Clinical characteristics associated with readmission among patients undergoing vascular surgery

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Objective: **Readmission after a vascular surgery intervention is frequent, costly, and often considered preventable. Vascular surgery outcomes have recently been scrutinized by Medicare because of the high rates of readmission. We determined patient and clinical characteristics associated with readmission in a cohort of vascular surgery patients.**

Methods: **From 2009 to 2013, the medical records of all patients (n = 2505) undergoing interventions by the vascular surgery service at a single tertiary care institution were retrospectively reviewed. Sociodemographic and clinical characteristics were examined for association with 30-day readmission to the same institution.**

Results: **The 30-day readmission rate to the same institution was 9.7 % (n = 244). Procedures most likely to result in readmission were below-knee (25%), foot (22%), and toe amputations (19%), as well as lower extremity revascularization (22%). Patients covered by Medicaid (16.8%) and Medicare (10.0%) were most likely to be readmitted, followed by fee-for-service (9.5%), self-pay (8.0%), and health maintenance organizations (5.5%; $P < .05$). Patients urgently admitted were more likely to be readmitted (16.2%) than those electively admitted (9.1%; $P < .01$). Patient severity as rated using the All Patient Refined Diagnosis Related Groups software (3M Health Information Systems, Wallingford, Conn) predicted readmission (16.2% high vs 6.2% low severity; $P < .01$). Initial length of stay was longer for readmitted than non-readmitted patients (8.5 vs 6.1 days, respectively; $P < .01$). Intensive care unit admission during the initial hospitalization was associated with higher readmission rates in univariable analysis (18.3% with vs 9.5% without intensive care unit stay; $P < .05$). Discharge destination was also a strong predictor of readmission (rehabilitation, 19.2%; skilled nursing facility, 16.2%; home, 6.2%; $P < .01$). The effects of urgent admission, proximity to hospital, length of stay, lower extremity open procedure or amputation, and discharge destination persisted in multivariable logistic regression ($P < .05$).**

Conclusions: **To reduce readmission rates effectively, institutions must identify high-risk patients. Efforts should focus on subgroups undergoing selected interventions (amputations, lower extremity revascularization), those with urgent admissions, and patients with extended hospital stays. Patients in need of postacute care upon discharge are especially prone to readmission, requiring special attention to discharge planning and coordination of postdischarge care. By focusing on subgroups at risk for readmission, preventative resources can be efficiently targeted. (J Vasc Surg 2014;59:1349-55.)**

Hospital readmission has become the focus of quality improvement efforts owing to the added cost placed on patients and the health care system. An estimated $17.4 billion per year was spent on readmissions for Medicare patients during the last decade.[1] The Patient Protection and Affordable Care Act serves to address this issue with the creation of the Hospital Readmission Reduction Program. This policy mandates the Centers for Medicare and Medicaid Services (CMS) to reduce payment to hospitals with higher-than-expected 30-day readmission rates in specified patient populations.[1,2] The first penalties took effect in 2012 and were applied to hospitals with high readmission rates for heart failure, acute myocardial infarction, and pneumonia.[3] New measures have been formulated that will expand these penalties to additional patient populations.

Vascular surgery may soon become a target for readmission penalties for two reasons. First, Jencks et al[1] found that vascular surgery patients have an overall 30-day readmission rate of 24.9%; only patients with congestive heart failure and psychoses are readmitted more frequently. Second, most vascular surgery readmissions are considered preventable.[4] To prevent readmissions, reduce health care cost, and improve the quality of patient care, a better understanding is needed of the association between upstream clinical factors and vascular surgery readmissions.

Existing literature on 30-day readmission rates after vascular procedures is limited but has shown some association with selected patient comorbidities, postoperative complications, discharge to skilled nursing facility (SNF), and prolonged length of stay.[3,5-7] Brooke et al[8] recently synthesized this literature and recommend studying vascular surgery readmissions as characterized by four phases of care: (1) patient, procedural, and structural characteristics, (2) postoperative care, (3) planning and executing patient discharge, and (4) the readmission itself.

