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Thirty-day Readmission and Mortality among Medicare Beneficiaries Discharged to Skilled Nursing Facilities after Vascular Surgery

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Abstract

Background—Readmission within 30 days of an acute hospital stay is frequent, costly, and increasingly subject to penalties. Early readmission is most common after vascular surgery; these patients are often discharged to skilled nursing facilities (SNF), making post-acute care an essential partner in reducing readmissions. We characterize 30-day readmissions among vascular surgery patients discharged to SNF to provide evidence for this understudied segment of readmission after specialty surgery.

Materials and Methods—We utilize the CMS Chronic Conditions Warehouse, a longitudinal 5% national random sample of Medicare beneficiaries to study 30-day readmission or death after discharge to SNF following abdominal aortic aneurysm (AAA) repair or lower extremity revascularization (LER) from 2005–2009. Descriptive statistics and logistic regression with LASSO (Least Adaptive Shrinkage and Selection Operator) were used for analysis.

Results—2197 patients underwent an AAA procedure or LER at 686 hospitals and discharged to 1714 SNF. 800 (36%) were readmitted or had died at 30 days. In adjusted analysis, predictors of readmission or death at 30 days included SNF for-profit status (OR=1.2; p=0.032), number of hospitalizations in the previous year (OR=1.06; p=0.011), number of comorbidities (OR=1.06; p=0.004), emergent procedure (OR=1.69; p<0.001), renal complication (OR=1.38; p=0.003), respiratory complication (OR=1.45; p<0.001), thromboembolic complication (OR=1.57; p=0.019), and wound complication (OR=0.70; p=0.017).

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Discussion—Patients discharged to SNF following vascular surgery have exceptionally high rates of readmission or death at 30 days. Many factors predicting readmission or death potentially modify decision-making around discharge, making early detection, discharge planning, and matching patient needs to SNF capabilities essential to improving outcomes.

Keywords

Readmissions; Skilled nursing facilities; Vascular Surgery; Medicare; Mortality

INTRODUCTION

Readmission after vascular surgery is among the most common and the costliest on a per patient basis among surgical procedures.^{1,2} Approximately 24% of patients undergoing a vascular procedure are readmitted within 30 days; in contrast, the overall surgical readmission rate is less than 16%.² This is unsurprising given that patients undergoing vascular procedures are commonly older adults with compromised blood flow who suffer a high morbidity burden and often require significant post-operative care.^{3,4} Vascular procedures are becoming more common as the U.S. population ages and percutaneous techniques are available to frail patients who were not previously candidates for open surgery. As such, projected demand for vascular procedures is increasing at the highest rate among medical specialties.⁴

Management of postoperative recovery, which includes the surgical wound, in the setting of preexisting poor blood flow and comorbidity in these patients is uniquely complex. Moreover, patients are frequently discharged to skilled nursing facilities (SNF) with the goal of rehabilitation until they are ready to transition to a residential setting.^{5,6} The post-acute care setting is thus an essential partner in minimizing the incidence of adverse events in the post-operative period as hospitals decrease post-operative lengths of stay. As a result, SNF are increasingly the targets of accountable care organization efforts to coordinate care and improve outcomes.⁷⁻⁹ Skilled nursing facilities are ideal targets for improving outcomes, having been criticized as “the revolving door of rehospitalization” with nearly a quarter of Medicare-covered patients discharged to SNF returning to the hospital within 30 days.¹⁰ This suggests that discharging hospitals may anticipate a level of patient care that is not available at SNF, and suboptimal care coordination frequently occurs between the hospital and SNF staff.

In a complex service delivery environment with competing demands, specialty surgical care providers caring for complex patients face a dearth of evidence informing (1) which patients are appropriate for discharge to skilled nursing facilities and (2) what SNF characteristics predispose patients to readmission. To inform transitional care for this vulnerable and growing patient population, we examine a) patients’ clinical characteristics and b) SNF organizational characteristics associated with 30-day readmission for vascular surgery patients to inform discharge planning and care coordination.

