ARDS Management: New Updates

Terrence Shenfield MS, RRT- ACCS, RPFT,NPS, AE-C
A & T Respiratory Lectures

Objectives

- Describe what is ALI
- Describe what is ARDS
- Describe the clinical picture
- Describe treatment options with mechanical ventilation
- Case study

Acute Respiratory Distress Syndrome

- An acute inflammatory condition in the lungs due to an underlying disease process or trauma
- 150,000 cases each year
- 40% to 50% mortality
- Common causes are sepsis or trauma
  - Acute onset of respiratory failure
  - Bilateral infiltrates on frontal chest radiograph
  - Absence of left ventricular failure (rule out cardiogenic pulmonary edema)
  - Hypoxemia with a ratio of $PaO_2/FiO_2<200$

ALI

- Same criteria as ARDS
- PaO2/FiO2 <300mmHg

ALI/ARDS

- Two types "primary" and "secondary"
- Direct (Primary) Injury
  - 70-80% cases
  - Pneumonia the most common 40-50%
  - Aspiration
  - Pulmonary contusion (chest trauma)
  - Inhalation of toxic gases
  - Near drowning

ALI/ARDS

- Indirect (Secondary) Injury (20%-30% of cases)
- Typically caused by systemic inflammation with generalized activation of mediators
  - Infection (sepsis, peritonitis)
  - Tissue Ischemia (necrosis, pancreatitis)
  - Tissue damage (trauma, CABG, post-op, some intoxications)

ALI/ARDS

- Independent Risk Factors
  - Old age
  - Infection
  - Neurological disease

Clinical Picture

- Cyanosis
- Tachypnea
- Dyspnea
- Crackles
- Extra-pulmonary manifestations of underlying disease
  - Inflammatory cascade

ALI/ARDS 3 Phases

- Initial acute phase (days)
  - Noncardiogenic pulmonary edema secondary to capillary leakage
- Second phase (1-2 weeks)
  - Inflammatory responses
  - IL-4 and IL-13 promote collagen deposition through TGF-β
  - Organization of edema into hyaline membranes
- Third phase
  - Fibrosis of pulmonary tissue

ALI/ARDS

- With time can progress to fibrosing alveolitis
- Lung compliance is reduced, and hypoxemia persists
- Pulmonary hypertension can progress to right heart failure
- Resolution can occur over 6-12 months
- Lung function can return to normal
- Overall mortality is approximately 50%

