Recruitment Maneuver and Mode Setting in Mechanical Ventilation

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108-5-16

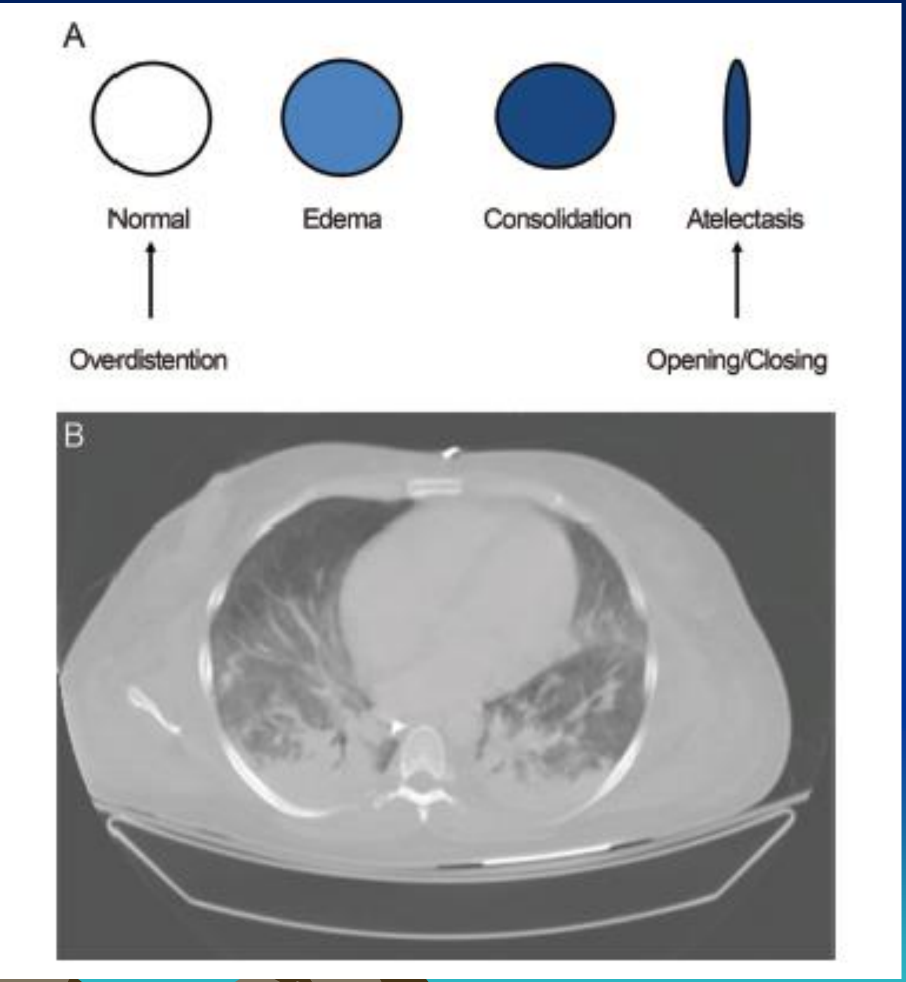
Introduction

- Ventilator management for injured lung is evolving.
- Pressure and volume limited lung protection.
- Risk of derecruitment if PEEP is not sufficient.
- Recruitment maneuvers can be used to augment other methods to improve aerated lung volume.

Curr Opin Crit Care 2014;20:63-68

ARDS

- ARDS characterized by heterogeneity, some alveoli are normal, some are collapsed, some are fluid-filled and some consolidated.



Respir Care 2015;60:1688-1704

Physiologic Concepts

- Stress: pressure applied to alveolus
- Strain: change in shape of alveolus caused by stress
  - Strain is associated with ventilator induced lung injury (VILI)

Respir Care 2015;60:1688-1704

Stress and Strain

- P (stress) = lung elastance x

$$\text{strain} \; \frac{\triangle V}{\text{functional residual capacity}}$$

$\triangle$ V : change in lung volume above functional residual capacity with the addition of PEEP

Respir Care 2015;60:1688-1704

Potential for Recruitment

- A stress raiser is the result of inhomogeneity with lungs.
- The benefit of recruitment maneuvers might be related the potential for alveolar recruitment in the lungs.
  - Lower PaO_2/FiO_2
  - Lower compliance

Respir Care 2015;60:1688-1704

Methods to Achieve Alveolar Recruitment

- Treatment of underlying disease
  - Removal of airway obstruction
  - Diuresis
  - Treatment of infection
- Sustained inflation followed by decremental PEEP
- Stepwise recruitment (incremental PEEP)
- APRV
- HFOV
- Sign
- Prone position

Type of Recruitment Maneuvers

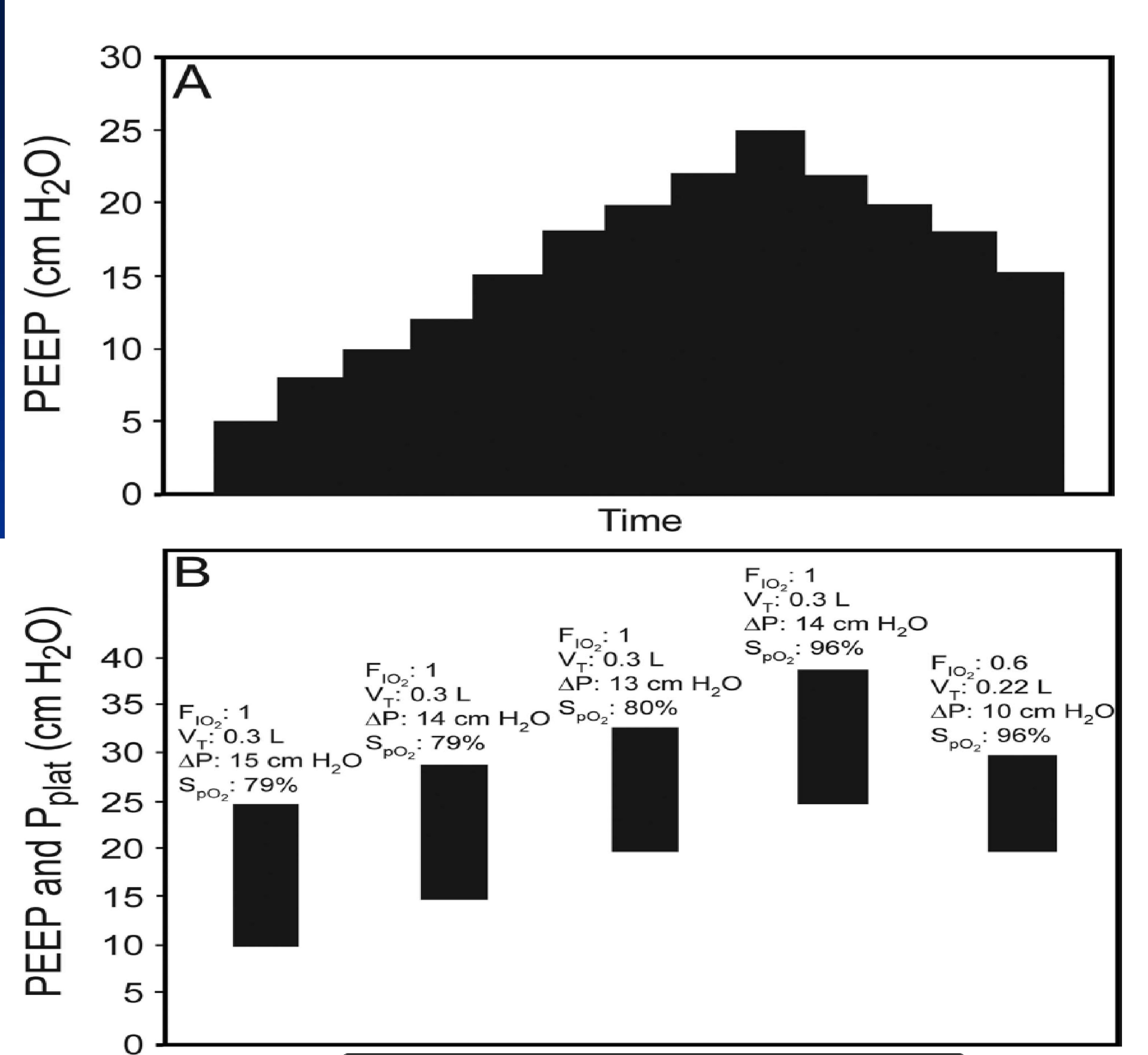
- Sustained inflation
  - – CPAP mode
    - increased pressure to 30-40 cmH_2O for 30-40 seconds
    - 35 to 45 cmH_2O for 30 seconds (ARDS network)
  - – Take notice of hypotension

Respir Care 2002;47:308-317

Type of Recruitment Maneuvers

- Stepwise recruitment
  - Increased PEEP in increments of 2-5 cmH_2O with a fixed Vt 6 mL/kg (ideal body weight)
  - Driving pressure (plateau pressure-PEEP), compliance, $SatO_2$ and blood pressure are monitored
  - PEEP increased if decreased driving pressure, plateau pressure<30 cmH_2O, increased Sat O_2.
  - Decreased PEEP to previous step if increased driving pressure, plateau pressure > 30 cmH_2O, decreased Sat O_2 or hypotension.
  - Each step 3-5 minutes

Am J Respir Crit Care Med 1995;152:121-128



A
PEEP (cm H_2O)
30
25
20
15
10
5
0
Time
B
PEEP and P_{plat} (cm H_2O)
40
35
30
25
20
15
10
5
0
F_{IO_2}: 1
V_T: 0.3 L
ΔP: 15 cm H_2O
S_{pO_2}: 79%
F_{IO_2}: 1
V_T: 0.3 L
ΔP: 14 cm H_2O
S_{pO_2}: 79%
F_{IO_2}: 1
V_T: 0.3 L
ΔP: 13 cm H_2O
S_{pO_2}: 80%
F_{IO_2}: 1
V_T: 0.3 L
ΔP: 14 cm H_2O
S_{pO_2}: 96%
F_{IO_2}: 0.6
V_T: 0.22 L
ΔP: 10 cm H_2O
S_{pO_2}: 96%

Airway Pressure Released Ventilation (APRV)

- Breathe spontaneously while receive high airway pressure, high pressure for alveolar recruitment.
- Trans-alveolar distending pressures are probably high during spontaneous breathing with airway pressure release ventilation, potential for lung injury.

Respir Care 2015;60:1688-1704

APRV

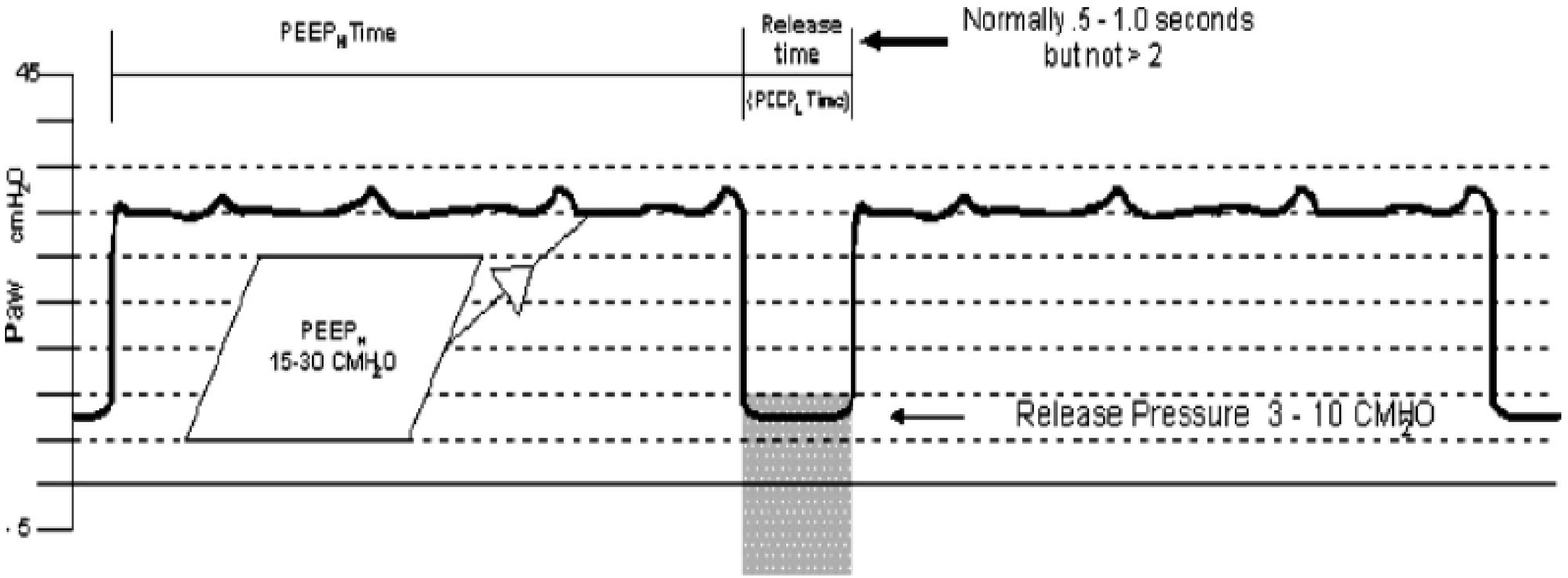


FIGURE 4. Airway pressure release ventilation (APRV) is a pressure-targeted, time-cycled mode of mechanical ventilation delivering continuous positive airway pressure with regular, intermittent and brief release in pressure. APRV allows unrestricted spontaneous breathing throughout the respiratory cycle.