METHODS

Data Source

We analyzed data from the CMS Chronic Conditions Data Warehouse (CCW), a 5% national random sample of Medicare beneficiaries who are followed over time after cohort entry.¹¹ We obtained CCW claims for all patients undergoing a vascular procedure for open or endovascular abdominal aortic aneurysm (AAA) repair or lower extremity revascularization with an associated qualifying diagnosis code (LER) for the years 2005–2009 using Current Procedure Terminology (CPT) and International Classification of Diseases, 9th Clinical Modification (ICD-9-CM) codes for the relevant procedures (full list in Appendix).

To evaluate SNF organizational characteristics, we linked the CCW data for qualifying inpatient stays with publicly available organization-level data from the Nursing Home Compare Provider and Deficiency File and the Nursing Home Compare Quality Measures File (located at <https://data.medicare.gov/data/nursing-home-compare>) using the provider number and year to match SNF data with CCW inpatient encounters.¹² We obtained a 58% same-year match for data for patients discharged to SNF and their corresponding SNF data; 39% of the remaining unmatched SNF discharges were matched to SNF facility data within 1 year, and the remaining 3% were matched to SNF data within 2 years of the discharge.

Inclusion Criteria

We included those patients discharged to SNF after a qualifying hospitalization with complete enrollment in Medicare Part A and Part B for 365 continuous days prior to the qualifying procedure to characterize comorbidity, and at least 60 days after discharge to capture 30-day readmission and 60-day mortality. These criteria permit the inclusion of patients discharged to and readmitted from SNF as well as patients discharged to SNF, sent home, and subsequently readmitted. We excluded patients discharged against medical advice and those who died during the qualifying hospitalization. We also excluded patients with incomplete data owing to Medicare health maintenance organization (HMO) enrollment or receipt of railroad benefits. If a patient had multiple qualifying hospitalizations during the study period, only the first hospitalization-readmission pair was included in analysis. We excluded those hospitals with very low vascular procedure volume based on criteria defined in Birkmeyer, et al. (2002) because they represent extreme outliers for whom suboptimal outcomes may be a consequence of the operative team's experience rather than postoperative care quality.^{13,14}

Dependent variables

The primary outcome of interest is readmission to an acute care hospital or death within 30-days of a qualifying vascular procedure and following discharge to SNF; we also examined death within 60 days. Readmitting diagnosis, which helps to contextualize the outcome, is classified into disease groups based on multilevel disease categories using Clinical Classification Software from the Healthcare Cost and Utilization Project.¹⁵

Independent variables

Patient characteristics—Patient characteristics include age at discharge, sex, and race (white vs. non-white). Any previous Medicaid eligibility and residence in a nursing home in the year prior to the procedure are also included in analysis.¹⁶

Clinical characteristics include the number of comorbidities defined by Charlson for the year prior to the intervention (range 0–17), and the use of a mobility device (first claim date for cane, walker, or wheelchair prior to qualifying hospitalization).^{17,18} Utilization of acute care is quantified as the number of hospitalizations in the year prior to the qualifying procedure. We also include emergent admission (versus routine), procedure type (AAA repair and/or LER), and whether the procedure was open or endovascular. In-hospital, postoperative complications defined in Greenblatt et al (2012) include cardiac complications, device failure, hemorrhage, neurological complication, respiratory complication, renal complication, venous thromboembolism, reoperation, and wound complication or surgical site infection; this definition avoids the accidental inclusion of comorbid/chronic conditions by using only those ICD-9 codes with the 99× prefix and/or an “acute” descriptor (as opposed to “chronic”).^{19, 20}

SNF Characteristics—Following existing research on SNF quality and readmissions, we include SNF organizational and staffing characteristics from the OSCAR data that are indicators of SNF quality of care.^{21–23} These include chain membership (one facility of many run by a parent organization), for-profit status, hospital-owned status, total number of quality deficiencies (range 0–55 in our data set) on the most recent survey, total number of beds, and proportion of Medicaid and Medicare residents. Relevant staffing variables include ratio of full-time equivalent registered nurses, LPN/LVNs, nurse administrators, and directors of nursing to beds, respectively.

Hospital Characteristics—Characteristics of the discharging hospital include whether it is a teaching hospital and whether it operates on a for-profit basis.

