Distribution Agreement

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature: DocuSigned by: D8E8F2B30FC64B0...

Olamide Alabi
Name

3/21/2023 | 9:55 PM EDT
Date

Title Examining Care Fragmentation After PAD Interventions: The Readmission Event

Author Olamide Alabi

Degree Master of Science

Program Clinical Research

Approved by the Committee

DocuSigned by:
Luke Brewster
C48FE755146B48A...

Luke Brewster
Advisor

DocuSigned by:
Amita Manatunga
AB1827790028472...

Amita Manatunga
Committee Member

DocuSigned by:
Dr. Nader Massarweh
D7931C2AD14D464...

Dr. Nader Massarweh
Committee Member

Accepted by the Laney Graduate School

Kimberly Jacob Arriola, PhD, MPH
Dean, James T. Laney School of Graduate Studies

TITLE PAGE

Examining Care Fragmentation After PAD Interventions: The Readmission Event

By

Olamide Alabi

M.D., University of Nebraska Medical Center, 2010

Advisor: Luke Brewster, MD PhD

An abstract of

A thesis submitted to the faculty of the

James T. Laney School of Graduate Studies of Emory University

in partial fulfillment of the requirements for the degree of the

Master of Science in Clinical Research

2023

ABSTRACT

Examining Care Fragmentation After PAD Interventions:

The Readmission Event

By Olamide Alabi

Background

Lower extremity revascularization (LER) for peripheral artery disease (PAD) is complicated by the frequent need for readmission. However, it is unclear if readmission at a non-index LER facility (i.e., a facility different from the one where the LER was performed) compared to the index LER facility is associated with worse outcomes.

Methods

This was a national cohort study of older adults who underwent open, endovascular, or hybrid LER for PAD (January 1, 2010 – December 31, 2018) in the Vascular Quality Initiative. This dataset was linked to Medicare claims and the American Hospital Association Annual Survey. The primary outcome was 90-day mortality and secondary outcomes were major amputation at 30- and 90-days after LER. The primary exposure was the first readmission after LER (categorized as occurring at the index LER facility versus a non-index LER facility). Multivariable logistic regression was used to assess the association between 90-day mortality and readmission location.

Results

Among 13,206 patients readmitted within 90-days of LER for PAD, 27.3% were readmitted to a non-index LER facility. Compared to patients readmitted to the index LER facility, those readmitted to a non-index facility had a lower proportion of procedure-related reasons for readmission (21.5% vs 50.1%, $p<0.001$). Most of the patients readmitted to a non-index LER facility lived further than 31 miles from the index LER facility (39.2% vs 19.6%, $p<0.001$) and were readmitted to a facility with a total bed size under 250 (60.1% vs 11.9%, $p<0.001$). Readmission to a non-index LER facility within 90-days was not associated with 90-day mortality, 30-day amputation, or 90-day amputation. However, readmission to a non-index LER facility with a procedure-related complication was associated with major amputation (30-day amputation: aOR 3.58 [95% CI, 3.00-4.27]; 90-day amputation: aOR 3.33 [95% CI, 2.93-3.80]).

Conclusion

While care fragmentation and readmission to a different facility after LER for PAD is not associated with amputation or death within 90-days, readmission for procedure-related complications is significantly associated with subsequent amputation. Quality improvement efforts should focus on understanding the role discontinuity of care plays in limb salvage as well as the reasons care fragmentation is associated with procedure-related failure.

Cover Page

Examining Care Fragmentation After PAD Interventions:

The Readmission Event

By

Olamide Alabi

M.D., University of Nebraska Medical Center, 2010

Advisor: Luke Brewster, MD PhD

A thesis submitted to the Faculty of the

James T. Laney School of Graduate Studies of Emory University

in partial fulfillment of the requirements for the degree of

Master of Science in Clinical Research

2023

Acknowledgments

I would like to thank Dr. Luke Brewster for his encouragement in applying for the MSCR program and the Department of Surgery for their support in action through funding this program. I am very grateful to all of my mentors at both the Atlanta VA and Emory University. I would also like to thank my partners for covering clinical duties when I was in classes and while preparing this MSCR Thesis. I am thankful for the help of Dr. Manatunga and other members of my thesis committee in reviewing drafts of this thesis.

Lastly, I would like to thank my family for their patience and support always but particularly during the MSCR program.

Table of Contents

Introduction

Peripheral artery disease (PAD) is a condition affecting over 10 million individuals in the United States (US) and is associated with high rates of morbidity and mortality.(1) In fact, a new diagnosis of severe PAD is associated with a 25% chance of lower extremity amputation at 1-year and a 50% chance of death at 5-years.(2,3) Depending on the severity of symptoms, a patient with PAD may be a candidate for a procedure that aims to improve blood flow to the legs in an attempt to improve pain and reduce the risk of amputation (i.e., lower extremity revascularization [LER]). LER is often performed in individuals of advanced age with comorbid conditions and there is a potential for post-procedure complications. All of these factors place PAD patients at risk for hospital readmission.(4,5) Payors, such as Medicare, are interested in readmission rates and have developed programs focused on monitoring and incentivizing reductions in readmission rats within 90-days after certain surgical procedures.(6) It is unclear whether and how outcomes after LER (e.g., mortality and amputation) are affected when a patient is readmitted to their index facility where an LER was performed as compared to a non-index facility.