We examine characteristics at these stages of care and hypothesize that patient severity, emergent admission,

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type of procedure, and discharge destination are associated with unplanned readmission. These results may allow us to identify those vascular surgical patients at high risk for readmission who may benefit from additional transitional care planning.

We use data available through the electronic medical record of a large, tertiary care medical center to assess clinical factors associated with unplanned readmission in a cohort of patients who underwent a procedure by the vascular surgery service. A more complete understanding of the influences driving unplanned readmission rates in vascular surgery patients will advise further efforts toward improving quality of care. Specifically, we examine an institutional database to identify sources of readmission for efficient use of resources in policy and protocol implementation.

METHODS

A retrospective review was performed for all procedures by the vascular surgery service between July 2008 and December 2012 at a tertiary care institution. Data collection was performed by the hospital Business Planning and Analysis Office. The study was approved by the hospital Institutional Review Board.

Study population. All patients who underwent a procedure by the vascular surgery service were included. We excluded patients who died during the primary hospitalization, patients who were discharged against medical advice, and patients who had scheduled readmissions, such as planned wound closures and contralateral procedures, ≤30 days of their first procedure. Patients required a surgical procedure code with service performed by a vascular surgeon for the primary admission.

Readmission was defined as an unplanned inpatient stay at the same institution ≤30 days of discharge from the primary hospitalization. We defined planned readmissions similar to the definition used by CMS; "a non-acute readmission for a scheduled procedure" that must not include "a primary discharge diagnosis of readmission that is acute or a complication of care" (CMS Planned Readmission Algorithm Version 2.1, 2013).[2] Readmissions for observation status (<24-hour stay) were not included as readmissions in this study because they were not captured in the administrative data set. Multiple readmissions ≤30 days by the same patient were only counted as one early readmission event. An admission >30 days after the primary hospitalization was counted as a new primary admission.

Explanatory variables of interest included age, race (white or nonwhite), sex, proximity to the primary hospital (in-county or remote residence), insurance type (fee for service, health maintenance organization, Medicare, Medicaid, and other/self-pay), intensive care unit stay, procedure category, length of stay (days), severity of illness assessed by the 3M All Patient Refined Diagnosis Related Groups (APR DRG) classification (3M Health Information Systems, Wallingford, Conn), and discharge destination (home, home with home health care, SNF, rehabilitation, and other facility).

The 3M APR DRG expands on the basic CMS DRG categories by adding a subclass to account for differences relating to severity of illness. The severity of illness subclass divides patients into four subgroups: minor, moderate, major, and extreme. The 3M APR DRG classification is calculated from patient comorbidities and complicating postoperative conditions and compiled using International Classification of Diseases-Ninth Revision codes for principal diagnoses, secondary diagnoses, and procedure codes as well as age, sex, and discharge disposition.[9]

Missing data. No missing data were present for the analysis variables. The variable that flagged readmission as scheduled or unscheduled was missing in 24% of observations. To ensure that we included only unplanned readmissions, we reviewed the principal diagnosis of the readmission for all readmitted patients and excluded those with planned procedures.

Statistical analysis. Analyses were performed using STATA 10 software (StataCorp LP, College Station, Tex). Percentages and medians with interquartile ranges were used to summarize analysis variables. The Pearson χ^2 test and Fisher exact test were used to characterize the associations between unplanned readmission and explanatory variables. Characteristics of unplanned readmissions were also summarized, including the principal diagnosis, length of stay, readmitting service, and discharge destination.

Multivariable logistic regression was used to examine predictors of unplanned readmission to the same institution ≤30 days. The 3M severity measure is a composite measure that includes a number of other explanatory variables of interest. Therefore, to avoid collinearity and adjusting for the same factors more than once, we excluded severity from the regression.

