**CARDIOLOGY GRAND ROUNDS**

**Presentation:** Refractory Cardiogenic Shock - A Changing Paradigm  
**Speaker:** Kasia M. Hryniewicz, MD  
Senior Consulting Cardiologist  
Minneapolis Heart Institute® at Abbott Northwestern Hospital  
**Date:** Monday, February 2, 2015, 7:00 – 8:00 AM  
**Location:** ANW Education Building, Watson Room  

**OBJECTIVES**  
At the completion of this activity, the participants should be able to:  
1. Discuss definition, clinical manifestation and medical therapy for refractory cardiogenic shock (RCS)  
2. Describe use of Extracorporeal Membrane Oxygenation (ECMO) in patients with RCS  
3. Cite MHI-ANW experience

**ACCREDITATION**  
**Physicians:** This activity has been planned and implemented in accordance with the Essential Areas and policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint sponsorship of Allina Health and Minneapolis Heart Institute Foundation. Allina Health is accredited by the ACCME to provide continuing medical education for physicians. Allina Health designates this live activity for a maximum of 1.0 AMA PRA Category 1 Credit™. Physicians should only claim credit commensurate with the extent of their participation in the activity.  
**Nurses:** This activity has been designed to meet the Minnesota Board of Nursing continuing education requirements for 1.2 hours of credit. However, the nurse is responsible for determining whether this activity meets the requirements for acceptable continuing education.  
**Others:** Individuals representing other professional disciplines may submit course materials to their respective professional associations for 1.0 hours of continuing education credit.

**DISCLOSURE STATEMENTS**  
**Speaker(s):** Dr. Hryniewicz has declared that she does not have a conflict of interest in making this presentation.  
**Planning Committee:** Dr. Michael Miedema, and Eva Zewdie have declared that they do not have any conflicts of interest associated with the planning of this activity. Dr. Robert Schwartz declared the following relationships - stockholder: Cardiomind, Interface Biologics, Aritech, DSI/Transoma, InstyMeds, Intervaleve, Medtronic, Osprey Medical, Stout Medical, Tricardia LLC, CoAptus Inc, Augustine Biomedical; scientific advisory board: Abbott Laboratories, Boston Scientific, MEDRAD Inc, Thomas, McNerney & Partners, Cardiomind, Interface Biologics; options: BackBeat Medical, BioHeart, CHF Solutions; speakers bureau: Vital Images; consultant: Edwards LifeSciences.
VA ECMO for cardiogenic shock – changing paradigm

Kasia Hryniewicz, M.D
Cardiology Grand Rounds
2-2-2015

• No disclosures
Definition

Cardiogenic shock (CS) is a clinical condition of inadequate tissue perfusion due to cardiac dysfunction.

Definition

• **Persistent hypotension** (systolic blood pressure <80 to 90 mmHg or mean arterial pressure 30 mmHg lower than baseline)
• **Severe reduction in the cardiac index** (<1.8 L/min per m² without support or <2.0 to 2.2 L/min per m² with support)
• **Adequate or elevated filling pressures**
**Definition**

*Refractory Cardiogenic shock:* Shock persists *despite* volume administration, inotropes and vasoconstrictors, and intra-aortic balloon pump (IABP)

**Etiology of cardiogenic shock**

- Acute myocardial infarction
- Myocarditis
- Peripartum Cardiomyopathy
- Decompensated chronic heart failure
- Post cardiotomy shock
- *Septic Shock with cardiac compromise*
- Biventricular failure
- Refractory malignant arrhythmias
Cardiogenic shock/AMI – quick facts

• The median time from MI to onset of cardiogenic shock 5.5 hours and 75% of patients developed shock within 24 hours.


