The Acute Kidney Injury Group

Modifying the Highest Mortality Rate in the Major AKI Adverse Outcome Other than Death

Loss ESRD & Incident Hemodialysis

EVA QI Program & AKI to ESRD Predictive Analytics

To Target Mortality & Hospitalization

Kevin Ho, M.D.
Renal-Electrolyte Division
UPMC & University of Pittsburgh
Grave Reality of Tunneled Dialysis Catheters

- TDCs are associated with increased complications compared to permanent AV fistulas: infection, inadequate clearance, thrombosis, readmission

- Most important: TDCs are associated with higher mortality in both prevalent and incident HD patients

- Without prior nephrology care, 91% of incident HD patients started dialysis with TDCs vs 2.9% with AVFs

- With >12 months nephrology care, 55.1% patients started with TDCs vs 24.4% with AVFs

- But overall >80% of incident HD patients initiated HD in U.S. using a TDC in 2007

- In contrast only 14.5% of incident HD patients used an AV fistula for their first outpatient HD treatment

USRDS Annual Data Report 2009
Importance of *early* permanent vascular access placement (arteriovenous fistula / AVF, arteriovenous graft / AVG) and *early* discontinuation of tunneled dialysis catheter (TDC) use

Vascular Access is the Largest Modifiable Mortality Risk Factor in Hemodialysis During 1st Year
Risk of Death is Highest During 1st 120 Days

- One-half of deaths (46%) occur within the 1st 120 days
- Dialysis catheters account for largest attributable fraction of mortality risk during Year 1 (≤120 d and >120 d) on HD among modifiable risk factors
- Primary cause of death = Cardiac

27.5 (≤120 d) vs 21.9 deaths (>120 d) /100 pers-yrs

Dialysis Outcomes & Practice Patterns Study (DOPPS), 1996-2004

VA Type Affects Mortality in HD Patients

• In 79,545 prevalent HD patients (mean vintage 3.6 yrs)
  ➢ Compared with AVFs, mortality risk is \textit{34\% greater} for prevalent TDCs

• Effect is even more pronounced in the 4,741 incident HD patients (vintage <90 d)
  ➢ Compared with AVFs, mortality risk is \textit{119\% greater} for TDCs
    43\% greater for baseline AV grafts

Lacson Jr E et al. AJKD 2009; 54:912-921
Converting Vascular Access Affects Mortality

• Conversion of vascular access in prior 4 months resulted in a change in mortality risk during next 8 months
  - In 70,852 prevalent HD patients
    - Converting TDC to AVF/AVG: 29% decrease in mortality risk
  - In 3,904 incident HD patients
    - Conversion of TDC to AVF: 50% decrease in mortality risk
    - TDC to AVF/AVG: 15% decrease in risk
Hypothesis

Prediction of Incident ESRD following AKI & Implementation of Early Vascular Access Planning with Early AV Fistula Placement Will Improve Survival when Mortality Risk is Greatest During Year 1 of Hemodialysis
Dialysis Catheter to Permanent Vascular Access in Incident HD Inpatients who Transition to Outpatient Hemodialysis

• Critical observation: Of 175 incident UPP hemodialysis patients (Presbyterian Hospital) referred to outpatient dialysis units (4/08-12/08)
  ➢ 85.1% initiated hemodialysis acutely as inpatients (149 of 175)
  ➢ May contribute to low observed rate of pre-ESRD nephrology care

• Current national vascular access guidelines (Fistula First) address only progression of CKD to ESRD in outpatients initiating hemodialysis (Stage 4 CKD: eGFR 15 – 29 ml/min/1.73m²)

• Baseline data (4/08-6/10): 826 patients initiated on hemodialysis, 459 patients were discharged on hemodialysis to outpatient dialysis units

• Of these incident HD inpatients, we examined a subset of 84 patients discharged on hemodialysis to 8 of 18 JV dialysis units
  ➢ 90.5% initiated hemodialysis using a TDC vs only 13.6% with pre-existing AVF/AVG

Inpatient Hemodialysis Initiation

826 consecutive adult inpatients* initiated on HD over 26 months; 466 dialysis-dependent at hospital discharge.

