A New Paradigm in Critical Care: The Acute Kidney Response Team

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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.
The difficulty of predicting postoperative acute kidney injury from preoperative clinical data

Daniel T. Engelman, MD, FACS, a,b and John A. Kellum, MD, FACP, MCCM c

Should urinary biomarkers be a standard component of evaluation after cardiac surgery?

Daniel T. Engelman, MD, FACS, a,b and John A. Kellum, MD, FACP, MCCM c
• 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 $\geq 0.3$ mg/dl ($\geq 26.5$ µmol/l) within 48 hours; or
- Increase in SCr to $\geq 1.5$ times baseline, which is known or presumed to have occurred within the prior 7 days; or
- Urine volume $< 0.5$ 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 OR $\geq 0.3$ mg/dl ($\geq 26.5$ µmol/l) increase</td>
</tr>
<tr>
<td>2</td>
<td>2.0–2.9 times baseline</td>
</tr>
<tr>
<td>3</td>
<td>3.0 times baseline OR Increase in serum creatinine to $\geq 4.0$ mg/dl ($\geq 353.6$ µmol/l) OR Initiation of renal replacement therapy OR In patients $&lt; 18$ years, decrease in eGFR to $&lt; 35$ ml/min per 1.73 m$^2$</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 $\times 1.5$ or decrease in GFR by 25%, or UO $<0.5 \text{ mL/kg/h}$ for 6 hours

**Injury (I)** - Increase in serum creatinine level $\times 2.0$ 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 $\times 3.0$, or serum creatinine $\geq \text{mg/dL}$ with at least a $0.5 \text{ mg/dL}$ 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 CT Surgery

<table>
<thead>
<tr>
<th>Type of CT Surgery</th>
<th>No AKI</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>901 (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>

N = 2973 CT Surgery Patients

2,209 consecutive patients who underwent either coronary artery bypass or valve surgery at 7 member hospitals of the Northern New England Cardiovascular Disease Study Group Cardiac Surgery Registry between July 2008 and December 2010.\textsuperscript{15} 

Short Term Survival Decreases With Increased AKI Severity

In-Hospital Mortality

Cumulative Survival

Time (Days)

No AKI
KDIGO Stage 1
KDIGO Stage 2
KDIGO Stage 3

6x
4x
35.9%
22.6%
6.1%

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

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*Department of Cardiothoracic and Vascular Anesthesia and Intensive Care Medicine, University Hospital of Vienna, Vienna, Austria; †Division of Anesthesia and Intensive Care, Hirslanden Klinik Im Park, Zurich, Switzerland; ‡Horton 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 (ΔCrea) within 48 h after cardiac surgery. Distribution of ΔCrea (top) and mortality rates calculated for intervals of ΔCrea 0.1 mg/dl. Data are presented as mean ± SEM.
Long-Term Survival Severely Impaired By a “Mild” Episode of AKI

The Cost of AKI

The Acute Kidney Injury Effect

- **LOS**: Total postoperative length of stay (days/patient)
- **Hospital Cost**: Total postoperative cost (US$/patient)
- **30-Day Readmission**: Percent of postoperative patients
- **Hospital Mortality**: Percent of postoperative patients

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

- **No AKI**
- **Moderate**
- **Severe**

- **LOS**: 5 days, 11 days, 16 days
- **Hospital Cost**: $18,500, $38,900, $52,600
- **30-Day Readmission**: 9.3%, 21.8%, 28.6%
- **Hospital Mortality**: 2.3%, 12.9%, 26.0%

- **2x - 3x Greater**
- **5x - 11x Greater**
Patients who developed postoperative AKI incurred a total hospital cost 159% higher than those patients who did not suffer renal dysfunction, with a mean adjusted cost of $42,600 compared to $26,700.
Prevention of cardiac surgery-associated AKI by implementing the KDIGO guidelines in high risk patients identified by biomarkers: the PrevAKI randomized controlled trial

Melanie Meersch\(^1\), Christoph Schmidt\(^1\), Andreas Hoffmeier\(^2\), Hugo Van Aken\(^1\), Carola Wempe\(^1\), Joachim Gerss\(^3\) and Alexander Zarbock\(^1\)*

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276 patients randomized after Cardiac Surgery with a NC >.3
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...
The NephroCheck® Test is intended to be used in patients who currently have or have had within the past 24 hours acute cardiovascular and or respiratory compromise as an aid in the risk assessment for moderate or severe AKI within 12 hours of patient assessment.
• The evaluation of patients’ clinical status together with the NephroCheck value initiatives a series of interventions to prevent the progression from acute kidney stress to injury.

