CLINICAL RESEARCH STUDY

THE AMERICAN JOURNAL of MEDICINE®

Physician Prevention of Acute Kidney Injury

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ABSTRACT

BACKGROUND: The frequency of acute kidney injury has become substantially greater over the recent past. Acute kidney injury, moreover, is associated with increased mortality and morbidity over both the short and long term. Despite these facts, its therapy has not changed significantly for many decades. Currently, therefore, prevention is the only action that can reduce the frequency and consequences of acute kidney injury.

METHODS: Charts of 492 patients were reviewed retrospectively for the presence of acute kidney injury based on creatinine elevation. One hundred seventy patients were found to have acute kidney injury defined as a sustained elevation of serum creatinine $\geq$ 0.3 mg/dL for 48 hours or more. An agent or event was determined to be responsible for renal injury if there was the defined increase in serum creatinine within 48 hours of exposure. Charts were reviewed to determine if the renal injury was preventable.

RESULTS: Fifty-one cases were considered to be preventable. Of these, 16 had not received saline prophylaxis for intravenous contrast when appropriate, 15 were not treated appropriately for hemodynamic instability or for hypertension, 9 had inappropriate use of medications, and 11 received multiple nephrotoxic agents.

CONCLUSIONS: In a retrospective analysis of 170 hospitalized patients who developed acute kidney injury during admission, 30% of episodes could have been avoided if physicians had taken appropriate preventive actions.

 • *The American Journal of Medicine (2015) 128, 1001-1006*

KEYWORDS: Acute kidney injury; Contrast-induced nephropathy; Hypotension; Nephrotoxicity

The frequency of acute kidney injury in hospitalized patients has been increasing over the past several years.[1,2] Kidneys are at a particularly high risk of injury from sepsis,[3] pharmacologic toxins,[4] and hypotension.[5] Additionally, many short and long-term consequences of acute kidney injury other than the need for fluid, electrolyte, and azotemia management have become recognized. Evidence for acute kidney injury as an independent risk factor for mortality has solidified over the years, with the increasing severity of injury resulting in a progressively higher risk of death.[6-12] It is now well recognized that acute kidney injury also is associated with an increased risk of developing chronic kidney disease and end-stage renal disease over time,[9,13-15] with this risk also increasing with increasing acute injury severity.[15] Recurrent episodes, moreover, can cause more damage per episode, with each new episode doubling the risk of developing chronic kidney disease in the future.[11] Acute kidney injury is also associated with increased hospital length of stay and cost.[10,14] Even seemingly small increases in serum creatinine of 0.3 mg/dL may result in long-term kidney injury and failure, as well as long-term morbidity and mortality, increased length of hospital stay, and cost.[16-24]

Unfortunately, no new therapeutic modalities for acute kidney injury have been established for decades. Supportive measures such as volume replenishment, avoidance of

Funding: None.

Conflict of Interest: None.

Authorship: All authors had access to the data and had a role in writing the manuscript.

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0002-9343/$ -see front matter
http://dx.doi.org/10.1016/j.amjmed.2015.04.017

excessive volume expansion, management of electrolyte abnormalities, avoidance of nephrotoxic agents, and various renal replacement modalities remain the only options for care once acute kidney injury has become established.[25] Given the multiple short- and long-term consequences of acute injury and the absence of specific treatment, prevention is paramount, especially as the incidence of acute kidney injury continues to increase.[1,2] With these considerations, we performed this study to identify those episodes of acute injury that physicians might have prevented had they taken different actions from those they took before the episode of injury.

CLINICAL SIGNIFICANCE

- Thirty percent of cases of acute kidney injury are preventable by physicians.
- Nonprophylaxed contrast-induced nephropathy accounts for 30% of those.
- Inattention to hemodynamics and use of nephrotoxins account for the remainder.

METHODS

The charts of 492 adult patients admitted to a tertiary care center over a 5-year period whose serum creatinine levels had increased by 0.3 mg/dL or greater were examined. Charts were identified using an electronic database. This 0.3-mg/dL increase was chosen due to the definition of acute kidney injury described by the Acute Kidney Injury Network,[21] as well as the evidence for deleterious effects cited above. The findings were reviewed by at least 2 of the authors, and sometimes 3. All patients developed acute kidney failure in the hospital.

Patients were excluded if they had a known history of end-stage renal disease, had received a recent kidney transplant, had < 3 serum creatinine determinations during admission, their serum creatinine levels had returned to baseline within 48 hours, or they were admitted for nephrectomy or dialysis initiation.

An agent or event was determined to be responsible for renal injury if there was the defined increase in creatinine within 48 hours of exposure and no other precipitating events could be identified. Nephrotoxic agents were those that had been described as causing acute renal injury in the literature. Hypotension was defined as a $\geq$ 20% drop in baseline blood pressure, and volume depletion defined as hypotension in the setting of diuresis or improvement in hypotension with administration of intravenous fluids. Baseline chronic kidney disease and end-stage renal disease were determined by review of the past medical history, or if the patient had multiple creatinine levels in the electronic medical record. The need for renal replacement therapy indicated for renal failure caused by the acute kidney injury was noted. The study was approved by the Northwestern University Human Studies Institutional Review Board.

RESULTS

A total of 548 individual patient episodes of the prescribed creatinine elevation occurred in 492 patients. Three hundred seventy-eight patient episodes were excluded from the study due to return of serum creatinine to baseline within 48 hours, or if nephrectomy or renal transplant had been performed, or there was a lack of adequate data points. The numbers of patient episodes for each exclusion criterion are presented in Table 1.

Of the 170 remaining episodes, there were 3 episodes in which the preventability of acute kidney injury could not be clearly determined during review of the available data, and these were excluded from further analysis, leaving a total of 167 episodes. All of the patients developed acute kidney injury during their hospitalizations. Stability of admission serum creatinine was determined by knowledge of prehospitalization creatinine levels from prior records or from demonstrated stability in the hospital until a documented renal insult occurred. All patients demonstrated the defining elevation of serum creatinine and maintained this elevation for longer than 48 hours. Baseline characteristics of these patients are summarized in Table 2. The mean age of the patients was 60 years, and 70 were female. The racial distribution reflects that of our hospital population as a whole. Ninety-three patients were admitted to the Medical Service and its sub-services. Sixty-seven patients were admitted to a Surgical Service, including the surgical intensive care unit. Twenty-two patients required dialysis during admission, with 16 receiving renal replacement therapy upon discharge or at time of death (in one additional patient it is unclear whether he was discharged on replacement therapy). Nephrology was consulted in 60 patients at an average duration of 1.8 days after recognition of a change in renal function. There were 2 cases in which one patient had 2 episodes of acute kidney injury during the same admission, the second of which was preventable. These were included in the appropriate data sets.

Of the 167 episodes of acute kidney injury, there were 51 episodes (30.5%) that were judged to be preventable. The

Table 1 Number of Patient Episodes Excluded per Criterion

Incorrect date of admission	1
Incorrect age group	1
Patient underwent nephrectomy	87
Insufficient laboratory data to determine presence of acute kidney injury	94
Acute kidney injury on admission without data to determine etiology	8
Rejection	1
Resolved within 48 hours	156
End-stage renal disease	18
Insufficient information in chart	10
Status post transplant	2
Total patient episodes	378