CHIRURGIE VASCULAIRE / VASCULAR SURGERY

INSURANCE TYPE IS A MAJOR PREDICTOR OF LOWER EXTREMITY AMPUTATION FOLLOWING INFRA-POPLITEAL ARTERIAL TRAUMA

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Conference Presentation: This study was presented at the 24th Annual Scientific Assembly of the Society of Black Academic Surgeons, April 24-26, 2014, Philadelphia, Pennsylvania

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Abstract

Background: Following traumatic infrapopliteal arterial injury, salvageability of the leg is often attributed to injury-related variables. We investigated factors influencing amputation. **Method:** The United States' National Trauma Data Bank was retrospectively examined identifying subjects aged ≥ 18 with tibial arterial injuries. Demographic, injury-related, co-morbid, and other variables were analyzed. Univariate and multivariable analyses determined predictors of lower extremity amputation.**Results:** 1921 subjects were included, mean age 38 years, 82% male, 65% had blunt injury, 58% white and 22% black. Insurance status: Private 24%, Self-Pay 20%, Medicare/Medicaid 17%, Other 14%, and Not-billed 1%. Average stay (days): ICU (4), hospital (15). Mortality was 2.5%. 13.6% had lower extremity amputation (10.6% below knee) and independent predictors of amputation were: male gender (OR:1.66,CI:1.11-2.34, P=0.012), Injury Severity Score (OR:1.62,CI:1.02-2.38, P<0.001), insurance status: Self-Pay (OR:1.76,CI:1.11-2.79, P=0.016), Medicare/ Medicaid (OR:1.66, CI:1.03-2.67, P=0.039), Other (OR:1.61,CI:1.01-2.58, P=0.047), Not-billed (OR:1.52,CI:1.01-2.28, P=0.043).

Conclusion: Insurance type is a major determinant of lower extremity amputation following traumatic infrapopliteal arterial injury.

Keywords: Lower extremity amputation, arterial trauma, insurance

Introduction

The epidemiology of lower extremity arterial trauma is extremely variable, depending on the geography, data source and the inclusion-exclusion criteria. Franz et al.1 retrospectively examined data from a level I trauma center and identified 65 patients with 75 lower extremity arterial injuries, giving an incidence of 0.39% of all trauma admissions over a 5-year period. The affected arterial distributions were: tibial (36.0%), superficial femoral (32.0%), popliteal (21.3%), profunda femoris (5.3%), and common femoral (5.3%) arteries. The majority of patients were young males and gunshot wounds (46.7%) were the most common mechanism of injury. Lower extremity amputation was the primary treatment modality for 4.6% of patients. Another 4.8% of patients initially received vascular-reconstruction but eventually underwent a major amputation. In their analysis of the National Trauma Data Bank (NTDB), 2002-2006, Kauvar et al[2] identified 651 patients with isolated lower extremity arterial injury. In this study, the incidences of specific arterial injuries were as follows: popliteal (35.5%), superficial femoral (27.8%), common femoral (18.4%), posterior tibial (12.6%) and anterior tibial (8.6%). The majority of patients (85.4%) were also male and penetrating trauma accounted for two-thirds of cases (66.2%). The mortality rate was 2.8% and 6.2% of patients underwent lower extremity amputation.

The primary goals of therapy for lower extremity arterial trauma are control of hemorrhage and limb salvage. Options for limb salvage, addressing the arterial injury and preserving blood flow include: primary repair, bypass, ligation, endovascular repair, thrombectomy and anticoagulation[1]. If these limb-salvage procedures are not feasible or end up in failure, amputation is the end result. Previous studies have sought to identify the injury characteristics, physiologic variables, and pre-existing co-morbidities that predict limb loss following lower extremity vascular trauma. In the study by Kauvar et al.[2] multiple arterial injuries and fracture were identified as independent predictors of amputation, whereas nerve and soft tissue injuries were not. Mullenix et al[3] analyzed data on 1395 patients with popliteal artery injuries from the 2003 version of the NTDB and reported that an associated fracture, complex soft tissue injury, nerve injury and the extremity Abbreviated Injury Score were independent predictors of amputation. In both studies,[2,3] the focus was on the effect of injury characteristics as predictors of amputation, with no examination of the role of the patients' pre-existing disease conditions or pre-injury access to quality healthcare.