• Routine adoption of these biomarkers allows their integration into the electronic medical records and alert/alarm systems.
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.

• Simple test with rapid turnaround time (~20 min). Only 100 μL of urine is required to complete a quantitative analysis.
**Clinical AKRT Implementation Plan: Our Pocket Card**

**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></th>
<th>Serum Creatinine</th>
<th>Urine Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Increase of 2.0 – 2.9 x baseline</td>
<td>&lt;0.5 ml/kg/h for 12 hours</td>
</tr>
<tr>
<td>3</td>
<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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**NC/Acute Kidney Response Team (AKRT) 2.0**

<table>
<thead>
<tr>
<th>Level</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 (CI/HR/Resp. fxn) 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>May use: ARBs/ACE-I, Toradol prn (if pre-op GFR&gt;60) Consider holding diuretics if Toradol given. Transfusion threshold Hgb &lt;7.0 unless oliguric.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HIGH (+) &gt;0.7</td>
<td>Avoid Nephrotoxins NSAIDs, ARBs/ACE-I, Vanco/Gentamycin Renal dosing of medications</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**IF PT BECOMES OLIGURIC:**
(UO <5 cc/kg/h X 3 hours) activate AKRT/Nephrology consult.

Use lactated ringers boluses if CVP<8; PAD<14; Hold Lasix unless pulmonary edema.

Repeat NC in 24hr

Goal directed therapy (keep PAD>14 with LR, No diuretics unless PAD>20 or CHF), reassess transfusion threshold. CI >2.5, SBP>130. Monitor SVO2, Echo if <55%

Nephrology Consult
Repeat NC in 24hr
Methods

• Study Period:
  • Pre Nephrocheck Group: July 2016- June 2017 (Historical Control)
  • Post Nephrocheck Group: July 2017-June 2018
Our Approach to Reduce AKI

- Cardiac Surgeons
- Nephrologist
- Cardiologist
- Advanced Practitioners
- Pharmacist
- Critical Care Nurses
Methods

- Obtained NC at 5 am on post operative day 1 in all isolated CABG patients for a 12 month period.

- Activated the multidisciplinary AKRT for patients with NC (>0.3).

- Implemented a predefined AKRT protocol.

- Compared outcomes the year prior to implementation of NC/AKRT (Pre NC) to one year following implementation of NC (Post NC).
Most Common Interventions

- Discontinuing nephrotoxins.

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

- Institute inotropes for depressed cardiac function to keep CI>2.2/SBP>120.

- Hemodynamic monitoring.

- Increased monitoring frequency of urine output.

- Early nephrology consultation.
## 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>
Comorbidity

<table>
<thead>
<tr>
<th>Condition</th>
<th>Pre-NC</th>
<th>Post-NC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes</td>
<td>147</td>
<td>114</td>
</tr>
<tr>
<td>Obesity</td>
<td>120</td>
<td>82</td>
</tr>
<tr>
<td>Heart Failure</td>
<td>84</td>
<td>70</td>
</tr>
<tr>
<td>Afib</td>
<td>130</td>
<td>127</td>
</tr>
<tr>
<td>Hyper tension</td>
<td>178</td>
<td>162</td>
</tr>
<tr>
<td>Stroke</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>CoPD</td>
<td>58</td>
<td>47</td>
</tr>
<tr>
<td>Sleep Apnea</td>
<td>68</td>
<td>68</td>
</tr>
</tbody>
</table>
NephroCheck® Results

- 43.9% in the < 0.3 category
- 49.6% in the 0.3 to 2.0 category
- 6.5% in the > 2.0 category
AKI Results (all stages combined)

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

- Pre NephroCheck: 16%
- Post NephroCheck: 4%

P = 0.012
AKI Results by KDIGO Stage

Percent of CABG Patients

41.0% Reduction
44.3% Reduction
100% Reduction

Stage 1 AKI
Stage 2 AKI
Stage 3 AKI

Pre NephroCheck
Post NephroCheck
## 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>
Summary Findings:

- AKI rates dropped from 14.74% to 7.84% (47% reduction) at our institution in post CABG patients.

