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Article

Podiatrists Decrease the Odds of Major Amputation in Patients with Diabetes and/or Peripheral Arterial Disease in All Practice Settings: A Retrospective Administrative Claims Data Analysis

Chia-Ding Shih ^{1,*}, Tina Javanbakht ², Dyane E. Tower ³, Rachel H. Albright ⁴, Tze-Woei Tan ¹, Brandon Brooks ⁵ and James S. Wrobel ⁶

- ¹ Division of Vascular Surgery and Endovascular Therapy, Keck Medicine of USC, Los Angeles, CA
- ² Legacy Health Podiatric Medicine and Surgery Residency, Portland, OR
- ³ American Podiatric Medical Association, MD
- ⁴ Stamford Health Medical Group, Department of Surgery, Stamford, CT
- ⁵ Columbia VA Health Care System, Columbia, SC, USA
- ⁶ Village Health, FL, USA
- * Correspondence: Chia-Ding.Shih@med.usc.edu

Abstract

Background/Objectives: The management of diabetic foot ulcers and/or peripheral arterial disease requires an interdisciplinary approach. Little has been written to demonstrate the effect of podiatry in non-academic settings. To demonstrate the impact of podiatrist on major non-traumatic lower extremity amputations (NTLEA) among patients with type 2 diabetes with foot ulcer and/or Peripheral arterial disease (PAD) using national administrative data. **Methods:** A retrospective cohort study using administrative data from all U.S states and territories between 2010 to 2022 to examine odds for major amputation (i.e., above-ankle) with and without podiatry. Interdisciplinary approach was defined as any surgical services performing major NTLEA in addition to podiatry care. Multivariable regression models were conducted to assess the primary outcome while controlling for age, gender, Charlson Comorbidity Index, obesity, tobacco use, chronic kidney disease, peripheral neuropathy, heart disease, presence of an ulcer, and presence of PAD. **Results:** Overall, 2% of the population experienced a major NTLEA (n=5,493). Adjusted odds of vascular and general surgeons performing major amputation were 3.82 (97.5% CI [3.61-4.06]) and 2.59 (97.5% CI [2.42-2.77]), respectively. Adjusted odds decreased to 1.38 (97.5% CI [1.21-1.57]) and 1.10 (97.5% CI [0.90-1.33]), respectively, when podiatry was involved in the care. **Conclusions:** Regardless practice settings, including podiatry with other surgical providers as part of the interdisciplinary approach for amputation prevention reduces the odds of major non-traumatic lower extremity amputation.

Keywords: interdisciplinary; podiatrist; diabetes mellitus; peripheral arterial disease; diabetic foot ulcers; lower extremity amputations; multidisciplinary care

1. Introduction

Diabetes mellitus (DM) is a national and international health crisis that is associated with many comorbidities and complications, such as diabetic foot ulcerations (DFU), frequently leading to non-traumatic lower extremity amputations (NTLEA) [1,2]. Up to 25% of individuals with DM will experience a DFU in their lifetime, and approximately 85% of NTLEA are preceded by a DFU [3]. In 2021, 38.4 million Americans had diabetes, including 8.7 million undiagnosed. Adults from low socio-economic statuses (SES) had a 37% higher prevalence of diabetes compared to high SES individuals

[1]. Evidence has suggested that NTLEA is associated with increased mortality particularly among patients with advanced age, diabetes, coronary artery disease (CAD), peripheral arterial disease (PAD), history of proximal amputation and/or end stage renal disease [4–6]. PAD, identified as infrapopliteal or tibial artery disease and calcification of vessels especially among patients with DM [8], is another leading cause of NTLEA and affects approximately 10 to 12 million people over the age of 40 in the United States and approximately 113-236 million people worldwide [2]. DM, especially when uncontrolled, increases the risk of PAD, defined as, the progression of chronic arterial occlusive disease of the lower extremities [7]. The incidence of PAD increases with the presence of DM which also has been known to accelerate PAD progression and severity [9]. The true prevalence of both DM and PAD in the same patient is difficult to quantify, however, literature estimates that DM has been associated with a 2- to 4-fold increase in the prevalence of PAD from 1996 to 2011 [6]. Risk factors such as age, tobacco use, hypertension, and diabetes are highly associated with PAD [3]. In the case of advanced PAD, patients often lose their limbs and potentially their lives. Similar to DM, the prevalence of PAD disproportionately affects lower SES communities worldwide [4].

