Acute Kidney Injury Electronic Alert for Nephrologist: Reactive versus Proactive?

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Key Words

Acute kidney injury · Electronic health records · Nephrology hospital practice

Abstract

Acute kidney injury (AKI) is a common complication of acute illnesses with significant impact on the mortality and morbidity. Early recognition of AKI allows clinicians to provide prophylactic interventions and to improve the outcomes of this deadly syndrome. Growing utilization and capabilities of electronic health records allow AKI risk stratification and early recognition with a potential effect on the processes of care and outcomes. We evaluate the current level of evidence on the impact of the AKI e-alert on the processes of care and outcomes. We then discuss the impacts of e-alerting in the design of the future of nephrology service within the hospital practices with suggestions regarding the role of nephrologists in management of AKI e-alert systems in order to improve the quality of care provided to AKI patients.

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Introduction

Acute kidney injury (AKI) is one of the most common complications of acute illnesses in intensive care units (ICUs) and hospitals [1–3]. The adverse impacts of AKI

on mortality and morbidity have been highlighted in a significant number of modern studies. When critically ill patients develop AKI, they not only have higher mortality and morbidity but also their length of stay (LOS) in the ICU and hospital as well as the associated cost significantly increases [4, 5]. The clinical and financial burden of this syndrome on the healthcare systems in both developed and developing countries is very large [6]. Unfortunately, despite the gravity of AKI, no treatment has been developed that effectively reverses the injury to the kidney and restores its function. Therefore, preventing development and progression of AKI and management of any subsequent complications are the only available options to avoid the unfavorable outcomes associated with AKI [7]. Risk stratification of critically ill patients and early recognition of AKI are essential in the process of care for critically ill patients [8–10].

In the majority of healthcare institutions, emergency medicine physicians, critical care providers or hospitalists are on the forefront of these tasks. Usually, nephrology services are requested only when AKI has reached advanced stages; hence, the involvement of nephrology in the care of AKI patients is limited to the management of advanced AKI, including providing renal replacement therapies (RRTs) [11]. The emergence of more advanced electronic health records (EHRs) and their ability to identify appropriate patients allow nephrologists to adopt a more proactive role in the prevention and management of AKI.

In this article, we review the current level of evidence regarding the importance of early AKI recognition, the role of the EHR in the identification of AKI and also our suggestions relating to changes in the practice of acute nephrology.

Early Recognition

In the conceptual model of AKI, the Acute Dialysis Quality Initiative investigators suggested AKI to be a process that starts with damage in high-risk individuals and progresses with decreased glomerular filtration rate (GFR), kidney failure and death [12]. As the GFR progressively declines, the possibility of complications, including mortality, continues to rise [13]. Traditional functional biomarkers of AKI, including serum creatinine, cystatin C and urine output, are inherently unable to detect injurious processes in the kidney during the early phases of damage. This can lead to the late detection of AKI after the therapeutic window for any intervention has significantly narrowed [14]. To avoid such delays in the care of critically ill patients who develop AKI, risk stratification models and biomarkers of early kidney injury have been developed [15, 16]. Clinical models and novel injury and stress biomarkers of AKI can identify patients while the therapeutic window is more open and the chance of a successful clinical intervention to prevent development and progression of AKI is higher [17].

Prevention of AKI could be provided in 3 distinct timelines. For primary AKI prevention, identification of patients with increased risk of AKI prior to exposure to any injurious agent would be critical. Determining which patients are at high risk would enable clinicians to choose less nephrotoxic strategies in the process of treatment or management of out- or in-patient settings. One example of this type of prevention that was shown to curtail the incidence of AKI was recently published [18]. The authors demonstrated that remote ischemic preconditioning of the kidneys of high-risk patients scheduled for cardiovascular surgery was very effective in avoiding AKI and the need for RRT (absolute risk reduction 15%, 95% CI 2.6–27.4, $p = 0.02$; and absolute risk reduction 10%, 95% CI 2.3–17.8, $p = 0.01$, respectively). Following exposure to the injurious process, it is important to identify the existence or extent of injury in order to strategize treatment plans accordingly. An example of a secondary prevention study was reported by Endre et al. [19]. These investigators used a panel of biomarkers to identify patients who had evidence of tubular cell injury in order to provide them with a therapeutic in-

