

Acute Respiratory Distress Syndrome

ARDS: Background

- Within ICUs, 10-15% of admitted patients and up to 20% of mechanically ventilated patients meet criteria for ARDS
- Estimated mortality of 34%
 - Within 72 hours, is usually because of underlying illness
 - Later from multi-organ failure
- Associated with shock/sepsis, trauma, pneumonia, aspiration, pancreatitis, amniotic fluid or fat embolism, near drowning, smoke inhalation/burns, post-bypass
- Multiple stages of ARDS

ARDS: Diagnosis – New Berlin Definition

- Origin of pulmonary edema
 - No PCWP, echo OK
 - Clinical judgment that 1^o cause is not hydrostatic
 - Cardiogenic pulmonary edema or fluid overload may coexist with ARDS
- Oxygenation deficit: PEEP \geq 5

Severity	P:F Ratio	Vent Days	Mortality
Mild	300	5	27%
Moderate	200	7	32%
Severe	100	9	45%

ARDSNet: Lung Trauma

- Mechanical ventilation is the cornerstone of supportive treatment, but can contribute to lung injury
 - **Barotrauma**
 - **Volutrauma**
 - **Atelectrauma**
 - **Biotrauma**
- Too low TV causes atelectasis, hypoxemia, hypercarbia, and inflammation
- Too high TV or not enough PEEP causes V/Q mismatch, alveolar capillary injury, inflammation, pulmonary HTN, and barotrauma

ARDSNet protocol

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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*

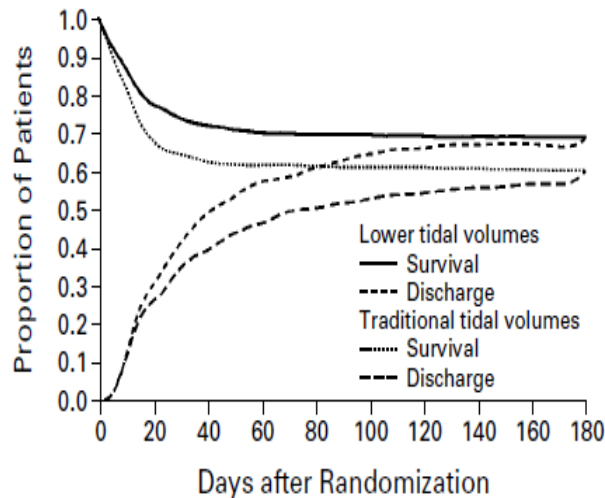


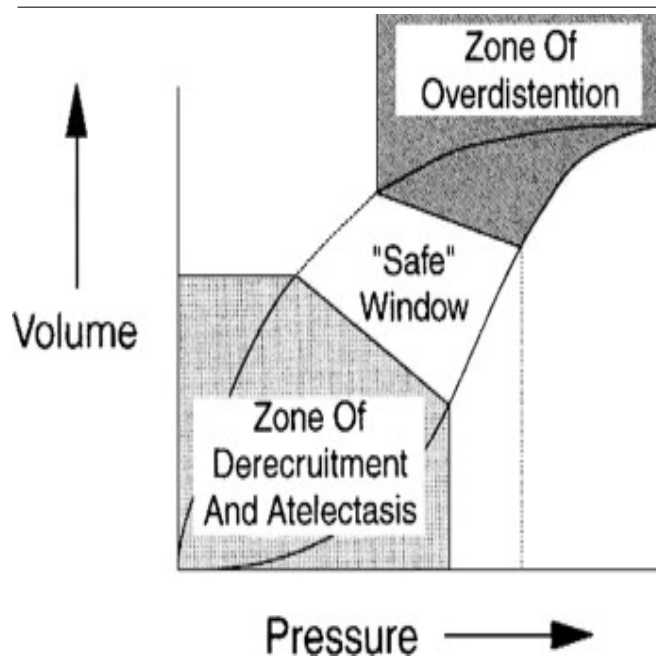
Figure 1. Probability of Survival and of Being Discharged Home and Breathing without Assistance during the First 180 Days after Randomization in Patients with Acute Lung Injury and the Acute Respiratory Distress Syndrome.

