Overuse of early peripheral vascular interventions for claudication

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ABSTRACT

Objective: Guidelines from the Society for Vascular Surgery and the Choosing Wisely campaign recommend that peripheral vascular interventions (PVIs) be limited to claudication patients with lifestyle-limiting symptoms only after a failed trial of medical and exercise therapy. We sought to explore practice patterns and physician characteristics associated with early PVI after a new claudication diagnosis to evaluate adherence to these guidelines.

Methods: We used 100% Medicare fee-for-service claims to identify patients diagnosed with claudication for the first time between 2015 and 2017. Early PVI was defined as an aortoiliac or femoropopliteal PVI performed within 6 months of initial claudication diagnosis. A physician-level PVI utilization rate was calculated for physicians who diagnosed >10 claudication patients and performed at least one PVI (regardless of indication) during the study period. Hierarchical multivariable logistic regression was used to identify physician-level factors associated with early PVI.

Results: Of 194,974 patients who had a first-time diagnosis of claudication during the study period, 6286 (3.2%) underwent early PVI. Among the 5664 physicians included in the analysis, the median physician-level early PVI rate was low at 0% (range, 0%-58.3%). However, there were 320 physicians (5.6%) who had an early PVI rate ≥14% (≥2 standard deviations above the mean). After accounting for patient characteristics, a higher percentage of services delivered in ambulatory surgery center or office settings was associated with higher PVI utilization (vs 0%-22%; 23%-47%: adjusted odds ratio [aOR], 1.23; 48%-68%: aOR, 1.49; 69%-100%: aOR, 1.72; all $P < .05$). Other risk-adjusted physician factors independently associated with high PVI utilization included male sex (aOR, 2.04), fewer years in practice (vs ≥31 years; 11-20 years: aOR, 1.23; 21-30 years: aOR, 1.13), rural location (aOR, 1.25), and lower volume claudication practice (vs ≥30 patients diagnosed during study period; ≤17 patients: aOR, 1.30; 18-29 patients: aOR, 1.35; all $P < .05$).

Conclusions: Outlier physicians with a high early PVI rate for patients newly diagnosed with claudication are identifiable using a claims-based practice pattern measure. Given the shared Society for Vascular Surgery and Choosing Wisely initiative goal to avoid interventions for first-line treatment of claudication, confidential data-sharing programs using national benchmarks and educational guidance may be useful to address high utilization in the management of claudication. (J Vasc Surg 2020;71:121-30.)

Keywords: Claudication; Peripheral vascular intervention; Utilization

An estimated 11% of all medical procedures are unnecessary,[1] a quality issue that has garnered increased attention, given the U.S. health care cost crisis. Although the problem has been described worldwide,[2] an estimated 2.7% of annual Medicare spending is spent on low-value services in the United States, affecting 42% of beneficiaries.[3] To address this problem, physicians have developed appropriateness criteria, formed specialty association guidelines, and participated in the Choosing Wisely initiative, which seeks to improve quality of care and the distribution of finite health care resources through appropriate use of tests, treatments, and procedures using evidence-based guidelines.[4]

In 2015, the Society for Vascular Surgery (SVS) partnered with Choosing Wisely to identify common low-value practices in vascular surgery that should be questioned by physicians and patients. One of the measures identified was the use of invasive vascular interventions for first-line treatment of patients with intermittent claudication.[5] In addition, following studies reporting that lower extremity endovascular interventions had tripled from the late 1990s to mid-2000s,[6,7] both the SVS and the American Heart Association published guidelines recommending that procedures such as lower extremity bypass operations and endovascular peripheral vascular interventions (PVIs) for claudication be performed only for patients with persistent lifestyle-limiting claudication

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after a trial of medical management and exercise therapy.[8,9] Notably, both sets of guidelines cited the very low risk of progression of claudication to chronic limb-threatening ischemia,[8,9] with major amputation occurring in <5% of affected patients after 10 years of follow-up.[10] In contrast, a recent study of Medicare beneficiaries found that 4.1% of patients undergoing outpatient atherectomy for claudication required subsequent major amputation within just 1.5 years,[11] suggesting that PVI carries a risk for limb loss that may be worse than the natural history of medically managed claudication.

In this study, we sought to explore adherence to the published practice guidelines for treatment of intermittent claudication[8,9] by examining physician practice patterns of early PVI performed within 6 months of a new diagnosis of claudication and to identify patient and physician characteristics associated with early PVI. In addition, we examined whether these practice patterns could be used to identify outlier physicians with high utilization of early PVI for claudication.