[*includes pre-existing ESRD (renal transplant, peritoneal dialysis) not on HD during preceding 12 mo.]

Subset of 84 incident HD inpatients discharged on HD to 8 dialysis units

26 Months (4/08 – 6/10)

Initiate Inpatient HD n=826

Discharge To Outpatient Dialysis n=466 (56.4%)

Inpatient Death n=214 (25.9%)

Inpatient Renal Recovery n=146 (17.7%)

Lost to followup n=3

Outpatient HD Other Dialysis Units n=375

Outpatient HD Affiliated DCI Units n=84

Outpatient PD n=4

Inpatient Subset (n=84)

<table>
<thead>
<tr>
<th>Incident HD Inpatients</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-ESRD</td>
<td>54 (64%)</td>
</tr>
<tr>
<td>ESRD: Peritoneal Dialysis</td>
<td>13 (16%)</td>
</tr>
<tr>
<td>ESRD: Prior Renal Transplant</td>
<td>17 (20%)</td>
</tr>
</tbody>
</table>

Andersen S...Ho K. Amer J Kidney Dis 2011; 57(4): A21, P-19
Vascular Access Conversion During 1st HD Year

In our subset of incident HD inpatients, **conversion from TDC to permanent vascular access** required a median time = **101 days**

Comparable to 4,532 U.S. incident HD patients (<30d) in DOPPS Study I, II

Bradbury BD et al. AJKD 2009; 53:804-814
Dialysis Catheter to Permanent Vascular Access in Incident HD Inpatients who Transition to Outpatient Hemodialysis

- 13.1% Pts Pre-existing AVFs
- 54% Pts Initiating HD with TDC Received AVF/AVG
- Inpatient (Pre-Discharge)
  - Ultrasound Vein Mapping
  - AV Fistula (AV Graft) Surgery/Creation

- 90.5% TDC
- Initial Vascular Access Used for Inpatient HD

- 9.5% AVF

- Inpatient Hemodialysis Initiation
  - 12.2% Pts mean 5 d median 7 d
  - Ultrasound Vein Mapping
  - AV Fistula (AV Graft) Surgery/Creation

- Subset of Incident HD Inpatients n=84
  - 4/08-6/10
  - 826 Inpatients Initiate HD

- Outpatient (Post-Discharge)
  - Ultrasound Vein Mapping
  - AV Fistula (AV Graft) Surgery/Creation

- 87.8% Pts mean 92.4 d median 67.5 d
- DISCHARGE
  - Outpatient Hemodialysis Units

- 88.4% Pts mean 112 d median 105.4 d
Inpatient vascular access planning for incident HD inpatients is clinically appropriate if specific patients can be predicted early on to remain dialysis-dependent with no renal recovery at 3 months following dialysis initiation, thereby fulfilling the CMS definition of ESRD.

Are There Data to Justify Early Vascular Access Planning in Inpatients?

Are there data predicting which inpatients acutely initiated on hemodialysis for AKI will require outpatient hemodialysis 3 months later for ESRD? Yes.
THE KEY: Low Renal Recovery in Inpatients Starting Hemodialysis Transitioning to Outpatient Hemodialysis

54 Inpatients Known CKD Status in Prior 1 Yr (no ESRD/CKD-T) Initiated on Hemodialysis

<table>
<thead>
<tr>
<th>Pre-Admission CKD Stage (GFR ml/min/1.73m²)</th>
<th>Total Patients</th>
<th>Prior Renal Care</th>
<th>Renal Recovery at 3 Months Post-Initiation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td>No CKD</td>
<td>6</td>
<td>n/a</td>
<td>2 (33)</td>
</tr>
<tr>
<td>Stage 1 (≥90)</td>
<td>1</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Stage 2 (60 to &lt;90)</td>
<td>0</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Stage 3A (30 to &lt;45)</td>
<td>7</td>
<td>2 (29)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Stage 3B (45 to &lt;60)</td>
<td>14</td>
<td>6 (43)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Stage 4 (15 to &lt;30)</td>
<td>19</td>
<td>15 (79)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Stage 5 (&lt;15)</td>
<td>7</td>
<td>6 (86)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Total CKD Stages 1-5</td>
<td>48</td>
<td>29 (60)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

