Ultrasound guidance versus conventional technique for radial artery puncture in septic shock patients: a randomized controlled trial

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February 12, 2021

Abstract

Background: Arterial puncture, for obtaining an analysis of blood gas, is an interventional procedure often performed in emergency departments and intensive care units. Our goal in this study is to compare the traditional method and ultrasound (US) guided method in radial artery puncture for blood gas analysis in septic shock patients. Methods: This is a prospective, randomized study. Septic shock patients over 18 years of age who needed a radial artery puncture sample for blood gas analysis were included in the study. Patients with local infection or trauma at the puncture site, arteriovenous fistula, vascular graft, coagulopathy, Allen test positive and those who did not want to participate in the study were excluded. Patients were randomized into 2 groups: radial arterial puncture obtained through an US guided technique or radial arterial puncture by conventional method. The main outcomes are success at the first entry, the number of attempts and time to success after enrollment. Results: 50 eligible patients were randomized into two groups. The success rate of the first puncture in the ultrasound group and the palpation group was 80% and 42%, respectively. The number of attempts and time to success significantly increased in conventional group. Conclusion: The US-guided method has been found to be more successful in terms of success at the first entry, number of attempts, time to success compared to the conventional method.

1.Introduction

Arterial puncture, for obtaining an analysis of blood gas, is an interventional procedure often performed in emergency departments and intensive care units. This procedure is used to evaluate many diseases such as acute respiratory distress syndrome (ARDS), severe sepsis, septic shock, diabetic ketoacidosis, acute respiratory failure, heart failure, cardiac arrest, asthma, and chronic obstructive pulmonary disease (COPD) [1,2].

Radial artery puncture (RAP) is more commonly used than femoral and axillary arteries due to its superficial location and lower risk of complications[3]. However, undesirable conditions such as vascular complications, pain, numerous attempts and failure to attempt may occur due to this procedure[4-6]. RAP is classically performed using the digital palpation method[7] but it may be difficult to use this method in hemodynamically unstable patients, those with variable vascular anatomy, and obese patients[8]. In shock patients, a weak radial artery pulse due to hypovolemia and poor angiosclerosis may cause difficulty in the classical method[9]. In the literature, high success and fewer complications have been reported in interventions such as central venous catheters, peripheral venous catheters, and arterial catheters by using ultrasound (US)[10-12].

Our aim in this study is to compare the traditional method of radial artery puncture for the purposes of blood gas analysis with the method accompanied by US, in septic shock patients.

2. Materials and Methods

2.1. Study design and setting

This randomized trial was both prospective and nonblinded; it was carried out in the ED of a tertiary care teaching hospital between January 1, 2020 and April 1, 2020. The institutional review board (Ethics Committee Ruling number: 2020/514/169/5) approved this study and all of the patients—or their family members—signed the written informed consent.

2.2. Selection of patients

The study qSOFA (quick sepsis related organ failure assessment) included septic shock patients over 18 years of age who needed a radial artery puncture sample for blood gas analysis; a score of 2 or more and persistent hypotension requiring vasopressor to keep the mean arterial pressure (MAP) at 65 mmHg and lactate being 2 mmol / L or more[13]. Patients with local infection or trauma to the puncture site, arteriovenous fistula, vascular graft, coagulopathy disorder, those with a positıve Allen test, and those who did not want to participate in the study were excluded. The use of US for radial artery puncture is an interventional procedure that is currently performed in our clinic, and clinicians who have point-of-care US certificate perform this procedure. Patients were only allowed to participate in this trial once.

2.3. Methods of measurement

Once enrollment was complete, the patients were then randomized. From of the original group, fifty-nine patients were found to be eligible for the trial. Those patients were divided at random and placed into the US-guided group or the conventional group, in a 1:1 allocation ratio.

In the group that was guided with US, a conventional US device and a vascular probe was used—allowing for US guidance to be performed in real time. After the skin was disinfected with a local antiseptic the puncture site had sterile gel applied; only when the probe touched the skin was a timer was started. The physicians were able to locate the radial artery through the use of the various modes of the US (including the 2B mode, the color-flow mode, and the pulse-wave mode). They centered the radial artery in the center of the screen. A vascular probe was situated perpendicular to the artery. Next, with respect to the probe, a 23 G needle was inserted at a 70 angle; it was targeted at the center of the arterial lumen. The physician was then able to manipulate and control the physical location of the needle in real time, in keeping with the short-axis approach[14]. In the conventional group, once the skin was disinfected with a local antiseptic, the timer began when palpation to find the radial artery began, since that was the first contact with the skin. Once the physician identified the artery, they inserted a 23 G needle at 70 angle. Once blood return was identified, the timer was stopped, and the attempt would be considered successful. Once the results of the blood gas analysis demonstrated that the puncture was indeed arterial, success was confirmed. After the start of the trial, no methodology changes were made.