Incidence of shock complicating AMI

Overall incidence 5-8%

• The majority of patients have a STEMI, but CS occurs in 2.5% (NSTEMI)
• 40-50,000 cases/year

<table>
<thead>
<tr>
<th>Condition</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV failure</td>
<td>79%</td>
</tr>
<tr>
<td>Severe MR</td>
<td>7%</td>
</tr>
<tr>
<td>VSD</td>
<td>4%</td>
</tr>
<tr>
<td>Isolated RV infarct</td>
<td>2%</td>
</tr>
<tr>
<td>Tamponade</td>
<td>1.4%</td>
</tr>
<tr>
<td>Other</td>
<td>7%</td>
</tr>
</tbody>
</table>

Shock Registry Data.
**Risk factors**

- Older age
- Anterior MI
- Hypertension
- Diabetes mellitus
- Multi-vessel coronary artery disease
- Prior MI or diagnosis of heart failure
- STEMI
- Left bundle branch block on the electrocardiogram (ECG)

**Symptoms/signs**

- signs of systemic hypoperfusion (eg, cool extremities, oliguria, and/or alteration in mental status)
- severe systemic hypotension
- respiratory distress due to pulmonary congestion.
RCS—quick facts

- In-hospital mortality due to refractory cardiogenic shock (RCS) remains in *excess of 50%*
- Medical therapy using inotropic agents and vasopressors is often *ineffective* for adequate hemodynamic support.
The New England Journal of Medicine

EARLY REvascularization IN ACRU MYOCARDIAL INFARCTION COMPLICATED BY CARDIOGENIC SHOCK

Jules S. Hochman, M.D., Lynn A. Szekely, M.D., John G. Webb, M.D., Timothy A. Sandler, M.D., Harvey D. White, M.D., J. David Talley, M.D., Christopher J. Bailey, M.D., Alice K. Jacob, M.D., James S. Slater, M.D., Jacques Col, M.D., Solly M. McGuire, Ph.D., and Pierre R. Lesur, M.D., FOR THE SHOCK INVESTIGATORS

ABSTRACT

Background: The leading cause of death in patients hospitalized for acute myocardial infarction is cardiogenic shock. We conducted a randomized trial to evaluate early revascularization in patients with cardiogenic shock.

Methods: Patients with shock due to left ventricular failure complicating myocardial infarction were randomly assigned to emergency revascularization (152 patients) or initial medical stabilization (150 patients). Revascularization was accomplished by either coro-

C ARDI GENIC shock complicates 7 to 10 percent of cases of acute myocardial infarction and is associated with a 70 to 80 percent mortality rate. Cardiogenic shock remains the leading cause of death in patients hospitalized with myocardial infarction in the reperfusion era. Clinical shock is a poor predictor of mortality in patients who have undergone revascularization for shock. However, shock has a poor prognosis. In small series of patients

Shock trial

• Inclusion criterion: shock due to LV failure complicating myocardial infarction

• 302 pts randomly assigned to emergency revascularization (n=152) or initial medical stabilization (n=150).
**Shock trial results**

- No difference in mortality at **30 days** (46.7% vs 56%, p=0.11)
- Significant decrease in all cause mortality at **6 months** (50.3% vs. 63.1% p=0.027).

**Shock - pathophysiology**

Methods

• Randomized, prospective, open-label, multicenter trial
• 600 patients with CS complicating acute myocardial infarction, randomly assigned to
  - IABP, (301 pts) or
  - no IABP (299 pts)
  plus early revascularization
• The primary end point \( \rightarrow \) 30-day all-cause mortality.
Results

• At 30 days
  119 patients in the IABP group (39.7%) and
  123 patients in the control group (41.3%) had died ($P = 0.69$).

Management of RCS

Revascularization for AMI

Pharmacologic support

- Vasopressors and inotropes
  (norepinephrine, vasopressin, dopamine, neosinephrine, dobutamine, milrinone)

Mechanical support

- IABP???
- Full mechanical support (ECMO?)

Figure 1. Time-to-Event Curves for the Primary End Point.
Time-to-event curves are shown through 30 days after randomization for the primary end point of all-cause mortality. Event rates represent Kaplan-Meier estimates.
What is ECMO?

• It’s an artificial lung that keeps Mummy up at night...
  - Jan Czenezzew, 8 years old

I have no clue...

  Maya Czenezzew, 14 years old
What is ECMO?

- ECMO stands for Extracorporeal Membrane Oxygenation.
- The ECMO circuit acts as an artificial heart and lung for the patient while on ECMO.

