Managing Complex Patients
Critical Care Medicine

Alice A Tolbert Coombs MD MPA FCCP
National Minority Forum
Washington, DC
Complex Patients in the ICU

• Objectives

• Review recent updates in Critical Care Medicine with Sepsis/Septic Shock and Adult Respiratory Syndrome
  • Discuss ARDS and Sepsis/Septic Shock New Definitions and Diagnosis Review Treatment and Mortality

• Review the Impact of Resources, Health care Workforce on Outcome in hospitalized Critically Ill Patients

• Describe how racial disparities( African Americans) impact mortality in Sepsis/Septic Shock
US Leading Causes of Death 2013
Total Deaths 2,596,993

1. Diseases of heart (heart disease)
2. Malignant neoplasms (cancer)
3. Chronic lower respiratory diseases
4. Accidents (unintentional injuries)
5. Cerebrovascular diseases (stroke)
6. Alzheimer’s disease
7. Diabetes mellitus (diabetes)
8. Influenza and pneumonia
9. Nephritis, nephrotic syndrome and nephrosis (kidney disease)
10. Intentional self-harm (suicide)
11. Septicemia
12. Chronic liver disease and cirrhosis
13. Essential hypertension and hypertensive renal disease (hypertension)
14. Parkinson’s disease
ICU Hospitalization

- Respiratory diagnosis - ventilator support,
- Acute Myocardial Infarction,
- Intracranial hemorrhage or cerebral infarction,
- Percutaneous cardiovascular procedure with drug-eluting stent
- Septicemia or severe sepsis without mechanical ventilation.
- Poisoning and toxic effects of drugs/Alcohol,
- Heart failure, shock, cardiac arrhythmia, conduction disorders, renal failure, GI hemorrhage, and diabetes,
- Cancer
Leading causes of Death

**ICU**
- Septicemia
- Cardiovascular
- Acute Respiratory Failure
- Cancer
- Trauma

**Hospital**
- Cardiovascular
- Cancer
- Hospital Errors
Critical Care Medicine

- Quality/Safety
  - Outcomes
  - Process Measures
  - Risk-Stratifying-APACHE-Models for predicting ICU LOS in critically ill patient groups, such as Acute Physiology and Chronic Health Evaluation (APACHE) IV for adult patients in benchmarking

- Access
- Cost
- Providers/Workforce
- Prevention
- Shared Decision Making
Quality/Safety/Cost

Outcome
Mortality
Re-Admission
Return to Operating Room
LOS-3.8D ave

Process Measures
Bundles
VAP
CRBSI
AMI
Pneumonia
CHF
DVT

Appropriate-Evidence Based Care
Efficiency
Cost Savings ICU
Intensivist-Led Team Base Care
24 Hour Provider Care
Differentiate Cost and Payment
Hospital Acquired Condition HAC
Never Events
Mortality

- Overall Mortality—patients admitted to adult ICUs average 10% to 29%.
- Mechanism—the leading causes of death in the ICU are multi-organ failure, MOF mortality rate of up to 15-28%.
- MOF, cardiovascular failure, and sepsis.
- If > one organ fails new-onset renal failure has a mortality rate of up to 61%.
- Severe respiratory failure has a mortality rate ranging from 20% to 50%.
- Sepsis, the second leading cause of death in non-coronary ICUs, has a mortality rate 45%. 1/2 develop acute renal failure, 1/5 require MV acute respiratory failure.
- Pediatric mortality rate associated with sepsis is 25%.
- Overall mortality rate for pediatric ICU patients ranges from 2% to 6%.
Is there a shortage of Critical Care Physicians?

- Critical Care Beds - 10-20% of all hospital beds
- 30% of overall acute care hospital costs
- Cost projected to increase U.S. population ages and illnesses become more complex.
- Shortage of critical care physicians and nurses, and the demand for intensivists outstrips the supply by five- to six-fold
- Telemedicine enables a small number of intensivists to oversee the care of a large number of patients
Patty Duke
The Epidemiology of Sepsis in the United States from 1979 through 2000

Greg S. Martin, M.D., David M. Mannino, M.D., Stephanie Eaton, M.D. and Marc Moss, M.D.

