RECRUITMENT MANEUVERS

- Theoretical benefit to periodic recruitment in both ARDS and routine intraoperative setting
- Avoidance of tidal shear stress
- Small studies have shown benefit but data are equivocal
- How much, how long? (Ramp, cyclic, brief sustained)
- Which patients? (Responders vs non-responders)
- Risk of hypotension and hemodynamic collapse

BENEFITS OF APRV ARE MOSTLY LINKED TO MAINTENANCE OF SPONTANEOUS RESPIRATION

- Recruitment, especially adjacent to diaphragm
- Decreased intrathoracic pressure (Lower Ppl but local Increase in Ptp)
- Improved PaO2
- Better V/Q matching (when 10-30% of V_E is spont)
- Improved CI (periodic reduction in transthoracic pressure)
- Improved organ perfusion (renal, gut)

Recruitment Maneuvers

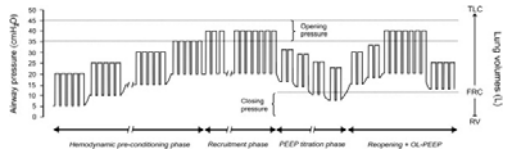


Fig. 1 Schematic representation of a cycling lung recruitment maneuver in healthy lungs. The maneuver is performed in pressure control ventilation using a driving pressure that results in a tidal volume (VT) of 6 mL/kg. Respiratory rate is set to 15, I:E r...

Gerardo Tusman , Stephan H. Bohm , Fernando Suarez-Sipmann

Alveolar recruitment during mechanical ventilation – Where are we in 2013?

Trends in Anaesthesia and Critical Care, Volume 3, Issue 5, 2013, 238 - 245

http://dx.doi.org/10.1016/j.tacc.2013.06.003

LIMITATIONS AND CONTRAINDICATIONS

- Works best with spontaneous respiration and lower levels of sedation
- Permissive Hypercapnea may compromise cerebral blood flow in setting of intracranial hypertension
- Intrinsic PEEP may become problematic (i.e. in setting of severe COPD)
- Evidence of outcome benefit is limited

LOW STRETCH AND OPEN LUNG: APRV

- Time-cycled switching between high and low pressure
- Delta Pressure = mechanically delivered V_T
- Setting T_{high} and T_{low} enables rate adjustment
- Unrestricted spontaneous breathing (PSV)
- True APRV, $T_{low} \leq 1.5$ seconds

GOALS WHEN SETTING APRV

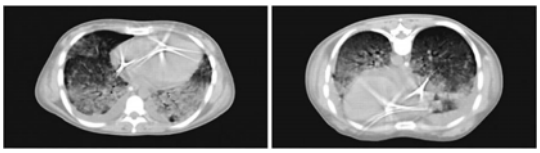
- Tidal volume 6ml/kg, Plateau ≤ 30 cm H_2O
- Duration of high pressure should allow spontaneous breathing
- Duration of low pressure should allow complete expiration and minimize intrinsic PEEP
- Target light to moderate sedation (Ramsay 2-3, RASS 0 to -2)

TROUBLESHOOTING IN APRV

- Asynchrony is most likely when pressure is released during spontaneous inspiration or reapplied during spontaneous expiration
- Timing of high and low pressures may need to be adjusted
- Titrate sedation
- "Synchronized" APRV is being developed

WHAT IF APRV IS NOT WORKING? (↓PAO_2 *AND* ↑$PACO_2$)

- Prone Positioning
- Theoretical benefit



- Several meta-analyses showed benefit, but RCTs had not, potential risks

TROUBLESHOOTING IN APRV: LOW PAO_2

- Increase low pressure (may effect Ve)
- Decrease T_{low}
- Ensure adequate spontaneous respiratory rate
- Inhaled nitric oxide or flolan may decrease shunt

PRONE POSITIONING

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JUNE 6, 2013 VOL. 368 NO. 23

Prone Positioning in Severe Acute Respiratory Distress Syndrome

Claude Guérin, M.D., Ph.D., Jean Reignier, M.D., Ph.D., Jean-Christophe Richard, M.D., Ph.D., Pascal Beuret, M.D., Arnaud Gacouin, M.D., Thierry Boulain, M.D., Emmanuelle Mercier, M.D., Michel Badet, M.D., Alain Mercat, M.D., Ph.D., Olivier Baudin, M.D., Marc Clavel, M.D., Delphine Chatellier, M.D., Samir Jaber, M.D., Ph.D., Sylvène Rosselli, M.D., Jordi Mancebo, M.D., Ph.D., Michel Sirodot, M.D., Gilles Hilbert, M.D., Ph.D., Christian Bengler, M.D., Jack Richecoeur, M.D., Marc Gainnier, M.D., Ph.D., Frédérique Bayle, M.D., Gael Bourdin, M.D., Véronique Leray, M.D., Raphaele Girard, M.D., Loredana Baboi, Ph.D., and Louis Ayzac, M.D., for the PROSEVA Study Group*

