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Accuracy of Point of Care Blood Sugar Measurement in Patients Admitted to Intensive Care Unit with Shock and on Vasopressor Support

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Abstract

Background and Aim: Point of care (POC) glucometry is most widely used method for monitoring blood sugar levels in the Intensive care unit (ICU). But, the accuracy of bedside glucometry using capillary blood is controversial in patients with shock. We aimed to compare the accuracy of POC glucometry with laboratory blood glucose measurements in patients with shock and requiring Noradrenaline infusion. *Methods*: This is Prospective, Observational study done on 100 consecutive patients admitted to ICU with shock categorized into two groups of 50 each, requiring two different doses of Noradrenaline infusion (Group A: 5 mcg/min and Group B: 10 mcg/min). POC capillary, POC venous and laboratory venous blood sugar measurements were simultaneously done in each patient. *Results*: ANOVA test was performed which showed that there was no statistical significance between the blood samples and also between the two groups (F value 0.022, p value 0.978). In Group A, stronger correlation was found between POC venous and lab venous blood sugar measurements ($r=0.886$, $p<0.01$) whereas in Group B, stronger correlation was found between POC capillary and lab venous blood sugar measurements ($r=0.897$, $p<0.01$) *Conclusion:* POC glucometer blood sugar estimation using capillary blood quite accurately correlates with the POC glucometry using venous blood and the laboratory values, even in patients with Noradrenaline infusion, provided all the confounding factors are eliminated before measuring blood sugar levels.

Keywords: Blood glucose monitoring; Point of care glucometer; Shock.

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Introduction

Critically ill patients are prone to wide fluctuations in blood sugar levels and these dysglycaemias are proven to increase both morbidity and mortality [1,2]. Hence, it is important for the clinicians to closely monitor glycaemic levels in patients admitted to ICU. Blood sugars are usually estimated in the ICU either by POC glucometers or by sending blood samples to the laboratory. Main drawbacks of laboratory measurements are higher cost, time consuming posing practical difficulties in managing critically ill patients. On the contrary, glucometers are easy to use, portable and provide

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instant results. Hence, many ICUs use POC glucometers for monitoring blood sugar levels.

Several studies have shown that, blood sugar levels measured by bedside capillary glucometer were highly inaccurate and would over estimate blood sugar levels especially in patients with hypotension, anaemia, hypoxia and those requiring vasopressor support [3,4,5].

There are not many studies done comparing glucometer blood sugar levels on patients with different doses of vasopressors. As noradrenaline is the predominantly used vasopressor in most critical care units, we undertook this study to compare the accuracy of bedside glucometers in patients with shock and requiring noradrenaline infusions. Further, we correlated the POC glucometer results with laboratory values.

Objective of the study

To determine whether POC capillary and POC venous blood sugar measurements correlate accurately at two different doses of Noradrenaline infusion in critically ill patients admitted to ICU with shock.

Materials and Methods

Study Participants and Recruitment

We conducted a prospective observational study in a 14 bedded adult ICU. The study was done over a six month period between August 2018 to January 2019. Study group consisted of 100 consecutive patients of either sex, aged between 18 to 65 years, getting admitted to ICU with shock and initiated on Noradrenaline infusion. Shock was defined as mean arterial pressure (MAP) < 65 mmHg.

Patients with hypovolemic shock due to severe active bleeding, haematocrit < 20%, coagulopathy, thrombocytopenia (Platelet count < 50000/ mm^3), pregnant and breast feeding women, patients with severe hypoxia (SpO_2 < 90 with O_2), hyperbilirubinemia, severe acidosis (pH < 7.20), patients on medications such as acetaminophen, mannitol, ascorbic acid were excluded from the study. In addition, patients requiring more than one vasopressor and those who didn't give consent for the study were also excluded.

Patients were divided into 2 groups, Group A and Group B, based on the dose of noradrenaline infusion. *Group A* consisted of patients presented with shock and requiring noradrenaline infusion of 5 mcg/min. Group B consisted of patients with shock and requiring noradrenaline infusion of 10 mcg/min.

Patient Data Collection

Demographic data collected include age, sex and anthropometric measurements. Baseline vital parameters recorded include MAP, heart rate, respiratory rate and oxygen saturation (SpO_2). Baseline lab parameters done were haemoglobin, platelet counts, bleeding time and clotting time, serum bilirubin and arterial blood gas (ABG).