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective national cohort study
- **Key Findings:** For 5664 physicians who diagnosed 194,974 patients with claudication, the mean early peripheral vascular intervention rate (within 6 months of claudication diagnosis) was 3.5%, with 320 physicians (5.6%) who had an intervention rate ≥14% (≥2 standard deviations above mean). Physicians with higher intervention rates performed a greater percentage of their interventions in an ambulatory center or office-based laboratory compared with a hospital setting.
- **Take Home Message:** This study suggests that practice patterns in large data can identify outlier physicians with high utilization of early peripheral vascular intervention for patients newly diagnosed with claudication.

METHODS

Study population. We used 100% Medicare fee-for-service claims to identify patients diagnosed with claudication for the first time between January 1, 2015, and December 31, 2017. Claudication was defined by *International Classification of Diseases* (ICD) codes (ICD-9: 440.20, 440.21, 443.9; ICD-10: I70.20, I70.21, I73.9). We then determined whether each patient underwent an aortoiliac or femoropopliteal PVI within 6 months after the first claudication diagnosis (ie, an early PVI) based on *Current Procedural Terminology* codes (Supplementary Table, online only). We chose the 6-month cutoff for our analysis because the optimal exercise program for improving claudication pain in patients with peripheral artery disease uses intermittent walking to near-maximal pain during a program of at least 6 months.[12] The latest follow-up date was June 30, 2018. We required the early PVI to be performed by the same physician who made the initial diagnosis of claudication.

We excluded patients who had a PVI (regardless of the indication) before the first claudication diagnosis (n = 11,953); patients who had a diagnosis of chronic limb-threatening ischemia (ie, rest pain or tissue loss; Supplementary Table, online only) before or within 6 months after the first claudication diagnosis (n = 1,473,217); patients who received the first claudication diagnosis from a nonproceduralist (n = 1,402,572), defined as a physician who did not perform any PVI (regardless of indication) during the study period; patients who had <12 months of enrollment in Medicare Parts A and B before the first claudication diagnosis (n = 38,271) to ensure a minimal washout period and to have enough claims data available to assess comorbidities; patients younger than 18 years (n = 4); and patients missing demographic information (n = 90). This study was approved by the Johns Hopkins Medicine Institutional Review Board with waiver of informed consent because the data are publicly available.

Patient characteristics. We obtained patients' demographic information including age, sex, race, and ZIP code of residence from the Medicare Master Beneficiary Summary File. ZIP code was mapped to Federal Information Processing Standard (FIPS) code using the sashelp.zipcode file (SAS Institute, Cary, NC). FIPS code was used to determine state and census region of residence. We then mapped FIPS code to core-based statistical area (CBSA) code using CBSA to FIPS County Crosswalk available from the National Bureau of Economics Research.[13] CBSA code was used to determine the population density of residence as urban or rural. Urban areas were metropolitan areas containing an urban core of ≥50,000 population.[14] Rural areas were all areas that did not qualify as metropolitan.

We reviewed patients' claims within the 12 months before and on the day of the first claudication diagnosis to determine the comorbidity status of end-stage renal disease, diabetes, and hypertension as well as history of ever smoking. To define a comorbidity, we required at least one diagnosis from the inpatient claims or at least two diagnoses recorded >30 days apart from the outpatient or carrier claims.[15,16] To define an ever smoker, we required at least one diagnosis of smoking from any type of claim.[17] We also determined whether patients had undergone noninvasive testing with ankle-brachial indices within 3 months before or after the first claudication diagnosis using the codes listed in the Supplementary Table (online only).

Physician characteristics. We calculated a physician-level early PVI rate for all physicians who diagnosed >10 patients with claudication for the first time and performed at least one PVI (regardless of indication) during the study period. The denominator was the number of patients a physician diagnosed with claudication for the first time, and the numerator was the number of patients from the denominator who underwent a PVI within 6 months of the diagnosis of claudication by the same physician. We plotted the national distribution of physician-level early PVI rate in a histogram. Physician outliers were defined as those physicians who had an early PVI rate ≥2 standard deviations from the mean. We obtained information on physicians' characteristics from Medicare Data on Provider Practice and Specialty[18] and Physician Compare National Downloadable File.[19] Physician characteristics of interest included sex, years since graduation from medical school (stratified by decade), primary specialty, census region of practice location, population density of practice location, number of patients diagnosed with claudication for the first time during the study period (stratified by tertiles), and overall percentage of services delivered in the setting of a freestanding ambulatory surgery center (ASC) or office-based laboratory (OBL) vs an inpatient or outpatient hospital setting during the study period (stratified by quartiles). Medicare Data on Provider Practice and Specialty have summary statistics on each physician's number of service line items rendered for Medicare beneficiaries by setting in each year, which we used as the source for estimating a physician's percentage of services delivered in an ASC or OBL.

