HFO/VG: This changes everything

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High-Frequency Oscillation (HFO) has been available to clinicians as a mode of ventilation for decades, although evidence supporting its use for decreasing chronic lung disease (CLD) has been lacking. A large study by Durand et al. of 512 infants indicated that at the least, HFO was as safe in the premature population as conventional ventilation. (1) Other studies from Europe have been more positive when looking at long term outcomes.

In the U.S., the only device available to clinicians to provide HFO has been the Sensormedics® oscillator. In Europe and the rest of the world, other ventilators are available which offer both conventional and HFO modalities. The Babylog® 8000 plus (Drager) was the first of such devices available in Canada. It came with the advantage of volume measurement in HFO mode, later incorporated into the VN 500 as "volume guarantee" (VG) in HFO mode.

Several factors compound the difficulty faced with ventilating the micro-preemie. As resuscitation is offered to smaller and smaller babies, the inherent structure of these infants becomes increasingly important. Small babies have small airways with high resistance. This resistance results in longer time constants and invariably air trapping to one degree or another.

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Clinicians using the Sensormedics® face a problem here for several reasons. The machine does not measure volume, and it is a very powerful ventilator; too powerful in fact for these smaller infants. Historically the workaround here has been to increase frequency to reduce the size of the resulting high-frequency tidal volume (VThf). This, of course, creates a problem because longer time constants call for lower frequencies, not higher ones. Finally, the machine is loud, and the circuit is cumbersome which makes the interaction between infant and parent difficult.

With the advent of VG in HFO mode, this can be greatly mitigated. Typically no circuit change is required if switching to HFO mode with these machines, and since VG adjusts actual volume delivered independent of frequency, we can now decrease frequencies to allow for the longer expiratory times demanded by small patients. Because CO_2 clearance is primarily a function of tidal volume ($DCO_2=f*VTHF^2$), a decrease in frequency and increased VT will compensate and maintain minute volume without increasing amplitude a great deal. Lower amplitude combined with the lowest possible tidal volumes theoretically should be more lung protective.

As well, newer machines offer adjustable I:E ratios. The VN 500 will allow 1:3 I:E, and the Leoni plus, also (Lowenstein Medical) 1:3. While increasing I:E ratio does result in increased amplitude, it also mitigates air trapping; and if the resulting dynamics are more efficient, this may allow for decreased overall ventilation settings.

The other problem with higher frequencies is the nature of gas flow itself. As frequency increases, amplitude must increase to maintain volume. This eventually results in turbulent low, ventilatory inefficiency and may contribute to airway instability as amplitude approaches MAP.

The unit I practice in has been using HFO for over 20 years, first with the Babylog 8000 plus, and over the last ten years, via the Drager VN 500 and Leoni plus. VG is used almost always in HFO mode, and we typically do not ventilate micro-preemies conventionally at all. While not hard evidence, it is our belief that this practice contributes significantly to our very low CLD rates, overall about 8% and 50% in the ≤24-week group.

From a physiological perspective, HFO should afford these vulnerable infants more lung protection since volume ventilation is difficult when there is very limited physiologically functioning volume within their lungs. In addition, the volumes required may be impossible to deliver without air trapping due to time constants and fragile, floppy airways that are prone to rupture at the pressures often required to volume ventilate these infants.

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When used with an understanding of both physiology and the physics of gas flow, HFO/VG as a modality offers clinicians a first line mode for lung protection provided of course that proper MAP is achieved for optimal compliance. This is something the HIFI trial of the early '80s should have taught us, but a lesson that seems to be lost to many clinicians.

We also ventilate extensively with the Bunnell Life Pulse Jet ventilator. The point at which this machine is used is a topic for another discussion.

References:

1. *High-Frequency Oscillatory Ventilation versus Conventional Mechanical Ventilation for Very-Low-Birth-Weight Infants Sherry E. Courtney, M.D., David J. Durand, M.D., Jeanette M. Asselin, R.R.T., M.S,Mark L. Hudak, M.D.,,Judy L. Aschner, M.D., and Craig T. Shoemaker, M.D. for the Neonatal Ventilation Study Group**

2. *August 29, 2002 N Engl J Med 2002; 347:643-652 DOI: 10.1056/NEJMoa012750*

Note: Proprietary software and devices are mentioned. This is not an endorsement of the device(s) but rather a commentary on a mode available.

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