Is Freezing an Issue with Pulse Oximetry Pulse Rate in the Delivery Room?

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Is Freezing an Issue with Pulse Oximetry Pulse Rate (PR) Signal?

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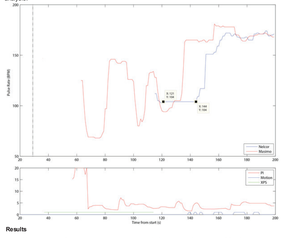
Abstract Text:

Purpose

Pulse oximetry use in the DR is standard of care. However, some monitors can localize the pulse oximeter signal faster than others. (Goldstein, et al PAS 2014). Once a signal has been obtained, reliable PR monitoring can reduce inappropriate intervention during the first minutes of life. We compared two pulse oximeters in the DR and assessed for the presence of possible freezing in PR, once a valid signal was obtained.

Methods

The Covidien Nellcor N600X (Mansfield, MA) and Masimo Radical 7 (Irvine, CA) were compared in 80 neonates in a delivery room environment. Oximeter probes were attached to left and right foot to minimize discrepancy in perfusion. Monitoring was initiated simultaneously. Both oximeters were placed in their fastest and most sensitive settings. Monitoring continued at least until the 5 min APGAR. PR data were sampled to a computer interface. Signal quality was compared during motion and both oximetry readings were assessed for the presence of "non-continuous" recording by analyzing each reading for the presence of stepwise as opposed to fine granularity of the PR reading (see graphic). A MATLAB script was used to analyze data from both monitors. A benchmark of 8s of unchanged PR was set as evidence of potential freezing, especially in the context of motion sensing. Monitor performance was evaluated by waveform analysis.



Results

In the 80 patients, the Radical 7 analysis demonstrated 248 episodes of unchanged PR ≥ 8 seconds; the N600X, 327 episodes (p <0.05).

Conclusion

Although a uniform pulse rate is not impossible, in an at risk undergoing transition to an extrauterine environment, there should be beat to beat variability. Although an averaged pulse rate and analysis of trended data can give an approximation of response in the transitional period, motion sense (blue line at bottom) was noted to be correlated with "freezing" (no beat to beat variability for greater than 8 seconds) in the N600X-signal significantly more times than that of the Radical 7. Freezing artifact may preclude adequate monitoring. In the evaluation of an at risk neonate in the delivery room environment, enhanced pulse oximetry pulse rate fidelity is crucial.

Introduction:

The use of pulse oximetry in the delivery room (DR) has been expanded. Guided PR and saturation (SpO_2) monitoring can reduce inappropriate intervention during the first minutes of life. For successful monitoring, it is important that the pulse oximeter function during the initial assessment and resuscitation. Function of the oximeter is not confined to the simple presence of a signal, but validation of the signal as well. In an environment of high motion and low perfusion, aberrant PR values can be misleading. Although many oximeters have an indication for use in neonates, their function in the DR may not be equivalent.

Objective:

We compared two pulse oximeters in the DR and assessed for the presence of possible freezing in PR, once a valid signal was obtained.

Methods:

The Covidien Nellcor N600X (Mansfield, MA) and Masimo Radical 7 (Irvine, CA) were compared in 78 neonates following cesarean section as part of quality improvement (QI) to assess pulse oximetry performance in a DR environment. After the patient was placed on the warmer, oximeter probes were attached to left and right foot to minimize discrepancy in perfusion. Both oximeters were placed, and monitoring was initiated simultaneously according to manufacturer's recommendation. Both oximeters were placed in their fastest and most sensitive settings. Data was simultaneously sampled from both oximeters through a computer interface at 1 Hz. PR and SpO_2 monitoring continued until each oximeter transduced a valid PR and SpO_2, and the baby completed at least the 5 min APGAR. Signal quality was compared during motion and both oximetry readings were assessed for the presence of "non-continuous" recording by analyzing each reading for the presence of stepwise as opposed to fine granularity of the oximetry saturation and PR readings (see graphic). Matlab 2012b was used for data categorization and STATISTICA, version 12 (www.statsoft.com.StatSoft, Inc. (2013)) was used for data analysis. Signal quality was compared during motion and both oximetry readings were assessed for the presence of "non-continuous" recording by analyzing each reading for the presence of stepwise interruptions in the tracing as opposed to fine granularity of the PR reading (see graphic). MATLAB was used to analyze data from both monitors. A benchmark of 8s of unchanged PR was set as evidence of potential freezing. Monitor performance was evaluated by waveform analysis, especially in the context of motion sensing. The de-identified QI data were approved as part of chart review by the Riverside County Medical Center (Moreno Valley, CA) Institutional Research Board (IRB) to present for research purposes.

