Comparison of Cerebral Oximeter and Pulse Oximeter Values in the First 72 Hours in Premature, Asphyctic and Healthy Newborns

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ABSTRACT

Aim: *The monitoring of oxygenation is essential for providing patient safety and optimal results. We aimed to determine brain oxygen saturation values in healthy, asphyctic and premature newborns and to compare cerebral oximeter and pulse oximeter values in the first 72 hours of life in neonatal intensive care units.*

Methods: *This study was conducted at the neonatal intensive care unit (NICU) of Van Yüzüncü Yil University Research and Administration Hospital. Seventy-five neonatal infants were included in the study (28 asphyxia, 24 premature and 23 mature healthy infants for control group). All infants were studied within the first 72 hours of life. We used a Somanetics 5100C cerebral oximeter (INVOS cerebral/somatic oximeter, Troy, MI, USA). The oxygen saturation information was collected by a Nellcor N-560 pulse oximeter (Nellcor-Puriton Bennet Inc, Pleasanton, CA, USA).*

Results: *In the asphyxia group, the cerebral oximeter average was 76.85 ± 14.1, the pulse oximeter average was 91.86 ± 5.9 and the heart rate average was 139.91 ± 22.3. Among the premature group, the cerebral oximeter average was 79.08 ± 9.04, the pulse oximeter average was 92.01 ± 5.3 and the heart rate average was 135.35 ± 17.03. In the control group, the cerebral oximeter average was 77.56 ± 7.6, the pulse oximeter average was 92.82 ± 3.8 and the heart rate average was 127.04 ± 19.7.*

Conclusion: *Cerebral oximeter is a promising modality in bedside monitoring in neonatal intensive care units. It is complementary to pulse oximeter. It may be used routinely in neonatal intensive care units.*

Keywords: Monitoring, newborn, neonatal intensive care unit

Comparación de los Valores del Oxímetro Cerebral y el Oxímetro de Pulso en las Primeras 72 Horas de los Recién Nacidos Sanos, Asfícticos, y Prematuros

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RESUMEN

Objetivo: *El monitoreo de la oxigenación es esencial para proporcionar seguridad y resultados óptimos al paciente. El objetivo de este trabajo fue determinar los valores de saturación de oxígeno cerebral en recién nacidos sanos, asfícticos, y prematuros, y comparar los valores del oxímetro cerebral y los valores del oxímetro de pulso en las primeras 72 horas de vida de los neonatos en las unidades de cuidados intensivos.*

Métodos: *Este estudio fue realizado en la Unidad Neonatal de Cuidados Intensivos (UNCI) en el Hospital Universitario de Administración e Investigación Van Yüzüncü Yil. Setenta y cinco neonatos se incluyeron en el estudio (28 asfícticos, 24 prematuros, y 23 maduros sanos para el grupo control). Todos los recién nacidos fueron estudiados dentro de las primeras 72 horas de vida. Utilizamos un oxímetro cerebral Somanetics modelo Invos 5100C (oxímetro cerebral/somático INVOS, Troy, MI, USA). La información sobre la saturación de oxígeno fue recogida por un oxímetro de pulso Nellcor N-560 (Nellcor-Puriton Bennet Inc, Pleasanton, CA, USA).*

Resultados: *En el grupo de asfixia, el promedio correspondiente al oxímetro cerebral fue ± 76.85 14.1, el promedio del oxímetro de pulso fue 91.86 ± 5.9, y el ritmo cardíaco promedio fue de 139.91 ± 22.3.*

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En el grupo de prematuros, el oxímetro cerebral indicó un promedio de ± 79.08 9.04, el oxímetro de pulso señaló un promedio de 92.01 ± 5.3, y el promedio del ritmo cardíaco fue de ± 135.35 17.03. En el grupo control, el promedio del oxímetro cerebral fue 77.56 ± 7.6, el promedio del oxímetro de pulso fue 92.82 ± 3.8, y el ritmo cardíaco promedio fue de 127.04 ± 19.7.

