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Journal

Journal of Vascular Surgery, 78(4)

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Publication Date

2023-10-01

DOI

10.1016/j.jvs.2023.05.047

Peer reviewed

Published in final edited form as:

J Vasc Surg. 2023 October ; 78(4): 1003–1011. doi:10.1016/j.jvs.2023.05.047.

Long-term outcomes after lower extremity bypass in the actively smoking claudicant

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Abstract

Objective: Smoking is known to increase complications, including poor wound healing, coagulation abnormalities, and cardiac and pulmonary ramifications. Across specialties, elective surgical procedures are commonly denied to active smokers. Given the base population of active smokers with vascular disease, smoking cessation is encouraged but is not required the way it is for elective general surgery procedures. We aim to study the outcomes of elective lower extremity bypass (LEB) in actively smoking claudicants.

Methods: We queried the Vascular Quality Initiative Vascular Implant Surveillance and Interventional Outcomes Network LEB database from 2003 to 2019. In this database we found 609 (10.0%) never smokers (NS), 3388 (55.3%) former smokers (FS), and 2123 (34.7%) current smokers (CS) who underwent LEB for claudication. We performed two separate propensity score matches without replacement on 36 clinical variables (age, gender, race, ethnicity, obesity, insurance, hypertension, diabetes, coronary artery disease, congestive heart failure, chronic obstructive pulmonary disease, chronic kidney disease, previous coronary artery bypass graft, carotid endarterectomy, major amputation, inflow treatment, preoperative medications and treatment type), one of FS to NS and a second analysis of CS to FS. Primary outcomes included 5-year overall survival (OS), limb salvage (LS), freedom from reintervention (FR), and amputation-free survival (AFS).

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AUTHOR CONTRIBUTIONS

Conception and design: RJP, SZ, AG, MBM Analysis and interpretation: RJP, SZ, VJ, NRV, MBM Data collection: Not applicable
Writing the article: RJP, VJ, NRV
Critical revision of the article: RJP, SZ, AG, MBM
Final approval of the article: RJP, SZ, VJ, NRV, AG, MBM Statistical analysis: RJP, SZ
Obtained funding: Not applicable
Overall responsibility: MBM

Presented at the 2023 Vascular Annual Meeting of the Society for Vascular Surgery, National Harbor, Maryland, June 14–17, 2023.

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

Author conflict of interest: none.

Results: Propensity score matches resulted in 497 well-matched pairs of NS and FS. In this analysis we found no difference in terms of OS (HR, 0.93; 95% CI, 0.70–1.24; $P = .61$), LS (HR, 1.07; 95% CI, 0.63–1.82; $P = .80$), FR (HR, 0.9; 95% CI,0.71–1.21; $P = .59$), or AFS (HR, 0.93; 95% CI,0.71–1.22; $P = .62$). In the second analysis, we had 1451 well-matched pairs of CS and FS. There was no difference in LS (HR, 1.36; 95% CI,0.94–1.97; $P = .11$) or FR (HR, 1.02; 95% CI,0.88–1.19; $P = .76$). However, we did find a significant increase in OS (HR, 1.37; 95% CI,1.15–1.64, $P < .001$) and AFS (HR, 1.38; 95% CI,1.18–1.62; $P < .001$) in FS compared with CS.

Conclusions: Claudicants represent a unique nonemergent vascular patient population that may require LEB. Our study found that FS have better OS and AFS when compared with CS. Additionally, FS mimic nonsmokers at 5-year outcomes for OS, LS, FR, and AFS. Therefore, structured smoking cessation should be a more prominent part of vascular office visits before elective LEB procedures in claudicants.

Keywords

Smoking; Lower extremity bypass; Amputation; Claudication

Cigarette smoking is responsible for an estimated 480,000 deaths per year in the United States alone, with millions of individuals suffering from associated comorbid chronic diseases.[1] Active smokers are at increased risk of developing complications during and after surgical procedures, including poor wound healing, coagulation abnormalities, and cardiovascular and pulmonary events.[2] These observations are prevalent considerations when recommending elective surgical interventions across many subspecialties, including colorectal, plastics, and cardiothoracic.[3–5] It has also been well-established that a brief, surgeon-delivered evidence-based smoking cessation advice has a measurable impact on patients' acknowledgement of smoking harms and desire to quit.[6]

Smoking cessation has been proven to be particularly crucial in the management of peripheral arterial disease (PAD) because of its strong associations with decreased disease progression, improved graft patency, and lower occurrence of perioperative complications.[7–10] This circumstance has led the Society for Vascular Surgery practice guidelines for asymptomatic atherosclerotic occlusive disease and claudication to recommend a Class 1A level of evidence for smoking cessation.[11] Prior studies specifically exploring the effects of smoking on lower extremity bypass (LEB) surgery have focused on the short-term and long-term effects of active smoking on graft patency in LEB.[10,12,13] Although the current consensus is that active smoking associates strongly with decreased graft patency, only one study clearly characterizes decreased 5-year and 10-year survival in active smokers after LEB.[10,12,13] Further information regarding the effects of smoking on long term outcomes of overall survival (OS), limb salvage (LS), and reintervention in LEB will help to inform physicians in their clinical decision-making and counseling of patients.

