Peer Reviewed

Recruitment Maneuvers: Not Just for Recruitment

Rob Graham, R.R.T./N.R.C.P.

I dedicate this column to the late Dr. Andrew (Andy) Shennan, the founder of the perinatal program at Women's College Hospital (now at Sunnybrook Health Sciences Centre). To my teacher, my mentor and the man I owe my career as it is to, thank you. You have earned your place where there are no hospitals and no NICUs, where all the babies do is laugh and giggle and sleep.

"While high-frequency jet ventilation (HFJV) is reputed to be the gentlest form of invasive ventilation, the mean airway pressures typically generated by this mode may not be sufficient to recruit the lung. "

While high-frequency jet ventilation (HFJV) is reputed to be the gentlest form of invasive ventilation, the mean airway pressures typically generated by this mode may not be sufficient to recruit the lung. "Conventional" breaths have traditionally been superimposed on HFJV to open the lung, be it on the admission table post-resuscitation or later to re-inflate areas of collapse. They were usually referred to as "sigh breaths."

Until recently, these breaths have used inspiratory times (Ti) of 0.4-0.5 seconds at 20 cmH2O or more pressures and rates of 2 to 5 or more. Whether or not the pressures used were below or above the HFJV peak inspiratory pressure (PIP) is an ongoing debate. If the pressure of the conventional breath is higher than HFJV PIP, the jet ventilator will pause for the duration of the conventional breath, whereas HFJV ventilation will continue if conventional PIP is less than HFJV PIP. These parameters were common before the advent of volume-targeted modes. The short Ti may not have been efficient at recruiting areas of low compliance, and combined with high PIP, may have resulted in volutrauma to areas of higher compliance.

This led some clinicians to challenge the traditional parameters used in "sigh breaths" and the term "sigh breath" itself. Since the purpose of using HFJV is to avoid the damage resulting from high pressures, why use them? Rather than using high PIP and short Ti, lower PIP helps avoid volutrauma in compliant areas. Holding that pressure longer allows pendelluft to occur and gently opens up less compliant areas. Furthermore, the term "recruitment maneuver" (RM) more aptly describes the purpose for using them.

While, as a general rule, I avoid using RMs as much as possible, I (and others) have found this strategy most effective in clinical practice. Beyond initial recruitment and targeting localised collapse, intermittent use of RMs provides the pressure required to bring new alveoli into the fold and participate in gas exchange since HFJV MAP may not be sufficient. However, RMs are of greater utility than just for recruitment.

"Beyond initial recruitment and targeting localised collapse, intermittent use of RMs provides the pressure required to bring new alveoli into the fold and participate in gas exchange since HFJV MAP may not be sufficient. However, RMs are of greater utility than just for recruitment."

In previous columns, I have described using RMs to offload the cardiovascular system and facilitate venous return, mainly when cerebral congestion is a concern. Maintaining appropriate MAP is essential for oxygenation and alveolar and airway stability. Adding RMs in concert with less PEEP produces the same MAP, but while the resulting MAP is the same, the profile is different. From a mathematical perspective, the area under the curve is the same, but the curve is different. Lower PEEP between RMs provides a greater pressure gradient for venous return (potentially increasing preload and decreasing afterload). Longer RM Ti affords more time for pendelluft to occur and the higher pressure to act on areas of atelectasis.

HFJV PIP is responsible for a small portion of MAP, typically 1-3 cmH_2O. Nevertheless, as it is decreased, the resulting MAP provides less support for airway/alveolar stability and recruitment of new growth. As oxygenation improves, PEEP is reduced. Since PEEP is the largest contributor to MAP, this is when stability can be lost. Using RMs at 1-3 per minute helps preserve stability as MAP decreases during the weaning process. This is a recent addition to my practice and has helped weaning and extubate babies with significant chronic lung disease and ensured optimal recruitment should be the first preparation for dexamethasone. The anti-inflammatory effect of steroids does not improve pulmonary function if the lungs are not recruited (nothing does!), and this may be one of the reasons a baby has little or no response to "DART" (**D**examethasone dosing: **A R**andomized **T**rial) (1).

"This is a recent addition to my practice and has helped weaning and extubate babies with significant chronic lung disease and ensured optimal recruitment should be the first preparation for dexamethasone. The anti-inflammatory effect of steroids does not improve pulmonary function if the lungs are not recruited (nothing does!), and this may be one of the reasons a baby has little or no response to "DART" (1)."

Ventilating infants with chronic lung disease (CLD) presents an ongoing challenge. The use of RMs in the management of chronic lung disease (CLD) in a "hybrid approach" with HFJV was discussed in a previous column (2).

RMs are not the exclusive realm of HFJV. When using next-generation multi-mode ventilators offering high-frequency oscillation (HFOV), RMs are an available adjunct and may be used similarly. They are seldom used but may yet find their place in HFOV. In the past, conventional breaths with "sigh breath" parameters were often used at a rate of 2 during HFOV, a practice that may be resurrected but with RM Ti and PIP.

Eventually, volume-targeted HFOV (HVO-VT) will become available to American clinicians. It has been several years since my first column in Neonatology Today, titled "HFO-VG: This Changes Everything." (HFO-VG is the Draeger® name for the mode I will refer to as HFO-VT.) In the hopes regulatory approval comes sooner than later, allow me to provide a refresher and share personal practice.