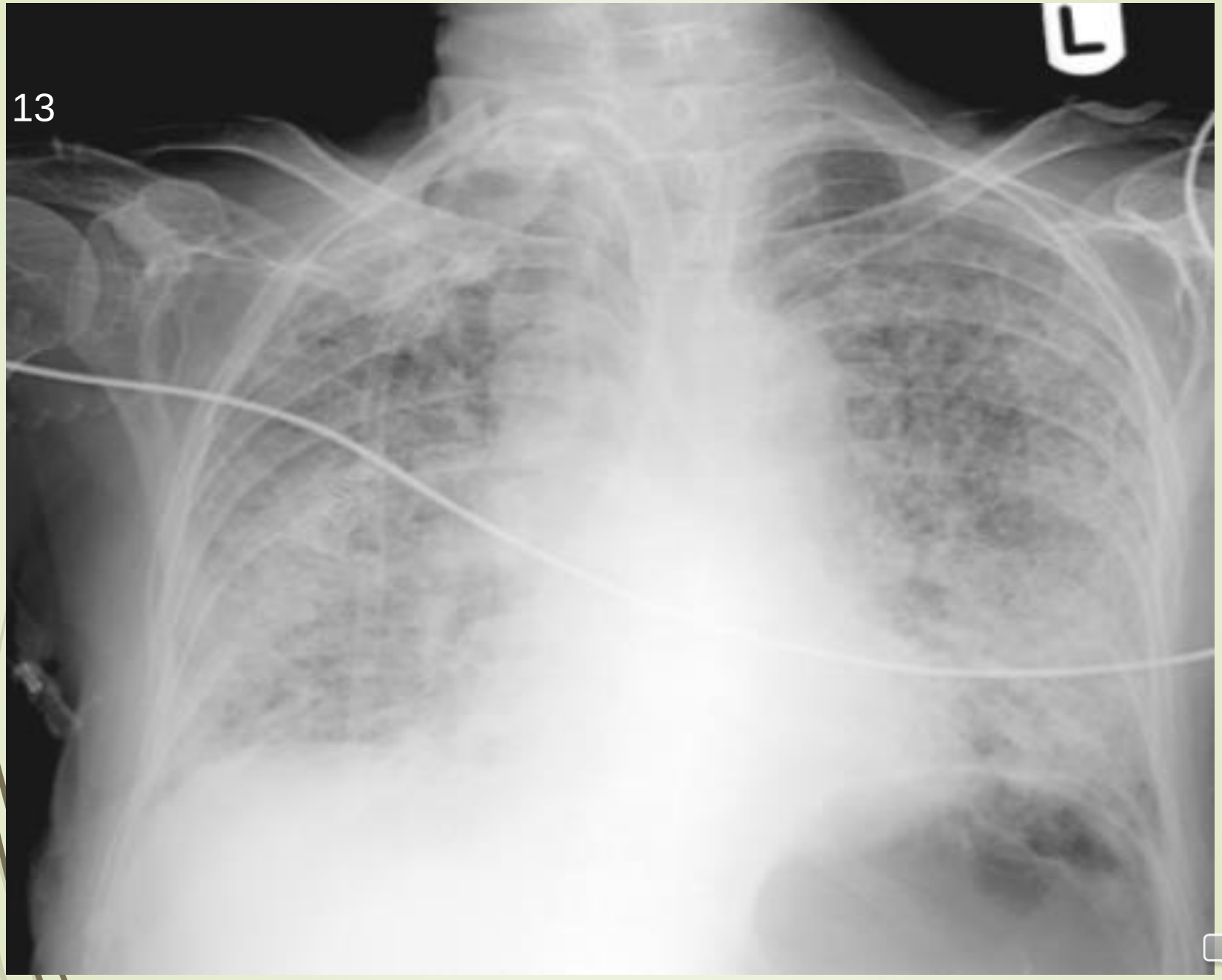
ALI/ARDS
Pulmonary Insult

- Interstitial and alveolar edema
- Increase extravascular lung water
- Increased stiffness and weight of lungs
- Compression atelectasis
- Reduction of compliance
- Decrease of functional residual capacity
- Increase intrapulmonary shunting

Diagnostic Workup

- Medical History
  - Acute onset of respiratory failure in combination with an underlying insult that initiates the pulmonary inflammation
- CXR
  - Bilateral infiltrates
- Echocardiography or PA catheterization
- Documented PCWP <18mmHg
  - Exclusion of significant LV dysfunction (this rules our cardiogenic pulmonary edema)

13



Diagnostic Workup

- ABG and FiO2
  - PaO2/FiO2 <200 (ARDS)
  - <300 ALI
  - Hypoxemia
  - Hypocapnia
    - Anxiety and increased ventilatory drive
    - Respiratory acidosis typically follows

Early Management

- Ventilatory support
- ?? NIV
  - Fully conscious
  - Cooperative
  - Hemodynamically stable
  - Tolerant of short periods off vent support
  - Able to take large breaths
  - Terminate if no marked improvement in 1 hour

