REFLECTIONS ON NEONATAL PULSE OXIMETRY

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I am old enough to remember a time before the advent of pulse oximetry. That may shock some of you. It is beginning to shock me. There was a time in the NICU when there were no continuous non-invasive monitors of oxygenation, neither pulse oximetry nor transcutaneous PO2 monitoring. Fear not though readers. This is not one of those screeds written by a curmudgeon who goes on and on about "the good old days". I have very little pleasant nostalgia about how we cared for neonates in 1979.

The pulse oximeter has been one of the greater advances in respiratory care since I started pushing IPPB machines around a long time ago. But only now, 25 years later, are we beginning to realize the full potential of the pulse oximeter to improve outcomes of care.

The early days of neonatal pulse oximetry were heady times. Finally, we had a way of evaluating oxygenation without poking babies for cap gases or leaving unsightly red rings on their skin from transcutaneous monitors. Regrettably, the use of oximeters spread more rapidly than the expansion of our knowledge of how to use them.

It was hoped they would aid us against what was then called retrolental fibroplasia (now called retinopathy of prematurity). We were taught that prevention of prolonged periods of hyperoxemia could help prevent the development of this condition, which in its worse forms causes permanent loss of vision. We assumed that if we put the oximeter on and used the upper alarm limits to keep the saturations from going too high, we could ensure that the patients did not have PaO2 > 90 mmHg.

However, we soon learned that there was a fly in the ointment. The pulse oximeters were discovered to have significant limitations. The readings appeared highly variable at times. Or sometimes the machines simply stopped reading altogether. We learned that they did not work well at all in the presence of motion artifact and low perfusion.

One crotchety neonatologist I used to work with called them random number generators. Because of the frequent instability of readings, when you set the alarms at reasonable limits hoping to ensure acceptable saturations, the monitors alarmed incessantly. If you widened the alarm limits you could get some modest relief from alarm overload, but then you appeared to be allowing saturation ranges that might be considered unsafe.

In the early 1990's I did some research for one of the pulse oximeter companies. I signed a research contract, so they owned the data. We wanted to establish the ranges of pulse oximeter readings that would best ensure keeping the PaO2 between 50-90 mmHg. We gathered over 300 paired pulse oximeter readings and simultaneous blood gases in an NICU. I tried a whole slew of different combinations of high and low saturation limits, calculating the specificity and sensitivity of each combination. Sensitivity here can be defined as the likelihood that when the saturations readings were within the established limits, the PaO2 was within the desired ranges (50-90). The specificity is the likelihood that when the saturation readings are outside the established limits, the PaO2 was outside the desired range. The best combination I could come up with resulted in a sensitivity of 80% and a specificity of 60%. In other words, 20% of the time

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when the pulse oximeter said the saturations were within the safe range, the PaO2 was not, and 40% of the time when the pulse oximeter said the saturation was outside the safe range, the PaO2 was in the safe range. Pretty crummy performance if you ask me. Of course the manufacturer challenged my research skills, saying I must have done something wrong, since they were sure the oximeter performed better than that. They owned the data, which never got published.

The problems with alarms continued. Clinical studies of the validity of pulse oximeter alarms yielded disturbing data. Studies in neonates and pediatrics showed that; 1) 44-63% of all critical care alarms were caused by pulse oximeters, 2) 94% of oximeter alarms were considered non-significant and 3) 71% were false.

Lest I be accused of all doom and gloom regarding neonatal pulse oximetry, I have good news. Technological advancements in signal processing have significantly improved the performance of some brands of oximeters.

However, the more important question about continuous pulse oximetry is whether it makes any difference. Does it affect processes and thereby outcomes? Just because the monitor performs well, does not necessarily mean it can be proven that it is beneficial to patients. I am happy to announce, that when superior pulse oximetry technology is combined with well standardized processes, the result is improved outcomes. Durbin and colleagues showed that more reliable oximetry reduces the frequency of arterial blood gas analyses and hastens oxygen weaning after cardiac surgery. And in one of the most interesting studies ever done on the impact of properly applied advanced oximetry technology, Chow et al showed that the introduction of superior pulse oximetry technology into an NICU, when combined with a rigorous oxygen management protocol, resulted in significant reductions in rates of retinopathy of prematurity.

Thus, we have happily progressed significantly since the introduction of pulse oximetry in the NICU. The technology is much better, and we are finally beginning to learn how to use it.

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5. Route tubes and catheters having different purposes in different, standardized directions (e.g., IV lines routed toward the head; enteric lines toward the feet). This is especially important in the care of neonates.
6. Inform non-clinical staff, patients and families that they must get help from staff whenever there is a real or perceived need to connect or disconnect devices or infusions.
7. For certain high-risk catheters (e.g., epidural, intrathecal, arterial), label the catheter and do not use catheters that have injection ports.
8. Never use a standard luer syringe for oral medications or enteric feedings.
9. Emphasize the risk of tubing misconnections in orientation and training curricula.
10. Identify and manage conditions and practices that may contribute to health care worker fatigue, and take appropriate action.

This Sentinel Event Alert is the latest alert in the Sentinel Event Alert series JCAHO began in February 1998. Healthcare organizations must implement the recommendations in the Sentinel Event Alert or reasonable alternatives to remain in compliance with JCAHO standards. For more information regarding this alert and previous alerts, visit www.jcipatientsafety.org.