Amplitude (A) and frequency (ƒ) have independent effects on delivered volume (Vt) during HFOV. Increasing A results in larger Vt, but increasing ƒ has an inverse effect. As ƒ increases, less time is available to deliver volume at a given A, resulting in a decrease in Vt, while the increase in available delivery time with lower ƒ increases Vt. Higher ƒ also increases the risk of gas trapping. Unfortunately, when using older oscillators (such as the Sensormedics®), their high power necessitates using increased ƒ to avoid delivering high Vt to small babies (who are at greatest risk for gas trapping), even using minimum A. Clearance of CO_2 (referred to as DCO_2) is the product of ƒ x Vt^2, thus small increases in Vt, regardless of how produced, produce a large increase in CO_2 clearance.

When using HVO-VT, CO_2 clearance is represented by the DCO_2 equation, but A and ƒ are decoupled. Changes in ƒ no longer result in changes to Vt size; instead, A increases or decreases as ƒ increases or decreases to maintain the set Vt target. This avoids the constraints of traditional HFOV when delivering Vt. The big difference using HVO-VT is that Vt remains constant regardless of changes to A or ƒ as long as A settings are sufficient to provide it. The effects of changes in a baby's position are less challenging since ventilation status is maintained by A, adjusting automatically to maintain Vt.

Without Vt monitoring, HFOV parameters are adjusted based on "chest wiggle" (a subjective measure that can result in large changes in delivered Vt.) Even though HFOV pressures attenuate rapidly, upper airways may still be subjected to damaging sheer stresses produced by large A. HVO-VT allows clinicians to provide minute ventilation (MV) at the lowest possible A by decreasing ƒ and compensating by increasing Vt. Decreasing ƒ linearly decreases MV, but since increases in Vt increase DCO_2 exponentially, a small increase in Vt will maintain it.

It is my practice (and a general principle in the unit in which I practice) to ventilate with A, which would be considered relatively low by clinicians used to conventional HFOV. Changing to HFJV is considered if A is required to ventilate exceeds 20-25 cmH2O and/or Vt required exceeds 2-2.5 ml/kg. I will change to HFJV if A of 20 cmH_2O is required, but I will exceed 2.5 ml/kg (my upper limit is 3 cmH_2O) if it is not expected to be required for longer than a few hours, especially in larger babies. The rationale is that as Vt increases, the lung protective benefits of HFOV wane.

Changes in ƒ do not have an inverse effect on MV when using HVO-VT; instead, MV increases with higher ƒ (and vice-versa) until a combination of gas trapping and less efficiency ablate the effect, at which point further increases in ƒ will decrease MV. Furthermore, the higher A required to deliver Vt in less time may necessitate increasing MAP to avoid airway instability.

"In medicine, the lag time between evidence provided from studies to adoption in clinical practice is excruciatingly long. There may be little or no evidence when it comes to ventilation. Knowledge of physiology, the interaction between the pulmonary system and others, and judicious, objective observation may be the only guide available when modifying ventilation clinical practice."

Within the NICU where I work, HVO-VT is the first-line mode used when ventilating babies under 30 weeks PMA, and babies under 25 weeks PMA are often ventilated with HFJV within a few days, if not initially with "nano-prems". Conventional modes are rarely used and are usually reserved for larger babies requiring short-term invasive support.

Adopting these principles has resulted in our NICU having amongst the world's lowest rates of chronic lung disease, even with the tiniest, lowest PMA babies. It is worth noting that these outcomes have not changed significantly as the use of non-invasive ventilation has increased.

"Challenge your assumptions" is good advice in any situation and topic. This includes mechanical ventilation in the NICU. In medicine, the lag time between evidence provided from studies to adoption in clinical practice is excruciatingly long. There may be little or no evidence when it comes to ventilation. Knowledge of physiology, the interaction between the pulmonary system and others, and judicious, objective observation may be the only guide available when modifying ventilation clinical practice. In my place of work, this was the primary factor (along with available published evidence) in switching from conventional ventilation to HFOV and in the increased use of HFJV.

In the quest to "first do no harm," we should all be investigators.

References:

1. Lex W Doyle, Peter G Davis, Colin J Morley, Andy McPhee, John B Carlin; DART Study Investigators; Pediatrics. 2007 Apr;119(4):716-21. doi: 10.1542/peds.2006-2806.
2. Graham, R, Neonatology Today, Volume 18, Issue 6 https://neonatologytoday.net/newsletters/nt-jun23.pdf
3. Graham, R, Neonatology Today, Volume 14, Issue 1 https://www.neonatologytoday.net/newsletters/nt-jan19.pdf

Disclosures: The author receives compensation from Bunnell Inc for teaching and training users of the LifePulse HFJV in Canada. He is not involved in sales or marketing of the device nor does he receive more than per diem compensation. Also, while the author practices within Sunnybrook H.S.C. This paper should not be construed as Sunnybrook policy per se. This article contains elements considered "off label" as well as maneuvers, which may sometimes be very effective but come with inherent risks. As with any therapy, the risk-benefit ratio must be carefully considered before they are initiated.

NT

Corresponding Author

Rob Graham, R.R.T./N.R.C.P.
Advanced Practice Neonatal RRT
Sunnybrook Health Science Centre
43 Wellesley St. East
Toronto, ON
Canada M4Y 1H1
Email: rcgnrcp57@yahoo.ca
Telephone: 416-967-8500