Topic: Lung protective ventilation

Associate Editor Graeme A'Court interviews Dr. David Willms, Pulmonary/Critical Care physician and Co-director, Critical Care service at Sharp Memorial Hospital, San Diego, USA.

Q1: Please tell me about how you developed an interest in this topic?

Answer: When I joined the practice group I'm in, in the late 80s/early 90s, they were already using pressure control ventilation in severe ARDS patients in an effort to reduce distending pressures. I believe the primary consideration at the time was to decrease overt barotrauma. Around that same time, I began to develop a program for veno-venous ECMO at our facility, in light of the reports coming out of Milan (Gattinoni) and Marburg (Lennartz) demonstrating successful application of a newer approach to ECMO, including use of low frequency positive pressure ventilation ('lung rest'). Gattinoni's CT scan studies and the concept of the 'baby lung' in ARDS were also highly influential in my thinking about how to safely ventilate. An accumulation of animal data on VILI, and the report by Keith Hickling in Christchurch of remarkable outcomes in the use of permissive hypercapnia (i.e. using very low tidal volumes) in severe ARDS cases further accelerated my interest in lung protection, which has now become a lifelong pursuit.

Q2: A: What are your thoughts on lung recruitment maneuvers and is there a place for them since the most recent publications have thrown some doubt on the overall benefit of them?
B: do you have these tools on the ventilators and are they used on a regular basis?

Answer: I will sometimes use a recruitment maneuver in hypoxemic respiratory failure patients, especially when I am trying to determine a satisfactory PEEP level. We use ventilators that allow for a recruitment maneuver at the end of a machine-performed incremental pressure-volume curve maneuver, so that is typically my approach. However, I do not routinely prescribe recruitment maneuvers in ARDS patients, in part due to the negative or at least equivocal results in controlled studies, including the 'ART' study; and also drawing conclusions from the negative HFOV trials where the higher mean airway pressures (simulating a recruitment maneuver) actually increased mortality.

Q3: What are your thoughts of the use of driving pressure, mechanical power, pressure limitation, 6 mls/kg or adjusting the tidal volume based on compliance

Answer: I think we have to acknowledge that the most robust data supporting improved outcomes from ventilator management in ARDS remains the low tidal volume/low plateau pressure approach as demonstrated in the original ARDSnet trial, but also supported by various other studies before and since. That said, the 6 mL/kg predicted body weight tidal volume target remains a somewhat arbitrary choice, and the control group choice of 12 mg/kg tidal volume suspect. In particular, I find the studies on driving pressure and mechanical power limitation intriguing, and mechanistically logical, but think we need a bit more prospective study before adopting these approaches as routine. That said, when I have a patient on VV ECMO for ARDS, I assiduously try to reduce driving pressure to less than or equal to 15 cmH2O, and attempt to keep set respiratory rate very low, to achieve a low (calculated) mechanical power applied to the lungs.

Q4: How do you set "optimal" PEEP? Is it based on improving PaO2, mechanics, or trying to have an open lung strategy?

Answer: If I have ever set the 'optimal PEEP' on any patient in my career, I'm pretty sure it was by accident, because I remain unsure as to the best determinant of this goal. In general I tend to set PEEP based on FiO2 requirement (similar to ARDSnet PEEP:FiO2 table – generally the 'high' table). In some cases, especially early in the course and if the patient is paralyzed or sedated to the point of no respiratory effort, I will perform a pressure-volume curve (we mostly use ventilators where this is a feature in the software), and determine PEEP based on analysis of the curve, inflection points and hysteresis. I have not yet used best compliance, or esophageal pressure monitoring to set PEEP, but am considering using both approaches in selected patients in the near future.

Q5: Can you please describe your thoughts on the use of esophageal pressure monitoring as a strategy for lung recruitment and or setting PEEP?

Answer: I have only done this a few times in the past, but with recent ventilator features which make use of esophageal pressure monitoring more facile, I do plan to start using this more frequently. I think especially in the morbidly obese ventilated patient, esophageal pressure data may facilitate our confidence in using higher levels of PEEP, and plateau pressure, when we are able to confidently know actual transpulmonary pressure. In my experience, these patients often are ventilated with insufficient levels of PEEP, and consequently requiring higher levels of FiO2 and probably this has contributed to longer times on mechanical ventilation.

Q6: Which mode or strategy do you use for lung protection? Would you consider newer modes of ventilation "closed loop" that automatically adjust to match the changes of the patient's lungs and as well maybe better synchrony?

Answer: Limitation of tidal volume and plateau pressure remain the primary approach to lung protection, in patients with acute lung injury. Although I recognize the specific mode of ventilation may not be as important, I tend to use a volume targeted, pressure limited mode in most of my acute lung injury patients (e.g. APV CMV or PRVC). The rationale for this is well documented, albeit unproven in terms of ultimate outcome. We do have ventilators which have adaptive support ventilation (ASV), and I often use this mode for routine ventilator management in a variety of different clinical situations, but for moderate or worse ARDS patients I prefer a volume targeted mode as ASV can sometimes allow the patient to experience excessive inspiratory effort or higher than desired tidal volumes, both of which theoretically may be injurious.