APRV

- Putensen et al:
  - Patients with trauma at risk for ARDS
  - Ventilated with APRV versus conventional PCV who were heavily sedated and paralyzed.
  - Improved lung mechanics, oxygenation, less sedation requirements.

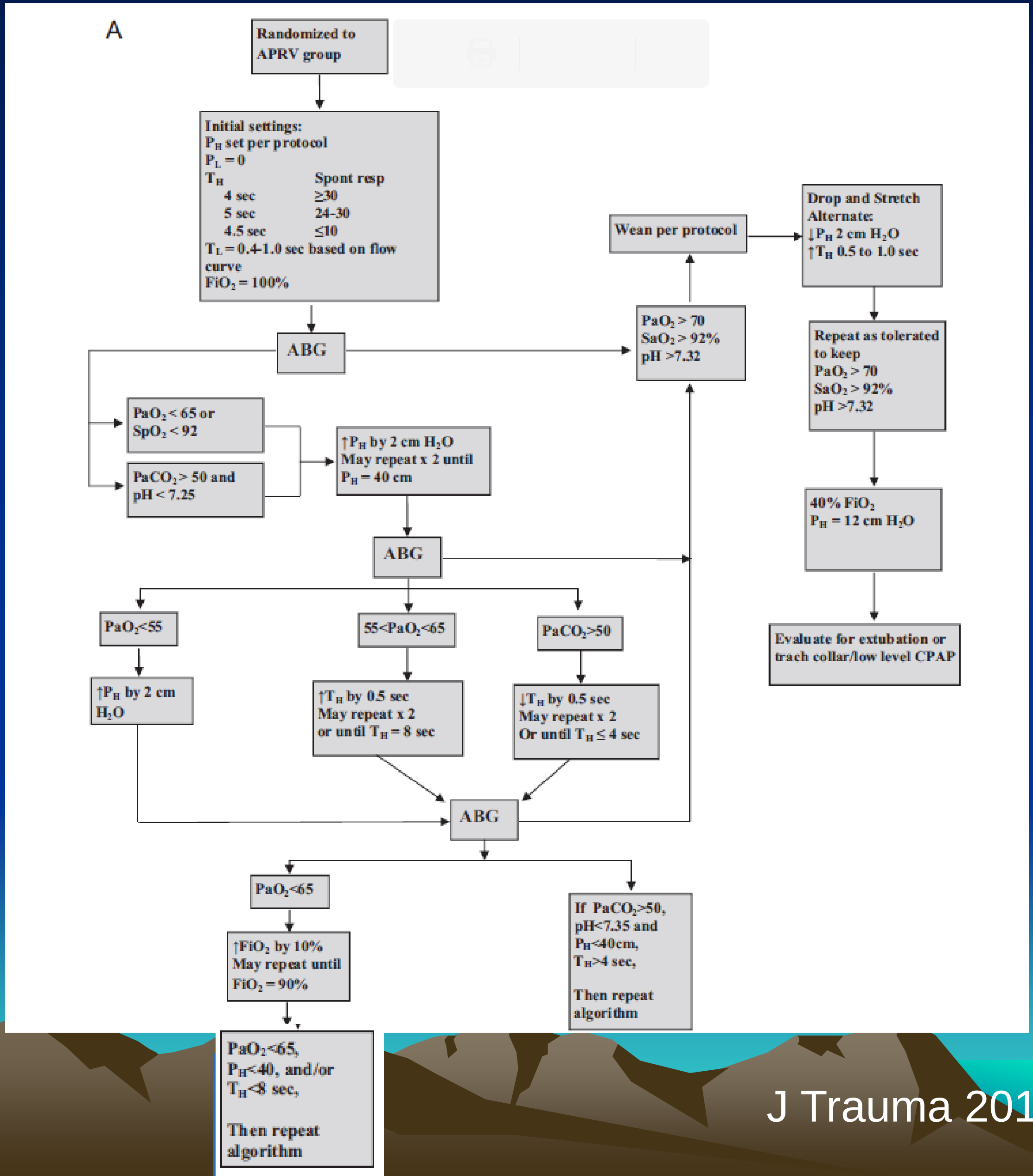
Am J Respir Crit Care Med 1999;159:1241– 8

APRV vs LOVT (low tidal volume ventilation)

- For patients sustaining significant trauma requiring mechanical ventilation for greater than 72 hours.
  - APRV : 31 patients
    - PaO_2 < 65 mmHg -> P_H increased 2 cmH_2O -> increased T_H by 0.5 second , repeated 2 times until P_H= 40 cmH_2O, T_H=8 seconds
    - $PaCO_2$ > 50 mmHg -> decreased T_H by 0.5 second, repeated 2 times until $T_H \leqq 4$ second
  - LOVT: 32 patients
    - Tidal volume 6 ml/kg, minute ventilation: 6 liter, PEEP:10
    - Decreased Vt 1ml/kg if peak airway pressure > 40
    - PaO_2 < 65 mmHg, increased PEEP 2 cmH_2O until PEEP>25, or Ppeak >40