Background

In the US, over 10 million individuals have PAD, which manifests as lower extremity pain, nonhealing wounds, and gangrene.(1) Procedural management decisions are largely determined based on patient's symptoms at presentation. Those with severe symptoms are evaluated to determine if they would benefit from LER. However, LER can be associated with several major post-procedural complications such as hospital readmission, reintervention, amputation, or even death.(7,8)

Over time, the US healthcare system has placed greater attention on the development of programs that focus on improved quality and decreased costs. For example, the Center for Medicare & Medicaid Services (CMS) launched the Bundled Payment for Care Improvement initiative in 2013 and its successor, BPCI-Advanced (BPCI-A) in 2018.(6) These programs are intended to move health care payments away from a fee-for-service model and instead towards an episode-based payment structure that is triggered by a hospitalization for a specific indication and extends through 90-days after discharge. Through BPCI-A, healthcare organizations are incentivized to decrease the costs associated with the care they provide (e.g., reducing hospital readmissions) within that 90-day post-procedural period. Overall, this program provides incentives for high quality care that is better coordinated, more efficient, and potentially cost-effective. While LER volume continues to rise, there is no data to benchmark readmission rates after LER for PAD beyond the historical standard 30-day window typically used to evaluate post-procedure outcomes.

Care fragmentation has not been universally defined. However, in general, it refers to an absence of continuity of care.(9) Care fragmentation can have some important repercussions for patients. For example, primary care fragmentation has been associated with an increase in emergency room visits and hospitalizations.(10) The findings are similar for post-surgical care. Patients who have an operation at one facility, develop a problem after discharge requiring inpatient care, and are readmitted to a facility that is different than the facility where they had their operation have worse outcomes.(11) While better coordinated care seems to result in improved outcomes in medical patients who require hospitalization, there is little information on how this impacts patients after vascular surgery or, specifically, LER.(12,13)

Therefore, the primary aim of this study was to estimate the proportion of 90-day and 30-day readmission after LER. Our second aim was to focus on those who had readmission within 90-days and determine if readmission to a non-index facility is associated with higher rates of 90-day mortality, 30-day amputation, and 90-day amputation when compared to those who were readmitted to their index facility.

Methods

The primary aim of this study was to create a national cohort of patients at Vascular Quality Initiative (VQI) participating centers who underwent LER between January 2010 and December 2018 and estimate the proportion of 90-day and 30-day readmission. Our second aim was to examine those who had readmission within 90-days and determine if readmission to a non-index facility is associated with higher rates of 90-day mortality, 30-day amputation, and 90-day amputation compared to those who were readmitted to their index facility. Our hypothesis is that care fragmentation at readmission (as defined by a readmission to a non-index facility) is associated with worse post-LER outcomes.

Study Design and Data Sources

This was a national cohort study included individuals over age 18 who underwent LER for PAD between January 1, 2010 and December 31, 2018 with further analysis (aim two) of a subset of the cohort who had a subsequent readmission within 90 days. Care fragmentation is often thought of as the dispersion of a patient's care across different hospital systems and health care providers. In this study, we define care fragmentation as a readmission after LER to a non-index facility (i.e., a hospital where the index LER was not performed). Data used for analysis in this study were abstracted from three datasets. To address the first aim of estimating 90-day readmissions after LER, we linked the VQI dataset to

Medicare claims. To address the second aim of exploring outcomes among those readmitted within 90-days based on readmission location, we additionally linked the data from the first aim to the American Hospital Association (AHA) annual survey. Only the first unplanned readmission within 90-days was examined. The study was approved by the Emory University Institutional Review Board. We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines.(14)

VQI registry

The VQI procedural registry collects demographic, clinical, procedural, and outcomes data for patients receiving common vascular procedures at over 900 centers in the United States (US) and Canada who participate voluntarily.(15) The VQI provides reports of risk-adjusted outcomes to participating centers for patients who undergo vascular procedures.

Medicare database

Medicare is a federally funded program that provides health insurance to US citizens over the age of 65 as well as those under age 65 with a disability or on dialysis. For this study, we used beneficiary enrollment and claims files including all ambulatory, inpatient, and professional services data from the Chronic Conditions Warehouse of CMS.

AHA database

The AHA represents over 6500 hospitals and health care systems. Their annual survey, which has a response rate over 75%, collects data including total bed size and total inpatient and outpatient surgical volume from responding hospitals.

Database linkage

VQI patients were linked to their respective Medicare claims file at the patient-level and only procedures completed in the US were included. Details of the linkage methods utilized have been previously described.(16,17) The linked dataset is overseen by the Vascular Implant Surveillance and Interventional Outcomes Network (VISION).(18) Specifically, we used the 2018 VISION Medicare-claims linkage dataset to complete this retrospective cohort study.

Study Population

From the 2018 VISION dataset we identified all individuals who underwent LER at a VQI participating center between January 1, 2010 and December 31, 2018. This included all peripheral vascular intervention (PVI), supra-inguinal bypass (SUPRA), and infra-inguinal bypass (INFRA) modules within the VQI. We excluded individuals who had their procedure performed for the indications of aneurysm or acute limb ischemia as well as those patients who were discharged to hospice (which was <1% of the cohort). Those individuals who were not enrolled in fee-for-service Medicare at the time of their VQI procedure were excluded. For aim two, we also excluded any individual who had an index LER within an office-based setting as patients cannot be readmitted to an office-based laboratory because it is not an inpatient facility. Any patients who had a Medicare designated planned readmission, were transferred to a short-term hospital at the end of their index hospitalization, discharged against medical advice, or those who died prior to a 90-day readmission were excluded from analysis in aim two.

