Preventing AKI in Cardiac Surgery

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DISCLOSURES

Consultant for Astute Medical, Zimmer-Biomet, and Edwards Lifesciences
Our old standard protocol for patients with no creatinine rise on POD #1

• Patients maintained on vasopressors and inotropes prn to keep MAP >65 and CI >2.0

• Full dose potentially nephrotoxic medications (antibiotics, ACE-I’s, ARB’s)

• High threshold for blood transfusion (no transfusions for HCT > 21)

• Maintain > 30 cc/hr of urine output with a combination of Lasix and fluids (often at the same time)

• Swan or minimally invasive (FloTrac) monitor, central line and arterial lines, and Foley all removed and patients transferred to telemetry the morning after surgery.
LIMITATIONS:

• Serum creatinine has been shown to be a lagging indicator of AKI development and it is easily influenced by many factors, including sex, muscle mass and other medications.

• Urine output is monitored in most critical care settings, however, the ability of urine output to predict subsequent AKI complications after cardiac surgery is limited.
Section 2: AKI Definition

2.1.1: AKI is defined as any of the following (Not Graded):
- Increase in SCr by \( \geq 0.3 \text{ mg/dL} (\geq 26.5 \text{ μmol/L}) \) within 48 hours; or
- Increase in SCr to \( >1.5 \text{ times baseline} \), which is known or presumed to have occurred within the prior 7 days; or
- Urine volume \(<0.5 \text{ mL/kg/h for 6 hours} \).

2.1.2: AKI is staged for severity according to the following criteria (Table 2). (Not Graded)

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Staging of AKI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage</td>
<td>Serum creatinine</td>
</tr>
<tr>
<td>1</td>
<td>1.5-1.9 times baseline</td>
</tr>
<tr>
<td></td>
<td>OR</td>
</tr>
<tr>
<td></td>
<td>( \geq 0.3 \text{ mg/dL} (\geq 26.5 \text{ μmol/L}) ) increase</td>
</tr>
<tr>
<td>2</td>
<td>2.0-2.9 times baseline</td>
</tr>
<tr>
<td></td>
<td>OR</td>
</tr>
<tr>
<td></td>
<td>( \geq 4.0 \text{ mg/dL} (\geq 353.6 \text{ μmol/L}) ) increase</td>
</tr>
<tr>
<td></td>
<td>OR</td>
</tr>
<tr>
<td></td>
<td>OR in patients &lt;18 years, decrease in eGFR to (&lt;35 \text{ mL/min per 1.73 m}^3 )</td>
</tr>
</tbody>
</table>

Classifications of Loss and End-stage disease are beyond the current scope of follow-up. Code yes if the patient meets the highlighted RIFLE Failure criteria or if dialysis was newly required post op.

Risk (R) - Increase in serum creatinine level X 1.5 or decrease in GFR by 25%, or UO \(<0.5 \text{ mL/kg/h for 6 hours} \)

Injury (I) - Increase in serum creatinine level X 2.0 or decrease in GFR by 50%, or UO \(<0.5 \text{ mL/kg/h for 12 hours} \), or decrease in GFR by 75%; UO \(<0.3 \text{ mL/kg/h for 24 hours} \), or anuria for 12 hours

Failure (F) – Increase in serum creatinine level X 3.0, or serum creatinine \( \geq \text{mg/dL} \) with at least a 0.5 mg/dL rise, or decrease in GFR by 75%; UO \(<0.3 \text{ mL/kg/h for 24 hours} \), or anuria for 12 hours

Loss (L) - Persistent ARF, complete loss of kidney function > 4 weeks
**AKI Prevalence After Cardiac Surgery**