2.4. Outcome

The successful number of outcomes completed in the first attempt was the primary outcome of this work. One break of the skin corresponds to “one attempt” being made. The secondary outcomes of this work include the number of attempts made before there was a successful puncture and the time that elapsed until that successful puncture was made.

2.5. Sample Size and Statistical Analysis

To be able to determine the sample size, the power analysis was completed with the use of G*Power (v3.1.9) software. The power analysis was then used to estimate the minimum sample size required for this research. This analysis suggests that the study would need to include at least a minimum of 47 patients with 0,05 significance level and 95% power for the test.

The SPSS v.23 program was used for the analysis of the results. Frequencies and percentages of variables were given as basic statistics. The Wilcoxon Signed Ranks Test was performed to determine differences among categorical variables for related samples. Correlation coefficients (Kendall’s Tau b) were calculated to find significant relations among variables.

3. Results

From January 2020 through April 2020, screening was conducted on 59 patients who results lead to nine patients being excluded; this was completed before the randomization process (Figure 1). The remaining 50 patients were then placed into two groups at random: the US-guided group (n=25) or the conventional group (n=25). Once the total number of needed subjects was reached, the trial ended.

Data of variables used in the study are summarized with frequency and percentages. Most of the patients (78%) were older than 66 years and 58% of them were female (Table 1). The first attempt success rate for the US-guided group is 72% and for the conventional group is just 40% (Table 2).

The percentage of one puncture with US is 72% which is greater than the percentage without US which was 36%. The number of 2-3 punctures with US in percent is lower than without US, and the percentage of more than 3 punctures without US is 26 while there is no more than 3 punctures with US (Table 3). In general, it is true that when US is used the number of punctures will be smaller. When the groups were compared according to the time of success, it was seen that the US-guided group was lower in percentage than the conventional group (Table 4).

Kendall's Tau b correlation coefficients were calculated among variables and are given in Table 5. There are no correlations among age and sex with any other variables. There is one on one negative relation between the success at the first entry and the number of attempts using US, which means if the first entry is successful then the number of attempts will be one, otherwise 2-3, but no more than 3. There is a significant correlation -0.594 between success at the first entry and the time to success with US. Also, the correlation coefficient between the number of attempts and the time until success with US is 0.594, which is a statistically significant level. These results show that when success at the first entry does not occur then the time to success will be higher. Also, if the time to success takes longer than the number of attempts will be higher.

If US is not used, there is -0.76 significant correlation between the success at the first entry and the number of attempts which is also significant. There is a significant negative correlation (r=-0.305) between the success without US at the first entry and the time to success without US. Also, there is a positive significant correlation (r=0.498) between the time to success without US and the number of attempts without US. Correlation analysis results show that when the success at the first entry happens, then the time to success will be lower.

4. Discussion

It has been found in this study that radial artery puncture which is guided with US decreases the amount of time to success as well as the number of attempts required than the conventional technique. Additionally, the success rate of first attempts is increased considerably when US is utilized.

Radial artery puncture and cannulation is an invasive procedure which is commonly used in different setting such as operating rooms, intensive care units, and emergency rooms. Arterial cannulation allows for blood pressure the be measured, for blood to be sampled in order to analyze blood gas, and for guiding fluid therapy in surgical patients or the critically ill[15].

Currently, US is broadly used for arterial puncture and cannulation; real-time US permits the visualization and puncture of the artery in real-time. Within a number of randomized controlled trials and meta-analyzes, the conventional technique along with US-guided radial artery cannulation can be seen. In one such analysis by Tang et al. (which was comprised of 482 patients from 7 randomized studies), it was reported that US guidance in radial artery catheterization significantly increased the success rate of the first attempt when compared with the conventional technique[16]. In another meta-analysis (including 2402 patients from 13 randomized studies), Gu et al. reported that US guidance further reduced average success attempts, the time to average success, and hematoma complications when compared to the conventional technique[8]. Similarly, in our study, the first attempt success rate of the US-guided group was 72% while the success rate was only 40% in the traditional group.

