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Washington University Emergency Medicine Journal Club

Lower tidal volume in patients at risk for acute respiratory distress syndrome

Vignette

It is 0200 and you are working in the trauma critical care (TCC) area of your beloved emergency department. During the chaotic shift, three patients require endotracheal intubation. The first patient is a 55 year old man with a history of lymphoma in remission, and he is status post splenectomy. He arrived hypoxic with a S_pO_2 of 85% and tachypneic with a respiratory rate of 30. It is obvious what is needed and he is immediately intubated successfully without complication in room 5 of the TCC. His post-intubation chest radiograph shows bilateral alveolar opacities congruent with multi-focal pneumonia, and acute respiratory distress syndrome (ARDS).

You walk out of room 5 and see an obtunded 22 year female vomiting in room 6. She is intoxicated and smells of alcohol, and a quick biopsy of her belongings shows several prescription bottles. You think this is likely a polysubstance overdose, and because of her mental status and lack of gag, you intubate for airway protection. Vomitus is around her vocal cords during direct laryngoscopy and she has significant secretions noted by the respiratory therapist. Her post-intubation chest radiograph shows a right lower lobe infiltrate, most congruent with aspiration.

As you exit room 5, you are called to room 4 because of the arrival of a 45 year old man who was trying to light his cigarette while bent over a brewing batch of methamphetamines. Shockingly, a small eruption occurred. Upon arrival, he is alert (also intoxicated) and you note that he has minimal burns, all located to his face, with singed hairs and soot in his mouth. You perform a quick fiberoptic examination of his upper airway, and note edematous and erythematous tissue in his posterior oropharynx, extending distally to his vocal cords. Given this inhalation injury and potential for upper airway obstruction, you intubate him, which is uneventful. His post-intubation chest radiograph is remarkable only for some interstitial edema.

You are happy that you have successfully performed perhaps the most defining trait of a well-trained emergency physician- securing an emergent airway. Your respiratory therapist is asking for ventilator orders, and she has set each patient at what appears to be pretty standard settings, with a tidal volume of 500mL for each patient. Noting that the median ICU wait time at your institution is around 6 hours, you wonder if this catch-all mechanical ventilation prescription is the most appropriate strategy. You are now considering the evidence regarding tidal volume for patients with ARDS, but especially for the two patients at risk for ARDS.

	Patient 1	Patient 2	Patient 3
Clinical risk/condition	Sepsis 2^0 pneumonia	Aspiration	Inhalation injury
ARDS status	Present	At-risk	At-risk
Height	6’ 0”	5’ 0”	5’ 6”
PBW (kg)	77.6	45.5	63.8
Tidal volume	500	500	500
mL/kg PBW	6.4	10.9	7.8
PEEP	5	5	5
F_iO_2	1.0	1.0	1.0

PICO Question
Population: Mechanically ventilated adult patients at risk for ARDS, but without the syndrome.
Intervention: Low tidal volume (≈6mL/kg PBW).
Comparison: Conventional tidal volume.
Outcome: Incidence of ARDS early after ICU admission from the ED (i.e. within ≈5 days).

Search Strategy

MEDLINE, EMBASE, CINHAL, and the Cochrane Library were searched using:
Acute Lung Injury
"Acute Lung Injury"[Mesh] OR "Acute Lung Injury" OR “Acute Lung Injuries” OR "Ventilator-Induced Lung Injury"[Mesh] OR "Ventilator-Induced Lung Injury” OR “Ventilator-Induced Lung Injuries” OR “Ventilator Associated Pneumonia” OR “ventilation induced lung injury” OR “VILI”

AND

Prevention
Prevent* OR prevention OR prophylax* OR prophylac* OR chemoprevent* OR thwart* OR "ward off" OR "ward-off" OR pre-emptive* OR preemptive* OR chemoprophyla*

AND

Outcome
(outcome* OR ((treatment* OR protocol*) AND (respond* OR response*)) OR failure* OR mortality OR fatal* OR death OR dead OR deaths OR "passed away" OR demise* OR Recurren* OR progression OR progressed OR relaps* OR growth OR grew OR growing OR regression OR survival OR cure OR cures OR "quality of life" OR qol OR morbidit* OR adverse OR "side effect" OR "side effects" OR event OR events OR nausea OR nauseous OR vomit* OR emesis OR comfort* OR pain OR

painful OR painfree OR pain-free OR stress OR analges* OR "Outcome Assessment Health Care "[Mesh] OR "Mortality"[Mesh] OR "mortality "[Subheading] OR "Survival"[Mesh] OR "Survival Analysis"[Mesh] OR "Quality of Life"[Mesh] OR "Pain Measurement"[Mesh] OR "Health"[Mesh] OR "Health Status Indicators"[Mesh] OR "Health Status"[Mesh])