- Low TV reduces mortality in ARDS by 22%
- Low TV (6 mL/kg IBW) reduces volutrauma
- Limiting Pplat ≤ 30 cm H2O reduces volutrauma
- Permissive hypercapnia
 - May incr RR to 35 until auto-PEEP
 - If pH < 7.15, increase TV by 1ml/kg until > 7.15 (may go above Pplat of 30)
 - May use bicarb to keep pH > 7.15

ARDS: Other Ventilatory Strategies

CARING FOR THE
CRITICALLY ILL PATIENT

Ventilation Strategy Using Low Tidal Volumes, Recruitment Maneuvers, and High Positive End-Expiratory Pressure for Acute Lung Injury and Acute Respiratory Distress Syndrome
A Randomized Controlled Trial



- JAMA 2008: Open Lung Vent
 - Recruited with high airway pressures followed with high PEEP
 - No difference in mortality, barotrauma, or vent days as compared to low TV strategy
 - May have resulted in more overdistention than recruitment
 - Not sure if PEEP or recruitment maneuver the culprit
 - May be helpful in refractory hypoxemia

ARDS: Other Ventilatory Strategies

REVIEW

CE **EDUCATIONAL OBJECTIVE:** Readers will enumerate the advantages and disadvantages of airway pressure release ventilation as an alternative mode of mechanical ventilation in acute respiratory distress syndrome

ARIEL MODRYKAMIEN, MD
Assistant Professor of Medicine,
Pulmonary, Sleep and Critical Care
Medicine Division, Creighton University
School of Medicine, Omaha, NE

ROBERT L. CHATBURN, MHHS, RRT-NPS
Clinical Research Manager,
Department of Respiratory Therapy, Cleveland Clinic

RENDELL W. ASHTON, MD
Respiratory Institute, Cleveland Clinic

Airway pressure release ventilation:
An alternative mode of mechanical
ventilation in acute respiratory
distress syndrome



High-Frequency Oscillation in Early Acute Respiratory Distress Syndrome

Niall D. Ferguson, M.D., Deborah J. Cook, M.D., Gordon H. Guyatt, M.D., Sangeeta Mehta, M.D., Lori Hand, R.R.T.,
Peggy Austin, C.C.R.A., Qi Zhou, Ph.D., Andrea Matte, R.R.T., Stephen D. Walter, Ph.D., Francois Lamontagne, M.D.,
John T. Granton, M.D., Yaseen M. Arabi, M.D., Alejandro C. Arrolliga, M.D., Thomas E. Stewart, M.D.,
Arthur S. Slutsky, M.D., and Maureen O. Meade, M.D., for the OSCILLATE Trial Investigators
and the Canadian Critical Care Trials Group*

› CCJM 2011: **APRV**

- Improves hemodynamics and oxygenation
- **No improvement in mortality**

› NEJM 2013: **HFOV**

- **Increased mortality** RR 1.33 (1.09-1.64)
- Independent of baseline oxygenation or compliance
- Increased need for vasopressors, sedation, and paralytics
- Trial stopped early

ARDS: Other Ventilatory Strategies

Inhaled Nitric Oxide for Acute Respiratory Distress Syndrome and Acute Lung Injury in Adults and Children: A Systematic Review with Meta-Analysis and Trial Sequential Analysis

Arash Afshari, MD,*† Jesper Brok, MD, PhD,†§ Ann M. Møller, MD, MSDC,†|| and Jørn Wetterslev, MD, PhD§

Dellinger et al. *Critical Care* 2012, 16:R36
<http://ccforum.com/content/16/2/R36>



RESEARCH

Open Access

Association between inhaled nitric oxide treatment and long-term pulmonary function in survivors of acute respiratory distress syndrome

R Phillip Dellinger^{1*}, Stephen W Trzeciak¹, Gerard J Criner², Janice L Zimmerman³, Robert W Taylor⁴, Helen Usansky⁵, Joseph Young⁵ and Brahm Goldstein⁵

- Anes Anal 2011: iNO
 - Transiently increase oxygenation
 - No improvement in mortality
 - May increase risk of renal failure
 - RR 1.59 (1.15-2.16)
- J Crit Care 2012: iNO
 - Fewer restrictive defects on PFTs in 6 mos
 - The difference remained even after correcting for morbid obesity

ARDS: Other Ventilatory Strategies

Use of corticosteroids in acute lung injury and acute respiratory distress syndrome: A systematic review and meta-analysis*

Benjamin M. P. Tang, PhD; Jonathan C. Craig, PhD; Guy D. Eslick, PhD; Ian Seppelt, MBBS;
Anthony S. McLean, MBBS

- Crit Care Med 2009:
- Reduced mortality and improved morbidity with no increase in infection or myopathy with low dose corticosteroids (NNT of 4)
- However, patients were drawn from different populations and treatment regimens varied, so it is unclear when steroids are most useful, at what dose, and for how long

ARDS: Fluid Management - FACCT

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Comparison of Two Fluid-Management Strategies in Acute Lung Injury

The National Heart, Lung, and Blood Institute Acute Respiratory Distress Syndrome (ARDS) Clinical Trials Network*

The NEW ENGLAND
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Pulmonary-Artery versus Central Venous Catheter to Guide Treatment of Acute Lung Injury

