



Risk factors for complications following decompression of non-traumatic compartment syndrome



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ARTICLE INFO

Keywords:

Compartment syndrome
Atraumatic
Non-traumatic
Exertional
Fasciotomy

ABSTRACT

Purpose: To investigate the rate of and risk factors for complications following non-traumatic compartment syndrome decompression.

Methods: The National Surgical Quality Improvement Program database was queried from 2006 to 2016 for non-traumatic compartment syndrome diagnosis codes. Multivariate analysis was performed to identify risk factors for 30-day complications and hospital readmissions.

Results: Overall complication, major complication, minor complication, and hospital readmission rates were 4.5%, 2.5%, 2.3%, and 2.0%, respectively. Active smoking was identified as a risk factor for post-operative complication (95%CI 1.19–9.24).

Conclusion: The complication profile of non-traumatic compartment syndrome decompression is higher than that of traditional elective orthopaedic surgery.

Level of evidence: IV.

1. Introduction

Compartment syndrome occurs when fascia limits intracompartmental volume in the setting of fluid accumulation and tissue expansion ultimately leading to muscle ischemia and cell death. Common sites of compartment syndrome include the leg and forearm.^{1–3} For the majority of cases, this typically develops following a traumatic event, particularly high energy long bone fractures, and emergent decompression fasciotomy is the gold standard for treatment. Complications from decompression fasciotomy are multifaceted in nature, primarily related to neurologic deficits, wound complications, venous insufficiency, and limb loss. One study reviewed 94 patients who underwent fasciotomy for extremity trauma and found a postoperative complication rate of 31%.⁴

Compartment syndrome can also result from non-traumatic causes, including exertional compartment syndrome often seen in athletes. Although fasciotomy is also recommended for patients with exertional compartment syndrome, there has been a relative paucity of information focusing on complication rates following decompression of non-traumatic compartment syndrome. A few studies have reported postoperative complication rates in adults ranging from 11 to 19%, though

small sample sizes limit the reliability of these studies.^{5–9} Although these studies have estimated postoperative complication rates in patients treated for non-traumatic compartment syndrome, there is little known about specific risk factors for postoperative complication.

This lack of information is particularly problematic because decompression of non-traumatic compartment syndrome is often characterized as akin to traditional elective orthopedic procedures, which generally have extremely low rates of postoperative complication.^{10,11} Knowledge of patient complication rates and risk factors for complications following fasciotomies of non-traumatic compartment syndrome is critical for surgeons and other healthcare providers to appropriately educate and counsel patients. The aim of this study was to determine patient risk factors for complications following decompression fasciotomy of non-traumatic compartment syndrome using the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database.

2. Methods

The ACS-NSQIP database was queried with International Classification of Diseases, Ninth and Tenth Editions (ICD-9 and ICD-10)

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<https://doi.org/10.1016/j.jor.2019.04.017>

Received 17 February 2019; Accepted 15 April 2019

Available online 01 May 2019

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Table 1
ICD-9 and ICD-10 diagnosis codes to identify non-traumatic compartment syndrome.

Location	Code	Number of Cases (n)
Upper Extremity	M79.A11	1
	M79.A12	0
	M79.A19	0
	M79.A1	0
	729.71	6
Total Upper Extremity		7
Lower Extremity	M79.A21	62
	M79.A22	78
	M79.A29	6
	M79.A2	6
	729.72	191
Total Lower Extremity		343
Unspecified Extremity	M79.A	1
	729.79	2
Total Unspecified Extremity		3
Total Cases		353

diagnostic codes related to compartment syndrome from January 1, 2006 to December 31, 2016. ICD-9 and ICD-10 codes used for database search are listed in Table 1. To further refine the pool of included cases, Current Procedural Terminology (CPT) codes associated with each case were identified and used to further exclude cases involving traumatic or vascular etiologies. Patients admitted to the hospital prior to the day of surgery were also excluded. Several continuous variables representing medical comorbidities were queried from this database, including age, smoking status, recent weight loss, steroid use, dialysis use, ASA classification, and comorbidities (COPD, hypertension, diabetes, and bleeding disorders).

The primary endpoint assessed was occurrence of one or more complications, including both major and minor as defined by the ACS-NSQIP database, following decompression fasciotomy of non-traumatic compartment syndrome. Both univariate and multivariate logistic regressions were performed to assess for patient demographics or comorbidities that represent individual risk factors for complications following decompression fasciotomy for non-traumatic compartment syndrome.

2.1. Statistical analysis

Univariate analysis was performed for each individual patient demographic and medical comorbidity in order to determine appropriate variables to eventually incorporate in multivariate analysis. Univariate analysis included both 2-sample z-test and chi-square test with Fisher's exact analysis. All analysis was performed with SPSS Statistics version 21.0 software (IBM Corporation, Armonk, New York).