The management of patients who suffer from DM and/or PAD, especially those with non-healing wounds, is complex and costly. Epidemiological studies estimated annual costs for concomitant DM and PAD ranging from \$84 billion to \$380 billion annually [6]. DM and/or PAD comorbidities and complications require management by multiple specialists, however, the disorganized and fragmented structure of the current healthcare system may lead to increased costs [5]. These increased costs are especially seen among patients with high fragmentation of healthcare with \$1,085 more in total adjusted costs per person per year than among patients with low fragmentation of healthcare [5]. Studies from academic medical centers, where care is consolidated and perhaps relatively streamlined, demonstrate improved NTLEA rates owing to a interdisciplinary team approach [10–13]. A common theme in the current literature on diabetic foot management is the close knit relationship between podiatry and various specialists. Systematic reviews have also shown that a team approach improved NTLEA rates specifically by following international guidelines in which podiatrists are involved in preventive, subacute and acute settings [15,16]. While an interdisciplinary team may be more easily established within a healthcare system and/or academic medical center, such a team is not limited to only those settings.

Referrals between podiatry and other specialists to manage patients with DM and/or PAD are common. Such referral patterns occur in any practice setting. As mentioned prior, literature has underscored the important role of podiatrists as part of the multidisciplinary or interdisciplinary team in healthcare systems and academic medical centers to manage lower extremity wounds and prevent NTLEA among patients with DM and/or PAD [6–8]. However, the effect of collaboration between podiatry and surgical specialists to prevent major NTLEAs outside the healthcare systems or academic medical center is not well known. This study used administrative claims data to demonstrate the impact of podiatry on major NTLEA among patients with type 2 diabetes, a foot ulcer and/or patients with PAD, regardless of care setting.

2. Materials and Methods

This study utilized administrative claims from PearlDiver (Pearl-Diver Technologies, Fort Wayne, IN, USA) to conduct a retrospective cohort study. The PearlDiver Mariner10 database is a Health Insurance Portability and Accountability Act–compliant national database between October 2010 and October 2022. The data file contains claims information from all U.S. states and territories from private and public payers. The file also contains demographic characteristics, location (e.g., region, state, and ZIP code), diagnosis, procedure, and provider specialty submitted with each claim.

Inclusion criteria were patients with an International Classification of Diseases, 9th/10th Revision, Clinical Modification (ICD-9/10-CM) for DM AND for a foot wound/ulcer AND a Current Procedural Terminology (CPT) code for debridement and/or people with an ICD-9/10 code for PAD AND a CPT code for either vascular studies or vascular procedures [17,18]. **[Appendix A]** Patients who were not seen by one of the studied specialties (i.e. podiatry, general surgery, orthopedic

surgery, plastic surgery, vascular surgery) within the window of 1 year prior and 2 years after being eligible for the final population were excluded. The studied speciality was a variable that was available in the dataset as a “provider type.” The objective of this study was to investigate the impact of incorporating an interdisciplinary approach on major NTLEA in comparison to patients who were treated by only one type of specialist. We defined the interdisciplinary approach as podiatry in addition to surgical providers that perform major NTLEA. The primary outcome of the study was odds of major NTLEA.

Chi-square analysis was performed initially for population characteristics and demographics in relationship to amputations status. Multivariable regression models were then conducted with major or no major NTLEA as the outcome with the exposure to podiatric surgery while controlling for age, gender, Charlson Comorbidity Index (CCI), obesity, tobacco use, chronic kidney disease (CKD), peripheral neuropathy, heart disease, presence of an ulcer, and presence of PAD. Since PAD and DM are known independent risk factors for NTLEA, we performed a sensitivity analysis including PAD patients only which was defined as people with diagnosis of PAD + vascular study on record, and then controlled for DM/DFU in the multivariable analysis. Significant difference is defined as a P-value <0.025. The presented study follows STROBE reporting guidelines [9].