N Engl J Med
Volume 348;16:1546-1554
April 17, 2003
• This analysis of discharge data from over 750 million acute care hospitalizations shows that the rate of sepsis more than doubled from 1979 to 2000

• However, mortality from any cause declined from 28 percent in the early years of the study to 18 percent in more recent years

• Since 1988, gram-positive organisms have become the predominant pathogens causing sepsis

• The outcomes of sepsis have improved, but there are major disparities among population groups

• Among nonwhites, the incidence and mortality were nearly twice those among whites

• "" Special Article Patient Safety: Adverse Drug Events in Ambulatory Care Patient Safety: Adverse Drug Events in Ambulatory Care -->In this study of four adult primary care practices, 25 percent of patients who received a prescription had an adverse drug event

• No events were fatal or life-threatening, but approximately 4 percent of patients had a serious adverse event

• Many adverse events could have been prevented if a different medication had been chosen or could have been ameliorated by discontinuation of the drug when symptoms related to it developed

• This study suggests that adverse drug events are common among outpatients and that many adverse events are avoidable
### Characteristics of Patients with Sepsis, According to Subperiod

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age — yr</td>
<td>57.4±28.9</td>
<td>59.3±22.9</td>
<td>60.8±16.2</td>
<td>60.8±13.7</td>
</tr>
<tr>
<td>Male sex — %</td>
<td>49.6</td>
<td>48.9</td>
<td>46.8</td>
<td>48.0</td>
</tr>
<tr>
<td>Race — no./100,000 population (% of patients)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>92.1 (01.2)</td>
<td>166.4 (80.3)</td>
<td>167.8 (78.5)</td>
<td>186.3 (76.3)</td>
</tr>
<tr>
<td>Black</td>
<td>163.0 (15.2)</td>
<td>301.7 (16.0)</td>
<td>322.8 (17.2)</td>
<td>374.2 (17.7)</td>
</tr>
<tr>
<td>Others</td>
<td>181.3 (3.6)</td>
<td>298.0 (13.7)</td>
<td>300.6 (14.8)</td>
<td>370.5 (16.0)</td>
</tr>
<tr>
<td>Length of hospital stay — days</td>
<td>17.0±8.5</td>
<td>15.6±6.0</td>
<td>15.3±4.0</td>
<td>11.8±2.0</td>
</tr>
<tr>
<td><strong>Coexisting conditions — % of patients</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>5.7</td>
<td>7.3</td>
<td>9.3</td>
<td>12.1</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>8.6</td>
<td>9.9</td>
<td>13.6</td>
<td>15.2</td>
</tr>
<tr>
<td>Cancer</td>
<td>17.1</td>
<td>17.9</td>
<td>18.0</td>
<td>14.5</td>
</tr>
<tr>
<td>HIV infection†</td>
<td>—</td>
<td>1.0</td>
<td>2.1</td>
<td>2.0</td>
</tr>
<tr>
<td>Cirrhosis</td>
<td>2.4</td>
<td>2.5</td>
<td>2.2</td>
<td>2.3</td>
</tr>
<tr>
<td>Diabetes</td>
<td>12.2</td>
<td>14.5</td>
<td>16.0</td>
<td>18.7</td>
</tr>
<tr>
<td>Hypertension</td>
<td>7.0</td>
<td>9.2</td>
<td>13.6</td>
<td>18.6</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>No. of organs with failure — % of patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>83.2</td>
<td>78.1</td>
<td>74.0</td>
<td>66.4</td>
</tr>
<tr>
<td>1</td>
<td>13.6</td>
<td>17.9</td>
<td>20.1</td>
<td>24.6</td>
</tr>
<tr>
<td>2</td>
<td>2.7</td>
<td>3.5</td>
<td>4.8</td>
<td>7.1</td>
</tr>
<tr>
<td>≥3</td>
<td>0.5</td>
<td>0.5</td>
<td>1.1</td>
<td>1.9</td>
</tr>
</tbody>
</table>

