Objective Evaluation of Neonatal Ventilators

Choosing which ventilator to purchase can dramatically affect what type of care patients get, practitioners’ working environment, and the hospital’s “bottom line.” Choosing a ventilator is a complicated process, often confounded by competing stakeholders. Trying to balance the desires of the hospital management, physicians, and respiratory therapists can be tricky. Getting the right equipment for the patient can be even more difficult in the neonatal intensive care unit (NICU), because few ventilators are made especially for premature babies. Objective data and tools are critical for guiding the acquisition of new ventilators, or even deciding to continue on with the existing fleet. Published information on the value and effectiveness of individual devices and features is limited. Improved patient outcomes due to technology innovation are difficult to demonstrate.

In October 2001, Chatburn and Primiano published in Respiratory Care a ventilator-evaluation tool to guide intensive care unit ventilator purchases. They devised a checklist scoring system to objectively evaluate ventilators based on technical features, operator interface, and customer service. That system uses objective data to allow stakeholders to compare devices “head to head” in a data-centered way. The balanced approach to the evaluation includes such important details as the maintenance costs, which might otherwise be overlooked by an evaluation committee. Although slightly limited by the fact that it was not designed specifically for the NICU, and that new ventilator features have become available, Chatburn and Primiano’s tool is still highly relevant today. Scores for each device with the desired new features included can be incorporated in the evaluation by adding them to the Optional Functions section.

The ventilator-evaluation tool can provide a score based on the availability of a feature on a ventilator, but it can’t help in the evaluation of the clinical effectiveness of features and systems. Issues especially important to clinicians in the NICU, such as the work of breathing imposed by the machine and circuitry, monitoring and accuracy of delivered tidal volumes, and the functioning and effectiveness of the ventilator modes, must be evaluated in the laboratory and with clinical trials. In this issue of the Journal, DiBlasi et al report a laboratory investigation of the ventilator-imposed expiratory resistance of 4 neonatal ventilators. One of the ventilators they tested was a neonatal-only device that was cleared by the United States Food and Drug Administration in the early 1990s and is in widespread use in NICUs around the world. The other three are so called “cradle-to-grave” ventilators, all of which were cleared by the Food and Drug Administration after 2000. Are the newer devices superior? Are neonatal-only ventilators more effective for infants in the NICU, regardless of the ventilator’s release date? These important questions have yet to be answered.

There are some important revelations in the extensive laboratory evaluation by DiBlasi et al. It has long been accepted that the resistance of the endotracheal tube is a factor in gas exchange and work of breathing in neonatal patients. High expiratory resistance in a neonatal breathing system can impair gas exchange, elevate the work of breathing, delay ventilator weaning, and affect lung mechanics measurements. Imposed resistance through any or all of the airways can produce alveolar hyperinflation and intrinsic positive end-expiratory pressure (PEEPi). The common assumption that the small endotracheal tube required for neonatal mechanical ventilation is the largest contributor to expiratory resistance was not supported by the laboratory evaluation by DiBlasi et al. As a matter of fact, the ventilator-imposed expiratory resistance was greater than the expiratory resistance of the endotracheal tube and the external airway flow sensor combined, with all 4 ventilator brands. This finding justifies further research into the clinical implications of ventilator-imposed expiratory resistance and the impact of ventilator brand on work of breathing, PEEPi, and time to extubation.

Research by Yoder et al with 2 brands of neonatal ventilator and extremely-low-birth-weight baboons suggested that one of the ventilators had higher expiratory airway resistance and indices of impaired ventilation and generally required a higher ventilation rate, maximum inspiratory pressure, and mean airway pressure, which could have been the result of PEEPi.

Another important finding by DiBlasi et al is that the Dräger Babylog 8000plus, which is an earlier-generation ventilator, consistently had the lowest ventilator-imposed expiratory resistance, including during spontaneous breathing, which could be of great interest to clinicians who are considering updating their NICU ventilator fleet. How-
ever, was that finding due to the design of the expiratory valve of the Babylog 8000plus? Another possible explanation is that the neonatal continuous-flow ventilation mode may be superior to the bias flow modes that are primarily used in newer adult-to-infant ventilators. Unfortunately, we can’t ascertain from the DiBlasi et al report if the primary cause of the ventilator-imposed expiratory resistance was the ventilator’s exhalation system or the ventilator mode, since the Babylog was tested in a continuous-flow mode and the other 3 ventilators were not. Regrettably, the continuous-flow mode is not an option in most cradle-to-grave ventilators. However, the Cardinal/Viasys Avea can provide continuous-flow ventilation, in the pressure-control mode only, and a direct comparison between it and the Babylog 8000plus would be possible and would help to ascertain if the continuous-flow ventilation mode decreases ventilator-imposed expiratory resistance or if the Babylog 8000plus has a superior exhalation system.

Often when performing laboratory evaluations the researchers are hampered by the necessity of using ventilator settings that will work in all testing scenarios. This can limit the applicability of the results and sometimes even prevent the discovery of important results. In the DiBlasi et al study design the relatively short inspiratory time (0.25 s) may have prevented the discovery of PEEPi that may routinely occur clinically with all these devices, especially in disease conditions commonly found in the NICU. The tendency of clinicians to use different ventilator settings depending on the region of the country in which they practice, rather than settings based on patient pulmonary mechanics, can also impact the clinical effect of identical devices.

Respiratory therapists are accustomed to embracing new technology. We are an equipment-centered profession. The more complex the device, the more we dive into its intricacies and master its details. We are also optimists who believe in the power of technology to transform the patient’s outcome. But what if we discover that the older technology was better? Once ventilators reach a certain age, there is pressure to update the fleet. There is a great desire to constantly modernize our technology and stay current. Most, including myself, would argue that such a strategy is good for patients. Old ventilators can be outdated and not have clinically important features. Some of the newer ventilator features may improve patient monitoring, make new therapies possible without unapproved user modifications, or add modes desired by respiratory therapists and physicians alike. But what if the newer equipment is not actually superior? What if the old way of doing things was actually better for our patients? Might we lose a valuable tool or mode?

A final issue is the availability of equipment designed specifically for neonates. Is it possible to build a device that will function for all patients and still have it be the best device for each patient subgroup? As we periodically assess our ventilator fleets and discuss the possibility of purchasing new equipment, the question asked should always be: Is there something better available than what we are using now? Chatburn and Primiano’s ventilator-assessment tool should be used to objectively evaluate the presence of desired features and calculate other important factors such as maintenance costs. In addition, research, such as the excellent work by DiBlasi et al, is crucial to objectively evaluate manufacturers’ claims of benefits from modes and features and the limitations of individual devices.

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REFERENCES

The author reports no conflicts of interest related to the content of this editorial.

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