Early detection and management of critically sick newborn in neonatal intensive-care unit using perfusion index and pleth variability index in advanced pulse oximetry

Sir,

New generation pulse oximetry using "massimo signal extraction technology (SET)" is gaining momentum in the present era and is being extensively used as an adjunct to effective clinical assessment of sick neonates. These advanced type of monitors can pick up oxygen saturation in low perfusion state and is unaffected by motion artifact. It uses SET and parallel signal processing engines – DST®, FST®, SST™, and MST™ – To separate the arterial signal from sources of noise (including the venous signal) to measure saturation and pulse rate accurately, even during motion [1]. With Massimo SET®, false alarms have been reduced by over 95% while true alarm detection has increased to over 97% - even during conditions of motion and low perfusion [1,2]. In busy neonatal intensive-care unit (NICU) which cater huge preterm inborn and outborn populations, Massimo monitors effectively work in the management of sick newborns with reliability of displayed parameters. However, we are less sensitized to the use all the displayed parameters, which could give us early clues of hemodynamic instability in sick neonates. Perfusion index (PI) and Pleth variability index (PVI) are two such parameters (Fig. 1).

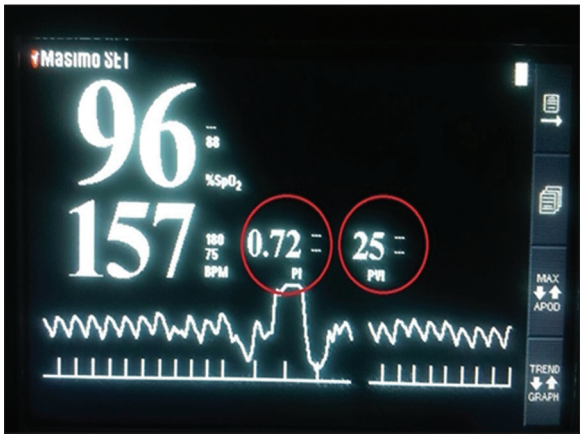

Figure 1: Perfusion index and Pleth variability index displayed in pulse oximetry

The PI is the ratio of the pulsatile blood flow to the nonpulsatile or static blood in the peripheral tissue. It is calculated by means of pulse oximetry by expressing the pulsatile signal (during arterial inflow) as a percentage of the nonpulsatile signal, both of which are derived from the amount of infrared (940 nm) light absorbed. Under stress-free conditions, newborn skin perfusion is higher than the oxygen demand. Skin PI value of ≤1.24 is an unambiguous and accurate predictor of illness severity (high Score for Neonatal Acute Physiology II score) and is independent of subjective means of interpreting neonatal health status [3]. PI was also found to correlate with calf muscle perfusion measured by near infrared spectroscopy in neonates [4]. The PI is an indirect, noninvasive, and continuous measure of peripheral perfusion in neonates that could become a standard for neonatal intensive care. Few scenarios, where we can have discrepancy between the perfusion and PI, are:

a. Hypothermia: neonates with low PI can have good perfusion
b. Polycythemia: sluggish flow due to polycythemia can cause low PI (Fig. 2).

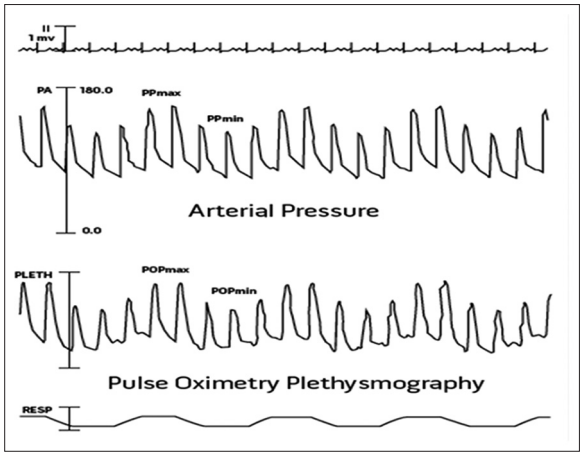

Figure 2: Relationship between respiratory variations in pulse oximetry plethysmographic waveform amplitude and arterial pulse pressure in ventilated patients [5]. PP: Pulse pressure, POP: Pulse oximetry plethysmography

PVI is the measurement that automatically and continuously calculates the respiratory variations in the photo plethysmographic waveform. It determines whether a sick newborn in shock is fluid responsive or not. The pumping action of the heart is directly influenced by relative changes in airway (intrapleural) pressure and blood pressure/blood volume [5]. During normal spontaneous inspiration, the increase in negative intra-thoracic pressure causes an increase in venous return. To accommodate the increased venous return, the ventricles stretch, known as cardiac preload. Since preload is related to cardiac output, increased negative intra-thoracic pressure ultimately increases cardiac output. Conversely,

during normal expiration, there is an increase in positive intra-thoracic pressure resulting in a decrease in venous return and a decrease in cardiac output. PVI is a measure of the dynamic changes in the PI that occur during one or more complete respiratory cycles ([PI max-PI min]/PI max × 100%). The greater the PVI, the more likely the patient will respond to fluid administration. PVI value of more than 13-18 have been used in various studies in neonates and children with sensitivity of 83% and more [6,7]. PI and PVI will provide further information regarding the circulatory status of sick preterm neonates enabling better care. Thus, these can add to the armory of the clinician in addition to the clinical assessment, functional echocardiography parameters such as inferior vena cava collapsibility/distensibility index, and superior vena cava flow, to assess the hemodynamic status of the patients. Functional echocardiography in NICU though an emerging trend, but it requires expertise. Availability and affordability of echocardiography machine is an issue in many areas in India. It requires proper curriculum based training in echocardiography to practicing neonatologist. Pulse oximetry parameters are user-friendly and fairly easy to interpret by neonatal nurses and can alert resident neonatologist to correlate with clinical parameters.

To conclude, PI and PVI has the potential to become an adjunct to the clinical assessment of sick and preterm neonates. However, further studies are required for standardizing the clinical use of PI and PVI.

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