* Plus–minus values are means ±SE. HIV denotes human immunodeficiency virus.† Data are normalized for race in the 2000 U.S. Census.‡ HIV-specific coding appeared in 1986.
Population-Adjusted Incidence of Sepsis, According to Sex, 1979-2000


Numbers of Cases of Sepsis in the United States, According to the Causative Organism, 1979-2000

Case Presentation

- 29 y/o African American female presents to ER with cough, wheezing, SOB
- PE Temp 101 HR 110 BP 95/60 RR28 RA OSAT 88%, warm skin, dry mucous membrane
- Cardiac - Tachycardia JVP flat
- Lung - diffuse rhonchi bilaterally
- Neuro non-focal CXR, EKG, LABS CULTURES, Chest CT
- Clinical Decision making
- Hospital Course
- Progressive refractory hypoxemia and hypercemia
- Treatment
- Antibiotics, BD, Steroids, Pressors,
- What is next?
Pneumonia
Adult Respiratory Syndrome

- Chest Xray
- Chest CT
- ABG
- MV Management
Pathophysiology
Chest CT

Upper Lung
No evidence of a pulmonary embolism

Mid Lung
Extensive bilateral airspace disease left greater than right. Patchy Ground Glass appearance
Multilobar Pneumonia vs ARDS

Lung Bases
Extensive disease throughout the entire left lung and in the right lower lobe patchy areas in the right middle and upper lobe
### Table 3. The Berlin Definition of Acute Respiratory Distress Syndrome

<table>
<thead>
<tr>
<th></th>
<th>Acute Respiratory Distress Syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timing</strong></td>
<td>Within 1 week of a known clinical insult or new or worsening respiratory symptoms</td>
</tr>
<tr>
<td><strong>Chest imaging</strong></td>
<td>Bilateral opacities—not fully explained by effusions, lobar/lung collapse, or nodules</td>
</tr>
<tr>
<td><strong>Origin of edema</strong></td>
<td>Respiratory failure not fully explained by cardiac failure or fluid overload. Need objective assessment (e.g., echocardiography) to exclude hydrostatic edema if no risk factor present</td>
</tr>
<tr>
<td><strong>Oxygenation</strong></td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>$200 \text{ mm Hg} &lt; \text{PaO}_2/\text{FiO}_2 \leq 300 \text{ mm Hg}$ with PEEP or CPAP $\geq 5 \text{ cm H}_2\text{O}$</td>
</tr>
<tr>
<td>Moderate</td>
<td>$100 \text{ mm Hg} &lt; \text{PaO}_2/\text{FiO}_2 \leq 200 \text{ mm Hg}$ with PEEP $\geq 5 \text{ cm H}_2\text{O}$</td>
</tr>
<tr>
<td>Severe</td>
<td>$\text{PaO}_2/\text{FiO}_2 \leq 100 \text{ mm Hg}$ with PEEP $\geq 5 \text{ cm H}_2\text{O}$</td>
</tr>
</tbody>
</table>

Abbreviations: CPAP, continuous positive airway pressure; $\text{FiO}_2$, fraction of inspired oxygen; $\text{PaO}_2$, partial pressure of arterial oxygen; PEEP, positive end-expiratory pressure.

*a* Chest radiograph or computed tomography scan.

*b* If altitude is higher than 1000 m, the correction factor should be calculated as follows: $[\text{PaO}_2/\text{FiO}_2 \times (\text{barometric pressure/760}])$.