Analysis—Missing observations in analysis variables comprised less than 5% of the data and are dropped from analysis. Patient characteristics and organizational variables are summarized with means and standard deviations for continuous variables and percentages for categorical variables. Thirty-four plausible explanatory variables were selected for further screening for inclusion in multivariable analysis. Twenty of these variables related to patient-level characteristics, including age, sex, prior healthcare utilization, and indicators relating to post-operative complications before discharge to SNF. Eleven included variables related to SNF characteristics, including occupancy, for-profit status, staffing ratios, and patient demographics at the SNF relating to Medicare and Medicaid usage. Two variables related to hospital characteristics were included: for-profit status and an indicator for affiliation with a medical school. The year of index hospitalization for each patient was included as an indicator for each year between 2005 and 2009.

We use the group LASSO (Least Adaptive Shrinkage and Selection Operator) to select a useful, smaller subset of these variables while retaining explanatory power.^{24,25} The LASSO is similar to forward selection in that it selects a useful subset of predictors, but

avoids the well-known overfitting and bias issues that plague stepwise selection procedures¹. Descriptive analysis and model fits were performed using STATA v.13 and R using the msgl (multinomial sparse group lasso) package, respectively.^{26,27}

Because the goal of this analysis was to create simple explanatory models with interpretable coefficients, we refit ordinary logistic regression models using variables selected by the group LASSO; analysis and inference are presented for these OLS models. Since variable selection procedures tend to select variables correlated with the response, the p-values of models after variable selection tend to be optimistic. Specifically, variable selection methods can overfit to random noise in the dataset, and the amount of overfitting, or optimism, can be estimated via bootstrapping. The effect of variable selection on the predictive performance of the models was estimated following an “optimism” approach.²⁹ For the models in this paper, the optimism was estimated via the procedure in with 100 bootstrap resamplings. To assess model quality, the C statistics for each model were computed.²⁸ This study was approved by the Health Sciences Institutional Review Board at the University of Wisconsin.

RESULTS

Descriptive Characteristics

The SNF to which vascular surgery patients were discharged (Table I) had a mean of 136 beds (sd=90), were mostly chain members (56%), and operated for profit (66%). Mean occupancy was 84%, and the mean proportion of Medicaid-paid residents was 42%. The facilities had an average of 10.1 quality deficiencies (range 0–55). On average, SNF employed an average of 0.04 nursing administrators, 0.07 registered nurses, 0.12 LPN/LVNs, and 0.01 directors of nursing (all full time equivalents) per bed.

Discharges to SNF comprised approximately 13% of total discharges after a lower extremity or AAA procedure. Following the application of additional inclusion criteria (include only discharges to SNF, first hospitalization, and complete cases with variation in the outcome) 2197 patients who underwent procedures at 686 hospitals and discharged to 1714 SNFs were included in the final analysis. The characteristics of patients in our sample are summarized in Table II. The overall 30-day rate of readmission or death among those patients discharged to SNF following an AAA or lower extremity procedure was 36%; 22% of those 800 readmitted or dead patients were dead (as opposed to readmitted).

Patients who were discharged to SNF after a qualifying vascular procedure were a mean 80 years old (sd=7.1), 58% female, and 84% white. On average, they had been hospitalized twice in the year prior to the qualifying procedure, had more than 3 comorbid conditions (mean (sd) = 3.2 (2.6)), and had previously resided in a nursing home (81%); 7% used an assistive mobility device, such as a walker, cane, or wheelchair.

Eighty-four percent of patients underwent a lower extremity procedure, and 18% underwent an AAA procedure (categories not mutually exclusive). Thirty-three percent of procedures

¹We use the Bayesian Information Criterion to select the tuning parameter (λ), and the model variables in turn, for the two responses of interest (readmitted or dead within 30 days, and dead within 60 days). The model along the group LASSO λ sequence with the minimum BIC value was chosen for each outcome.

were emergent, and the majority (62%) were open rather than endovascular procedures. The most common in-hospital, post-operative complications were respiratory complications (35%), renal complications (21%), and cardiac (21%). Other common complications included stroke and neurological complications (16%). The median length of stay for these patients was 10 days (range 1–93 days).