Management

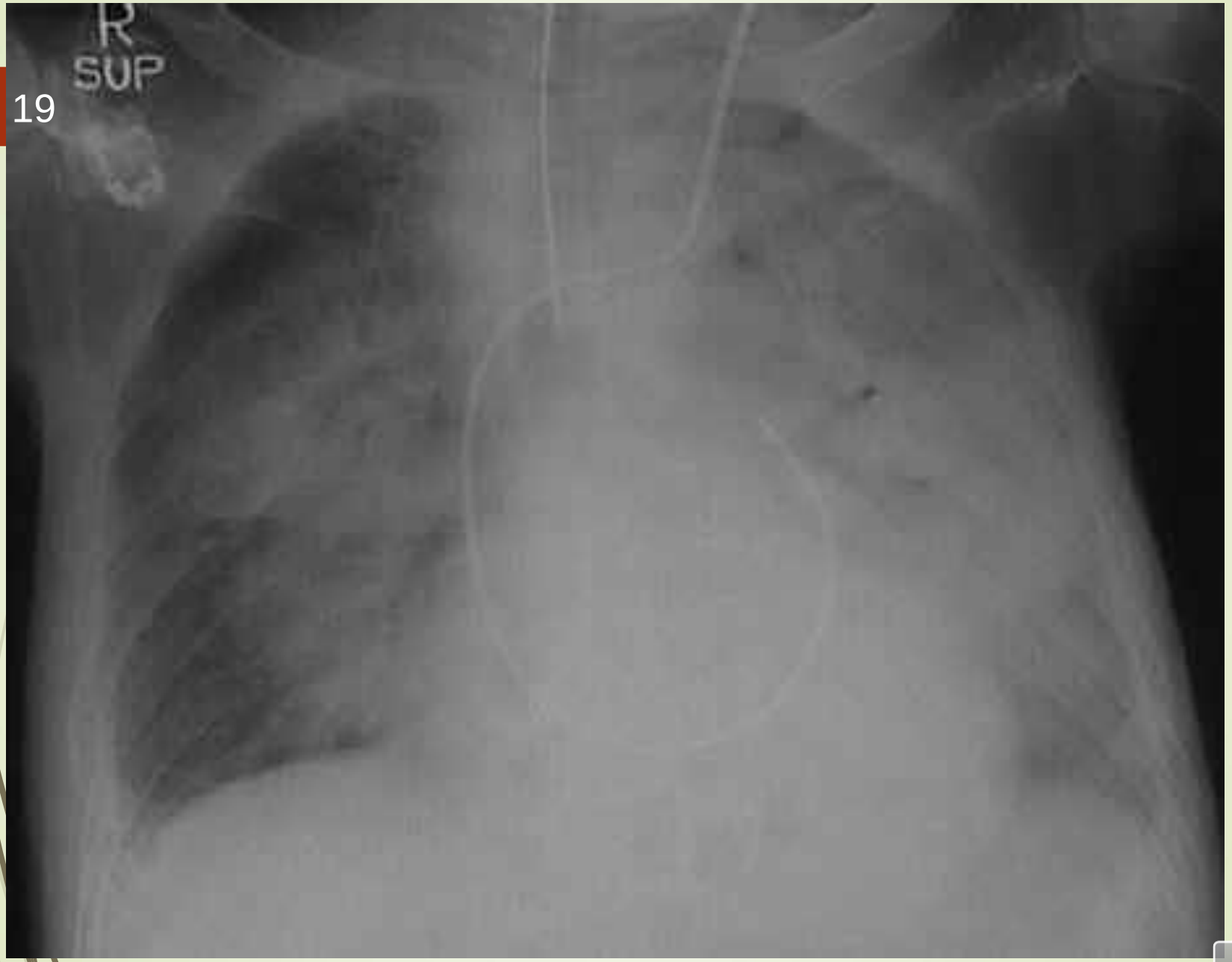
- Vast Majority of patients will require mechanical ventilation
  - Inadequate gas exchange due to flooded alveolar
- Potential complications from intubation
  - Prolonged hypoxemia
  - Aspiration
  - Misplacement of tube
  - Hemodynamic compromise

Case Study Scenario

- 40 yo HIV+ patient with bilateral interstitial infiltrates on CXR transferred to the ICU on face mask of 10L/min
- PCP suspected
  - Tx Bactrim and prednisone
- BP 112/70 HR 110 O2 Sat 94% RR 28
- 2 hours later patient noted to be lethargic with O2 Sat 77%

Case Study Scenario

- The fellow successfully intubates the patient
- Vent Settings
- A/C 500/14/5 FiO2 100%
- ABG
  - 7.24/42/60 on 100%
  - PaO2/FiO2= 60
  - What do we have ? ALI or ARDS? Why?