3. Results

3.1. Population Characteristics and Demographics

A total of 269,022 people met inclusion criteria (Table 1). A majority of the population (93%; n=249,593) were patients with PAD whereas 36,460 patients had diabetes and foot ulcer that was confirmed by at least one debridement. Approximately 2% of the population experienced a major amputation (n=5,493). The mean age of those who underwent major amputation was 63.8 years and 67.3 years for those who did not undergo major amputation (P<0.01) (Table 1). A majority of patients who underwent major amputation were male (66%, P<0.01) and used tobacco (66%, P<0.01). Several comorbidities were significantly associated with major amputation including heart disease (98%, P<0.01), CKD (65%, P<0.01), PAD (89%, P<0.01), foot ulcer and peripheral neuropathy (62%, P<0.01).. Podiatry was involved in the care of 7% of the NTLEA group and 4% in the no major NTLEA group. Patients who were cared for by vascular surgery had the highest NTLEA counts (n=3,313) followed by general surgery (n=1,530) then orthopedic surgery (n=620) and plastic surgery (n=158).

Table 1. Population Characteristics and Demographics.

Population Characteristics and Demographics			
Characteristics	Major Amputation n=5,493	No Major Amputation n=263,529	P-value
Age mean (SD)	63.8 (11.3)	67.3 (11.9)	<0.01
Sex ¹			
Male	3,612	134,756	<0.01
Female	1,881	128,771	
Tobacco use (%)	3,633 (66%)	141,334 (54%)	<0.01
Comorbidities (yes) %			
Obesity	2,574 (47%)	121,758 (46%)	0.31
Heart Disease	5,390 (98%)	245,856 (93%)	<0.01
CKD	3,582 (65%)	105,305 (40%)	<0.01
Diabetic Foot Ulcer	2,603 (47%)	33,858 (13%)	<0.01

<i>PAD</i>	4,874 (89%)	244,719 (93%)	<0.01
<i>Foot ulcer</i>	2,812 (51%)	37,264 (14%)	<0.01
<i>Peripheral Neuropathy</i>	3,396 (62%)	90,071 (34%)	<0.01
Provider Encounters (yes) %			
<i>Seen by Podiatric Surgery</i>	395 (7%)	11,125 (4%)	<0.01
<i>Seen by Vascular Surgery</i>	3,313 (60%)	63,569 (24%)	<0.01
<i>Seen by General Surgery</i>	1,530 (28%)	18,241 (7%)	<0.01
<i>Seen by Plastic Surgery</i>	158 (3%)	1,472 (0.5%)	<0.01
<i>Seen by Orthopedic Surgery</i>	620 (11%)	5,441 (2%)	<0.01
<i>Seen by Vascular + Podiatric Surgery</i>	293 (5%)	3,011 (1%)	<0.01
<i>Seen by GenSurg + Podiatric Surgery</i>	119 (2%)	1,312 (0.6%)	<0.01
<i>Seen by Plastics + Podiatric Surgery</i>	23 (0.4%)	175 (0.07%)	<0.01
<i>Seen by Ortho + Podiatric Surgery</i>	68 (1%)	494 (0.2%)	<0.01

¹ Two unknown sex in no major amputation group.

3.2. Multivariable Analysis

The multivariable analysis demonstrated that patients seen by vascular surgery without the addition of podiatry had the highest odds of NTLEA at 3.82 (97.5% CI, [3.61-4.06]) followed by orthopedic surgery at 2.78 (97.5% CI, [2.52-3.05]), general surgery at 2.59 (97.5% CI, [2.42-2.77]), and plastic surgery at 1.60 (97.5% CI, [1.34-1.90]). When the interdisciplinary approach included podiatry in addition to vascular or general surgery, the odds of NTLEA reduced to 1.38 (97.5% CI, [1.21-1.57]) and 1.10 (97.5% CI, [0.90-1.33]) for vascular and general surgery, respectively. (Table 2) There were not enough patients seen by podiatry in addition to orthopedic or plastic surgery to perform multivariable analysis. Adjusted OR in podiatric surgery (97.5%, CI, [0.61-0.76]) suggested that podiatric surgery was protective for major amputation.

