USE OF WRIST OR ANKLE AS SUBSTITUTE SITES FOR PLACEMENT OF PULSE OXIMETER IN NEONATAL INTENSIVE CARE

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ABSTRACT

Introduction

Pulse oximetry is widely used in Neonatal intensive care setting. Both wrist and ankle are widely used as substitute sites for probe placement in place of more commonly used sites such as palm and sole. However, little is known about the accuracy and response time of pulse oximetry when the probe is placed at wrist or ankle of neonates.

Objectives

The primary objective of this study was to compare the values of SpO2 reading at wrist with palm and ankle with sole in terms of correlation and accuracy. The secondary objective was to compare the response time to get a valid SpO2 reading at wrist with palm and ankle with sole.

Methodology

This was a prospective observational study conducted at Neonatal intensive care unit of Biratnagar Hospital from October 2020 to January 2021. After approval from institutional review committee, a total of 152 consecutive neonates admitted in NICU of either gender both term and preterm were enrolled for the study. Recording of SpO2, heart rate and response time was done by two pulse oximeters simultaneously. The SpO2 measurements at right palm and right wrist were recorded at 0, 30 seconds and 1 minute then simultaneous recording was done for the left palm and left wrist, right sole and ankle and left sole and ankle. Response time was also recorded for each of the readings.

Results

The results of our study show good correlation using regression analysis and good agreement using Bland-Altman plots between the values of SpO2 reading of paired measurements. The response times of the paired measurements were not significantly different. There was good correlation between the SpO2 of paired measurements. The correlation for right palm and wrist was 0.927 (P-value = 0.01) and that of left palm and wrist was 0.85 (P-value = 0.01). Similarly the correlation between right sole and ankle and left sole and ankle were 0.937 (P-value = 0.01) and 0.875 (P-value = 0.01) respectively. The bias (average difference) and precision (standard deviation of differences) were calculated. The bias and precision of the right palm and wrist, left palm and wrist, right ankle and sole; and left ankle and sole were (-0.00289, 0.76105), (-0.17982, 0.95049), (-0.03509, 0.786342) and (-0.14474, 0.859241) respectively.

Conclusion

Wrist and ankle can be used as substitute sites for pulse oximter placement in neonatal intensive care setting.

KEYWORDS

neonate, probe site, pulse oximeter, substitute sites

INTRODUCTION

The arterial oxygen saturation using pulse oximetry is commonly employed in neonatal intensive care as the fifth vital sign. The most important advantage of pulse oximeter is the capability to provide continuous, safe and effective monitoring of blood oxygenation non-invasively at the patient's bedside without the need for calibration.[1,2] Various factors may lead to inaccuracies of pulse oximetry in clinical practice. Factors like decreased cardiac output, increased or decreased systemic vascular resistance, hypothermia, elevated or dependent limb position, venous engorgement and regional anesthesia have been observed even if the device is functioning properly and is free from external interference.[3-5] Motion may interfere with the proper acquisition of reliable data or the interpretation of pulse oximeter readings.[6]

The measurement of SpO2 from different probe site may also affect accuracy. Finger probes appear to be more accurate than forehead, nose or earlobe probes during low perfusion states.[7] This can be a problem in newborn babies. Infants both term and preterm tend to have poor peripheral perfusion (acrocyanosis) in the first few hours of life. This can result in low signal strength and can affect the detection or processing of the biological signals thereby affecting the accuracy of pulse oximetry resulting in inaccurate signal and false alarm.[4,6,7] Moreover, choice of probe site may be difficult in sick infants due to intravenous lines for fluid infusion, or heparin locks for medication infusions on the dorsum of hands and feet. Wrist or ankles have been an alternative site for pulse oximeter probe location. However, little is known about the accuracy and response time of pulse oximetry when the probe is placed at wrist or ankle of neonates. Pulse oximeter response time is important for resuscitation purpose.

Very few studies have specifically evaluated pulse oximetry at the wrist and the ankle compared with more commonly used sites, the palm and the sole in newborn infants, or determined if there is any significant difference in the time to detect hypoxemia among them. So in this study, we have observed the correlation and agreement between SpO2 measured on the wrist with SpO2 measured on ipsilateral palm and the correlation and agreement between SpO2 measured on ankle is comparable with SpO2 measured on ipsilateral sole. We have also compared the response time to get a valid reading from the pulse oximeter probes placed at different sites to detect changes in oxygen saturation compared with more usual monitoring sites.

METHODOLOGY

This was a prospective observational study conducted at Neonatal intensive care unit of Biratnagar Hospital from October 2020 to January 2021. After approval from the institutional review committee, a total of 152 consecutive neonates admitted in NICU of either gender both term and preterm were enrolled for the study. Exclusion criteria included neonates whose parents were not willing to participate in the study, those in shock and those with core body temperature < 35°C or getting inotrope at high dose (Dopamin/Dobutamine > 10mcg/kg/min) and neonates with multiple congenital malformations.

