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Research Article

Congruency of Nasal Alar Pulse Oximetry and Arterial Blood Analysis in Patients with Burns Hospitalized in ICU

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Abstract

Introduction: Several pathological conditions can reduce blood supply to the organs, among which burns can be mentioned. By developing the volume depletion and reducing the cardiac contractility, burns can cause hypoperfusion. Further, in ICUs, since the finger pulse oximetryis commonly used instead of the measurement of the nasal alar oxygen saturation, the use of finger probe restricts pulse oximetry, especially in the cases of burns in four limbs. The present study is aimed to investigate the consistency between the nasal ala pulse Oximetry and arterial blood analysis in the patients with burns in 4 limbs and ears.

Materials and Methods: This study was conducted by evaluating diagnostic tests on all of the 18- to 60-year-old patients (N=51) with burns in four limbs and ears hospitalized in ICU. In the first 24h of the hospitalization, nasal alar pulse oximetry was performed and, simultaneously, an arterial blood specimen was sent to the laboratory to determine the oxygen saturation level. The obtained data were statistically analyzed using SPSS software.

Results: According to the obtained results, 31.4% of the patients were female and 68.6% were male. The most frequent cause of the burns was gasoline burning (21.6%). Wilcoxon test revealed that the average percentage of the arterial blood oxygen saturation in pulse oximetry method was significantly higher than the arterial blood specimens (P = 0.0001). Furthermore, using the intraclass correlation, the consistency of the average percentage of the arterial blood oxygen saturation in both methods of pulse oximetry and arterial blood gas analysis was reported as weak (ICC= 0.234). Regarding gender, the consistency level was reported as weak (ICC= 0.275) and very weak (ICC= 0.115) in males and females, respectively. With respect to the age groups, in the 41-50-year-old age group, very good consistency was observed between the recorded values of the arterial blood oxygen saturation using nasal alar pulse oximetry and the arterial blood specimenin the patients with burns in four organs and ears; however, it was reported to be weak in the other age ranges.

Conclusion: Level of consistency between the results of the percentage of the arterial blood oxygen saturation obtained from the methods of nasal alar pulse oximetry and arterial blood specimens was moderate and weak.

Keywords: Burns, Nose, Oximetry, Succinates

Introduction

Historically, burn injury has had poor prognosis. Advances in resuscitation by intravenous fluids, early removal of burn wounds, as well as grafting have increased the survival rate even for the patients with severe burns [1].

The initial assessment of the burned patient includes four vital assessments: management of the airway, assessment of other injuries, estimation of the burn extent, and diagnosis of carbon monoxide and cyanide poisoning. A severe and fast airway edema caused by direct thermal damage to the upper respiratory tract and smoke inhalation can be a potential deadly threat. Thus, it is vital to predict the need for intubation and create a primary safe airway [1].

Simultaneous with the initial examinations, the peripheral intravenous catheters with big holes should be inserted and fluid resuscitation should be initiated.

One of the most important factors in premature deaths in burns is carbon monoxide (CO) poisoning due to smoke inhalation. Carbon monoxide affinity for hemoglobin is quite 200-250 times more than oxygen affinity for hemoglobin, reducing the normal level of oxygenated hemoglobin that can quickly lead to anoxia and death. Unexpected neurological symptoms should be suspicious and the arterial hemoglobin carboxy levels should be measured because pulse oximetry is falsely high in such cases.

Thermal injuries deeply affect the systemic circulation; in particular, severe injuries disturb the microcirculation and result in cardiac dysfunctions. Hemodynamic management is a crucial part of the perioperative cares. Evaluating the adequacy of resuscitation and hemodynamic status of the patient is very important for anesthesiologists. Subsequent to the massive thermal injury, the burn shock occurs due to the intravascular hypovolemia and, in some cases, myocardial depression. The burn shock is detected by reduced cardiac output, increased systemic vascular resistance, and tissue hypoperfusion. Intravascular hypovolemia is caused by the microcirculation changes in both burned and non-burned tissues and accumulation of abundant fluid in the interstitial tissue.The skin lymph flow is immediately increased after the burn and remains in the increased state for almost 48 h. An extensive fluid shift occurs due to the variation of the factors affecting the Starling balance [2].

The burn-caused injury is unique regarding the microcirculatory dysfunction .Some disorders occur in all the Starling forces. Formation of edema in burned skin often occurs as an immediate consequence of the negative tissue hydrostatic pressure. Other hydraulic forces with micro vascular permeability lead to the leakage of fluid protein into the interstitial space. Although fluid replacement therapy is required for the treatment of hypovolemia, edema is exacerbated by the dilution of the plasma proteins (reduction of plasma oncotic pressure). The main effect of these changes is the development of a severe edema during 24-48h after the thermal injury and intravascular volume loss [2].