*c* This may be delivered noninvasively in the mild acute respiratory distress syndrome group.
Table 4. Predictive Validity of ARDS Definitions in the Clinical Database

<table>
<thead>
<tr>
<th></th>
<th>Modified AECC Definitiona</th>
<th>Berlin Definition ARDSa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ALI Non-ARDS</td>
<td>ARDS</td>
</tr>
<tr>
<td>No. (%) [95% CI] of patients</td>
<td>1001 (24) [23-25]</td>
<td>3187 (76) [75-77]</td>
</tr>
<tr>
<td>Progression in 7 d from mild, No. (%) [95% CI]</td>
<td>336 (34) [31-37]</td>
<td></td>
</tr>
<tr>
<td>Progression in 7 d from moderate, No. (%) [95% CI]</td>
<td>230 (13) [11-14]</td>
<td></td>
</tr>
<tr>
<td>Mortality, No. (%) [95% CI]D</td>
<td>263 (26) [23-29]</td>
<td>1173 (37) [35-38]</td>
</tr>
<tr>
<td>Ventilator-free days, median (IQR)b</td>
<td>20 (2-25) 12 (0-22)</td>
<td>20 (1-25) 16 (0-23)</td>
</tr>
<tr>
<td>Duration of mechanical ventilation in survivors, median (IQR), d</td>
<td>5 (2-10) 7 (4-14)</td>
<td>5 (2-11) 7 (4-14)</td>
</tr>
</tbody>
</table>

Abbreviations: AECC, American-European Consensus Conference; ALI, acute lung injury; ARDS, acute respiratory distress syndrome; PaO_{2}/FiO_{2}, fraction of inspired oxygen; IQR, interquartile range; PaO_{2}, arterial partial pressure of oxygen; PEEP, positive end-expiratory pressure.

aThe definitions are the following for ALI non-ARDS (200 mm Hg < PaO_{2}/FiO_{2} ≤ 300 mm Hg, regardless of PEEP), ARDS (PaO_{2}/FiO_{2} ≤ 200 mm Hg, regardless of PEEP), mild Berlin Definition (200 mm Hg < PaO_{2}/FiO_{2} ≤ 300 mm Hg with PEEP ≥ 5 cm H_{2}O), moderate Berlin Definition (100 mm Hg < PaO_{2}/FiO_{2} ≤ 200 mm Hg with PEEP ≥ 5 cm H_{2}O), and severe Berlin Definition (PaO_{2}/FiO_{2} ≤ 100 mm Hg with PEEP ≥ 5 cm H_{2}O).

bComparisons of mortality, ventilator-free days, and duration of mechanical ventilation in survivors across categories of modified AECC (ALI non-ARDS and ARDS) and across categories of Berlin Definition (mild, moderate, and severe) are all statistically significant (P < .001).
ARDS-Adult Respiratory Distress Syndrome
Clinical Course

• Follow-up 24 hours
The Association Between a *Darc* Gene Polymorphism and Clinical Outcomes in African American Patients With Acute Lung Injury


- The Darc side of Glycobiology in Acute Lung Injury
- Polymorphism (rs2814778) in the promoter region of Duffy antigen/receptor for chemokines (*Darc*) gene,
- Almost exclusively in people of African descent, results in isolated erythrocyte DARC deficiency
- Implicated in ALI pathogenesis in preclinical and murine models,
- Increase in circulating Duffy-binding, proinflammatory chemokines like IL-8.

**Methods:** Clinical data and biologic specimens from African American patients with ALI who enrolled in three randomized controlled trials were analyzed. Multivariate analysis accounted for proportion of African ancestry

**Results:** 132 subjects, 88 (67%) were Duffy null (*C/C* genotype). The Duffy null state was associated with a 17% absolute risk increase (95% CI, 1.4%-33%) in mortality at 60 days, a median of 8 fewer ventilator-free days.
Probability of survival to hospital discharge during the first 60 days according to Duffy status. Duffy-null individuals have increased risk of in-hospital death across the follow-up period. This is statistically significant (P = .04).
Sequence of events from initial injury to the development of ARDS. Trauma, hemorrhagic shock, or sepsis results in SIRS, causing EALI. As the disease progresses the patient is intubated and if placed on mechanical ventilation with nonprotective breath, would greatly exacerbate lung injury causing a secondary VILI. Thus, SIRS and VILI often work together to drive acute lung injury, which if unblocked will cause ARDS. EALI = early acute lung injury; SIRS = systemic inflammatory response syndrome; T/H/S = trauma/hemorrhagic shock/sepsis; VILI = ventilator-induced lung injury.
A, In vivo photomicrographs at inspiration and end expiration of subpleural alveoli (far left) following surfactant deactivation with Tween. To assess the μ-strain, individual alveoli were color-coded in yellow with nonalveolar tissue in red and the alveolar area calculated using computer image analysis at inspiration and expiration.

