as soft support. Strict aseptic precautions were observed while performing cannulation. Two consultants of our department who had been regularly performing ultrasound guided arterial cannulations in adult patients for the last three years participated in the study. We used 24-gauge Jelco ® iv catheter (Smiths Medical, UK)) for arterial cannulation in all patients. In 'Group A' radial artery was identified by using high frequency linear array probe (6-12 MHz, Sonosite, USA). Cannula was advanced using real-time ultrasound guidance until its tip was visualized in radial artery. Needle was removed at this point and cannula was advanced into the radial artery. In 'Group B' radial artery was located by palpation. Cannula was moved at 45 degrees angulation to skin until cannula was seen filled with blood. Cannula was then advanced 1-2 mm further and needle was removed and cannula further inserted into the artery. Successful arterial cannulation was described as free and brisk flow of bright red blood into the cannula. The cannula was then transduced and correct trace of arterial line was confirmed on monitor screen. Total number of attempts until successful cannulation were recorded.

All the data was recorded and studied using Statistical Package of Social Science (SPSS) version 26. Continuous variables that is number of attempts and age were measured as mean and standard deviation. Discrete variables that is success rate and gender were measured in terms of frequency and percentages. Chi-square analysis was performed to compute *p*-value. A *p*-value ≤0.05 was considered clinically suggestive.

RESULTS

Eighty term neonates were included in the study. The primary outcome was success at first and secondary outcome was number of attempts and adverse outcomes. Both set of patients were comparable with respect to age weight and gender. The mean age of patients in Group A was 14.13±10.077 days and 15.93±9.68 days in Group B. The mean weight was 2.42±0.270 and 2.5±0.27 in Group A and Group B respectively. The Demographics were comparable in both study Groups. The number of successful first attempts in Group A patients was 33(82%) which was greater than Group B patients that is 21(52.5%) with p value 0.000. There were 1.38±1.005 in Group A patients and 4.00±1.396 in Group B patients (*p*-value 0.000), this means neonates in ultrasound Group required a smaller number of attempts than in palpation Group for successful cannulation (1±1 vs 4±2). Complications in terms of haematoma were also less in ultrasound Group 2(5%) vs 13(32.5%) (*p*-value <0.001). The frequency of vaso-spasm was 5(12.5%) in Group A patients which was smaller as compared to 25(62.5%) in Group B patients (*p*-value <0.000). None of our patient developed thrombosis. The statistics are summarized Table.

DISCUSSION

The decision of invasive arterial blood pressure monitoring by placement of an arterial catheter is determined by extensiveness of surgical procedure and medical situation of a neonate. Due to advancements in neonatal care, the present-day anaesthesiologists frequently encounter neonates who

undergo surgical interventions for correction of congenital or acquired conditions. There are a lot of anaesthetic concerns regarding surgical neonates, but the foremost concern is always intravascular access. Our setup is hub of neonatal surgery where we also get referrals from various peripheral hospitals. Neonatal intensive care unit is well established, and we provide invasive intravascular access in difficult cases. Preparing surgical neonate for extensive surgeries has led us to discover different modalities to expedite intravascular access and to reduce complications. One such modality is real-time ultrasonography. Getting familiar with ultrasound is of key importance for accomplishing image guided interventions. The routine use of dynamic ultrasound guided needle tip navigation for intravenous access in adults and children has become a foundation stone of image guided vascular access for neonates. We have shared our experience in our study that in neonates, real-time ultrasonography-guided radial artery cannulation increases the chances of success of first attempt cannulation and decreases the total number of attempts for successful cannulation.[8] Incidence of procedure related complications like haematoma formation also decrease when real-time ultrasonography is used for radial artery cannulation.[9,10] In past two decades ultrasound has gained popularity among anaesthetists for cannulation of central venous and arterial cannulation in adults and numerous clinical trials have proven its superiority over traditional landmark technique.[11] In recent years numerous meta-analyses established the dominance of ultrasound in radial artery catheterization over the conventional palpation technique in both adult age Group and children but in neonates very few studies are present.[12]

Table: The Association of Statistical Variables of Study Groups (n=80)