Pre-Admission CKD Stage: Determined within 1 Yr prior to admission - nephrology documentation > other MD documentation > average of ≥ 3 baseline Cr values.
Prior Renal Care: Nephrology followup (including renal transplantation followup for CKD-T)
Renal Recovery at 3 Months: Discontinuation of hemodialysis as a result of improved renal function within 90 days of initiating hemodialysis as inpatient

39% CKD 3A+3B
35% CKD 4
13% CKD 5
11% No CKD

Clinical Basis for Early Vascular Access Planning Initiative in Inpatients

Inpatient AKI-on-CKD Leads to ESRD

- Multicenter, observational study of 9,425 Taiwanese post-surgical inpatients admitted to surgical ICU and surviving to hospital discharge
  - CKD = baseline eGFR <45ml/min/1.73m² (Stage 3B+4+5)

- Risk of ESRD in AKI-on-CKD vs AKI-without-CKD, AHR = 19.8

<table>
<thead>
<tr>
<th>CKD status</th>
<th>AKI status</th>
<th>Long-term dialysis, HR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No prior CKD</td>
<td>No AKI</td>
<td>1 (reference)</td>
</tr>
<tr>
<td></td>
<td>+ AKI</td>
<td>4.64 (2.51-8.56)*</td>
</tr>
<tr>
<td>+ Prior CKD</td>
<td>No AKI</td>
<td>40.86 (20.01-83.50)*</td>
</tr>
<tr>
<td></td>
<td>+ AKI</td>
<td>91.6 (49.3-170.1)*</td>
</tr>
</tbody>
</table>

Wu V-C et al. Kidney Int 2011(Dec);80:1222-1230
**Early Vascular Access Planning Initiative**

**New Paradigm: EVA**

What is our proposed QI approach?

**Early Vascular Access Planning Initiative aims to:**
Reduce conversion time from TDC to permanent vascular access & reduce hospitalization and mortality of hemodialysis patients in Year 1
Shifting & Modifying Access Conversion Curve

Hypothesis: Early Vascular Access Conversion Reduces Mortality in Year 1

TDC to Permanent Vascular Access Conversion

% Patients with AVF (AVG)

Discharge

EVA

Usual

Mortality Rate

Time (months)
Effect of Inpatient Early Vascular Access Planning on Outpatient Hemodialysis Vascular Access Outcomes, Hospitalization, Mortality

EVA QI Measures

- Pre-implementation baseline status of inpatient vascular access planning
- Evaluate post-discharge outpatient effectiveness of QI mechanism

Data-sharing agreements: The Renal Network, DCI and FMC dialysis providers

Primary Measures

- **EVA planning event occurrence** (vein mapping, Vascular Surgery consultation, vascular surgery, followup visit)
- **Conversion time from initial inpatient TDC placement to (a) initial AVF/AVG placement (inpatient or outpatient) and (b) initial AVF/AVG use (two-needle) in outpatient dialysis center setting**
- **Hospitalization & mortality rates of incident HD inpatient patients during the first 6 months and 12 months post-index hospital discharge**

- date of initial TDC placement
- date of vein mapping procedure
- date of Vascular Surgery inpatient / outpatient consultation
- date of Vascular Surgery outpatient follow-up appointment
- date of initial AVF/AVG placement (inpatient or outpatient)
- date of conversion from TDC use to AVF/AVG use for outpatient HD treatments
- duration of pre-ESRD nephrology care prior to hemodialysis initiation
- occurrence of pre-dialysis erythropoiesis stimulating agent (ESA) therapy
- total hospital days post-index hospitalization within 1 year
- mortality events post-index hospitalization within 1 year
An analytical system to **Predict** which **Inpatients** -- Develop **Acute Kidney Injury (AKI)**, initiate on hemodialysis, then **Transition to ESRD**

**AKI to ESRD**
**Predictive Analytics**

“Non-recovery of renal function after AKI may be an important contributor to growth in the number of incident end-stage renal disease (ESRD) cases out of proportion to the increase in the prevalence of CKD.”

