Overview of ARDS Ventilator Management Strategies

University Hospital Respiratory Care
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Patient with ARDS

Use a Basic Lung Protective Ventilation Strategy (see #1)

Asynchrony?

Yes

No

PaO2/FiO2 <150?

No

Yes

- Consider nonrespiratory causes (eg, PFO, PE, etc)
- Fluid restriction and diuresis as necessary

PaO2/FiO2 <150?

No

Yes

Per clinical situation, consider:

* Strong recommendation for:
  - Prone

* Conditional recommendation for:
  - Higher PEEP
  - Recruitment maneuvers

* Evidence for efficacy is limited:
  - Neuromuscular Blockade
  - Pes
  - APRV
  - Inhaled prostacyclin / iNO
  - ECMO

* Strong recommendation against:
  - HFOV

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Lower PEEP/Higher FiO2 table

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Higher PEEP/ Lower FiO2 table (from ROSE study)

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Consider Lower PEEP for patients with low PEEP responsiveness potential (ie, P/F ≥150); Higher PEEP if higher PEEP responsiveness potential (P/F <150) or BMI ≥35

1: Basic Lung Protective Ventilation

- ARDS Network ventilation strategy:
  a. Use VCV or PCV, targeting VT 6 mL/kg PBW
  b. Maintain Pplat ≤30 cm H2O
  c. PEEP/FiO2 per table (see bottom of page)
  d. If consolidation is asymmetrical, consider placing ‘good lung’ in dependent position

2: Patient-Ventilator Asynchrony

* Consider minor ventilator adjustments (eg, flow rate & pattern, inspiratory pause)
* Assess potential to treat with pharmacologic agents (eg, sedation, NMB), especially in pt with severe ARDS and strong respiratory drive (double-trigger)
* For double-triggering, consider increasing VT 1 mL/kg (max 8 mL/kg), provided Pplat <30 cm H2O
* For flow asynchrony, consider a variable flow pressure breath mode of ventilation:
  - Volume targeted PC (PRVC, VC+, Autoflow)
  - Pressure control, pressure support

Prone Positioning

* Consider after initial 12-24 hrs of stabilization
* Use 16 hr/day (generally 4 pm to 10 am)
* Discontinue when:
  - instability in prone position
  - supine x 4 hr, PaO2/FiO2 >150 on FiO2 ≤0.60 & PEEP ≤10

Higher PEEP

* For pts with PaO2/FiO2 <150, consider higher PEEP table

Recruitment Maneuvers

* Consider for pts with clear de-recruitment, negative PtP or PaO2/FiO2 <150
* Recommend PCV with: 1) 40/20-25 for 1-3 min (as tolerated) or 2) delta-P of 15 and increase PEEP by 5 up to PIP of 40
* If CPAP method used, limit to 15-30 seconds
* Provider should be at bedside if pressures >40 cm H2O used

Neuromuscular Blockade

* No benefit of routine use of NMB in moderate-severe ARDS.
* Consider use if significant asynchrony and concern for VILI

Esophageal Pressure (Pes) Guided Therapy

* Informs of transpulmonary end-inspiratory (PtP-plat) and end-expiratory (PtP-PEEP) pressures
* Requires AVEA ventilator & placement of Pes catheter

Airway Pressure Release Ventilation (APRV)

* Increases Pmean with lower Pplat; lacks outcomes benefit
* Concern for P-SILI in pt with strong respiratory drive

Inhaled Nitric Oxide (iNO)

* Start at 10 ppm
* If no response, discuss with team to consider stopping

NOTE: iNO is a very costly drug compared to alternatives

Extracorporeal Membrane Oxygenation (ECMO)

* Absolute contraindications: irreversible pulmonary process
* Evaluate, but lower survival if on vent 7-10 days pre-ECMO
* Consider if: PaO2/FiO2 ≤30 x 3 hrs or ≤30 x 6 hrs, or pH <7.25 w/ PaCO2 >60 x 6 hrs

High Frequency Oscillatory Ventilation (HFOV)

* Strong recommendation against routine use; may have benefit if PaO2/FiO2 <64; goal is to increase Pmean

Updated: 1/6/20

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GENERAL COMMENT
Low VT and minimizing Pplat is the only ventilation strategy with a high level of evidence of mortality benefit in ARDS. Therefore, a lung protective ventilation strategy (LPV) following the ARDS Network strategy (using pressure or volume ventilation) to limit VT (target 6 mL/kg; reduce to 5 or 4 mL/kg for high Pplat, 7 or 8 mL/kg for double-triggering) and Pplat (<30 cm H2O) should be the initial and primary strategy for all ARDS patients.