The hypotension associated with burn injury can be also resulted from myocardial depression.The thermal damage leads to the release of the inflammatory mediators such as tissue necrosis factor alpha (TNF œ), interleukin-I, and prostaglandins. TNF-œ and IL-I have inhibitory effects on myocardium. In the American institutes for burn injuries, trans esophageal echocardiography (TEE) is routinely carried out for the patients with severe injuries at the first 72 h of hospitalization. The information obtained from these observations indicates that considerable percentage of the patients has certain systolic dysfunction which is associated with the prolonged hospitalization in ICUs. If the patient survives after the initial burn shock and is adequately resuscitated, the inflammation caused by the hyper dynamic circulation will occur. This massive inflammation state or systemic inflammatory response syndrome (SIRS) is diagnosed by hypotension, tachycardia, certain reduction in the systemic vascular resistance, and increase in the cardiac output. SIRS starts with tachycardia, tachypnea, fever, and leukocytosis and leads to refractory hypotension and dysfunctions of multiple organs. The use of various combinations such as crystalloids, colloids, and hypertonic fluids has been recommended by several fluid resuscitation protocols [2].

Since 1986, pulse oximetry has been introduced as a standard monitoring by American Society of Anesthesia (ASA) and, subsequently, as a minimum standard by WHO and World Federation Societies of Anesthesiologists [3]. According to the WHO's standards, the use of pulse oximetry is a part of a safe surgery checklist [4].

The purpose of standard pulse Oximetry is non-invasive practical and continuous assessment and measurement of the arterial blood oxygen saturation degree [5]. Typically, a probe is placed on the patient's finger. The accuracy of pulse oximetry is not clearly comparable with the laboratory values, especially in the patients with anemia [5]. This unique advantage is due to the ability of continuous monitoring of hemoglobin saturation with oxygen and its simple and non-invasive function in providing the conditions for the measurement of the cardiorespiratory function [5]. Because of the pulse Oximetry capability in rapid diagnosis of hypoxemia, this device has become a standard care during anesthesia in the recovery room as well as the intensive care unit [3,6]. Moreover, pulse oximetry should be used for all the patients who have undergone sedation and may develop hypoxia [5].

Oximeters are devices that facilitate measuring the concentration of different types of hemoglobin. Oximeters emit the red and infrared light to the tissue bed. At the finger tip, light absorption is done by (pulsed) arterial blood. AC and DC components are the lights absorbed by the tissue bed [4,5].

Since pulse Oximetry identifies the arterial and venous blood flows by the pulse and shows the arterial blood oxygen saturation, the procedures that increase the venous flow or change the pulsatile status can disturb the ability of pulse Oximetry to estimate the arterial blood oxygen saturation [3,5,7].

One of the main problems of pulse Oximetry is the artifacts which are mainly caused by four major reasons: Ambient light, Low perfusion (weak pulse and finally low AC/DC ratio), Venous blood pulse (by patient´s movement), other light absorbers (abnormal hemoglobin by met hemoglobin, carboxyhemoglobin, and use of dyes and lacquer).

All of these problems and artifacts create noise signal and lead to abnormal values of SIO_2 [6].

Movement, low blood pressure (hypotension), and anemia are among the factors that might lead to the formation of the artifacts and, as a result, reduce the accuracy of pulse oximetry [7].

Fingers are the most common organs used for the placement of pulse oximetry probes; however, they might not be very suitable because the decreased blood supply caused by numerous reasons might result in the reduction ofthe pulsating signals and, consequently, decreased accuracy of pulse oximetry in showing the extent of the arterial blood oxygen saturation [3,8]. In addition, the use of fingers might be limited by injury, burns, presence in the surgical field, blood flow cut off by the barometer cuff, folding the arm, and trembling [9,10]. Some parts of the head such as ears, forehead, cheeks, tongue, and nasal ala are suggested for putting the probes because the blood supply to these organs provides enough pulsating signals even in the presence of significant pathologies; furthermore, the duration of non-saturation diagnosis of which is measured from some places on the head is shorter than shorter fingers [11,12].

