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Original
Contributions

USE OF RIFLE CRITERIA TO PREDICT THE SEVERITY AND PROGNOSIS OF ACUTE KIDNEY INJURY IN EMERGENCY DEPARTMENT PATIENTS WITH RHABDOMYOLYSIS

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□ **Abstract—Background: RIFLE criteria (Risk, Injury, Failure, Loss, End-stage) have not been evaluated in Emergency Department (ED) patients at risk of acute kidney injury (AKI). AKI occurs in rhabdomyolysis. Study Objectives: To use RIFLE criteria to stratify the severity of AKI and predict prognosis in ED patients with acute rhabdomyolysis. Methods: This is a retrospective study of consecutive patients with rhabdomyolysis over a 44-month period. Data included ED admission anion gap, blood urea nitrogen (BUN), calcium, phosphate, potassium, urinalysis, toxicology screen, and hematocrit. Creatine kinase, creatinines, and hematocrits were followed serially. Hospital length of stay (LOS) and need for dialysis were also recorded. Results: RIFLE categories were calculated for 135 patients. At admission, 60 (44%) had no AKI, 20 (15%) had Risk, 32 (24%) had Injury, and 23 (17%) had Failure. These categories were significantly associated with increasing magnitude of volume depletion, potassium, phosphate, BUN, and the anion gap. They predicted differences in LOS, dialysis, discharge creatinine, and the rate of normalization of the admission creatinine. Mortality was low (2%), as was morbidity. Only 8/132 surviving patients (6%) were discharged with a creatinine >2 mg/dL. Conclusions: The RIFLE categories correlated significantly with known markers of rhabdomyolysis and AKI. They also predicted LOS, dialysis, renal morbidity, and the timing of recovery. RIFLE criteria could be used to predict the outcome of ED patients and facilitate admission and discharge decisions. © 2012 Elsevier Inc.**

INTRODUCTION

In an effort to bring a uniform approach to the study of renal injury, the Acute Dialysis Quality Initiative introduced the term "acute kidney injury" (AKI) and developed a scheme for definition and stratification of injury severity called the RIFLE criteria (Risk, Injury, Failure, Loss, and End-stage kidney failure). The RIFLE criteria use small changes in serum creatinine or urine output to define severity categories that allow the prediction of clinical outcomes (Table 1) (1–4). RIFLE categories have been used to predict mortality in critically ill patients, burn victims, and postoperative cardiac patients (5–8). They have also been used to predict the need for dialysis support and blood products in patients with crush injuries (9).

Acute rhabdomyolysis is a common cause of AKI in Emergency Department (ED) patients. Rhabdomyolysis complicates psychomotor agitation, seizures, or coma, compartment syndromes, and crush injuries (10–16). It is reported to be exacerbated by the vasoconstrictive effects of sympathomimetic drugs such as cocaine and amphetamines (17–19). Certain pharmaceuticals, including statins and reverse transcriptase inhibitors, and metabolic

Table 1. Risk, Injury, Failure, Loss, and End-stage (RIFLE) Kidney Classification of Acute Kidney Injury

Class	Glomerular Filtration Rate (GFR) Criteria	Urine Output Criteria
Risk	Increased creatinine × 1.5 or GFR decrease >25%	<0.5 mL/kg/h × 6 h
Injury	Increased creatinine × 2 or GFR decrease >50%	<0.5 mL/kg/h × 12 h
Failure	Increased creatinine × 3 or GFR decrease >75%	<0.3 mL/kg/h × 24 h or anuria × 12 h
Loss	Complete loss of kidney function >4 weeks	
End-stage kidney disease	End-stage kidney disease >3 months	

Adapted from Bellomo et al. (3).

disorders that include hypothyroidism, hypokalemia, and infection, have also been associated with rhabdomyolysis (20–22).

Because AKI occurs, hospitalization is generally required. Data that allow prediction of the likelihood of progression or lack of progression of AKI could decrease the incidence of admission to inpatient medical services, particularly of those patients with acute psychiatric disturbances who would be better served on a psychiatric service.

This study uses RIFLE criteria to stratify ED patients with rhabdomyolysis at admission and at peak (maximum) creatinine levels. It evaluates ED admission laboratory predictors of the absence of AKI at any point in time. It also examines how well the admission RIFLE criteria predict outcomes such as length of stay, need for dialysis, the magnitude of the discharge creatinine, and time to resolution of AKI.

MATERIALS AND METHODS

Study Design

This is a retrospective study of consecutive patients with an ED diagnosis of rhabdomyolysis or acute renal failure recorded in a computerized ED patient database over a 44-month period. Patients with severe agitation, prolonged seizures, heat illness, prolonged immobilization, generalized weakness or muscle pain, myoglobinuria, or unexplained elevation of the admission creatinine were evaluated with a serum creatine kinase (CK) for evidence of rhabdomyolysis. All ED patients were evaluated by Emergency Medicine interns or residents supervised by Emergency Medicine faculty physicians. For study purposes, rhabdomyolysis was defined as elevation of any CK level above 999 U/L. This value has been selected as a cutoff by previous authors (12,19,23).

Our study used the first three categories of the RIFLE criteria (Risk, Injury, and Failure) to define AKI (see Table 1). The baseline creatinine used to calculate the RIFLE stage was the lowest measured serum creatinine in the normal range ($\leq$1.4 mg/dL). When a baseline could not be determined, for example, in patients who were discharged with an elevated creatinine, the patient with no history of renal disease was assumed to have had a normal baseline. The expected normal baseline creatinine was then calculated from the Modification of Diet in Renal Disease equation using an estimated glomerular filtration of 75 mL/min/1.73 m^2 according to Bellomo et al. (Table 2) (3).

Patients were assigned to two RIFLE categories: one based on their admission and a second based on their maximum creatinine value. The maximum RIFLE categories

Table 2. Acute Kidney Injury RIFLE Study Groups

	Number	Definition
Admission RIFLE category		
No AKI	60	No RIFLE criteria on ED admission creatinine measurements
Risk	20	Admission creatinine $\geq$ 1.5 × baseline
Injury	32	Admission creatinine $\geq$ 2 × baseline
Failure	23	Admission creatinine $\geq$ 3 × baseline
Maximum RIFLE category		
No AKI	56	No RIFLE criteria on two sequential creatinine measurements
Risk	19	Any creatinine $\geq$ 1.5 × baseline
Injury	34	Any creatinine $\geq$ 2 × baseline
Failure	26	Any creatinine $\geq$ 3 × baseline

RIFLE = Risk, Injury, Failure, Loss, and End-stage; AKI = acute kidney injury; ED = emergency department.
Due to the limited time course of this study, only the first three RIFLE categories were used. The baseline creatinine was the lowest creatinine in the normal range ($\leq$1.4 mg/dL) documented during hospitalization or estimated from the Modification of Diet in Renal Disease equation assuming a normal baseline glomerular filtration rate: GFR = 75 (mL/min per 1.73 m^2) = 186 × (serum creatinine) − 1.154 × (age) − 0.203 × (0.742 if female) × (1.210 if black) (3).