Outcomes

For aim one, the outcome of interest was 90-day and 30-day readmission. For aim two, the primary outcome was 90-day mortality. Secondary outcomes for aim two included 30-day and 90-day amputation. All outcomes were captured using Medicare claims data. Vital status was obtained from the VISION dataset with linkage to the Social Security Death Index.

Variables

The exposure of interest was the location where a readmission within 90-days occurred—defined as either a non-index LER facility or the index LER facility. Demographic covariates of interest were identified at the time of index LER within the VQI registry. Age group was categorized as 65 to 69 years, 70-74 years, 75-79 years, or 80 to 84 years, and 85 years and older. Information on patient sex was available. Race/ethnicity was initially categorized as African American or Black, Hispanic, White, and other. However, 81.4% (n=10 742) of the cohort was White. Therefore, we used the categories White and Non-White for all modelling. Comorbid conditions were abstracted from VQI registry and included coronary artery disease (CAD), congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), diabetes mellitus (DM), hypertension (HTN), and end stage kidney disease on dialysis. Preoperative functional status (ambulatory, ambulatory with assistance, and nonambulatory/wheelchair bound), preoperative living status (home, nursing facility, homeless), LER method (PVI, INFRA/SUPRA, and hybrid procedures), and history of prior amputation were also ascertained. We categorized PAD severity at time of index LER as: 1) asymptomatic or claudication; 2) ischemic rest pain; 3) tissue loss. The destination that a patient was discharged to after LER included home or home with home health services (this was combined into one category), rehabilitation facility, and skilled nursing facility.

Readmission primary diagnosis codes were reviewed using CMS data to determine if the readmission was procedure-related or not. Distance to facility was also obtained from CMS data and was measured as a straight line distance between the zip code centroid and the LER facility zip code in miles and then categorized into quartiles. The AHA annual survey data abstracted for this study included total bed size, adjusted admissions, and total surgical operations (calculated to include all inpatient and outpatient procedures performed at the facility). Each of these AHA variables were divided into quartiles. We linked each patient’s data to the Distressed Communities Index (DCI) using the five-digit zip code for each patient’s residence. The DCI is a tool that represents the economic well-being of a particular US zip code. A DCI score is available for all zip codes with a population over 500 persons. The score ranges from 0 (no distress) to 100 (severe distressed) and is typically categorized as prosperous (DCI score 0-19), mid-tier (DCI score 20-39), comfortable (DCI score 40-59), at-risk (DCI score 60-79), distressed (DCI score 80-100). For the purposes of this study, we combined the at-risk and distressed categories.

Statistical Analysis

Baseline characteristics, stratified by LER readmission site (index versus non-index), were compared using Chi-square and Wilcoxon Rank-sum tests as appropriate. For aim one, using the VISION dataset, we estimated crude and age-standardized proportions of 90-day and 30-day readmission using the direct method of standardization with standardized to the 2010 US population using 5-year age groups estimated from the American Communities Survey. For aim two, using the VISION dataset linked to the AHA annual survey, we created multivariable logistic regression models to determine the association between readmission to a non-index facility with: 1) 90-day mortality; 2) 30-day amputation; 3) 90-day amputation. Of note, 2.6% of the data was missing for each of the following variables: race/ethnicity, CAD, CHF, COPD, DM, HTN, dialysis, prior amputation, preoperative living status, discharge destination, DCI, and all AHA derived variables. A complete case analysis was performed. Analyses were conducted using SAS, version 9.4 (SAS Institute Inc., Cary, NC.). Two tailed $p<.05$ was considered significant.

Human subjects protection

Institutional Review Board approval was obtained at Emory University School of Medicine and at Weill Cornell Medicine. All of the VISION Medicare claims linked datasets are maintained on a secure, compliant server through Weill Cornell Medicine in accordance with CMS data management regulations and data use agreement. Identification of individual subject data or procedural site are not provided to the study investigators in accordance with the CMS data management regulations. Emory University School of Medicine has a data license that allows access to the AHA data.

Results

Aim one. Among 42 429 patients who had LER for PAD between 2010 and 2018 within the VISION dataset, the proportion who were readmitted within 90-days was 30.9% and the proportion who were readmitted within 30-days was 18.3% (**Table 1**).

Aim two. Of the original 42 429 patients identified in the VISION dataset, 28 068 were excluded as they did not have a 90-day readmission. After the making the other aforementioned exclusions, the remaining analytic cohort included 13 206 patients. Demographic and clinical information about this study cohort is provided in **Table 2**. Among this cohort, 7 730 (58.5%) were male, 10 742 (81.4%) were White, and 1 933 (14.6%) were African American or Black. White patients (82.9% vs 80.8%, p=.01) and patients who lives more than 31.4 miles away from their index LER facility (39.2% vs 19.6%, p<.001) were readmitted to a non-index facility more often than an index facility within 90-days after LER. Comorbid conditions of interest were found to be in similar prevalence regardless of the readmission location. Overall, 42.2% of readmissions were secondary to procedure-related complications. Patients who were readmitted within 90-days for a procedure-related complication were readmitted to their index facility more often than a non-index facility (50.0% vs 21.5%, p<.001).