Several factors can reduce blood supply to the organs, among which burns can be mentioned [13]. By developing hypovolemia (volume depletion) and reducing cardiac contractility, burns can cause hypoperfusion. Also, burning the organs or placement of the organ in the surgical field is one of the reasons that might restrict the use of the finger probe for pulse Oximetry, especially in the cases of burns in four organs [5,14]. Regarding the fact that, in hospital wards, finger pulse oximetry is commonly used and other organs are used less frequently and, since measurement of the nasal ala arterial blood oxygen saturation is not commonly applied and the reflectance pulse Oximetry probe for burned patients is not available in the market, the present study was aimed to assess the accuracy of nasal ala pulse Oximetry in the patients with burns in four limbs and ears.

Materials and Methods

After approval of the study protocol and its confirmation by the Vice Chancellor for Research of Faculty of Medicine, this study was conducted through the evaluation of the diagnostic tests (cross-sectional) on all the patients with burns in four limbs and ears admitted to the ICU at Velayat Hospital.

All 18-60-years-old patients with burns in four limbs and ears during 6 months period(Aug2015-Feb2016) underwent the simultaneous nasal ala pulse oximetry with neonatal probes (Masimo) using a fixed pulse Oximetry device (Saadat, Iran)at the first 24h of hospitalization (after obtaining their informed consent). Simultaneously, the arterial blood specimens of the patients were collected as 2cc heparin from the femoral area through aseptic technique and sent to the hospital laboratory to determine the arterial blood oxygen saturation.

Other information of the patients including demographic data such as age, sex, and burn cause along with the oxygen saturation measured by nasal ala pulse oximetry and ABG was recorded in a researcher-made form.

Those patients on whose nasal ala probe insertion was impossible or whose arterial blood sampling was impossible due to blood gas analysis were excluded from the study.

The statistical analysis of the obtained data was performed using SPSS (v.19) software.

Result

The present study was conducted on 51 patients. Based on the obtained results, 31.4% of the patients were female and 68.6% were male. The age frequency distribution of the patients is presented in Table 1. The most frequent cause of the burns was gasoline burning (21.6%) (Table 2). Wilcoxon test showed that the average percentage of arterial blood oxygen saturation in pulse oximetry method was significantly higher than that of the arterial blood specimens (P=0.0001) (Table 3). Further, using the intraclass correlation, the consistency of the average percentage of the arterial blood oxygen saturation in pulse oximetry and arterial blood specimen methods was reported as weak (ICC=0.234) (Table 4). Regarding gender, the consistency level was reported to be weak in males (ICC=0.275) and very weak in females(ICC=0.115).Considering the age group, in the 41-50-year-old group, the consistency between the recorded values of the arterial blood oxygen saturation with nasal ala pulse oximetry and arterial blood specimen in the patients with burns in four organs and ears was very good (ICC=0.97),while it was reported as weak in other age groups (Table 5).

Age range	No.	Percentage
Below 20 years old	7	13.7
21-30 years old	9	17.6
31-40 years old	15	29.4
41-50 years old	8	15.7
51-60 years old	6	11.8
Above 60 years old	6	11.8
Total	51	100

Table 1: Age frequency distribution of patients with burns in four organs and ears

Burn cause	No.	Percentage
Tyner	8	15.7
Fire	8	15.7
Boiled water	9	17.6
Gasoline	11	21.6
Gas explosion	10	19.6
Oil-oil light	3	5.9
Car crash	1	2
Alcohol	1	2
Total	51	100

Table 2: Burn cause frequency distribution of patients with burns in four organs and ears

Arterial blood oxygen saturation recording method	No.	Mean	SD	Z value	Statistical estimation
Arterial blood specimen	51	90.63	10.32	4.83	P=0.001
Nasal ala pulse Oximetry	51	97.33	4.71		

Table 3: Comparing recorded values of arterial blood oxygen saturation with ala pulse oximetry and arterial blood specimen

Arterial blood oxygen saturation recording method	No.	Mean	SD	Intraclass correlation	Statistical estimation
Arterial blood specimen	51	90.63	10.32	0.234	P=0.048
Nasal ala pulse oximetry	51	97.33	4.71		

Table 4: Investigating consistency of recorded values of arterial blood oxygen saturation by septum pulse oximetry and arterial blood specimens in patients