Statistical analysis. Patient- and physician-level characteristics were described using median (interquartile range [IQR]), mean ± standard deviation, and count (percentage), as appropriate. Univariable logistic regression analyses were used to assess the association of individual patient and physician characteristics with early PVI. We then used a hierarchical logistic regression model to identify risk-adjusted patient- and physician-level characteristics associated with the use of an early PVI. The outcome modeled was whether a patient underwent an early PVI (ie, within 6 months of the initial diagnosis of claudication). The first-level covariates included patient characteristics including age, sex, race, comorbidities, and smoking history. The second-level covariates included physician characteristics including sex, years in practice, census region of practice, population density of practice, primary specialty, number of patients diagnosed with claudication for the first time, and percentage of services delivered in a freestanding ASC or OBL. We included a random intercept for physician to account for patient clustering within physician. All statistical analyses were performed using SAS Enterprise Guide version 7.1 (SAS Institute).

RESULTS

Patient cohort. Overall, 194,974 patients had a first-time diagnosis of claudication during the study period, of whom 6286 (3.2%) underwent PVI within 6 months (Table I). Among those patients who underwent PVI, the median time from claudication diagnosis to intervention was 22 days (IQR, 4-53 days). Patients who underwent early PVI more frequently had recent noninvasive testing with an ankle-brachial index within 3 months of the first claudication diagnosis (50.1%) than patients without an early PVI (45.5%), although testing rates were low in both groups.

The median patient age was 71.6 years (IQR, 67.3-78.0 years), 56.8% (n = 110,680) were male, and 81.7% (n = 159,390) were white. The majority of patients lived in urban locations (79.5% [n = 154,920]), and approximately half lived in the South (48.4% [n = 94,328]). Forty-four percent of patients (n = 85,676) had a history of smoking, hypertension was present in 87.5% (n = 170,697), diabetes was present in 40.4% (n = 78,846), and end-stage renal disease was present in 3.1% (n = 6141).

Physician cohort. There were 5664 physicians who diagnosed >10 patients with claudication for the first time during the study period. The median and mean early PVI rates were 0% (IQR, 0%-5.9%) and 3.5% ± 5.4%, respectively. More than half of physicians (54.5% [n = 3086]) had an early PVI rate of 0%. There were 320 physicians (5.6%) who had PVI rates ≥14%, which was ≥2 standard deviations above the mean (Fig).

The majority of physicians included in the analysis were male (95.9% [n = 5430]) and practiced in urban locations (92.6% [n = 5243]; Table II). The median number of years in practice was 23 years (IQR, 16-30 years), and the median number of patients who received a new diagnosis of claudication during the study period was 22 (IQR, 15-34). The highest proportion of physicians were cardiologists (48.6% [n = 2755]), followed by vascular surgeons (30.7% [n = 1738]), radiologists (10.1% [n = 573]), general surgeons (5.3% [n = 299]), and cardiothoracic surgeons (3.2% [n = 183]). The median percentage of services delivered in an ASC or OBL was 46.8% (IQR, 22.3%-67.9%).

Patient and physician characteristics associated with early PVI. Based on univariable logistic regression analysis, patient characteristics associated with higher early PVI rates included age 65 to 74 years, male sex, hypertension, and smoking (all $P < .001$; Table III). Asian or Hispanic race/ethnicity (vs white) was associated with lower early PVI rates (both $P \leq .002$; Table III). Physician characteristics associated with higher early PVI rates included male sex, 11 to 30 years in practice (vs ≥31 years), rural location, lower volume claudication practice, and higher percentage of services delivered in an ASC or OBL vs a hospital-based setting (all $P \leq .01$; Table III). Physicians practicing in the Northeast had lower rates of early PVI compared with physicians practicing in the South (Table III; $P \leq .02$).

Table I. Characteristics of patients who underwent early (within 6 months of receiving a diagnosis of claudication) peripheral vascular intervention (*PVI*) vs those managed without an intervention