Table 2. Final Multivariable Model Examining Provider Type and Major Amputation.

Multivariable Model Examining Provider Type and Major Amputation				
	Crude OR	97.5% CI	Adjusted OR¹	97.5%CI
<i>Podiatric Surgery</i>	1.76	1.58-1.95	0.68	0.61-0.76
<i>Vascular Surgery</i>	4.78	4.53-5.05	3.82	3.61-4.06
<i>General Surgery</i>	5.19	4.88-5.52	2.59	2.42-2.77
<i>Plastic Surgery</i>	5.27	4.45-6.21	1.60	1.34-1.90
<i>Orthopedic Surgery</i>	6.04	5.52-6.58	2.78	2.52-3.05
<i>Vascular + Podiatric Surgery</i>	4.88	4.30-5.50	1.38	1.21-1.57
<i>GenSurg + Podiatric Surgery</i>	4.33	3.63-5.32	1.10	0.90-1.33

Plastics + Podiatric	--	--	--	--
Surgery ²				
Ortho + Podiatric	--	--	--	--
Surgery ²				

¹ Controlled for age, gender, CCI, obesity, tobacco use, CKD, peripheral neuropathy, heart disease, presence of an ulcer and presence of PAD. ² There were not enough patients seen by podiatry in addition to orthopedic or plastic surgery to perform multivariable analysis.

3.3. Sensitivity Analysis

The sensitivity analysis revealed similar results, demonstrating our primary analysis was robust to these population differences (Vascular Alone: OR 5.84, p-value <0.01, DPM Alone: OR 1.00, p-value 0.67, Vascular + DPM: OR 1.86, p-value <0.01).

4. Discussion

Our findings support that podiatrists play a crucial role in the interdisciplinary approach to reduce major NTLEA in patients with DM and/or PAD. Most notably, the odds of major NTLEA was reduced when podiatrists were involved in care along with either vascular or general surgeons. While this finding coincides with prior studies in the academic medical center setting, to our knowledge this was the first study utilizing administrative claims data to demonstrate that the addition of podiatry in an interdisciplinary approach in any healthcare setting can reduce the odds of major NTLEA, a health status that is associated with increased mortality.

NTLEA has long been a marker to track the health of a population. HealthyPeople, a US federal government initiative to track the population’s health, includes the trend of amputation rate [10]. NTLEA has been an essential indication for the health of the population because it is closely related to mortality [11]. Complications of DM such as angiopathy, neuropathy, and nephropathy can further compound the effect of PAD among the aging population and increase the risk of NTLEA. [12,13] NTLEA is also thought to be a reflection of overall cardiovascular condition. Individuals who have had NTLEA often have a history of CAD, stroke or CKD[13]. As a result, the management of such a population requires a team approach and different specialists at different levels of care. Podiatry, a specialty that focuses on diabetic foot prevention, management and surgery plays an unique and essential role in this population. Based on previous research, the inclusion of podiatry contributes to better outcomes and cost-savings. Skrepnek et al. found that excluding podiatrists from Medicaid in Arizona cost the system \$48 for every \$1 the payer thought they would save [14]. Poor outcomes and increased costs were the result of podiatrists being excluded from providing care for Medicaid patients in Arizona [14]. As a result, podiatrists are no longer excluded from Medicaid in Arizona. Additionally, the professional relationship between vascular surgery and podiatry has been proven to be an economic value in limb salvage efforts [15].

While collaboration between vascular and podiatric providers to prevent amputation has been well demonstrated in recent literature, the evidence behind such a team approach often occurs in a healthcare system or an academic medical center in the United States. As an example, the UCSF Center for Limb Preservation makes use of vascular and podiatric surgery co-directorship to provide interdisciplinary care that leads to better outcomes and minimization of hospital readmissions in high risk populations. [7] A 2020 systematic review found that ninety-four percent of studies reported a reduction in major amputations after the implementation of a team approach.[6] The “toe and flow” model where podiatrists and vascular specialists see patients with diabetes and/or PAD in one clinical setting has been advocated for a number of years in the US.[16] The partnership between vascular and podiatry has shown to reduce foot complications and major amputations due to better communication and organization between the specialties.[6] Furthermore, across 10 United States Department of Veteran Affairs (VAs), a special care unit designed to prevent NTLEA was also proven to be successful, with the use of the Foot Systems Assessment tool. [17] There was a significant

association between facility-level foot care program coordination and rates of diabetes-related amputations.[17] Such collaboration was further advocated by various medical and nursing associations and published in a recent clinical practice guideline.[18] [2] These guidelines support the interdisciplinary approach for the management of PAD-related lower extremity complications.[2]