The aim of this study was to investigate the outcomes of elective LEB surgery in actively smoking claudicants, with a particular focus on the impact of smoking on long-term outcomes. Our study aims to contribute to the existing body of literature on the impact of smoking on surgical outcomes and to provide current insights into the management of

active smokers with PAD. Claudicants, even life-limiting claudicants, represent a unique vascular patient population that does not require an emergent limb- or life-saving procedure. Therefore, we hypothesize that smoking cessation at this juncture cannot only prevent disease progression, but also can also help long-term outcomes after a LEB. Our goal is to help determine whether smoking cessation counseling should be a more prominent part of vascular office visits before and after LEB.

METHODS

Dataset.

The Vascular Quality Initiative (VQI) is a prospectively collected registry with preoperative, intraoperative and postoperative variables at 1000 centers in the United States and Canada.[14,15] This study was conducted with the Vascular Implant Surveillance and Interventional Outcomes Network (VISION), which is a collaboration between VQI and MDEpiNet to link VQI data to Medicare claim data allowing long-term outcomes analysis.[16] We used the infrainguinal bypass dataset after obtaining approval from the VQI Research Advisory Committee for VQI-VISION data (Protocol #4772 and #4991). The VQI-VISION is a deidentified registry and, therefore, individual consent and institutional review board approval were not required.

Population.

Patients who underwent an infrainguinal LEB between 2003 and 2019 were included in our analysis. Inclusion criteria were any patient in the VISION Medicare database with arterial occlusive disease pathology and claudication symptoms. Exclusion criteria were any concomitant suprainguinal procedures, aneurysm pathology, or acute limb ischemia symptoms. Patients with missing data regarding smoking status were excluded. Smoking status was used to create three sub-groups of never smokers (NS), former smokers (FS) defined as quitting >1 month before the intervention, and current smokers (CS) defined as smoking cigarettes, pipes, or cigars within the past month. Our aim was to determine if smoking cessation was advantageous and, therefore, compared CS with FS to determine whether individuals should be encouraged to stop smoking and compared FS with NS to determine the difference in long-term outcomes between individuals who never smoked vs those who quit successfully.

Variables.

Baseline characteristics included demographics (age, sex, ethnicity, obesity, insurance type), comorbidities (diabetes, hypertension, congestive heart failure, coronary artery disease [CAD], chronic obstructive pulmonary disease [COPD], chronic kidney disease [CKD], and American Society of Anesthesiologists class), surgical history (prior carotid endarterectomy, carotid artery stent, coronary artery bypass graft [CABG] or percutaneous coronary intervention [PCI], prior major amputation, prior inflow procedure, prior ipsilateral intervention, prior contralateral intervention), preoperative and discharge medications (aspirin, P2Y12 inhibitors, statins, anticoagulation, beta-blockers, angiotensin-converting enzyme inhibitor), and procedure details (anesthesia type, procedure time, conduit choice,

concomitant endarterectomy, level of treatment [supragenicular vs infragenicular]) were collected.

Outcomes.

Long-term outcomes were assessed at five years. Primary outcomes included freedom from reintervention (FR) and amputation-free survival (AFS). Secondary outcomes included OS and LS. Major amputation was defined as any amputation above the ankle. Reintervention was defined as any intervention after the index procedure.

Statistical analysis.

Continuous and binary variables were analyzed using the Student *t* test, rank-sum test, and Pearson χ^2 test, respectively. Given the significant variation in baseline characteristics between NS, FS, and CS we elected to use propensity score matching based on smoking status. One-to-one propensity score matching without replacement was used to balance the cohorts. LEB was balanced on 36 dimensions by the nearest neighbor principle with a caliper size of 0.10 for FS and CS and a caliper size of 0.01 for NS and FS. An adequate match was achieved with an absolute standardized difference of <0.10 in all baseline covariates. Kaplan-Meier survival estimates, log-rank test, and univariate Cox regression models were used to analyze outcomes of interest. All analyses were performed using Stata 17.0 (StataCorp, College Station, TX).

RESULTS

There were a total of 6070 patients who underwent LEB between 2003 and 2019 and met our inclusion criteria before matching. Of these patients, 3338 (55.0%) self-categorized as FS, 2123 (35.0%) self-identified as CS, and 609 (10.0%) were NS.

Baseline characteristics of FS vs CS.

When comparing FS and CS, 3338 (61.1%) were FS and 2123 (38.9%) were CS. Before matching, CS were younger (66.5 ± 7.8 years vs 71.2 ± 7.5 years) and had a higher proportion of COPD (40.7% vs 28.8%); FS had a greater proportion of patients with hypertension (91.9% vs 86.9%), diabetes (45.1% vs 35.0%), CAD (51.8% vs 41.5%), and CKD (31.9% vs 22.0%) compared with CS. After matching we were left with 1451 pairs of FS and CS who had an open LEB (Table I) with a standardized difference of <0.10. This cohort was balanced and matched on 36 variables (sex; prior ipsilateral lower extremity intervention; preoperative use of anticoagulation, beta-blockers, P2Y12 inhibitors, angiotensin-converting enzyme inhibitors, and statins; discharge P2Y12 inhibitor use; obesity; type of insurance [Medicare or non-Medicare]; diabetes; procedure time length; COPD; CKD; previous CABG/PCI; and prior contralateral lower extremity intervention) to a caliper of 0.10.

