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Nduka-obi Ossai, Billy T. Hour & Harold M. Szerlip

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CLINICAL STUDY

Border-Crossers' Nephropathy: The Risk of Coming to America

Nduka-obi Ossai¹, Billy T. Hour¹ and Harold M. Szerlip^{1,2}

¹Department of Medicine, University of Arizona, South Campus, Tucson, AZ, USA; ²Section of Nephrology, Department of Medicine, University of Arizona, Tucson, AZ, USA

Abstract

Immigrants attempting to cross the border often wander for days without food or water, subsequently developing acute kidney injury (AKI) secondary to rhabdomyolysis. In this article, we describe our experience with myoglobinuric AKI in these border crossers. Records from all patients in the custody of the border patrol from 1 June 2010 to 30 June 2011, who had AKI defined by the Acute Kidney Injury Network (AKIN) criteria and a CK > 1000 IU/L, were reviewed. The age, gender, temperature, days in the desert, initial serum creatinine, CK on presentation, need for dialysis, length of hospital stay, and serum creatinine at discharge were recorded and analyzed. Forty-two patients developed myoglobinuric AKI with a mean age of 32.5 years. Among them, 38 were males and four females. There was a mean of 4.2 days in the desert. Seven had stage 1 AKI, 10 stage 2, and 25 stage 3.5 patients required hemodialysis. Only one patient had a temperature >100.6°F on arrival. CKs ranged between 1101 and 447,966 IU/L. Mean length of stay was 4 days. Two patients were discharged on hemodialysis and eight were discharged with serum creatinine levels of >1.3 mg/dL. This is the largest series of myoglobinuric AKI reported in border crossers. The kidney injury is presumably due to the excessive heat combined with volume depletion. We have coined the term "border crossers' nephropathy" for this disorder. This is a serious problem that has both political and economic consequences on both sides of the border.

Keywords: rhabdomyolysis, myoglobinuria, border crosser, acute kidney injury

The 380-mile border between Mexico and Arizona has become a prime entry point for persons a state the U.S. and the state of the state o the United States. Due to increased enforcement, these individuals usually attempt to cross the border in desolate areas where they may wander for days without food or water before being "rescued" by border patrol agents. These harsh conditions often result in the disruption of normal physiologic processes with ensuing organ failure.

Exertional rhabdomyolysis complicated by myoglobinuric acute kidney injury (AKI) is a major cause of hospitalization of illegal immigrants crossing the US-Mexico border in southern Arizona. These immigrants often walk long distances in the desert under the scorching heat of the sun's rays on treacherous terrain with limited access to fluids. The summer of 2010 was one of the five hottest summers on record.¹ During 2010, 232 individuals died trying to cross the border into Arizona and 212,202 people were apprehended in the Tucson Sector.^{2,3} The University of Arizona Medical Center, South Campus is one of the closest tertiary care medical centers to the Mexican border. Detainees who suffer from any medical conditions are often brought to this medical center for management.

The reported incidence of myoglobinuric AKI caused by exertional rhabdomyolysis has varied, with studies and case reports historically being limited primarily to military, paramilitary personnel, and marathon runners.^{4,5} In this article, we describe our experience with myoglobinuric AKI in border crossers admitted to our hospital during the period 1 June 2010-30 June 2011. The primary aim of this study was to illustrate the complications, risks, and possible financial implications involved in crossing the border.

METHODS

We conducted a chart review of all patients in the custody of the United States Border Patrol admitted between the period 1 June 2010-30 June 2011 who carried a dis-

Address correspondence to Harold M. Szerlip, University Medical Center, South Campus, 2800 East Ajo Way, Tucson, AZ 85713, USA Tel.: +520 626 1859; Fax: +520 621 2919; E-mail: hszerlip@deptofmed.arizona.edu Received 5 December 2012; Revised 23 January 2013; Accepted 1 February 2013

charge diagnosis of rhabdomyolysis and/or AKI. The diagnosis of AKI was confirmed using the Acute Kidney Injury Network (AKIN) creatinine criteria.⁶ If the creatinine was elevated at admission, a diagnosis of AKI was made if the difference between the discharge (lowest) creatinine and the peak creatinine fulfilled AKIN staging (a decrease in creatinine by at least 0.3 mg/dL). For those patients who were discharged on hemodialysis, it was assumed that they had stage 3 disease if they gave no previous history of kidney disease. The diagnosis of rhabdomyolysis was established using an arbitrary creatine kinase (CK) value of greater than 1000 IU/L and the presence of blood on the urine dipstick. Exclusion criteria were non-border crossers with rhabdomyolysis, border crossers with rhabdomyolysis but without AKI, and border crossers with AKI but with CK < 1000 IU/L.