The finger print transmittance pulse oximeter manufactured by Technocare Medisystems, Gujarat, India was used for this study. Recording of SpO2, heart rate and response time was done by two pulse oximeters simultaneously. The SpO2 measurements at right palm and right wrist were recorded at 0, 30 seconds and 1 minute then simultaneous recording was done for the left palm and left wrist, right sole and ankle and left sole and ankle. At the same time, heart rate as well as response time was also recorded for each of the readings. Response time was noted as the time to obtain a valid SpO2 reading after placement of pulse oximeter. In neonates receiving phototherapy, the light was temporarily turned off during the procedure.

Data analysis was done using SPSS version 21. The relationship between the paired SpO2 measurements was analyzed using regression analysis. Bland-Altman plots were derived from the average difference and standard deviation of differences between the paired data. In addition, the mean and standard deviation of the paired differences were calculated. P-value less than 0.05 were considered significant for all tests.

RESULTS

A total of 152 patients were enrolled for the study and 456 paired measurements were made in between them. The mean birth weight of infants was 3182.32±458.9 gms, the median gestational age was 39 weeks and the median postnatal age was 3 days. The M: F ratio was 1.23.Table 1 shows the patient characteristics.

Table 1: Patient Characteristics [Values are expressed in (Mean±SD, range), (Median, IQR)* and (frequency, %)**]

	Mean ± SD	Range
Weight (gms)	3182.32 ± 458.9	1300 – 3989
Heart Rate (bpm)	130.79 ± 15.83	100 – 162
Mean Arterial Pressure (mmHg)	66.4 ± 9.37	49 – 87
Hb (gm/dL)	15.46 ± 1.43	13 – 18
Temperature (°C)	36.32 ± 0.4	35.6 – 37
Gestational age (weeks)*	39	38 – 40
Post natal age (days)*	3	2 – 4
Male**	84	55.3
Female**	68	44.7
Ventilation**	3	2
Vasopressors**	33	21.7

With 152 patients enrolled into the study, 456 paired measurements were made in between them. Mean SpO2

readings and response time were calculated for each reading and paired correlation was derived using regression analysis (Pearson's correlation coefficient). The Bland-Altman plots were derived to analyze the bias and precision in between the paired observations. The paired correlation for SpO2 and the paired comparison in between response time are shown in Table 2.

Table 2: Paired correlation between SPO2 measurements (*P-value for correlation)

Probe site	SPO2 (%) Mean ± SD	Correlation coefficient (r)	P–Value*
Right Palm	96.18 ± 1.93	0.927	0.01
Right Wrist	96.18 ± 2.02		
Left Palm	96.22 ± 1.77	0.85	0.01
Left Wrist	96.40 ± 1.68		
Right Sole	96.53 ± 2.21	0.937	0.01
Right Ankle	96.56 ± 2.21		
Left Sole	96.37 ± 1.73	0.875	0.01
Left Ankle	96.51 ± 1.71		

Figure 1 (A) and 1(B) shows the linear relationship between SpO2 measured at the right palm and the right wrist and SpO2 measured at the left palm and left wrist respectively. There was good correlation of SpO2 at right palm and right wrist and between left palm and left wrist.

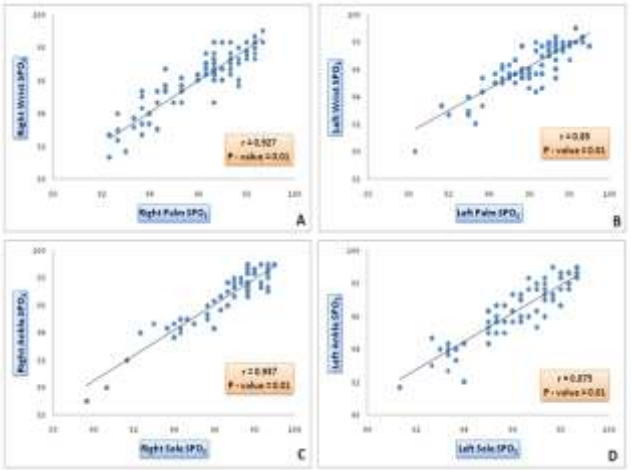

Figure 1: Linear correlation between paired measurements; Right palm-Right Wrist (A), Left palm-Left wrist (B), Right sole-Right ankle (C), Left sole-Left ankle (D)

Figure 1(C) and 1(D) shows the linear relationship between SpO2 measured at right sole and right ankle and SpO2 measured at left sole and left ankle respectively. There was good correlation between the paired measurements.