<table>
<thead>
<tr>
<th>Type of CT Surgery</th>
<th>No AKI (Risk)</th>
<th>Mild AKI (Risk)</th>
<th>Moderate AKI (Injury)</th>
<th>Severe AKI (Failure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Types</td>
<td>1708 (57%)</td>
<td>637 (22%)</td>
<td>386 (13%)</td>
<td>242 (8%)</td>
</tr>
<tr>
<td>Isolated CABG</td>
<td>291 (63%)</td>
<td>328 (23%)</td>
<td>136 (10%)</td>
<td>58 (4%)</td>
</tr>
<tr>
<td>Valve surgery</td>
<td>324 (51%)</td>
<td>151 (24%)</td>
<td>99 (15%)</td>
<td>66 (10%)</td>
</tr>
<tr>
<td>Aortic surgery</td>
<td>213 (45%)</td>
<td>86 (18%)</td>
<td>92 (19%)</td>
<td>84 (18%)</td>
</tr>
<tr>
<td>Thoracic surgery</td>
<td>268 (67%)</td>
<td>63 (16%)</td>
<td>49 (12%)</td>
<td>21 (5%)</td>
</tr>
<tr>
<td>Heart transplant</td>
<td>2 (6%)</td>
<td>9 (26%)</td>
<td>10 (29%)</td>
<td>13 (38%)</td>
</tr>
</tbody>
</table>
**Readmission Rates**

30-Day Readmissions (%)

- **No AKI**: 9.3%
- **Mild (Stage 1)**: 16.1%
- **Moderate (Stage 2)**: 21.8%
- **Severe (Stage 3)**: 28.6%

**KDIGO**
REDUCED SHORT-TERM SURVIVAL

In-Hospital Mortality

Cumulative Survival

Time (Days)

No AKI
KDIGO Stage 1
KDIGO Stage 2
KDIGO Stage 3

6.1%
22.6%
35.9%

4x
6x
30-DAY MORTALITY INCREASES

Minimal Changes of Serum Creatinine Predict Prognosis in Patients after Cardiotoracic Surgery: A Prospective Cohort Study

ANDREA LASSNIGG,* DANIEL SCHMIDLIN,† MOHAMED MOUHIEDDINE,* LUCAS M. BACHMANN,‡ WILFRED DRUML,§ PETER BAUER, and MICHAEL HIESMAYR*

*Department of Cardiotoracic and Vascular Anesthesia and Intensive Care Medicine, University Hospital of Vienna, Vienna, Austria; †Division of Anesthesia and Intensive Care, Hirlanden Klinik im Park, Zürich, Switzerland; ‡Hornen Centre, University Zurich, Zurich, Switzerland; §Acute Dialysis Unit, Department of Internal Medicine III, University Hospital of Vienna, Vienna, Austria; and ‡Department of Medical Statistics, University of Vienna, Vienna, Austria

Figure 1. Thirty-day mortality and change in serum creatinine ($\Delta$Crea) within 48 h after cardiac surgery. Distribution of $\Delta$Crea (top) and mortality rates calculated for intervals of $\Delta$Crea 0.1 mg/dl. Data are presented as mean ± SEM.
LONG-TERM SURVIVAL

\[ \chi^2 = 41.1; P < 0.0001 \]
The AKI Effect

The Acute Kidney Injury Effect

<table>
<thead>
<tr>
<th></th>
<th>NoAKI</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOS(^{14})</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital Cost(^{14})</td>
<td>$18,500</td>
<td>$38,900</td>
<td>$52,600</td>
</tr>
<tr>
<td>9.3%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28.6%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-Day Readmission(^{15})</td>
<td>1x</td>
<td>2x</td>
<td>3x</td>
</tr>
<tr>
<td>Hospital Mortality(^{14})</td>
<td>2.3%</td>
<td>12.9%</td>
<td>26.0%</td>
</tr>
<tr>
<td>2x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12x</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Short-term & long-term consequences associated with increasing AKI severity

LOS: Total postoperative length of stay (days/patient);
Hospital Cost: Total postoperative cost (US$/patient);
30-Day Readmissions: Percent of postoperative patients;
Hospital Mortality: Percent of postoperative patients.
THE ACUTE KIDNEY RESPONSE TEAM (AKRT)

• So what do we do and how do we do it?
• Developed a protocol to integrate the use of NephroCheck into a multidisciplinary Acute Kidney Response Team (AKRT) to potentially reduce AKI development, severity and the number of patients who need dialysis.
• Designed a stepped alarm system for surgeons, advanced practitioners, nephrologists, critical care physicians and nurses that starts with the drawing of the urinary biomarker at 5:30 am the morning.
Our Multidisciplinary Approach to Reduce AKI