Two settings for TLow using APRV and two PEEP levels with a Vt of 6 mL/kg were studied with CMV. In the APRV group with improperly set TLow at 10% (ie, 90% of the lung volume was exhaled), there was large μ-strain on the alveoli as they recruited and collapsed with each breath. There was also significant μ-strain with CMV PEEP5 with less recruitment during inspiration. CMV PEEP16 reduced the μ-strain but failed to recruit all alveolar whereas APRV with properly set TLow at 75% (25% of the lung volume was exhaled) both recruited and stabilized (ie, minimal μ-strain) alveoli (original magnification × 10).

It is not the size of the Vt being delivered to the lung but the size of the change in individual alveolar Vt that is critical in preventing ventilator damage to the pulmonary parenchyma. Data mean ± SEM; a = P < .05.
From: Mechanical Ventilation as a Therapeutic Tool to Reduce ARDS Incidence


A, B, Pressure/time profile (PTI) (A) and \( \text{Pao}_2/\text{Fio}_2 \) ratio (B) over time (48 h) following peritoneal sepsis and gut ischemia/reperfusion (PS + I/R)-induced ARDS in anesthetized pigs. Two treatments groups were tested: (1) Preemptive APRV and (2) ARDSnet LTV applied after the animal desaturates similar to how it is currently used clinically. A sham group with surgery but without PS + I/R was also tested. APRV resulted in a significant increase in PTI that was associated with dramatic protection of lung function measured as a \( \text{Pao}_2/\text{Fio}_2 \) ratio. Lung protection was so complete that the \( \text{Pao}_2/\text{Fio}_2 \) ratio values in the APRV group were similar to the sham group, whereas the LTV group developed severe respiratory failure (ie, ARDS) with a mean \( \text{Pao}_2/\text{Fio}_2 \) ratio well below 200. Data mean \( \pm \) SEM. * = \( P < .05 \) vs both groups. LTV = low tidal volume ventilation. See Figure 3 legend for expansion of other abbreviations. (Adapted with permission from Roy et al.31)
Lung histology at inspiration and expiration to determine the microstrain (μ-strain) caused by mechanical ventilation on the terminal airway (individual alveoli and conducting airways: respiratory bronchiole, alveolar duct, and alveolar sac) (hematoxylin and eosin. Note the relative small size of the conducting airways (green) and the open and well-inflated alveoli (lilac).

In the remaining groups, ARDS was caused by Tween instillation. Two settings for the time set at duration at low pressure (TLow) using APRV and two PEEP levels with a tidal volume (Vt) set a 6 mL/kg were studied with conventional mechanical ventilation (CMV). In the APRV group with improperly set TLow at 10% (i.e., 90% of the lung volume was exhaled), there is a dramatic overdistension of the conducting airways (green) and increased dynamic μ-strain with ventilation. CMV with PEEP5 again showed a large dynamic μ-strain on conducting airway with more alveolar collapse (lilac). PEEP16 improved alveolar inflation (lilac) and reduced but did not eliminate conducting airway overdistension. APRV with properly set TLow at 75% (25% of the lung volume was exhaled) was the closest to control with reduced conducting airway size and μ-strain during ventilation and open, well-inflated alveoli (lilac). APRV = airway pressure release ventilation; PEEP = positive end-expiratory pressure.

(Reprinted with permission from Kollisch-Singule et al.44)
Role of ECMO in Management of Refractory ARDS in the Intensive Care Unit: A National Survey on Perspectives of the Adult Critical Care Physicians and Trainees


Survey was sent to 320 critical care fellowship programs and a total of 327 responses: (44% trainees/56% CC faculty)

ARPR was considered as the initial choice (42%) RARDS inhaled nitric oxide 28%, prone positioning 18%, ECMO 12% by respondents. 69% described that ECMO was available at their institution for RARDS.