Blood Glucose Measurements

Three blood samples of which 2 venous and 1 capillary were drawn from each patient simultaneously. One of the venous sample was sent to the laboratory for glucose measurement. The other venous and capillary blood samples were tested bedside using POC glucometer.

Capillary blood sample was obtained by pricking the finger with lancet after sterilization with alcohol swab. Venous sample was obtained from either peripheral vein using hypodermic syringe needle after sterilization of site with alcohol swab or from central venous catheter (CVC). Initial 5ml of blood was discarded if the blood sample was drawn from CVC to prevent the error of estimation of blood sugar from the blood present in the CVC tubing.

Principle

POC glucometry was done using ACCU-CHEK^R Performa glucometer (Roche, Germany). Glucose dehydrogenase in the glucometer strip converts the glucose in the blood sample to gluconolactone. This reaction liberates 2 electrons that react with a coenzyme, Pyrrolo Quinoline Quinone (PQQ) electron receptor. The complete reaction creates a harmless electrical current that the meter interprets as blood glucose.

Laboratory estimation of sugar levels of venous whole blood is done by glucose oxidase peroxidase method. Two to three millilitres of whole blood is centrifuged at 2500 rpm for 10 minutes to separate plasma, and the blood glucose is measured by reflectance photometry.

Ethical Considerations

The study was initiated only after obtaining Institutional Ethical Committee (IEC) approval. Informed consent was taken from the patient or the patient's next of kin prior to the study.

Statistical analysis

ANOVA test was performed to check if the means of the three blood samples are statistically significant to each other. Pearson Correlation was used to determine whether POC capillary and venous blood sugar measurements accurately correlate with laboratory estimation of venous blood sugar at different doses of Noradrenaline infusion.

Results

One hundred consecutive patients with shock on Noradrenaline infusion admitted to ICU were categorised in to 2 groups (Group A and Group B), with 50 patients in each group. Patients in both groups were comparable with respect to Age, Hb%, Platelet count etc.. as shown in Table 1.

Mean values of POC capillary, POC venous and laboratory venous blood glucose levels are shown in Table 2. ANOVA test was performed which showed that there was no statistical significance between the blood samples and also between the groups. F value for both the groups is 0.022 and p value is 0.978.

Pearson Correlation was used to determine whether capillary and venous blood sugar measurements accurately correlate with laboratory estimation of venous blood sugar at different doses of Noradrenaline Infusion. There was a significant correlation between the capillary, venous and lab venous blood sugar measurements in both the groups. In Group A, stronger correlation was found between POC venous and lab venous blood sugar measurements ($r=0.886$, $p<0.01$) whereas in Group B, stronger correlation was found between POC capillary and lab venous blood sugar measurements ($r=0.897$, $p<0.01$) as shown in Table 3.

Table 1: Characteristics of patients who received 5 mcg and 10 mcg Noradrenaline.

Parameters	5 mcg (Group A) Mean ± SD (Std. Deviation)	10 mcg (Group B) Mean ± SD (Std. Deviation)
Age	53.70 ± 17.78	50.32 ± 19.44
Hb%	10.79 ± 2.71	10.91 ± 2.43
Platelet count	1.85 ± 0.97	1.88 ± 0.94
Capillary Blood Sugar	141.52 ± 58.49	158.12 ± 73.48
Venous Blood Sugar	139.10 ± 57.47	160.94 ± 69.64
Lab Venous Blood Sugar	140.24 ± 57.49	158.36 ± 81.09

Table 2: Mean values of POC capillary, POC venous and Lab venous blood glucose levels

Nor Adrenaline Dosage	Parameters	Mean ± SD (Std. Deviation)	ANOVA	
			$F_{(df btw + df wthn)}$	p value
5 mcg	Capillary Blood Sugar	141.52 ± 58.49	$0.022_{(2,147)}$	0.978
	Venous Blood Sugar	139.10 ± 57.47		
	Lab Venous Blood Sugar	140.24 ± 57.49		
10 mcg	Capillary Blood Sugar	158.12 ± 73.48	$0.022_{(2,147)}$	0.978
	Venous Blood Sugar	160.94 ± 69.64		
	Lab Venous Blood Sugar	158.36 ± 81.09		

Table 3: Correlation among patients who received 5 mcg and 10 mcg Noradrenaline.