- Cardiac Surgeons
- Nephrologist
- Cardiologist
- Advanced Practitioners
- Pharmacist
- Critical Care Nurses
**THE NEPHROCHECK TEST 2.0 (Feb 2019)**

Intended to aid in assessing the risk of moderate to severe acute kidney injury (AKI)

**WHO TO TEST**

All cardiac surgery patients on post-op day 1 at 05:30

**WHO NOT TO TEST**

Pre-op creatinine >2, on dialysis or received methylene blue

**STAGES OF ACUTE KIDNEY INJURY (AKI)**

<table>
<thead>
<tr>
<th>Serum Creatinine</th>
<th>Urine Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase of 2.0 – 2.9 x baseline</td>
<td>&lt;0.5 ml/kg/h for 12 hours</td>
</tr>
<tr>
<td>Increase of &gt;3x baseline or increase of Scr to &gt;4mg/dL or initiation of RRT</td>
<td>&lt;0.3 ml/kg/h for 24 h or anuria for 12 h</td>
</tr>
</tbody>
</table>

**WHEN & HOW TO TEST**

1. Pt meets test inclusion: at 0530 POD1 collect fresh urine specimen (at least 10 ml)

2. Results will show up in CIS chemistry section under urine miscellaneous – click for value range. Lab will report results in time for HVCC 08:00 team rounds

**AKI ACTION PLAN (on back of card)**

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<table>
<thead>
<tr>
<th>NC/ACUTE KIDNEY RESPONSE TEAM (AKRT) 2.0</th>
<th>FAST TRACK</th>
<th>TELE UNIT @ 4PM</th>
<th>ACTIVATE AKRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEG &lt;0.3</td>
<td>Keep Foley and monitor hourly UO until afternoon rounds. Transfer to telemetry (after 4PM) if all other transfer criteria are met (Cl/HR/Resp. ftx) and no oliguria treatment was required.</td>
<td>Keep Foley and monitor hourly UO. Maintain hemodynamic monitoring.</td>
<td></td>
</tr>
<tr>
<td>LOW (+) 0.3 - 0.7</td>
<td>VANC/GENTAMYCIN</td>
<td>AVOID NEPHROTOXINS NSAIDS, ARBs/ACE-I, VANC/GENTAMYCIN</td>
<td>AVOID NEPHROTOXINS NSAIDS, ARBs/ACE-I, VANC/GENTAMYCIN</td>
</tr>
<tr>
<td>HIGH (+) &gt;0.7</td>
<td>Transfusion threshold Hgb &lt;7.0 unless oliguric.</td>
<td>Renal dosing of medications</td>
<td></td>
</tr>
</tbody>
</table>

**Goal directed therapy**

(keep PAD>14 with LR, No diuretics unless PAD>20 or CHF), reassess transfusion threshold. Cl >2.5, SBP>130. Monitor SV02, Echo if <55%

Nephrology Consult
Repeat NC in 24hr
### Sample Size

<table>
<thead>
<tr>
<th>Exclusion Criteria</th>
<th>Pre- NC (Initial N = 302)</th>
<th>Post NC (Initial N = 274)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient with Baseline Scr &gt;2 (CKD &amp; ESRD)</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Final Sample Size</td>
<td>285</td>
<td>255</td>
</tr>
</tbody>
</table>
## Demographics

<table>
<thead>
<tr>
<th></th>
<th>Pre-NC (Count = 302)</th>
<th>Post-NC (Count = 274)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>74</td>
<td>53</td>
</tr>
<tr>
<td>Male</td>
<td>228</td>
<td>221</td>
</tr>
<tr>
<td><strong>Age Group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 50</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>50's</td>
<td>60</td>
<td>47</td>
</tr>
<tr>
<td>60's</td>
<td>105</td>
<td>97</td>
</tr>
<tr>
<td>70's</td>
<td>99</td>
<td>89</td>
</tr>
<tr>
<td>80's</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Indian or Alaska Native</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Asian</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Black or African American</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Hispanic</td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td>Unknown</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>White</td>
<td>257</td>
<td>227</td>
</tr>
</tbody>
</table>
NephroCheck® Results