Results:

In the 80 patients, the Radical 7 analysis demonstrated 248 episodes of unchanged PR ≥ 8 seconds; the N600X, 327 episodes (p <0.05).

No differences were present in gender, birthweight, APGAR score, gestational age, the use of O_2, or illness severity. Most patients were born at term and sent to the well-baby nursery following delivery.

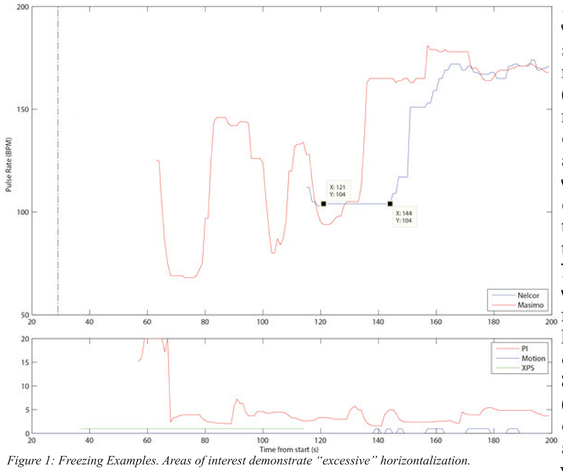


Figure 1: Freezing Examples. Areas of interest demonstrate "excessive" horizontalization.

Discussion:

The first generation conventional oximetry was designed for well perfused, non-moving adult patients. When the older conventional oximeters were not able to reliably transduce through motion artifact, low perfusion, and other interfering signals, interpretation was subject to scrutiny. Oximetry was considered cumbersome and potentially dangerous because of the risk of misinterpretation. Clinicians were taught to simultaneously monitor the heart rate with a stethoscope in the DR because of an unreliable pulse oximeter PR signal.

The improved technologies resulted in a paradigm shift. Improved reliability produced in a change in the day to day practice in the NICU. Oximeters are no longer turned off because of incessant alarming. Improved monitoring regimens resulted in a reduction in both retinopathy and unnecessary oxygen titration.

In this same context, oximetry is now a standard of care in the delivery room: its use is no longer subject to debate. An understanding of the normal saturation range in the moments following birth prevents unnecessary intervention as the neonate transitions from the intrauterine environment. Administration of oxygen is not indicated at every delivery. PR should be predictive of the actual propagated heart rate. Nevertheless, this is a challenging environment, replete with low perfusion, motion, a wet skin interface, and perhaps even interference from bright lighting of a surgical or delivery suite.

Inadvertent intervention (including chest compressions) especially during motion and low perfusion cannot be avoided unless a reliable PR is obtained and documented to be reflective of actual changes in the newborn.

In the DR, the ability of an oximeter to monitor through motion is crucial. We previously studied the effects on SpO_2. The Radical 7 produced a more rapid display of a valid SpO_2 as noted in a previous study. The Masimo Radical 7 oximeter displayed a valid SpO_2 after 39.1±61.5 seconds; the N600X required 76.5±61.3 seconds. ($p<0.0002$). Baseline monitor performance was evaluated by evaluating average SpO2 once a SpO_2 value was obtained over the entire sample period. Over the total duration of sampling, the Radical 7 SpO_2 was 77±11%; the X600N SpO_2 was 76±10% (NS). Potential freezing was noted in the Radical 7 in 0.10±0.34 (n=8) of the samples versus 0.5 8±1.37 (n=45) in the X600N ($p<0.004$). Total duration of potential freeze time averaged across all samples was 3.0±10.4 seconds for the Radical 7 and 15.4±37.0 seconds for the X600N ($p<0.005$). Not all samples had evidence of freezing. Although mean SpO_2 were equivalent over the defined epoch, freezing of the N600X may have real implications in the initiation of unnecessary clinical intervention. Extensive freezing was noted in the X600N SpO_2 signals. All oximeters should be able to recognize when there is not sufficient fidelity in the signal transduced to report an adequate reading. Above all, it is important that the oximeter not display erroneous data.

