Original Article

Evaluation of an Arterial Blood Sampling Device and Its Function in Accelerating and Facilitating Blood Sampling

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Abstract

Background: Arterial blood sampling is among the basic standards in critically ill patients. The aim of this study was to examine an inventive sampling device in facilitating arterial blood sampling in comparison to the conventional method using an insulin syringe.

Methods and materials: This randomized interventional clinical trial was performed on 100 patients admitted to Qaem and Imam Reza Hospitals in Mashhad in 2016 for whom two arterial blood gas (ABG) samples were indicated. The patients were randomly selected by the visiting operator on a daily basis. The operator visited the hospital on certain days and took two samples from the selected patients.

Results: The patients' mean age was 45.31±16.15 years. In the insulin syringe group, venous blood gas sampling was in 24% and arterial sample in 76%. In the designed device group, same figures were 12.1% and 87.9%, respectively. Sampling score (p=0.01), unsuccessful attempts with and without needle removal from the skin (p=0.01), and need for vertical and horizontal needle displacement for sampling (p=0.01) were significantly differed between the two groups. Localized swelling score and its size, localized bruising, palpable arterial spasm and the spasm duration was significantly less for the inventive device (p<0.05). Satisfaction score of patients and operator were significantly higher in the device group (p=0.01).

Conclusion: The study device had desirable function in facilitating and accelerating arterial blood sampling. Its application can be further approved by future studies.

Keywords: Arterial blood sampling, Facilitated sampling, Accelerated sampling, Intensive Care Unit

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Introduction

Arterial blood gas (ABG) analysis is a major part of the diagnosis and management of the oxygenation status, acid-base balance and ventilation in critically ill patients (1). Accordingly, blood sampling from the radial artery for studying ABG is a common procedure in adult patients and one of the basic skills for medical students (2). On the other hand, accurate ABG results are highly dependent on the appropriate sampling method, correct transfer to the laboratory and sample analysis; multiple errors can occur in any steps. The most common errors that occur in the first stage include non-arterial sample, air bubbles in the syringe, insufficient or excessive anticoagulants, delayed analysis and not preserved at low temperatures (1). The other technical errors during sampling from the radial artery for ABG include hematoma, arteriospasm, vasospasm, anaphylactic reaction to local anesthetics, infection transmission to the patient or the operator by needle stick, bleeding, vascular edema, vasovagal response, pain, peripheral nerve injury, ischemia, thrombosis and arterial laceration (3-6). Therefore, in this study we aimed to investigate an inventive semi-automated blood-sampling device for safe and facilitated arterial blood sampling. This is a small, pocked-sized and portable device which is made up of a syringe holder (without compromising its sterility) and two compression keys for moving the piston and the battery. Moreover, the complications and adverse events related to ABG sampling were compared with the conventional method to better verify the application of this device.

Methods

This randomized clinical trial was performed on 100 patients (200 ABG sample) hospitalized in the intensive care units (ICU) of two University Hospitals in Mashhad (Northeast of Iran). All cases in whom daily ABG samples were indicated were enrolled. The study protocol was approved by the research ethics committee of Mashhad university of medical sciences (IRCT 201810117041373N1); it was initially described to each patient and an informed consent was obtained from each participant prior to study entrance and sampling.

Patients with reduced consciousness (GCS<15), any type of arrhythmia, anatomic variations and low blood pressure which made it difficult to simply palpate the radial artery were excluded from the study.

First sampling was done by the conventional method (insulin syringe) and the inventive device took the second blood sample after 6 hours. A single operator (ICU specialist) did sampling throughout the study. The inventive device performance is as follows. After placing the syringe in the device, the operator holds the device with the prominent (right) hand on the skin and looks for the pulse with the other hand. Then the needle tip is inserted into the skin and at this exact moment by pressing a key, the device piston rises a few centimeters causing suction in the syringe. By the control and guidance of the left hand the needle tip is moved towards the best and most accurate site with the strongest arterial pulse. As soon as the needle is inserted into the lumen, the blood is aspirated into the syringe and the operator can take the exact amount of blood only with continued key pressure with the index finger of the prominent hand.

The required data were then collected in a researcher-made checklist consisting of demographic characteristics of the patients (age, sex, BMI), the time required for blood sampling (from the entry of needle into the skin to its removal), the number of failed attempts and the number of times required for blind needle displacement, the incidence of adverse complications such as localized swelling and its size, localized bruising, arterial spasm, the duration of sustained spasm and also the patient and operator's satisfaction level were also recorded. The level of pain was measured by the NRS-11 pain scoring system. Eventually the collected data were inserted into the SPSS software Ver.20 and the outcome was analyzed and interpreted by an experienced statistician. Due to the non-normal data distribution the Wilcoxon signed-rank test was applied. The significance level was set at $p<0.05$.