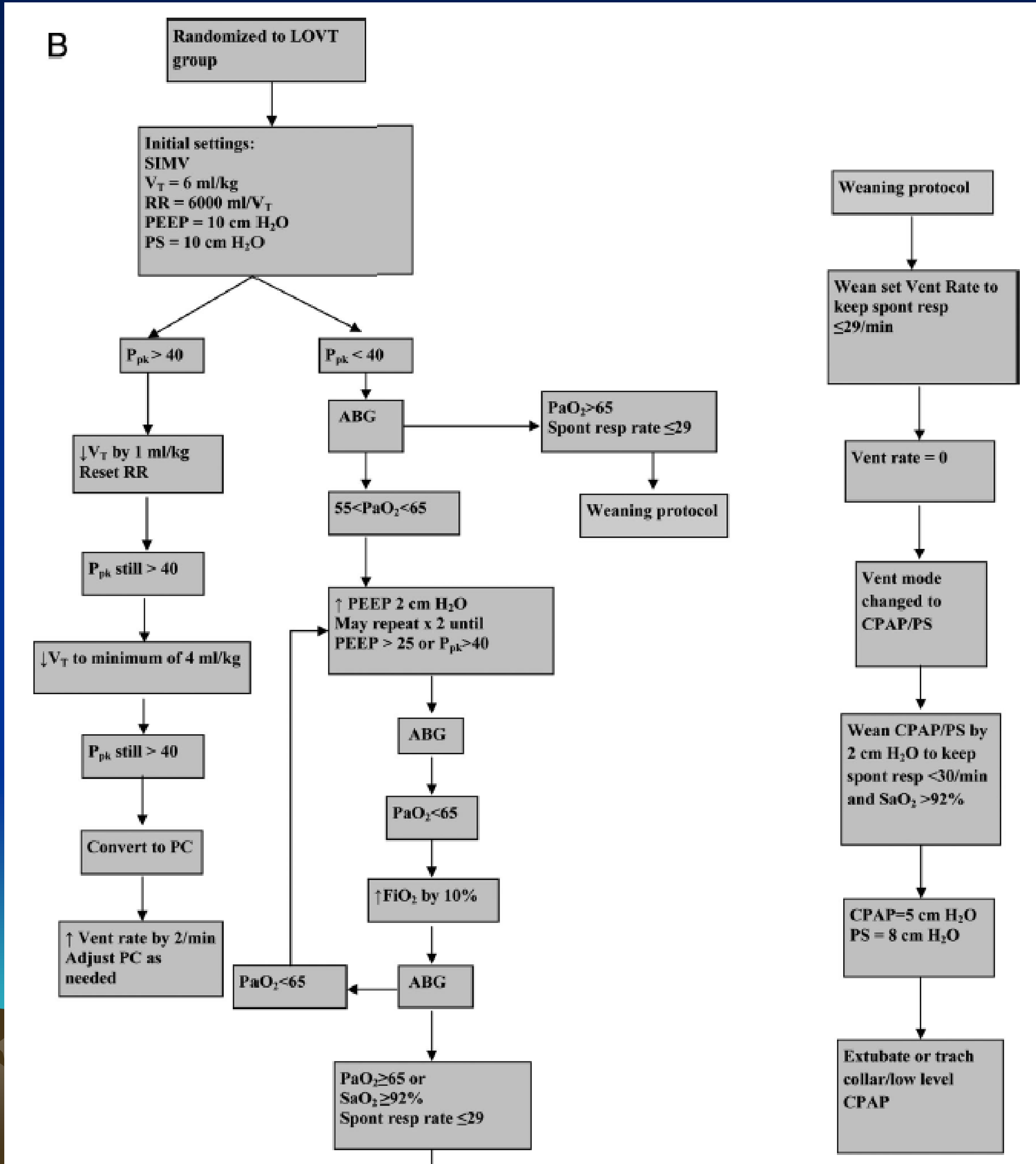
J Trauma 2010;69:501-510

APRV Group



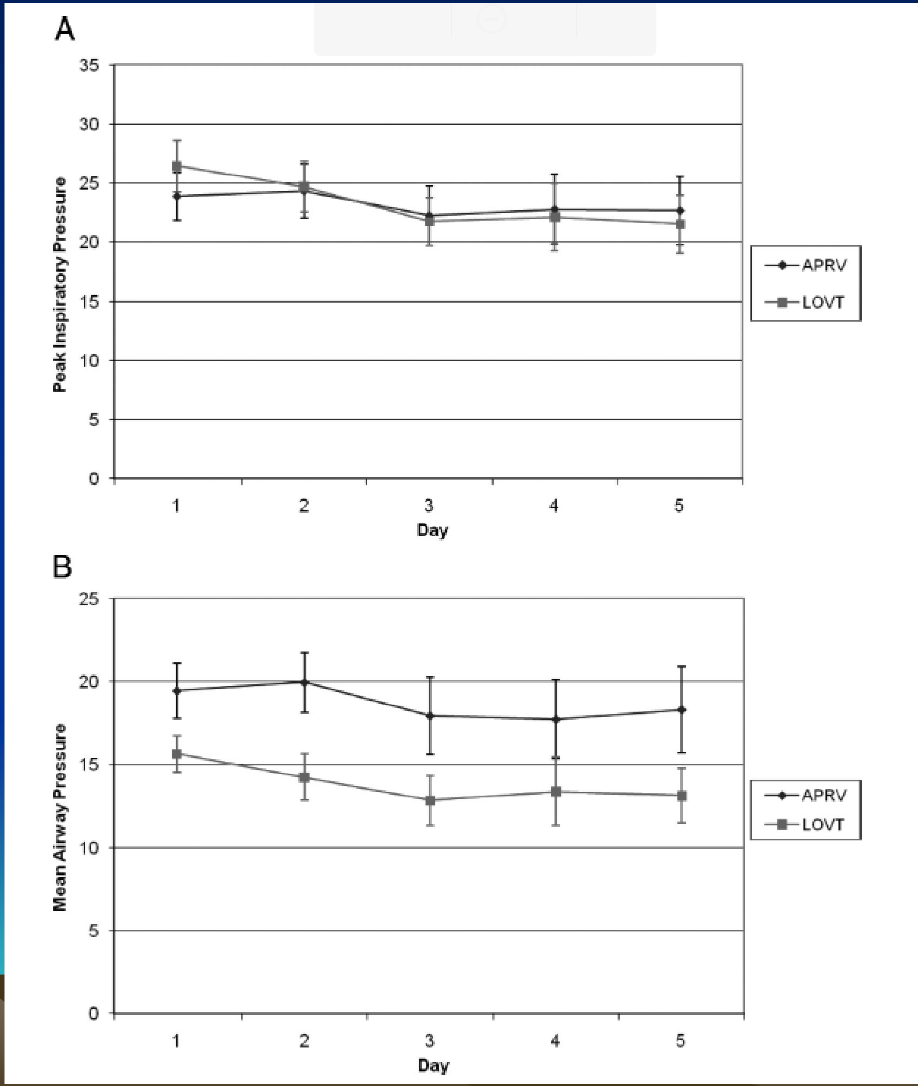
J Trauma 2010;69:501-510

LOVT group



J Trauma 2010;69:501-510

Peak and Mean Airway Pressure



P<0.001

J Trauma 2010;69:501-510

Oxygenation

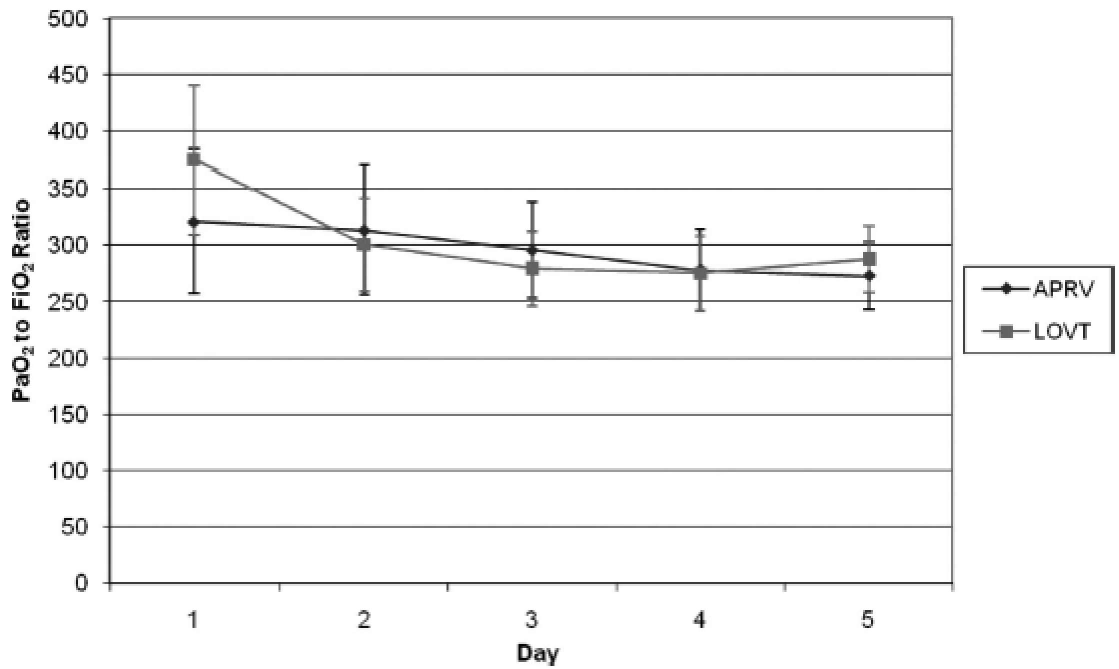


Figure 2. PaO_2 to FiO_2 ratios did not differ between groups throughout the period of observation.

J Trauma 2010;69:501-510

Outcomes

TABLE 2. Outcome Data

Dependent Measure	APRV	LOVT
Ventilator days	10.49 ± 7.23	8.00 ± 4.01
ICU length of stay (d)	16.47 ± 12.83	14.18 ± 13.26
Pneumothorax	0	3.1%
VAP per patient	1.00 ± 0.86	0.56 ± 0.67
Tracheostomy (%)	61.3	65.6
Failure of modality (%)	12.9	15.6
Mortality (%)	6.45	6.25

J Trauma 2010;69:501-510

APRV vs LOVT (low tidal volume ventilation)

- APRV seems to have a similar safety profile as the LOVT.
- Trends for APRV patients to have increased ventilator days, ICU LOS, and ventilator-associated pneumonia
  - may be explained by initial worse physiologic derangement demonstrated by higher Acute Physiology and Chronic Health Evaluation II scores.

J Trauma 2010;69:501-510

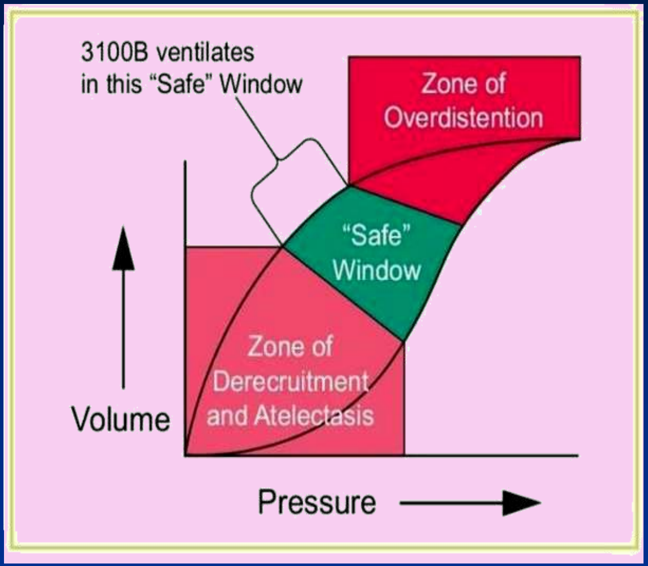
High frequency oscillatory ventilation (HFOV)

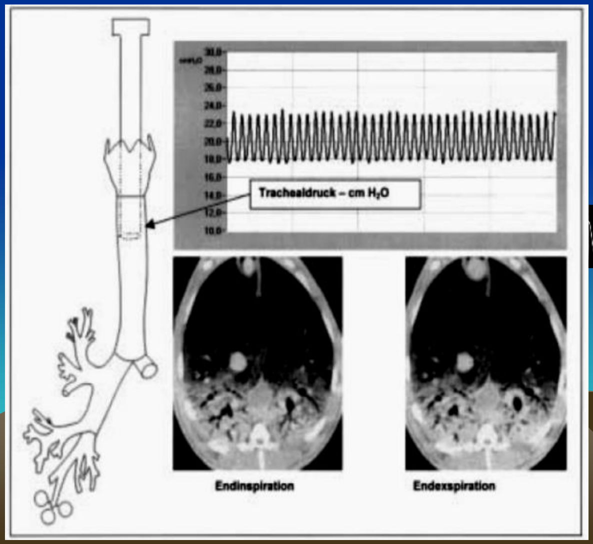
- Increase airway pressure and promote alveolar recruitment.
- Small tidal volume: 1 to 4 ml/kg, frequency: 3 to 15 Hz
- Less risk of over-distention, prevent VILI.

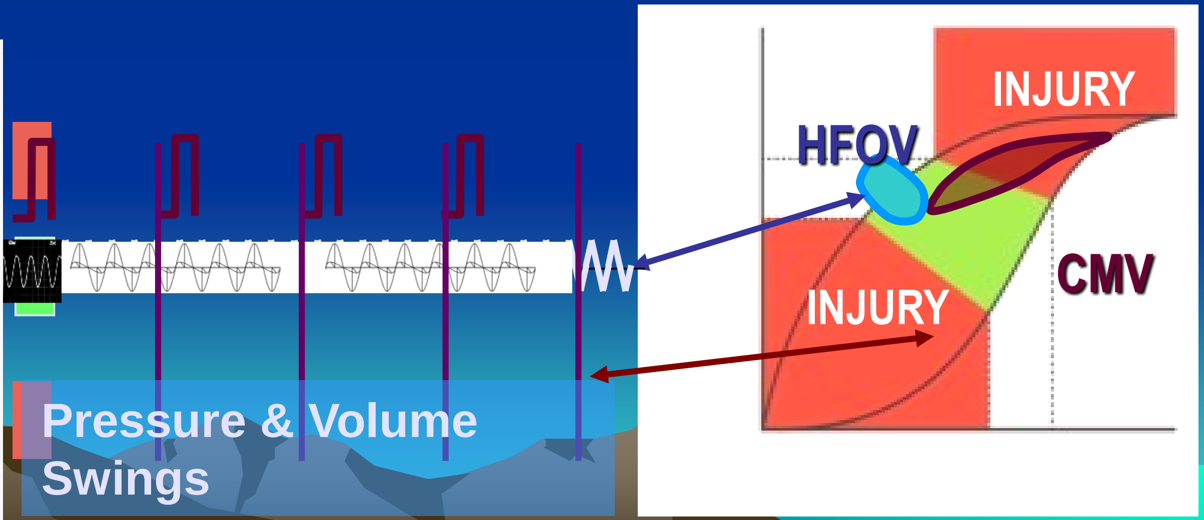
Respir Care 2015;60:1688-1704

HFOV Operates in the Safe Zone of Ventilation

- There are 2 injury zones in MV
  - Low lung volume ventilation -- tears adhesive surfaces
    ⇒ Atelectrauma
  - High lung volume ventilation -- overdistension
    ⇒ Volutrauma / Barotrauma

