2016 Disclosures

• Salary support: Canada government
• Grant support: Canada/Alberta government
• Speaking honoraria/travel: academic institutions
• Speaking/consulting: Baxter Healthcare Corp.
• Steering Committee: Spectral Medical Inc.
• Data Safety Monitoring Committee: LJPC
Objectives

1. Define automated e-Alerts for the detection of AKI

2. Review evidence on development, implementation and performance of automated e-Alerts for AKI

3. Review evidence on integration of clinical decision support for AKI
THE beginning clinical clerk, the house officer and the practicing physician are all confronted with conditions that are frustrating in every phase of medical action. The purpose of this article is to accept and use of paramedical personnel and a more positive attitude about the computer in medicine. Eventually, for every physician all three areas will be an obligatory part of his professional envi-

9/10
Pt. received 40 units of regular insulin yest. because of B & 4+ urine sugars. Got 2000 cc Amigen yest. & 500 cc D,W. Was febrile all night up to 40 at 8 PM this gradually came down to 39. 8 PM yest. suctioned & coughed up c return of ½ cup of thick white sputum — cultured also blood cultures. Was in must. tent c mucousmist overnight. At 4 PM yest had B-R base. Sputum smear unremarkable — WBC's but no bacteria.

9/10-12:30
10 o'clock urine 2-3+/0. Given 10 U reg. ins. at 12:30 PM. Temp. down to 38? Suctioned N.T. 0 little return. However during suctioning pt. vomited 100-150 cc green fluid. Proximal jejunostomy tube draining well now.

9/11-9 AM
Urine 3+ given 10 U reg. insulin. Pt. was hiccuping all night & this AM. Evacuating tube passed 8 500.1500 cc biliary fluid removed. Labine-

Imp: prob. resolving now
Plan: KUB and continue small feedings
d. Sepsis: afebrile now on Ampicillin. see flow sheet. Reculture tomorrow.

b. R.LL. Pneumonia: Film of 9/28 shows some ↑ in this process. Will repeat P.A. chest tomorrow & cultures.

c. Colonic-Cutaneous Fistula: Continues to drain semi-formed stool several times per day; the problem is that stool drains onto granulating abd. wound.

Plan: culture stool; Remove some non-func stay sutures; Freq dressings & consider colostomy bag for fistula

10/3
#1 Chronic Relapsing Pan.: c. Pan. insufficiency: Cotayzn-B will be begun (special purchase)
Electronic Alerts to Prevent Venous Thromboembolism among Hospitalized Patients

Nils Kucher, M.D., Sophia Koo, M.D., Rene Quiroz, M.D., M.P.H., Joshua M. Cooper, M.D., Marilyn D. Paterno, B.S., Boris Soukonnikov, M.S., and Samuel Z. Goldhaber, M.D.

RCT of EHR-generated alert for patients at high risk for VTE (n=2506) ~ MD had to acknowledge alert but could decide on whether to order or withhold

<table>
<thead>
<tr>
<th>Measure</th>
<th>Intervention Group (N=1255)</th>
<th>Control Group (N=1251)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical</td>
<td>125 (10.0)</td>
<td>19 (1.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Compression stockings</td>
<td>52 (4.1)</td>
<td>7 (0.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pneumatic boots</td>
<td>73 (5.8)</td>
<td>12 (1.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pharmacologic</td>
<td>296 (23.6)</td>
<td>163 (13.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Unfractionated heparin</td>
<td>213 (17.0)</td>
<td>81 (6.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Warfarin</td>
<td>28 (2.2)</td>
<td>41 (3.3)</td>
<td>0.11</td>
</tr>
<tr>
<td>Enoxaparin</td>
<td>55 (4.4)</td>
<td>41 (3.3)</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Kucher et al NEJM 2005
Randomized trial of automated, electronic monitoring to facilitate early detection of sepsis in the intensive care unit*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intervention</th>
<th>Controls</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to Abx</td>
<td>6.0 (2.4-18.8)</td>
<td>6.1 (2.5-21.0)</td>
<td>0.95</td>
</tr>
<tr>
<td>6-hr fluid administration</td>
<td>1019 (1241)</td>
<td>964 (1196)</td>
<td>0.57</td>
</tr>
<tr>
<td>ICU stay</td>
<td>3.0 (2.0-5.0)</td>
<td>3.0 (2.0-4.0)</td>
<td>0.22</td>
</tr>
<tr>
<td>Hospital stay</td>
<td>5.7 (2.8-10.5)</td>
<td>4.7 (2.7-8.1)</td>
<td>0.08</td>
</tr>
<tr>
<td>Mortality</td>
<td>14%</td>
<td>10%</td>
<td>0.29</td>
</tr>
</tbody>
</table>

No details of implementation and no concomitant CDS

Hooper et al CCM 2012
Validation of an electronic surveillance system for acute lung injury

Impact of a computer-generated alert system on the quality of tight glycemic control

Development and validation of an electronic medical record-based alert score for detection of inpatient deterioration outside the ICU
Why e-Alerts for AKI?