		Group A Mean±SD n=40	**Group B Mean±SD n=40**	***p*-value**
Age (Days)		14.13±10.077	15.93±9.68	0.404
Weight (Kg)		2.42±0.270	2.505±0.27	0.381
Number of Attempts		1.38±1.005	4.00±1.396	<0.001
		Fequency (%)	**Fequency (%)**	
Success at First Attempt		33(82.0)	21(52.5)	<0.001
Gender	Male	24(60.0)	19(47.5)	0.370
	Female	16(40.0)	21(52.5)	
Hematoma	Yes	2(5.0)	13(32.5)	<0.001
	No	38(95.0)	27(67.5)	
Vasospasm	Yes	5(12.5)	25(62.5)	-
	No	35(87.5)	15(37.5)	
	No	0(0)	0(0)	

Radial artery cannulation in neonates is considered very difficult and challenging due to small diameter of arteries, close proximity to the skin, loose vascular tissue making arteries very mobile, weak pulsation and relatively lower blood pressure.[13,14] In clinical practice, failure to cannulate arteries in neonates undergoing major surgeries can lead to severe challenges in the anaesthetic management.[15] There are few studies done on usefulness and efficiency of ultrasound in neonates. Our study agrees with these studies that ultrasound is a useful technique for arterial cannulation in neonates and should always be given priority whenever it is available.

Udea and colleagues performed a study in which they compared success rates of ultrasound guided versus Doppler techniques for radial artery catheterization in infants and children. Participants were 12 trainee anaesthesiologists. Successful first attempt was thirty three percent with ultrasonography Group in contrast to Doppler Group which was fifteen percent. The success rate on the whole was greater in imaging Group compared to doppler Group. This led them to the conclusion that use of ultrasound-guided radial arterial catheterization in infants and small children provides a greater probability of success at the maiden attempt compared to the Doppler-guided technique even when less experienced anaesthesiologists performed the procedure.[16]

In another study performed by Gopalasingam *et al.,* they compared traditional palpation technique with ultrasound assisted dynamic needle tip positioning for arterial catheterization in 40 children. This randomised controlled trial was performed by anaesthesia residents. The primary outcome was to measure the maiden attempt success rate. The maiden attempt success was significantly higher in dynamic needle tip navigation and positioning Group compared with the palpation Group (36/40 vs. 28/40, p=0.022). They concluded that ultrasound-guided dynamic needle tip navigation technique is superior to palpation method and it should be a preferred approach rather than a rescue procedure.[17]

Arnold *et al.,* performed a study to establish the usefulness of ultrasonographic (US) guidance for radial artery cannulation. It was a multicentre study based on format of a randomized controlled trial done prospectively on a population sample of six hundred and ninety-eight adult patients with mean age of 69±7 years. All the patients underwent cardiac catheterization with radial artery as a access route.

Patients were divided into two study Groups with palpation of artery as technique for one Group of participants (351) real-time US guidance as technique for another Group (347 participants). The number of attempts were recorded which were found to be minimal in US guidance Group [mean: 1.65±1.2 vs. 3.05±3.4]. Moreover, the success rate at first attempt improved to sixty four percent versus forty three percent. Eighteen patients in the palpation were converted to ultrasound guidance after five minutes delay and failure to pass cannula by palpatory method. Arnold *et al.,* concluded that the ultrasonographic assistance helps in improving the success rate of radial artery cannulation and can be used for trans-radial cardiac catherterization.[18]

Gottlieb *et al.,* in their review article suggested use of vessel compression as primary, and colour and pulse Doppler as supplemental techniques for selection of an artery or vein. They also mentioned the limitation of the dependence of procedure on competency of the operator. In their research they also suggested that more than twenty prior successful peripheral intravascular access by operator can reduce the chances of unsuccessful attempts by same operator.[19]

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LIMITATION OF STUDY

There are few limitations of our study. First, cannulations were accomplished by consultant anaesthetists who had been regularly using ultrasound for adult, neonatal and paediatric arterial cannulations. Secondly it was not a placebo-controlled double-blind study.

CONCLUSION

In conclusion, compared to traditional palpation method, real-time ultrasound-guided technique is not only superior for radial artery cannulation in neonates in terms of increased first attempt success rate and fewer complications. Therefore, we recommend use of real-time ultrasound guidance for arterial cannulation in neonates.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

AR & KM: Data acquisition, data analysis, critical review, approval of the final version to be published.

AH & UEM: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

SAMR & NTB: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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