Lower extremity amputations are still performed at extremely high rates in patients with peripheral arterial disease (PAD).4 It is unclear whether the same potentially modifiable risk factors that predispose patients to PAD and subsequent amputation also increase the risk of amputation in the setting of lower extremity arterial trauma.

We sought to determine if potentially modifiable factors, including pre-existing disease conditions and insurance type, contribute significantly to lower extremity amputation following infrapopliteal (tibial) artery trauma.

Patients and Methods

Study design and patient selection

This is a retrospective analysis of the United States' National Trauma Data Bank, utilizing the data sets between the years 2007 to 2010. Patients who were 18 years of age and older with tibial artery injuries were identified using the International Classification of Diseases, Ninth Revision, Clinical Modification diagnostic codes 904.51 (injury to anterior tibial artery), 904.53 (injury to posterior tibial artery) and 904.50 (injury to tibial vessel[s], unspecified). Patients who died on arrival or in the Emergency Department were excluded from this study. The following variables were abstracted from the NTDB: demographics (age, gender, ethnicity, insurance type), mechanism of injury (blunt, penetrating), Injury Severity Score (ISS), co-morbidities, hospital length of stay, intensive care unit (ICU) length of stay, lower extremity major amputation (below knee amputation, above knee amputation) and in-hospital mortality.

a. Outcome measures

The primary outcome measure was lower extremity amputation. Secondary outcome measures included hospital length of stay, intensive care unit (ICU) length of stay and in-hospital mortality.

b. Statistical analysis

Summary statistics were used to describe continuous variables while percentages were used to describe categorical variables. Categorical variables were compared using either the Chi-square or Fisher's exact test. For comparison of continuous variables, the Student t-test or the Mann-Whitney U-test, as appropriate, was employed. Univariate and multivariable analyses were performed to determine the independent predictors of lower extremity amputation. Statistical significance was defined as $P<0.05$. All analyses were performed using Stata, version 11 (StataCorp, College Station, Texas).

Results

a. Demographics

A total of 1921 patients were included. The study population was relatively young, with a mean age of 38 years and predominantly male (82%). White patients made up 58% of the study population. Blacks and Hispanics accounted for 22% and 2% respectively. Private insurance (24%), Self-pay (20%) and Medicare/Medicaid (17%) were the most frequent insurance types (Table 1).

Table 1. Patient Characteristics and Outcomes N=1921

Variables	
Age, mean (SD), years	38
Male, n (%)	82
Ethnicity, n (%)	
White	1105 (58)
Black	419 (22)
Hispanic	38 (2)
Other	237 (12)
Unknown	122 (6)
Insurance Type, n (%)	
Private insurance	469 (24)
Self-pay	379 (20)
Medicare/Medicaid	318 (17)
Other Insurance type	267 (14)
Not-billed-for-any-reason	23 (1)
Co-morbidities, n (%)	
Hypertension requiring medication	224 (11.7)
Diabetes mellitus	96 (5.0)
Current smoker	180 (9.4)
Dialysis-dependent renal failure	2 (0.1)
Obesity	63 (3.3)
Mechanism of Injury, n (%)	
Blunt	1244 (65)
Penetrating	677 (35)
Injury Cause, n (%)	
Gunshot wounds	486 (25.3)
Motorcycle crash	385 (20.0)
Motor vehicle crash	300 (15.6)
Stab wound	191 (9.9)
Fall	149 (7.8)
Pedestrian	149 (7.8)
Bicyclist	16 (0.8)
Other(s)	245 (12.8)
Length of hospital stay, mean (SD),days	15 (15)
ICU length of stay, mean (SD),days	4 (9)
In-hospital mortality, n (%)	47 (2.5)

SD, standard deviation; ICU, intensive care unit

b. Injury-related variables

Nearly two-thirds (65%) of injuries were due to blunt trauma, while the remaining 35% resulted from penetrating trauma. Gunshot wounds were the most common cause of tibial artery injuries (25.3%), followed by motorcycle crash (20.04%), motor vehicle crash (15.6%) and stab wounds (9.9%), Table 1. The distribution of ISS was as follows: ISS < 9 (23%), ISS ≥ 9 and ≤ 15 (49%), ISS ≥ 16 and ≤ 24 (11%) and ISS ≥ 25 (11%). The ISS was unknown in 5% of cases. Associated tibial fractures were present in 19.9% of patients, fibular fractures in 16.6%, and combined tibial and fibular fractures in 34.8%. Popliteal artery injury was the most common associated vascular injury (6.5%), followed by peroneal vein injury (5.2%), Table 2. The posterior tibial nerve was injured in 8.6% of cases.