Results

In total 100 patients were studied; 73 males and 27 females. The patients' mean age was 45±16 years and their BMI was 24.48±3.75 kg/m^2. Based on the

Table 1: Comparison of the mean arterial sampling time between the two groups.

Sampling time (s)	No.	Mean	SD.	P-value
Insulin syringe	100	18.60	4.72	0.01
Invented device	100	10.92	3.09	

SD: standard deviation; Significance level in Wilcoxon test was set at P<0.05

gasometer results, in the conventional group the blood samples revealed venous blood in 24 (24%) and arterial blood in 76 (76%). In the inventive device group, the mentioned figures were 12 (12.1%) and 87 (87.9%), respectively. A significant difference was observed between the two groups (31.6% vs. 13.8%), indicating significantly lower venous blood samples in the inventive device group (p=0.01, Table 1).

Moreover, the mean number of failed attempts without the need for needle removal from the skin (p=0.01), the number of failed attempts with the need for needle removal (p=0.01), and the need for either vertical or horizontal needle displacement (p=0.01) differed significantly between the two groups (Table 2).

Sampling complications such as localized swelling and swelling size, bruising, arterial spasm incidence and duration was significantly different between the two sampling methods (Table 3). The mean satisfaction score also significantly different between the two groups for both the patient and the operator (p=0.01); it was significantly more when using the inventive device (Table 4).

Table 2: Comparison of the mean number of failed attempts for arterial blood sampling between the two groups.

Failed attempts		No.	Mean	SD.	P-value
With no need for needle removal	Insulin syringe	100	0.63	0.6	0.01
	Invented device	100	0.11	0.1	
With the need for needle removal	Insulin syringe	100	0.62	0.6	0.01
	Invented device	100	0.21	0.2	
With vertical needle displacement	Insulin syringe	100	0.45	0.4	0.01
	Invented device	100	0.04	0.0	
With horizontal needle displacement	Insulin syringe	100	0.55	0.5	0.01
	Invented device	100	0.17	0.1	

SD: standard deviation; Significance level in Wilcoxon test was set at P<0.05

Discussion

Due to the many problems caused by arterial blood sampling, researchers have long been proposing various methods for increasing the success rate of ABG sampling, pain alleviation and complications reduction. In a study from Denmark the researcher suggested using ultrasound for finding the location of the radial artery; they reported that the success rate of sampling in the ultrasound group was not significantly different from the control group (89.6% vs. 94.5%, p=0.18). Regarding the results of the current study, the success rate of sampling by the semi-automated device was significantly higher than the conventional method. On the other hand, in the latter mentioned study the sampling duration and cost in the ultrasound group was significantly higher than the control group (150s vs. 55s, p<0.001), whereas the sampling duration by the semi-automated sampling device was significantly less than the conventional method. Therefore, in the

Table 3: Comparison of arterial blood sampling related complications between the two groups.

Complications			No.	Mean	SD.	P-value
Localized swelling	Insulin syringe	Yes	40	1.87	0.33	0.01
		No	60	1.88	0.32	
	Inventive device	Yes	12	1.58	0.51	
		No	88	1.60	0.49	
Localized swelling size	Insulin syringe		100	1.16	0.63	
	Inventive device		100	0.34	0.24	0.01
Bruising	Insulin syringe	Yes	35	1.82	0.38	0.008
		No	65	1.81	0.39	
	Inventive device		18	1.66	0.48	
			82	1.64	0.48	
Arterial spasm incidence	Insulin syringe	Yes	23	2.00	0.0	0.01
		No	77	1.94	0.22	
	Inventive device	Yes	4	1.76	0.42	
		No	96	1.77	0.42	
Spasm duration (min)	Insulin syringe		99	0.28	0.2	0.01
	Inventive device		100	0.04	0.01	

SD: standard deviation; Significance level in Wilcoxon test was set at P<0.05

mentioned study the routine use of ultrasound for ABG sampling was considered neither logical nor practical (7). Accordingly, the routine use of the invented semi-automated sampling device seems to be both logical and practical and also cost-effective.

Furthermore, the results of the present study showed a significant difference in the timing, number of failed attempts with and without needle removal and the need for vertical or horizontal needle displacement between the two groups; the mean score being significantly less in the semi-automated device group.

Ballesteros-Peña et al. (2017) used the NRS-11 pain scoring system for comparing the pain perception between vein catheterization and arterial puncture for gas testing. The mean pain score with venipuncture was 2.8 whereas it was 3.6 for arterial puncture. They stated that the severity of pain is related to the anatomic sampling area and the difficulty of the procedure. The difficulty was defined as the number of attempts and the time required achieving success in this procedure (8). It is worth noting that based on our knowledge, Ballesteros-Peña et al. study was the only study, which has compared vein and arterial puncture for the level of pain perceived by the patient. Taken together, it can be concluded that pain which is one of the main undesired effects of ABG sampling is associated with the sampling duration and the number of failed attempts in the procedure. Therefore, according to their results and comparing it with ours, it seems that by the application of the inventive device, in addition to reduced sampling time and fewer failed attempts, the level of pain can also be mitigated.