RESULTS

All patients. The database query identified 2505 patients undergoing vascular surgery interventions during the study period (Table I). Although mortality and stroke rate information were not available in this database, linked institutional National Surgical Quality Improvement Program data information provided a 30-day mortality rate of 3.5% and stroke rate of 1.3%. The overall 30-day readmission rate to the same institution was 11.9% (n = 301). Of the readmitted patients, 57 (19%) were planned and 244 (81%) were unplanned. The 30-day unplanned readmission rate to the same institution was 9.7% (n = 244) when excluding the 57 patients (2.2%) who had a planned readmission. Patients were a median age of 66 years, 61% were men, and 94.3% were white. Elective admissions accounted for 63% of the patients undergoing procedures (n = 1578), whereas 37% of procedures occurred for individuals who were admitted urgently or emergently (n = 927).

Nine surgeons treated the 2505 patients. The range of procedures performed by the individual surgeons was 116 to 584. Given faculty procedure specialization and care for different patient populations, we adjusted for patient

Table I. Characteristics of 2505 patients undergoing vascular procedures, 2009 to 2013

Variable	*Median or No. (N = 2505)*	*(IQR) or %*	*Readmitted* *Median (IQR) or %*	P
Age, years	66	(18)	64 (17.5) vs 66 (18) NR	.34
Sex				
Female	984	39.3	9.6	.8
Male	1521	60.7	9.9	
Race				
White	2362	94.3	9.8	.93
Nonwhite	143	5.7	9.1	
Proximity to hospital				.02
In-county residence	715	28.5	12.0	
Remote residence	1790	71.5	8.8	
Illness severity score				<.001
Low severity	461	18.4	4.3	
Medium severity	903	36.0	7.5	
High severity	762	30.4	12.7	
Very high severity	379	15.1	15.6	
Clinic follow-up				<.001
Outpatient visit in 30 days	2048	81.8	10.7	
No outpatient visit	457	18.2	5.5	
Admission type				<.001
Emergent	927	37.0	14.6	
Elective	1578	63.0	6.9	
Insurance				.02
Medicare	1544	61.6	10.0	
Medicaid	125	5.0	16.8	
HMO	238	9.5	5.5	
Fee for service	461	18.4	9.5	
Other/self-pay	137	5.5	8.0	
ICU status				.02
No ICU stay	2434	97.2	9.5	
ICU stay	71	2.8	18.3	
Procedure type				.02
Open	2116	84.5	10.3	
Endovascular	389	15.5	6.4	
Index LOS, days	5	(6)	7 (7) vs 4 (6) NR[a]	<.001
Discharge destination				<.001
Home	1440	57.5	6.7	
Home with home health	498	19.9	10.8	
SNF	333	13.3	16.2	
Rehabilitation center	130	5.2	19.2	
Other facility	104	4.2	14.4	
30-day unplanned readmission	244	9.7	NA	NA

HMO, Health maintenance organization; *ICU,* intensive care unit; *IQR,* interquartile range; *LOS,* length of stay; *NA,* not applicable; *NR,* not readmitted; *SNF,* skilled nursing facility.

severity using the APR DRG severity index score and reassessed surgeon-specific readmission rates. With adjustment for patient severity, physicians did not have significantly different readmission rates ($P > .05$).

Univariate analysis. Bivariable associations between unplanned readmission and additional variables of interest are also summarized in Table I. Demographic characteristics are not associated with unplanned readmission. Patients who reside in the same county as the medical center are more likely to be readmitted to the same institution ($P = .02$) compared with those who live in another county. Patients with higher illness severity are readmitted more frequently, with severe patients readmitted three times more frequently than patients with low illness severity ($P < .001$). Outpatient postoperative clinic visit ≤30 days is strongly associated with unplanned readmission to the same institution (10.7% vs 5.5% with no visit; $P < .001$). Patients admitted urgently or emergently are more likely to be readmitted at a rate of 14.6% compared with electively admitted patients, who are readmitted 6.9% of the time ($P < .01$). Any intensive care unit stay during the primary hospitalization is also associated with readmission ($P = .02$). Discharge destination is significantly associated with 30-day readmission, with readmission from a rehabilitation facility (19.2%) and SNF (16.2%) being markedly higher than readmission after discharge to home without assistance (6.7%; $P < .001$).