Baseline characteristics of NS vs FS.

We then compared NS 609 (15.4%) with FS 3338 (84.6%). Before matching, FS patients were younger (71.2 ± 7.5 years 72.8 ± 9.6 years) and more likely to have Medicare insurance (71.8% vs 69.7%), hypertension (91.9% vs 90.5%), CAD (51.8% vs 45.3%),

COPD (28.8% vs 8.0%), or congestive heart failure (12.8% vs 11.2%) compared with NS. After matching we were left with 497 pairs of NS and FS (Table II) with a standardized difference of <0.10. This cohort was balanced and matched on 36 variables (age, sex, race, prior contralateral lower extremity intervention, prior ipsilateral lower extremity intervention, prior inflow treatment, type of anesthesia, preoperative aspirin use, discharge statin use, CAD, concomitant endarterectomy, COPD, CKD, history of CABG/PCI, history of carotid endarterectomy, or CAS, prior major amputation, ethnicity, and type of graft) to a caliper of 0.01.

Outcomes: FS vs CS.

Table III presents the 5-year outcomes for OS, FR, LS, and AFS. Before matching when comparing FS with CS, there was a significantly greater AFS (67.2% vs 63.2%; $P = .030$) in FS compared with CS and no significant difference in FR, LS, or AFS. However, after matching we found FS had a significantly greater OS (73.7% vs 65.1%; $P = .0002$) and AFS (70.8% vs 60.6%; $P < .001$) compared with CS. There was no significant difference in LS or FR after matching in FS and CS.

Table IV represents the Cox regression 5-year analysis. Before matching, there was no significant difference in all-cause mortality, reintervention, or major amputation in CS compared with FS. CS were found to have a 13% increase risk of major amputation or death compared with FS (hazard ratio [HR], 1.13; 95% CI, 1.01–1.26; $P = .027$) (Fig 1, A). However, once matching was performed, CS were found to have a 37% increased risk of mortality (HR, 1.37; 95% CI, 1.15–1.64; $P < .001$) and 38% increased risk of major amputation or death (HR, 1.38; 95% CI, 1.18–1.62; $P < .001$) compared with FS (Fig 1, B).

Outcomes: NS vs FS.

Table III presents the 5-year outcomes for OS, FR, LS, and AFS. Before matching when comparing NS with FS there was no significant difference in OS, FR, LS, or AFS and this finding persisted even after matching.

Table IV represents the Cox regression 5-year analysis. Before matching, there was no significant difference in all-cause mortality, reintervention, major amputation, or major amputation or death (HR, 0.96; 95% CI, 0.79–1.17; $P = .670$) (Fig 2, A) in FS compared with NS. Additionally, once matching was performed, there remained no significant risk difference in mortality, reintervention, major amputation, or major amputation or death (HR, 0.93; 95% CI, 0.71–1.22; $P = .622$) in FS compared with NS (Fig 2, B).

DISCUSSION

Our study found no significant difference between NS and FS in AFS and OS, demonstrating that smoking cessation may lead to positive long-term outcomes such as those of NS. Additionally, we observed a significant increase in OS and AFS in FS compared with CS. These results suggest that quitting smoking before LEB may improve long-term outcomes, particularly regarding OS and AFS.

Smoking is a risk factor for PAD overall, but has shown to be a particular risk factor for those with critical limb ischemia.[17] LEB is one of the most durable procedures performed for claudicants.[18] Overall, claudication represents a unique opportunity for smoking intervention owing to the nonacute nature of the condition compared with acute limb ischemia. In acute limb ischemia, LS takes immediate priority and smoking cessation discussions are important postoperatively. However, in claudicants, the goal is to prevent disease progression to the point of acute or chronically worsening limb ischemia to either rest pain or tissue loss. Claudicants, therefore, do not require emergent procedures and smoking cessation discussions can have merit preoperatively in these specific scenarios.

Smoking is known to be detrimental to wound healing, endothelial function, and vascular remodeling, which may contribute to worse outcomes after LEB.[19] In our study, NS and FS had similar outcomes, demonstrating that these detrimental effects may be reversible. Past studies support the claim that smoking damage to endothelial cells may be reversible in a dose-dependent fashion.[20] Smoking cessation may lead to overall long-term improvement in outcomes, even after periods of sustained smoking. This finding is consistent with a previous study that shows improved AFS for patients with PAD for individuals who quit smoking compared with active smokers.[8]