Association with 90-day mortality

Table 3 presents data from the multivariable models. Compared to readmission to the index LER facility, readmission to a non-index facility was not associated with 90-day mortality (adjusted odds ratio [aOR], 1.09; [95% confidence interval [CI], 0.93-1.27]). Factors associated with an increased likelihood of 90-day mortality include older age, limited to no preoperative functional status, and worse severity of PAD on presentation (all in a dose-dependent fashion), CHF (aOR, 1.41; 95% CI, 1.25-1.60), dialysis (aOR, 2.97; 95% CI, 2.51-3.53), and discharge to a skilled nursing facility compared to home (aOR, 1.98; 95% CI, 1.74-2.25). Factors associated with a lower likelihood of 90-day mortality include Non-White race (aOR, 0.84; 95% CI, 0.72-0.99), DM (aOR, 0.87; 95% CI, 0.88-0.98), prior amputation (aOR, 0.83; 95% CI, 0.71-0.98), patients from comfortable (aOR, 0.78; 95% CI, 0.67-0.92) and mid-tier (aOR, 0.82; 95% CI, 0.70-0.96) communities compared to at risk/distressed communities, and patients who had an open rather than endovascular LER (aOR, 0.64; 95% CI, 0.55-0.74).

Association with 30-day and 90-day amputation

Compared to readmission at an index LER facility, readmission to a non-index facility was not associated with 30-day or 90-day amputation ([30-day: aOR, 0.78; 95% CI, 0.61-1.00]; [90-day: aOR, 0.95; 95% CI, 0.80-1.14]). Women were less likely to undergo amputation ([30-day: aOR, 0.72; 95% CI, 0.61-0.85]; [90-day: aOR, 0.66; 95% CI, 0.58-0.75]) as were patients with hypertension (90-day: aOR, 0.76; 95% CI, 0.61-0.95). Patients who underwent open bypass and hybrid procedures were also less likely to have subsequent 30-day and 90-day amputation. Patients with DM, on dialysis, those with more severe presentation of PAD, and a history of prior amputation were all more likely to undergo 30-day and 90-day amputation. Discharge to a skilled nursing facility rather than home was associated with increased risk of amputation ([30-day: aOR, 1.54; 95% CI, 1.28-1.84]; [90-day: aOR, 1.53; 95% CI, 1.33-1.76]). Readmission for a procedure-related complication was also associated with an increased likelihood of amputation ([30-day: aOR, 3.58; 95% CI, 3.00-4.27]; [90-day: aOR, 3.33; 95% CI, 2.93-3.80]).

Discussion

Readmission care fragmentation has been shown to compromise quality of care, increase costs, and been associated with poorer patient outcomes.(13,19-21) There is a need to understand drivers of and subsequent outcomes after care fragmentation. However, there is little data available that characterizes the association of readmission care fragmentation on outcomes after LER. In this regard, our study demonstrates several important findings: First, readmission care fragmentation after LER in and of itself is not associated with 90-day mortality, 30-day amputation, or 90-day amputation. Second, patients with advanced age and who are discharged to a skilled nursing facility are more likely to die within 90-days after LER. This finding highlights an opportunity to improve care coordination in specific patient groups. Finally, readmission care fragmentation for patients who have a procedure-related complication is associated with an increased risk of limb loss.

Patients who are readmitted to a hospital after major surgery often have better outcomes if they go to the same hospital where they had their operation.(13,22-24) Some potential explanations for this include that the quality of care or available resources at the index facility are more robust than at the hospital where a readmission occurs, surgeon care continuity may contribute to decreased mortality, or perhaps regionalization of care for those who need major surgery may be important to improve survival. These studies largely focused on several major abdominopelvic and/or cancer-related operations and do not specifically review outcomes for patients undergoing LER. The findings from our study, which focuses on a cohort of patients who were readmitted after LER, contradict these previous findings in that readmission care fragmentation alone was not associated with 90-day mortality. One possible explanation for this finding is that readmission after LER related to exacerbations of comorbid conditions can largely be treated successfully at local and/or smaller hospitals. However, procedure-related complications, such as reinterventions, make up a significant proportion of the indications for readmission.(25,26) In our study, 42.2% (n= 5 578) of all readmissions were due to procedure-related problems. Our data suggests this is a major driver of readmission and patients readmitted for this reason have poor 90-day outcomes if the readmission occurs at a non-index facility. One explanation for this is the lack of a universal, electronic method by which in-hospital patient data is shared. This makes continuity of care specific to a complex procedure or a complex patient more difficult when it occurs outside the setting of the index facility where the operation was performed.

Discharge to a skilled nursing facility and older age are known risk factors for death after hospital discharge.(27,28) In one review of hospitalized patients discharged to a skilled nursing facility, age was one of the strongest predictors of mortality within 6-months.(29) This may be secondary to a shorter life expectancy in older adults in general, a higher prevalence of comorbid conditions, worse preoperative functional status, or because patient frailty increases with age. Because of the known association between older age, patients presenting from skilled nursing facilities, and worse postoperative outcomes, some centers have created multi-level interventions for these vulnerable groups of patients to decrease both readmission and mortality rates.

Limitations

There are several limitations to consider in the current study. This is an observational study using data from a procedural registry linked to claims data as well as a dataset including facility-level data. As such, causation cannot be ascertained from the study design. Given the linkage to Medicare claims data, this limits our analysis to patients over age 65 and it is not known if the same findings can be attributed to younger individuals who undergo LER. In addition, the cohort only included patients who underwent LER at VQI participating centers. While there are over 900 centers that participate in the VQI, participation is voluntary and may not be representative of the care provided at a non-participating center. The same can be said of those facilities that respond to the AHA annual survey (aim two of this study only included information for facilities that responded).