Procedure type is associated with the unplanned 30-day readmission rate (Table II). Readmission is the highest among patients undergoing lower extremity amputations,

Table II. Characteristics of the procedure by unplanned readmission (n = 2505)

Procedure	*Procedure volume, No.*	*% Readmitted*	*% of Readmitted patients (n = 244)*
Abdominal	691	5.5	15.6
EVAR	196	5.1	4.1
Open AAA	279	5.0	5.7
Occlusive	184	6.0	4.5
Other abdominal	32	9.4	1.2
Head/neck	372	3.2	4.9
Carotid endarterectomy	328	3.0	4.1
Carotid stent	24	0.0	0.0
Other head/neck	20	10.0	0.8
Lower extremity	597	13.7	33.6
Endovascular	98	8.2	3.3
Open	499	14.8	30.3
Thoracic	127	7.1	3.7
TEVAR	78	6.4	2.0
TAA/TAAA	49	8.2	1.6
Upper extremity	82	7.3	2.5
Reconstruction	24	16.7	1.6
First rib	58	3.4	0.8
Wound debridement/ excision	101	14.9	6.1
Amputations	399	17.8	29.1
BKA	104	24.0	10.2
AKA	45	13.3	2.5
Foot	201	16.4	13.5
Other	49	14.3	2.9
Other procedures	136	8.1	4.5
Endovascular	18	11.1	0.8
Venous	15	13.3	0.8
Skin graft	21	4.8	0.4
Fasciotomy/ fasciectomy	40	10.0	1.6
Open	42	4.8	0.8

AAA, Abdominal aortic aneurysm; *AKA,* above-knee amputation; *BKA,* below-knee amputation; *EVAR,* endovascular aneurysm repair; *TAA,* thoracic aortic aneurysm; *TAAA,* thoracoabdominal aortic aneurysm; *TEVAR,* thoracic endovascular aortic repair.

with a rate of 24.0% for below-the-knee amputation (BKA), 16.4% for forefoot and distal amputations, and 13.3% for above-the-knee amputation (AKA). Patients undergoing open lower extremity procedures are also readmitted frequently (14.8%). Together, BKA amputations and open revascularizations account for 34% of all patients treated and 59.4% of readmissions during the study period.

Readmission data. Characteristics of 30-day, same institution unplanned readmissions are presented in Table III. Of these, 60.2% of patients are readmitted to the vascular surgery service, with ~40% returning to a different hospital service. Within the first week of discharge, 28.3% of 30-day readmissions occur.

Wound complications (inclusive of surgical site infection, hematoma, seroma, and wound dehiscence) are the most common readmitting diagnosis (37%), followed by other vascular complications (9.4%). Surgical site infection accounted for 20.1% of the readmissions. During this time period, Surgical Care Improvement Project data were

Table III. Characteristics of the 30-day readmission (n = 244)

Variable	*No. or median*	*% or (IQR)*
Readmitted to vascular service	147	60.2
Readmitted within first 7days	69	28.3
Readmission LOS, days	5	(6)
Readmitting diagnosis		
Wound infection or complication	90	36.9
Vascular complication[a]	23	9.4
Gastrointestinal	19	7.8
Device or graft	15	6.1
Cardiac complication	13	5.3
Respiratory complication	13	5.3
Renal complication	12	4.9
Hematoma	11	4.5
Other	48	19.7
Discharge destination		
Dead	9	3.7
Home	69	28.3
Home with home health	67	27.5
SNF	63	25.8
Rehabilitation facility	22	9.0
Other facility	14	5.7

IQR, Interquartile range; *LOS,* length of stay; *SNF,* skilled nursing facility.
[a]Ischemic ulcer, rest pain, etc.

assessed, and compliance with preoperative antibiotic use by the vascular surgery service was 94.6%, similar to the overall mean compliance rate of 94.5% reported to The Joint Commission by hospitals nationwide. Medical complications are responsible for 23% of readmissions (gastrointestinal, 7.8%; pulmonary, 5.3%; cardiac, 5.3%; and renal, 4.9%). Mortality during the readmission is 3.7%. Although 77.4% patients are discharged to home (with and without home health care), they account for 55.8% of total readmissions. Approximately 13% of patients are discharged to SNFs but account for 25.8% of the total readmissions. Rehabilitation centers account for 5.2% of total discharges; therefore, despite having the highest readmission rate (19.2%), they only account for 9% of total readmissions.