Given the importance of smoking cessation for patients with PAD, studies have been conducted on how best to communicate this with patients. A review found that vascular surgeons can create a teachable moment during visits with patients and that a combination of standardized advice, telephone counseling, and pharmacotherapy combined can have the best outcome.[21] The Vascular Physician Offer and Report (VAPOR) trial specifically looked at these three components and a retrospective review of almost 14,000 patients found that any two smoking cessation components (physician-delivered advice and referral to smoking counseling services, physician-delivered advice and nicotine replacement therapy, or referral to smoking counseling services and nicotine replacement) was associated with a 30-day cessation of smoking with the combination of physician advice and nicotine replacement being the most impactful.[22] Additionally, the Vascular Study Group of New England registry found that, of 2606 patients (33%) who self-reported as CS, 1429 (45%) quit within the first year with counseling, of which 657 (46%) had undergone a LEB.[23] Finally, the VAPOR randomized controlled trial found that a short standardized intervention can be added to vascular surgery clinics to encourage patients to quit smoking.[24]

Prior literature has demonstrated that active smoking has worse outcomes including mortality and AFS.[8,25] This finding was demonstrated in a National Surgical Quality Improvement Program analysis of 30-day outcomes, as well as a single-institution cohort of 700 patients.[8,25] The single-institution study followed active smokers for 1 year and found that one-third of active smokers stopped smoking. Compared with active smokers, the FS were found to have improved mortality and AFS at 5 years.[8]

There is a paucity of studies that have analyzed smoking status in LEB using VQI. To our knowledge, this study represents the only propensity score-matched VQI study comparing NS with FS and FS with CS who underwent LEB. A VQI study by Gabel et al[26] found that 44% of patients undergoing intervention for intermittent claudication were active

smokers and that these patients were younger and had few comorbidities, with smoking cessation most likely in those undergoing an open procedure such as LEB. Overall, our study demonstrates that smoking cessation should be encouraged with a focused discussion around methods to quit with patients before LEB for claudication.

Limitations.

Our study has several limitations. First, the retrospective nature of our study does not allow us to identify the causation of outcomes of LEB in actively smoking claudicants. Second, our study is limited by the availability of data in VQI VISION LEB database, because are all large registries. Third, under-reporting of outcomes could be biasing the data; however, owing to random audits and of cases and variables, these issues are largely mitigated. Fourth, our study is limited by lack of smoking characterization, such as duration and intensity, as well as change in smoking status between initial encounter documented in VQI and follow-up or recidivism. Additionally, the VISION database represents patients with Medicare and, therefore, is less applicable to younger populations. The VISION database does not code laterality for all reinterventions. Future studies can assess short-term operative outcomes with a larger sample size using only the VQI. With respect to OS, we do not have information regarding cause of death; therefore, this outcome could be attributed to cardiac issues, malignancy, or limb ischemia. Finally, our study is limited by other factors that may influence outcomes such as antiplatelet therapies or baseline differences between the groups; however, we did try to mitigate potential confounding variables with a propensity score matching analysis.

CONCLUSIONS

This large, multicenter, national, Medicare-linked study confirms the detrimental effect of smoking on outcomes of claudicants undergoing LEB. CS had worse OS and AFS compared with individuals who quit smoking ≥1 month before LEB. Additionally, were able to demonstrate that quitting smoking can improve the 5-year outcomes to match nonsmokers' OS, LS, FR, and AFS. We believe this study demonstrates the importance of structured smoking cessation discussions and tools during the vascular office visits before and after LEB. Smoking cessation should be a prominent part of vascular planning and can be an important adjunct to successful elective LEB procedures in patients with PAD presenting with lifestyle-limiting claudication. Further studies are needed to validate our findings in a more prospective nature.

Acknowledgments

R.J.P. is funded through the National Library of Medicine, T15 Postdoctoral Training Grant Fellowship Program in Biomedical Informatics (Grant T15LMO11271).

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ARTICLE HIGHLIGHTS

Type of Research:

A retrospective review of prospectively collected Vascular Quality Initiative Vascular Implant Surveillance and Interventional Outcomes Network data

Key Findings:

Propensity matching of 497 pairs of never and former smokers (FS) found no difference in survival or amputation-free survival. However, 1451 pairs of current and FS found a significant increase in survival (hazard ratio, 1.37; $P < .001$) and amputation-free survival (hazard ratio, 1.38; $P < .001$) in FS.

Take Home Message:

FS have better overall survival and amputation-free survival when compared with current smokers, whereas FS mimic nonsmokers at 5-year outcomes for survival, limb salvage, freedom from reintervention, and amputation-free survival.

