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COMMENT

Neonatal ventilation data: finding insight in chaos, or the new Hubble telescope

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In this issue, Chong et al.[1] describe and validate a novel method to take the impenetrable mass of data generated by the 80,000 or so breaths/day recorded in a ventilator's memory, organize it, categorize it, query it, and study it. They do this by their development of special computing techniques that greatly expand the algorithms provided by ventilator manufacturers, using the raw pressure and flow data captured at 100 Hz and re-creating the individual breaths in all their complexity. They can generate loops and waveforms from individual breaths or consolidate the data into time-based intervals, breath types, and provide information about the sub-phases of each breath; for example, initiation as spontaneous or ventilator derived, duration of inspiratory flow, presence or absence of an inspiratory hold, asynchrony, and many other combinations. A 24-h sample can be analyzed for evaluation in 2 min. The authors also studied data not used for algorithm development to compare the accuracy of the algorithm to 3 samples of 5 min each that were hand-analyzed and collated by specially trained physician. They demonstrate how a 24-h sample may be broken down into intervals occurring around specific events for better understanding of what happened. Finally, this program, called *Ventiliser*, is open sourced, freely available, and usable on any platform that allows data to be downloaded from the ventilator in use.

Understanding the interaction of the sick neonate requiring respiratory support with the devices we use to provide it has been at times opaque, at times through a glass darkly, but rarely clear. Smith et al. published an early effort to shed light on what happens during mechanical ventilation in this journal in 1969.[2] This study of 6 infants of roughly 2000 g with respiratory distress syndrome (RDS) used controlled ventilation with paralysis and varied respiratory rate and peak inspiratory pressure. They found that P_aO_2 varied directly with pressure and indirectly with rate and concluded that mechanical ventilation might be useful in the treatment of RDS. Over the next decade, we learned about positive end-expiratory pressure,[3] mean airway pressure,[4] and the potentially harmful interactions between an infant breathing spontaneously but out of phase with the ventilator and cerebral blood flow.[5] This new worry resulted in techniques to allow the infant to synchronize with the ventilator-delivered breaths, first by trying to "capture" the infant into the phase of the ventilator, then by actual synchronization.[6,7] During the 1980s, technology was developed that added the newly developed personal computer to graphically present information obtained on a breath-to-breath cycle at the bedside.[8] This was revolutionary as there had never been reliable techniques that could be applied outside of a laboratory setting to study infants in real time during acute illness. This technique was used in a number of studies over the years but had the limitation of being only intermittently available as it was a stand-alone device, rolled from patient to patient for sampling of a few breaths.[9–13]

During the 1990s, the microprocessor became standard in the new generation of neonatal ventilators, with the ability to display real-time graphics of pressure, flow, and volume, as well as the combinations of pressure versus flow or volume versus flow. Most ventilator systems added data ports to allow information down-loading in one form or another. While the use of graphic information was variable among clinicians, information on how to use these displays was described in some detail and at least some became familiar with this important new perspective in treatment of neonatal respiratory failure.[14,15]

In spite of this real progress, these techniques have never been used to their full potential. There are a number of reasons for this. Thankfully, with the introduction of surfactant therapy, the greater use of noninvasive techniques like continuous positive airway pressure, and the push for both early nutrition and early extubation, the severity of respiratory compromise has decreased in many of the babies who previously went on to severe bronchopulmonary dysplasia and death. Also, even though the devices we use today are as different from those used in the 1970s as a computer is to an abacus, mechanical ventilation can be used effectively if not optimally without paying much attention to these data displays because many babies are not ventilated long enough to cause much long-lasting harm through ignorance. Also, the use of these newer techniques, with fully synchronized ventilation, tidal volume targeting, waveform display, and data availability, has not resulted in the "silver bullet" many of us hoped would dramatically improve outcomes. Some might argue that delving deeper into this mass of available data is like asking how many fairies can dance on the head of a pin. Even if it were possible to know the answer, what difference would it make?

The difference could be the ability to better understand both the changing patient and the impact of support. Uses for these data-sampling techniques seem limited only by our imagination and the questions we find important. As an example, the authors recently published a paper looking at an adjustable parameter on many ventilators, the pressure rise time (PRT), or slope to peak pressure.[16] Basically, this parameter (which many may find obscure!) changes the shape of the inspiratory pressure waveform from a square wave to a triangular wave. Both may deliver the same peak pressure, but because mean airway pressure is measured by the area under the curve of the pressure wave, a short rise time (square wave) will produce higher mean airway

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pressure and should impact the time for volume delivery. When volume targeting is used, the impact is unclear and has not been previously studied. This parameter is almost never changed, since there has been no information on whether it makes any real difference. In this study, the authors compared different modes of volume-targeted ventilation and showed some important differences in how volume was delivered and at what pressure requirements using different PRTs. The study was not designed to show clinical differences but to raise questions about how we may better deliver this type of support.

Is this the Hubble telescope for neonatal ventilation? In the sense that it will allow access to distant galaxies of information hidden in the starlight of datapoints, it may be. At least now it is possible to look at the interaction between baby and ventilator differently, with fresh insight and new questions.

ADDITIONAL INFORMATION

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