Multivariable analysis. In multivariable analysis (Table IV), odds of readmission are lower after elective procedures than after emergent procedures (odds ratio [OR], 0.72; 95% confidence interval [CI], 0.53-0.99; $P = .04$). Health maintenance organization insurance coverage is also associated with a lower odds of readmission (OR, 0.43; 95% CI, 0.22-0.84; $P = .01$). The odds of readmission increases 1.03 times (95% CI, 1.01-1.05; $P = .001$) for each additional day of primary hospital stay. A lower extremity amputation or open revascularization leads to a 2.35 increased odds (95% CI, 1.71-3.23; $P < .001$) of readmission compared with other vascular procedures. Discharge to SNF also remains significant, with a 1.54 increased odds (95% CI, 1.00-2.37; $P = .05$) of readmission in adjusted analysis. Patients residing within the county of the primary hospital are more likely to return to that hospital when readmitted than patients residing further from the primary hospital (OR, 1.71; 95%

Table IV. Multivariable analysis predicting unplanned readmission (n = 2505)

Variable[a]	*OR (95% CI)*	P
Age	0.99 (0.98-1.01)	.40
Male	1.07 (0.81-1.42)	.64
Nonwhite	0.71 (0.38-1.32)	.28
In-county residence	1.71 (1.26-2.31)	<.001
Elective admission	0.72 (0.53-0.99)	.04
Insurance		
HMO	0.43 (0.22-0.84)	.01
Medicaid	1.32 (0.73-2.41)	.36
Medicare	1.00 (0.66-1.51)	.99
Other/self-pay	0.80 (0.39-1.66)	.55
ICU stay	1.61 (0.82-3.14)	.16
Index LOS	1.03 (1.01-1.05)	<.001
Endovascular procedure	1.11 (0.69-1.79)	.67
Lower extremity open or amputation	2.35 (1.71-3.23)	<.001
Discharge destination		
Home with home health	1.16 (0.80-1.69)	.44
SNF	1.54 (1.00-2.37)	.05
Rehabilitation facility	1.49 (0.87-2.55)	.14
Other facility	1.13 (0.56-2.25)	.74
C statistic	.72	

CI, Confidence interval; *HMO,* health maintenance organization; *ICU,* intensive care unit; *LOS,* length of stay; *OR,* odds ratio; *SNF,* skilled nursing facility.

[a]Reference categories: female, white, remote residence, low severity, emergent admission, fee for service, insurance, no ICU, open procedure, and discharged to home.

CI, 1.26-2.31; $P = .001$). A multivariable analysis performed without inclusion of the patient residence variable, given concerns for collinearity, found that length of stay, procedure type, and discharge destination remained significantly associated with rates of readmission ($P < .05$) and that amputation or lower extremity intervention approached significance ($P = .06$).

DISCUSSION

This study is the largest single-institution review of readmission within a vascular surgery population. A broad vascular surgery practice that includes all major open and endovascular procedures is evaluated. With the high burden of unplanned readmissions in vascular surgery and policy changes that are likely to follow, it is imperative to understand who is most likely to be readmitted and the most common causes of readmission. The overall same-hospital unplanned readmission rate of 9.7% in our sample was similar to the 8.9% unplanned readmission rate in another single-institution study.[4]

Wound complications (postoperative infections, infected amputation stumps, and dehiscence) were the most common principal diagnosis for readmissions in this study sample. In the Project of Ex-Vivo Vein Graft Engineering via Transfection III (PREVENT III) trial focusing on lower extremity intervention for critical limb ischemia, the overall 30-day readmission rate was 24.4%, and 39.8% of those readmissions were because of wound infections.[5] Similarly, 37% of readmissions in our broad sample of vascular procedures were due to wound infections. Wound complication rates for vascular procedures other than lower extremity interventions are not insignificant; the most common reason for readmission after open and endovascular abdominal aortic aneurysm (AAA) repair is wound complication.[3] Another study showed that the wound complication rates of endovascular AAA repair are higher than those of open AAA repair.[6] It is unlikely that wound infections will decrease with increasing use of endovascular therapy.