Age range	Arterial blood oxygen saturation recording method	No.	Mean	SD	Intraclass correlation	Statistical estimation
Below 20 years old	Arterial blood specimen	7	97.42	1.13	0.6	P=0.94
	Nasal ala pulse oximetry	7	98.71	1.25		
21-30 years old	Arterial blood specimen	9	91.77	8.62	0.17	P=0.58
	Nasal ala pulse oximetry	9	98	2.39		
31-40 years old	Arterial blood specimen	15	86.28	12.8	0.11	P=0.41
	Nasal ala pulse oximetry	15	98.46	2.13		
41-50 years old	Arterial blood specimen	8	91.87	9.47	0.97	P=0.0001
	Nasal ala pulse oximetry	8	93.87	10.28		
51-60 years old	Arterial blood specimen	6	87.16	13.37	0.47	P=0.31
	Nasal ala pulse oximetry	6	98	4		
Above 60 years old	Arterial blood specimen	6	93.66	5.12	0.27	P=0.601
	Nasal ala pulse oximetry	6	95.83	2.22		

Table 5: Investigating consistency of recorded values of arterial blood oxygen saturation by ala pulse Oximetry and arterial blood specimens in patients considering age groups

Discussion

In the study by Secker, et al. (1997), the patients were divided into two groups with low vascular resistance and normal vascular resistance, and the arterial blood oxygen saturation was measured by pulse Oximetry and compared with the O_2Sat level obtained from the arterial blood specimens. Finally, they concluded that under low vascular resistance conditions, pulse Oximetry showed O_2Sat level significantly lower than the real level (P<0.001).In the present study, the arterial blood oxygen saturation in pulse Oximetry method was significantly higher than the ABG method (pulse Oximetry: 98.72 and ABG: 95.68, P=0.0001). Results of the present study were inconsistent with those of the above-mentioned work. This inconsistency could be due to the use of nasal ala for pulse oximetry in the present study. Regarding the fact that the nasal ala blood is supplied directly from the branches of the carotid artery and since in hypotensive conditions, the rate of blood supply for vital organs such as heart and brain is higher than that of other organs including the fingers, higher level of O_2Sat in pulse oximetry could be justified [15,16].

In the retrospective cohort study by Wilson et al. in Canada published in 2010, 88 patients with acute sepsis and septic shock were investigated. These patients were classified into two hypoxemic and non-hypoxemic groups, and the O_2Sat level was compared using pulse oximetry and ABG methods. They found that in the pulse oximetry method, the O_2Sat level was higher in both hypoxemic and non-hypoxemic groups (mean difference: 2.75%); however, this difference was intensified in the presence of hypoxemia (mean difference in the hypoxemic and non-hypoxemic groupswas 4.9% and1.89%, respectively). In the present study, O_2Sat level in pulse Oximetry was higher than ABG, which was consistent with the above-mentioned work [3].

In the research by Brimacombeet al. in Australia whose results were published in 2000, pulse Oximetry was applied to two 47- and 64-year-old male patients with septic shock and multiorgan failure, for whom the finger pulse Oximetry was impossible, using the pediatric pulse Oximetry probe behind the endotracheal tube and then they obtained results were compared to the ABG method [8].

In another study by Yu and Liu published in 2007, the results of pulse oximetry with pediatric pulse Oximetry probe in the vicinity of the tracheal tube were compared with the O_2Sat results derived from simultaneous ABG in two patients (a 32-year-old woman and a 50-year-old man), for whom the finger pulse oximetry was not possible due to the shock [12].

Results of both studies confirmed the pharyngeal oximetry. In the present research, the consistency level of the arterial blood oxygen saturation in two methods of pulse oximetry and ABG was moderate and good only in the age groupof 31-40 years old, while it was weak in the other age groups. In terms of gender, the level of consistency between the two methods in men and women was weak (ICC = 0.33) and moderate (ICC = 0.58), respectively.

In conclusion, based on the obtained results, in the patients with burns in four limbs and ears, for whom the finger and earlobe pulse oximetry and ABG were impossible, nasal ala pulse Oximetry could be used instead of ABG and finger pulse oximetry only in the 31-40-year-old age group, especially in women. However, in the other age groups, this consistency was weak and the O_2Sat level was likely to be indicated falsely higher than the real level when the patient was in hypoxic conditions. And this finding seems one of limitations of our study.

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Footnotes

Authors' Contribution

Soudabeh Haddadi: study design, and conduct, datacollection, and manuscript preparation; Shideh Marzban : study design, data collection; Arman Parvizi: study design, data collection, and manuscript preparation; Arsalan Dadashi : study design, data collection; Zahra Atrkar Roshan : data analysis, manuscript preparation; SeyedehSiminMirmohamadi Kiyarash : study design, and conduct, datacollection, and manuscript preparation and Zakiyeh Jafariparvar: : study design, datacollection, and manuscript preparation.

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