**ECMO Circuits**

VA-ECMO

- Femoral Artery
- Internal Jugular

VV-ECMO

- Recirculating Oxygenated Blood
- De-oxygenated Blood
Very short historic background

• 1956 – first heart-lung machine was used by Dr. Gibbon.
• 1971 – first successful ECMO placed by Dr. Hill
• 1975 – first newborn ECMO in CA by Dr. Bartlett
• 1980 – first ECMO center in the world started by Dr. Bartlett at the University of Michigan
• Currently 90+ ECMO centers in the US
Study design

- Retrospective review of adult patients who required an MCSD due to CS
- The etiology of RCS included acute MI in 49% and acute decompensated HF in 27%.
- VA ECMO was chosen in cases of unknown neurologic status, complete hemodynamic collapse or severe coagulopathy.

Study results

- 90 pts received an MCSD for refractory CS (RCS), 21 (23%) of whom had active CPR.
  - Mean age was 53±14 years, 71% M, 60% had IABP
  - short-term VAD in 49% and VA ECMO in 51%.
  - Median length of support was 8 days
  - Myocardial recovery in 18% and heart transplantation in 11%.
  - Survival to hospital discharge was 49%.
  - Ongoing CPR to be an independent risk factor for mortality
ECMO for cardiogenic shock

Outcomes and long-term quality-of-life of patients supported by extracorporeal membrane oxygenation for refractory cardiogenic shock

81 pts
46% survival to discharge
34% survived 11 months

Risk of ICU death
- Female gender
- CPR during insertion
- 24h urine output < 500
- Hepatic failure

E-CPR

- 26 pts with out of hospital arrest
- Average age 40 (+/- 15)
- 54% male
- Time from cardiac arrest to initiation of ECMO 77 min (+/- 51)
- 4 patients survived to Discharge (15%)
Total number of patients 5603
56% survived ECLS
41% survived to DC

When should ECMO be considered?

- Refractory cardiogenic shock (VA)
- If the process is:
  - Severe (mortality > 80-90%)
  - Acute
  - Potentially reversible
ECMO: Advantages:

Immediate application

Biventricular support

Oxygenation

Refractory malignant arrhythmias do not affect the flow

Bridge to more durable devices (LVAD)

VA ECMO – and what next?

Bridge to Recovery (most common):
- Acute MI after revascularization,
- Myocarditis,
- Postcardiotomy
- Drug intoxication

Transplant/Long term VAD:
- Unrevascularizable acute MI,
- Chronic, decompensated heart failure
Contraindications to VA ECMO
- **absolute**

- Unreliable heart and *not* a candidate for transplant or VAD
- *Chronic* organ dysfunction (emphysema, cirrhosis, renal failure),
- Compliance (financial, cognitive, psychiatric, or social limitations) for further therapies if needed

Contraindications to VA ECMO
- **relative**

- Contraindication for anticoagulation ?
- Advanced age ?
- Obesity ?
How does it work at ANW...

• Level 1 ECMO call (ext 31290)
• Discussion between HF cardiologist/interventionalist/intensivist /CT surgeon
• Placement in the cath lab with perfusionist present
• ECMO management on H 4100
ANW Shock Team

Management

ECMO circuit  Patient
Excellent perfusionists

Management of ECMO

- Anticoagulation
- Adequate volume
  - Low flows/chatter of the lines
    - hypovolemia
    - cannula obstruction
    - VC obstruction
- Management of circuit ABG
Management of the patient

- Hemodynamic management
- Fluid and electrolyte
- Hematology
- Anticoagulation
- Respiratory
- Renal
- Neurologic
- Nutrition

Hemodynamic monitoring

- ECG/HR
- A-line/saturation
- S-G catheter
- Cerebral perfusion
- EEG
Hemodynamic monitoring

- **Goal** - rest the lungs and heart
- **Aim** for MAP 65-85 mmHg
- Often hypotension upon initiation of ECMO
  - low preload
  - loss of pulsatility and cardiac contractility (continuous flow)
  - significant vasodilatation due to SIRS
- Hypertension (more common in neonates)

Cerebral perfusion

- VA ecmo → retrograde flow, so **uncertain** brain perfusion
Cerebral Oximeter

- Near infrared spectroscopy (NIRS)

NIR light can be used to measure regional cerebral tissue oxygen saturation (rSO₂).