Efforts to reduce early postoperative wound complications are important for other areas of surgery. Surgical site complications are fairly common after laparotomy, occurring in 23% of patients,[10] and are even higher among elective colorectal surgical patients.[11] Another study found that the most significant independent risk factor for readmission with wound complication was a postoperative inpatient wound complication (OR, 4.20).[12] Successful efforts at reducing postoperative wound complications before discharge may decrease readmission rates. However, it is also possible that patients are being discharged without a wound complication and then return with an infection. Interventions to reduce surgical site infections initiated before or after discharge may be necessary to reduce early readmission rates.

Patients undergoing amputations had the highest risk of readmission (18%). Other data sets have identified amputations as a significant source of patient morbidity, 30-day mortality, and readmission. The Veterans Administration NSQIP data reported 30-day mortality rates of 6.3% for BKA and 13.3% for AKA.[13] Our overall amputation 30-day mortality rate, obtained by linking institutional data to the NSQIP data set, is 8.9%. Although 30-day readmission was not measured in the VA NSQIP study, the readmission rate was 70.6% during the median follow-up time of 32.1 months.[13] Another study found that initial amputation often leads to subsequent revisions and conversions to higher-level amputations. Specifically, 21.4% of patients require additional procedures after BKA, with 12.9% undergoing conversion to AKA and 8.5% undergoing contralateral amputations.[14]

Despite our use of various modalities to assess the appropriate level of amputation, including ankle-brachial indices, pulse volume recordings with transcutaneous oxygenation, and imaging with computed tomography angiography, magnetic resonance angiography, duplex ultrasound, and angiography to assess appropriate inflow for wound healing, rates of readmission for wound complications remain high. Specifically, 30.1% of readmissions in the amputation patients were secondary to wound complications. Of those admitted with wound complications, 92.0% underwent repeat interventions. Existing literature and our rates of readmission with subsequent morbidity after amputation suggest that this patient population requires considerable resources, with further need for improved postoperative management strategies.

Lower extremity procedures have demonstrated high readmission rates,[4] which we see in our analysis. When high-risk surgical procedures were examined in the Medicare population, readmission after bypass occurred 19% of

the time; higher readmission rates were experienced only after cystectomy and cardiac valve replacement.[15]

In our experience, endovascular lower extremity procedures are associated with a lower readmission rate. Another study has suggested that endovascular procedures are not protective from readmission. However, that study assessed a unique subset of patients with critical limb ischemia undergoing tibial interventions; these patients had a 30-day readmission rate of 29.6%.[16] The lower rate of readmission in our analysis may be secondary to procedure indication; we evaluated not only procedures for critical limb ischemia but also for lifestyle-limiting claudication.

Readmission rates after endovascular interventions compared with open revascularization procedures may require further analysis. Overall, however, high readmission rates after lower extremity revascularization procedures demonstrated in this study agree with others' findings and demonstrate the need for additional postoperative management strategies in this subgroup.

An association was seen between discharge destination and early readmission. This is consistent with findings from previous studies, which show an effect of increased readmission after discharge to SNFs. Approximately one-quarter of the overall Medicare patient population discharged to SNFs is readmitted.[17] In another study of patients undergoing AAA repair, the adjusted odds of readmission after discharge to a SNF was 2.5 times those discharged to home.[3] We can speculate that to reduce readmissions, hospitals will need to better coordinate care with SNFs. Transitional care models have been implemented with integrated case management in the outpatient setting after infrapopliteal bypass interventions, with a reduction in hospital readmissions and costs.[18] Coordination of care between hospitals and SNFs and rehabilitation centers is necessary for all vascular patients, and evidence-based protocols must be created to make this process more efficient.