Patient characteristics	Patients without an early PVI (n = 188,688)	Patients with an early PVI (n = 6286)	*P* value
Age, years	71.7 (67.3-78.1)	70.5 (66.9-76.3)	<.0001
≤64 years	24,481 (13.0)	841 (13.4)	
65-74 years	96,588 (51.2)	3593 (57.2)	
75-84 years	52,195 (27.7)	1481 (23.6)	
85-94 years	14,802 (7.8)	365 (5.8)	
≥95 years	622 (0.3)	6 (0.1)	
Sex			
Male	106,805 (56.6)	3875 (61.6)	<.0001
Female	81,883 (43.4)	2411 (38.4)	
Race			
White	154,147 (81.7)	5243 (83.4)	<.0001
Black	19,970 (10.6)	676 (10.8)	
Asian	3570 (1.9)	67 (1.1)	
Hispanic	4472 (2.4)	116 (1.9)	
North America Native	947 (0.5)	32 (0.5)	
Other or unknown	5582 (3.0)	152 (2.4)	
Population density of residence			
Urban	150,242 (79.6)	4678 (74.4)	<.0001
Rural	38,446 (20.4)	1608 (25.6)	
Census region of residence			
Midwest	39,200 (20.8)	1417 (22.5)	<.0001
Northeast	31,045 (16.5)	675 (10.7)	
South	91,126 (48.3)	3202 (50.9)	
West	26,907 (14.3)	983 (15.6)	
Other	410 (0.2)	9 (0.1)	
ABI within ±3 months of claudication diagnosis			
Yes	85,918 (45.5)	3151 (50.1)	<.0001
No	102,770 (54.5)	3135 (49.9)	
Comorbidities			
ESRD	5960 (3.2)	181 (2.9)	.21
Diabetes	76,289 (40.4)	2557 (40.7)	.70
Hypertension	165,062 (87.5)	5635 (89.6)	<.0001
Smoking history			
Never	106,897 (56.7)	2401 (38.2)	<.0001
Ever	81,791 (43.4)	3885 (61.8)	

ABI, Ankle-brachial index; *ESRD,* end-stage renal disease.
Categorical variables are presented as number (%). Continuous variables are presented as median (interquartile range).

Based on hierarchical logistic regression modeling, patient characteristics associated with high early PVI rates included age 65 to 74 years ($P < .001$), male sex (odds ratio [OR], 1.14; 95% confidence interval [CI], 1.08-1.20), hypertension (OR, 1.16; 95% CI, 1.06-1.27), and smoking (OR, 2.02; 95% CI, 1.91-2.14). Asian patients had a lower odds of receiving early PVI compared with white patients (OR, 0.70; 95% CI, 0.54-0.91). Risk-adjusted physician characteristics associated with higher early PVI rates included male sex (OR, 2.04; 95% CI, 1.61-2.56), 11 to 20 years [OR, 1.23; 95% CI, 1.11-1.36) or 21 to 30 years (OR, 1.13; 95% CI, 1.03-1.25) in practice (vs ≥31 years in practice), rural location (OR, 1.25; 95% CI, 1.09-1.440), lower volume claudication practice ($P < .001$), and higher percentage of PVI services provided in an ASC or OBL ($P \leq .001$; Table III). Compared with physicians in the lowest quartile of ASC or OBL use, the odds of early PVI utilization increased sequentially for each ASC or OBL utilization quartile (Table III; *P* value for trend <.001). There were also significant variations in early PVI utilization by practice specialty and region (Table III).

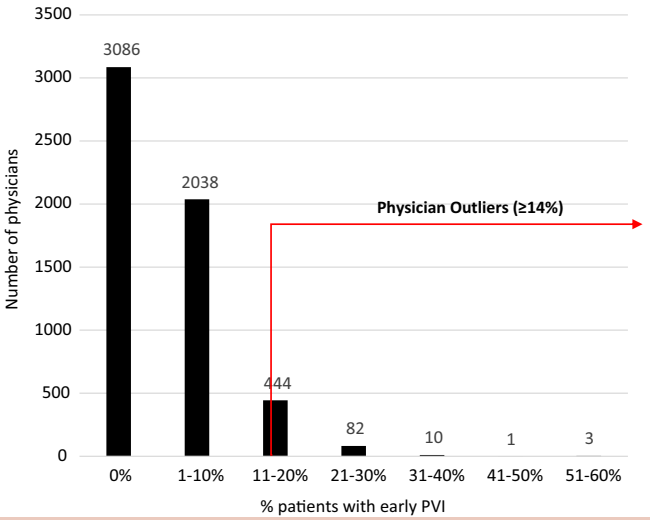

Fig. National distribution of physician-level early peripheral vascular intervention (*PVI*) rate.

Description of top outlier physicians. There were 320 physicians with an early PVI rate ≥14%. These 320 physicians collectively performed 1366 procedures on 7068 patients newly diagnosed with claudication during the course of the 2-year study period. The top three outlier physicians had early PVI rates >50% (Table IV). Notably, all three of those physicians performed >70% of their PVI interventions in an ASC or OBL. Among the top 10 physician outliers, all were male, the median number of years in practice was 24 years (range, 13-35 years), and the number of patients diagnosed with claudication varied widely (median, 16 patients; range, 11-57 patients). Cardiologists composed 50.0% (n = 5) of the group, followed by vascular surgeons (20.0% [n = 2]) and general surgeons (20.0% [n = 2]) and one radiologist (10.0%). Of the top 10 outliers, their patients' median time from claudication diagnosis to PVI ranged from 0 to 47 days (median, 11.8 days).