tervention. Although this study did not show an improvement in the incidence and outcomes of AKI, this investigation is considered an excellent proof of concept for secondary prevention study designs [19, 20]. Finally, if AKI does materialize, tertiary prevention is required to avoid associated complications. In this phase, clinicians need to identify risk factors and nephrotoxic processes that should be avoided; this, in turn, should mitigate the chances of AKI recurrence and limit its complications [21]. A recently published study showed that early initiation of RRT using continuous modality among those with AKI stage II could lead to significantly improved outcomes [22].

The main preventive interventions are optimization of effective blood volume, maintaining mean arterial pressure and avoiding nephrotoxins [23], all of which are very time sensitive. Suggested strategies to provide timely preventive measures include, but are not limited to, the use of early biomarkers of stress and injury [24], clinical risk stratification models [25–28], a furosemide stress test [29, 30] and use of the renal angina index [31–33].

The Role of the EHR in Early Recognition of AKI

Following the enactment of the American Recovery and Reinvestment Act and the Health Information Technology for Economic and Clinical Health Act in 2009, the EHR has been increasingly utilized to enhance the quality of care provided to patients in various settings [34]. The meaningful use of information technology incentive programs provided by the Centers for Medicare and Medicaid Services has expedited implementation of the EHR in healthcare systems across the country [35]. The literature on the impact of the EHR on the practice of critical care, and particularly AKI, is unsettled and growing [36]. A majority of studies indicate that electronic systems designed to predict and identify AKI do impact the quality of care for critically ill patients. Most studies show that changes implemented in the process of care as the result of the electronic alert systems were able to improve patient outcomes, including lowering AKI incidence and progression [37–40] and, in some cases, decrease mortality [41]. Other investigators were not able to determine any benefit from the use of the EHR in detection and prevention of AKI [42–44]. The major differences among the results of these studies may be due to the heterogeneity of their designs. Differences in the technology, human factors and methods of delivery can directly impact the EHRs utility in the care of AKI patients. EHRs may differ in their technological complexity and abilities, and the manner in

which each EHR is used to provide alerts also bears significant importance. The efficacy of EHR-driven alert systems can be affected not only by the way alerts are delivered, for example, to avoid habituation and enhance compliance, but also by concerns over increasing physicians' workload and fatigue [36]. In addition, choosing the appropriate recipient of these alerts and the relevance and accuracy of alarms have an impact on the outcomes [45].

Early Involvement of the Nephrologist

One of the more relevant factors in this domain is the level of expertise of the alert recipient. For example, Colpaert et al. [39] were able to show improvement in the processes of care when the alert was sent to the intensivists; however, Wilson et al. [44] were not able to replicate this finding when house staff in the ICU and ward received the alerts. Among all the studies included in this review, the majority of alerts were sent to providers who deal with acute illnesses in the ICU or hospital; these included emergency room providers, hospitalists, intensivists or hospital house staff. The alerts were rarely delivered to nephrologists who may be available in the acute care setting. Therefore, the exact impact of such alerts on patient care processes or outcomes when they are delivered to the nephrology teams is not very clear.

On the other hand, the level of evidence to support the early involvement of nephrologists in the care of patients with AKI is very convincing. Mehta et al. [46] in a retrospective study of ICU patients found that nephrology consultation for patients with AKI is delayed by >48 h in 28% of patients, and this, in turn, was associated with higher mortality and ICU/hospital LOS. In another study, Ponce et al. [11] reported that only 52% of patients with AKI had a nephrology consultation, and in 62% of the patients, it was delayed >48 h. Among those with delayed nephrology consultation, the ICU mortality rate was significantly higher (65 vs. 88%, $p < 0.001$). Finally, in a recent Brazilian cohort, investigators noted similar results (OR for mortality regardless of the need for dialysis among those with a delayed nephrology consult was 4.04 with 95% CI 1.65–8.15; OR for dialysis dependence on hospital discharge 3; 95% CI 1.43–6.29) [47].