Our findings suggested that the interdisciplinary approach, although potentially easier to foster in a hospital-based or academic medical center setting, is still possible in the community. Nonetheless, despite sustained advocacy to include podiatry in the interdisciplinary approach to reduce NTLEA, our analysis indicated that only 7% of major NTLEA patients and 4% of no major NTLEA patients had a podiatrist as part of their care team. There are several factors that may contribute to the low rates of having a podiatrist as part of a patient's care team. There could be a lack of podiatrists, patient-specific factors related to transportation or financial constraints, unaware of the condition by the patients and/or referring providers or challenges associated with the referral process.[19] Recent qualitative studies interviewing patients with DFU history continued to raise similar concerns and complaints. At the individual level, lack of knowledge of diabetic foot and insurance coverage as well as wound care supplies seemed to hinder the outcome.[20,21] Fragmented communication between providers including the lack of timely referral. Participants identified that "improved access often came too late to alter their course." [21] Another group of participants further stressed that "insufficient preventative foot care and education before DFU onset." [20] Some respondents even experienced initial misdiagnoses which delayed care." [20] The qualitative and quantitative findings indicated the need for improvement to increase access to podiatric care in a timely manner so disease processes may be intervened earlier and amputations may be prevented. .

A number of limitations exist in this study. First, we only included claims in the United States. Second, the study relied on administrative claims data, including ICD-9, ICD-10, and CPT codes, which can have misclassifications, coding errors, limited anatomical and clinical detail, specifically DFU severity. Third, our analysis did not include DFU referrals from primary care physicians as our primary interest of the study was to investigate the impact of podiatrists on major NTLEA. Fourth, the unique role of podiatrists in the US may explain the support of the "toe-and-flow" model, whereas podiatrists may not be able to provide surgical intervention in other countries. Therefore, the findings of this study may only apply to the healthcare environment in the United States. Fifth, the low percentage of podiatry involvement could be a result of categorization of podiatrists that was not accurately classified during some of the years within the dataset. Furthermore, due to the inherent limitations of retrospective cohort studies, our findings can only suggest, and not prove, causality. Nonetheless, our findings support an interdisciplinary approach to manage high risk patients with diabetes and/or PAD so NTLEA can be mitigated and patient outcomes can be optimized.

5. Conclusions

Managing multimorbidity, which is often seen in patients with DFU, can be challenging. The benefits of multidisciplinary DM care teams are well-documented. Our findings highlighted the importance of the inclusion of podiatry within an interdisciplinary approach in the management of patients with DM and/or PAD regardless of practice setting. The inclusion of podiatry is an essential part of the "Toe and Flow" model which is shown to be effective in NTLEA prevention. Further research aims at investigating potential barriers that limit this crucial interdisciplinary approach in the care of patients with DM and/or PAD outside of structured healthcare systems such as academic medical centers is warranted and may provide insight on how to further improve patient outcomes.

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, CDS, BB and JSW.; methodology, CDS, BB, JSW.; software, RA, DET; validation, BB, TWT and JSW; formal analysis, RA, DET.; investigation, X.X.; resources, DET; data curation, RA, DET; writing—original draft preparation, CDS, TJ; writing—review and editing, CDS, TJ, RA, DET, TWT, BB, JSW.; visualization, TJ; supervision, CDS, TWT, JSW; project administration, CDS. All authors have read and agreed to the published version of the manuscript."

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Institutional Review Board Statement: Ethical review and approval were waived for this study due to the study utilized de-identified administrative data.

Informed Consent Statement: Patient consent was waived due to the study utilized de-identified administrative data.