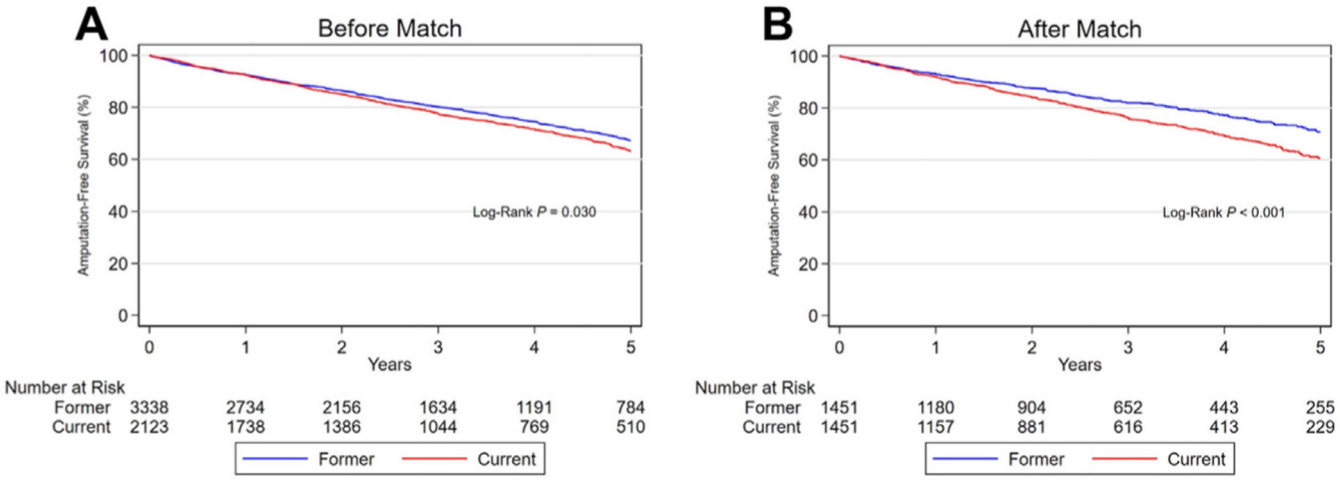

Fig 1.

Amputation-free survival (AFS) in former vs current smokers (CS) undergoing lower extremity bypass (LEB). **(A)** Before matching. **(B)** After matching.

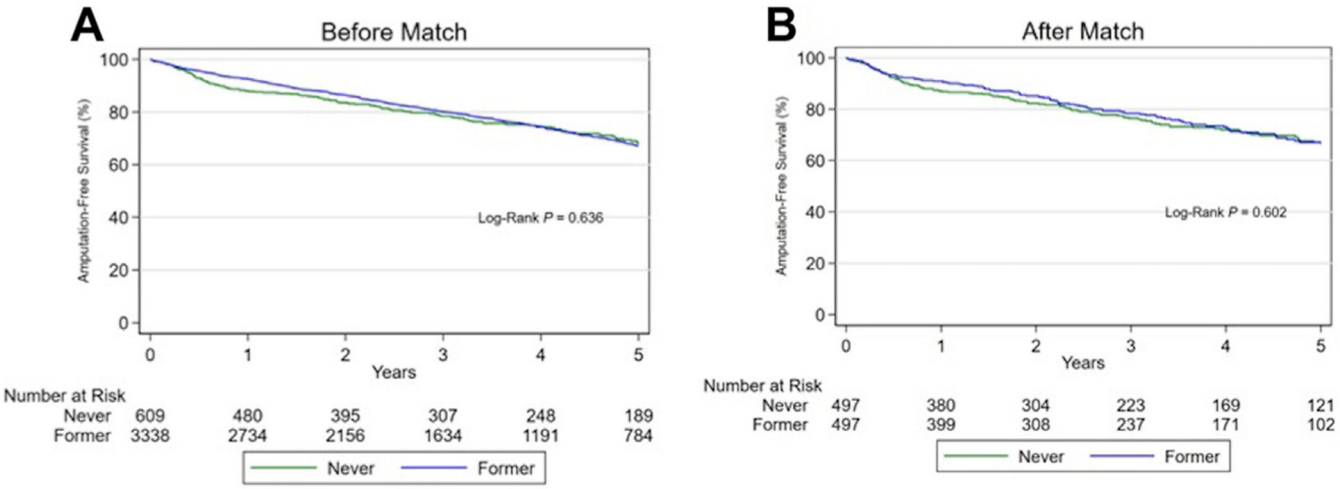

Fig 2.

Amputation-free survival (AFS) in never vs former smokers (FS) undergoing lower extremity bypass (LEB). **(A)** Before matching. **(B)** After matching.

Table I.

Baseline characteristics of open lower extremity bypass (LEB) former smokers (*FS*) and current smokers (*CS*) before and after matching