Among patients who are not critically ill, non-referral or delayed nephrology referral for AKI was also shown to be significantly associated with the higher need for RRT and in-hospital mortality when patients developed AKI. In this study, authors reported that among 1,572 patients with hospital-acquired AKI, no nephrology referral or

late referral (mean of 7.8 ± 3.4 vs. 3.6 ± 1.2 days for early referral group) was very common (22 and 58%, respectively). Among those with late nephrology consultation, the absolute risk of the need for RRT was 7% higher when compared with patients who had early nephrology engagement (number of patients who needed the early involvement of the nephrologist to avoid 1 RRT was 14 patients (NNT = 14)). In addition, authors found that after adjustments for multiple factors (including age, sex, Charlson Comorbidity Index, medical vs. surgical type, AKI cause and stage, need for RRT), no or late nephrology referral was associated with higher in-hospital mortality and worse renal outcomes [48].

Reactive versus Proactive Nephrology Service

The structure of nephrology services provided to AKI patients in critical care or hospital settings is highly variable among institutions. This variability could impact the quality of nephrology care provided to acutely ill patients. While in some institutions intensivists provide dialysis for critically ill patients, in other healthcare systems, general nephrologists become engaged with the care of AKI patients only when requested by critical care services. In a few hospitals, a highly specialized critical care nephrology group is responsible for such care. Independent of the core structure for these services, nephrologists are usually engaged when patients have more advanced AKI and generally require initiation of RRT. Although the effect of these different approaches on AKI outcomes is not very clear, it is evident that the impact of earlier nephrology involvement is significant.

With the advances made in the EHR and its growing capacity to identify patients at high risk for AKI or those who are in the initial stages of AKI, it is a moral and ethical obligation to shift nephrology practices from being reactive to becoming proactive. In the reactive team structure, nephrology care providers wait to hear from consulting services and depend on the primary care physicians in the emergency department, ICU or hospital to notify them. As outlined above, delayed referrals in the ICU and hospital setting are very common, and late nephrology consultation results in the higher need for dialysis and can lead to increased mortality (fig. 1a). In a proactive nephrology practice structure, a team of nephrologists monitors all patients in the hospital and critical care setting using the EHR. For patients identified to be at high risk, nephrologists review each case in detail and make recommendations regarding limiting expo-

Fig. 1. Reactive nephrology team structure (a); proactive nephrology team structure (b). ED = Emergency department.

Table 1. Advantages and disadvantages of reactive vs. proactive nephrology team structure

Reactive nephrology practice		Proactive nephrology practice	
pros	cons	pros	cons
No need for costly change in current practice	Delayed nephrology engagement	Early nephrology engagement	Change of culture
Prevention of additional cost of: – Training staff – Nephrologist time – Design and implementation of EHR-based alerts	Increase the need for RRT	Lower need for RRT	Prevention of additional cost of: – Training staff – Nephrologist time – Design and implementation of EHR-based alerts
	Increase in-hospital mortality	Lower in-hospital mortality	
	Upstream cost	Downstream cost savings	

asures or modifying risks. This results in decreased incidence of AKI development or progression, which translates to less need for RRT and lower in-hospital mortality rates (fig. 1b). This, in turn, has a significant potential to save downstream costs of RRT, prolonged hospital stay and mortality. Either of these approaches carries advantages and disadvantages (table 1). The costs associated with changing the culture of nephrology practice, implementation of the EHR and additional nephrology services could be offset by downstream savings.

Conclusion

AKI is a grave complication of critical illnesses. Early interventions by providers and, particularly, by nephrologists have been shown to decrease the health and financial burden of AKI. EHRs have the ability to identify patients who are at high risk of AKI or in the early stages of AKI. Redesigning current practices by using the EHR to engage nephrologists early on in the care of AKI patients appears to be the next step in the process to mitigate the impact of AKI on healthcare systems and patients.

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Ethics

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