Data Availability Statement: The data presented in this study are not available due to the administrative data is subscribed through a third party and access is restricted.

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Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

- NTLEA Nontraumatic lower extremity amputation
- DM Diabetes mellitus
- PAD Peripheral arterial disease
- DFU Diabetic foot ulcer
- CAD Coronary artery disease

Appendix A

Study population was defined by International Classification of Diseases, 9th/10th Revision, Clinical Modification (ICD-9/10-CM) for DM AND for a foot wound/ulcer AND a Current Procedural Terminology (CPT) code for debridement and/or people with an ICD-9/10 code for PAD AND a CPT code for either vascular studies or vascular procedures.

Disease	
diabetic foot ulcer	ICD-10
Type 2 diabetes with ulceration	E11.621
Type 2 diabetes with peripheral circulatory complications, controlled	E11.50
Type 2 diabetes with peripheral circulatory complications, uncontrolled	E11.51
Type 2 diabetes with gangrene	E11.52
Type 2 diabetes with complications	E11.8
Type 2 diabetes with neuropathy, unspecified	E11.40
Type 2 diabetes with mononeuropathy	E11.41
Type 2 diabetes with polyneuropathy	E11.42
Peripheral arterial disease	ICD-10

Unspecified atherosclerosis of native arteries of extremities, right leg	I70.201
Unspecified atherosclerosis of native arteries of extremities, left leg	I70.202
Unspecified atherosclerosis of native arteries of extremities, bilateral legs	I70.203
Unspecified atherosclerosis of native arteries of extremities, unspecified extremity	I70.209
Atherosclerosis of native arteries of extremities with intermittent claudication, right leg	I70.211
Atherosclerosis of native arteries of extremities with intermittent claudication, left leg	I70.212
Atherosclerosis of native arteries of extremities with intermittent claudication, bilateral legs	I70.213
Atherosclerosis of native arteries of extremities with intermittent claudication, unspecified extremity	I70.219
Atherosclerosis of native arteries of extremities with rest pain, right leg	I70.221
Atherosclerosis of native arteries of extremities with rest pain, left leg	I70.222
Atherosclerosis of native arteries of extremities with rest pain, bilateral legs	I70.223
Atherosclerosis of native arteries of extremities with rest pain, unspecified extremity	I70.229
Atherosclerosis of native arteries of right leg with ulceration of thigh	I70.231
Atherosclerosis of native arteries of right leg with ulceration of calf	I70.232
Atherosclerosis of native arteries of right leg with ulceration of ankle	I70.233
Atherosclerosis of native arteries of right leg with ulceration of heel and midfoot	I70.234
Atherosclerosis of native arteries of right leg with ulceration of other part of foot	I70.235
Atherosclerosis of native arteries of right leg with ulceration of other part of lower leg	I70.238
Atherosclerosis of native arteries of right leg with ulceration of unspecified site	I70.239

Atherosclerosis of native arteries of left leg with ulceration of thigh	I70.241
Atherosclerosis of native arteries of left leg with ulceration of calf	I70.242
Atherosclerosis of native arteries of left leg with ulceration of ankle	I70.243
Atherosclerosis of native arteries of left leg with ulceration of heel and midfoot	I70.244
Atherosclerosis of native arteries of left leg with ulceration of other part of foot	I70.245
Atherosclerosis of native arteries of left leg with ulceration of other part of lower leg	I70.248
Atherosclerosis of native arteries of left leg with ulceration of unspecified site	I70.249
Atherosclerosis of native arteries of extremities with gangrene, right leg	I70.261
Atherosclerosis of native arteries of extremities with gangrene, left leg	I70.262
Atherosclerosis of native arteries of extremities with gangrene, bilateral legs	I70.263
Atherosclerosis of native arteries of extremities with gangrene, other extremity	I70.268
Atherosclerosis of native arteries of extremities with gangrene, unspecified extremity	I70.269
Peripheral vascular disease, unspecified	I73.9
Embolism and thrombosis of arteries of the lower extremities	I74.3
Embolism and thrombosis of iliac artery	I74.5
Embolism and thrombosis of other arteries	I74.8
Stricture of artery	I77.1
Dissection of iliac artery	I77.72
Complication of other artery following a procedure, not elsewhere classified, initial encounter	T81.718A
Complication of other artery following a procedure, not elsewhere classified, subsequent encounter	T81.718D