Conclusions

Readmission care fragmentation in and of itself is not associated with perioperative mortality or amputation. However, readmissions to non-index facilities for procedure-related complications are strongly associated with subsequent limb loss. This finding suggests more focus should be placed on the prevention of procedural complications that require hospital readmission and potential reintervention. An important first step would be exploring the role that care fragmentation, specifically in those individuals who require reintervention during a readmission, has on perioperative outcomes. It reintervention care fragmentation is associated with poor outcomes, one potential future line of investigation could be finding ways to optimize care continuity for patients after LER through closer follow-up by the operative team so that when reintervention becomes necessary it is more readily identified and managed at the index facility. In addition, because of the known association between racial and economic disparities and amputation rates, it will also be important to explore how reintervention care fragmentation affects different communities as well.

References

1. Fowkes GF, Rudan D, Rudan I, et al. Comparison of global estimates of prevalence and risk factors for peripheral artery disease in 2000 and 2010: a systematic review and analysis. *Lancet* 2013;382:1329-40.
2. Long CA, Mulder H, Fowkes FGR, et al. Incidence and Factors Associated With Major Amputation in Patients with Peripheral Artery Disease: Insights From the EUCLID Trial. *Circulation Cardiovascular quality and outcomes*. 1010;13(7):e006399.
3. Grenon SM, Vittinghoff E, Owens CD, Conte MS, Whooley M, Cohen BE. Peripheral artery disease and risk of cardiovascular events in patients with coronary artery disease: insights from the Heart and Soul Study. *Vasc Med*. 2013;18(4):176-184.
4. Secemsky EA, Schermerhorn M, Carroll BJ, et al. Readmissions After Revascularization Procedures for Peripheral Arterial Disease: A Nationwide Cohort Study. *Ann Intern Med*. 2018;168(2):93-99.
5. Moussa Pacha H, Mir T, Al-Khadra Y, et al. Trends and causes of readmission following peripheral vascular intervention in patients with peripheral vascular disease. *Catheter Cardiovasc Interv*. 2021;98(3):540-548.
6. Bundled Payments Care Initiative Advanced. 2022. (Accessed January 28, 2023., 2023, at https://innovation.cms.gov/initiatives/bpci-advanced.)
7. Gonzalez AA, Cruz CG, Dev S, Osborne NH. Indication for Lower Extremity Revascularization and Hospital Profiling of Readmissions. *Ann Vasc Surg* 2016;35:130-7.
8. Vogel TR, Kruse RL. Risk factors for readmission after lower extremity procedures for peripheral artery disease. *J Vasc Surg* 2013;58:90-7.e1-4.
9. Haggerty JL, Reid RJ, Freeman GK, Starfield BH, Adair CE, McKendry R. Continuity of care: a multidisciplinary review. *BMJ*. 2003;327(7425):1219-1221.
10. Edwards ST, Greene L, Chaudhary C, Boothroyd D, Kinosian B, Zulman DM. Outpatient Care Fragmentation and Acute Care Utilization in Veterans Affairs Home-Based Primary Care. *JAMA Netw Open.* 2022;5(9):e2230036.
11. Brooke BS, Goodney PP, Kraiss LW, Gottlieb DJ, Samore MH, Finlayson SR. Readmission destination and risk of mortality after major surgery: an observational cohort study. *Lancet*. 2015;386(9996):884-895.
12. van Walraven C, Oake N, Jennings A, Forster AJ. The association between continuity of care and outcomes: a systematic and critical review. *J Eval Clin Pract*. 2010;16(5):947-956.
13. Tsai TC, Orav EJ, Jha AK. Care Fragmentation in the Postdischarge Period: Surgical Readmissions, Distance of Travel, and Postoperative Mortality. *JAMA Surg.* 2015;150(1):59–64.
14. Ghaferi AA, Schwartz TA, Pawlik TM. STROBE Reporting Guidelines for Observational Studies. *JAMA Surg*. 2021;156(6):577-578.
15. The Vascular Quality Initiative. 2023. (Accessed January 12, 2023, 2023, at http://www.vascularqualityinitiative.org/.)