Economic impact. The overall Medicare-allowed payment for all 6286 early PVIs was $77,832,218 (professional fee, $20,841,019; facility fee, $56,991,199). The Medicare-allowed payments for the 1366 early PVIs performed by outlier physicians was $17,766,467 (professional fee, $5,781,219; facility fee, $11,985,248). The median Medicare payment for early PVI across all patients newly diagnosed with claudication was $0 for those treated by inlier physicians (IQR, $0-$435) and $1983 for patients treated by outlier physicians (IQR, $1455-$2941).

DISCUSSION

In this national study of Medicare claims data, we studied practice patterns and physician factors associated with high utilization of early PVI in the 6 months after a new claudication diagnosis. We found that although the majority of physicians followed published practice guidelines recommending judicious use of early PVI for claudication, there was a small proportion of physicians with high early PVI rates that fell well outside the mean intervention rates of their peers. After risk adjusting for patient characteristics, we identified a number of physician characteristics associated with high early PVI utilization, including sex, years in practice, and claudication practice volume. Notably, we also found that physicians who delivered a higher percentage of services in an ASC or OBL tended to have higher early PVI utilization rates compared with those who deliver more services in a hospital-based setting. Our findings suggest that there is room for improvement in the treatment of early claudication in the United States and highlight an opportunity to identify outlier physicians using a peer-benchmarked practice pattern measure.

During our study period of 2015 to 2017, we found that the physician-level distribution of early PVI rates was right skewed, and more than half of physicians had an early PVI rate of 0%. This suggests wide adoption of existing clinical practice guidelines[8,9] compared with earlier reports on interventions for claudication. In 1984, Cronenwett et al[20] reported an annual operation rate of 9% in their cohort of 91 men with claudication, whereas Muluk et al[10] found that the 10-year cumulative incidence of surgical revascularization was 18% in a study of 2777 male veterans with claudication who received care at a Veterans Affairs hospital between 1983 and 1998. The more conservative practice patterns we found in our study also likely reflect a number of other factors, including increasing knowledge of the outcomes of medical management and walking programs[8,9]; Medicare reimbursement of supervised walking programs, which was newly established beginning in 2018[21]; and awareness of the complications associated with PVI in patients with an otherwise low risk for limb loss, including need for reintervention or major amputation.[11,22] Importantly, patients do not accept the risks associated with interventions for claudication; in a survey of 50 patients with claudication, the median risk acceptance for major amputation and death as a complication was 0%.[23] Furthermore, there was no association between shorter walking distance and greater acceptance of amputation risk with treatment.[23]

The association between higher early PVI rate and high-volume ASC or OBL services supports the concern that some procedures for claudication may be overused for financial gain. Our findings additionally describe baseline ASC and OBL utilization that can be used for comparison of trends in utilization over time as the reimbursement landscape continues to evolve. Medicare reimbursement differs significantly by the location where a procedure is performed. For example, the 2018 Medicare reimbursement for a femoropopliteal atherectomy and stent placement (*Current Procedural Terminology* code 37225) is $10,864 for procedures performed in an ASC

Table II. Physician[a] characteristics stratified by early peripheral vascular intervention (*PVI*) rate (<14% vs ≥14%)