RECOMMENDED READING
Guidelines or Reviews on ARDS Management:

Setting VT:
* Standard is targeting 6 mL/kg PBW & limit Pplat ≤30 cm H2O; drive pressure (ie, keep <12-15) may be more important than VT or Pplat
1. The ARDS Network. NEJM 2000; 342(19):1301-1308 [Pivotal ARDS RCT, 861 pts, reduced mortality with 6 mL/kg BW & Pplat ≤30, is current standard of care]
2. Amato MBB, et al. NEJM 2015;372:747-755 [Secondary analysis of 9 RCTs showing that drive pressure is strongly associated with survival, VT and Pplat were not]

PEEP
* For most pts the lower PEEP table should be used. For pts with ARDS and P/F <150 and/or those with high Ppl, the Higher PEEP table should be considered
1. Briel M, et al. JAMA 2010; 303:865-873 [Patient-level meta-analysis; higher PEEP associated with improved mortality in subgroup of patients with PaO2/FiO2 <200 (moderate & severe ARDS), suggested harm of high PEEP in mild ARDS (PaO2/FiO2 >200)

Prone Positioning (PP)
* PP improves respiratory mechanics and hemodynamics which improve both oxygenation and RV function; is associated with lower inflammatory mediator levels
2. Low respiratory compliance in ARDS using prone ventilation: a meta-analysis of 4 RCTs, 256 ARDS pts, reduced mortality and Pplat reduction >15 cm H2O in Pes-guided prone ventilation vs not prone (RR 0.66, 95% CI 0.49-0.91) [Sahetya SK, et al. Am J Respir Crit Care Med 2017;196:1519-1525]

Neuromuscular Blockade (NMB)
* Although Papazian suggests benefit for ARDS pts with P/F <150, ROSE showed no benefit of NMB when high PEEP used
1. Papazian L, et al. NEJM 2010; 363:1107-1116 [ACURASYS RCT, showed improved survival: group P/F<150 NMB (cisatricurium) for first 48 hr of management, without increasing muscle weakness; used low PEEP maneuver in both groups and heavy sedation in control group]
2. Moss M, et al. NEJM 2019; 380:1997-2008 [ROSE RCT showed no difference in 90-d mortality; used high PEEP in both groups and light sedation in control group]

Airway Pressure Release Ventilation
* Other than Zhao, over 15 RCTs have NOT shown superiority of APRV vs conventional MV. Concern exists about strong resp drive and P-SIL in severe ARDS.
2. Zhou Y, et al. Intensive Care Med 2017;43:1648-1659 [RCT (138 ARDS pts); early application of APRV associated with improved oxygenation and respiratory mechanics, decreased Pplat and reduced duration of ventilation and ICU stay; trend toward lower ICU mortality (19.7 vs 34.3%, p=0.053)]

Inhaled Nitric Oxide and Inhaled Prostacyclin
* iNO improves oxygenation, reduces shunt thru PFO, helps safe transport to UM, no mortality benefit, is associated with AKI, costly (>$3,500/day not reimbursed)

ECMO
* Rescue therapy for severe hypoxic RF (ARDS w/ P/F <60 on >80% O2) after medical and MV optimized (incl NMB, PEEP, fluid/HD). Consider early consult.
3. Combes A, et al. NEJM 2018; 378:1965-1975 [ELOLAR RCT; inclusion: P/F <50 x hrs, or 80 x hrs, or systolic blood pressure <80 mm Hg and PaO2/FiO2 <100]; lower trend in 60-d mortality w/ECMO (35 vs 46%; RR 0.76; 95% CI 0.55 to 1.04, p=0.09)); crossover to ECMO in 28% of control, had higher mortality (57%)

HFOV
* Harmful in mild and moderate ARDS; may be beneficial in very severe (P/F<64) ARDS
2. Young D, et al. N Engl J Med 2013; 368(9):806-813 [OSCARG RCT of 795 severe ARDS patients; no mortality difference (41.7 vs 41.1%)]
3. Meade MO, et al. Am J Respir Crit Care Med 2017;196:727-733 [Patient-level meta-analysis (4 RCT, 1552 pt); HFOV increases mortality for most ARDS patients, may improve survival in patients with severe hypoxemia (ie PaO2/FiO2 <64); barotrauma higher with HFOV]

Updated 1/13/20