Nor Adrenaline Dosage	Pearson Correlation	Capillary Blood Sugar	Venous Blood Sugar	Lab Venous Blood Sugar
5mcg	Capillary Blood Sugar	1	.977**	.864**
	Venous Blood Sugar	.977**	1	.886**
	Lab Venous Blood Sugar	.864**	.886**	1
10mcg	Capillary Blood Sugar	1	.982**	.897**
	Venous Blood Sugar	.982**	1	.891**
	Lab Venous Blood Sugar	.897**	.891**	1

**. Correlation is significant at the 0.01 level (2-tailed).

Discussion

Maintaining normoglycemia is important in managing patients admitted to critical care unit, because both hypoglycemia and hyperglycemia increase morbidity and mortality [6,7,8,9].

POC glucometers are widely used to monitor blood sugar levels in the ICU. In the present study efforts were made to eliminate various confounding factors that can affect POC glucometer recordings such as patients with MAP < 65 (with or without vasopressors), low haematocrit (<20%), severe hypoxia (SpO_2<90 with O_2), severe acidosis (pH < 7.20), hyperbilirubinemia and patients on medications such as acetaminophen, mannitol, ascorbic acid [10,11,12,13,14].

Studies done by Petersen et al., Ata Mahmoodpoor et al., Carlo Jan Pati-an Garingarao et al. and Deven Juneja et al recommended that, POC blood glucose estimation using arterial or venous blood would be more appropriate in hemodynamically unstable patients [2,15,16,17]. Accordingly, in the present study, we preferred venous blood because, arterial cannulations were not routinely done for all patients admitted to our ICU.

As noradrenaline is the most commonly initiated vasopressor for patients admitted to ICU in shock and proven to influence POC glucometer measurements, we decided to evaluate the concordance of 2 different doses of noradrenaline infusion that is 5 mcg/min and 10 mcg/min on POC glucometer measurements using capillary blood with venous blood in patients with shock.

According to the revised ISO 15197:2013 criteria, glucometers' accuracy is acceptable, if >95% of POC blood sugar values fall within ± 15% of the reference method for blood glucose values ≥100 mg/dl and fall within ±15 mg/dl for blood glucose values <100 mg/dl [18].

Study done by M. Fekih Hassen et al., reported that, capillary finger stick blood glucose measurement did not correlate with serum glucose levels in patients with vasopressor infusion when compared to patients without vasopressors, there was more than 40 mg/dL difference in about 40% of patients [19]. The vasopressors used in the study were Dopamine, Adrenaline and Noradrenaline.

Study done by Pulzi et al. reported that, in patients receiving Noradrenaline infusion, POC blood glucose measurement using arterial blood had more concordance with laboratory values than POC measurements done with capillary blood sample [20]. Their study further suggested that, patients not on Noradrenaline showed better concordance (81.5%) than patients on Noradrenaline infusions (71%).

Study done by Carlo Jan Pati-an Garigarao et al. noted that, POC glucometer met minimum ISO 2003 accuracy criteria in 95.7% normotensive patients, whereas the accuracy decreased to 79.8% in hypotensive patients on vasopressors [16].

None of the above mentioned studies met revised ISO 15197: 2013 criteria, which is acceptable accuracy norm for bedside glucometers.

On the contrary, our study results did not correlate with the above mentioned studies. According to our data, there is no significant difference in the blood sugar levels done using POC glucometer with capillary or venous sample and the results also correlated well with the reference laboratory values done with venous blood. Furthermore, there was no significant difference in blood sugar levels in patients with different doses of noradrenaline infusion. According to our analysis we found that, when confounding factors are avoided or minimized, the POC glucometer estimation of capillary blood glucose correlates better with laboratory values irrespective of the dose of vasoconstrictors used.

Conclusion

According to our study, POC glucometer measurements using capillary blood quite accurately estimate blood glucose levels even in patients on vasopressors provided there are no confounding factors that can influence the results. When there are few confounding factors it would be ideal to get blood sugar estimation using venous or arterial blood either with POC glucometer or estimate the blood glucose in the laboratory.

There are couple of limitations to our study, firstly, this is a single centered study with small sample size and secondly, we did not include patients requiring two or more vasopressors. But, with patients on vasopressors, studies suggest POC blood sugar measurement using central venous blood or using automated blood analysers would be more appropriate [21,22]. Further studies with larger sample size, using more advanced methods and involving patients with more vasopressors might draw better conclusions.

Conflict of Interest: None

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