All variables from univariate analysis resulting in P values < 0.3 were included in a binary logistic regression model. Binary logistic regression was performed, and odds ratios with 95% confidence intervals were calculated for all independent predictors of postoperative complications. Any predicting variable with P value < 0.05 was considered statistically significant.

3. Results

3.1. Database query

ACS-NSQIP database search by ICD-9 and ICD-10 codes resulted in the identification of 492 cases. Fourteen CPT codes were identified in the 492 cases that suggested a traumatic or vascular etiology for compartment syndrome (Table 2). Exclusion criteria involving these CPT codes and pre-operative hospital admission removed 139 cases for a study population of 353 cases (Table 1).

Of the 353 patients who underwent decompression for non-

Table 2
Required pre-operative variables and CPT codes identified used to exclude cases of with concomitant procedures and traumatic etiologies.

Required Pre-operative Variables	
Elective Surgery	
Functionally Independent	
Non-ventilated	
No Prior History of Cancer	
No Evidence of Wound Infections Prior to Surgery	
No Transfusions Administered Preoperatively	
No Evidence of Sepsis at Time of Surgery	
Not Admitted Prior to Surgery	
Excluded CPT Codes	
20005	Incision of deep abscess
24685	Treat ulnar fracture
20690	Apply bone fixation device (uniplanar ex-fix)
27156	Under repair, revision, and/or reconstruction procedures on the pelvis and hip joint
27792	Treatment of ankle fracture
27635	Excision or curettage of bone cyst
35256	Under repair procedures blood vessel other than for fistula, with or without patch angioplasty
27880	Lower extremity amputation
28120	Partial excision of bone, talus, or calcaneus
27899	Other procedure on leg
29868	Meniscal transplant, knee arthroscopy
27415	Osteochondral knee allograft
29873	Knee arthroscopy
27027	Decompression fasciotomy(ies), pelvic (buttock) compartment(s)

traumatic compartment syndrome, there was a total of 20 post-operative complications (11 major and 9 minor) and 7 hospital readmissions. The major and minor complication rates in this cohort was 2.5% (9 patients) and 2.3% (8 patients), respectively. The most common major and minor complications were return to the operating room (1.7%, 6 patients) and superficial surgical site infection (SSSI) (1.4%, 5 patients), respectively. This cohort required seven post-operative hospital readmissions (2.0%).

The overall complication rate was 4.5% (16 patients). Table 3 shows all frequency of all complications, both major and minor. A list of each variable tested in the univariate analysis is depicted in Table 4.

3.2. Univariate analysis

Smoking (P = 0.024) and dialysis use (P = 0.045) were found to be significant risk factors for adverse events in univariate analysis.

3.3. Multivariate analysis

Binary logistic regression revealed smoking (OR, 3.32; 95% CI, 1.19–9.24; P = 0.022) as a significant predictor of postoperative complications (Table 4). Dialysis use, ASA classification, presence of bleeding disorders, and hypertension were not found to be statistically significant.

4. Discussion

Relatively little has been published on patient risk factors for postoperative complications of decompression of non-traumatic compartment syndrome. Overall, this analysis found that the rate of post-operative complications within 30-days following decompression of non-traumatic compartment syndrome to be 4.5%. Additionally, smoking was found to be the only statistically significant independent risk factor for postoperative complication.

A 2016 systematic review reported an overall complication rate of 13% following release of chronic exertional compartment syndrome.¹² The difference in complication rate between this study and our analysis

Table 3
Major and minor complications identified from the study population of 353 cases.

Complication	Individual Complications		Patients with Complications	
	Number (n)	Percent (%)	Number (n)	Percent (%)
Major				
Return to Operating Room	6	1.7		
Acute Renal Failure	0	0		
Reintubation	1	0.3		
Failure to Wean	1	0.3		
Wound Dehiscence	3	0.8		
Deep Incisional Surgical Site Infection	0	0		
Myocardial Infarction	0	0		
Stroke	0	0		
Sepsis	0	0		
Septic Shock	0	0		
Pulmonary Embolism	0	0		
Cardiac Arrest	0	0		
Organ/Space Surgical Site Infection	0	0		
Total Major Complications	11	3.1	9	2.5
Minor				
Bleeding requiring transfusion	2	0.6		
Superficial Surgical Site Infection	5	1.4		
Pneumonia	1	0.3		
Urinary Tract Infection	1	0.3		
Deep Venous Thrombosis	0	0		
Renal Insufficiency	0	0		
Total Minor Complications	9	2.5	8	2.3
All Complications	20	5.7	16	4.5
Readmission	7	2.0		