The National Heart, Lung, and Blood Institute Acute Respiratory Distress Syndrome (ARDS) Clinical Trials Network*

- NEJM 2005:
 - Conservative IVF improved oxygenation and decreased vent/ICU days without increasing shock or need for HD
- NEJM 2006:
 - PAC guided therapy did not improve survival and had more complications than CVL (arrhythmias)

ARDS: Fluid Management - Diuresis

A randomized, controlled trial of furosemide with or without albumin in hypoproteinemic patients with acute lung injury*

Greg S. Martin, MD, MSc; Marc Moss, MD; Arthur P. Wheeler, MD; Meredith Mealer, RN; John A. Morris, MD; Gordon R. Bernard, MD

- Use of diuretics has been studied as well, but are limited because of risk of acute kidney injury
- Crit Care Med 2005:
 - Albumin/furosemide strategy promising because hypoproteinemia contributes to rapid development of ARDS
 - While oxygenation improved, the sample size was too small to comment on other outcomes

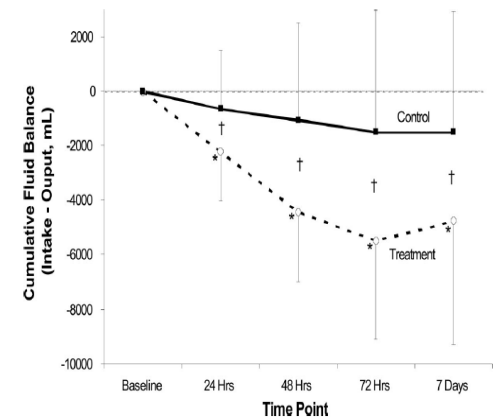


Figure 3. Cumulative fluid balance during the study period, comparing patients treated with furosemide and albumin (treatment, *dashed line*) or furosemide and placebo (control, *solid line*). Points are mean values with error bars depicting standard error of the mean (mean \pm SD) at each time point. *Significant differences from baseline; †significant between-group differences at $p < .05$.

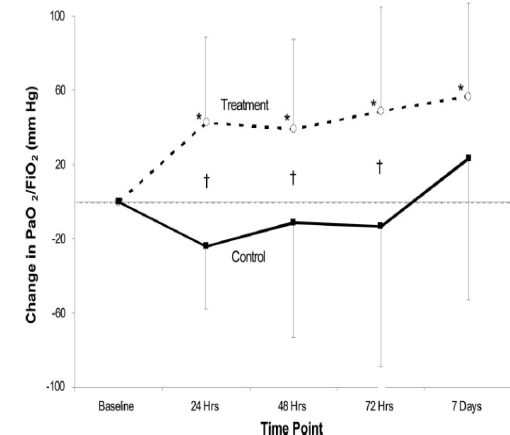
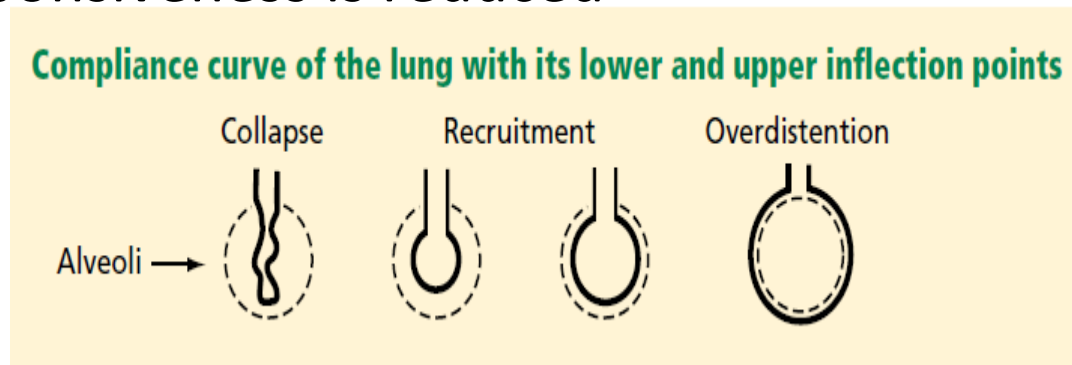


Figure 4. Changes in oxygenation from baseline in hypoproteinemic patients with acute lung injury treated with furosemide and albumin (treatment, *dashed line*) or furosemide and placebo (control, *solid line*). Points are mean values with error bars depicting standard error of the mean (mean \pm SD) at each time point. *Significant differences from baseline; †significant between-group differences at $p < .05$.