TROUBLESHOOTING IN APRV: HYPERCARBIA OR ACIDOSIS

- Mild to moderate acidosis may be protective, but worsening acidosis can be problematic
- Try to minimize intrinsic PEEP by lengthening T_{low}
- Raise high pressure setting to increase V_T
- Bronchodilator therapy, corticosteroids (if COPD)

PRONE POSITIONING

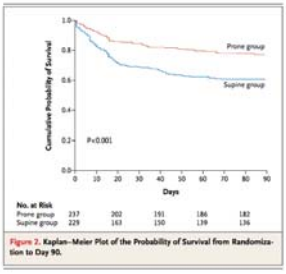


Figure 2. Kaplan–Meier Plot of the Probability of Survival from Randomization to Day 90.

1. 466 patients with early severe ARDS
2. 12-24h stabilization period
3. Randomized to supine versus prone for at least 16h per day
4. All ICUs had at least five years proning experience
5. Mortality reduction of %50

OSCILLATION

- Two major trials published in 2013
- OSCAR showed no benefit vs conventional low-stretch
- OSCILLATE showed increased mortality

OSCAR: N Engl J Med 2013;368:806-13.

OSCILLATE: N Engl J Med 2013;368:795-805

ECMO: CESAR TRIAL LIMITATIONS

- Single center trial
- No safety analysis (6% mortality prior to transport)
- Randomized early and degree of ARDS was severe
- 17 patients (19%) were transferred and improved prior to ECMO
- No standardized protocol (many controls did not receive lung protective ventilation)

ECMO: CESAR TRIAL

Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR): a multicentre randomised controlled trial

Giles J Peek, Miranda Mugford, Ravindranath Tiruvoipati, Andrew Wilson, Elizabeth Allen, Mariamma M Thalanany, Clare L Hibbert, Ann Truesdale, Felicity Clemens, Nicola Cooper, Richard K Firmin, Diana Elbourne, for the CESAR trial collaboration

Lancet 2009; 374: 1351-63

NON-CONVENTIONAL SALVAGE MODES

- Appear to depend on experience of the center
- Which patients will benefit?
- What is the optimal timing and duration of therapy?

ECMO: CESAR TRIAL

- 180 Pts with potentially reversible ARDS (Murray score ≥ 3)
- Excluded PIP >30 or FIO >80% for >7d
- Randomized to conventional ventilation or transfer to a single center with intent to start ECMO
- 6m survival 63% in ECMO group vs. 47% in controls (p=0.03)

Peek GJ, et al.: Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR): a multicentre randomised controlled trial. Lancet 2009, 374:1351-1363

PRACTICAL CONSIDERATIONS FOR THE OR

- Does the procedure need to be done in the OR?
- Does the patient need the ICU ventilator?
- Can the patient tolerate repositioning (trial in the ICU)
- Can the patient tolerate even a transient disconnect (consider clamping the tube)
- Is paralysis necessary? (If so, APRV = pressure control)

IS THIS PATIENT SAFE TO TRACH?

Relative Contraindications:

- **Difficult anatomy**
- **Significant coagulopathy**
- **Proximity to site of recent surgery or trauma**
- **Potential instability (hemodynamics, ICP)**
- **Severe gas exchange problems:** e.G. Fio2 >0.6 and PEEP >10 cm H2O

Intensive Care Society UK, Standards 2014

DOES THIS APPLY TO MY PATIENTS?