Complication of other artery following a procedure, not elsewhere classified, sequela	T81.718S
Complication of unspecified artery following a procedure, not elsewhere classified, initial encounter	T81.719A
Complication of unspecified artery following a procedure, not elsewhere classified, subsequent encounter	T81.719D
Complication of unspecified artery following a procedure, not elsewhere classified, sequela	81.719S

non-invasive vascular study[22]	cpt codes
Duplex scan of lower extremity arteries or arterial bypass grafts	93926/93925 (partial/com plete)
Duplex scan of upper extremity arteries or arterial bypass grafts	93931/93930 (partial/com plete)
limited bilateral noninvasive physiologic studies of upper or lower extremity arteries, (eg, for lower extremity: ankle/brachial indices at distal posterior tibial and anterior tibial/dorsalis pedis arteries plus bidirectional, doppler waveform recording and analysis at 1-2 levels, or ankle/brachial indices at distal posterior tibial and anterior tibial/dorsalis pedis arteries plus volume plethysmography at 1-2 levels, or ankle/brachial indices at distal posterior tibial and anterior tibial/dorsalis pedis arteries with, transcutaneous oxygen tension measurement at 1-2 levels)	93922
complete bilateral noninvasive physiologic studies of upper or lower extremity arteries, 3 or more levels (eg, for lower extremity: ankle/brachial indices at distal posterior tibial and anterior tibial/dorsalis pedis arteries plus segmental blood pressure measurements with bidirectional doppler waveform recording and analysis, at 3 or more levels, or ankle/brachial indices at distal posterior tibial and anterior tibial/dorsalis pedis arteries plus segmental volume plethysmography at 3 or more levels, or ankle/brachial indices at distal posterior tibial and anterior tibial/dorsalis pedis arteries plus segmental transcutaneous oxygen tension measurements at 3 or more levels), or single level study with provocative functional maneuvers (eg,	93923

measurements with postural provocative tests, or measurements with reactive hyperemia)	
noninvasive physiologic studies of lower extremity arteries, at rest and following treadmill stress testing, (ie, bidirectional doppler waveform or volume plethysmography recording and analysis at rest with ankle/brachial indices immediately after and at timed intervals following performance of a standardized protocol on a motorized treadmill plus recording of time of onset of claudication or other symptoms, maximal walking time, and time to recovery) complete bilateral study	93924
endovascular diagnostic only	CPT codes
Introduction of catheter, aorta	36200
Selective catheter placement, arterial system, each first-order, lower-extremity	36245
Selective catheter placement, arterial system, second-order, lower-extremity	36246
Selective catheter placement, arterial system, third-order, lower-extremity	36247
Selective catheter placement, arterial system, beyond third order, lower- extremity	36248
endovascular procedure[23]	CPT codes
Transluminal peripheral atherectomy, open; aortic	35481
Transluminal peripheral atherectomy, open; iliac	35482
Transluminal peripheral atherectomy, percutaneous; aortic	35491
Transluminal peripheral atherectomy, percutaneous; iliac Outflow	35492
Transluminal balloon angioplasty, open; femoral-popliteal	35456
Transluminal balloon angioplasty, open; tibioperoneal trunk and branches	35459
Transluminal balloon angioplasty, percutaneous; tibioperoneal trunk or branches, each vessel	35470
Transluminal balloon angioplasty, percutaneous; femoral-popliteal	35474