Arterial puncture is usually a painful procedure, especially when more than one attempt is required[17]. The conventional method can cause pain and dissatisfaction in patients due to the large number of skin punctures and the long procedure time. But the use of US has advantages such as a decrease in the number of initiatives, processing time, and patient dissatisfaction[18]. In our study, it was observed that the number of attempts decreased as well as the time to success when US was utilized. The findings of this study are in line with the findings of previous studies. There are studies in the literature reporting that the use of US in the radial arterial line procedure is superior to the conventional technique. Levin and colleagues in 69 adult patients requiring intraoperative monitoring, with US use, they reported an improvement in the success rate of the first pass from 34% to 62%, and the average number of attempts was less[19]. Schwemmer and colleagues, in their study on 30 infants, they found that the first pass success rate with US increased from 20% to 67%[20]. Shiver and colleagues reported that there was an improvement from 50% to 87% in the first pass success rate of US use in 60 emergency room patients with critical illnesses, and a decrease in procedure time of 107 seconds versus 314 seconds[21]. In another randomized study, it was reported that the use of US did not provide any benefit, but in this study, researchers emphasized that most of the US users had insufficient experience[22].

Limitations

There are a few limitations with this study. Only a single center was used and the trial was not blinded. The use of US for radial artery puncture is an interventional procedure currently performed in our clinic; therefore, operators may have been convinced before examining the value of using US. In this study, puncture times were compared without including the amount of time it took to prepare, but it can be assumed that this amount of time would be longer since the US device would need some amount of preparation time before it could be used. Initially, the sample size of our study was small; therefore, larger sample studies are needed to confirm the clinical significance of this approach.

In conclusion, this study shows that radial artery puncture for blood gas analysis is supported by the use of US guidance, in septic shock patients. The US-guided method has been found to be more successful in terms of success at the first entry, number of attempts, and the time to success when compared to the conventional method.

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Table 1: Distribution of Age and Sex

		Frequency	Percent
Age	18-45	2	4,0
	46-65	9	18,0
	66-79	21	42,0
	80+	18	36,0
	Total	50	100,0
Sex	Female	29	58,0
	Male	21	42,0
	Total	50	100,0

Table 2: Distribution of success rate of the first entry with US-guided and Conventional Group

	Frequency	Percent
Success with US-guided group	14 (-)	28,0
	36 (+)	72,0
	50	100,0

Success with conventional group	30 (-)	60,0
	20 (+)	40,0
	50	100,0

Table 3: Comparison of groups by number of attempts

		Frequency	Percent
US-guided group	1	36	72,0
	2-3	14	28,0
	Total	50	100,0
Conventional group	1	18	36,0
	2-3	19	38,0
	3+	13	26,0
	Total	50	100,0

Table 4: Comparison of groups by time to success

		Frequency	Percent
US-guided group	0-10 min.	19	38,0
	11-20 min.	23	46,0
	21+ min.	8	16,0
	Total	50	100,0
Conventional group	0-10 min.	6	12,0
	11-20 min.	31	62,0
	21 + min.	13	26,0
	Total	50	100,0

Table5: Correlation Coefficients Among Variables

Correlations

Kendall's tau_b	Success With US-GG at the first entry	Correlati
		Sig. (2-ta
		N
	Number of attempts with US-GG	Correlati
		Sig. (2-ta
		N
	Time to success with US-GG	Correlati
		Sig. (2-ta
		N
	Success With CG at the first entry	Correlati
		Sig. (2-ta
		N
	Time to success with CG	Correlati
		Sig. (2-ta
		N
	Number of attempts with CG	Correlati
		Sig. (2-ta

	Age	N Correlati Sig. (2-ta
	Sex	N Correlati Sig. (2-ta
		N
. Correlation is significant at the 0.01 level (2-tailed).	**. Correlation is significant at the 0.01 level (2-tailed).	**. Corre
. Correlation is significant at the 0.05 level (2-tailed).	*. Correlation is significant at the 0.05 level (2-tailed).	*. Correl

US-GG: Ultrasound-guided group, CG: Conventional group

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