Increasing inpatient days after a procedure were associated with an increased readmission rate. Among patients discharged after open and endovascular thoracic aneurysm repair, early discharge was associated with lower readmission and mortality after adjusting for in-hospital complications and patient comorbidities.[7] Longer length of stay was also a predictor of readmission after AAA repair[3] and after a lower extremity intervention.[19] Early discharge pathways have been proven safe and cost-effective after colectomy, coronary artery bypass surgery, and thoracic aneurysm repair.[7,20,21] We found that 28% of 30-day readmissions occurred within the first week of discharge. Despite our finding of increased readmission rates with increased length of stay, the high rate of early readmission suggests the possibility of premature discharge or undiagnosed postoperative complications upon discharge. Further cost-effectiveness and clinical outcomes analyses are needed in this area for vascular surgery patients.

Most vascular surgery patients in our study were insured by Medicare, and any penalty for readmission would therefore significantly affect the vascular service's practice. Currently, Medicare has taken a leading role in value-based care initiatives, such as accountable care organizations. A shift toward reimbursement that values quality of care is occurring with other payers and requires that we understand and then make efforts to improve outcomes such as preventable readmissions.

Notably, we found that nearly 20% of all readmissions to the same hospital within 30 days of a vascular procedure were planned. Although we ultimately excluded these patients from analysis, this significant percentage of planned readmissions indicates that claims-based analyses of readmissions that do not account for planned readmissions may overestimate the incidence of unplanned and preventable readmission in the vascular surgical population. Rather, vascular surgery patients often have planned wound closures and contralateral procedures soon after a primary vascular intervention. This is relatively unique in surgical practice and may account for the fact that readmissions for vascular patients are highest among surgical specialties in the Medicare population. In addition, limb salvage often results in subsequent reintervention or amputation $\leq$30 days (ie, a readmission), but a favorable outcome for these patients makes a great difference in their quality of life and their ability to independently perform activities of daily living.

This study has some limitations. Possibly the clearest limitation is the inability to capture readmissions to other institutions using business planning and analysis data in a retrospective manner. The overall readmission rate to any institution is likely to be higher. Although Jackson et al[4] found no vascular surgery readmission to alternate hospitals in a small prospective portion of their study, a large database study focused on a subset of vascular patients with AAAs found that 35.7% of these patients were readmitted to a different hospital.[3] This discrepancy highlights the need for further investigation into where and why patients are being readmitted to facilities other than the institution where primary procedures were performed, which is beyond the scope of this study.

This study is observational, with the goal of gaining insight to reduce readmissions at a large tertiary care institution. Using administrative databases limits the accessibility to variables of possible interest; in this case, we do not have access to patency rates for various types and indications of lower extremity bypass procedures. Studying a single academic medical center limits the generalizability of our results. However, our approach is instructive for other vascular services seeking to identify specific areas and subgroups of patients where applied interventions may improve quality of care.

CONCLUSIONS

Postoperative unplanned vascular readmissions are a major burden to patients and health care systems. We demonstrate a need for interventions to reduce wound complications and to improve care as patients transition from the inpatient to the outpatient setting. Patients identified at risk are those undergoing amputation and lower

extremity revascularization and those in need of continued higher level of care upon discharge. The primary care setting, SNF staff training, and advances in technology all offer options for improved surveillance. This study serves as a guide for focusing interventions on vascular subgroups at increased risk for unplanned early readmission.

