Predictors of Poor Outcomes in Acute Forearm Compartment Syndrome

Dafang Zhang, MD; Stein J. Janssen, MD, PhD; Matthew Tarabochia, MD; Arvind von Keudell, MD; Brandon E. Earp, MD; Neal Chen, MD; Philip Blazar, MD

Investigation Performed at: Brigham and Women’s Hospital

Introduction

Acute compartment syndrome is a rare but serious disorder of increased intra-compartmental pressure causing decreased tissue perfusion. The forearm is the most commonly affected location in acute compartment syndrome of the upper extremity. In general, the treatment for acute compartment syndrome is prompt diagnosis and emergent fasciotomy.

Purpose

In this study, we use “poor outcome” as a composite variable, which we defined as (1) death, (2) limb amputation, (3) persistent neurologic deficit, or (4) contracture. The primary objective of this study was to identify factors associated with poor outcomes in patients with acute forearm compartment syndrome.

Methods

A retrospective study was conducted of all fasciotomies performed for acute forearm compartment syndrome at two Level I trauma centers over a fifteen-year time period from January 1, 2000 to June 30, 2015. Patients were queried using diagnosis codes compartment syndrome of the upper extremity. After exclusion of miscoded patients, prophylactic fasciotomies, and fasciotomies performed at outside hospitals, our final cohort included 130 patients with acute compartment syndrome of 130 forearms treated with fasciotomies.

Our response variable was poor outcome, defined as one or more of (1) death, (2) limb amputation, (3) neurologic deficit, or (4) contracture. The following patient-related factors were studied: age, sex, race, body mass index (BMI), modified Charlson Comorbidity Index, diabetes mellitus, mechanism of injury, and traumatic versus nontraumatic mechanism of injury. The following vital signs on presentation were studied: systolic blood pressure, respiratory rate, and peripheral oxygen saturation. The following laboratory values were studied: potassium, creatinine, blood urea nitrogen (BUN), hemoglobin, hematocrit, platelets, partial thromboplastin time (PTT), prothrombin time (PT), international normalized ratio (INR), total protein, albumin, lactate, base excess, creatine kinase at presentation, and peak creatine kinase. The following treatment-related factors were studied: origin of consult, use of compartment pressure measurement, and time from injury to fasciotomy.

Results

Poor outcomes occurred in 43 out of 130 patients (33%) after fasciotomies for acute forearm compartment syndrome. These included five deaths and five limb amputations. The remaining 120 patients were followed for median 135 days (interquartile range 58 to 410 days). At final follow-up, there were 21 patients with neurologic deficits and 31 with contractures. 19 patients had both neurologic deficits and contractures.

Multivariable logistic regression analyses showed that serum creatine kinase ($p = 0.003$) was the only factor independently associated with poor outcomes in patients with acute forearm compartment syndrome. Higher creatine kinase levels are correlated with higher percentages of patients with poor outcomes.

Serum creatine kinase level (U/L)	Patients with poor outcomes (n)	Total patients (n)	Percent with poor outcomes (%)
0 – 250	1	18	6
251 – 1,250	14	41	34
1,251 – 6,250	2	7	29
6,251 – 31,250	8	14	57
31,251 – 156,250	11	12	92

ROC curve analysis showed that serum creatine kinase on presentation has potential utility as a predictor of poor outcomes in acute forearm compartment syndrome. Lower creatine kinase cutoff levels are more sensitive for poor outcomes, whereas higher creatine kinase cutoff levels are more specific. A serum creatine kinase cutoff of 300 U/L exhibits greater than 90% sensitivity for poor outcomes, but with only 35% specificity. By contrast, a serum creatine kinase cutoff of 10,000 U/L exhibits 95% specificity for poor outcomes, but with only 43% sensitivity.

Serum creatine kinase level (U/L) cutoff	Sensitivity (%)	Specificity (%)	AUC (%)
100	97	4	41
300	92	35	58
1,000	65	73	70
3,000	54	82	71
10,000	43	95	74
30,000	30	98	70
100,000	5	100	61

Discussion

Acute compartment syndrome of the upper extremity is a limb- and life-threatening disorder. Early diagnosis and emergent surgical fasciotomy are paramount to avoid irreversible tissue ischemia, neurologic deficits, and contractures. We have shown in this retrospective cohort study that serum creatine kinase levels on presentation are associated with poor outcomes in patients with acute forearm compartment syndrome.

While a creatine kinase level of 10,000 U/L was found to be the optimal cutoff by ROC analysis, the morbidity of missed acute compartment syndrome is so great that surgeons may value a sensitive screening test for the highest risk patients with acute forearm compartment syndrome, at the cost of specificity. We propose a creatine kinase level of 300 U/L as a sensitive cutoff and a level of 10,000 U/L as a specific cutoff for poor outcomes in acute forearm compartment syndrome. When creatine kinase reaches 300 U/L, the surgeon may more aggressively consider fasciotomy in the correct clinical context, at a time when extensive myonecrosis has not yet occurred. A creatine kinase level of 10,000 U/L or above is useful for patient counseling, because it more accurately predicts a poor final outcome.

Disclosures

No funding was received in support of this project. The authors have no financial disclosures.

References

1. Prasarn ML, Ouellette EA. Acute compartment syndrome of the upper extremity. J Am Acad Orthop Surg. 2011;19(1):49-58.
2. McQueen MM, Gaston P, Court-Brown CM. Acute compartment syndrome. Who is at risk? J Bone Joint Surg Br. 2000;82:200-203.
3. Bodansky D, Doorgakant A, Alsousou J, Iqbal HJ, Fischer B, Scicluna G, Bowers M, Narayan B. Acute Compartment Syndrome: Do guidelines for diagnosis and management make a difference? Injury. 2018;49(9):1699-1702.
4. Elliott KG, Johnstone AJ. Diagnosing acute compartment syndrome. J Bone Joint Surg Br. 2003;85(5):625-632.
5. von Keudell AG, Weaver MJ, Appleton PT, Bae DS, Dyer GS, Heng M, Jupiter JB, Vrahas MS. Diagnosis and treatment of acute extremity compartment syndrome. Lancet. 2015;386(10000):1299-1310.
6. Kalyani BS, Fisher BE, Roberts CS, Giannoudis PV. Compartment Syndrome of the Forearm: A Systematic Review. J Hand Surg Am. 2011;36A:535-543.
7. Duckworth AD, Mitchell SE, Molyneux SG, White TO, Court-Brown CM, McQueen MM. Acute Compartment Syndrome of the Forearm. J Bone Joint Surg Am. 2012;94:e63(1-6).