16. Hoel AW, Faerber AE, Moore KO, et al. A pilot study for long-term outcome assessment after aortic aneurysm repair using Vascular Quality Initiative data matched to Medicare claims. *J Vasc Surg* 2017;66:751-9.e1.
17. Columbo JA, Martinez-Camblor P, MacKenzie TA, et al. Comparing Long-term Mortality After Carotid Endarterectomy vs Carotid Stenting Using a Novel Instrumental Variable Method for Risk Adjustment in Observational Time-to-Event Data. *JAMA network open* 2018;1:e181676.
18. Tsougranis G, Eldrup-Jorgensen J, Bertges D, et al. The Vascular Implant Surveillance and Interventional Outcomes (VISION) Coordinated Registry Network: An effort to advance evidence evaluation for vascular devices. *J Vasc Surg* 2020;72:2153-60.
19. Reschovsky JD, Hadley J, Saiontz-Martinez CB, Boukus ER. Following the money: factors associated with the cost of treating high-cost Medicare beneficiaries. *Health Serv Res*. 2011;46(4):997-1021.
20. Hussey PS, Schneider EC, Rudin RS, Fox DS, Lai J, Pollack CE. Continuity and the costs of care for chronic disease. *JAMA Intern Med*. 2014;174(5):742-748.
21. Frandsen BR, Joynt KE, Rebitzer JB, Jha AK. Care fragmentation, quality, and costs among chronically ill patients. *Am J Manag Care*. 2015;21(5):355-362.
22. Brooke BS, Goodney PP, Kraiss LW, Gottlieb DJ, Samore MH, Finlayson SR. Readmission destination and risk of mortality after major surgery: an observational cohort study. *Lancet*. 2015;386(9996):884-895.
23. Justiniano CF, Xu Z, Becerra AZ, et al. Effect of care continuity on mortality of patients readmitted after colorectal surgery. *Br J Surg*. 2019;106(5):636-644.
24. Funk RJ, Pagani FD, Hou H, et al. Care fragmentation predicts 90-day durable ventricular assist device outcomes. *Am J Manag Care*. 2022;28(12):e444-e451.
25. Tsai TC, Joynt KE, Orav EJ, Gawande AA, Jha AK. Variation in surgical-readmission rates and quality of hospital care. *N Engl J Med*. 2013;369(12):1134-1142.
26. Glance LG, Kellermann AL, Osler TM, et al. Hospital readmission after noncardiac surgery: the role of major complications. *JAMA Surg*. 2014;149(5):439-445.
27. Hakkarainen TW, Arbabi S, Willis MM, Davidson GH, Flum DR. Outcomes of Patients Discharged to Skilled Nursing Facilities After Acute Care Hospitalizations. *Ann Surg*. 2016;263(2):280-285.
28. Allen LA, Hernandez AF, Peterson ED, et al. Discharge to a skilled nursing facility and subsequent clinical outcomes among older patients hospitalized for heart failure. *Circ Heart Fail*. 2011;4(3):293-300.
29. Chandra A, Takahashi PY, McCoy RG, et al. Risk Prediction Model for 6-Month Mortality for Patients Discharged to Skilled Nursing Facilities. *J Am Med Dir Assoc*. 2022;23(8):1403-1408.

Figure 1.

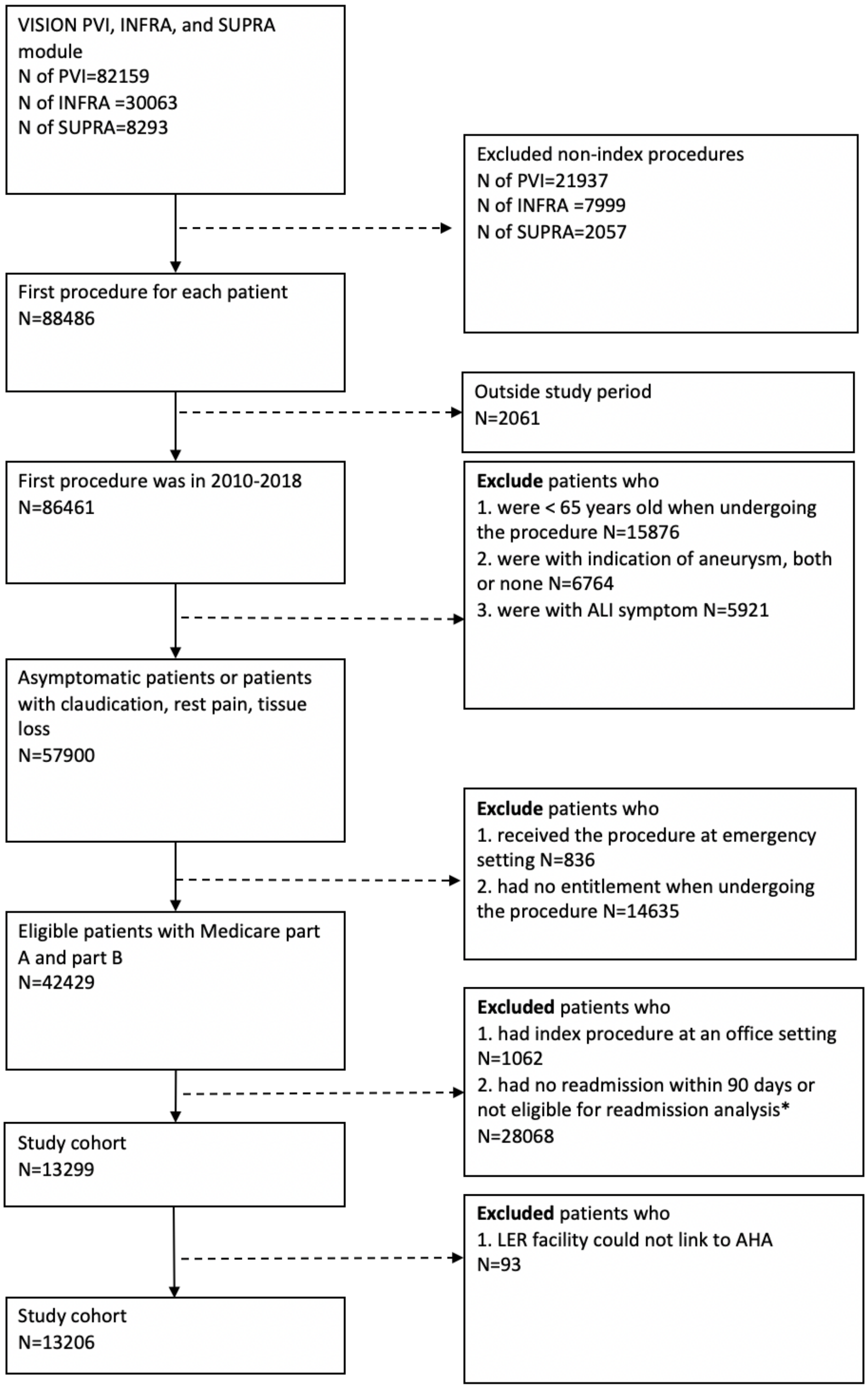

Figure 1. Study flow diagram

Table 1. Proportion of 90-day and 30-day readmission after LER

	90-day				30-day		
	Crude	Adjusted (lower, upper bound)			Crude	Adjusted (lower, upper bound)	
Readmission	30.93%	30.99%	(30.43, 31.56)		18.30%	18.31%	(17.89, 18.73)

