ON - AND OFF - SITE NEWBORN MONITORING - A LITERATURE REVIEW

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Abstract:

The newborn admitted to the Neonatal Intensive Care Unit is subjected to various types of treatment from invasive means of correcting deficits to more apparently harmless means. Most of the treatment courses are prone to a keen analysis of hemodynamic and sensory parameters that mainly describe the quality of systemic blood flow, but also give information regarding the neurological and sensorial status of the newborn. One of the most common means of patient monitoring is the pulse oximeter that returns valuable information regarding both peripheral oxygen saturation and heart rate. However, all the monitors from in the NICU bring a harmful sound intensity that may affect both patients and medical personnel, therefore an off-site neonate monitoring system is needed.

Key words: NICU**,** pulse oximetry, newborn/neonate monitoring,

Introduction

The Neonatal Intensive Care Unit (NICU) is supposed to provide an environment that replaces the uterus, providing a place of optimal growth and health recovery for the ill neonate (1). However, medical personnel is incomparable to human alerting and treatment systems, therefore the NICU is overcrowded by means of monitoring the newborn and alerting systems.

This paper considers the various means of newborn monitoring in the NICU and aims to define the needs of clinicians and nurses concerning alerts that regard the patients' clinical status.

Material and Methods

A detailed literature research was conducted using the PubMed online database. We used as key words "pulse oximetry" (1834), "newborn/neonatal monitoring" (32974), "newborn heart rate variability" (7028) and "oxygen saturation" (4368), "wireless pulse oximetry" (51), "NICU monitor alert" (8). The search returned a total of 40 relevant papers. As to the paucity of relevant publications we decided not to define a specific time-frame.

Results and discussions

1. NICU clinical monitoring: hemodynamic and sensory parameters

Monitoring the neonate is usually done by interpreting direct and indirect parameters of systemic blood flow, but also by brain and other sensory monitoring as described below:

1.1 Blood pressure

Blood pressure measurement is the most common used method to assess the neonatal hemodynamic status (2).

1.2 Heart rate

Hemodynamic monitoring, concerning heart rate involves the ventricular output which is determined by stroke volume. In neonates, the circulatory status is mainly evaluated by heart rate, as the only modifiable variable is the heart rate, the stroke volume is considered to be fixed (2).

1.3 Urine output

Dependent on fluid intake, after stabilization, urine output is a poor marker of circulatory failure in the absence of a direct relationship with systemic blood flow (2).

1.4 Brain activity

Most neonates in the NICU are at risk for brain injury, so brain activity monitoring is indicated. The electroencephalogram (EEG), a non-invasive monitoring method should be considered in neonates with seizures, hypoxic-ischaemic encephalopathy, intraventricular haemorrhage, periventricular leukomalacia and stroke (3).

1.5 Pain assessment

Assessment of pain in the newborn is very difficult, because neonates cannot express verbally their discomfort. However, various pain scales have been created. These scales consist of multifactorial observations including physiological parameters (4). To mention physiological parameters, as the autonomous nervous system: CF increase, AP decrease, O_2 saturation decrease, etc. (5).

2. Pulse oximetry

Considering the above mentioned NICU monitoring parameters, we focus our review on pulse oximetry.

Pulse oximetry is one of the most common means of patient monitoring as it returns valuable data concerning the patient's both hemodynamic and sensory status.

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2.1. History

In 1760, Johann Heinrich Lambert, was the first to describe the relationship between light absorption, strength of light and light path length, that was further investigated by August Beer, and published as the Beer-Lambert Law in 1852 (6).

Based on the Beer-Lambert Law, the first to measure the rate of spectral changes of light penetrating tissue when circulation was interrupted, was Karl von Vierordt in 1876. But only in 1931 Ludwig Nicolai measured red light transmission through a hand. In 1940, after great research, JR Squire realized that there was a difference in red light transmission before and after blood expelling from the hand with a pressure cuff. This difference was a function of saturation.

Further, during the World War II, Glen Millikan in 1942, developed a lightweight red and infrared ear clip, that he named "oximeter". And, Wood in 1949, mathematically extended the "oximeter" resulting into a unique function of saturation.

Moreover, Takuo Aoyagi, after obtaining Wood's work in Japanese, reproduced an oximeter earpiece that he used to measure "dye dilution curve, but required calibration with a blood sample". Continuing his study, Aoyagi tested various wavelengths and methods of implementing pulse oximetry (7). His device was first commercialized in 1981, and for the monitoring of oxygen saturation in the newborn it was used starting with 1986 (6).

2.2. Basic principles of pulse oximetry

Pulse oximetry measures peripheral oxygen saturation (SpO2) and heart rate (HR) continuously and noninvasively. It is based on the Beer-Lambert law that relates the light intensity to the properties of the materials through which the light is travelling; and photoplethysmography a method used to detect blood volume changes in the microvascular bed of the tissue (6, 8).

The oximeter consist of a "light emitter" and a "light sensor", which are aligned on opposite sides of a narrow part of body, such as palm, forefoot, finger. The "emitter" sends equal intensities of red and infrared light of wavelengths of 660 nm and 940 nm into the tissue. The "sensor" detects the ratio of red to infrared that emerges and returns the percentage saturation of haemoglobin with oxygen is calculated and displayed (9).

2.3 Pulse oximetry uses

In the NICU a real help was granted regarding the signal of significant change in oxygen saturation in the neonate (10). Thus, by setting alarm limits a great oxygenation control can be achieved. Even more, heart rate can be also monitored by a pulse oximeter as it returns a pulsatile wave signal in concordance with the discontinuous light absorption in the arteries.

3. Alerts and sounds in the NICU

The Neonatal Intensive Care Unit (NICU) is a very busy department and it involves neonates with various conditions that need a close monitoring and a rather highly specialized treatment related to the condition they are in.

The noise in the NICU is higher than advised. The typical average sound intensity in the NICU is of about 54dBA (11), that exceeds the value of 45 dB at which there is cause for concern (1). Thus both the neonates and the care-givers are prone to stress given by alarms going on and off in the NICU, that is why nurses prefer selecting a longer oxygen saturation averaging time that will reduce the number of alarms going on but may also mask serious fluctuations in oxygenation (12).

4. Off -site monitoring

We defined as "off-site monitoring" of the newborn, the means in which a neonate admitted to the NICU may be monitored by using a remote system. For this, literature returned few published papers in which means of monitoring are scares and imply some external changes.

Conclusions

Serious advances have been made in patient monitoring both on-site (next to the patient, within the department) and off-site (at a distance) by using modern information transmitting devices. However regarding the NICU, literature research gives little to no information regarding the off-site patient monitoring systems. Thus research is needed to create solutions in off-site patient monitoring and why not, at least partly, bring noise reduction solutions to the NICU.

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