- Negative Predictive Value (NPV) with NC Threshold = 0.3 was 100%.

- Sensitivity = 100 %; Specificity = 46.3%.

- It did not affect the length of stay.

- 30 Day readmission rates were unchanged at 9.5% for both groups.

- Further investigation is warranted in larger prospective studies.
Results

• Negative Predictive Value (NPV) with 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.
What if we change our “neg” NC to <.7?

<table>
<thead>
<tr>
<th>NephroCheck Value</th>
<th>Percent of Cardiac Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.7</td>
<td>75.1%</td>
</tr>
<tr>
<td>0.7 to 2.0</td>
<td>18.5%</td>
</tr>
<tr>
<td>&gt; 2.0</td>
<td>6.4%</td>
</tr>
</tbody>
</table>
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 was estimated by Cox regression model.
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 by a multidisciplinary team.

- Future research is needed to determine the optimal NephroCheck threshold to trigger the AKRT team.

  - We used 0.3
  
  - A higher value (i.e. 0.7) may reduce “false positives” without significantly compromising patient safety.
Billing for “Suspected AKI”

ICD-10-CM Official Guidelines for Coding and Reporting

Section III. Reporting Additional Diagnoses
General Rules for Other (Additional) Diagnoses

For reporting purposes the definition for “other diagnoses” is interpreted as additional conditions that affect patient care in terms of requiring:
- clinical evaluation; or
- therapeutic treatment; or
- diagnostic procedures; or
- extended length of hospital stay; or
- increased nursing care and/or monitoring.

The UHDDS item #11-b defines Other Diagnoses as “all conditions that coexist at the time of admission, that develop subsequently, or that affect the treatment received and/or the length of stay. Diagnoses that relate to an earlier episode which have no bearing on the current hospital stay are to be excluded.” UHDDS definitions apply to inpatients in acute care, short-term, long term care and psychiatric hospital setting. The UHDDS definitions are used by acute care short-term hospitals to report inpatient data elements in a standardized manner. These data elements and their definitions can be found in the July 31, 1985, Federal Register (Vol. 50, No. 147). pp. 31038-40.

Since that time the application of the UHDDS definitions has been expanded to include all non-outpatient settings (acute care, short-term, long term care and psychiatric hospitals; home health agencies; rehab facilities; nursing homes, etc). The UHDDS definitions also apply to hospice services (all levels of care).

The following guidelines are to be applied in designating “other diagnoses” when neither the Alphabetic Index nor the Tabular List in ICD-10-CM provide direction. The listing of the diagnoses in the patient record is the responsibility of the attending provider.

A. Previous conditions
If the provider has included a diagnosis in the final diagnostic statement, such as the discharge summary or the face sheet, it should ordinarily be coded. Some providers include in the diagnostic statement resolved conditions or diagnoses and status-post procedures from previous admission that have no bearing on the current stay. Such conditions are not to be reported and are coded only if required by hospital policy. However, history codes (categories Z80-Z87) may be used as secondary codes if the historical condition or family history has an impact on current care or influences treatment.

B. Abnormal findings
Abnormal findings (laboratory, x-ray, pathologic, and other diagnostic results) are not coded and reported unless the provider indicates their clinical significance. If the findings are outside the normal range and the attending provider has ordered other tests to evaluate the condition or prescribed treatment, it is appropriate to ask the provider whether the abnormal finding should be added. Please note: This differs from the coding practices in the outpatient setting for coding encounters for diagnostic tests that have been interpreted by a provider.

C. Uncertain Diagnosis
If the diagnosis documented at the time of discharge is qualified as “probable”, “suspected”, “likely”, “questionable”, “possible”, or “still to be ruled out” or other similar terms indicating uncertainty, code the condition as if it existed or was established. The bases for these guidelines are the diagnostic workup, arrangements for further workup or observation, and initial therapeutic approach that correspond most closely with the established diagnosis. Note: This guideline is applicable only to inpatient admissions to short-term, acute, long-term care and psychiatric hospitals.

1. ICD-10-CM Official Guidelines for Coding and Reporting FY 2017 (October 1, 2016 - September 30, 2017): Section III. Reporting Additional Diagnoses; C. Uncertain Diagnosis, pg. 105-6