can likely be attributed to the inclusion of studies with more than 30 days of complication follow-up in the systematic review and the strength in having a larger cohort in this present study. Although little data exists surrounding the impact of smoking on non-traumatic compartment syndrome specifically, its impact on increasing risk of complications following surgery generally has been well-established.¹³ Kwiatkowski et al. reported postoperative wound infection to be significantly higher in smokers and recommended for surgeons to use current and total lifetime nicotine use as a significant consideration prior to elective surgery.¹⁴ Additionally, Moller et al. found that a smoking intervention consisting of counseling and nicotine replacement was able to significantly reduce postoperative complication rates in patients undergoing hip and knee replacement.¹⁵ These studies highlight both the importance not only the importance of identifying current and prior smokers as well as attempting to modify risk factors as able through smoking cessation.

With regard to other risk factors for post-operative complication, Packer et al. used patient-reported outcomes to suggest that age below 23 years as well as isolated anterior compartment release to be factors

associated with improved subjective function and satisfaction after fasciotomy.¹⁶ This analysis also suggested that increasing age may serve as a potential risk factor for postoperative complication of non-traumatic compartment syndrome. Our analysis did not reflect age as a risk factor for postoperative complication, however it was likely not powered to detect an effect by age with only 3 patients over the age of 65 years old included in our study population.

Decompression for non-traumatic compartment syndrome has generally considered to be an outpatient procedure akin to traditional elective orthopedic surgeries. However, the outcomes from this analysis and other studies suggest complication rates to be significantly higher than what would be expected, given an overall 30-day complication rate of 4.5%.¹² These findings will be critical both to inform healthcare providers as well as better educate patients. Finally, this study adds smoking to the list risk factors for postoperative complication following decompression of non-traumatic compartment syndrome, which also will allow physicians to better identify patients at an increased risk and modify that risk when able.

Table 4
Univariate and multivariate analysis of risk factors for adverse events (AE).

Variable	Univariate Analysis			Multivariate Analysis	
	Any AE (n = 16)	No AEs (n = 337)	p-value	Odds Ratio (95% CI)	p-value
Age > 65, n (%)	0 (0)	3 (0.89)	1.0	–	–
Active Smoker, n (%)	7(43.75)	64(18.99)	0.024	3.32 (1.19–9.24)	0.022
Recent weight loss, n (%)	0 (0)	1 (0.30)	1.0	–	–
COPD, n (%)	0 (0)	0 (0)	1.0	–	–
Hypertension, n (%)	2 (12.5)	21 (6.23)	0.280	–	–
Diabetes, n (%)	0 (0)	2 (0.59)	1.0	–	–
Steroid use, n (%)	0 (0)	2 (0.59)	1.0	–	–
Bleeding Disorder, n (%)	1 (6.25)	5 (1.48)	0.244	–	–
Dialysis, n (%)	1 (6.25)	0 (0)	0.045	–	–
ASA class > 2, n (%)	2 (12.5)	11 (3.26)	0.112	–	–

*Hypertension requiring medication.

**Regular administration of corticosteroids or immunosuppressants for a chronic condition within 30 days of index procedure.

4.1. Limitations

The primary limitations of this study are those inherent to the utilization of the ACS-NSQIP database. Analysis of the NSQIP database is limited by the agreed upon variables and data collected at each of the participating institutions. For instance, the NSQIP database does not collect data beyond the 30-day post-operative period or rates of known complications of interest including hypersensitivity or superficial peroneal neuritis.¹² Furthermore, those patients who required a return to the operating room had no pre-operative diagnosis to explain the need for secondary intervention such as incomplete release, wound dehiscence, wound infection, or nerve exploration. Additionally, this study was limited in its ability to specifically analyze cases related to exertional compartment syndrome. In this study, initial case query was based on ICD-9 and ICD-10 codes for non-traumatic compartment syndrome. Unfortunately, there is not granularity in ICD coding to identify only cases of exertional compartment syndrome. Although the authors were able to exclude cases of traumatic compartment syndrome and those cases that may have been mistakenly coded as atraumatic but were associated with other traumatic injuries, other etiologies of non-traumatic compartment syndrome, while rare, are possible and include bleeding disorders, vascular disease, and prolonged limb compression, which are unlikely to be excluded by our methodology.¹⁷

5. Conclusions

The post-operative complication risk profile associated with decompression for non-traumatic compartment syndrome has generally considered similar to other traditional elective orthopedic procedures, however the current study suggests a higher rate of post-operative complication. Additionally, smoking was found to be an independent risk factor for postoperative complication following decompression off non-traumatic compartment syndrome.

Funding source

No funding source was utilized in the execution of this research study.

Author contribution

All authors contributed significantly to the execution of this

research study from design and data analysis to writing and revision.

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