Conclusión: *Oxímetro cerebral es una modalidad prometedora para el monitoreo de cabecera en las unidades de cuidados intensivos neonatales, y complementa la función del oxímetro de pulso. Puede utilizarse rutinariamente en las unidades de cuidados intensivos neonatales.*

Palabras claves: Unidad de cuidados intensivos neonatales, monitoreo, recién nacido

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INTRODUCTION

The cerebral oximeter (CO) provides a direct method for measuring cerebral oxygen saturation. Pulse oximeter (PO) is a non-invasive, painless and reliable method for measuring oxygen saturation (SpO_2) in blood (1). The PO value is affected by numerous factors. The area of measurement should be dry and clean with minimal movement. Dysrhythmia, shock, perfusion failure, abnormal pulsations, abnormal haemoglobin, use of vasoconstrictors, artefacts, dark skin, thick skin and excessively hairy skin may lead to incorrect results (1−6). Cerebral oximeter is a non-invasive technique based on near-infrared spectroscopy (NIRS), an optic technique similar to PO. Near-infrared spectroscopy uses infrared light and penetrates into live tissues and brain tissue. Near-infrared spectroscopy measures the infrared light absorbed through the tissue including pigments which allows continuous and non-invasive viewing of brain oxygenation (7). Pulsatile flow is not required for NIRS. Thus, it is useful in cardiopulmonary arrest and other non-pulsatile conditions (8).

We aimed to determine brain oxygen saturation values in healthy, asphyctic and premature newborns and to compare cerebral oximeter and pulse oximeter values in the first 72 hours of life in neonatal intensive care units.

SUBJECTS AND METHODS

This study was performed in the Neonatal Intensive Care Unit of Yüzüncü Yil University Faculty of Medicine Research and Practice Hospital between May 2008 and September 2009. The families consented to this study. Three families withdrew from the study and three patients were excluded because they did not satisfy the study criteria. Somanetics 5100C (INVOS cerebral/somatic oximeter, Troy, MI, USA) CO measure device was used in this study. Self-adhesive neonatal sensors were attached to the centre of the patients' foreheads. Data on SpO_2 were collected by a Nellcor N-560 (Nellcor-Puriton Bennet Inc, Pleasanton, CA, USA) PO device. The probe of the device was placed onto the right wrist of the patients. Initial values of CO, PO and peak heart rate (PHR) were obtained and then every hour for 24 hours. A total of 25 values were recorded.

Seventy-five neonatal infants were included in the study (28 asphyxia, 24 premature and 23 mature healthy infants for control group). All infants were studied within the first 72 hours of life. The infants with respiratory distress syndrome, transient tachypnoea of the newborn, sepsis, septic shock, pneumonia, congenital infection, congenital heart disease, or congenital anomaly were excluded from the study. White blood cell count, haemoglobin, haematocrit, platelet count, creatinine kinase, creatinine kinase-MB, alanine transamin-ase, aspartate transaminase, lactate dehydrogenase, uric acid and C-reactive protein were analysed in serum. pH, partial pressure of carbon dioxide (pCO_2), partial pressure of oxygen (pO_2), bicarbonate (HCO_3) and base deficit levels were analysed in blood gases.

The data were analysed by SPSS v 15.0 for Windows software. The analysis of variance (ANOVA) and Student's *t*-test were performed. A p-value < 0.05 was considered to indicate statistical significance. The study was approved by the Ethics Committee of the Faculty of Science, Yüzüncü Yil University.

RESULTS

All cases (n: 75) were included in the study in the initial first hour and then in the 72nd hour. Mean duration of inclusion was 30.6 (± 21.5) hours. Thirty patients were female (40%) and 45 patients were male (60%). The lowest infant weight was 1370 g, the highest was 4000 g, and the mean weight was 2622 (± 817) g. The youngest mother was 17 years and the oldest was 47 years. Mean age of mother was 29.4 (± 7.6) years. One patient was born at home (1.3%) and 74 were born at a hospital (98.7%). Twenty-six patients were delivered *via* vaginal delivery (34.7%) and 49 patients were delivered through Caesarean section (65.3%). The earliest born infant was 29 weeks of age; the latest born infant was 40 weeks old. Mean period of gestation was 36.13 (± 3.5) weeks. Demographic data of all patients are demonstrated in Table 1.