Characteristics Associated with Readmission or Death within 30 days

Of the 800 readmitted or dead patients at 30 days, an additional 77 died between 30 and 60 days, rendering a 32% total 60-day mortality for readmitted patients; 47 patients who were not readmitted died within 60 days of discharge (3% mortality for patients with no 30-day readmission). Facility characteristics for readmitted and not readmitted patients are summarized in Table III. In bivariate analysis, the only characteristic associated with readmission was being discharged to a for profit SNF (0.64 vs. 0.69; $p < 0.01$). Patient characteristics (Table IV) were more strongly associated with readmission including the number of hospitalizations in the year prior, number of comorbidities, and in-hospital postoperative complications. Specifically, renal, respiratory, and thromboembolic complications were positively associated with readmission (renal: 19% not readmitted vs. 26% readmitted; respiratory: 31% vs. 41%; VTE: 4% vs 8%; all p -values < 0.01).

Multivariable Analysis Predicting Readmission or Death

Patient characteristics associated with increased odds of readmission or death were hospitalization in the year prior to the procedure, a greater number of comorbidities, and having an emergent operation (Table V). The strongest predictors of 30-day readmission or death were postoperative complications, including respiratory, renal, and thromboembolic complications; these increased the odds of readmission or death between 1.38 and 1.67 times. The only organizational characteristic associated with readmission or death was being discharged to a for-profit SNF, which increased the odds of readmission or death 1.23 times. Experiencing a surgical site infection and subsequently being discharged to SNF was protective against readmission or death within 30 days.

Patient characteristics associated with death within the 60 days after discharge were age, number of comorbidities, and having an emergent operation (Table VI). Having a AAA procedure (rather than lower extremity) and using a mobility device, such as walker or wheelchair, were protective. Again, the strongest predictors of 60-day death were postoperative complications, including respiratory or neurological complications; these increased the odds of readmission or death between 1.67 and 1.84 times, respectively.

Readmitting Diagnoses

The readmitting diagnoses for the 800 patients readmitted after discharge to SNF are listed in Table VII. The most common readmitting diagnoses were related to postoperative infection and surgical complications. Specifically, septicemia ($n=34$), cellulitis ($n=47$), and surgical (device and wound) complications ($n=89$) accounted for 21% of total readmissions; only 13% of these patients had a postoperative inpatient diagnosis of surgical site infection, indicating that the majority of these readmissions were for complications that developed after discharge. Circulatory disorders were the second most common reason for readmission

(19% of readmissions), with the largest single contributor being CHF exacerbation (n=42). Respiratory and gastrointestinal complications were also common, each accounting for approximately 9% of readmissions and driven largely by pneumonia (n=26) and hemorrhage (n=25), respectively.

DISCUSSION

Millions of hospitalized Medicare beneficiaries are discharged to a post-acute care setting annually, and close to 20% of Americans over age 70 have vascular disease.^{30,31} To inform transitional care for these patients – who require additional attention with respect to discharge planning, coordination of care, and communication between patients, clinical staff, and caregivers – we examined readmission and mortality rates among Medicare beneficiaries (mean age 80) who were discharged to SNF after undergoing a vascular intervention.

In our analysis, we found a readmission rate over 30% for vascular patients discharged to SNF, markedly higher than the readmission rates for all SNF-discharged Medicare beneficiaries (23.5%) and all Medicare beneficiaries undergoing vascular surgery (24%).^{2,10} The fact that 30% are readmitted also means that 70% of the time patients avoid a prolonged hospitalization and that hospital resources can be used to care for patients requiring more acute care at the time. However, the high rate of rehospitalization and subsequent mortality for these patients indicates that hospitals discharge older, medically complex patients who (1) are high risk for developing an additional post-discharge complication requiring rehospitalization and (2) require significant, protocolized care coordination and discharge planning by both hospitals and SNF.

Moreover, 60-day mortality among patients readmitted within 30 days after SNF discharge was ten times higher than mortality among patients who did not return to the hospital following discharge. The notable difference in mortality among readmitted patients is consistent with previous work demonstrating, for example, a 5-fold increase in mortality among readmitted patients who underwent AAA repair.^{19,32} Although readmitted patients as well as patients who die within 60 days of a procedure have preexisting morbidity that predisposes to poorer outcomes, our study shows that many of the factors related to readmission and mortality are potentially modifiable complications of the surgical procedure.