R
SUP


SN 1105.10
ALESSIO ANTON
M RIANIMAZION
.50mm/7.50 1.5:1

Management

- "Open up the lung and keep the lung open"
- During the early phase of ALI/ARDS opening up lung compressed by the weight of inflammatory exudate improves arterial oxygenation
- Attempting this during later phases of ARDS when collapsed lung has becomes fibrotic is difficult

Recruitment Maneuvers

- An administration of high ventilation pressure to a patient for a brief period
- Aim is to reinflate collapsed lung tissue, thus "recruiting" that tissue
- Aim is also to prevent "de-recruitment" by applying PEEP after the maneuvers
- The desired outcome is improved oxygenation
- There are specific indications

Contraindications for RM

- Hemodynamic compromise:
  - Recruitment maneuvers cause a transient loss of venous return, compromising cardiac output.
- Existing barotrauma
- Increased intracranial pressure
- Predisposition to barotrauma:
  - Apical bullous lung disease
  - Focal lung pathology eg. lobar pneumonia

Recruitment Maneuver

- Manual Hyperinflation
  - Clamp the ETT at end inspiration
  - Attach a bag valve with a PEEP valve
  - Bag patient at a PEEP of 15-20 cm H2O for 20-30 sec
  - This is performed 2-3 times then patient is placed back on the vent with a PEEP of 15-20