Percent of Patient

<table>
<thead>
<tr>
<th>NephroCheck Value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.3</td>
<td>43.9%</td>
</tr>
<tr>
<td>0.3 to 2.0</td>
<td>49.6%</td>
</tr>
<tr>
<td>&gt; 2.0</td>
<td>6.5%</td>
</tr>
</tbody>
</table>
AKI Results (all stages combined)

Percent of CABG Patients with Stage 1 or Greater Acute Kidney Injury

P = 0.012

SD = 16%
SD = 12%
SD = 8%
SD = 4%
SD = 0%

Pre NephroCheck
Post NephroCheck
AKI Results by KDIGO Stage

<table>
<thead>
<tr>
<th>Stage</th>
<th>Pre NephroCheck</th>
<th>Post NephroCheck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1 AKI</td>
<td>14%</td>
<td>41.0% Reduction</td>
</tr>
<tr>
<td>Stage 2 AKI</td>
<td>4.3%</td>
<td>44.3% Reduction</td>
</tr>
<tr>
<td>Stage 3 AKI</td>
<td>1%</td>
<td>100% Reduction</td>
</tr>
</tbody>
</table>

Percent of CABG Patients
## Length of Stay

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-NC Mean (SD)</th>
<th>Post NC Mean (SD)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-Surgical LOS</td>
<td>7.8 (4.8)</td>
<td>7.8 (6.6)</td>
<td>0.90</td>
</tr>
</tbody>
</table>
MOST COMMON INTERVENTIONS

• Avoiding over-diuresis on POD #1

• Discontinuing nephrotoxins.

• Raising the PAD pressure to 14-16 mm/Hg with balanced crystalloid.

• Instituting inotropes for depressed cardiac function to keep CI>2.5 & SBP>130.

• Prolonging hemodynamic monitoring.

• Increasing the frequency of urine output monitoring.

• Obtaining an early nephrology consultation.
FURTHER THOUGHTS....

• As the negative predictive value (NPV) with a NC threshold of 0.3 was 100%:
  • These patients may be candidates for liberal early use of potentially nephrotoxic agents such as: aggressive diuresis, ACE-I’s, ARB’s, Antibiotics, Toradol, etc

• Is the “positive NC” value of .3 too low? (Too many false negatives)

• A higher positive value (i.e. 0.7) may reduce “false positives” without significantly compromising patient safety.
Figure 4 Risk for KDIGO stage 2 to 3 AKI (A) and MAKE30 (B) as a function of urine [TIMP-2]/[IGFBP7]. Risk at each [TIMP-2]/[IGFBP7] value.
CONCLUSIONS

• An Acute Kidney Response Team (AKRT) triggered by NephroCheck and implementation of AKI stress modulators reduced the progression to AKI.

• The success of the AKRT is related to the successful formation and coordination of a multidisciplinary team.

• Future research is needed to determine the optimal NephroCheck threshold to trigger the AKRT team.
ERAS CARDIAC SOCIETY - MISSION

To optimize perioperative care of cardiac surgical patients through collaborative discovery, analysis, expert consensus, and dissemination of best practices.

• A research-based approach using selected pre-, intra-, and post-operative interventions in concert to optimize outcomes and the patient experience.

• ERAS programs have been a standard practice in Europe for many years and consist of up to 21 different components.

• These enhanced recovery programs have demonstrated significant reductions in LOS, blood loss, time to ambulation, and complications; and increases in patient satisfaction around pain.

• They and are being used in 95% of surgery patients in the UK.
We are a “Disruptive” Society

• Suggesting that standard accepted perioperative practices may be wrong:
  • Elective patients should be optimized with 4 weeks of prehab prior to surgery.
    (Especially those with malnutrition, anemia, frailty, ETOH/smoking)
  • Ending preop dietary restrictions
  • Wire cerclage versus rigid sternal fixation
  • Ambulation restrictions
  • Chest tube management strategies
  • Increased ambulation and less dietary restrictions

• “Perioperative Medicine”
  • Includes preoperative period
  • May be more important to outcomes than the intraoperative component of CT Surgery

• What is Patient-Centered “Value”? 