Physician characteristics	Physicians with an early PVI rate <14% (n = 5344)	Physicians with an early PVI rate ≥14% (n = 320)	*P* value
Sex			
Male	5115 (95.7)	315 (98.4)	.02
Female	229 (4.3)	5 (1.6)	
Years since medical school graduation	23 (16-31)	21 (15-29)	.06
≤10 years	395 (7.4)	21 (6.6)	
11-20 years	1761 (33.0)	126 (39.4)	
21-30 years	1748 (32.7)	98 (30.6)	
≥31 years	1308 (24.5)	67 (20.9)	
Unknown	132 (2.5)	8 (2.5)	
Census region of practice location			
Midwest	1187 (22.2)	80 (25.0)	.001
Northeast	892 (16.7)	29 (9.1)	
South	2538 (47.5)	152 (47.5)	
West	720 (13.5)	59 (18.4)	
Other	7 (0.1)	0 (0.0)	
Population density of practice location			
Urban	4954 (92.7)	289 (90.3)	.11
Rural	390 (7.3)	31 (9.7)	
Specialty			
Cardiology	2584 (48.4)	171 (53.4)	.33
Cardiothoracic surgery	172 (3.2)	11 (3.4)	
General surgery	282 (5.3)	17 (5.3)	
Radiology	548 (10.3)	25 (7.8)	
Vascular surgery	1651 (30.9)	87 (27.2)	
Other	107 (2.0)	9 (2.8)	
No. of patients diagnosed with claudication for the first time during study period	22 (15-35)	18 (13-25)	<.0001
≤17	1886 (35.3)	156 (48.8)	
18-29	1692 (31.7)	115 (35.9)	
≥30	1766 (33.1)	49 (15.3)	
Percentage of services delivered in ASC or OBL	46.3 (21.5-67.7)	53.5 (33.8-70.8)	.0006
0%-22%	1370 (25.6)	55 (17.2)	
23%-47%	1388 (26.0)	77 (24.1)	
48%-68%	1293 (24.2)	99 (30.9)	
69%-100%	1293 (24.2)	89 (27.8)	
Time from claudication diagnosis to PVI, days	28 (8-55)	19 (8-37)	<.0001

ASC, Ambulatory surgery center; *OBL*, office-based laboratory.
Categorical variables are presented as number (%). Continuous variables are presented as median (interquartile range).
[a]Included physicians who diagnosed >10 patients with claudication for the first time during the study period.

compared with only $765 for procedures performed in a hospital setting.[24] This must be considered in the broader context of ASC utilization for Medicare beneficiaries. Hollenbeck et al[25] found that rather than redistributing patients from hospital settings to ASCs, outpatient surgery rates in areas where ASCs were opened increased by 10.9% between 2001 and 2010, which was significantly higher than the 2.4% increase where ASCs were already present and 0.6% increase in areas where ASCs were never present. In another study of Medicare claims for endovascular interventions, there was a 298% increase in atherectomy cases in the OBL setting from 2011 to 2014 compared with a 27% increase in the hospital outpatient setting.[26] These trends are particularly concerning, given that office-based PVI has been associated with a higher risk of repeated revascularization compared with PVI performed in other settings.[27]

Table III. Hierarchical logistic regression assessing patient- and physician-level characteristics associated with early peripheral vascular intervention (PVI)

Patient-level characteristics	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Age		
≤64 years	0.92 (0.86-1.00)	0.84 (0.77-0.91)
65-74 years	Reference	Reference
75-84 years	0.76 (0.72-0.81)	0.77 (0.72-0.82)
85-94 years	0.65 (0.58-0.72)	0.73 (0.65-0.82)
≥95 years	0.27 (0.12-0.60)	0.37 (0.16-0.83)
Sex		
Male	Reference	Reference
Female	0.81 (0.77-0.85)	0.88 (0.83-0.93)
Race		
White	Reference	Reference
Black	1.00 (0.92-1.09)	1.04 (0.95-1.14)
Asian	0.53 (0.41-0.68)	0.70 (0.54-0.91)
Hispanic	0.74 (0.61-0.89)	0.91 (0.74-1.11)
North America Native	1.00 (0.70-1.43)	0.93 (0.64-1.36)
Other or unknown	0.80 (0.68-0.94)	0.91 (0.77-1.09)
End-stage renal disease		
Yes	0.90 (0.77-1.05)	0.90 (0.77-1.06)
No	Reference	Reference
Diabetes		
Yes	1.01 (0.96-1.06)	1.02 (0.96-1.08)
No	Reference	Reference
Hypertension		
Yes	1.25 (1.15-1.36)	1.16 (1.06-1.27)
No	Reference	Reference
Smoking		
Ever	2.13 (2.02-2.25)	2.02 (1.91-2.14)
Never	Reference	Reference
Physician-level characteristics	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)**
Sex		
Male	Reference	Reference
Female	0.51 (0.43-0.61)	0.49 (0.39-0.62)
Years since medical school graduation		
0-10 years	0.98 (0.87-1.10)	1.12 (0.96-1.31)
11-20 years	1.23 (1.15-1.31)	1.23 (1.11-1.36)
21-30 years	1.09 (1.02-1.17)	1.13 (1.03-1.25)
≥31 years	Reference	Reference
Census region of practice location		
Midwest	1.02 (0.96-1.09)	1.03 (0.93-1.14)
Northeast	0.59 (0.54-0.64)	0.65 (0.58-0.74)
South	Reference	Reference
West	1.01 (0.94-1.09)	1.01 (0.90-1.13
Other	0.18 (0.05-0.73)	0.26 (0.06-1.22)
Population density of practice location		
Urban	Reference	Reference
Rural	1.30 (1.19-1.42)	1.25 (1.09-1.44)
Specialty		
Cardiology	1.05 (0.99-1.11)	0.96 (0.88-1.05)
Cardiothoracic surgery	0.88 (0.75-1.03)	0.77 (0.61-0.96)

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Table III. Continued.