(Wu V-C et al. Kidney Int 2011;80:1222-1230)
Goal: Real-Time Data Capture

AKI to ESRD Predictive Analytics Data Capture

1 Yr Pre-Admission Risk Factor Data

Pre-Existing / Chronic Risk Factor ICD-9 Diagnosis Data
- Chronic kidney disease/stage older age
diabetes Type 1,2
LV, RV dysfunction, CHF severe vascular heart disease
endstage liver disease
anemia, erythropoietin use
hyperalbuminemia
proteinuria

1 Yr Pre-Admission Risk Factor Laboratory Dataset
- baseline Cr (Established)
- associated BUN
- urine albumin
- urine protein/Cr
- serum albumin
- serum potassium
- hemoglobin

Post-Dischage 1-Y Outpatient Data

Hospitalization Data
- hospital days / mo
- admission diagnosis
- discharge diagnosis
- renal outcomes data
- vascular access data
- 1 Yr Post-Hospitalization
- 1 Yr Post-Mortality

Dialysis Provider
- Dialysis Unit start date
- Form 2728 data
- HD: incenter, SNF, home
- ethnicity, race
- medical insurance type
- employment status
- prior erythropoietin use
- Vasc Access Data
- Initial vasc access type
- 1st AVF (AVG) use date
- TDC treatment days
- AVF (AVG) treatment days
- renal recovery, death

Data Sharing Agreements
- ESRD Renal Network & Dialysis Provider

Discharge & Admission to Outpatient Dialysis Unit
- hospital days / mo
- admission diagnosis
- date of death
deaths/patient days at risk

AKI Diagnosis, Risk Factor, Renal & VA Outcomes Data
- 1 Yr Pre-Admission Chronic Risks
- Admission Chronic Risks
- Acute Illness / Hospitalization Data
- Renal Consult Diagnostic Data
- Acute Insciting Factors / Markers
- Discharge Diagnostic Data
- Renal Outcome Data
- Vascular Access Data
- 1 Yr Post-Initiation Hospitalization
- 1 Yr Post-Initiation Mortality

Triggers Data Collection
- 1-Y Laboratory Dataset
- BP, calc MAP (< threshold)
- Pre-Existing/Chronic Risk Factor ICD-9 Diagnosis Data
- Lab Data
- Acute Laboratory Dataset
- Usodium, Ucr, Urine eos
- Clinical Dataset
- Urine output (24 hr)
- COP (< or > thresholds)

Dialysis Data
- Renal replacement initiation date
- 1st acute hemodialysis date
- 1st CVVHD date
- Renal Recovery
- Death, CMO
- HD Vasc Access Data
- TDC (1st) insertion date
- EVA activation (by Renal) date
- Renal RB education date
- Vascular surgery date
- AVF (AVG) surgery date
- Conversion time TDC to VD

Data Collection
- Triggers Data Collection
- Hospitalization Data
- Pre-Existing/Chronic Risk Factor ICD-9 Diagnosis Data
- Laboratory Dataset
- Acute Laboratory Dataset
- Usodium, Ucr, Urine eos
- Clinical Dataset
- Urine output (24 hr)
- COP (< or > thresholds)

Goal: Real-Time Data Capture

KHo AKI-EVA 02/06/12
AKI to ESRD Predictive Analytics
AKI Risk Factors (HITS), Biomarkers, EVA, Disposition

Pre-Existing Risk Factor(s)

1st HIT

Acute Precipitating Factor(s)