• AKI is a common syndrome and increasingly encountered in hospitalized patients
• AKI imposes significant risk for major morbidity and mortality
• AKI is costly and expensive
• AKI care is suboptimal
Selected Findings of the 2009 NCEPOD report:

• ~ 50% of AKI care was considered **poor**
• ~ 45% had **unacceptable delays** in recognizing AKI
• ~ 20% of AKI was predictable and **avoidable**
• ~ 13% had complications of AKI missed, 17% of which were avoidable and 22% **managed badly**
• ~ 29% had **inadequacies** in clinical management of AKI
Variation in Risk and Mortality of Acute Kidney Injury in Critically Ill Patients: A Multicenter Study

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>KDIGO classification</th>
<th>p value</th>
<th>RIFLE classification</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>adjusted OR (95% CI)*</td>
<td></td>
<td>adjusted OR (95% CI)*</td>
<td></td>
</tr>
<tr>
<td>Center effect (Center 2 as ref.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Center 1</td>
<td>4.27 (3.66–4.99)</td>
<td>&lt;0.001</td>
<td>5.38 (4.55–6.37)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Center 3</td>
<td>2.57 (2.19–3.03)</td>
<td>&lt;0.001</td>
<td>3.35 (2.81–4.00)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Center 4</td>
<td>5.61 (4.07–7.75)</td>
<td>&lt;0.001</td>
<td>5.09 (3.64–7.12)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Center 5</td>
<td>6.04 (5.23–6.98)</td>
<td>&lt;0.001</td>
<td>7.54 (6.43–8.83)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Center 6</td>
<td>2.69 (2.29–3.16)</td>
<td>&lt;0.001</td>
<td>3.56 (2.99–4.26)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age in 5-year increment</td>
<td>1.06 (1.04–1.07)</td>
<td>&lt;0.001</td>
<td>1.07 (1.05–1.08)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Males</td>
<td>1.10 (1.01–1.21)</td>
<td>0.031</td>
<td>0.97 (0.88–1.06)</td>
<td>0.453</td>
</tr>
<tr>
<td>APACHE 3 in 5-point increment</td>
<td>1.22 (1.21–1.23)</td>
<td>&lt;0.001</td>
<td>1.22 (1.21–1.23)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

- Retrospective study
  - n=15,132, 6 hospitals
- Incidence AKI ~ 15-44%
- RRT use ~ 5-12%
- Mortality ~ 20-36%
- Considerable variability:
  - Case-mix
  - Residual confounders
  - Process of care differences
Approaches to Derivation, Development and Refinement of Automated AKI Alerting Systems

Detection

Alerting

Exposures

- Technological factors
  - Availability
  - Accuracy
  - Clinical relevance
  - Basic vs advance

- Human factors
  - Alarm philosophy
  - Prioritization
  - Textual information
  - Habituation
  - Target (physician, trainee, allied health staff)
  - Context (clinical, administrative)

- Delivery methods
  - Hierarchy of delivery
  - Timing (frequency, real-time vs batched)
  - Acknowledgement requirements
  - Placement
  - Visualization

Outcome Assessment

- Alert
- Provider
- Provider Behavior
- Logistical Outcome
- Provider Acceptance
- Clinical Outcome
Objectives: Describe the methods for designing and implementing e-alerts for AKI, their impact on quality of care indicators and processes of care (i.e., monitoring, investigations), patient-centered outcomes (i.e., death, RRT) and health services use (i.e., ICU admission, hospital stay)

Design: Systematic review + evidence synthesis

Search: Comprehensive peer reviewed strategy

Study Selection: 1) original data from RCT; 2) all hospitalized patients; 3) studies where e-alert implemented for AKI; 4) report impact on one process of care, patient outcome or measure of health services use
1. E-alerts are significantly heterogeneous in design (i.e., detection algorithms, modes of alerting, degrees of intrusiveness)

2. E-alerts have have been variably implemented (i.e., seldom formal education, training or processes to ensure audit and feedback)

3. E-alerts have seldom included directed clinical decision support (CDS) and if included has not been context-specific and questionably feasible
Mortality

Use of Renal Replacement Therapy
Automated, electronic alerts for acute kidney injury: a single-blind, parallel-group, randomised controlled trial