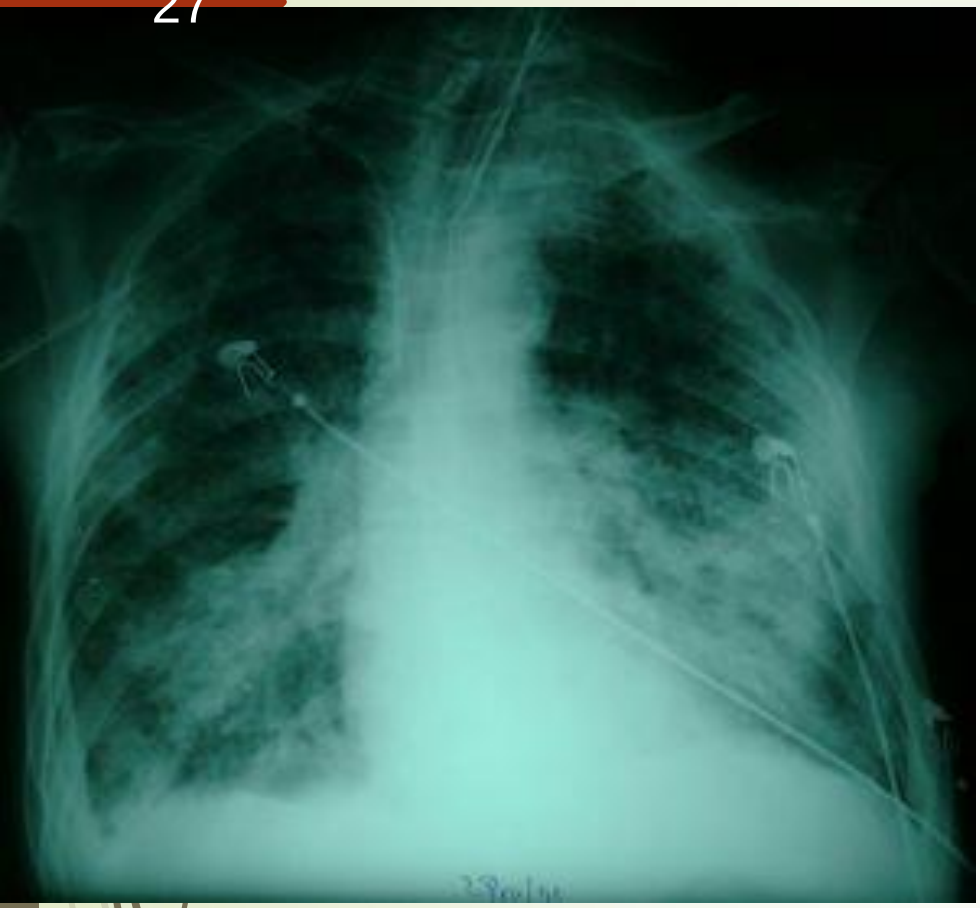
Recruitment Maneuver

- Prolonged inspiratory pause
  - PCV
  - Total inspiratory pressure increased to 40cm H2O after which an inspiratory hold of 40 sec is applied
  - This is repeated 3 times

Recruitment Maneuver

- PEEP Maneuver
  - Increase PEEP to 40cm H2O for 40 seconds
  - Lower tidal volumes 4-6 cc/kg
  - This should be performed three times then place patient back on normal vent mode with PEEP 15-20

Pre and post recruitment maneuvers



Ventilator Mode

- No proven mode conclusively proven superior in ARDS
- ARDSnet protocol
- APRV
- Adult HFOV
- Nitric oxide
- Prone positioning

Ventilator Induced Lung Injury

- VILI caused by over distension with tidal opening and closing of lung units
- Small lesions in the alveoli and airway trigger an inflammatory response
- Inflammation generalized can lead to multiple organ dysfunction, the most significant cause of death in ARDS patients

ARDSnet- May 2004 New England Journal of Medicine

Lower PEEP/higher FiO2

FiO_2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7
PEEP	5	5	8	8	10	10	10	12

FiO_2	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	14	14	14	16	18	18-24

Higher PEEP/lower FiO2

FiO_2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5
PEEP	5	8	10	12	14	14	16	16

FiO_2	0.5	0.5-0.8	0.8	0.9	1.0	1.0
PEEP	18	20	22	22	22	24

Tidal Volume

- No proven mode conclusively proven superior in ARDS
- Tidal Volume 4-6ml/kg shown to decrease mortality (9%)
- Low tidal volume ventilation might reduce CO2 elimination –permissive hypercapnia

PEEP

- Positive End Expiratory Pressure
- Prevents collapse of open and perfused lung regions and thus maintain arterial oxygenation
- Prevents cyclical opening and closing of airway
- May cause overdistension/barotrauma

Inspiratory : Expiratory Ratio

- I:E ratio reversal
- Longer inspiratory time increases intra-alveolar mixing
  - Improves CO2 removal
- Shorter expiratory time prevents time-dependent alveolar collapse
- Inverse I:E ratio with PCV

APRV Vs. ARDSnet Protocol Ventilation For ARDS/ALI

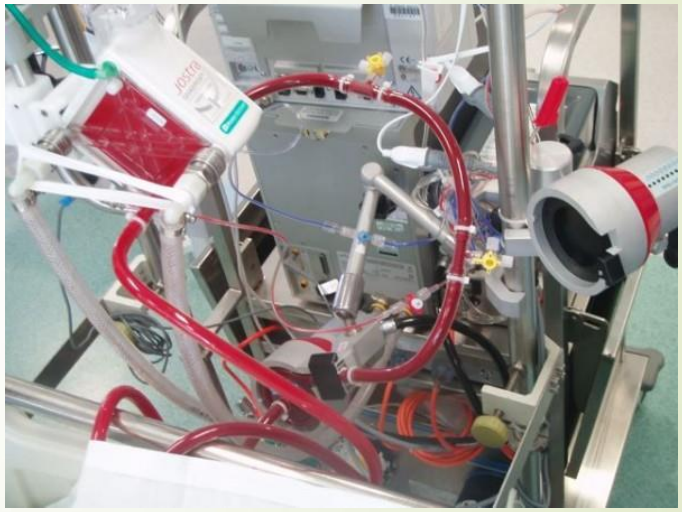
- Open lung ventilation strategy
- Minimize VILI
- Keep plateau pressures < 30cmh2o
- Findings
  - Mortality was the same
  - Fewer inflammatory mediators (IL-1, TNF, cytokines) , were present with APRV

Adult HFOV- Not good news!