Physician-level characteristics	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
General surgery	0.96 (0.85-1.09)	0.88 (0.73-1.05)
Radiology	0.50 (0.44-0.56)	0.52 (0.44-0.61)
Vascular surgery	Reference	Reference
Other	0.94 (0.79-1.11)	0.92 (0.71-1.19)
No. of patients diagnosed with claudication for the first time during study period		
≤17	1.08 (1.02-1.15)	1.30 (1.19-1.43)
18-29	1.30 (1.22-1.38)	1.35 (1.22-1.50)
≥30	Reference	Reference
Percentage of services delivered in ASC or OBL		
0%-22%	Reference	Reference
23%-47%	1.37 (1.26-1.49)	1.23 (1.09-1.38)
48%-68%	1.59 (1.47-1.72)	1.49 (1.32-1.68)
69%-100%	1.60 (1.49-1.73)	1.72 (1.52-1.94)

ASC, Ambulatory surgery center; *CI*, confidence interval; *OBL*, office-based laboratory; *OR*, odds ratio.

Other physician factors that were independently associated with higher early PVI rates for claudication included male sex, few years in practice, and lower volume claudication practice. The latter two findings suggest that there is a role for improved education about the indication for and risk factors associated with invasive interventions for claudication. In a retrospective review of vascular surgery resident case logs, Keeling et al[28] demonstrated that resident-logged interventions for claudication increased by 62% during a 6-year period, nearly all of which was attributable to an increased number of endovascular interventions. This suggests that there may be a need for better trainee education about the appropriateness of using invasive interventions to treat claudication. In addition to the SVS and American Heart Association guidelines that clearly describe the medical management for claudication, including use of an aspirin, statin, cilostazol (when appropriate), and supervised exercise therapy,[8,9] the SCORE curriculum for vascular surgery has a dedicated module designed to educate trainees about the treatment of intermittent claudication.[29] These resources should be standard fare in the vascular trainee and attending toolbox, and a trial of medical management before consideration of any intervention should be recognized as standard of care. Notably, our cohort of physicians was mainly composed of cardiologists (49%) and vascular surgeons (31%), demonstrating a continued growth of cardiologists providing PVIs in recent years. Previously, Goodney et al[6] reported that between 1996 and 2006, cardiologists' percentage of PVIs grew from 23% to 41%. As a result, it is important that a directed educational initiative be included in cardiology curricula as well.

The use of a peer-benchmarked performance report to improve outlier performance is not a new concept. On a hospital level, the American College of Surgeons National Surgical Quality Improvement Program uses a validated, risk-adjusted, outcomes-based program designed to provide meaningful outcomes data benchmarked to like-medical centers.[30] Similarly, the Vascular Quality Initiative provides institution-level feedback on performance and outcomes in vascular surgery.[31] These prior benchmarking successes have largely focused on examining how peer-benchmarked feedback can decrease costs and improve outcomes in surgery.[32-34] However, in addition to institution-level feedback, physician-level feedback can be powerful in quality improvement.[35] In a recent study of 2329 Mohs micrographic surgeons,[36] the distribution of individualized peer-benchmarked performance reports successfully reduced the number of stages per case in 83% of outliers, resulting in an estimated $11 million in health care savings. Similarly, peer benchmarking also substantially changed physician behavior in a cohort of physicians who received peer comparison letters about their high-volume prescribing frequency of quetiapine in older patients.[37] Finally, in a study at our institution, we observed a reduction in unnecessary blood transfusions among surgeons who were given a transfusion report accounting for case type, complexity, and comorbidity relative to peers[34] and are now applying the model in a national collaborative to reduce opioid overprescribing in narcotic-naive patients after standardized procedures.[38] These studies demonstrate that physicians with outlier practice patterns can be identified using claims data and that individual physician-level feedback can have an impact on the problem of low-value and unnecessary care. We suggest that the SVS consider a confidential physician-level feedback