F Perry Wilson, Michael Shashaty, Jeffrey Testani, Iram Aqeel, Yuliya Borovskiy, Susan S Ellenberg, Harold I Feldman, Hilda Fernandez, Yevgeniy Gitelman, Jennie Lin, Dan Negoianu, Chirag R Parikh, Peter P Reese, Richard Urbani, Barry Fuchs

- **Design**: RCT at single tertiary hospital, stratified by ward
- **Population**: Hospitalized patients to medical/surgical wards
- **Intervention**: Randomized (patient-level) to automated “disruptive” text-alert sent to covering providers (resident/NP) and unit pharmacists indicating new AKI (KDIGO) or standard-of-care (no alert)
- **Outcome**: Maximum change in SCr; use of RRT; death within 7 days
No difference in any secondary process outcomes: renal consultation (~12%); documentation of AKI (~45%); contrast exposure (~15%); fluid bolus (~36%); aminoglycoside (~7%); NSAID exposure (~7%); ACE/ARB exposure (~24%); renal ultrasound (~8%); SCr tests within 48 hr (2 [2-3])

<table>
<thead>
<tr>
<th></th>
<th>Alert (n=1201)</th>
<th>Usual care (n=1192)</th>
<th>p value</th>
<th>Composite p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>7 days after randomisation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase in creatinine from randomisation, %</td>
<td>0.0% (0.0–18.4)</td>
<td>0.6% (0.0–17.5)</td>
<td>0.81</td>
<td>0.88</td>
</tr>
<tr>
<td>Dialysis</td>
<td>87 (7.2%)</td>
<td>70 (5.9%)</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>Death</td>
<td>71 (5.9%)</td>
<td>61 (5.1%)</td>
<td>0.40</td>
<td></td>
</tr>
</tbody>
</table>

Perry et al Lancet 2015
Process of Care Measures

- **Primary**: Nephrotoxin dose-adjustment or discontinuation
- **Secondary**: Changes in frequency of monitoring, investigations or management (medication review; medical record documentation; fluid prescription; vasoactives or diuretic use; nephrology consultation)

Prescription of fluid therapy

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental Events</th>
<th>Control Events</th>
<th>Weight</th>
<th>Odds Ratio M–H, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colpaert 2012</td>
<td>441</td>
<td>49</td>
<td>569</td>
<td>4.80 [3.51, 6.57]</td>
</tr>
<tr>
<td>Perry 2015</td>
<td>426</td>
<td>422</td>
<td>1192</td>
<td>1.00 [0.85, 1.19]</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>2617</strong></td>
<td><strong>1761</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>2.18 [0.46, 10.31]</strong></td>
</tr>
</tbody>
</table>

Total events: 867 471

Heterogeneity: Tau² = 1.24; Chi² = 76.26, df = 1 (P < 0.00001); I² = 99%

Test for overall effect: Z = 0.98 (P = 0.32)
Impact of real-time electronic alerting of acute kidney injury on therapeutic intervention and progression of RIFLE class

Kirsten Colpaert, MD; Eric A. Hoste, MD, PhD; Kristof Steurbaut; Dominique Benoit, MD, PhD; Sofie Van Hoecke, PhD; Filip De Turck, PhD; Johan Decruyenaere, MD, PhD

1514 ICU patient admissions
- Excluded admissions (435)
  - Exclusion criteria (399)
  - Overlapping episode (36)

1079 admissions included

Pre-alert control group
- N = 227
  (AKI sniffing without alerting the physician)
  - 569 AKI alerts

Alert group
- N = 616
  (AKI sniffing with real-time alerting to physician)
  - 1416 AKI alerts

Post-alert control group
- N = 236
  (AKI sniffing without alerting the physician)
  - 608 AKI alerts
92.3% of all ALERTS were based on urine output

Colpaert et al CCM 2012
An educational approach to improve outcomes in acute kidney injury (AKI): report of a quality improvement project

- Inadequate implementation strategies may be confounder in trials in our review

- Providing multifaceted education can improve provider satisfaction and confidence in their ability to diagnose and manage AKI.
A sustained quality improvement program reduces nephrotoxic medication-associated acute kidney injury

- **Study:** Prospective QI project (2011-2015)
- **Population:** 2,358 admissions (n=1,749)
- **Exposure:** Hospitalized children receiving either AG $\geq 3$ days or $\geq 3$ nephrotoxins (3,243 exposures)
- **Intervention:** EHR alert + CDS (pharmacy driven) to monitor SCr + dose-adjust
- **Outcomes:**
  - ↓ exposure rate by 38%
  - ↓ AKI rate by 64%
  - Avoided 398 episodes AKI

*Goldstein SL et al KI 2016*
Impact of Compliance with a Care Bundle on Acute Kidney Injury Outcomes: A Prospective Observational Study