- Duncan Young et al. High-Frequency Oscillation for Acute Respiratory Distress Syndrome. OSCAR Trial. NEJM 2013; DOI: 10.1056/NEJMoa1215716(January 22, 2013 online)
- Niall Ferguson et al. High-Frequency Oscillation in Early Acute Respiratory Distress Syndrome. OSCILLATE Trial. NEJM January 22 2013.
- Both trails showed increased mortality associated with the use of HFOV
- Reason? Maybe better adherence to low tidal volume strategy

ECMO

- A recent international trial showed that in patients with very severe ARDS
- 60-day mortality was not significantly lower with ECMO compared with a conventional mechanical ventilation strategy
- More studies are needed to define ECMO's potential role in ARDS.



Inhaled Nitric Oxide

- Pulmonary vasodilator
- Improves VQ ratio
- Improves oxygenation in 60% of cases
- Lasts 2-3 days
- Overall mortality is the same if you didn't use NO


ALESSIO ANTO
RIANIMAZION

Prone Positioning

- Prone positioning
  - Pleural pressure more evenly distributed to dorsal regions of lung
  - More homogeneous distribution of pressure
  - Improved ventilation perfusion ratio
- Oxygenation improves in 70% patients
  - Typically within minutes
  - Must be used for 12 or more hours for improvement

Nosocomial pneumonia or VAPS

- Nosocomial pneumonia is greater in ARDS patients
- VAP risk increases 3%/day in the 1st week
- VAP associated with increase mortality of 20-30%
- Prescribe appropriate antibiotic therapy if indicated

2024 New Guidelines

- Corticosteroid use
- Venovenous extracorporeal membrane oxygenation (VV-ECMO)

Should Patients with ARDS Receive Systemic Corticosteroids?

- Corticosteroids are anti-inflammatory medications that inhibit the synthesis of proinflammatory mediators present in ARDS
- Corticosteroids have been found to reduce mortality in COVID-19–related acute hypoxemic respiratory failure
- Corticosteroids were evaluated in 19 RCTs including 2,790 patients
- Pooled analysis demonstrated that corticosteroids probably decrease mortality, duration of mechanical ventilation, and hospital stay

Should Patients with ARDS Receive VV-ECMO?

- Suggest the use of VV-ECMO in selected patients with severe ARDS
- VV-ECMO facilitates oxygenation and carbon dioxide removal in patients with ARDS by draining blood from the venous system, allowing it to pass through a gas-exchange device, and then returning it to the venous system
- It is an invasive, resource-intensive technology available at specialized centers that incurs significant cost and requires a considerable amount of human health resources.
- VV-ECMO was evaluated in two RCTs that included 429 patients
- Polled analysis demonstrated that it decreased mortality and increased ventilator free days and the use of vasopressor-free days

Other considerations

Should Patients with ARDS Receive Neuromuscular Blockade?

Should Patients with ARDS Receive Higher Compared with Lower PEEP, with or without Lung Recruitment Manuevers?

