

**Acute Respiratory Distress Syndrome/  
Acute Lung Injury**

**Arthur Jones EdD, RRT**

<http://www.geocities.com/jonesapjr/index.html>

**Learning Objective**

- ^ Describe the etiologies, manifestations, diagnostic techniques and current management strategies for acute respiratory distress syndrome and acute lung injury.

**Definitions & Etiologies**

**Acute lung injury/ARDS**

- ^ ALI/ARDS is a syndrome that is response to injury and not a disease.
- ^ There is much variability in pathology and pathophysiology.
- ^ Acute Lung Injury (ALI)
  - ◆ hypoxemic respiratory failure
  - ◆ severe version- Acute Respiratory Distress Syndrome (ARDS).

**Characteristics:**

- ^ Bilateral pulmonary infiltrates on chest x-ray
- ^ Pulmonary Capillary Wedge Pressure <18 mm Hg
- ^ PaO<sub>2</sub>/FiO<sub>2</sub> <300 = ALI
- ^ PaO<sub>2</sub>/FiO<sub>2</sub> <200 = ARDS

Link to ARDS  
<http://www.nlm.nih.gov/medlineplus/ency/article/000103.htm>

**Characteristics:**

- ^ surfactant deficiency
- ^ decreased lung compliance
- ^ decreased lung volume

**Synonyms (history):**  
▲ Da Nang lung- Viet Nam  
▲ shock lung  
▲ non-cardiogenic pulmonary edema  
▲ leaky capillary syndrome  
▲ acute lung injury  
▲ diffuse alveolar damage

**Etiologic mechanisms**  
▲ direct lung injury (pulmonary)  
    ◆ inhalation injury  
    ◆ pneumonia  
    ◆ aspiration  
▲ indirect lung injury (extrapulmonary)  
    ◆ shock  
    ◆ sepsis  
    ◆ transfusion related injury  
    ◆ pancreatitis

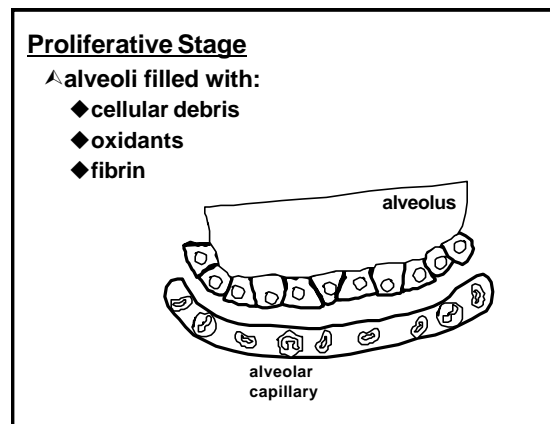
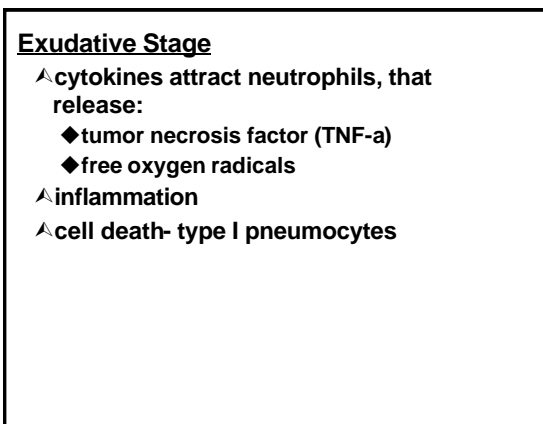
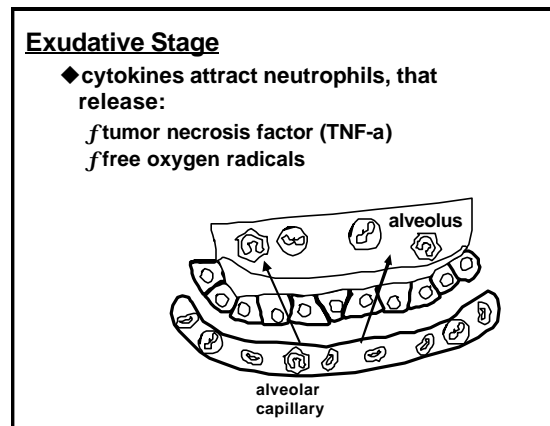
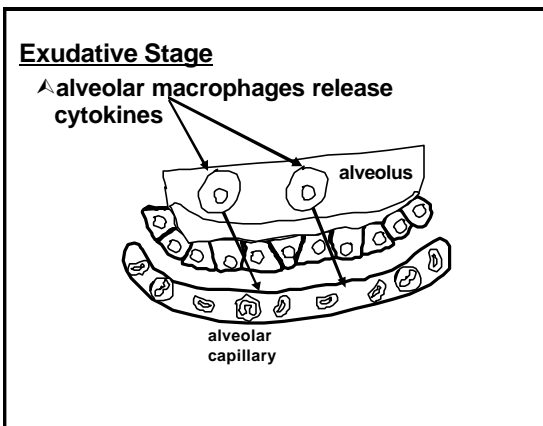
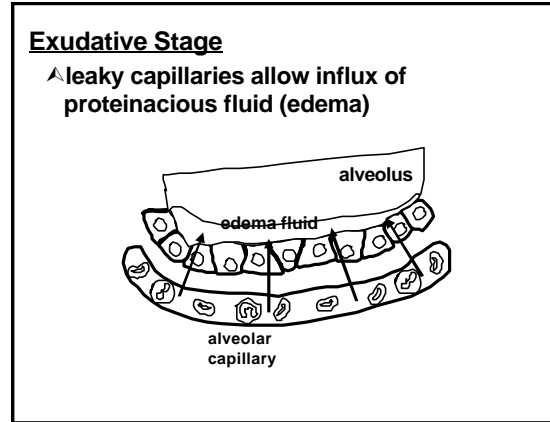
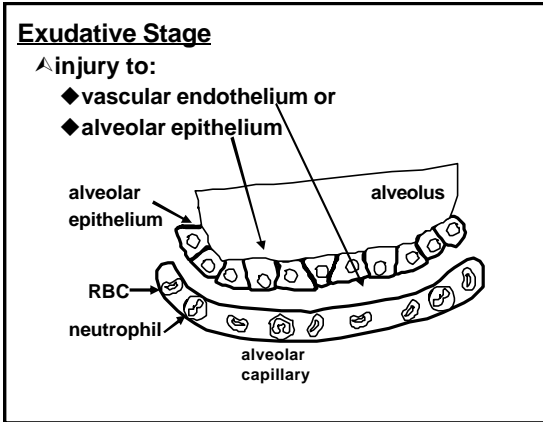
**Predisposing Conditions**  
▲ trauma, shock  
▲ aspiration  
▲ oxygen toxicity  
▲ toxic fumes  
▲ sepsis

