Effect of Transient and Sustained Acute Kidney Injury on Readmissions in Acute Decompensated Heart Failure

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Although acute kidney injury (AKI) is common in heart failure, yet the impact of the onset, timing, and duration of AKI on short-term outcomes is not well studied. AKI was defined as an increase in serum creatinine SCr of ≥0.3 mg/dl or 1.5 times relative to the admission and further categorized as transient AKI (T-AKI: SCr returning to within 10% of baseline); sustained AKI (S-AKI: those with at least 72 hours of hospital stay and did not meet T-AKI); and unknown duration AKI (U-AKI: those with less than 72 hours stay and did not meet T-AKI). Reference category was no AKI (stable or <0.3 mg/dl change in SCr). The main outcome was 30-day all-cause hospital readmission. Unadjusted and adjusted association between AKI category of interest and main outcome was represented as percent and relative risks with 95% CIs. Statistical significance was set at an alpha of 0.05. From the Cerner Health Facts sample, 14,017 of 22,059 available subjects met the eligibility criteria. Approximately, 19.2% of our sample met the primary outcome. Compared with no AKI (readmission rate of 17.7%; 95% CI 16.4% to 18.9%), the adjusted rate of readmission was highest in patients with S-AKI (22.8%, 95% CI 20.8% to 24.8%; p <0.001), followed by 20.2% (95% CI 17.5% to 22.8%; p = 0.05) in T-AKI patients. Compared with no AKI, the adjusted relative risk of 30-day readmission was 1.29 (95% CI 1.17 to 1.42), 1.14 (95% CI 1.00 to 1.31), and 1.12 (95% CI, 1.01 to 1.26) in S-AKI, T-AKI, and U-AKI, respectively. In conclusion, both sustained AKI and patients with transient elevation still remain at a higher risk of readmission within 30 days. Future studies should focus on examining process-of-care after discharge in patients with different patterns of AKI.   © 2017 Elsevier Inc. All rights reserved. (Am J Cardiol 2017;119:1809−1814)

Acute decompensated heart failure (ADHF) is one of the most common causes of hospitalization worldwide. In the United States, there are over 1 million hospitalizations annually, and the treatment of heart failure exceeded 39 billion dollars; with 60% of the cost related to hospital care.[1,2] Patients with ADHF are at increased risk mortality during hospitalization (5% to 15%).[3] In addition, those who survive are at a high risk of readmissions within 30 days of discharge.[4−6] The identification of high-risk groups or risk factors for readmission and enactment of measures to prevent its occurrence is one of the key priorities to improve health outcomes and reduce health care costs.[3] In patients with ADHF, acute kidney injury (AKI) affects 1 in 3 admissions.[7−10] AKI is associated with increased risk of longer hospital stay, mortality, and higher costs of care.[11−15] Most studies examining outcomes associated AKI in ADHF have used "static" definitions that rely on either peak creatinine or creatinine at discharge, relative to the admission value. However, in practice, clinicians often review and implement their treatment choices based on severity, progression, and recovery status of AKI. Changes in serum creatinine are known to impact therapeutic choices such as use and dosage of diuretics or renin-angiotensin aldosterone system inhibitors (RAAS), as well as processes of care such as involvement of subspecialty consultations or planning of postdischarge care. Although key elements in the natural history of AKI influence both in-hospital treatment and discharge disposition; yet, little is known regarding the association between patterns of progression of AKI during hospitalization and its effect on readmissions. In this study, we examined whether timing of occurrence (AKI on admission or during hospitalization) and course (transient or sustained AKI) of AKI would independently influence the risk of hospital readmission in patients with severe ADHF. In particular, we were interested in describing the incidence and postdischarge outcomes of transient and sustained AKI and allow the clinicians to be better informed during discharge disposition of these high-risk patients.

Methods

The data were derived from the Cerner Health Facts Database (Cerner Corporation, Kansas City, Missouri).[16−18] Health Facts includes Health Insurance Portability and Accountability Act (HIPPA) compliant, deidentified data captured from electronic health records dating back to 2000. A local institutional review board (Baystate Medical Center,

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See page 1813 for disclosure information.

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Springfield, MA) considered this research exempt from institutional review board review.

From the Cerner Health Facts sample, we identified 22,059 subjects hospitalized from January 1, 2008, to January 12, 2010, with a primary discharge diagnosis of ADHF, age ≥18 years, and prescribed a diuretic during hospitalization. Diuretic prescriptions considered for inclusion were loop diuretics (furosemide, torsemide, bumetanide, and ethacrynic acid) and nonloop diuretics (triamterene, metolazone, acetazolamide, hydrochlorothiazide, spironolactone, chlorthalidone, amiloride, and chlorothiazide). From this population, we selected the first available admission that required >1 day of hospitalization. Patients with hospitalization episodes occurring within 24 hours of each other were considered as a single acute care episode, as these were likely to be administrative discharges/transfers to different units. We further excluded those with end-stage renal disease (defined by international classification of diseases version 9 clinical modification [ICD-09-CM] code designation of 585.6 during that hospitalization), or those requiring hemodialysis during the admission (defined by procedure code 39.95[19]), or those who died or were discharged to hospice. Finally, to assess the natural history of renal function during ADHF, we restricted the sample to those subjects with 3 or more values of SCr during the hospitalization (Figure 1).