Symptomatic complaints described in the admission history were noted. We recorded the age, gender, days in the desert, temperature, initial creatinine and CK, length of hospital stay, creatinine on discharge, and need for hemodialysis using an Excel spreadsheet. Spearman's rank correlations were calculated using the statistical package on the spreadsheet.

RESULTS

During the study period, 42 people were diagnosed with myoglobinuric AKI. The common complaints on presentation were generalized body weakness and aches, foot blisters, and pain. On presentation, all patients were vigorously resuscitated with either 0.9% sodium chloride or a mixture of sodium chloride and sodium bicarbonate.

The demographics of this population are shown in Table 1. The age and gender reflects those of the usual persons crossing the border. The mean age was 32.5 years (range 18–53) with 22 patients (52.4% of the study population) \leq 30 years of age; 38 (90.5%) were male and 4 (9.5%) female.

The patients had wandered in the desert between 1 and 10 days with a mean of 4.2 days. Eight of the patients had stage 1 AKI, 12 had stage 2, and 22 had stage 3. Five patients (12%) required renal replacement therapy (RRT). The range of CKs was between 1101 and 447,966 IU/L. There were 18 patients who had CK <10,000 IU/L; eight with CK between 10,000-20,000 IU/L; five with CK between 20,000-30,000 IU/L; and 11 with CK > 30,000 IU/L. No patients with stage 1 AKI, one patient with stage 2 AKI, and nine patients with stage 3 AKI had a CK > 30,000, one patient with stage 2 AKI. Only one patient had a temperature > 100.6° F on arrival. Length of hospital stay was between 1 and 17 days with a mean of 4.0 days. There were more patients admitted with myoglobinuric renal failure during the hotter summer months than during the cooler months (data not shown). Whether this

Table 1. Clinical and demographic characteristics of the patients.

Total patients: 42	Mean	Range
	IIICull	Tunge
Age (in years) (± 8.8)	32.5	18–53
Gender		
Males: 38 (90.5%)	32.1	18–53
Females: 4 (9.5%)	36.5	22-53
Days in desert (SD)	4.2 (±1.73)	1-10
Creatinine (initial, mg/dL) (SD)	3.7 (±3.04)	1.0-13.4
CPK (initial, IU/L) (SD)	37,234 (±7870)	1101-447,966
Creatinine (discharge, mg/dL) (SD)	1.4 (±2.07)	0.6–10.6
Length of hospital stay (SD)	4.0 (±3.26)	1-17
AKI stage 1 $n = 7$		
AKI stage 2, $n = 10$		
AKI stage 3, $n = 25$		
(5 required RRT)		

reflects an effect of temperature or the increase in the number of persons crossing the border during those months is unclear.

As would be expected, the average creatinine and CK of the patients requiring RRT were greater than that of patients not requiring RRT [8.38 mg/dL (\pm 2.03) and 149,830 IU/L (\pm 151,739) vs. 3.1 mg/dL (\pm 2.51) and 22,019 IU/L (\pm 33,991)]. There was no difference in the number of days in the desert between the patients who required RRT and those who did not. As has been shown previously, there was a strong relationship between CK and creatinine (at CK > 30,000 IU/L, the mean creatinine = 7.1 mg/dL, refer to Figure 1). The relationship between CK values and the length of hospital stay is shown in Figure 2. Not surprisingly, the higher the CK value, the longer the duration of hospital stay (r =.25).

Five patients (12%) required hemodialysis during the course of their hospital stay. The patients who underwent dialysis had CKs and creatinines >45,000 IU/L and 6 mg/dL, respectively. Their average length of stay was 7.8 days with a range of 4–17 days. Dialysis was initiated in these patients because they remained oliguric despite aggressive fluid resuscitation. Except for the oliguria, no other parameter distinguished them from patients who did not require dialysis. Three (60%) of the dialyzed patients recovered without further need for dialysis on discharge while two (40%) were discharged on hemodialysis. Unfortunately, their outcomes were not known. In total, eight (19%) patients were discharged from the hospital with elevated creatinine >1.3 mg/dL.