Q7: What are your thoughts on dealing with dys-synchrony including adjusting the ventilator to match the patient and as well diaphragmatic injury? (Challenging question)

Answer: The management and avoidance of ventilator dyssynchrony starts with having a high index of suspicion it may be occurring, and careful observation of the patient and displayed ventilator waveforms. I try to look at a number of ventilator settings and adjust trigger sensitivity, inspiratory flow (if in volume mode), PEEP, tidal volume, set rate, inspiratory time/I:E ratio, flow termination threshold and others to attempt to optimize synchrony. I believe that a trial-and-error approach at the bedside is often necessary, and this requires a dedicated clinician with interest, knowledge, and time to perform this. If necessary, additional sedation or neuromuscular paralysis may be needed. In the last several years, I have become an advocate for intermittent single-dose paralytic dosing in tough cases; for reasons that are unclear to me, this sometimes breaks the cycle of dyssynchrony, even after the paralytic effect wears off.

Q8: Can you please share your thoughts on the use of neuromuscular blockers and permissive hypercapnia as part of management for lung protective ventilation?

Answer: The trial by Papazian et al from France spurred me to use neuromuscular paralysis more often in patients with early, moderate or severe ARDS, as a 48-hour intentional therapy. With the failure to demonstrate a mortality benefit in subsequent clinical research, I have reverted to a stance that I will use neuromuscular paralysis if the patient demonstrates dyssynchrony despite adequate sedation and ventilator adjustment, or if oxygenation goals cannot be met without it. I try to limit the duration of paralysis with frequent attempts at weaning, and if necessary, increased systemic sedation, which obviously contradicts our general goal of minimizing sedation in ICU patients - but 'que sera sera'. Permissive hypercapnia in my view is a surrogate for reduction in mechanical power of ventilation, and I don't think there is much doubt that, in ARDS patients specifically, this is a strategy that results in improved outcomes, although the data is somewhat indirect. In difficult-to-ventilate non-ARDS patients such as severe status asthmaticus, or advanced COPD, permissive hypercapnia can be the difference between life and death, primarily by allowing avoidance of the terrible effects of overdistention and air trapping.

Q9: Do you use proning in your ICU practice and what is your experience?

Answer: I do. We apply prone therapy to most patients with moderate or severe ARDS. I have proned patients for over 30 years, but increasingly so following studies demonstrating a mortality benefit, especially when applied early in the course of therapy. During the height of the Covid pandemic we did this innumerable times and saw the benefit empirically. It is still an underutilized supportive therapy for the patient with ARDS, and should be used early and for adequate duration of time. In my experience, the 2 most common mistakes with regard to proning are: delay in starting prone therapy; and terminating prone therapy too soon. Also, what I think is most commonly misunderstood about proning therapy is that the beneficial effect on mortality is likely unrelated to its impact on oxygenation; and therefore many times its use is terminated based on oxygen parameters rather than a global assessment of the trajectory of improvement in lung injury. We need to keep in mind one of the crucial lessons from ARDSnet: improvement in a physiological parameter (oxygenation) may not translate into a survival benefit. There is more at play here.

Q10: What are your thoughts on ECMO or ECCO2r as a solution for many patients with ARDS or do you feel they are overused due to the lack of understanding optimal PEEP and lung recruitment?

Answer: Veno-venous ECMO is a legitimate salvage therapy for selected patients with ARDS (and some other selected conditions). The appropriate application of ECMO for ARDS Is complicated by the over-reliance on case series (e.g. during H1N1 pandemic); somewhat flawed prospective trials; and conflicting data. Nevertheless, lessons have been learned, the technology has advanced significantly, and in selected cases it should be offered in centers with adequate training and expertise.

Q11: In your opinion, what are the unanswered questions in the field of mechanical ventilation?

Answer: Virtually all major questions in mechanical ventilation remain unanswered, or with incomplete answers. Examples of unanswered questions include: What is the optimal tidal volume for patients with ARDS? Or non-ARDS patients? Which mode(s) of ventilation are preferable, and for which patient populations? How do we best identify ventilator dyssynchrony? What are the best strategies to address dyssynchrony? What is the best way to set PEEP (a > 50 year question!)? The complexity, and in fact, beauty of mechanical ventilatory support is that it remains as much an art as it is a science. What must continue to be a driving principle is the time-honored dictum in all of

medicine: “Primum non nocere” – First of all, do no harm. If we can keep this in mind, we will give our patients compassionate and evidence-based, but individualized ventilatory care.