Our analysis revealed that more than a quarter of readmitted patients were diagnosed with a wound infection or device complication. Extant literature documents that wound infection accounts for 38% of overall complications among surgical patients and often leads to readmission.^{33,34} The burden of wound complications experienced by vascular surgery patients, in particular those undergoing lower extremity interventions, is especially high; wound complication in this group is 44%.³⁵ The implications of a wound infection in a vascular patient can be devastating, with local surgical site infection requiring readmission with intravenous antibiotic administration. Deep wound infections often require wound debridement and can result in graft failure, the need for reintervention, graft rupture with significant bleeding, limb loss, and death.^{36,37} Early diagnosis of wound complications by

SNF staff, ensuring that surgical incisions are kept clean and dry, and treatment with oral or IV antibiotics at SNF are essential to stemming readmissions in this population.

Respiratory, digestive and circulatory complications were also common readmitting diagnoses, jointly accounting for almost 40% of readmissions; many of these result from medication reconciliation errors, including medication errors related to managing chronic conditions like CHF as well as acute fluid imbalances in the postoperative interval.³⁸ Hospitals and post-acute care facilities may be able to mitigate these complications by ensuring medication reconciliation prior to discharge (including beta blockers and diuretics). In addition, SNF may be able to reduce these complications by ensuring that patients with comorbid CHF, vascular disease, or a relevant post-operative complications are mobilized/exercised, weighed daily for monitoring of fluid balance, and receive a post-operative consultation from a cardiologist or pulmonologist as indicated. In addition, deep breathing and incentive spirometry as part of SNF rehabilitation for patients at higher risk for respiratory complications may improve outcomes. Accordingly, medication reconciliation, identifying early warning signs (shortness of breath, behavioral symptoms, dehydration, etc.), and facilitating communication with acute care settings are hallmarks of interventions to reduce readmissions from SNF, such as INTERACT (Interventions to Reduce Acute Care Transfers), which has a demonstrated impact on readmissions after discharge to SNF.³⁹ Discharging patients to SNF that already receive a large number of patients from that hospital may also improve care coordination.^{40,21}

Contrary to expectation, the use of a mobility device was protective against death within 60 days of discharge, and in-hospital wound infection protected against readmission or death within 30 days. The use of a mobility device potentially serves as surrogate for frailty and high fall risk, which could lead to a greater dedication of rehabilitation and nursing resources and post-operative preventive care in the hospital and in SNF. Wound infection in the immediate postoperative interval may be protective because, similar to using a mobility device, these patients may also receive greater wound care and nursing resources at SNF.

The only SNF characteristic associated with readmission or death was for-profit status. For profit SNFs were marginally more likely to have patients readmitted or die within 30 days, indicating that these SNFs may send patients who develop complications back to the hospital more frequently, rather than expending resources to manage their issues at the SNF. Additionally, whereas patient age uniquely predicted death at 60 days, prior utilization and for-profit SNF uniquely predicted readmission or death at 30 days. This indicates that previous care patterns and SNF organizational factors may play an essential role in readmission independent of clinical factors and mortality risk. This finding is consistent with previous work demonstrating that for-profit SNF have higher rates of readmission generally.^{41–43}

Our results should be interpreted in the context of some important limitations. Our study is generalizable only to the population of Medicare beneficiaries undergoing vascular surgery who are discharged to SNF and may not represent all vascular patients. Specifically, selection bias from including only those patients discharged to SNF may have produced some of our unexpected findings regarding the protective effect of wound infection or

mobility device. Our study also utilizes claims data, which lacks detailed clinical information and contains coding errors, leading to potential errors in the identification of postoperative events and comorbid conditions.⁴⁴ In addition, we are unable to discern whether readmissions are planned or unplanned. We utilize data up to 2009 (prior to the mandate to reduce readmissions), and practice patterns have since changed as hospitals have directed resources to reducing readmissions. Moreover, the model fit for our multivariable analyses predicting readmission or death was relatively weak (C statistic=0.61–0.67). Although this is similar to the model fit in other retrospective analyses of claims data predicting readmission (for a review see Kansagara, et al), the insight gleaned from studying readmissions in retrospective claims data is limited and should be considered a first step in identifying clinical targets for reducing readmissions and improving outcomes.⁴⁵ In addition, we do not examine amputation in our study, which is a major source of readmissions, but can result because of conditions other than major vascular disease, such as diabetes or trauma. Amputation after revascularization is a particularly salient event for older adults, and we describe the prevalence of amputation and mortality in this cohort of Medicare beneficiaries in detail in previously published work.⁴⁶ In addition, we may have omitted some covariates that are critical to our outcome and may be correlated with the independent variables in our model, such as preoperative lab values, intraoperative events, and additional sociodemographic information. These limitations are offset by the considerable advantage of studying outcomes in a large, longitudinal, nationally representative, random sample of Medicare beneficiaries.