	Before matching (n = 5461)			After matching (n = 2902)		
Variable	**FS (n = 3338 [61.1%])**	**CS (n = 2123 [38.9%])**	**Standardized difference**	**FS (n = 1451 [50.0%])**	**CS (n = 1451 [50.0%])**	**Standardized difference**
Age, years	71.2 ± 7.5	66.5 ± 7.8	0.61127	68.1 ± 7.2	68.6 ± 6.3	−0.08551
Gender			0.09499			0.00000
Male	2373 (71.1)	1416 (66.7)		979 (67.5)	979 (67.5)	
Female	965 (28.9)	707 (33.3)		472 (32.5)	472 (32.5)	
Race			0.06102			0.02128
White	2924 (87.6)	1815 (85.6)		1240 (85.5)	1229 (84.7)	
Non-White	412 (12.4)	306 (14.4)		211 (14.5)	222 (15.3)	
Ethnicity			0.01272			0.01855
Non-Hispanic	3213 (96.6)	2046 (96.8)		1400 (96.7)	1397 (96.3)	
Hispanic	113 (3.4)	67 (3.2)		48 (3.3)	53 (3.7)	
ASA class			0.00255			0.06701
1–3	2708 (84.5)	1699 (84.6)		1245 (85.9)	1210 (83.4)	
4–5	496 (15.5)	309 (15.4)		205 (14.1)	240 (16.6)	
Obesity			0.23747			0.01237
Nonobese	2133 (64.2)	1584 (75.0)		1058 (72.9)	1050 (83.4)	
Obese	1192 (35.8)	528 (25.0)		393 (27.1)	401 (27.6)	
Insurance			0.07954			0.02225
Medicare	2102 (71.8)	1228 (68.1)		986 (68.0)	1001 (69.0)	
Non-Medicare	826 (28.2)	574 (31.9)		465 (32.0)	450 (31.0)	
Hypertension	3063 (91.9)	1844 (86.9)	0.16316	1311 (90.5)	1290 (88.9)	0.05384
Diabetes	1504 (45.1)	742 (35.0)	0.20767	539 (37.1)	544 (37.5)	0.00712
CAD	1727 (51.8)	881 (41.5)	0.20689	652 (44.9)	637 (43.9)	0.02020
Congestive heart failure	427 (12.8)	232 (10.9)	0.05803	177 (12.2)	172 (11.9)	0.01059
COPD	960 (28.8)	864 (40.7)	0.25255	540 (37.2)	532 (36.7)	0.01142
CKD	1058 (31.9)	463 (22.0)	0.22398	354 (24.4)	366 (25.2)	0.01915
CABG/PCI	1467 (47.1)	702 (37.0)	0.20596	524 (36.1)	532 (36.7)	0.01146

Variable	Before matching (n = 5461)			After matching (n = 2902)		
	FS (n = 3338 [61.1%])	CS (n = 2123 [38.9%])	Standardized difference	FS (n = 1451 [50.0%])	CS (n = 1451 [50.0%])	Standardized difference
History of carotid endarterectomy and carotid artery stent	478 (14.3)	248 (11.7)	0.07863	182 (12.5)	189 (13.0)	0.01445
Prior major amputation	42 (14.3)	36 (1.7)	0.03624	23 (1.6)	21 (1.4)	0.01128
Prior inflow treatment	779 (23.3)	468 (22.1)	0.03038	365 (25.2)	320 (22.1)	0.07308
Prior ipsilateral lower extremity intervention	1218 (36.5)	665 (31.4)	0.10887	486 (33.5)	499 (34.4)	0.01892
Prior contralateral lower extremity intervention	1119 (33.5)	602 (28.4)	0.11157	447 (30.8)	456 (31.4)	0.01340
Aspirin	2545 (76.2)	1512 (71.3)	0.11359	1096 (75.5)	1059 (73.0)	0.05835
P2Y12 inhibitors	1182 (35.4)	673 (31.7)	0.07853	533 (36.7)	514 (35.4)	0.02727
Statin	2681 (80.3)	1560 (73.6)	0.16177	1103 (76.0)	1117 (77.0)	0.02276
Beta-blocker	2035 (61.0)	1105 (52.1)	0.17996	759 (52.3)	765 (52.7)	0.00828
ACE inhibitor	1736 (59.3)	929 (51.5)	0.15726	788 (54.3)	794 (54.7)	0.00830
Anticoagulation	470 (16.1)	228 (12.6)	0.09764	180 (12.4)	189 (13.0)	0.01862
Concomitant endarterectomy	1196 (35.9)	644 (30.4)	0.11822	500 (34.5)	469 (32.4)	0.04536
Level of treatment			0.10786			0.04920
Above knee	1446 (43.4)	1033 (48.4)		698 (48.2)	662 (45.7)	
Below knee	1882 (56.5)	1083 (51.2)		750 (51.8)	785 (54.3)	
Procedure time	215.7 ± 100.1	198.0 ± 98.1	0.17894	202.8 ± 93.8	202.4 ± 101.0	0.00413
Anesthesia type			0.00202			0.01545
Regional	154 (4.6)	97 (4.6)		49 (3.4)	45 (3.1)	
General	3184 (95.4)	2025 (95.4)		1402 (96.6)	1405 (96.9)	
Discharge aspirin	2859 (85.8)	1779 (83.9)	0.05306	1263 (87.0)	1230 (84.8)	0.06540
Discharge P2Y12 inhibitors	2790 (84.8)	1673 (80.7)	0.10720	1185 (81.7)	1214 (83.7)	0.05438
Discharge statin	1610 (48.3)	1044 (49.2)	0.01777	760 (52.4)	758 (52.2)	0.00276
Discharge beta-blocker	2060 (62.6)	1120 (54.0)	0.17494	795 (54.8)	799 (55.1)	0.00554
Discharge ACE inhibitor	1441 (58.3)	790 (51.9)	0.12937	670 (54.5)	663 (54.3)	0.00523
Discharge anticoagulation	746 (22.4)	397 (18.7)	0.09121	282 (19.5)	286 (19.7)	0.00661
Graft type			0.00740			0.01929
Autogenous	1627 (48.9)	1027 (48.5)		676 (46.7)	689 (47.6)	
Nonautogenous	1703 (51.1)	1091 (51.5)		773 (53.3)	758 (52.4)	

ACE, Angiotensin-converting enzyme; *ASA*, American Society of Anesthesiologists; *CAD*, coronary artery disease; *CABG*, coronary artery bypass graft; *COPD*, chronic obstructive pulmonary disease; *CKD*, chronic kidney disease; *PCI*, percutaneous coronary intervention.