1. Early referral (<1 week) to ECMO was felt to improve patient outcomes by 90% of the respondents.
2. 58% responded that ECMO improved survival in RARDS and 68% felt that ECMO was not associated with overt complications in RARDS.
3. 80% felt lack of expertise amongst critical care physicians in managing ECMO.
4. 70% suggested that they had some exposure to ECMO technology not sufficient to manage patients on ECMO. 90% respondents answered that ECMO training should be part of the critical care curriculum.

5. CONCLUSIONS: ECMO not preferred as first line TX RARDS. lack of training and expertise to management of patients receiving ECMO support.

6. CLINICAL IMPLICATIONS: training is not enough to manage patients placed on ECMO support.
From: Mechanical Ventilation as a Therapeutic Tool to Reduce ARDS Incidence


Figure Legend:

Lung histology at inspiration and expiration to determine the microstrain ($\mu$-strain) caused by mechanical ventilation on the terminal airway (individual alveoli and conducting airways: respiratory bronchiole, alveolar duct, and alveolar sac) (hematoxylin and eosin). We defined alveoli as individual structures not connecting adjacent alveoli (lilac), the conducting airways were defined as airways extending from the alveolar duct proximally connecting multiple alveoli (green) and the remaining structures including interstitium, blood vessels, and lymphatics (magenta). The control group was uninjured, showing normal changes in the terminal airway during ventilation. Note the relative small size of the conducting airways (green) and the open and well-inflated alveoli (lilac). In the remaining groups, ARDS was caused by Tween instillation. Two settings for the time set at duration at low pressure (TLow) using APRV and two PEEP levels with a tidal volume (Vt) set a 6 mL/kg were studied with conventional mechanical ventilation (CMV). In the APRV group with improperly set TLow at 10% (ie, 90% of the lung volume was exhaled), there is a dramatic overdistension of the conducting airways (green) and increased dynamic $\mu$-strain with ventilation. CMV with PEEP 5 again showed a large dynamic $\mu$-strain on conducting airway with more alveolar collapse (lilac). PEEP 16 improved alveolar inflation (lilac) and reduced but did not eliminate conducting airway overdistension. APRV with properly set TLow at 75% (25% of the lung volume was exhaled) was the closest to control with reduced conducting airway size and $\mu$-strain during ventilation and open, well-inflated alveoli (lilac).

APRV = airway pressure release ventilation; PEEP = positive end-expiratory pressure. (Reprinted with permission from Kollisch-Singlet et al. 44)
Hospital Course

- Transferred to MGH, Team inserted Cannula and the patient was placed on ECMO by transport team Cardiac Surgeon
- ECMO week wean and transition to MV Trached SBT to rehab
- Complications-polyneurothy, ambulates with walker
- Patient Returned for Grand Rooms
Patient Grand Rounds
Characteristics of Patients Hospitalized for Acute Myocardial Infarction, Heart Failure, or Pneumonia, According to Race or Ethnic Group, 2005 and 2010.

What happens to the patients who can’t Speak
The Untold Stories

• Autopsy-Role in disclosing cause of Death
• Autopsy have decrease to 1 in 20 Hospital Death
• Cause of Death disclosed by Autopsy is different from what was formerly diagnosed prior Autopsy in 25% of cases
• Medical Errors elucidation
• Results- Impact on Family
The snoring, tiredness, observed apnea, high BP (STOP) and snoring, tiredness, observed apnea, high BP-BMI, age, neck circumference and gender (STOP-Bang) questionnaires developed in response to the need for a concise, user-friendly OSA screening tool in preoperative clinics.

The STOP questionnaire includes four questions related to snoring, tiredness, observed apnea and high blood pressure, and shows a moderately high level of sensitivity (65.6%) and specificity (60%) in detecting OSA (AHI > 5) in surgical patients.

Moderate to severe OSA (AHI > 15), the sensitivity and specificity of the STOP questionnaire are 74% and 53%, respectively.

Severe OSA (AHI > 30), sensitivity is 80% and specificity is 49%.