This technique uses principles of optical spectrophotometry that make use of the fact that biological material, including the skull, is relatively transparent in the NIR range.
**NIRS Cerebral Saturation**

- **Normal**: > 50%
- **Abnormal**: < 50% or > 20% decrease from baseline
- Low has been associated with cerebral dysfunction in cardiac patients
- Does **NOT** rely on pulse pressure

**Factors affecting regional cerebral saturation**

- BP
- CO2 concentration
- Pump blood flow
- Arterial oxygen saturation
- Hct
- Level of anesthesia
- Temperature
Knowing about complications...

- Bleeding
- Ischemia → limb, cerebral
- Infection
- Pulmonary complications
COMMUNICATIONS and TEAM WORK is KEY!

MHI/ANW Experience
Outcomes: Survival

- Total of 37 patients:
  - Age – mean 61, 28 males (75%)
  - Mean time on support 5 days
  - Median LOS – 13 days
    - 13 pts (35%) died during in-hospital course.
    - 24 pts (65%) survived the index admission
    - 9/24 pts (24%) – discharged home

Survival – MHI/ANW 2012-2013

- Inpatient 65%
- 1 year 57%
- E-CPR 85%
ANW experience: Survival

- Majority of deaths occur within the first 15 days (~33%).
- Another 10-11% between 15 days and 4 months.

Among those who were discharged from initial hospitalization, survival rate (by 2/2014): 87.5% (21/24) with a median follow-up time of 450 days.

Bridge to LVAD
### Bridge to LVAD (n=9) vs. Not Bridge to LVAD (n=53)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Bridge to LVAD</th>
<th>Not Bridge to LVAD</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Years), mean (SD)</td>
<td>50.4 ± 17.3</td>
<td>59.6 ± 12.3</td>
<td>0.057</td>
</tr>
<tr>
<td>Male, (%)</td>
<td>7 (77.8)</td>
<td>36 (67.9)</td>
<td>0.55</td>
</tr>
<tr>
<td>Hypertension, (%)</td>
<td>3 (60.0)*</td>
<td>16 (47.1)*</td>
<td>0.59</td>
</tr>
<tr>
<td>Diabetes, (%)</td>
<td>1 (11.1)</td>
<td>12 (22.6)</td>
<td>0.43</td>
</tr>
<tr>
<td>History of tobacco, (%)</td>
<td>4 (44.4)</td>
<td>27 (60.9)</td>
<td>0.72</td>
</tr>
<tr>
<td>History of CAD, (%)</td>
<td>1 (11.1)</td>
<td>17 (32.1)</td>
<td>0.20</td>
</tr>
<tr>
<td>History of CHF, (%)</td>
<td>5 (55.5)</td>
<td>13 (24.5)</td>
<td>0.058</td>
</tr>
<tr>
<td>Chest pain, (%)</td>
<td>5 (55.5)</td>
<td>26 (49.1)</td>
<td>0.72</td>
</tr>
<tr>
<td>Shortness of breath, (%)</td>
<td>4 (44.4)</td>
<td>31 (58.5)</td>
<td>0.43</td>
</tr>
<tr>
<td>Cardiac arrest, (%)</td>
<td>3 (33.3)</td>
<td>24 (45.3)</td>
<td>0.50</td>
</tr>
<tr>
<td>CPR, (%)</td>
<td>2 (22.2)</td>
<td>20 (40.0)</td>
<td>0.31</td>
</tr>
<tr>
<td>ECMO duration (Days), median (25th, 75th percentile)</td>
<td>7 (6, 12)</td>
<td>5 (3, 7)</td>
<td>0.034</td>
</tr>
<tr>
<td>Admit EF, median (25th, 75th percentile)</td>
<td>10 (10, 10)</td>
<td>25 (10, 60)</td>
<td>0.008</td>
</tr>
<tr>
<td>Initial creatinine, median (25th, 75th percentile)</td>
<td>1.74 (1.23, 2.38)</td>
<td>1.11 (0.92, 1.50)</td>
<td>0.040</td>
</tr>
<tr>
<td>In-hospital death, (%)</td>
<td>2 (22.2)</td>
<td>24 (46.2)</td>
<td>0.18</td>
</tr>
</tbody>
</table>