DISCUSSION

There have been no published case series describing myoglobinuric renal failure in illegal immigrants. This is the largest series of myoglobinuric AKI reported in border crossers. The presumed etiology is excessive heat combined with volume depletion and stressful exercise. We have coined the term "border-crossers' nephropathy" for this disorder. Exertional rhabdomyolysis is a



Figure 1. Relationship of creatine kinase (CK) categories to serum creatinine.



Figure 2. Creatine kinase (CK) and mean length of hospital stay.

potentially dangerous condition that involves release of intracellular contents from skeletal muscle in concentrations that may cause myoglobinuric AKI. The presence of risk factors predisposing to exertional rhabdomyolysis includes high heat, inadequate hydration, and excessive physical exertion.^{4,5} The major life-threatening complication of myoglobinuria is acute tubular necrosis. The exact mechanism by which AKI results from myoglobinuria is not well understood. If myoglobin is infused into animals, renal injury occurs only if there is concomitant volume depletion and/or acidosis.⁷

Postulated mechanisms are direct toxic effect of myoglobin to the kidney tubules, release of oxygen free radicals, obstruction of the tubular lumen by excess myoglobin that is filtered at the glomerulus and renal vasoconstriction⁸ Heat, stress, hypovolemia with decreased renal perfusion and acidification of urine are crucial precipitating and aggravating factors.

Strenuous, prolonged, repetitive unaccustomed exercise can cause exertional rhabdomyolysis that is clinically significant. Patel et al. describes cases of exertional rhabdomyolysis in athletes leading to myo-globinuric acute renal injury and acute renal failure.⁶

It is believed that depletion of ATP, damage to the sarcolemma, excess calcium accumulation in the intracellular compartment, and the release of intracellular proteins into the bloodstream all contribute to AKI. However, with cessation of the activity, rest, and early aggressive fluid replacement, the renal function will recover.

Some of these patients may have had prerenal azotemia without tubular damage. Without having wellvalidated biomarkers of tubular injury, it is oftentimes difficult to distinguish hemodynamic changes in serum creatinine from changes caused by injury. Nevertheless, elevations in creatinine require longer periods of observation and utilization of greater resources. This is evident in our patient population by the very fact that these patients were admitted to the hospital.

A total of five (12%) patients underwent hemodialysis. This is a fairly large proportion considering that many patients recover from rhabdomyolysis simply with aggressive fluid resuscitation. The average age of these patients was 27.4 years. They had a longer average length of hospital stay, higher creatinine on discharge, and higher average initial CK.

As we have shown, acute exertional rhabdomyolysis complicated by AKI is an important cause of hospitalization amongst illegal immigrants crossing the southern Arizona-Mexico border into the United States. AKI worsens the prognosis and increases the length of hospital stay of patients admitted with acute rhabdomyolysis. A significant percentage of these patients were returned to their country of origin with elevated creatinines. It is becoming increasingly recognized that AKI is a major precipitant of chronic kidney disease.^{9,10} Recent data suggest that even if the creatinine returns to normal after an episode of AKI, there is a greater risk for the future development of CKD.¹¹ The clinical course of these patients is unknown. We assume that the longterm outcome from myoglobinuric AKI should not differ from other causes and it would be expected that some of these patients will have a decline in their renal function and they will require treatment that would be difficult to obtain.

To date, there have been no large studies conducted which describe the complications of border crossers developing myoglobinuric renal failure. The large number of cases admitted to our hospital during the 13month period of this study highlights the problem of illegal immigration and its financial burden on the taxpayer. Many of these patients may inevitably develop CKD and require follow-up with a nephrologist in their home country. The economic ramifications of having to care for the complications of "border-crossers' nephropathy" may be huge. Our study highlights a common problem that has not been addressed and which has both political and financial ramifications. Perhaps the best way to limit the economic impact is to prevent it from occurring. Further studies would be needed for verification and to bring to light a common problem that has been overlooked in southern Arizona.

Declaration of interest: The authors report no conflict of interest or support. The authors alone are responsible for the content and writing of the paper.

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