Other adverse events accompanying arterial blood sampling were also taken into account in the present study. Accordingly, the mean localized swelling score and swelling size, bruising, arterial spasm incidence and its duration were significantly different between the two studied groups. The mean score for all the mentioned complications was lower in the inventive device group.

Jensen et al. (2018), in a study performed during the years 2014 to 2015 aimed to determine whether standardizing technique elements of the arterial puncture process could improve its success rate; they collected blood samples by standardizing the sampling method and the success rate was calculated as 83.6%. Each attempt to obtain an ABG sample measured statistically and then the standardization charts for the location, position and method of performing the work designed and made available to the process organizers (9). In 2017, another sampling was done in which the success rate of the procedure reached to 89.2%. They concluded that standardization and correct ABG performance lead to higher success rates and fewer complications (9); their results were in accordance to our findings.

In the current study the patients' and operator's mean satisfaction score was significantly different in the two studied groups (p=0.01), being significantly higher in the inventive device group. This can be justified by the reduced sampling time, reduced number of failed attempts and the lower rate of complications by using this device.

Nevertheless, the main strength of the present

Table 4: Comparing the mean satisfaction score of the patients and the operator between the two groups.

Satisfaction		No.	Mean	SD.	P-value
Patient	Insulin syringe	100	5.72	1.22	0.01
	Inventive device	100	7.85	0.92	
Operator	Insulin syringe	100	5.86	1.01	0.01
	Inventive device	100	8.95	0.95	

SD: standard deviation; Significance level in Wilcoxon test was set at P<0.05

study was the introduction of an inventive device for the first time in the world which can facilitate arterial blood sampling and which its efficiency and practicality has been confirmed. However, further studies are required to better approve its superiorities for routine ABG sampling in medical centers. In this way in addition to the introduction of a novel medical product to the Iranian and global medical markets, it can facilitate the path to the mass production of the device, aimed at minimizing injury to patients besides increasing the accuracy of medical procedures. It can also be the intellectual basis for making other devices for similar purposes.

However, as the studied device is inventive and novel, its comparison with other similar products was not possible, which can be considered as one of the main limitations of this study. It is anticipated that with performing future studies the efficiency of the device can be further justified and it can become more practical in medical centers. Among the other study limitations, the small sample size and the incompliance of some patients can be mentioned.

Conclusion

The findings of this study showed that the application of the newly invented device for arterial blood sampling reduces the sampling time, the number of unsuccessful attempts and related complications while increasing the satisfaction level of both the patient and the operator when compared with the conventional sampling method. Therefore, it can be concluded that the semi-automated device has acceptable functionality in accelerating and facilitating sampling. Still, further studies are required to approve its use and exploitation.

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Conflicts of Interest

Although one of the authors was the inventors of the device, she had no role in gathering or analysis of the data. However, performing future larger studies by other medical centers would be helpful.

References

1. Sood P, Paul G, Puri S. Interpretation of arterial blood gas. Indian J Crit Care Med 2010;14(2):57-64.
2. Dev S. P, Hillmer M. D, Ferri M. Arterial puncture for blood gas analysis. N Engl J Med 2011;364(5):e7.
3. Shrake K, Blonshine S, Brown R, Ruppel G, Wanger J, Kochansky M. AARC clinical practice guideline: Sampling for arterial blood gas analysis. Respiratory Care. 1992;37:913-4.
4. Raffin TA. Indications for arterial blood gas analysis. Ann Intern Med 1986;105(3):390-8.
5. Slockblower JM, National Committee for Clinical Laboratory Standards. Procedures for the collection of diagnostic blood specimens by venipuncture; approved standard. 6th ed. Wayne, Pa: CLSI; 2007.
6. Weibley RE, Riggs CD. Evaluation of an improved sampling method for blood gas analysis from indwelling arterial catheters. Crit Care Med 1989;17(8):803-5.
7. Laursen CB, Pedersen RL, Lassen AT. Ultrasonographically guided puncture of the radial artery for blood gas analysis: a prospective, randomized controlled trial. Ann Emerg Med. 2015;65(5):618-9.
8. Ballesteros-Peña S, Vallejo-De la Hoz G, Fernández-Aedo I; en representación del grupo de trabajo DIASURE. Pain scores for intravenous cannulation and arterial blood gas test among emergency department patients. Enferm Clin. 2018;28(6):359-364.
9. Jensen PR, Markewitz BA. Improved Success Rate of Arterial Puncture for Blood Gas Analysis through Standardization. Lab Med 2018;49(2):175-178.