LER, lower extremity revascularization

Table 2. Baseline Characteristics of Patients Readmitted after LER to Index and Non-Index Facilities

	Total N=13,206	Readmit Index N=9,600 (72.7%)	Readmit Non-Index N=3,606 (27.3%)	p
SOCIODEMOGRAPHIC FACTORS				
Age				<.001
65-69	4,127 (31.3)	3,116 (32.5)	1,011 (28.0)	
70-74	2,699 (20.4)	1,942 (20.2)	757 (21.0)	
75-79	2,382 (18.2)	1,715 (17.9)	667 (18.5)	
80-84	1,940 (14.7)	1,377 (14.3)	563 (15.6)	
>85	2,058 (15.6)	1,450 (15.1)	608 (16.9)	
Female sex	5,476 (41.5)	3,930 (40.9)	1,546 (42.9)	.04
Hispanic	210 (1.6)	146 (1.5)	64 (1.8)	.85
Race				.01
White	10,742 (81.4)	7,754 (80.8)	2,988 (82.9)	
Black	1,933 (14.6)	1,463 (15.2)	470 (13.0)	
Other	319 (2.4)	236 (2.5)	83 (2.3)	
Coronary artery disease	4,897 (37.1)	3,570 (37.2)	1,327 (36.8)	.67
Congestive heart failure	3,869 (29.3)	2,781 (29.0)	1,088 (30.2)	.18
Chronic obstructive pulmonary disease	3,930 (29.8)	2,838 (29.6)	1,092 (30.3)	.43
Diabetes mellitus	7,669 (58.1)	5,578 (58.1)	2,091 (58.0)	.88
Dialysis	1,800 (13.6)	1,312 (13.7)	488 (13.5)	.84
Hypertension	12,179 (92.3)	8,855 (92.3)	3,324 (92.2)	.87
Prior amputation	1,790 (13.6)	1,293 (13.5)	497 (13.8)	.64
Distance to index facility (in miles)				<.001
Q1: 0-4.8	3,278 (24.8)	2,820 (29.4)	458 (12.7)	
Q2: 4.9-12	3,337 (25.3)	2,621 (27.3)	716 (19.9)	
Q3: 12.1-31.3	3,292 (24.9)	2,275 (23.7)	1,017 (28.2)	
Q4: 31.4-2487.6	3,299 (25)	1,884 (19.6)	1,415 (39.2)	
Distressed Communities Index				.04
Prosperous	3,081 (24)	2,258 (24.1)	823 (23.5)	
Comfortable	2,780 (21.6)	2,002 (21.4)	778 (22.2)	
Mid-tier	2,522 (19.6)	1,789 (19.1)	733 (20.9)	
At risk-Distressed	4,481 (34.8)	3,313 (35.4)	1,168 (33.4)	
PREOPERATIVE FACTORS				
Preop Functional status				.59
Full ambulation	7,593 (58)	5,550 (58.2)	2,043 (57.3)	
Ambulatory with assist	4,164 (31.8)	3,018 (31.7)	1,146 (32.1)	
Bedbound	1,343 (10.3)	966 (10.1)	377 (10.6)	
Severity of PAD on Presentation				.17
Asymptomatic/Claudication	3,526 (26.7)	2,559 (26.7)	967 (26.9)	
Rest pain	2,186 (16.6)	1,571 (16.4)	615 (17.1)	
Tissue Loss	7,494 (56.7)	5,470 (57.0)	2,024 (56.1)	
PROCEDURE AND POSTOPERATIVE CHARACTERISTICS				
Method of LER				<.001
Endovascular	8,827 (66.8)	6,303 (65.7)	2,524 (70.0)	
Open surgical	3,665 (27.8)	2,774 (28.9)	891 (24.7)	
Hybrid	714 (5.4)	523 (5.4)	191 (5.3)	
Discharge location				.005
Home + Homecare	8,455 (64.1)	6,153 (64.1)	2,302 (63.9)	
SNF	3,738 (28.3)	2,702 (28.2)	1,036 (28.8)	
Rehab	1,000 (7.6)	735 (7.7)	265 (7.4)	
Readmission related to procedure	5,578 (42.2)	4,803 (50.0)	775 (21.5)	<.001

LER, lower extremity revascularization; PAD, peripheral artery disease; Preop, preoperative; SNF, skilled nursing facility; Rehab, rehabilitation facility.