---

**ECLS Registry Report**

**Center Specific Summary**  
January, 2015  
Abbott Northwestern Hospital (313)

### Overall Outcomes

<table>
<thead>
<tr>
<th>Category</th>
<th>Total Patients</th>
<th>Survived ECLS</th>
<th>Survived to DC or Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pediatric</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac</td>
<td>1</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>Adult</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>10</td>
<td>6</td>
<td>60%</td>
</tr>
<tr>
<td>Cardiac</td>
<td>47</td>
<td>30</td>
<td>64%</td>
</tr>
<tr>
<td>Total</td>
<td>58</td>
<td>37</td>
<td>64%</td>
</tr>
</tbody>
</table>

Survived ECLS: 100%; Survived to DC or Transfer: 100%
Case 1

- 54 years old male, no PMH, significant family hx of CAD
- Presents with sudden onset CP while at work
- 911 called, cardiac arrest in ED, CPR initiated
- cath lab → coronary angiogram
Case 1

• Despite successful PCI with DES to LM persistent cardiogenic shock requiring multiple pressors and inotropes
• Rising lactate levels
• 2D echo...
Case 1 – initial ECHO

ECMO
Case 1 – ECHO 5 days later

Case 1 – f/u

• Successful explantation of ECMO circuit
• Final EF 30% with moderate MR
• NYHA class 1
• On HF therapies and ICD
Case 2

- 50 years old female, no PMH, started to feel dizzy, while teaching karate class
- 911 called, anterior and lateral ST elevation, in ambulance progressive hypotension, clammy, cardiac arrest while pulling into ambulance bay of ANW
- Manual CPR started, then LUCAS initiated
- Cath lab $\rightarrow$ coronary angiogram $\rightarrow$...
Case 2

- Dissection of LCx into LM and LAD
- Unsuccessful PCI
- Not a surgical candidate
- Decision about ECMO placement despite on-going CPR with LUCAS, with adequate MAPs

Case 2 - initial 2 D ECHO
Case 2 – hospital course

- Shock liver, acute renal failure requiring CVVH-D
- ARDS
- Rhabdo – bilateral fasciotomies
- Day 2 – CT head demonstrated bilateral cerebellar infarcts
- Multiple multi-disciplinary/family meetings...

Case 2 – hospital course

- Sedation weaned to off and patient starts following simple and complex commands
- EF still less than 10%
- Decision to move with permanent LVAD
- Resolution of pulmonary edema
- Return of renal function to normal
- Transmetatarsal amputation R foot
- Rehab, now back to work, driving!
Year in review...

- Daily multidisciplinary rounding
- Monthly multidisciplinary ECMO conference with case presentation (CME – 3rd Tuesday of the month H3226 EVERYBODY welcome!)
- Monthly operational meeting
- Level 1 ECMO call system
- ECMO database
- Research projects, presentations, publications
- ECMO sym lab
- Training for RNs/paramedics

Save the date for May 1st conference...

Advanced Cardiopulmonary Support for the Critically Ill Adult

SAVE-THE-DATE
Friday, May 1, 2015 | 8 a.m.–4:30 p.m.
American Swedish Institute, Minneapolis, MN

TOPICS INCLUDE:
- ECMO | Refractory Hypoxemia | Target temperature
- Management | Ventricular Assist Devices
- Patient Experience | Case Studies "Cheating Death"
Acknowledgement

- HF team
- Intensivists – Dr. Seatter
- Interventionalists
- CT Surgery – Dr. Sun
- Vascular surgery
- Perfusionists
- Anesthesia
- 4100 RNs and RTs
- Echo techs – Jon Fink
- David Hildebrand
- And ... special thanks to Sharom Wahl – CVICU Clinical Nurse Specialist

Questions ?
Thank You!