Patients were compared by mother's age, delivery week, Apgar score in the 1st minute, Apgar score in the 5th minute, body weight, white blood cell counts, haemoglobin levels, haematocrit levels, thrombocyte counts, uric acid,

Table 1: Comparison of groups by their demographic characteristics

Parameters	Asphyxia group (n = 28) count (%)	Premature group (n = 24) count (%)	Control group (n = 23) count (%)	All groups (n = 75) count (%)
Birth				
Home	0 (0%)	1 (4.2%)	0 (0%)	1 (1.3%)
Hospital	2 (100%)	23 (95.8%)	23 (100%)	74 (98.7%)
Delivery				
Vaginal	12 (42.9%)	5 (20.8%)	9 (39.1%)	26 (34.7%)
Caesarean section	16 (57.1%)	19 (79.2%)	14 (60.9%)	49 (65.3%)
Gender				
Female	8 (28.6%)	11 (45.8%)	11 (47.8%)	30 (40%)
Male	20 (71.4%)	13 (54.2%)	12 (52.2%)	45 (60%)
Mean study inclusion (hour)	30.2 ± 23.0	35.5 ± 21.3	26.1 ± 19.5	30.6 ± 21.5
Mean weight (g)	2847 ± 818	1884 ± 510	3117 ± 488	2622 ± 817
Mean mother's age (year)	30.2 ± 6.6	28.5 ± 7.6	29.3 ± 8.9	29.4 ± 7.6
Mean pregnancy (week)	37.0 ± 3.8	32.7 ± 2.0	38.5 ± 0.5	36.1 ± 3.5

C-reactive protein, aspartate transaminase, alanine transaminase, lactate dehydrogenase, creatinine kinase, creatinine kinase-MB, pH, pCO_2, pO_2, HCO_3 and base deficits. These conditions are shown in Table 2.

In the asphyxia group, the mean value for CO was 76.85 ± 14.1, mean value for PO was 91.86 ± 5.9 and mean PHR was 139.91 ± 22.3. In the premature group, mean value for CO was 79.08 ± 9.04, mean value for PO was 92.01 ± 5.3,

Table 2: Comparison of groups by their mean parameters

Parameters	Asphyxia group	Premature group	Control group
Mother's age (year)	30.2	28.5	29.3
Pregnancy (week)	37.0[a]	32.7[c]	38.5[b]
Apgar score at 1st minute	3.32[a]	5.86	6.83
Apgar score at 5th minute	5.42	8.32[c]	5.42[b]
Weight	2847[a]	1884	3117[b]
White blood cell count	22594.64[a]	13022.08	14303.04[b]
Haemoglobin level	16.55	17.04	17.44
Haematocrit level	50.68	51.21	52.66
Platelet count	220071.43	211833.33	239347.83
C-reactive protein	6.47[a]	3.00	3.00[b]
Uric acid	8.665[a]	5.891	5.091[b]
Aspartate transaminase	186.64[a]	42.75	60.83[b]
Alanine transaminase	73.89[a]	11.74	16.61[b]
Lactate dehydrogenase	2684.89[a]	986.38	982.74[b]
Creatinine kinase	2622.68[a]	273.29[c]	514.61[b]
Creatinine kinase-MB	623.82[a]	68.04	64.52[b]
pH	7.26[a]	7.37	7.38[b]
pCO_2	36.79[a]	31.67	29.35[b]
pO_2	73.36	66.08	72.91[b]
HCO_3	16.55[a]	18.33	16.54[b]
Base deficit	-10.11[a]	-5.13	-6.17[b]

[a]: A significant difference was noted when the asphyxia group and premature group were compared to each other ($p < 0.05$)

[b]: A significant difference was noted when the asphyxia group and control group were compared to each other ($p < 0.05$)

[c]: A significant difference was noted when the premature group and control group were compared to each other ($p < 0.05$)

pCO_2: partial pressure of carbon dioxide, pO_2: partial pressure of oxygen, HCO_3: bicarbonate

and mean PHR was 135.35 ± 17.03. In the control group, mean value for CO was 77.56 ± 7.6, mean value for PO was 92.82 ± 3.8 and mean PHR was 127.04 ± 19.7.

In statistical analysis, PO values were significantly low and PHR values were significantly high in the asphyxia group compared to the control group. Cerebral oximeter values were slightly low in the asphyxia group and no significant differences were found ($p > 0.05$). The CO value was significantly different in the asphyxia and premature groups ($p < 0.05$). For PO values, no significant differences were recorded ($p > 0.05$) in the asphyxia and premature groups. The PHR value was significantly different in the asphyxia and premature groups ($p < 0.05$). As the result of correlation analysis: moderate correlation was determined between CO and PO, and this correlation was significant. A negative and poor correlation was found between CO and PHR. There was a non-significant relationship between PHR and PO.