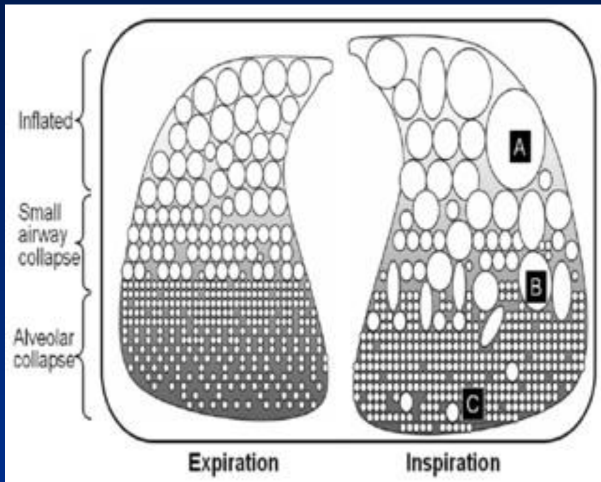




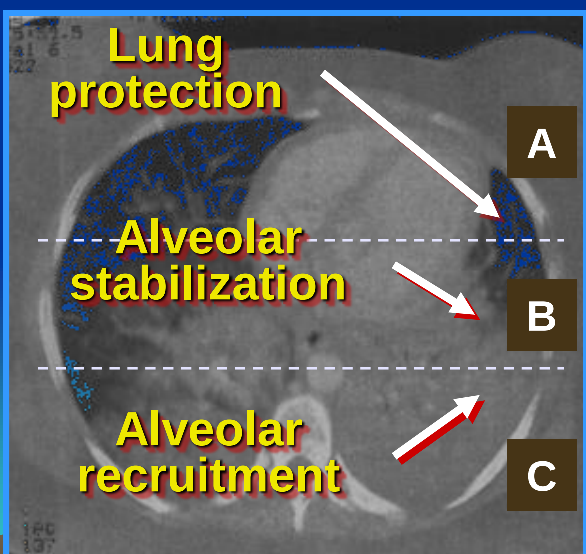


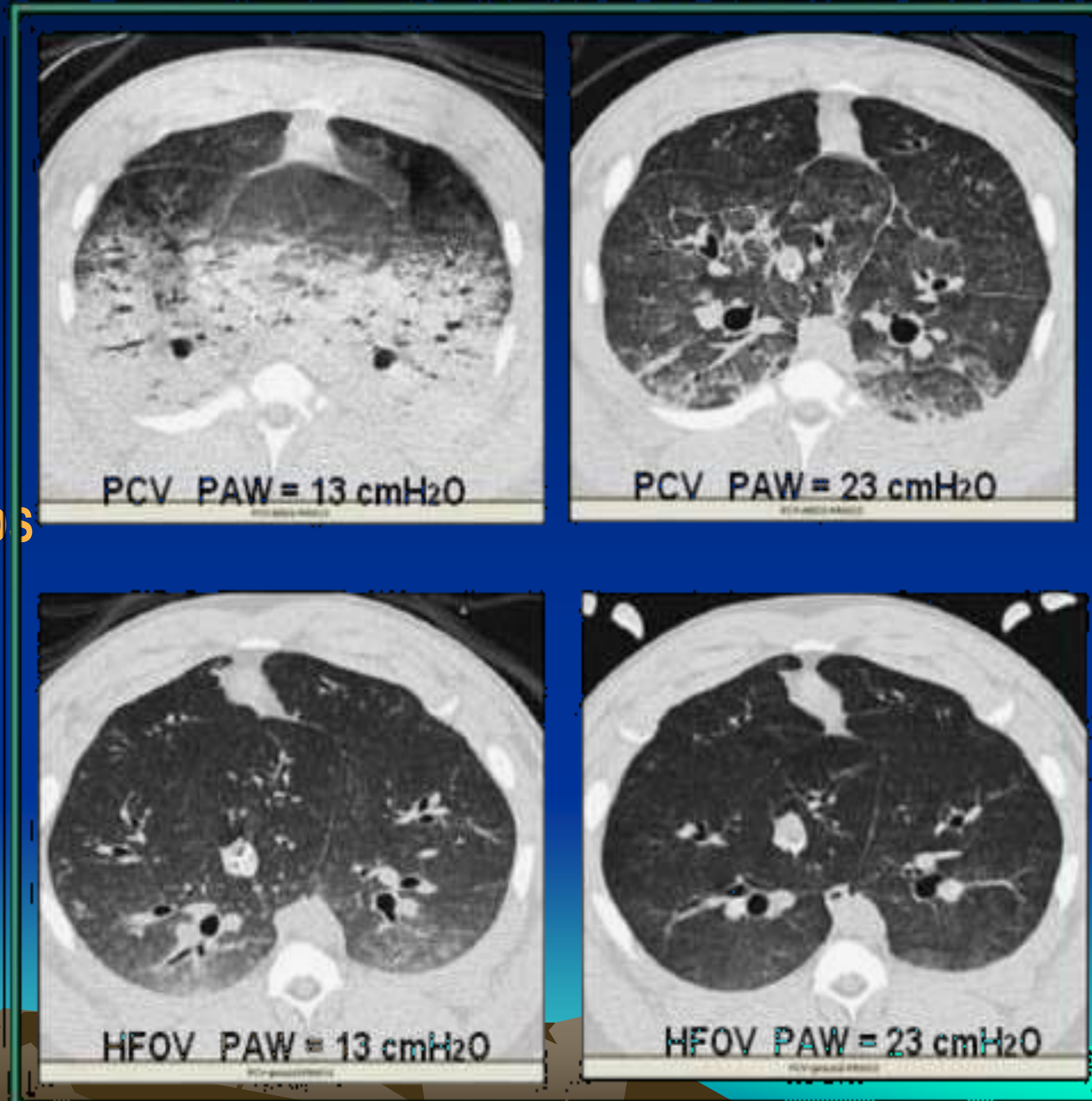
Froese AB. *Crit Care Med* 1997; 25:906–908
Luecke T, et al. *Anaesthesist* 2000; 49:972–980

Comparisons of CT images with PCV & HFOV



Ventilatory Strategies for ARDS

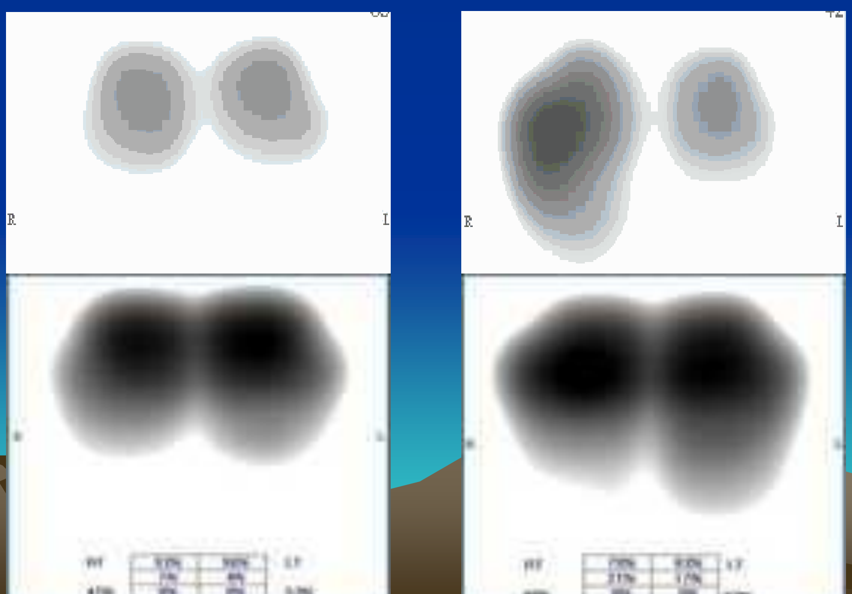


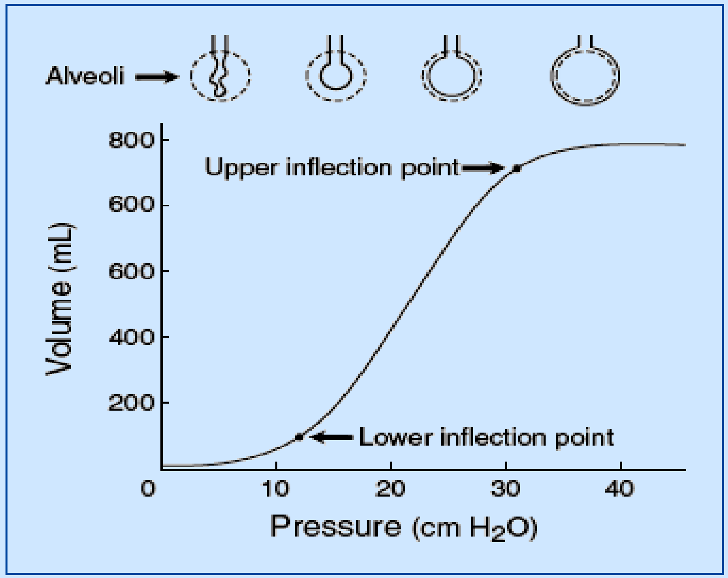


Luecke T. *Crit Care Med* 2005; 33, 155

HFOV & Lung Recruitment Maneuvers

- Intermittently increasing MAP during HFOV
- Initiate at high MAP
  - 40-50 cm H_2O
  - 40-60 seconds duration





Medoff BD *et al. Crit Care Med* 2000; 28:1210
Krishnan RKM *et al. Intensive Care Med* 2004; 30:1195–1203
Crit Care 2007, 23: 248

HFOV in Early ARDS

- Ferguson et al assigned HFOV to new-onset moderate to severe ARDS.
- This study stopped early with an in-hospital mortality of 47% in the HFOV group, compared to 35% in the control group (RR of death with HFOV:1.33, 95% CI 1.09-1.64)

N Engl J Med 2013;368:795-805

Meta-analysis of HFOV on Mortality

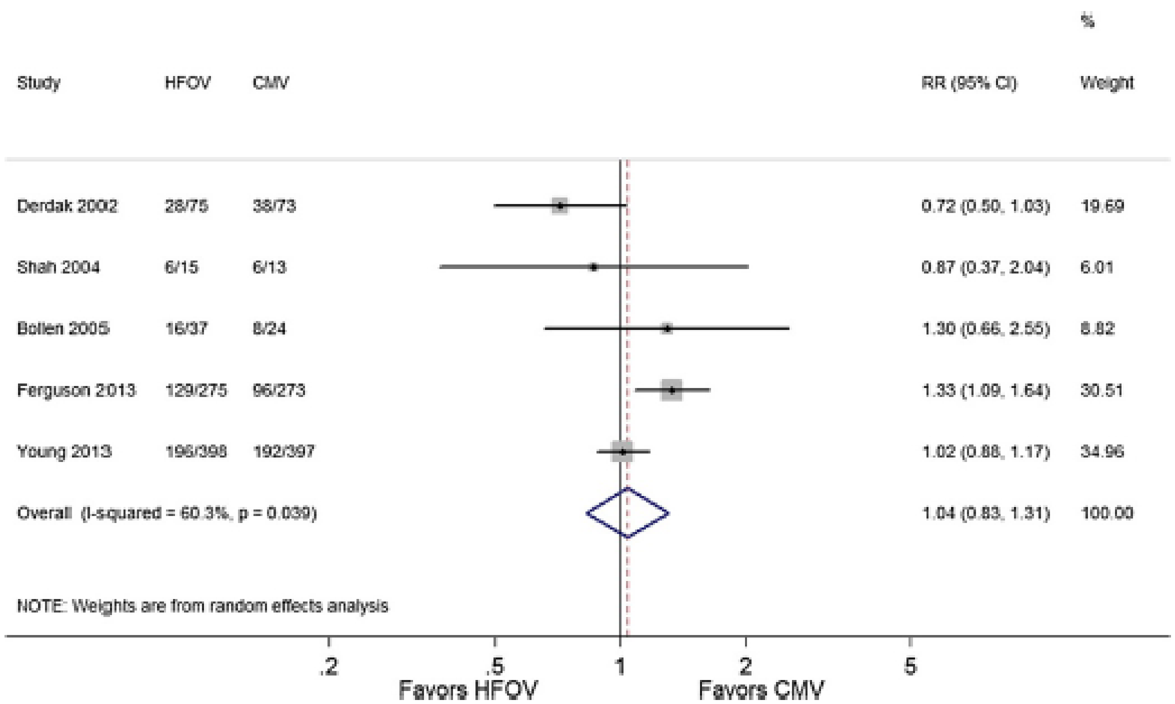


Figure 2 Forest plot showing the effect of HFOV on 30-day or hospital mortality. HFOV, high-frequency oscillatory ventilation; CMV, conventional mechanical ventilation; RR, risk ratio; CI, confidence interval.

Crit Care 2014;18:R102

Sigh

- Use mode with PCV+ (biphasic positive airway pressure).
- Positive airway pressure at 35 cmH_2O for 3-4 seconds at rate of 2 sighs/minute or 1 sigh/minute.