Circuit malfunction

International Summary - January, 2015

<table>
<thead>
<tr>
<th>Cardiac Complications (0-30 days)</th>
<th>No. Reported</th>
<th>% Reported</th>
<th>No. Survived</th>
<th>% Survived</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical: Oxygenator failure</td>
<td>416</td>
<td>6.7%</td>
<td>103</td>
<td>25%</td>
</tr>
<tr>
<td>Mechanical: Raceway rupture</td>
<td>18</td>
<td>0.3%</td>
<td>6</td>
<td>33%</td>
</tr>
<tr>
<td>Mechanical: Other tubing rupture</td>
<td>30</td>
<td>0.5%</td>
<td>10</td>
<td>33%</td>
</tr>
<tr>
<td>Mechanical: Pump malfunction</td>
<td>99</td>
<td>1.6%</td>
<td>28</td>
<td>28%</td>
</tr>
<tr>
<td>Mechanical: Heat exchanger malfunction</td>
<td>32</td>
<td>0.5%</td>
<td>18</td>
<td>56%</td>
</tr>
<tr>
<td>Mechanical: Dots oxygenator</td>
<td>734</td>
<td>11.6%</td>
<td>215</td>
<td>30%</td>
</tr>
<tr>
<td>Mechanical: Dots bridge</td>
<td>242</td>
<td>3.9%</td>
<td>74</td>
<td>31%</td>
</tr>
<tr>
<td>Mechanical: Dots bleedercap</td>
<td>370</td>
<td>5.9%</td>
<td>90</td>
<td>24%</td>
</tr>
<tr>
<td>Mechanical: Dots hemoliter</td>
<td>257</td>
<td>4.3%</td>
<td>67</td>
<td>26%</td>
</tr>
<tr>
<td>Mechanical: Dots other</td>
<td>846</td>
<td>13.6%</td>
<td>290</td>
<td>34%</td>
</tr>
<tr>
<td>Mechanical: Air in circuit</td>
<td>197</td>
<td>3.2%</td>
<td>57</td>
<td>29%</td>
</tr>
<tr>
<td>Mechanical: Capsule connections</td>
<td>36</td>
<td>0.6%</td>
<td>18</td>
<td>50%</td>
</tr>
<tr>
<td>Mechanical: Cannula problems</td>
<td>373</td>
<td>0.0%</td>
<td>137</td>
<td>34%</td>
</tr>
<tr>
<td>Hemorrhagic: GI hemorrhage</td>
<td>66</td>
<td>1.1%</td>
<td>9</td>
<td>14%</td>
</tr>
<tr>
<td>Hemorrhagic: Cardiopulmonary site bleeding</td>
<td>663</td>
<td>10.8%</td>
<td>209</td>
<td>32%</td>
</tr>
<tr>
<td>Hemorrhagic: Surgical site bleeding</td>
<td>1,872</td>
<td>30.0%</td>
<td>527</td>
<td>31%</td>
</tr>
<tr>
<td>Hemorrhagic: Hemolysis (Hgb &gt; 50 mgl/dl)</td>
<td>683</td>
<td>10.9%</td>
<td>194</td>
<td>28%</td>
</tr>
<tr>
<td>Hemorrhagic: Disseminated intravascular coagulation (DIC)</td>
<td>246</td>
<td>3.9%</td>
<td>45</td>
<td>18%</td>
</tr>
<tr>
<td>Neurologic:Brain death clinically determined</td>
<td>66</td>
<td>1.1%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Neurologic: Seizures: clinically determined</td>
<td>423</td>
<td>0.8%</td>
<td>135</td>
<td>32%</td>
</tr>
<tr>
<td>Neurologic: Seizures: EEG determined</td>
<td>183</td>
<td>2.9%</td>
<td>55</td>
<td>30%</td>
</tr>
<tr>
<td>Neurologic: CNS infection by USCT</td>
<td>220</td>
<td>3.5%</td>
<td>59</td>
<td>27%</td>
</tr>
<tr>
<td>Neurologic: CNS hemorrhage by USCT</td>
<td>707</td>
<td>11.3%</td>
<td>171</td>
<td>24%</td>
</tr>
<tr>
<td>Renal: Creatinine 1.5 - 3.0</td>
<td>693</td>
<td>11.1%</td>
<td>163</td>
<td>24%</td>
</tr>
<tr>
<td>Renal: Creatinine &gt; 3.0</td>
<td>121</td>
<td>1.9%</td>
<td>38</td>
<td>31%</td>
</tr>
<tr>
<td>Renal: Dialysis required</td>
<td>516</td>
<td>8.3%</td>
<td>100</td>
<td>19%</td>
</tr>
<tr>
<td>Renal: Hemofiltration required</td>
<td>1,618</td>
<td>25.9%</td>
<td>460</td>
<td>28%</td>
</tr>
<tr>
<td>Renal: CVVH required</td>
<td>421</td>
<td>6.4%</td>
<td>66</td>
<td>36%</td>
</tr>
</tbody>
</table>