**Predisposing Conditions**  
▲ narcotic overdose  
▲ pancreatitis  
▲ fat embolism  
▲ near drowning  
▲ transfusion- transfusion-  
    associated lung injury (TRALI)  
▲ eclampsia/pre-eclampsia  
▲ amniotic embolism

**Pathophysiology**

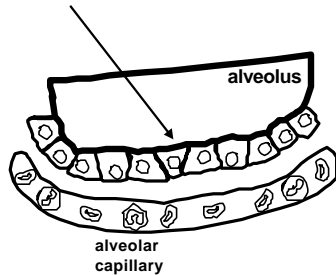
**ARDS Pathophysiology**  
▲ Initial insult  
    ◆ directly to lung  
    ◆ indirectly, via system  
▲ Pathology stages  
    ◆ exudative (4-7D after onset)  
    ◆ proliferative (1-3 wks.)  
    ◆ recuperative or fibrotic (3-4 wks)

Link to article on ALI/ARDS  
<http://www.aafp.org/afp/20030115/315.html>



**Proliferative Stage**

- ◆ surfactant depleted/inactivated
- ◆ hyaline membrane formation



**Resolution or Fibrosis**

- △ phagocytosis of debris or
- △ collagen deposition- fibrosis with lung like a liver

Link to gross pathology of fibrosis following ALI/ARDS  
<http://library.med.utah.edu/WebPath/LUNGHTML/LUNG096.html>

**Manifestations & Complications**

**Manifestations**

- △ There is variability in ARDS
  - ◆ pulmonary, vs. extrapulmonary etiology
  - ◆ consolidation vs. edema
  - ◆ post-traumatic vs. non-traumatic

**Manifestations**

- △ There is variability in ARDS
  - ◆ pulmonary, vs. extrapulmonary dx- consolidation vs. edema
  - ◆ post-traumatic vs. non-traumatic
  - ◆ variability will affect:
    - f* duration of illness
    - f* response to ventilation strategies; e.g., PEEP, recruitment maneuvers (RM)
    - f* prognosis

**Manifestations**

- △ Onset- hours to days after initial insult
- △ Physical signs
  - ◆ tachypnea
  - ◆ retractions; e.g., supraclavicular
  - ◆ abdominal paradox- diaphragmatic fatigue
  - ◆ crackles, rhonchi, bronchial sounds
- △ Progressive, refractory hypoxemia
- △ Decreased lung compliance ( $C_L$ )

**Manifestations**

- ^ CXR
  - ◆ Decreased lung volumes
  - ◆ Fluffy alveolar infiltrates
  - ◆ Air bronchograms
  - ◆ Hyaline membrane

