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Preoperative Frailty Increases Risk of Nonhome Discharge after Elective Vascular Surgery in Home-Dwelling Patients

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Background: Patient-centered quality outcomes such as disposition after surgery are increasingly being scrutinized. Preoperative factors predictive of nonhome discharge (DC) may identify at-risk patients for targeted interventions. This study examines the association among preoperative risk factors, frailty, and nonhome DC after elective vascular surgery procedures in patients living at home.
Methods: The 2011–2012 National Surgical Quality Improvement Project database was queried to identify all home-dwelling patients who underwent elective vascular procedures (endovascular and open aortic aneurysm repair, suprainguinal and infrainguinal bypasses, peripheral endovascular interventions, carotid endarterectomy, and stent). Preoperative frailty was measured using the modified frailty index (mFI; derived from Canadian Study of Health and Aging). Univariate and multivariate logistic regression analysis was performed to examine the association of frailty and nonhome DC.
Results: Of 15,843 home-dwelling patients, 1,177 patients (7.4%) did not return home postoperatively. Frailty (mFI $>$ 0.25) conferred a significantly increased 2-fold risk of nonhome DC disposition for each procedure type. Frailty, female gender, open procedures, increasing age, end-stage renal disease, and occurrence of any postoperative complication were associated with increased risk of nonhome DC. On multivariate logistic regression analysis, frailty increased the odds of nonhome DC by 60% (odds ratio 1.6, 95% confidence interval 1.4–1.8) after adjusting for other covariates. In the presence of complications, the risk of nonhome DC was 27.5% in frail versus 16.5% in nonfrail patients ($P < 0.001$). In the absence of complications, although absolute risk was lower, frail patients were nearly twice as likely to not return home (frail 5.5% vs. nonfrail 2.75%, $P < 0.001$).
Conclusions: Frail home-dwelling patients undergoing elective vascular procedures are at high risk of not returning home after surgery. Preoperative frailty assessment appears to hold potential for counseling regarding postsurgery disposition and DC planning.

INTRODUCTION

Patient-centered outcomes are defined as measures influenced by patient preferences, autonomy, and needs, such as functional status, symptoms, and health-related quality of life. In the recent decades, most surgical quality improvement programs have focused on in-hospital morbidity and mortality, with post-discharge (DC) disposition being

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understudied and poorly understood.[1] DC disposition (location) is a useful patient-centered metric because of easy measurement and potential for quality improvement efforts as suggested by recent studies.[2,3] Home-dwelling patients undergoing elective surgery weigh the quality of surgical recovery by their ability to safely return and recover at home with their family rather than prolonged recovery periods in a nursing home or facility. Time in skilled nursing or rehabilitation facilities is sometimes necessary to regain functional independence, depending on surgical intensity, patient-related factors, occurrence of postoperative adverse events, and social support. However, DC to skilled nursing or rehabilitation facilities has been shown to be associated with increased complications, frequent readmissions, and increased mortality[4−14] and is thus not a benign process.

Frailty is defined as a biologic syndrome of decreased reserve and resistance to stressors, resulting from cumulative declines across multiple physiologic systems, and causing vulnerability to adverse outcomes.[15] The geriatric literature describes several different measures of frailty, but there is no single gold standard measure. A frailty index (FI) based on a deficit accumulation model was developed by Rockwood et al. using the Canadian Study of Health and Aging (CSHA)—a measure of the cumulative burden of symptoms, diseases, conditions, and disability.[16,17] Frailty has been also described as a phenotypic model by Fried et al.[18] developed using the Cardiovascular Health Study that is a constellation of 5 components (weight loss, exhaustion, weakness, slowness, and reduced physical activity). Recent studies on various surgical disciplines have shown frailty to be an independent risk factor for predicting morbidity and mortality.[19−24] The association of frailty with patient-centered outcomes such as DC disposition has been shown in a few disciplines such as trauma,[25] cardiac,[20] and oncologic[26,27] surgery. Vascular surgery represents a specialty with a high degree of potential for treatment of frail and sarcopenic patients with two-thirds of vascular surgery operations in the United States performed in individuals 65 years and older.[28] Previously home-dwelling vascular surgery patients with low physiological reserve (frailty) may have a reduced ability to recover from the insults of a major stressor like surgery resulting in nonhome DC disposition.