Crit Care Med 2015;43:1823-1831

Sigh vs Sustain Inflation

Figure 1

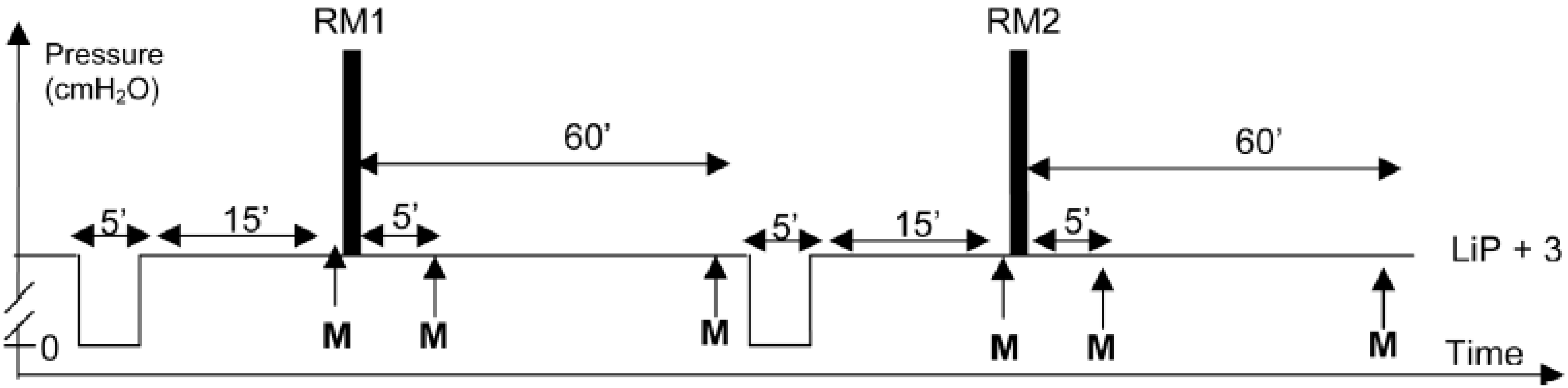
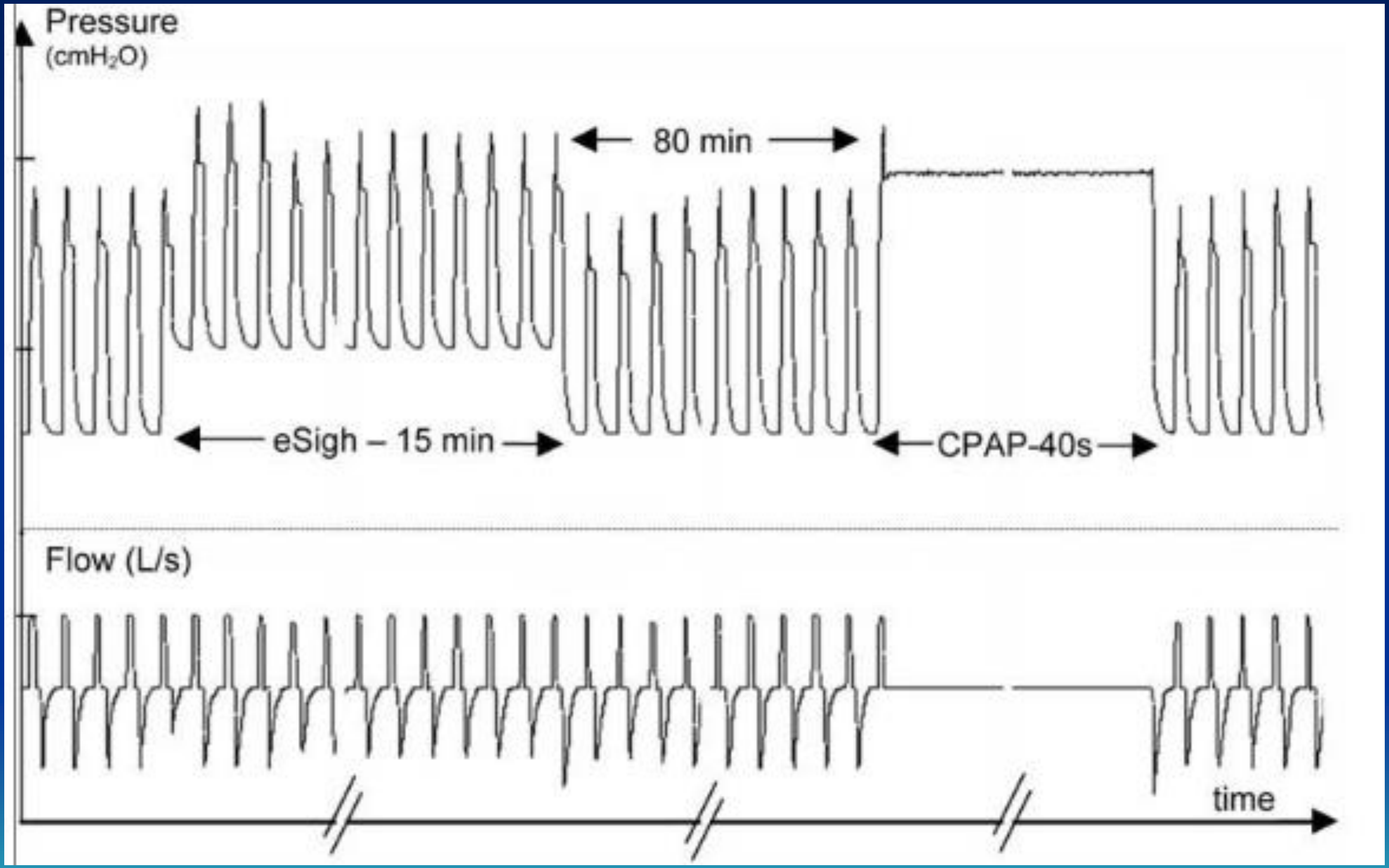


Illustration of the time course of the study. Nineteen patients ventilated with protective lung strategy first had a washout period of 5 minutes of zero end-expiratory pressure ventilation. After 15 minutes of stabilization in positive end-expiratory pressure (PEEP) ventilation, baseline measures (M) were obtained. Then, patients were randomly asssigned to benefit from one of the two recruitment maneuvers (RMs): RM1 or RM2 (that is, continuous positive airway pressure or extended sigh). At 5 and 60 minutes after RM, measurements were obtained. After this first part of the study, a second washout period was performed followed by 15 minutes of ventilation in PEEP and the second RM was performed. The same measurements were performed at baseline and at 5 and 60 minutes after RM. M indicates blood gas analysis, recruited volume by pressure-volume curve method, hemodynamics, and respiratory parameters. LIP, lower inflection point.

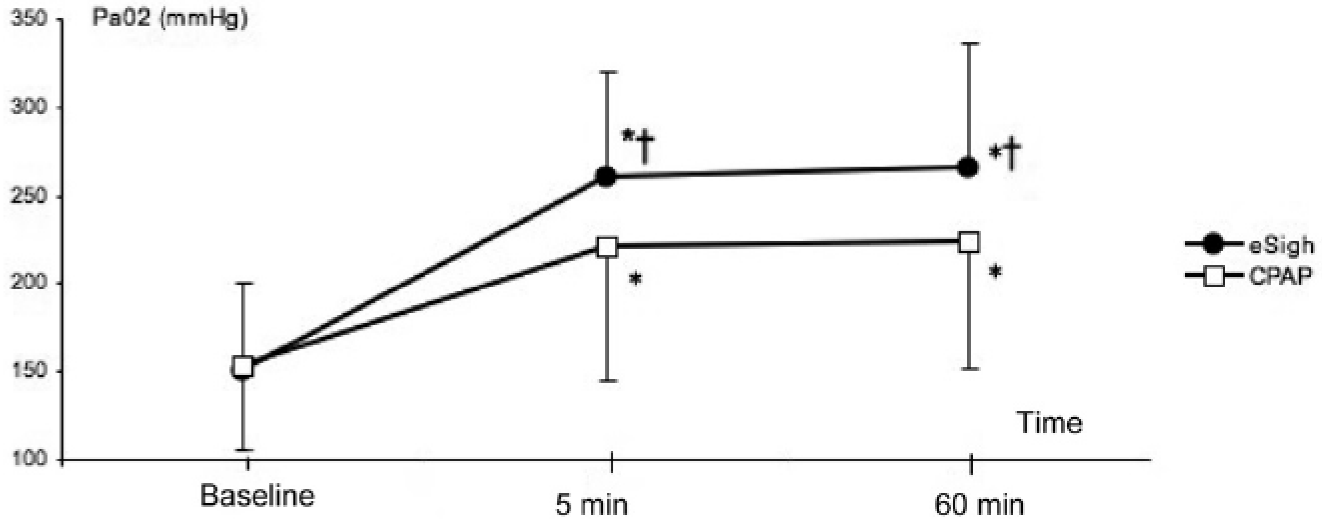
Sigh vs Sustain Inflation



Crit Care 2008;12:R50

Sigh vs Sustain Inflation

Figure 3



Both recruitment maneuvers increased oxygenation. Extended sigh (eSigh) induced a significantly higher increase in arterial partial pressure of oxygen (PaO_2) than continuous positive airway pressure (CPAP) at 5 and 60 minutes after the recruitment maneuver. * significant versus baseline, † significant versus CPAP.

Crit Care 2008;12:R50

Chest Wall Modification

- Decompression of the abdomen
- Drainage of pleural effusion
- Relaxation of the thoracic and abdominal muscle
- Using upright or prone position

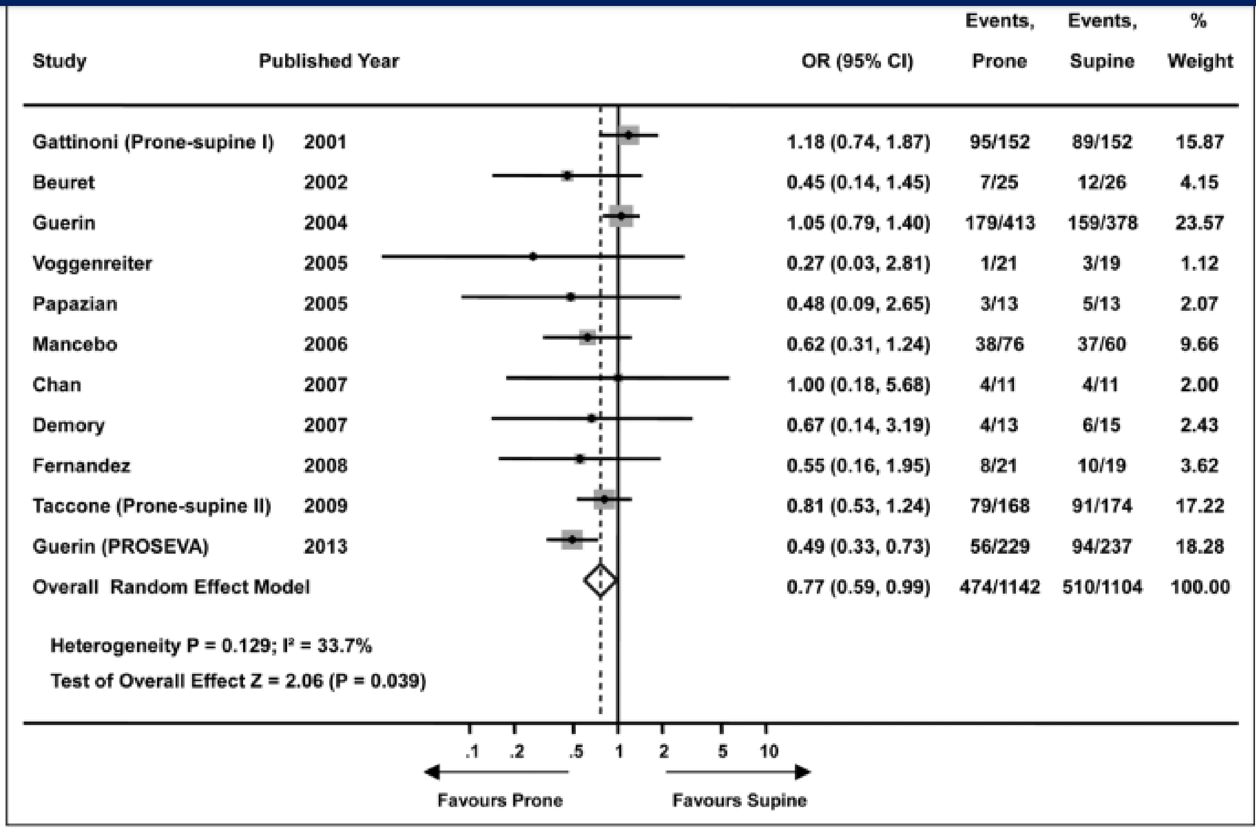
Curr Opin Crit Care 2014;20:63-68

Prone Positioning

- Recruitment of non-aerated alveoli and make lung more homogenous.
- Shift in heart weight from lung beneath it onto the ventral chest wall.
- It producing regional PEEP-like effect that consolidates the dorsal recruitment associated position change.
- Prone position may reduce lung stress and strain in severe ARDS.
- Survival benefit for severe ARDS.