Estimating Fluid Responsiveness in ARDS

- PPV/SVV depends on the effects of mechanical ventilation on intracardiac pressure variation, which is influenced by
 - TV, translating to change in airway pressure (depends on lung compliance)
 - Transmission of change in airway pressure to pericardial space (depends on lung compliance)
- If respiratory compliance is < 30 mL/cm H₂O, the ability of pulse pressure variation to predict fluid responsiveness is reduced



Estimating Fluid Responsiveness in ARDS

Passive leg-raising and end-expiratory occlusion tests perform better than pulse pressure variation in patients with low respiratory system compliance*

Xavier Monnet, MD, PhD; Alexandre Bleibtreu, MD; Alexis Ferré, MD; Martin Dres, MD; Rim Gharbi, MD; Christian Richard, MD; Jean-Louis Teboul, MD, PhD

- Crit Care Med 2012: Pulse Pressure Variation does not predict fluid responsiveness in low lung compliance
- Defined increased cardiac index in response to 500 mL bolus as fluid responsive
- Assessed pulse pressure variation versus passive leg raise on fluid responsiveness
- If **compliance > 30**, fluid responsiveness was predicted by **PPV > 12%** and PLR-induced increase in CI >10%
- If **compliance < 30**, fluid responsiveness was predicted by **PPV > 4%** and PLR-induced increase in CI >10%
 - However, the predictive value of PPV (specificity only 64%)
- This demonstrated that in **non-compliant lungs, PPV was not a good predictor of fluid responsiveness, but PLR remained a good predictor**

ARDS and the Perioperative Period

Intraoperative Risk Factors for Acute Respiratory Distress Syndrome in Critically Ill Patients

Christopher G. Hughes, MD, Lisa Weavind, MD, Arna Banerjee, MD, Nathaniel D. Mercaldo, MS, Jonathan S. Schildcrout, PhD, and Pratik P. Pandharipande, MD, MSCI

PERIOPERATIVE MEDICINE

Preoperative and Intraoperative Predictors of Postoperative Acute Respiratory Distress Syndrome in a General Surgical Population

James M. Blum, M.D.,* Michael J Stentz, M.D., M.S.,† Ronald Dechert, R.R.T., D.P.H., M.S.,‡ Elizabeth Jewell, M.S.,§ Milo Engoren, M.D.,|| Andrew L. Rosenberg, M.D.,# Pauline K. Park, M.D.**

- Anes Anal 2010:
 - Intraoperative IVF > 20 ml/kg/hr increased postop ARDS
 - OR 3.8 (p = 0.04)
- Anes 2013:
 - Postop ARDS is more likely after cardiac, thoracic, vascular, and trauma surgery – incidence of 0.2% in the general surgical population
 - Risk factors: males, ASA 3-5, emergent surgery, renal failure, COPD, and multiple anesthetics during admission
 - After matching preop risk, intraoperative predictors included higher driving pressure, FiO₂, pRBC transfusions, and liters of crystalloid

Putting it All Together: Preop Assessment

- Etiology/Stage of ARDS
 - Pneumonia/Aspiration – may benefit from bronchoscopy
 - Sepsis/trauma/burns – needs fluid resuscitation vs fluid overloaded
- Severity of ARDS
 - Oxygenation deficit – P:F ratio, PEEP, advanced vent support
 - Ventilatory deficit – permissive hypercapnia, pH management
 - Lung compliance – effect on monitors, effect of increased abdominal pressures
 - Right heart failure
- Safety of transport – Ambubag not likely to be sufficient
 - PEEP valve vs transport ventilator, supine vs elevated HOB
 - Bedside surgery vs cancelling surgery
 - Try not to derecruit your patient when changing circuits
- Risk factors for postop ARDS
 - ASA 3-5, emergent surgery, renal failure, COPD, multiple trips to OR
 - Cardiac, thoracic, vascular, or trauma surgery

Putting it All Together: Intraop Plan

- Ventilator management
 - $TV \leq 6 \text{ mL/kg IBW}$
 - PEEP for hypoxemia rather than escalating FiO_2 above 60%
 - Watch for hypotension when escalating PEEP
 - Perform recruiting maneuvers – be careful in emphysema/bulla
 - Consider inversing I:E ratio to favor inspiration
 - But watch out for air trapping, auto-PEEP and barotrauma
 - Call for an ICU ventilator if unable to adequately oxygenate or ventilate patient and tell surgeons to wrap it up
- pH management
 - Allow permissive hypercapnia down to pH 7.15
 - If RR already 35 or auto-PEEP evident, give bicarb to correct pH
- Fluid management
 - Limit IVF in the absence of tissue hypoperfusion (normal lactate/ScvO₂)

Putting it All Together: Postop Plan

- Will likely remain intubated if significant vent support
- Safe transport of patient including ventilator, PEEP valve, HOB elevated, monitors, and emergency supplies
- Give good sign out to the ICU resident because the surgery resident probably still has no idea what happened