Table 2. Concomitant Vascular Injuries

Vascular Injury	n	%
Common femoral artery	19	1.0
Superficial femoral artery	29	1.5
Popliteal artery	125	6.5
Popliteal vein	41	2.1
Peroneal vein	100	5.2

Table 4. Variables With No Effect on Lower Extremity Amputation

Variables	Odds Ratio (95% CI)	P-Value
Smoking	0.71 (0.42-1.19)	0.20
Diabetes Mellitus	1.33 (0.72-2.47)	0.37
Hypertension	1.02 (0.65-1.59)	0.95
Obesity	1.26 (0.63-2.50)	0.52

c. Outcome measures

The average hospital length of stay and ICU length of stay was 15 days and 4 days respectively. In-hospital mortality was relatively low at 2.5%. Major lower extremity amputation was performed in 262 patients (13.6%): below knee amputation (BKA) in 204 patients (10.6%) and above-knee amputation (AKA) in 58 patients (3.0%).

d. Independent predictors of lower extremity amputation

From the multivariable analyses, the following variables were identified as independent predictors of lower extremity amputation in patients with tibial artery injury: male gender, Injury Severity Score, Medicare/Medicaid insurance, self-pay insurance, patients who were "not-billed-for any reason", and other insurance types other than private insurance, Table 3. Pre-existing co-morbidities had no identifiable effect on lower extremity amputation, Table 4.

Table 3. Independent Predictors of Lower Extremity Amputation

Predictors	Odds Ratio (95% CI)	P-Value
Medicare/Medicaid	1.66 (1.03-2.67)	0.039
Self-pay	1.76 (1.11-2.79)	0.016
Other Insurance type	1.61 (1.01-2.58)	0.047
Not-billed-for-any-reason	1.52 (1.01-2.28)	0.043
Male	1.66 (1.11-2.34)	0.012
Injury Severity Score	1.62 (1.02-2.38)	<0.001

Our study shows that male gender, ISS and insurance type are independent predictors of lower extremity amputation following tibial artery trauma, whereas pre-existing co-morbidities such as diabetes mellitus, hypertension, smoking and obesity were not. For every 1 point increase in ISS, the odds of a lower extremity amputation increased by 62%. This effect of ISS is consistent with earlier published studies.3,5 We also noted that compared to female patients, males were 66% more likely to undergo a lower extremity amputation (OR: 1.66, CI: 1.11-2.34). This female survival superiority in trauma has been previously reported. Haider et al 6 evaluating sexual dimorphism in trauma outcomes using the NTDB reported that women not only demonstrated a 21% lower risk of death than males, but they also had decreased odds of developing life-threatening complications.

The effect of insurance type as a major determinant of lower extremity amputation following tibial artery trauma is particularly intriguing. From our data, patients who were covered by Medicare/Medicaid had a 66% increased odds of undergoing a lower extremity amputation; self-pay patients had 76% increased odds; other insurance types 61%; and "not-billed-for any reason" 52% increased odds of lower extremity amputation. Several studies have sought to uncover social factors that may directly or indirectly influence the need or decision to amputate versus salvage the lower extremity following significant trauma. Weber et al.7 examined 10,082 patients with open femoral fractures and 22,479 patients with open tibial and fibular fractures using data from the National Trauma Data Bank. They concluded that an ethnic disparity exists in the management of lower extremity open fractures, with older blacks having greater odds of amputation that is not explained by mechanism of injury as compared to whites of the same age group. The

Lower Extremity Assessment Project (LEAP), a multicenter prospective outcome study involving eight level 1 trauma centers in the United States studied 601 patients with severe limb threatening lower extremity injuries.4 The investigators noted that patients with private insurance were 2.5 times more likely to undergo a delayed amputation compared with those without insurance or those with Medicaid / Medicare. This suggests that privately insured patients were more likely to have had attempts at limb salvage than the uninsured or those insured by government-sponsored programs.