AND

Adults
"Young Adult"[Mesh] OR "Young adults" OR "Young Adult" OR "Adult"[Mesh] OR "adults" OR "adult" OR "Middle Aged"[Mesh] OR "Middle age" OR "Aged"[Mesh] OR "Aged" OR Elder* OR "Aged, 80 and over"[Mesh] OR "Oldest Old" OR Nonagenarian* OR Octogenarian* OR Centenarian* OR "Frail Elderly"[Mesh] OR "Frail Older Adults" OR "Frail Older Adult"

AND

PubMed NOT Animal Studies
NOT (("Animals"[Mesh]) NOT ("Animals"[Mesh] AND "Humans"[Mesh]))

This yielded a total of 1,704 potentially relevant articles, of which 1,652 were excluded based on title on abstract. This left 52 full text articles, which were further reviewed to assess appropriateness and relevance to the journal club topic.

Article 1: Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. The Acute Respiratory Distress Syndrome Network. N Engl J Med. 2000 May 4;342(18): 1301-8. Answer Key.

Article 2: Fuller BM, Mohr NM, Dettmer M, et al. Mechanical ventilation and acute lung injury in emergency department patients with severe sepsis and septic shock: an observational study. Acad Emerg Med. 2013 Jul;20(7):659-69. Answer Key.

Article 3: Determann RM, Royakkers A, Wolthuis EK, et al. Ventilation with lower tidal volumes as compared with conventional tidal volumes for patients without acute lung injury: a preventive randomized controlled trial. Crit Care. 2010;14(1):R1. Answer Key.

Article 4a: Fuller BM, Mohr NM, Drewry AM, Carpenter CR. Lower tidal volume at initiation of mechanical ventilation may reduce progression to acute respiratory distress syndrome: a systematic review. Crit Care. 2013 Jan 18;17(1):R11. Answer Key.

Article 4b: Serpa Neto A, Cardoso SO, Manetta JA, et al. Association between use of lung-protective ventilation with lower tidal volumes and clinical outcomes among patients without acute respiratory distress syndrome: a meta-analysis. JAMA. 2012 Oct 24;308(16):1651-9. Answer Key.

Bottom Line

With an incidence of close to 200,000 patients annually (Rubenfeld 2005), a mortality rate of about 40% (Bersten 2002, Rubenfeld 2007), and prolonged physical and mental sequelae in survivors, it is clear that ARDS is one of the most important problems in critical care. A treatment still does not exist for the underlying pathophysiology of the syndrome, and low tidal volume ventilation remains the only consistent mortality benefit across syndrome severity. Given these facts, prevention of ARDS has become increasingly important, and the focus of increasing study and funding priorities.

A major question, and topic of controversy, is "Should lower tidal volume be used prophylactically to prevent ARDS in at-risk patients?" Tidal volume is a major risk factor for the development of ventilator-associated lung injury (VALI). This has been established in animals models of lung injury and human data in patients with ARDS. ARDS is relatively common in the ED. Observational data and a small randomized controlled trial (Determan 2010) show that lower tidal volume may reduce progression to ARDS. This was further studied by two recently published systematic reviews (Serpa Neto 2012, Fuller 2013), which both concluded that the majority of data does point to a therapeutic benefit to low tidal volume ventilation to prevent ARDS.

Another major question is "Can the ED play a role in the treatment and prevention of ARDS?" Observational data shows that a significant minority of patients have ARDS in the ED (Fuller 2013). Clinical data also shows that progression to ARDS occurs early after ICU admission, with a median onset of 30 hours (Shari 2011). This temporal relationship suggests a potential causal link to treatment provided (or not provided) during the ED and early ICU course. Despite this, not a single trial of mechanical ventilation has ever been conducted in the ED. Further highlighting the importance of ARDS prevention, patients progressing to ARDS experience increased morbidity and mortality.

With respect to mechanical ventilation in the ED, there is limited data. What does exist tells us that tidal volumes commonly delivered are highly variable, and potentially injurious ventilation practices exist. This provides rationale for quality improvement, knowledge translation, and randomized trials in these ED patients.