Table 3. Association Between Sociodemographic, Preoperative, Procedural, and Postoperative Characteristics With Outcomes of Interest

	90-day Mortality aOR (95% CI)	30-day Amputation aOR (95% CI)	90-day Amputation aOR (95% CI)
Readmit non-index facility	1.09 (0.93-1.27)	0.78 (0.61-1.00)	0.95 (0.80-1.14)
SOCIODEMOGRAPHIC CHARACTERISTICS			
Age			
65-69	REFERENT		
70-74	1.21 (0.99-1.47)	0.92 (0.72-1.18)	0.92 (0.77-1.10)
75-79	1.38 (1.13-1.68)	1.06 (0.82-1.37)	1.01 (0.84-1.22)
80-84	1.75 (1.44-2.13)	1.06 (0.81-1.40)	0.84 (0.68-1.04)
>85	2.50 (2.07-3.02)	1.13 (0.86-1.48)	0.90 (0.73-1.11)
Sex			
Male	REFERENT		
Female	0.95 (0.84-1.06)	0.72 (0.61-0.85)	0.66 (0.58-0.75)
Race			
White	REFERENT		
Non-White	0.84 (0.72-0.99)	1.62 (1.34-1.97)	1.71 (1.47-1.98)
Coronary artery disease	1.11 (0.99-1.25)	1.04 (0.88-1.23)	1.01 (0.89-1.15)
Congestive heart failure	1.41 (1.25-1.60)	1.07 (0.89-1.27)	0.98 (0.85-1.12)
Chronic obstructive pulmonary disease	1.13 (1.00-1.28)	0.94 (0.78-1.13)	0.90 (0.78-1.04)
Diabetes mellitus	0.87 (0.77-0.98)	1.34 (1.12-1.62)	1.55 (1.35-1.79)
Dialysis	2.97 (2.51-3.53)	1.90 (1.52-2.37)	1.64 (1.37-1.95)
Hypertension	1.00 (0.80-1.25)	0.82 (0.61-1.09)	0.76 (0.61-0.95)
Prior amputation	0.83 (0.71-0.98)	1.40 (1.15-1.71)	1.51 (1.29-1.76)
Distance to index facility (in miles)			
Q1: 0-4.8	REFERENT		
Q2: 4.9-12	0.92 (0.79-1.08)	0.94 (0.75-1.18)	1.07 (0.90-1.27)
Q3: 12.1-31.3	1.02 (0.87-1.20)	1.26 (1.01-1.57)	1.20 (1.01-1.43)
Q4: 31.4-2487.6	0.98 (0.83-1.16)	1.21 (0.96-1.54)	1.09 (0.90-1.30)
Distressed Communities Index			
Prosperous	0.86 (0.74-1.01)	1.01 (0.81-1.27)	0.80 (0.67-0.94)
Comfortable	0.78 (0.67-0.92)	1.04 (0.84-1.30)	0.91 (0.77-1.08)
Mid-tier	0.82 (0.70-0.96)	0.98 (0.78-1.22)	0.82 (0.69-0.97)
At risk-Distressed	REFERENT		
PREOPERATIVE CHARACTERISTICS			
Preop Functional Status			
Full ambulation	REFERENT		
Ambulatory with assist	1.36 (1.19-1.55)	1.23 (1.02-1.47)	1.13 (0.98-1.29)
Bedbound	1.90 (1.59-2.27)	1.26 (0.98-1.63)	1.27 (1.04-1.55)
Severity of PAD on Presentation			
Asymptomatic/Claudication	REFERENT		
Rest pain	1.48 (1.20-1.82)	2.64 (1.86-3.74)	3.03 (2.33-3.93)
Tissue Loss	1.65 (1.39-1.95)	3.47 (2.57-4.69)	4.99 (4.00-6.24)
PROCEDURE AND POSTOPERATIVE CHARACTERISTICS			
Method of LER			
Endovascular	REFERENT		
Open surgical	0.64 (0.55-0.74)	0.75 (0.61-0.91)	0.66 (0.57-0.77)
Hybrid	0.97 (0.75-1.26)	0.50 (0.31-0.79)	0.59 (0.43-0.82)
Discharge location			
Home + Homecare	REFERENT		
SNF	1.98 (1.74-2.25)	1.54 (1.28-1.84)	1.53 (1.33-1.76)
Rehab	1.11 (0.88-1.41)	1.01 (0.72-1.42)	1.23 (0.97-1.56)
Readmission related to procedure	0.57 (0.50-0.65)	3.58 (3.00-4.27)	3.33 (2.93-3.80)
READMISSION FACILITY CHARACTERISTICS			
Total Bed Size			
Q1: 10-50	REFERENT		
Q2: 251-483	1.20 (0.96-1.50)	1.01 (0.71-1.44)	1.13 (0.86-1.47)
Q3: 484-726	1.31 (0.97-1.76)	1.23 (0.79-1.90)	1.20 (0.86-1.68)
Q4: 727-2877	1.31 (0.92-1.86)	1.26 (0.77-2.05)	1.19 (0.82-1.72)
Adjusted Admissions			
Q1: 650-25663	REFERENT		
Q2: 25664-45180	0.96 (0.77-1.21)	101 (0.71-1.45)	1.11 (0.85-1.45)
Q3: 45181-66981	0.73 (0.53-0.99)	1.03 (0.66-1.62)	1.19 (0.85-1.66)
Q4: 66982-245209	0.64 (0.45-0.90)	0.97 (0.59-1.59)	1.22 (0.84-1.77)
Total Surgical Volume			
Q1: 43-9224	REFERENT		
Q2: 9225-19348	0.90 (0.74-1.09)	1.16 (0.86-1.58)	1.02 (0.81-1.28)
Q3: 19349-30099	0.99 (0.77-1.28)	0.95 (0.65-1.40)	0.87 (0.65-1.16)
Q4: 30100-138011	1.06 (0.78-1.43)	0.99 (0.65-1.53)	0.89 (0.64-1.23)

aOR, adjusted odds ratio; LER, lower extremity revascularization; PAD, peripheral artery disease; Preop, preoperative; SNF, skilled nursing facility; Rehab, rehabilitation facility.