The effect of social factors on lower extremity amputation has also been studied in non-trauma populations. Holman et al.8 studied 65,881 white and 24,600 black amputees, all insured by Medicare and concluded that black patients were much less likely than whites to undergo attempts at limb salvage prior to amputation. They recommended additional studies to explore whether this disparity might be attributable to race-related differences in severity of arterial disease, patient preferences, or physician decision making. Our group has also recently reported that blacks make up a disproportionately high percentage of critical limb ischemia patients who undergo amputation; and a disproportionately low percentage of critical limb ischemia patients who undergo revascularization.9 It appears, therefore, that two major social determinants of amputation versus limb salvage are ethnicity and insurance type. The current study identified insurance type, but not ethnicity, as an independent predictor of amputation following tibial artery trauma.

There has been an increasing surge of interest in the relationship between trauma outcomes and insurance type in the United States, either through deliberate study or by serendipitous discovery.[10,12] Trauma systems are one of the most standardized systems of care in the United States and one would expect that every trauma patient is treated in a standardized format regardless of insurance status. Recent evidence appears to suggest that the trauma outcomes may be influenced by insurance type to a greater extent than one would imagine. In a previous analysis of the National Trauma Data Bank, our group showed that insurance status is a potent predictor of mortality in both blunt and penetrating trauma[10] Yeh et al.[11] also studied 32,746 patients with sternal fracture using the NTDB and showed that patients who were uninsured (self pay) had an 81% increased odds of mortality, whereas those who were insured had decreased odds of mortality. In that study, privately insured patients had a 34% reduced odds of mortality, those with workers compensation had 30% reduced odds of mortality, Blue Cross Blue Shield patients had a 29% reduced odds of mortality, Medicaid patients had a 29% reduced odds of mortality, and no-fault automobile had a 19% decreased odds of mortality. Furthermore, Haider et al.12 studied 429,751 patients using the NTDB and concluded that ethnicity and insurance status each independently predicted outcome disparities after trauma, with black, Hispanic, and uninsured patients having worse outcomes. In this study, the authors reported that insurance status appeared to have the stronger association with mortality after trauma.

Results of these and similar studies have led some to question whether the decision-making and trauma care processes are influenced by insurance type and, if so, to what extent. The role of implicit or unconscious bias in healthcare is also being increasingly discussed. In a nationally representative random survey of 2,608 physicians whose major professional activity is direct patient care, when asked how often they thought the healthcare system treated patients unfairly based on whether or not they had insurance, 72% of respondents noted that the system treated these patients “very/somewhat often” unfairly.13 Whether unconscious bias exists in trauma care remains to be determined.

The theory that insurance status may serve as a surrogate for the adequacy of primary care treatment of underlying co-morbidities has been proposed.[14,15] One explanation may be that at the time of sustaining a traumatic injury, the insured patient is more likely to have had co-morbidities such as diabetes, hypercholesterolemia and hypertension treated and may, therefore, perhaps be in a better position to undergo limb salvage. The findings of our multivariable analyses showing that these traditional risk factors were not significant predictors of amputation, however, would lend less support for this theory.

There are several limitations to our study. To begin with, by using the NTDB, we are unable to examine the real time decision-making processes that go into determining whether a patient receives limb salvage procedures or amputation at the initial evaluation or during

subsequent treatment. Secondly, due to the retrospective nature of our study, the analysis relies on the accuracy of data reported in the NTDB. Furthermore, we are unable to establish cause and effect using this type of analysis. In spite of these limitations, the NTDB provided us with the ability to use a relatively large sample size to study the determinants of lower extremity amputation following tibial artery trauma, and the use of multivariable analysis helped to control for possible confounders.

Conclusion

We conclude that insurance type is a major predictor of lower extremity amputation following infrapopliteal (tibial) artery trauma and our study supports a growing body of evidence that trauma outcomes are influenced to a greater extent by insurance type than previously thought. With the passage of the Patient Protection and Affordable Care Act in 2010, it has been projected that millions of Americans have already become insured and many more are expected to be insured in the coming years. It would be interesting to see whether lower extremity amputation rates after infrapopliteal artery trauma would reduce as the number of insured Americans increases.

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