2nd HIT

AKI Evolution

Resolve

3rd HIT

No Recovery

ESRD

CKD

Outpatient

Inpatient

Develop / Use Biomarkers

Model Precipitating Factors

Model Amplifying Factors

Model Baseline Factors

MODEL BASELINE FACTORS

MODEL PRECIPITATING FACTORS

MODEL AMPLIFYING FACTORS

CKD ESRD

KHo AKI-ESRD 09/05/12
AKI to ESRD Predictive Analytics

Outpatient
1st HIT

Analytic Hierarchy Process

Pre-Existing Risk Factor(s)
Age
Albuminuria
Proteinuria
Chronic Kidney Disease
ESLD
Hyperuricemia
Genomics

Inpatient
Admission Hospitalization

2nd HIT

Analytic Hierarchy Process

Acute Precipitating Factor(s)
Acute MI
CHF
Sepsis
Hemodynamics
Cardiac Surgery
IV Contrast Medications

AKI Evolution

3rd HIT

Analytic Hierarchy Process

Amplifying Factor(s)
AKI Severity
AKI Duration
AKI Recurrence

Outpatient
Acute IHD
No Recovery
ESRD

KHo AKI-ESRD 09/10/12
EVA QI Program & AKI to ESRD Predictive Analytics

QI Review Number 0000593
Approved 11/4/10 UPMC QI Review Committee

• Donald D. Wolff, Jr Center for Quality Improvement & Innovation at UPMC
  Susan Martin MS; Mary Kay Wisniewski; Todd Pollock; Jeffrey C. McKibben

• UPMC (AKI Predictive Analytics Project)
  David Russell, Tami Minnier, RN, MSN, Oscar Marroquin, MD

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  Enrique Mu, PhD

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  Rabih Chaer MD; Ellen Dillavou MD; Carol Mannix CRNP

• Dept. Epidemiology/Dept. Neurosurgery
  Yue-Fang Chang PhD, MPH

• The Renal Network (ESRD Networks 4 (PA, DE), 9 (IN, KY, OH), 10 (IL))
  Judy Stevenson, RN; Suzanne M. Kirschbaum, RN, CNN; Shane Perry

• Dialysis Clinics Inc
  Klemens Meyer, MD (New England Medical Center); Geraldine Bojarski, RN, CNN, CCRN
"Testing What We Think We Know" (excerpt)

"The administrative demands of clinical care, on one side, and the competition for research funding on the other, make it increasingly difficult for researchers to see patients. They become isolated from standard practice, and their ability to study it diminishes. Clinicians who are well positioned to study these issues are increasingly directed toward enhancing productivity — questions about how can we do this better, faster or more consistently — instead of questions about whether the practices are warranted in the first place."

-- H. Gilbert Welch,
Dartmouth Institute for Health Policy & Clinical Practice
New York Times, August 9, 2012
Decision Analysis: Analytic Hierarchy Process

• Computer decision support analytics to predict risk of -- AKI, initiation of acute hemodialysis, long-term dialysis requirement (ESRD) – will utilize AHP for decision analysis

• Analytic Hierarch Process (AHP) developed by Thomas Saaty (Katz Grad School of Business, Univ. of Pittsburgh) is a structured method for organizing multiple factors to analyze complex decisions by creating a hierarchy of sub-problems
  – Elements of the hierarchy consist of careful measurements or rough approximations, tangible or intangible factors, understood or poorly understood qualities
  – At each level, pairwise comparisons are organized into a matrix and weights are derived for each element of the hierarchy
  – Analysis uses these pairwise comparisons to measure the impact of items from one level of the hierarchy on elements belonging to the next higher level
  – The hierarchy structure is based on Goal, Alternatives to reach the Goal, Criteria against which each Alternative needs to be measured
Italian NEFROINT Prospective Database