DISCUSSION

Cerebral oximeter is a non-invasive optic technique based on NIRS which allows continuous and synchronous monitoring of the oxygen saturation of cerebral tissue (7, 9, 10). Cerebral oximeter is a promising modality in neonatal intensive care units (11).

Today, the central nervous system imaging techniques are quite advanced. These imaging techniques have advanced in identifying neurological, anatomical and structural anomalies. However, in the central nervous system functions, screenings are not at the desired level. In today, the standard of care monitoring is based on maintaining intraoperative and postoperative blood pressure to ensure proper cerebral perfusion and cerebral oxygenation. However, cerebral oxygenation may be inadequate even if proper blood pressure is sustained (12).

Cerebral oximeter measurement is the only non-invasive method for simple interventions in the continuous monitoring of cerebral blood oxygen saturation and for improving cerebral oxygen deficiencies. Clinical studies showed that CO usage improved results and decreased neurological complications and reduced hospital costs. Near-infrared spectroscopy is a promising technique as a clinical device for bedside measurements of cerebral blood flow and as a cerebral imaging approach revealing structure and function (13). Correlations were observed between NIRS and SpO_2 during the graded hypoxia recorded in voluntary individuals (9). The first controlled study of CO was performed in 2006 by Rais-Bahrami *et al* (13). In this study, veno-venous extracorporeal membrane oxygenization was compared to cerebral venous oxygen saturation measured in neonatal infants. The CO value was found to be between 30% and 100% for neonatal infants in this system (13). According to observations, PO and CO values were correlated. One parameter increased or decreased as the other one increased or decreased.

A lot of CO devices have performed for normal oxygen saturation values. Weiss *et al* (14) using NIRO 300 (Hamamatsu Photonics), found a mean CO value of 60.5% ± 11.5%. Misra *et al* (15), using INVOS 3100, recorded a mean CO value of 67.2% ± 8.4%. Yoshitani *et al* (16), using INVOS 4100 and NIRO 300, found a mean CO value of 66% ± 8% and 66% ± 7%, respectively. In a study of 31 infants, Aldrich *et al* (17) detected the mean value of CO measured within 30 minutes after delivery as 22–73%. Schwartz *et al* (18) determined the mean value of CO in 18 healthy adults subjects as 68% ± 5%. On the other hand, Grubhofer *et al* (19) measured the mean CO values in the first three days of newborn premature infants as 54–65.7%, 61.9–82.3% and 67.8–80.1%, respectively. Isobe *et al* (20) determined CO as 67–74% when SpO_2 was above 95%.

In our study, mean value for CO was 76.85 ± 14.1, mean value for PO was 91.86 ± 5.9, and mean PHR was 139.91 ± 22.3 in the asphyxia group. The mean value for CO was 79.08 ± 9.04, mean value for PO was 92.01 ± 5.3 and mean PHR was 135.35 ± 17.03 in the premature group. Mean value for CO was 77.56 ±7.6, mean value for PO was 92.82 ± 3.8 and mean PHR was 127.04 ± 19.7 in the control group. According to the literature, our values were slightly higher. This may be explained by the younger age of our patients which allowed for easier penetration of infrared light into the brain tissue due to the thin skin.

In our study, PO values were significantly low in the asphyxia group and PHR values were significantly high compared to the control group. However, CO values were slightly low in the asphyxia group and no significant differences were found ($p > 0.05$).

When the asphyxia and the control groups were compared, no significant difference was found between PHR, PO and CO. This might be because patients in the asphyxia group were connected to a mechanical ventilator or put on support oxygen.

There was moderate correlation between CO and PO. This correlation was significant. A negative and poor correlation was found between CO and PHR. A poor relationship existed between PHR and PO. This relationship was not significant.

In summary, CO seems to assist in restoring decrease in brain-oxygen flow. It may be helpful in the clinical management of asphyctic infants. Cerebral oximeter is a promising modality in the bedside monitoring in neonatal intensive care units. It is complementary to PO and may be used routinely in neonatal intensive care units.

AUTHOR'S CONTRIBUTION

A Kaya designed the study and was involved in data collection and writing; M Okur and E Sal helped with the data collection and writing; E Peker and M Köstü helped with data collection; O Tuncer and E Kirimi came up with the idea for the study and provided consultation; E Kirimi also did the statistics. All authors gave final approval of the study.

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