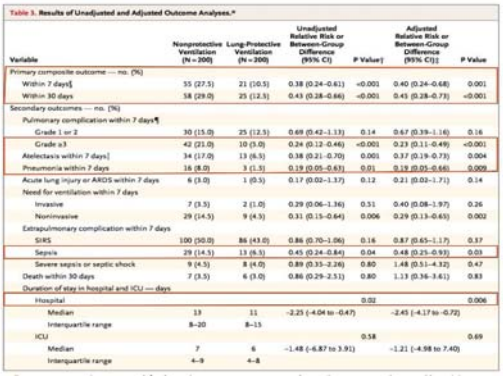


Table 3. Results of Unadjusted and Adjusted Outcome Analyses.*

Variable	Nonprotective Ventilation (N = 200)	Lung-Protective Ventilation (N = 200)	Unadjusted Relative Risk or Between-Group Difference (95% CI)	P Value†	Adjusted Relative Risk or Between-Group Difference (95% CI)‡	P Value
Primary composite outcome — no. (%)						
Within 7 days§	55 (27.5)	21 (10.5)	0.38 (0.24–0.61)	<0.001	0.40 (0.24–0.68)	0.001
Within 30 days	58 (29.0)	25 (12.5)	0.43 (0.28–0.66)	<0.001	0.45 (0.28–0.73)	<0.001
Secondary outcomes — no. (%)						
Pulmonary complication within 7 days¶						
Grade 1 or 2	30 (15.0)	25 (12.5)	0.69 (0.42–1.13)	0.14	0.67 (0.39–1.16)	0.16
Grade ≥3	42 (21.0)	10 (5.0)	0.24 (0.12–0.46)	<0.001	0.23 (0.11–0.49)	<0.001
Atelectasis within 7 days‖	34 (17.0)	13 (6.5)	0.38 (0.21–0.70)	0.001	0.37 (0.19–0.73)	0.004
Pneumonia within 7 days	16 (8.0)	3 (1.5)	0.19 (0.05–0.63)	0.01	0.19 (0.05–0.66)	0.009
Acute lung injury or ARDS within 7 days	6 (3.0)	1 (0.5)	0.17 (0.02–1.37)	0.12	0.21 (0.02–1.71)	0.14
Need for ventilation within 7 days						
Invasive	7 (3.5)	2 (1.0)	0.29 (0.06–1.36)	0.11	0.40 (0.08–1.97)	0.26
Noninvasive	29 (14.5)	9 (4.5)	0.31 (0.15–0.64)	0.006	0.29 (0.13–0.65)	0.002
Extrapulmonary complication within 7 days						
SIRS	100 (50.0)	86 (43.0)	0.86 (0.70–1.06)	0.16	0.87 (0.65–1.17)	0.37
Sepsis	29 (14.5)	13 (6.5)	0.45 (0.24–0.84)	0.04	0.48 (0.25–0.93)	0.03
Severe sepsis or septic shock	9 (4.5)	8 (4.0)	0.89 (0.33–2.26)	0.80	1.48 (0.51–4.32)	0.47
Death within 30 days	7 (3.5)	6 (3.0)	0.86 (0.29–2.51)	0.80	1.13 (0.36–3.61)	0.83
Duration of stay in hospital and ICU — days						
Hospital				0.02		0.006
Median	13	11	−2.23 (−4.04 to −0.47)		−2.45 (−4.17 to −0.72)	
Interquartile range	8–20	8–15				
ICU				0.58		0.69
Median	7	6	−1.48 (−6.87 to 3.91)		−1.21 (−4.98 to 7.40)	
Interquartile range	4–9	4–8				

DOES THIS APPLY TO MY PATIENTS?

What we do know:

- 90% of patients undergoing general anesthesia with mechanical ventilation will have atelectasis
- Blum et al. found that 46% of patients had hypoxemia during anesthesia, and 4% had P/F ratios under 100 mmHg
- Multiple recent investigations have found that the majority of patients are ventilated with tidal volumes 9-10ml/kg and without application of PEEP

Blum JM, e al. A description of intraoperative ventilator management and ventilator strategies in hypoxic patients. Anesth Analg 2010;110:1616e22

Jaber S, et al. A multicenter observational study of intra-operative ventilator management during anesthesia: tidal volumes and relation to body weight. Anesthesia 2012;67:999e1008

Hess DR, et al. A 5-year observational study of lung-protective ventilation in the operating room: a single-center experience, J Crit Care; in Press

DOES THIS APPLY TO MY PATIENTS?

- Lung injury from mechanical ventilation is well-documented
- ARDS likely represents a multiple hit model
- We should focus on minimizing the blows we deliver

DOES THIS APPLY TO MY PATIENTS?

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

A Trial of Intraoperative Low-Tidal-Volume Ventilation in Abdominal Surgery

Emmanuel Futier, M.D., Jean-Michel Constantin, M.D., Ph.D., Catherine Paugam-Burtz, M.D., Ph.D., Julien Pascal, M.D., Mathilde Eurin, M.D., Arthur Neuschwander, M.D., Emmanuel Marret, M.D., Marc Beaussier, M.D., Ph.D., Christophe Gutton, M.D., Jean-Yves Lefrant, M.D., Ph.D., Bernard Allaouchiche, M.D., Ph.D., Daniel Verzilli, M.D., Marc Leone, M.D., Ph.D., Audrey De Jong, M.D., Jean-Etienne Bazin, M.D., Ph.D., Bruno Pereira, Ph.D., and Samir Jaber, M.D., Ph.D., for the IMPROVE Study Group*

n engl j med 369;5 nejm.org august 1, 2013

THANK YOU

QUESTIONS?