• Italian multicenter prospective data collection to study AKI

• NEFROINT database
  – Interactive, web-based, full-stack web application framework (Ruby on Rails utilizing Ruby programming language)
  – Data entry via electronic case report forms
  – Eight data sections:
    • Demographics, anthropometrics, admission diagnoses
    • Comorbidities (including nephrotoxin exposure)
    • Initial ICU day data (calculates APACHE II, SAPS II, SOFA scores)
    • Vital signs, urine output, laboratory values (daily)
    • Sepsis
    • AKI (daily RIFLE/AKIN stage defined); alert for RIFLE class, Risk
    • Renal replacement therapy
    • Outcomes (ICU/hospital mortality, renal outcomes at ICU discharge/death)

• Test: Prospective data collection for 576 consecutive, non-ESRD incident patients in ten ICUs (9/09 – 4/10)
  – AKI defined = RIFLE class, Risk
  – Baseline Cr defined = lowest SCr in preceding 3 mo.
    (or estimated based on MDRD eGFR=75ml/min/1.73m2, ADQI Working Group)

Garzotto F et al. Blood Purif 2011;31:159-171
Observation: PD patients – lower early mortality risk in Year 1 compared to HD patients - Why?

Canadian Organ Replacement Register (2001-2008)
38,512 Canadian Incident Dialysis (HD/PD) patients (63% HD-CVC; 17% HD-AVF/AVG; 19% PD)

- Year-1 mortality of HD-AVF/AVG patients (n=6,663): the same as PD patients (n=7,412)
- In contrast Year-1 mortality: 80% higher for HD-CVC patients (n=24,437) (HR1.8, 95%CI:1.6-1.9)

Conclusion: TDCs are the issue

Perl J et al. JASN 2011; 22:1113-1121
Does Earlier AVF Placement Translate to Earlier AVF Use & Fewer TDC-Associated Treatments in Year 1?

**HD-TDC in the 1st Year of Hemodialysis**

Early vs. Late AVF/G

- **Early AVF placement** ≤ 90 days (n=29)
- **Late AVF placement** > 90 days (n=38)

- Functional measure of outpatient TDC use,
  Defined: \( \text{HD}_{TDC} = \left( \frac{\text{No. outpatient HD treatments using TDC}}{\text{No. of total outpatient HD treatments}} \right) \) during time interval (\( \text{HD}_{TDC} \) is inverse to AVF/G use)

- EARLY AVF/G group exhibited lower TDC use with mean \( \text{HD}_{TDC} \) values of 57% and 33% for months 3 to 6 months and months 6 to 12, respectively, in comparison to 91% and 74% for the LATE AVF/G group

Effect of Inpatient Early Vascular Access Planning on Outpatient Hemodialysis Vascular Access Outcomes, Hospitalization, Mortality

UPMC Inpatient Early Vascular Access (EVA) Planning Initiative

– Approval: Nov. 4, 2010 to K. Ho / UPMC QI Review No. 0000593
– Nephrology-activated EMR menu (MD, MLP)
– Bundled, multi-component, multi-level mechanism at Presbyterian Hospital

EVA Basic Components

• ✓ Cerner EMR order menu “Hemodialysis Vascular Access Planning”
  – Vascular Surgery consultation for AVF/AVG placement
  – Vein mapping (ultrasound, bilateral upper extremities)
  – Hemodialysis Nurse Educator for vascular access (Acute HD Unit)

• ✓ Monthly tracking of incident HD inpatients by Acute Dialysis Unit
• ✓ Hemodialysis RN “champion” vascular access educator
• ✓ Cerner/Powerchart Vascular Access Planning Patient Tracking list
• ✓ Vascular Surgery NP “champion” planning coordinator
• ✓ PSD-created MD billing code – 9999903 – tag incident HD patients
• ✗ UPMC Hemodialysis Vascular Access Planning Real-Time Database
• ✓ The Renal Network-UPMC data-sharing agreement (submitted 2/12)
• ✓ Dialysis Clinic Inc (DCI) provider QI data-sharing agreement
• ✗ Fresenius Medical Care (FMC) provider QI data-sharing agreement
• ✗ Electronic hospital discharge tracking of hemodialysis patients