Our study is the first to examine outcomes among vascular surgery patients who are discharged to SNF. Given the high rate of readmission among vascular surgery patients, the importance of the post-acute care setting to vascular surgery patients, and the prevalence of post-acute care discharges among Medicare beneficiaries, this work serves to inform post-operative transitional care for a cohort of patients who routinely experience poor outcomes. Hospitals increasingly face penalties for unplanned 30-day readmissions and incur the cost of poor outcomes with the advent of the accountable care organization (ACO). Administrators and clinicians are increasingly seeking ways to improve transitional care, and associated interventions will include intensive case management for patients with severe illness as well as improved discharge planning, communication across care settings, patient empowerment, and close coordination with outpatient care providers.

Facilities providing post-acute care, including SNF, are essential participants in these efforts. Streamlining the discharge process for patients rehabilitating in SNF and identifying those patients whose needs are well matched to SNF capabilities will help improve outcomes. In turn, SNF that receive a large proportion of patients in post-operative recovery should staff appropriately and train their workforce in wound evaluation and management, and recognition of early signs of a post-operative complication. As hospitals acquire and/or partner with SNF to manage the financial risk associated with the ACO, the introduction of SNF that specialize in post-acute care for medically complex surgical patients could be one way of improving outcomes for the cohort of patients who require post-acute care for the management of multiple comorbidities in addition to post-operative rehabilitation.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table I

Facility characteristics by readmission or death status at 30 days (n=2197)

SNF Characteristics	Mean (SD), or n (%)	Normal Recovery (n=1397)	Readmitted or dead (n=800)	p-value
Bed Size, mean (SD)	136.45 (89.94)	135.34 (87.90)	138.49 (93.40)	0.43
SNF occupancy, mean (SD)	84% (17%)	84% (17%)	84% (17%)	0.82
Number of deficiencies, mean (SD)	10.11 (7.22)	9.97 (7.11)	10.35 (7.41)	0.24
Nurse administrator to bed ratio, mean (S)	0.04 (0.03)	0.04 (0.03)	0.04 (0.02)	0.65
RN to bed ratio, mean (SD)	0.07 (0.10)	0.07 (0.10)	0.07 (0.10)	0.84
LPN/LVN to bed ratio, mean (SD)	0.12 (0.08)	0.12 (0.08)	0.12 (0.07)	0.41
Director of nursing to bed ratio, mean (SD)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.99
Proportion Medicaid residents, mean (SD)	0.42 (0.24)	0.41 (0.24)	0.42 (0.25)	0.22
Proportion Medicare residents, mean (SD)	0.24 (0.20)	0.25 (0.20)	0.24 (0.19)	0.67
Chain member, n (%)	1230 (56)	773 (55)	457 (57)	0.42
For profit, n (%)	1449 (66)	895 (64)	554 (69)	0.01
Hospital Characteristics				
Medical school affiliate, n (%)	807 (37)	518 (37)	289 (36)	0.66
For profit, n (%)	183 (8)	118 (8)	65 (8)	0.79

SNF = skilled nursing facility; RN = registered nurse; LPN = licensed practical nurse; LVN = licensed vocational nurse; SD = standard deviation;

Table II

Patient characteristics by readmission or death status at 30 days (n=2197)