**Manifestations**

- ^ CXR- ALI/ARDS

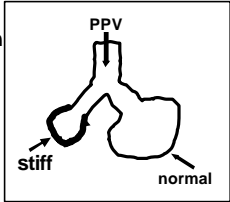
Link to images of ARDS following pulmonary contusion  
<http://www.trauma.org/archive/thoracic/CHESTcontusion.html>

Link to images of transfusion associated lung injury  
<http://www.cmaj.ca/cgi/content/figonly/177/2/149>

Link to images of acute lung injury with air bronchograms  
[http://www.ccmtutorials.com/rs/ali/01\\_ali.htm](http://www.ccmtutorials.com/rs/ali/01_ali.htm)

**Complications**

- ^ Ventilator-induced lung injury
  - ◆ ALI/ARDS is non-uniform
  - ◆ posterior lungs edematous, collapsed
  - ◆ normal lung units are subject to:
    - f* overdistension
    - f* loss of perfusion



**Complications**

- ^ Ventilator-induced lung injury
- ^ Ventilator-associated pneumonia- prolonged intubation
- ^ Multiple organ system failure- release of mediators from lung
- ^ Hemodynamic compromise (shock)
- ^ Sepsis
- ^ Pulmonary fibrosis

**Prognosis**

- ^ mortality- about 40%
- ^ prognosis better for trauma victims
  - ◆ younger
  - ◆ less comorbidity
- ^ severity correlates with duration of precipitating injury, not type of injury

**Prognosis**

- ^ 66% survivors have lung dysfunction
- ^ psychiatric illness- depression
- ^ cognitive impairment

## Diagnosis

### Differential diagnosis

- ^cardiogenic pulmonary edema
- ^inhalation injury
- ^aspiration
- ^pneumonia (many types)
- ^hypersensitivity pneumonitis

### Differential diagnosis

- ^cardiogenic pulmonary edema
- ^inhalation injury
- ^aspiration
- ^pneumonia (many types)
- ^hypersensitivity pneumonitis
- ^drug toxicity; e.g., amiodarone
- ^alveolar hemorrhage
- ^severe acute respiratory distress syndrome (SARS)- coronavirus

### ARDS vs. cardiogenic pulmonary edema

- ^ARDS- PCWP <18 mm Hg
- ^ARDS- alveolar exudate (proteins)
- ^Cardiogenic- cardiomegaly
- ^Brain natriuretic peptide (BNP) does not accurately differentiate

Link to study on BNP for differentiation of ARDS from cardiogenic pulmonary edema  
<http://ccforum.com/content/12/1/R3>

### Diagnostic Studies

- ^CT scan
  - ◆determine anteroposterior distribution of consolidation
  - ◆may predict effectiveness of pronation

Link to article on CT scanning and ARDS  
<http://ajrccm.atsjournals.org/cgi/content/full/164/9/1701>

### Diagnostic Studies

- ^Bronchoalveolar lavage
  - ◆distinguish between transudate and exudate
  - ◆identify or R/O infection
  - ◆identify inflammatory cells
  - ◆identify inflammatory mediators

**Diagnostic Studies**

- ^ Open lung biopsy
  - ◆ identify pathologic process
  - ◆ identify etiology

Link to article on the role of open lung biopsy in ARDS  
<http://www.chestjournal.org/cgi/content/full/125/1/197>

**Management**

**General strategies**

- ^ Treat underlying cause, if possible
- ^ Conservative fluid management improves outcomes
- ^ Pulmonary artery catheter monitoring
  - ◆ no improvement in outcomes
  - ◆ more complications

Link to study FACTT study synopsis  
<http://www.medscape.com/viewarticle/540991?rss>

**Ventilation Strategies**

- ^ Lung protective strategies
  - ◆ open lung technique
    - f* pressure control with volume guarantee (my recommendation)
    - f* optimal PEEP
    - f* TV < 7mL/kg IBW
    - f* recruitment maneuvers (RM)

Link to predicted body weight chart  
[http://www.ardsnet.org/system/files/pbwtables\\_2005-02-02\\_0.pdf](http://www.ardsnet.org/system/files/pbwtables_2005-02-02_0.pdf)

**Ventilation Strategies**

- ^ effectiveness of PEEP and RMs
  - ◆ contingent upon potentially recruitable alveoli
  - ◆ fluid-filled alveoli are not recruitable

**Ventilation Strategies**

- ^ Pressure-controlled inverse ratio ventilation
  - ◆ effective
  - ◆ pressure control with volume guarantee and inverse ratio ventilation may be effective

**Ventilation Strategies**

- ^ Airway pressure release ventilation
  - ◆ effective in selected patients
  - ◆ less likely to impair hemodynamics

Link to article on APRV and cardiac performance  
<http://ccforum.com/content/5/4/221>