Curr Opin Crit Care 2014;20:63-68
Crit Care Med 2014;42:1252-1262

Prone Positioning on Mortality



Study	Published Year	OR (95% CI)	Events, Prone	Events, Supine	% Weight
Gattinoni (Prone-supine I)	2001	1.18 (0.74, 1.87)	95/152	89/152	15.87
Beuret	2002	0.45 (0.14, 1.45)	7/25	12/26	4.15
Guerin	2004	1.05 (0.79, 1.40)	179/413	159/378	23.57
Voggenreiter	2005	0.27 (0.03, 2.81)	1/21	3/19	1.12
Papazian	2005	0.48 (0.09, 2.65)	3/13	5/13	2.07
Mancebo	2006	0.62 (0.31, 1.24)	38/76	37/60	9.66
Chan	2007	1.00 (0.18, 5.68)	4/11	4/11	2.00
Demory	2007	0.67 (0.14, 3.19)	4/13	6/15	2.43
Fernandez	2008	0.55 (0.16, 1.95)	8/21	10/19	3.62
Taccone (Prone-supine II)	2009	0.81 (0.53, 1.24)	79/168	91/174	17.22
Guerin (PROSEVA)	2013	0.49 (0.33, 0.73)	56/229	94/237	18.28
Overall Random Effect Model		0.77 (0.59, 0.99)	474/1142	510/1104	100.00

Figure 2. The effect of prone positioning on overall mortality by random-effects model. Forest plot with odds ratios (OR) for overall mortality associated with prone positioning (prone) versus supine positioning (supine) for individual trials and the pooled population. The *squares* and the *horizontal lines* indicate the ORs (by random-effects model) and the 95% CI for each trial included. The size of each square is proportional to the statistical weight of a trial in the meta-analysis. The *diamond* indicates the effect estimate derived from meta-analysis, with the center indicating the point estimate and the left and the right ends indicating the 95% CI.

Crit Care Med 2014;42, 1252-1262

Prone Positioning on Mortality

	No. of Trials	No. of Patients	Odds Ratio (95% CI) for Mortality	Interaction P
Statistical Model				
Fixed effects	11	2,246	0.82 (0.69-0.97)	
Radom Effects	11	2,246	0.77 (0.59-0.99)	
Lung Protective Ventilation				**0.015**
Yes	8	1,100	0.62 (0.48-0.79)	
No	3	1,146	1.04 (0.80-1.36)	
Duration of Prone Positioning				**0.015**
≥ 10 hours/session	8	1,100	0.62 (0.48-0.79)	
< 10 hours/session	3	1,146	1.04 (0.80-1.36)	
Patient Population				**0.021**
ARDS only	7	1,060	0.62 (0.48-0.80)	
ALI/ARDS	4	1,186	1.02 (0.76-1.36)	
Severe ARDS population (PaO2/FiO2 ratio)				0.635
≤ 150 mmHg	8	1,364	0.72 (0.55-0.95)	
> 150 mmHg	3	882	0.77 (0.38-1.55)	
HFOV were used with positioning				0.661
Yes	2	54	0.57 (0.18-1.82)	
No	9	2,192	0.77 (0.58-1.02)	
Adequate concealment of allocation				0.764
Yes	10	2,224	0.76 (0.58-0.99)	
No/unclear	1	22	1.00 (0.18-5.68)	

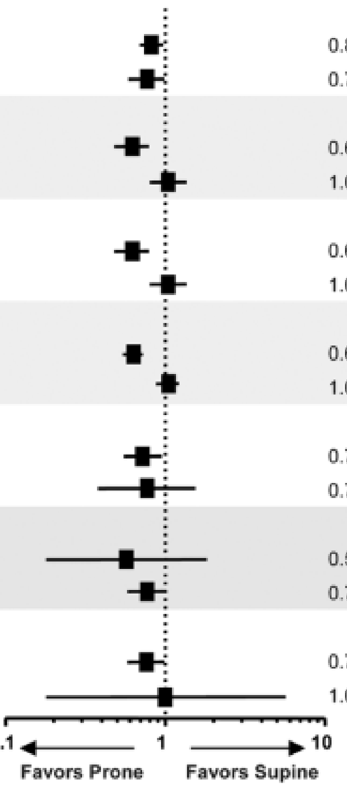


Figure 4. Stratified subgroup analyses according to the study protocols. The forest plot shows odds ratios (by random-effects model) for overall mortality associated with prone versus supine positioning with studies stratified according to 1) lung protective ventilation, 2) actual duration of prone positioning, 3) disease severity of patients, 4) Pao_2/Fio_2 ratio, 5) high-frequency oscillatory ventilation as a concomitant maneuver, and 6) adequacy of allocation concealment. The *squares* and the *horizontal lines* indicate the odd ratios (ORs) (by random-effects model) and the 95% CI for each trial included. The *dotted line* indicates the point of neutral effect for overall mortality (i.e., the point of random-effects model OR of 1.0). ARDS = acute respiratory distress syndrome, ALI = acute lung injury, HFOV = high-frequency oscillatory ventilation.

Crit Care Med 2014;42,1252-1262

Prone Positioning

- ATS/EISCCM/SCCM clinical practice guideline recommends that adult patients with severe ARDS receive prone positioning for more than 12 hours per day.

AJRCCM 2017; 195:1253-1263

Methods for Setting PEEP for ARDS

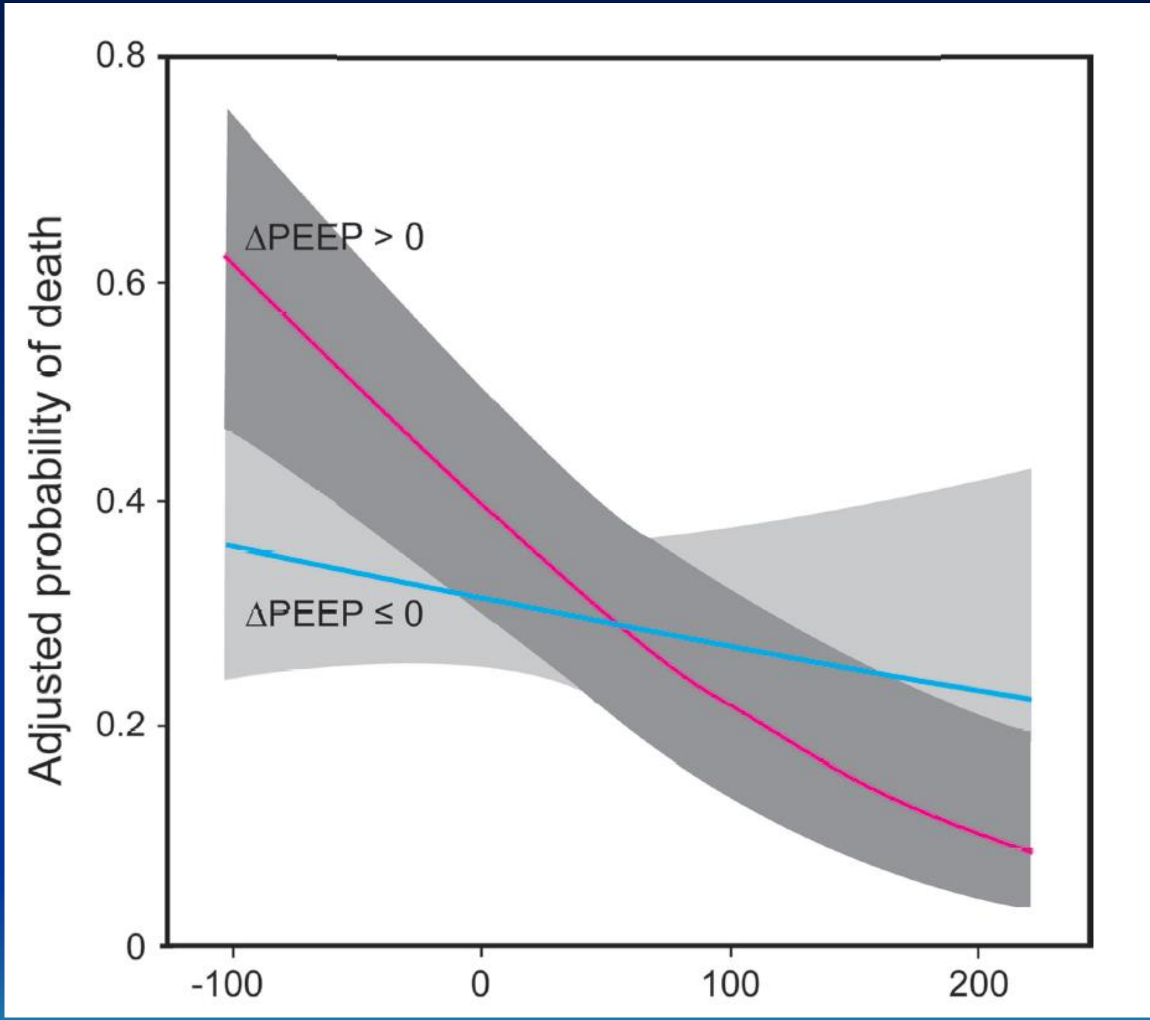
- Gas exchange
- Pressure volume curve
- Compliance
- Stress index
- Esophageal manometry
- Lung volume
- Imaging

Respir Care 2015;60:1688-1704

Gas Exchange

- A increased in PaO_2/FiO_2 when PEEP was increased was associated reduced mortality.
- A decreased in PaO_2/FiO_2 when PEEP was increased was associated increasing mortality.

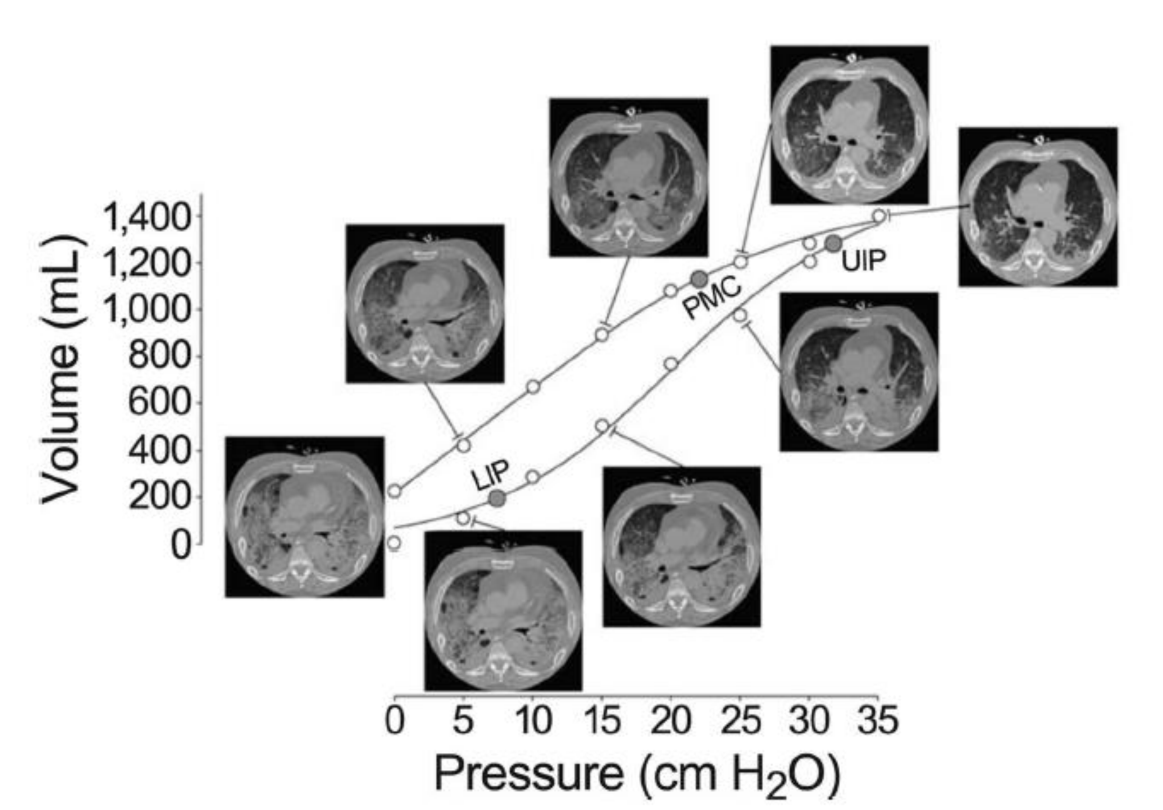
AJRCCM 2014;190:70-76



AJRCCM 2014;190:70-76

Pressure-volume Curve

Set PEEP to 2cmH_2O above lower inflection point.