Previously, we demonstrated the potential for missense with high motion, especially in patients who are poorly perfused. Missed or frozen data have been noted in a non DR environment. A "normal" resuscitation should result in steady improvement in both parameters. These were mainly normal newborns with predicted saturation values of high 90's and PR>100 within a reasonable transition time from the birth of the baby (usually within the first five minutes). All oximeters have not evolved to the same degree. There are important differences in the ability to rapidly transduce a valid saturation as well as PR between the two tested devices. Although there are a broad number of oximetry technologies available, it is important to identify those most likely to produce results in line with not only an expected outcome, but a rapidly changing PR as well as saturation associated with the extrauterine transition.

There are limitations to our data. This study did not seek to identify the duration or total time and validity of the measured pulse oximetry signals during the monitoring epoch. Success or failure of an oximeter cannot be measured by the total time that the oximeter appears to transduce a signal; rather, the fidelity of the signal transduced is the best arbiter.

Conclusion:

Inadvertent resuscitative efforts as well as administration of oxygen cannot be avoided unless a reliable PR and saturation are present. Freezing can have a significant effect on this presumption. In the DR, the ability of an oximeter to monitor through motion, low perfusion, rapidly changing PR, and initial sub-optimal SpO_2 is challenged. The Radical 7 produced what appeared to be a valid PR without the freezing noted on the N600X. The delay associated with freezing may have real clinical implications in the initiation of unnecessary therapy or the development of a false sense of security.

Bibliography:

1. Goldstein MR, Fayard E, Martorell L, Trupp D, Truong G, Solomon T, Czynski A, Lavery A, Nicolau Y, A Morkos, MD, Kim S, Phillips R, Febre A, Ibrahim T, Merritt TA, Hopper A, Peverini R. Use of Pulse Oximetry in the Delivery Room (DR): A Comparison of Two Different Oximetry Technologies. 2014 Pediatric Academic Societies' & Asian Society for Pediatric Research Joint Meeting. E-PAS2014:3843.587

2. Goldstein M, Sola A. Best Practice Checklist – Oxygen Management for Preterm Infants. [National Perinatal Association Guideline]. Neonatal INTENSIVE CARE Vol. 25 No. 2 n March-April 2012.

3. Goldstein MR, Pernia ML, Lawas-Alejo P, Yang LL, Sindel BD, Ochikubo CG, Furman GI, and Martin GI. Characterization of Neonatal Motion Relative to Pulse Oximetry Monitoring. ISIAPO 2002. International Symposium on Innovations and Applications of Pulse Oximetry. Lübeck, Germany. March 8 - 9, 2002.

4. Goldstein M, Martin G, Sindel B, Pernia M, Ochikubo C, Yang L, Lawas-Alejo P, and Furman G. The Anatomy of A Pulse Oximeter Evaluation: Nellcor N-595 and Masimo SET Radical Pulse Oximeters. AARC 2002. Tampa, Florida. October 5-8, 2002.

5. Goldstein MR, Louie N, Sindel BD, Furman GI, and Martin GI. A Survey of Indicators of Pulse Oximetry Validity. ASA 2003. San Francisco, California October 11-15, 2003. Anesthesiology 2003; 99:A556

6. Goldstein MR, Louie N, Yang LL, Ochikubo CG, and Martin GI. Is Pulse Search Technology a Predictor of Unreliable Saturation Monitoring? ASA 2003 Annual Meeting. San Francisco, California October 11-15, 2003. Anesthesiology 2003; 99: A555

7. Goldstein MR, Louie N, Ochikubo CG, Furman GI, Lawas-Alejo P, Sindel BD, Yang LL, Pernia ML, and Martin GI. New Generation Pulse Oximetry Signal Quality Indicators Are Not Universally Reliable. American Academy of Pediatrics 2003 National Conference and Exhibition. Perinatal Section. New Orleans, LA. October 31 - November 5, 2003

8. Goldstein MR, Furman GI, Sindel BD, Yang LL, Ochikubo CG, Pernia ML, Lawas-Alejo P, and Martin GI. Masimo Radical and N-595 Clinical Use Evaluation in the NICU. American Academy of Pediatrics 2003 National Conference and Exhibition. Perinatal Section. New Orleans, LA. October 31 - November 5, 2003. Thoracic Society. Orlando, FL.

Presenters have documented that they have nothing to disclose

Loma Linda University Children's Hospital

When Better Is Not Good Enough