35483 Transluminal peripheral atherectomy, open; femoral-popliteal	
Transluminal peripheral atherectomy, open; tibioperoneal trunk and branches	35485
Transluminal peripheral atherectomy, percutaneous; femoral-popliteal	35493
Transluminal peripheral atherectomy, percutaneous; tibioperoneal trunk and branches	35495
Transcatheter placement of an intravascular stent(s), (except coronary, carotid, and vertebral vessel), percutaneous; initial vessel	37205
Transcatheter placement of an intravascular stent(s), (except coronary, carotid, and vertebral vessel), percutaneous; each additional vessel	37206
Transcatheter placement of an intravascular stent(s), (noncoronary vessel), open; initial vessel	37207
Transcatheter placement of an intravascular stent(s), (noncoronary vessel), open; each additional vessel	37208
open procedure[23]	CPT codes
Bypass graft, with vein; axillary-femoral	35521
Thromboendarterectomy, including patch graft, if performed; iliac	35351
Thromboendarterectomy, including patch graft, if performed; iliofemoral	35355
Thromboendarterectomy, including patch graft, if performed; combined aortoiliac	35361
Thromboendarterectomy, including patch graft, if performed; combined aortoiliofemoral 35537 Aortoiliac bypass	35363
Bypass graft, with vein; aortobi-iliac	35538
Bypass graft, with vein; aortofemoral	35539
Bypass graft, with vein; aortobifemoral	35540
Bypass graft, with vein	35541

Aortofemoral bypass with vein	35546
Aortofemoral graft with vein. For aortofemoral graft with vein	35539
Bypass graft, with vein; aortoiliofemoral, unilateral	35548
Bypass graft, with vein; aortoiliofemoral, bilateral	35549
Bypass graft, with vein; aortofemoral-popliteal	35551
Bypass graft, with vein; ilioiliac	35563
Bypass graft, with vein; iliofemoral	35565
Bypass graft, with other than vein; axillary-femoral	35621
Bypass graft, with other than vein; axillary-popliteal or -tibial	35623
Bypass graft, with other than vein; aortoiliac	35637
Bypass graft, with other than vein; aortobi-iliac	35638
Bypass graft, with other than vein; aortobifemoral	35646
Bypass graft, with other than vein; aortofemoral	35647
Bypass graft, with other than vein; aortofemoral-popliteal	35651
Bypass graft, with other than vein; axillary-femoral-femoral	35654
Bypass graft, with other than vein; femoral-femoral	35661
Bypass graft, with other than vein; ilioiliac	35663
Bypass graft, with other than vein; iliofemoral	35665
Outflow	
Thromboendarterectomy, including patch graft, if performed; superficial femoral artery	35302
Thromboendarterectomy, including patch graft, if performed; popliteal artery	35303
Thromboendarterectomy, including patch graft, if performed; tibioperoneal trunk artery	35304
Thromboendarterectomy, including patch graft, if performed; tibial or peroneal artery,	35305
Thromboendarterectomy, including patch graft, if performed; each	35306

additional tibial	
Thromboendarterectomy, including patch graft, if performed; common femoral	35371
Thromboendarterectomy, including patch graft, if performed; deep (profunda) femoral	35372
Bypass graft, with vein; axillary-femoral-femoral	35533
Bypass graft, with vein; femoral-popliteal	35556
Bypass graft, with vein; femoral-femoral	35558
Bypass graft, with vein; femoral-anterior tibial, posterior tibial, peroneal artery	35566
Bypass graft, with vein; popliteal-tibial, -peroneal artery or other distal vessels	35571
In-situ vein bypass; femoral-popliteal	35583
In-situ vein bypass; femoral-anterior tibial, posterior tibial, or peroneal artery	35585
In-situ vein bypass; popliteal-tibial, peroneal	35587
Bypass graft, with other than vein; femoral-popliteal	35656
Bypass graft, with other than vein; femoral-anterior tibial, posterior tibial, or peroneal artery	35666
Bypass graft, with other than vein; popliteal-tibial or -peroneal artery	35671
Bypass graft; composite, prosthetic and vein	35681
Bypass graft; autogenous composite, two segments of veins from two locations	35682
Bypass graft; autogenous composite, three or more segments of vein	35683
Revision, lower extremity arterial bypass, without thrombectomy, open; with vein patch angioplasty	35879
Revision, lower extremity arterial bypass, without thrombectomy, open; with segmental vein interposition	35881
Revision, femoral anastomosis of synthetic arterial bypass graft in groin, open; with nonautogenous patch graft	35883

Revision, femoral anastomosis of synthetic arterial bypass graft in groin, open; with autogenous vein patch graft	35884
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