**Ventilation Strategies**

- ^ Permissive hypercapnea
  - ◆ allows non-advancement of settings
  - ◆ may reduce inflammation
  - ◆ may reduce mortality
  - ◆ acidemia can be managed with tromethamine (THAM)

**Ventilation Strategies**

- ^ Pronation
  - ◆ transient improvements in oxygenation
  - ◆ many studies found no changes in mortality
  - ◆ Mancebo et al- reduced mortality, if applied for 17H/d
  - ◆ CT may determine those who will benefit

**Ventilation Strategies**

- ^ High frequency oscillatory ventilation
  - ◆ as good as conventional ventilation
  - ◆ no improvement in mortality
- ^ Partial liquid ventilation
  - ◆ no benefits
  - ◆ very expensive

**Non-ventilatory therapeutics**

- ^ Surfactant instillation (children)
  - ◆ decreased mortality
  - ◆ decreased duration of ventilation

**Non-ventilatory therapeutics**

- ^ Surfactant instillation (children)
  - ◆ decreased mortality
  - ◆ decreased duration of ventilation
- ^ Surfactant instillation (adults)
  - ◆ no effects on mortality
  - ◆ quantity of surfactant for adults- expensive
- ^ Surfactant aerosol- Aerosurf™ under study

Link to information on Aerosurf™  
<http://www.discoverylabs.com/aerosurf.html>

**Non-ventilatory therapeutics****^ Nitric oxide**

- ◆ dilates vessels in ventilated alveoli
- ◆ short-term improvement in oxygenation
- ◆ no effects on mortality
- ◆ very expensive
- ◆ off-label use - no payment

**^ Aerosolized prostacyclin (Flolan)**

- ◆ same effects as NO
- ◆ less costly than NO

**Partial liquid ventilation****^ Lungs filled to FRC with perflubron (LiquiVent), with these properties:**

- ◆ high density - flows to dependent areas of lung
- ◆ low surface tension- increases compliance
- ◆ high solubility for O<sub>2</sub> and CO<sub>2</sub> - transports gases
- ◆ high volatility - quickly excreted

Link to picture of mouse immersed in LiquiVent (™)  
<http://www.opa.medicine.arizona.edu/horizons/2000/fall/mouse.jpg>

**Partial liquid ventilation****^ Physiologic effects:**

- ◆ increased lung compliance, due to:
  - f* decreased surface tension
  - f* alveolar recruitment
- ◆ decreased VILI due to increased compliance
- ◆ decreased shunt due to alveolar recruitment & diffusion across perflubron

**Partial liquid ventilation****^ Potential applications:**

- ◆ RDS - neonates
- ◆ meconium aspiration - not effective for adults
- ◆ alveolar proteinosis (1 case)
- ◆ ALI/ARDS

**Partial liquid ventilation****^ Procedure**

- ◆ perflubron instilled to FRC
- ◆ re-instillation required, due to evaporation

Link to picture of ventilation with LiquiVent (™)  
<http://www.opa.medicine.arizona.edu/horizons/2000/fall/liqavent.jpg>

**Partial liquid ventilation****^ Research findings**

- ◆ neonates - non-responders to surfactant survived (n = 10)
- ◆ adults - most recent trial (2006) found negative for PLV
- ◆ earlier trials did not compare PLV with lung protective ventilation

Click to download article on PLV for neonates with RDS  
<http://content.nejm.org/cgi/content/full/335/11/761>  
 Click to download article on PLV for adults with ARDS  
<http://ajrccm.atsjournals.org/cgi/reprint/173/8/882>

**Partial liquid ventilation**

- △ **Barriers to adoption**
  - ◆ expense
    - f perflubron
    - f time - dosing, redosing
  - ◆ lack of positive research findings
- △ **Opinion - PLV will not become a widely-used technique, at least for adults**

**Non-ventilatory therapeutics**

- △ **Corticosteroids**
  - ◆ many investigations (since 1970s)
  - ◆ no benefits
  - ◆ if started late, may increase mortality

**Non-ventilatory therapeutics**

- △ **Enteral EPA + GLA + antioxidants**
  - ◆ increased lung compliance
  - ◆ decreased duration of ventilation
  - ◆ no effects on mortality

Link to article on borage oil and ARDS  
<http://ncp.sagepub.com/cgi/content/full/19/6/563>

**Non-ventilatory therapeutics**

- △ **n-acetylcysteine (Mucomyst)**
  - ◆ intravenous infusion
  - ◆ antioxidant properties
  - ◆ more research needed

**Non-ventilatory therapeutics**

- △ **Albuterol aerosol**
  - ◆ increases  $C_{DYN}$  ==> decreased ventilation pressure
  - ◆ decreases lung edema
  - ◆ anti-inflammatory action- decrease TNF-a

Link to article on non-ventilatory therapeutics  
<http://www.chestjournal.org/cgi/reprint/131/3/913>

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