Intervention	Population	Precautions	Practical considerations
 Corticosteroids	$PaO_2/FiO_2 \leq 300$	• May be associated with increased risk of harm when initiated after > 14 days of mechanical ventilation • Monitor more closely for adverse effects in patients with immunosuppressed conditions, metabolic syndrome, or known or increased risk of fungal, parasitic, or mycobacterial infections	• Optimal regimen, including type of corticosteroid, is unknown • For patients with corticosteroid-responsive etiologies, regimen should be tailored to the specific condition • For other patients, regimens used in prior RCTs may be used • For patients that improve rapidly, consider discontinuation at time of extubation
 VV-ECMO	$PaO_2/FiO_2 < 80$ or pH < 7.25 with $pCO_2 \geq 60$	Conditions associated with increased risk for futility of treatment • Irreversible etiology of respiratory failure • Mechanical ventilation > 7 days • Immunosuppression • Multi-organ failure • Older age • Systemic bleeding or other contraindication to anticoagulation • Chronic medical condition and life expectancy <1yr • CNS hemorrhage or irreversible and incapacitating CNS pathology	• Less invasive therapies, including lung protective ventilation, prone positioning, and neuromuscular blockade, should be initiated prior to ECMO consideration • Resource limitations should be considered, with an emphasis on maximizing access for patients most likely to benefit from ECMO • For patients meeting these criteria at hospitals without ECMO capabilities, consider transfer to ECMO centers when feasible
 NMBAs	Early ARDS (≤ 48 hours of MV) with $PaO_2/FiO_2 \leq 100$	• Unknown and potentially increased incidence of neuromuscular weakness with infusions of > 48 hours duration • Use caution in patients with prior neuromuscular conditions	• Reduced mortality when compared to deep sedation. No mortality benefit when compared to light sedation • May have greater utility in patients with ventilator dyssynchrony not mitigated by ventilator changes • Either bolus dosing or continuous infusion may be appropriate • Consider cessation after 48 hours or earlier for patients that are improving rapidly • Cisatracurium most frequently used in clinical trials; optimal agent unknown
 High PEEP	$PaO_2/FiO_2 \leq 200$	• Respiratory mechanics, hemodynamics, and response to PEEP should be continuously monitored • Use additional caution in patients with severe hemodynamic instability or increased risk of barotrauma • Prolonged recruitment maneuvers should be avoided	• Optimal strategy is unknown; selected strategy should be tailored to clinician expertise • Potential strategies may include oxygenation-based titration or titration to maximal compliance or maximal safe plateau pressure • Deleterious clinical response to higher PEEP (i.e. worsened oxygenation, dead space, compliance, or hemodynamics) should prompt re-evaluation of PEEP level

Summary

- Adult respiratory distress syndrome and acute lung injury are not going away
- ARDSnet strategy seems to work
- New research is pointing to the use of corticosteroids as well as VV-ECMO in certain patients
- Neuromuscular Blockade
- Higher PEEP with out RM is being researched

References

- Liaqat, A., Mason, M., Foster, B. J., Kulkarni, S., Barlas, A., Farooq, A. M., ... & Pau, D. (2022). Evidence-based mechanical ventilatory strategies in ARDS. Journal of clinical medicine, 11(2), 319.
- Qadir N, Sahetya S, Munshi L, Summers C, Abrams D, Beitler J, Bellani G, Brower RG, Burry L, Chen JT, Hodgson C, Hough CL, Lamontagne F, Law A, Papazian L, Pham T, Rubin E, Siuba M, Telias I, Patolia S, Chaudhuri D, Walkey A, Rochwerg B, Fan E. An Update on Management of Adult Patients with Acute Respiratory Distress Syndrome: An Official American Thoracic Society Clinical Practice Guideline. Am J Respir Crit Care Med. 2024 Jan 1;209(1):24-36. doi: 10.1164/rccm.202311-2011ST. PMID: 38032683;
- Pelosi, P., Ball, L., Barbas, C. S., Bellomo, R., Burns, K. E., Einav, S., ... & Rocco, P. R. (2021). Personalized mechanical ventilation in acute respiratory distress syndrome. *Critical care*, *25*, 1-10..
- Amato, M. B., Meade, M. O., Slutsky, A. S., Brochard, L., Costa, E. L., Schoenfeld, D. A., ... & Richard, J. C. M. (2015). Driving pressure and survival in the acute respiratory distress syndrome. New England Journal of Medicine, 372(8), 747-755.