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AUTHOR CONTRIBUTIONS

Conception and design: TE, KK, JM
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REFERENCES

1. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. N Engl J Med 2009;360:1418-28.
2. Centers for Medicare & Medicaid Services. Available at: http://www.cms.gov. Accessed August 11, 2013.
3. Greenblatt DY, Greenberg CC, Kind AJ, Havlena JA, Mell MW, Nelson MT, et al. Causes and implications of readmission after abdominal aortic aneurysm repair. Ann Surg 2012;256:595-605.
4. Jackson BM, Nathan DP, Doctor LL, Wang GJ, Woo EY, Fairman RM. Low rehospitalization rate for vascular surgery patients. J Vasc Surg 2011;54:767-72.
5. McPhee JT, Nguyen LL, Ho KJ, Ozaki CK, Conte MS, Belkin M. Risk prediction of 30-day readmission after infrainguinal bypass for critical limb ischemia. J Vasc Surg 2013;57:1481-8.
6. Casey KK, Hernandez-Boussard TT, Mell MW, Lee JT. Differences in readmissions after open repair versus endovascular aneurysm repair. J Vasc Surg 2013;57:89-95.
7. Brooke BS, Goodney PP, Powell RJ, Fillinger MF, Travis LL, Goodman DC, et al. Early discharge does not increase readmission or mortality after high-risk vascular surgery. J Vasc Surg 2013;57:734-40.
8. Brooke BS, De Martino RR, Girotti MM, Dimick JB, Goodney PP. Developing strategies for predicting and preventing readmissions in vascular surgery. J Vasc Surg 2012;56:556-62.
9. Agency for Healthcare Research and Quality. 3M HIS APR-DRG classification software-overview. Available at: http://www.ahrq.gov/professionals/quality-patient-safety/quality-resources/tools/mortality/Hughessumm.pdf. Accessed September 2, 2013.
10. Murray BW, Cipher DJ, Pham TT, Anthony TT. The impact of surgical site infection on the development of incisional hernia and small bowel obstruction in colorectal surgery. Am J Surg 2011;202:558-60.
11. Itani KM, Jensen EH, Finn TS, Tomassini JE, Abramson MA. Effect of body mass index and ertapenem versus cefotetan prophylaxis on surgical site infection in elective colorectal surgery. Surg Infect (Larchmt) 2008;9:131-7.
12. Kassin MT, Owen RM, Perez SD, Leeds I, Cox JC, Schnier K, et al. Risk factors for 30-day hospital readmission among general surgery patients. J Am Coll Surg 2012 Sep;215:322-30.
13. Feinglass J, Pearce WH, Martin GJ, Gibbs J, Cowper D, Sorensen M, et al. Postoperative and late survival outcomes after major amputation: findings from the Department of Veterans Affairs National Surgical Quality Improvement Program. Surgery 2001;130:21-9.
14. Henry AJ, Hevelone ND, Hawkins AT, Watkins MT, Belkin MM, Nguyen LL. Factors predicting resource utilization and survival after major amputation. J Vasc Surg 2013;57:784-90.
15. Goodney PP, Stukel TA, Lucas FL, Finlayson EV, Birkmeyer JD. Hospital volume, length of stay, and readmission rates in high-risk surgery. Ann Surg 2003;238:161-7.
16. Vogel TR, Dombrovskiy VY, Carson JL, Graham AM. In-hospital and 30-day outcomes after tibioperoneal interventions in the US Medicare population with critical limb ischemia. J Vasc Surg 2011;54:109-15.
17. Mor V, Intrator O, Feng Z, Grabowski DC. The revolving door of rehospitalization from skilled nursing facilities. Health Aff (Millwood) 2010;29:57-64.
18. Rümenapf GG, Geiger SS, Schneider BB, Amendt KK, Wilhelm NN, Morbach SS, et al. Readmissions of patients with diabetes mellitus and foot ulcers after infra-popliteal bypass surgery—attacking the problem by an integrated case management model. Vasa 2013;42:56-67.
19. Vogel TR, Kruse RL. Risk factors for readmission after lower extremity procedures for peripheral artery disease. J Vasc Surg 2013;58:90-4.
20. Hendren SS, Morris AM, Zhang WW, Dimick JJ. Early discharge and hospital readmission after colectomy for cancer. Dis Colon Rectum 2011;54:1362-7.
21. Cowper PA, DeLong ER, Hannan EL, Muhlbaier LH, Lytle BL, Jones RH, et al. Is early too early? Effect of shorter stays after bypass surgery. Ann Thorac Surg 2007;83:100-7.

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