Curr Opin Crit Care 2008;14:80-86

Compliance

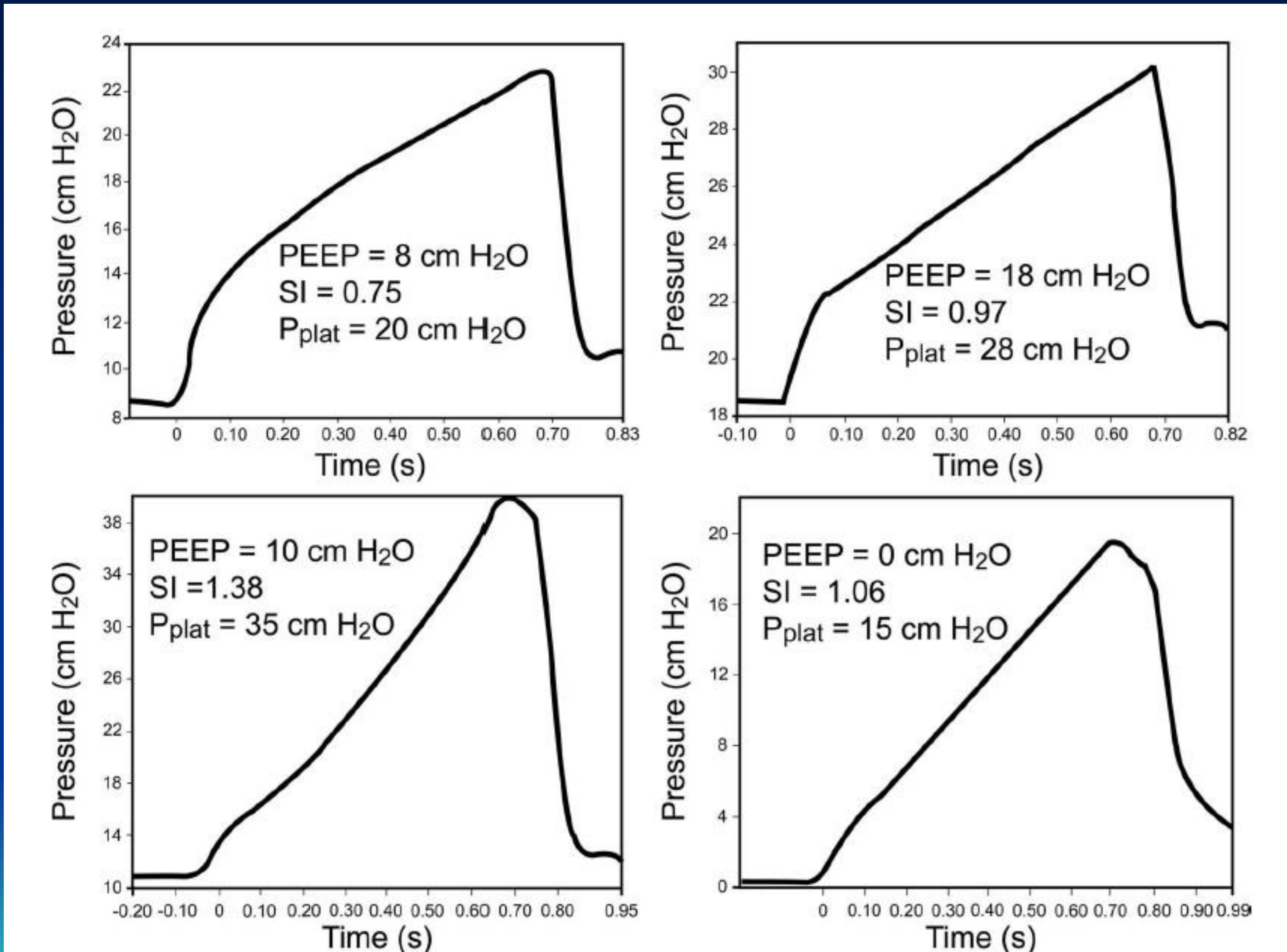
- Selecting the level of PEEP with the highest compliance.
- Compliance: Vt / (plateau pressure – PEEP)
- Increased mortality for driving pressure > 15 cmH_2O

Respir Care 2013;58:1416-1423
NEJM 2015;372:747-755

Stress Index

- A linear increase in pressure (stress index=1) suggests alveolar recruitment without over-distention.
- A decrease in compliance as lung are inflated (stress index > 1) suggest over-distention.
- A increase in compliance as lung inflated (stress index <1) suggest potential for additional recruitment.

Respir Care 2014:59:1773-1794



Respir Care 2014;59:1773-1794
Respir Care 2011;56:1555-1572

Esophageal Manometry

- Chest wall compliance may be reduced in patients with ARDS which result in increased in pleural pressure.
- Pleural pressure higher than alveolar pressure, causing alveolar collapse.
- Set PEEP greater higher than end-expiratory pleural pressure.
- Use of esophageal balloon to estimate pleural pressure.
- Beneficial for morbid obesity or abdominal hypertension.

Respir Care 2010;55:162-167
J Appl Physiol 2010;183:515-522

Lung Volume

- End-expiratory lung volume (EELV) during mechanical ventilation by using helium dilution or nitrogen washout techniques.
- A PEEP induced increase in EELV might be the result of recruitment.
- EELV to assess PEEP response improved if it is combined with measurement of compliance.

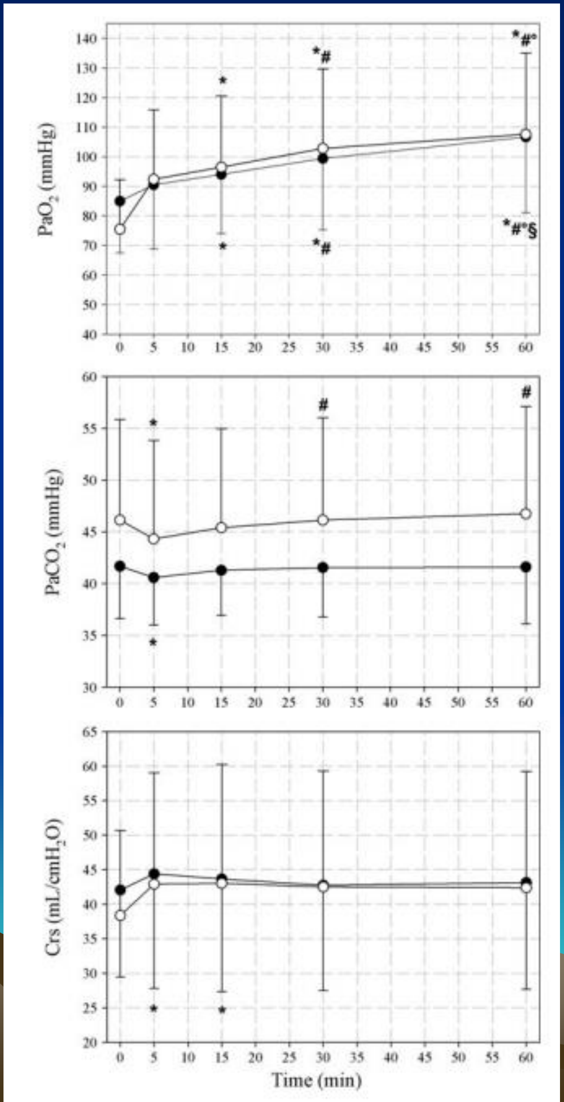
Intensive Care Med 2011;37:1595-1604
Crit Care 2011;12:R150

Imaging

- CXR
- Sonogram
  - Can not detect overdistention
- CT
  - Gold standard
- Electrical impedance tomography (EIT)
  - Estimate regional alveolar collapse and overdistention

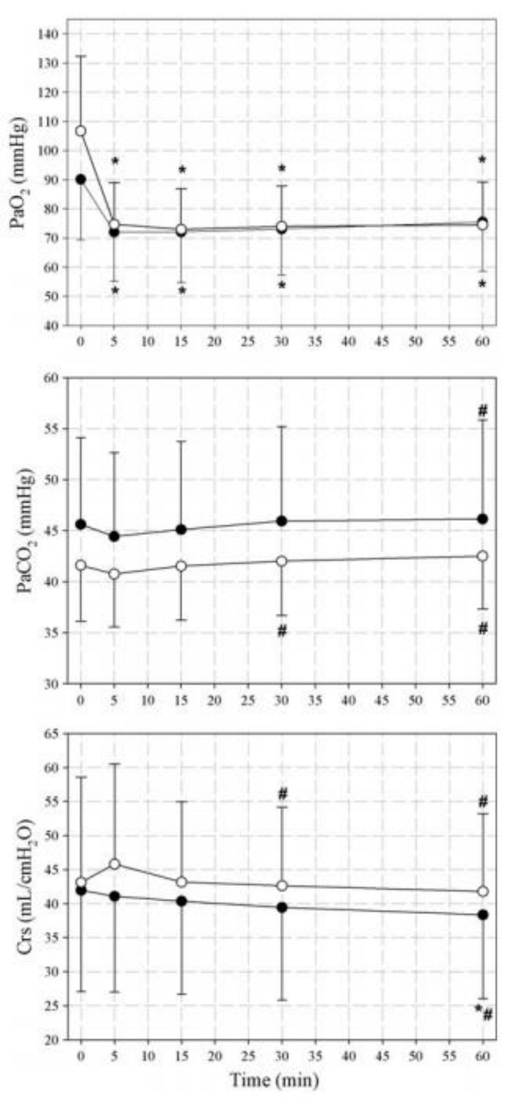
AJRCCM 2011;183:341-347
Respir care 2013;58:416-423
Anesthesiology 2015;122:437-447
Curr Opin Crit Care 2009;15:18-24

How long to wait between changes in PEEP



Intensive Care Med 2013;39:1377-1385

How long to wait between changes in PEEP



Intensive Care Med 2013;39:1377-1385

How long to wait between changes in PEEP

- The effect of change in PEEP will not be fully realized if too little time.
- Potentially injurious ventilation due to inappropriate PEEP if too much time.
- 5-minute might be used to judge the direction of change.

Intensive Care Med 2013;39:1377-1385

Lower PEEP/Higher F_{IO_2}

F_{IO_2}	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	5	5	8	8	10	10	10	12	14	14	14	16	18	18–24

Higher PEEP/Lower F_{IO_2}

F_{IO_2}	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5–0.8	0.8	0.9	0.9	1.0	1.0
PEEP	5	8	10	12	14	14	16	16	18	20	22	22	22	22	24