	Mean (SD) or n (%)	Normal Recovery (n=1397)	Readmitted or dead (n=800)	p-value
Age, mean (SD)	80.03 (7.15)	79.98 (6.96)	80.12 (7.47)	0.67
Hospitalizations in year prior, mean (SD)	1.89 (2.22)	1.75 (2.12)	2.14 (2.38)	<0.001
Number of comorbidities (Charlson), mean (SD)	3.22 (2.55)	3.06 (2.50)	3.51 (2.61)	<0.001
Female, n (%)	1275 (58)	819 (59)	456 (57)	0.46
White, n (%)	1854 (84)	1191 (85)	663 (83)	0.14
Ever Medicaid eligible, n (%)	610 (28)	385 (28)	225 (28)	0.78
Nursing home residence, n (%)	1770 (81)	1132 (81)	638 (80)	0.47
Mobility device, n (%)	143 (7)	90 (6)	53 (7)	0.87
AAA procedure, n (%)	400 (18)	267 (19)	133 (17)	0.15
Lower extremity procedure, n (%)	1850 (84)	1163 (83)	687 (86)	0.1
Open procedure, n (%)	1353 (62)	877 (63)	476 (60)	0.13
Emergent procedure, n (%)	721 (33)	409 (29)	312 (39)	<0.001
Cardiac complication, n (%)	464 (21)	284 (20)	180 (23)	0.23
Hemorrhagic complication, n (%)	194 (9)	128 (9)	66 (8)	0.47
Renal complication, n (%)	469 (21)	265 (19)	204 (26)	<0.001
Respiratory complication, n (%)	761 (35)	432 (31)	329 (41)	<0.001
Thromboembolic complication, n (%)	121 (6)	60 (4)	61 (8)	<0.001
Wound complication/infection, n (%)	254 (12)	174 (12)	80 (10)	0.08
Neurological complication, n (%)	346 (16)	205 (15)	141 (18)	0.07
Complication requiring reoperation, n (%)	46 (2)	33 (2)	13 (2)	0.25
Discharge year 2005, n (%)	537 (24)	354 (25)	183 (23)	0.23
Discharge year 2006, n (%)	493 (22)	310 (22)	183 (23)	
Discharge year 2007, n (%)	444 (20)	263 (19)	181 (23)	
Discharge year 2008, n (%)	410 (19)	266 (19)	144 (18)	
Discharge year 2009, n (%)	313 (14)	204 (15)	109 (14)	

AAA = abdominal aortic aneurysm; SD = standard deviation

Table III

Regression results from group lasso for predictors of readmission or death at 30 days

	OR	95% CI	p-value
SNF for-profit status	1.23	1.02–1.49	0.032
Hospitalizations in year prior	1.06	1.01–1.11	0.011
Number of comorbidities (Charlson)	1.06	1.01–1.10	0.004
Emergent procedure	1.69	1.15–1.68	<0.001
Renal complication	1.38	1.12–1.72	0.003
Respiratory complication	1.45	1.20–1.75	<0.001
Thromboembolic complication	1.57	1.01–2.30	0.019
Wound complication/infection	0.70	0.53–0.94	0.017

Adjusted c-statistic: 0.61; OR= odds ratio; CI=confidence interval; SNF = skilled nursing facility

Table IV

Regression results from group lasso for predictors of death at 60 days

	OR	95% CI	p-value
Patient age at discharge	1.06	1.04–1.08	<0.001
Number of comorbidities (Charlson)	1.11	1.05–1.16	<0.001
Mobility device	0.19	0.08–0.48	<0.001
AAA procedure	0.61	0.42–0.90	0.013
Emergent procedure	1.36	1.05–1.77	0.021
Respiratory complication	1.84	1.42–2.39	<0.001
Neurological complication	1.67	1.22–2.29	<0.001

Adjusted c-statistic: 0.67; OR=odds ratio; CI=confidence interval; AAA = abdominal aortic aneurysm

Table V

Readmission diagnoses by Clinical Classification Software (CCS) category (n=800)

Diagnosis: CCS Multilevel Category	n (%)
Infection/septicemia	34 (4.3)
Endocrine, nutritional, and metabolic disorders	32 (4.0)
Blood disorders	22 (2.8)
Mental Illness	<11 (<1)
Nervous system diseases	15 (1.9)
Circulatory disorders	154 (19.3)
Respiratory disease	73 (9.1)
Digestive disorders	68 (8.5)
Genitourinary conditions	32 (4.0)
Skin conditions/Cellulitis	47 (5.9)
Musculoskeletal/connective tissue disorders	27 (3.4)
Surgical Complications	89 (11.1)
Miscellaneous Symptoms	98 (12.3)
Residual/Other diagnoses	106 (13.3)

CCS = Clinical Classification Software