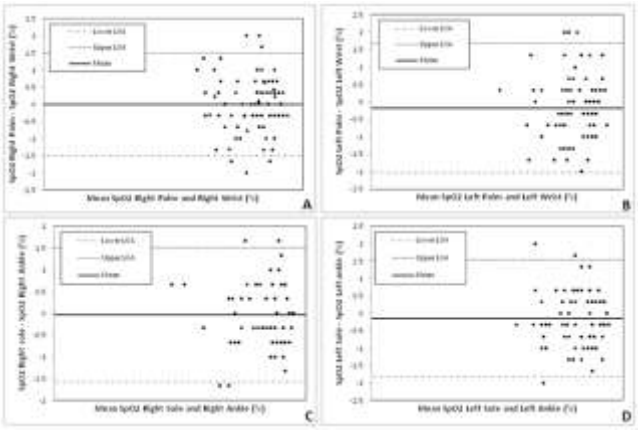

Figure 2: Bland-Altman plot for paired measurements; Right palm-Right Wrist (A), Left palm-Left wrist (B), Right sole-Right ankle (C), Left sole-Left ankle (D)

The Bland-Altman plots were derived from the results for each paired measurements of SpO2 (Figure 2). There was a good agreement between the each of the paired measurements implying good precision of the measurements. The average difference between the paired measurements of SpO2 (bias) and the standard deviation of differences between the paired measurements (precision) are shown in Table 3.

Table 3: Average difference, SD of differences and Response time for paired measurements

Probe site	Average difference	SD of differences	Response time (sec) Mean ± SD	P - Value
Right Palm	-0.0029	0.76105	11.75 ± 5.28	0.863
Right Wrist			11.66 ± 5.75	
Left Palm	-0.1798	0.95049	11.36 ± 4.72	0.747
Left Wrist			11.22 ± 5.10	
Right Sole	-0.0351	0.78634	12.66 ± 6.88	0.45
Right Ankle			12.32 ± 5.96	
Left Sole	-0.1447	0.85924	12.82 ± 5.8	0.172
Left Ankle			12.14 ± 6.03	

The time taken to obtain the initial SpO2 measurements (response time) from the probe sites was also compared. The paired measurements of SpO2 between different sites had no significant difference (P-value >0.05). Table 3 shows paired comparison between response times of the paired measurements.

DISCUSSION

Pulse oximetry is a valuable, noninvasive method for detecting hypoxemia in neonatal intensive care. Because of its significance; its measurement must be accurate, reliable and reproducible. The choice of probe placement may affect the accuracy of pulse oximeter reading. Both palm and sole are commonly used sites for probe placement in neonates. Interestingly, wrist and ankle are also commonly used as an alternative site for pulse oximeter probe placement in

neonates though with very little evidence related to its use in these sites. So, this study was planned to answer whether wrist and ankle can be the alternative site for pulse oximeter probe placement in neonatal care setting.

Our study shows good correlation (p value = 0.01) and good agreement between the SpO2 measurements of the each pair of probe placements. Various studies have been carried out to study the SpO2 measurements at different sites. One study done in neonatal age group with similar methodology to ours has demonstrated a good correlation and good agreement between the paired SpO2 measurements.[8] A study done in infants < 3 months of age undergoing cardiac surgery with cardiopulmonary bypass evaluated pulse oximeter readings from probes placed at hand and foot compared to SaO2 derived from simultaneously drawn arterial blood samples.[9] The authors found no significant difference between pulse oximeter readings obtained from the two sites. Another study analyzed pulse oximeter saturation data from upper extremities (finger and palm) and lower extremities (toe and sole) of fifty critically ill children, newborn to 2 years of age.[10] For SpO2> 90%, the authors found no significant difference in bias and precision when finger and palm were compared whereas a significant difference in bias and precision was reported when toe and sole were compared. This is in contrast to our study as well as Phattraprayoon N et al[8] where sole and ankle measurements also had correlated results. This is probably because both our study as well as Phattraprayoon N et al[8] have studied neonatal SpO2 readings with most of the readingsbeing> 90% whereas Sedaghat-Yazdi F et al[10] have studied SpO2 reading from critically ill cyanosed children.

Response time is the time required to get a valid SpO2 reading. The response time in between the various paired measurements was comparable in our study. This result is similar to a previous study where paired measurements from palm and wrist; and sole and ankle on either side were compared in neonates.[8] Other studies have compared a more centrally placed sensor to a peripherally placed sensor.[11-13] In a nutshell, the results from these studies indicate the more distal placement of the probe leads to increase in response time meaning delay in detection of events such as desaturation or resaturation indicating increased central to peripheral circulation time. Comparable value of response time in our study is probably because of the anatomic proximity of placement of the probes.

LIMITATIONS OF THE STUDY

Most of the readings of SpO2 were > 90% in our study and patients were hemodynamically stable at the time of data collection. So, accuracy of Spo2 reading at wrist or ankle for lower SpO2 and hemodynamic instability cannot be verified.

CONCLUSION

The results of our study suggest wrist and ankle can be used as substitute site in the place of palm and sole for SpO2 measurement in Neonatal intensive care setting in hemodynamically stable neonates. Further studies should be planned to study the accuracy of SpO2 reading in lower SpO2 reading and also in hemodynamically unstable patients.

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CONFLICTS OF INTEREST

None

FINANCIAL DISCLOSURE

None

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