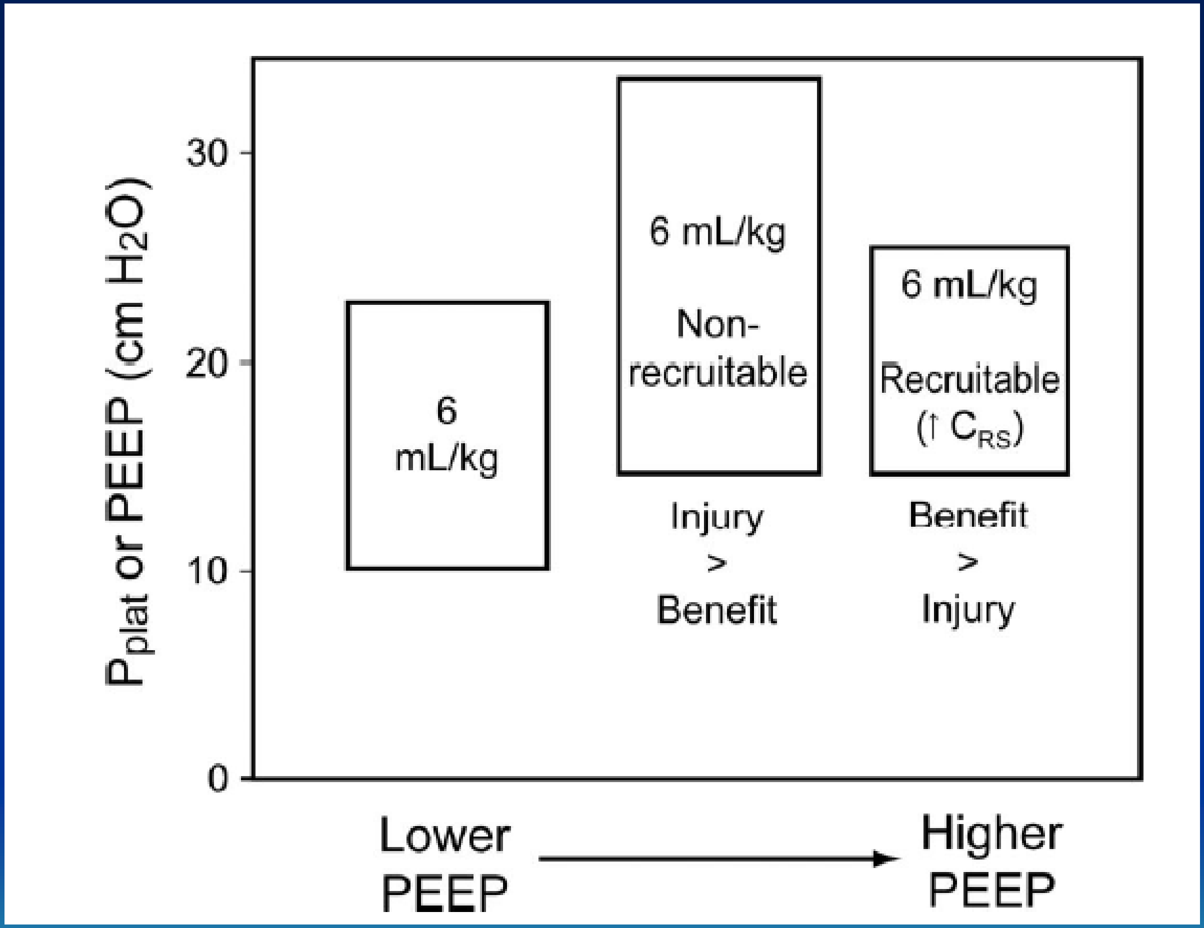
Fig. 4. Tables used to set combinations of F_{IO_2} and PEEP in the ARDS Network study. Data from Reference 59.

NEJM 2004;351:327-336

Higher PEEP vs Lower PEEP

- In moderate and severe ARDS, the mortality was 34.1% in the higher PEEP group 39.1% in the lower PEEP group (RR:0.9, 95%CI:0.81-1.00).
- In mild ARDS, mortality rate was 27.2% in the higher PEEP group 19.4% in the lower PEEP group (RR:1.37, 95%CI:0.98-1.92).

JAMA 2010;303:865-873



Respir Care 2011;56:1555-1572

Potential for Recruitment

- Severe ARDS
  - Lower PaO_2/FiO_2
  - Lower compliance
- Extra-pulmonary ARDS

Crit Care Med 2014;42:252-264
NEJM 2006;543:1775-1786
Intensive Care Med 2000;26:501-507

Contraindications

- Hemodynamic instability
- Pneumothorax or pneumomediastinum
- High risk for pneumothorax
  - Necrotizing pneumonia
  - Lung cysts

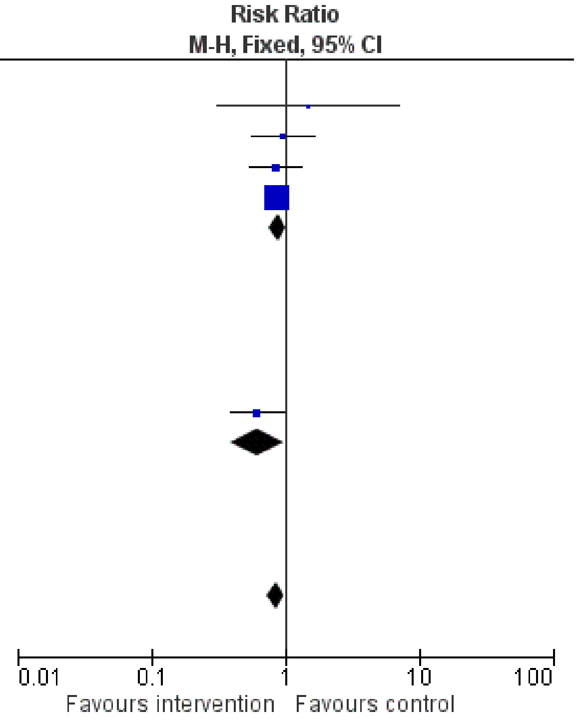
J Intensive Care Med 2011;26:41-49

Clinical Evidence of Recruitment Maneuvers

Primary Outcomes

ICU Mortality

Study or Subgroup	Intervention Events	Intervention Total	Control Events	Control Total	Weight	Risk Ratio M-H, Fixed, 95% CI
1.2.1 Open lung ventilation including recruitment manoeuvres						
Hodgson 2011	3	10	2	10	0.8%	1.50 [0.32, 7.14]
Huh 2009	14	30	13	27	5.6%	0.97 [0.56, 1.68]
Kacmarek 2016	25	99	30	101	12.1%	0.85 [0.54, 1.34]
Meade 2008	145	475	178	508	69.8%	0.87 [0.73, 1.04]
Subtotal (95% CI)		**614**		**646**	**88.2%**	**0.88 [0.75, 1.03]**
Total events	187		223			
Heterogeneity: Chi² = 0.60, df = 3 (P = 0.90); I² = 0%						
Test for overall effect: Z = 1.57 (P = 0.12)						
1.2.2 Recruitment manoeuvres						
Xi 2010	18	55	29	55	11.8%	0.62 [0.39, 0.98]
Subtotal (95% CI)		**55**		**55**	**11.8%**	**0.62 [0.39, 0.98]**
Total events	18		29			
Heterogeneity: Not applicable						
Test for overall effect: Z = 2.06 (P = 0.04)						
Total (95% CI)		**669**		**701**	**100.0%**	**0.85 [0.73, 0.99]**
Total events	205		252			
Heterogeneity: Chi² = 2.64, df = 4 (P = 0.62); I² = 0%						
Test for overall effect: Z = 2.12 (P = 0.03)						
Test for subgroup differences: Chi² = 2.02, df = 1 (P = 0.15), I² = 50.6%						



Forest plot of comparison: 1 Recruitment manoeuvres versus no recruitment manoeuvres, outcome: 1.7 ICU mortality.

Cochrane database Syst Rev 2016;November:17

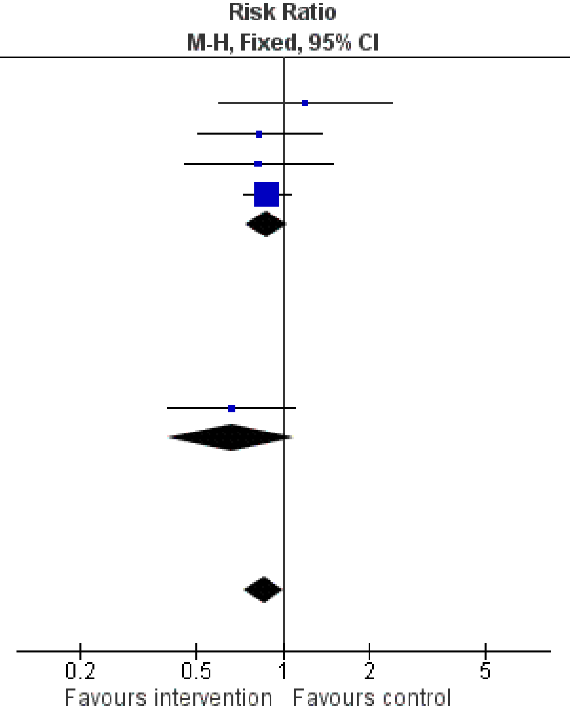
In-hospital Mortality

- Recruitment maneuvers did not reduce mortality in-hospital (RR 0.88, 95% CI 0.77 to 1.01, P = 0.07) (four studies; N = 1313, I^2 = 0%)

Cochrane database Syst Rev 2016;November:17

28-Day Mortality

Study or Subgroup	Intervention Events	Intervention Total	Control Events	Control Total	Weight	Risk Ratio M-H, Fixed, 95% CI
1.1.1 Open lung ventilation including recruitment manoeuvres						
Huh 2009	12	30	9	27	4.0%	1.20 [0.60, 2.39]
Kacmarek 2016	22	99	27	101	11.3%	0.83 [0.51, 1.36]
Liu 2011	14	50	17	50	7.2%	0.82 [0.46, 1.48]
Meade 2008	135	475	164	508	67.2%	0.88 [0.73, 1.06]
Subtotal (95% CI)		**654**		**686**	**89.8%**	**0.88 [0.75, 1.04]**
Total events	183		217			
Heterogeneity: Chi² = 0.87, df = 3 (P = 0.83); I² = 0%						
Test for overall effect: Z = 1.47 (P = 0.14)						
1.1.2 Recruitment manoeuvres						
Xi 2010	16	55	24	55	10.2%	0.67 [0.40, 1.11]
Subtotal (95% CI)		**55**		**55**	**10.2%**	**0.67 [0.40, 1.11]**
Total events	16		24			
Heterogeneity: Not applicable						
Test for overall effect: Z = 1.56 (P = 0.12)						
Total (95% CI)		**709**		**741**	**100.0%**	**0.86 [0.74, 1.01]**
Total events	199		241			
Heterogeneity: Chi² = 1.95, df = 4 (P = 0.75); I² = 0%						
Test for overall effect: Z = 1.86 (P = 0.06)						
Test for subgroup differences: Chi² = 1.06, df = 1 (P = 0.30), I² = 5.9%						



Forest plot of comparison: 1 Recruitment manoeuvres versus no recruitment manoeuvres, outcome: 1.1 28-Day mortality.

Cochrane database Syst Rev 2016;November:17

Secondary Outcomes

Oxygenation

- Recruitment maneuvers improved oxygenation 24 to 48 hours after randomization compared with standard care (MD -39.10, 95% CI -57.64 to -20.56, P < 0.0001).

Cochrane database Syst Rev 2016;November:17

Barotrauma

- Recruitment maneuvers did not significantly affect the risk of barotrauma (RR 1.09, 95% CI 0.78 to 1.53, P = 0.60).

Cochrane database Syst Rev 2016;November:17

Rescue Therapies

- An open lung ventilation strategy that included recruitment maneuvers had no effect on the use of rescue therapies for participants with severe hypoxemia (RR 0.64, 95% CI 0.27 to 1.51, P = 0.31). (I^2 = 74%)

Cochrane database Syst Rev 2016;November:17

Summary of Evidences

- Recruitment maneuvers in participants with ARDS reduced intensive care unit mortality without increasing the risk of barotrauma but had no effect on 28-day and hospital mortality.
- Meta-analysis have not found lasting improvement in clinical outcomes, possibly due to methodology and population heterogeneity.
-

Cochrane database Syst Rev 2016;November:17
Am J Respir Crit Med 2008;178:1156-1163

Take Home Message

- Recruitment maneuvers are helpful in increasing aerated lung volume, which decreases strain and derecruitment.
- Patients with early, severe ARDS with diffuse changes on chest radiograph and low lung compliance are good candidate for recruitment maneuver.
- Post-recruitment application of adequate PEEP, appropriate position and management of fluid balance are critical for maintain recruitment maneuver-generated gains.

Take Home Message

- PEEP should be selected as a balance between alveolar recruitment and overdistention
- PEEP of < 5 cmH_2O is probably harmful early in the course of ARDS.
- PEEP: 5-10 cmH_2O for mild ARDS, 10-15 cmH_2O in moderate ARDS, 15-20 cmH_2O in sever ARDS.
- Recruitment maneuvers should be used within lung protection and not just as a means of improving oxygenation.

Take Home Message

- There is variable potential for recruitment among patients with ARDS.
- Complications of recruitment maneuver are common but temporary, barotrauma appear to be rare.
- If a recruitment maneuver is effective, sufficient PEEP is necessary to maintain the recruitment.
- Evidence is lacking that use of recruitment maneuvers improve patient outcome except improving ICU mortality.

The End

Thanks for Your Attention !!