We extracted the following variables including demographics (age, gender, and race), co-morbid conditions (defined based on ICD-09 codes), laboratory values (serum sodium and blood urea nitrogen on admission, and all available serum creatinine [SCr] values during hospitalization), and medications (use of RAAS blockers, natriuretic peptides, or diuretics further classified into rout of administration and class of diuretics).

AKI during hospitalization was defined as an absolute increase in SCr of ≥0.3 mg/dl, or 1.5 times relative to the first available (admission) SCr (adapted from KDIGO clinical practice guidelines).[20] We postulated that there would be 3 clinically relevant courses of AKI based on timing and persistence of SCr increase. Therefore, patients developing AKI during hospitalization were further characterized into 3 mutually exclusive categories: (1) Transient AKI (T-AKI) was defined as those meeting AKI criteria during hospitalization and subsequently returning to within 10% of the admission SCr value within 72 hours of onset; (2) Sustained AKI (S-AKI) was defined as those who developed AKI during hospitalization, had at least 72 hours of hospital stay, but did not have a return of SCr to within 10% of admission level; and (3) Unknown duration AKI (U-AKI) included those patients who were discharged before at least 72 hours of hospital stay after developing AKI; they did not have sufficient time to determine resolution status (neither transient nor sustained definition). Those who did not develop an increase in their creatinine during hospitalization (AKI during hospitalization) were classified as: (1) AKI on admission (A-AKI), defined as those patients who experienced a decline in SCr by at least 0.3 mg/dl or 50% relative to admission level during treatment and (2) No AKI, defined as all the remaining patients with either stable SCr or with changes in SCr relative to admission in either direction of <0.3 mg/dl. The rationale for this classification was based
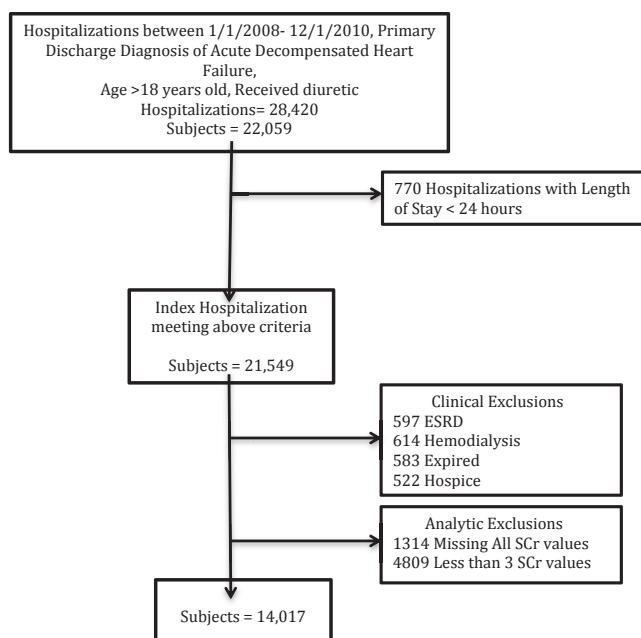

Figure 1. Derivation of study population.

upon the intent of capturing clinically relevant groups of patients based on creatinine changes that usually affect therapeutic decisions or discharge disposition.

The main outcome of interest was 30-day all-cause hospital readmission, defined as all inpatient visits occurring greater than 1 day but within 30 days after discharge of the index admission. Differences in subject characteristics between groups were evaluated using frequencies and percentages for categorical data and means and SDs for continuous data. Between-group differences were evaluated based on clinical grounds. We used a log-binomial generalized estimating equation accounting for hospital clusters to estimate the unadjusted and adjusted association between AKI category of interest and 30-day readmission. Using backward elimination, multivariable models evaluated age, gender, race, diabetes mellitus, use of an RAAS antagonist agent, use of natriuretics, type (loop, nonloop, or combination) and route of diuretic (oral or IV), admission SCr, admission serum sodium, and admission blood urea nitrogen. To achieve the most parsimonious model, variables were initially removed using a Wald test of p <0.25 followed by p <0.05. Covariates excluded from the model were added back in one at a time to determine the robustness of the results. All results are represented as percents and relative risks with 95% CIs. Statistical significance was set at 2-tailed alpha of 0.05. Analysis was conducted using Stata v12.1, StataCorp LP, College Station, Texas.

Results

In our sample of 14,017 subjects with ADHF, 49.8% of subjects were from the Northeast, 17.7% from the Midwest, 24.8% from the South, and 7.8% from the West (as designated in the database). Most hospitals (69.3%) were teaching hospitals, and in urban areas (99.96%), with 35% having