Values are mean ± standard deviation or number (%).

Table II.

Baseline characteristics of open lower extremity bypass (LEB) never smokers (*NS*) and former smokers (*FS*) before and after matching

	Before matching (n = 3947)			After matching (n = 994)		
Variable	**NS (n = 609 [15.4%])**	**FS (n = 3338 [84.6%])**	**Standardized difference**	**NS (n = 497 [50.0%])**	**FS (n = 497 [50.0%])**	**Standardized difference**
Age, years	72.8 ± 9.6	71.2 ± 7.5	0.17992	72.2 ± 9.6	72.0 ± 7.9	0.02174
Gender			0.47821			0.08863
Male	294 (48.3)	2373 (71.1)		256 (51.5)	234 (47.1)	
Female	315 (51.7)	965 (28.9)		241 (48.5)	263 (52.9)	
Race			0.17730			0.07057
White	494 (81.3)	2924 (87.6)		405 (81.5)	391 (78.7)	
Non-White	114 (18.8)	412 (12.4)		92 (18.5)	106 (21.3)	
Ethnicity			0.16017			0.08088
Non-Hispanic	564 (93.1)	3213 (96.6)		469 (94.4)	459 (92.4)	
Hispanic	42 (6.9)	113 (3.4)		28 (5.6)	38 (7.6)	
ASA class			0.00795			0.06525
1–3	480 (84.8)	2708 (84.5)		414 (84.7)	426 (86.9)	
4–5	86 (15.2)	496 (15.5)		75 (15.3)	64 (13.1)	
Obesity			0.05059			0.04820
Nonobese	404 (66.6)	2133 (64.2)		319 (64.4)	331 (66.7)	
Obese	203 (33.4)	1192 (35.8)		176 (35.6)	165 (33.3)	
Insurance			0.04548			0.01347
Medicare	350 (69.7)	2102 (71.8)		329 (70.3)	334 (70.9)	
Non-Medicare	152 (30.3)	826 (28.2)		139 (29.7)	137 (29.1)	
Hypertension	551 (90.5)	3063 (91.9)	0.04921	452 (90.9)	459 (92.4)	0.05093
Diabetes	288 (47.3)	1504 (45.1)	0.04455	244 (49.1)	220 (44.3)	0.09691
CAD	276 (45.3)	1727 (51.8)	0.12960	244 (49.1)	234 (47.1)	0.040428
Congestive heart failure	68 (11.2)	427 (12.8)	0.05044	60 (12.1)	51 (10.3)	0.05752
COPD	49 (8.0)	960 (28.8)	0.55569	40 (8.0)	32 (6.4)	0.06213
CKD	244 (40.3)	1058 (31.9)	0.17574	190 (38.2)	200 (40.2)	0.04122
CABG/PCI	225 (41.2)	1467 (47.1)	0.11844	202 (40.6)	200 (40.2)	0.00820

Variable	Before matching (n = 3947)			After matching (n = 994)		
	NS (n = 609 [15.4%])	FS (n = 3338 [84.6%])	Standardized difference	NS (n = 497 [50.0%])	FS (n = 497 [50.0%])	Standardized difference
History of carotid endarterectomy and carotid artery stent	61 (10.0)	478 (14.3)	0.13205	49 (9.9)	55 (11.1)	0.03945
Prior major amputation	15 (2.5)	42 (1.3)	0.08922	11 (2.2)	14 (2.8)	0.03856
Prior inflow treatment	58 (9.5)	779 (23.3)	0.37943	46 (9.3)	39 (7.8)	0.05038
Prior ipsilateral lower extremity intervention	201 (33.0)	1218 (36.5)	0.07344	177 (35.6)	186 (3.4)	0.03762
Prior contralateral lower extremity intervention	157 (25.8)	1119 (33.5)	0.17036	131 (26.4)	142 (28.6)	0.04960
Aspirin	417 (68.5)	2545 (76.2)	0.17440	345 (69.4)	344 (69.2)	0.00436
P2Y12 inhibitors	192 (31.5)	1182 (35.4)	0.08259	165 (33.2)	178 (35.8)	0.05504
Statin	443 (72.7)	2681 (80.3)	0.18007	363 (73.0)	359 (72.2)	0.01805
Beta-blocker	345 (56.7)	2035 (61.0)	0.08623	285 (57.5)	294 (59.2)	0.03439
ACE inhibitor	270 (53.9)	1736 (59.3)	0.10906	255 (54.6)	271 (57.7)	0.06161
Anticoagulation	87 (17.3)	470 (16.1)	0.03415	80 (17.1)	65 (13.9)	0.08953
Concomitant endarterectomy	129 (21.2)	1196 (35.9)	0.33047	111 (22.3)	116 (23.3)	0.02397
Level of treatment			0.19505			0.02534
Above knee	206 (34.0)	1446 (43.4)		170 (34.2)	176 (35.4)	
Below knee	400 (66.0)	1882 (56.6)		327 (65.8)	321 (64.6)	
Procedure time, minutes	212.3 ± 103.3	215.7 ± 100.1	−0.03367	213.3 ± 103.7	210.5 ± 102.5	0.02676
Anesthesia type			0.05116			0.04096
Regional	35 (5.7)	154 (4.6)		22 (4.4)	18 (3.6)	
General	574 (94.3)	3184 (95.4)		475 (95.6)	479 (96.4)	
Discharge aspirin	503 (82.6)	2859 (85.8)	0.08735	413 (83.1)	421 (84.7)	0.04381
Discharge P2Y12 inhibitors	450 (76.4)	2790 (84.8)	0.21225	384 (77.3)	383 (77.1)	0.00479
Discharge statin	274 (45.0)	1610 (48.3)	0.06703	234 (47.1)	245 (49.3)	0.04431
Discharge beta-blocker	348 (59.1)	2060 (62.6)	0.07199	300 (60.4)	309 (62.2)	0.03718
Discharge ACE inhibitor	220 (54.5)	1441 (58.3)	0.07744	209 (55.0)	216 (56.1)	0.02222
Discharge anticoagulation	153 (25.1)	746 (77.6)	0.060379	130 (26.2)	114 (22.9)	0.07486
Graft type			0.07569			0.03623
Autogenous	319 (52.6)	1627 (48.9)		258 (51.9)	249 (50.1)	
Nonautogenous	287 (47.4)	1703 (51.1)		239 (48.1)	248 (49.9)	