• **Design**: Before/After Study (11 months)

• **Population**: 2,297 hospitalized patients (2,500 AKI episodes)

• **Intervention**:
  - AKI e-alert (interruptive) linked to “care bundle”
  - Interruptive e-alert triggered by attempt to order blood work or medication in a patient identified as having AKI
  - e-alert would warn provider about AKI and request “care bundle” be completed
  - Once “care bundle” completed – provider could order tests or medications
  - e-alert could be overridden only after provider imputed reason
**AUDITS - The Acute Kidney Injury Care Bundle**

<table>
<thead>
<tr>
<th>Action</th>
<th>Parameter</th>
<th>Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assess History &amp; examine (VENUS)</td>
<td>Volume depletion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extrarenal history – JH &amp; JR (Haemoptysis, Haemolysis, Hypercalcaemia, Rash, Recent vascular intervention, raised CX)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nephrotoxins – check medications</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Urinary symptoms – overflow obstruction, haematuria, oliguria, colic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sepsis</td>
<td></td>
</tr>
<tr>
<td>Urine dipstick</td>
<td>No blood or protein – Pre renal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blood &amp; protein – Renal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Only blood – post renal or renal</td>
<td></td>
</tr>
<tr>
<td>Clinical Diagnosis</td>
<td>Think cause of AKI as Pre renal, Renal and Post renal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Classify and document AKI as per AKIN stage.</td>
<td></td>
</tr>
<tr>
<td>Investigations</td>
<td>U+E, bicarbonate, Glucose, ANCA, SLP, ECG, CXR, MSU or blood &amp; urine cultures depending on clinical suspicion.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>USS to r/o post renal cause.</td>
<td></td>
</tr>
<tr>
<td>Treatment - PUMP</td>
<td>Perfusion – ensure euvolemic status, ionotropes if required</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Underlying cause – remove nephrotoxins, antibiotics for sepsis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitor – EWS, volume status, Daily H+Es</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prevent complications - Fluid overload, adjust doses of medications, sepsis including removal of potential sources of sepsis</td>
<td></td>
</tr>
<tr>
<td>Seek advice</td>
<td>Seek renal advice (Bleep 8121) for all AKI stage 3 and, if extrarenal cause for AKI is suspected – as per the Trust guideline. Refer to &quot;DONUT&quot; on the website</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Consider HOU/TIU according to severity</td>
<td></td>
</tr>
</tbody>
</table>

**AKI Care Bundle**

Entered: ____________

Completed: ____________

**Instructions**
1. Attach patient label and fill in Box A
2. Detach square sticker, and place in Notes fold and follow
3. Detach round sticker, and place in front of Notes folder
4. File this backing sheet (with patient label) in designated audit tray

---

**Derby Hospitals NHS Foundation Trust**

**Kolhe et al. PLoS One 2015**
• Overall compliance with Care Bundle ~ 12.2%
• Pre/post-interruptive e-alert compliance ~ 2.2% vs. 21.6%
• AKI stage 3 ~ 15.7% completed bundle within 24 hr
• 70.9% had “appropriate” treatment measures implemented

<table>
<thead>
<tr>
<th>Care Bundle completion</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Within 24 hours</td>
</tr>
<tr>
<td>Proportion of AKI episodes with progression to higher AKI stage</td>
<td>9 (3.9%)</td>
</tr>
<tr>
<td>Length of stay in days†</td>
<td>11.2 (9.9, 12.4)</td>
</tr>
<tr>
<td>In-hospital case fatality</td>
<td>55 (18%)</td>
</tr>
<tr>
<td>30-day case fatality</td>
<td>77 (25.2%)</td>
</tr>
<tr>
<td>60-day case fatality</td>
<td>83 (27.1%)</td>
</tr>
</tbody>
</table>
Mortality associated with completion of care bundle within 24 hours of AKI detection/alert versus delayed or no completion
The Burden of Inbox Notifications in Commercial Electronic Health Records

- EHR-based notices to physicians are growing
- ↑ volume creates difficulty for discerning important vs. irrelevant information
- Translates into ↑ time spent reviewing and uncompensated workload

Figure. Quantities and Types of Notifications Received by Site and Physician Role
Summary

• AKI is common and increasing, contributes to less favorable patient outcomes and susceptible to suboptimal quality of care

• E-alerts can theoretically notified providers earlier of risk for or overt AKI

• Available evidence has shown variable impact of E-alerts in response to AKI on care processes and no meaningful improvement in patient outcomes or health services use

• E-alerts are likely context-specific and further rigorous evaluation is needed before widespread routine implementation
Thanks for Your Attention

Questions?

bagshaw@ualberta.ca