Table IV. Statistics of top 10 outlier physicians in the United States

Physician	Sex	Years since graduation	Location	Specialty	PVIs performed in ASC or OBL setting, %	Total No. of claudication patients diagnosed during study period	Early PVI rate	Median time from diagnosis to PVI, days
A	Male	29	Florida	Cardiology	77.0	12	58.3	12
B	Male	13	New Jersey	Radiology	100.0	11	54.5	12
C	Male	16	Florida	Vascular surgery	70.8	57	50.9	26
D	Male	16	Mississippi	Cardiology	37.0	27	44.4	2.5
E	Male	33	Kansas	Cardiology	100.0	19	36.8	5
F	Male	30	Kentucky	Cardiology	53.6	11	36.4	2
G	Male	19	North Carolina	General surgery	20.7	11	36.4	11.5
H	Male	34	Georgia	General surgery	96.1	14	35.7	47
I	Male	16	California	Cardiology	11.6	18	33.3	0
J	Male	35	California	Vascular surgery	91.9	22	31.8	29

ASC, Ambulatory surgery center; *OBL*, office-based laboratory; *PVI*, peripheral vascular intervention.

initiative using national benchmarks to address extreme outliers in the management of claudication.

Limitations of these results are inherent in the use of claims data, including lack of clinically relevant information, such as patient activity levels and severity of symptoms, as well as accuracy of comorbid conditions and smoking status. Although we excluded patients diagnosed with claudication who had rest pain, tissue loss (gangrene, ulcer), or other codes corresponding to chronic limb-threatening ischemia, it is possible that some patients were still miscoded. It is also difficult to describe the medical management prescribed for patients with claudication before the intervention; supervised exercise therapy is often discussed with patients in the outpatient setting but rarely formally prescribed, given that it was not reimbursed by Medicare until 2018.[21] Aspirin is available as an over-the-counter medication and thus frequently not documented in Medicare Part D claims. We excluded patients who had a diagnosis of claudication before seeing a proceduralist; thus, we cannot comment on PVI utilization practices for patients who were initially managed by nonproceduralists, such as internists. In addition, it is possible that despite our use of a 12-month washout period, there were patients who had been diagnosed with claudication before their Medicare coverage began and therefore may have been misclassified as having a new diagnosis. The strengths of our results include the use of a national patient cohort and the ability to identify specific physician characteristics associated with claudication practice patterns, including the location of PVI services provided.

CONCLUSIONS

We found that a practice patterns approach to quality science[39] can identify physicians with high utilization of early PVI for patients newly diagnosed with claudication. We additionally found that early PVI utilization was higher for physicians who had a higher percentage of services performed in an ASC or OBL setting. Given the shared SVS and Choosing Wisely initiative to reduce unnecessary invasive interventions, a confidential data-sharing program using national benchmarks and educational resources may be useful to address high early PVI utilization in the management of claudication.

AUTHOR CONTRIBUTIONS

Conception and design: CWH, CMH, PW, JB, CA, MM
Analysis and interpretation: CWH, CMH, PW, MM
Data collection: PW, MM
Writing the article: CWH, CMH, PW, JB, CA, MM
Critical revision of the article: CWH, CMH, PW, JB, CA, MM
Final approval of the article: CWH, CMH, PW, JB, CA, MM
Statistical analysis: PW
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Overall responsibility: CWH
CWH and CMH contributed equally to this article and share co-first authorship.

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Supplementary Table (online only). Billing codes used for analysis

Diagnosis or procedure	Code type	Codes
Claudication	ICD-9[a]	440.20, 440.21, 443.9
	ICD-10[b]	I70.20, I70.21, I73.9
Chronic limb-threatening ischemia	ICD-9[a]	440.22-440.24, 440.4, 440.8, 442.3, 444.22, 444.81, 445.02, 682.6-682.7, 707.1, 707.9, 785.4, 250.70, 250.80, 729.5, 730.27, 892.1, 998.83, 996.74
	ICD-10[b]	I70.22-I70.26, I70.8, I70.92, I72.4, I74.3, I74.5, I75.021-I75.022, L03.115-L03.116, L97, L98.499, I96, E11.52, E11.621, M79.609, M86.9, S91.329A, T81.89XA, T82.868A
Ever smoking	ICD-9[a]	305.1, V15.82
	ICD-10[b]	F17.2, Z72.0
Any previous PVI	CPT	35472, 35473, 35452, 35454, 35491, 35492, 35474, 35456, 35493, 37205, 37206, 37220, 37221, 37222, 37223, 37224, 37225, 37226, 37227
Aortoiliac PVI	CPT	37220, 37221, 37222, 37223
Femoropopliteal PVI	CPT	37224, 37225, 37226, 37227
Ankle-brachial index	CPT	93922, 93923, 93924

CPT, Current Procedural Terminology; PVI, peripheral vascular intervention.
[a] *International Classification of Diseases, Ninth Revision* (ICD-9) was used to identify diagnoses before September 30, 2015.
[b] *International Classification of Diseases, Tenth Revision* (ICD-10) was used to identify diagnoses after October 1, 2015.