ACE, Angiotensin-converting enzyme; *ASA*, American Society of Anesthesiologists; *CABG*, coronary artery bypass graft; *CAD*, coronary artery disease; *COPD*, chronic obstructive pulmonary disease; *CKD*, chronic kidney disease; *PCI*, percutaneous coronary intervention.

Values are mean ± standard deviation or number (%).

Table III.

Five-year outcomes before and after matching

Before match	FS (n = 3338 [61.1%])	CS (n = 2123 [38.9%])	Log rank *P* value	NS (n = 609 [15.4%])	FS (n = 3338 [84.6%])	Log rank *P* value
OS	69.9 (0.68–0.72)	67.8 (0.65–0.70)	.200	70.6 (0.66–0.75)	69.9 (0.69–0.72)	.694
FR	65.2 (0.63–0.67)	64.6 (0.62–0.67)	.722	65.1 (0.60–0.69)	65.2 (0.63–0.67)	.986
LS	93.8 (0.93–0.95)	92.0 (0.90–0.93)	.086	94.6 (0.92–0.96)	93.8 (0.93–0.95)	.821
AFS	67.2 (0.65–0.69)	63.2 (0.60–0.66)	.030	68.0 (0.63–0.72)	67.2 (0.65–0.69)	.636
After match	**FS (n = 1451 [50.0%])**	**CS (n = 1451 [50.0%])**	**Log-rank *P* value**	**NS (n = 497 [50.0%])**	**FS (n = 497 [50.0%])**	**Log-rank *P* value**
OS	73.7 (0.70–0.77)	65.1 (0.61–0.69)	.0002	69.2 (0.64–0.74)	69.5 (0.64–0.75)	.591
FR	67.8 (0.65–0.71)	65.7 (0.62–0.69)	.752	65.1 (0.59–0.70)	68.4 (0.63–0.73)	.555
LS	93.8 (0.92–0.95)	91.4 (0.89–0.93)	.075	94.1 (0.91–0.96)	93.4 (0.90–0.96)	.810
AFS	70.8 (0.67–0.74)	60.6 (0.57–0.64)	<.001	66.6 (0.61–0.72)	67.2 (0.61–0.72)	.602

AFS, Amputation-free survival; CS, current smoker; FR, freedom from reintervention; FS, former smoker; LS, limb salvage; NS, never smoker; OS, overall survival.

Values are % (95% confidence interval).

Table IV.

Cox regression for 5-year outcomes

	Before match	*P* value	After match	*P* value
CS vs FS				
All-cause mortality	1.08 (0.96–1.22)	.209	1.37 (1.15–1.64)	<.001
Reintervention	0.98 (0.88–1.09)	.729	1.02 (0.88–1.19)	.762
Major amputation	1.24 (0.95–1.62)	.115	1.36 (0.94–1.97)	.105
Major amputation or death	1.13 (1.01–1.26)	.027	1.38 (1.18–1.62)	<.001
FS vs NS				
All-cause mortality	0.96 (0.79–1.18)	.716	0.93 (0.70–1.24)	.613
Reintervention	1.00 (0.85–1.19)	.987	0.93 (0.71–1.21)	.589
Major amputation	0.95 (0.62–1.46)	.829	1.07 (0.63–1.82)	.802
Major amputation or death	0.96 (0.79–1.17)	.670	0.93 (0.71–1.22)	.622

CS, Current smoker; *FS*, former smoker; *NS*, never smoker. Values are hazard ratio (95% confidence interval).