In this study, we test the hypothesis that nonhome DC will be higher in patients with higher degree of preoperative frailty controlling for classic traditional and physiologic risk factors. We examine this hypothesis in home-dwelling patients undergoing elective vascular surgery to represent a sample cohort where frailty estimation can be performed as a preoperative risk stratification tool. We aim to evaluate the trends of nonhome DC in elective vascular surgery patients based on procedure type. We also aim to examine the effect modification of frailty, occurrence of complications, and nonhome DC after elective vascular surgery procedures.

METHODS

Database

All home-dwelling patients undergoing elective vascular surgery procedures in 2011−2012 within the American College of Surgeons National Surgical Quality Improvement Project (ACS-NSQIP) database were identified. The database contains prospectively collected clinical and surgical information of all major inpatient and outpatient surgical procedures performed at more than 200 participating hospitals in the United States and Canada. A comprehensive list of preoperative comorbidities, functional status, and laboratory values, as well as intraoperative variables and 30-day postoperative outcomes are available through the database. Patients under 16 years are not included in the NSQIP database. In addition, patients over 89 years were coded as 90+ to protect patient confidentiality. The ACS NSQIP training, data collection, and auditing process have been shown to be highly reliable with strong inter-rater reliability.[29] The database is deidentified and does not contain any protected health information (PHI). Institutional review board (IRB) approval and need for patient informed consent was waived after consultation with Emory IRB given the lack of PHI and deidentified nature of the database.

Study Population

Using Current Procedure Terminology® codes and International Classification of Diseases-9 diagnosis in the 2011−2012 ACS-NSQIP database, the following vascular surgery procedures were included: endovascular aortic aneurysm repair (EVAR), open abdominal aortic aneurysm (AAA) repair, suprainguinal and infrainguinal bypasses, peripheral endovascular interventions, carotid endarterectomy (CEA), and carotid stent. To include only elective repairs done on previously home-dwelling patients, we applied the following exclusion criteria: emergency status, critical patients with ventilator dependence, acute kidney failure, transfer from another acute care hospital, chronic care facility, or from an outside emergency department. We also excluded patients with incomplete frailty data and missing DC disposition data. The patients ineligible for DC—that is, those who in hospital—were also excluded. The final study cohort included 15,843 patients.

Study Variables

Our primary outcome was nonhome DC. DC destination is specified in the NSQIP database and nonhome DC included DC to rehabilitation facility, skilled nursing facility (SNF), and others/nonspecified. Secondary outcomes included occurrence of 30-day morbidity and length of stay. Thirty-day morbidity was further classified into the following: (1) major morbidity as defined by Clavien–Dindo class IV complications[30] (i.e., life-threatening complications or those requiring intensive care management: postoperative septic shock, myocardial infarction, cardiac arrest, pulmonary embolism, acute renal insufficiency requiring dialysis, ventilation > 48 hr, unplanned intubation, central nervous system complications (coma or stroke), graft failure) and (2) minor morbidity that included less severe complications (urinary tract infection, pneumonia, deep vein thrombosis/thrombophlebitis, and surgical site infection).

Modified Frailty Index

Our exposure variable was frailty as measured by the modified frailty index (mFI). The 11-point mFI derived from the CSHA frailty index[16,17] has been previously validated in the NSQIP database[31,32](Appendix 1). Frailty was used as a continuous variable (range 0–0.73) as well as a categorical variable. Presence of frailty was defined as mFI > 0.25 for comparative analysis across groups in univariate and multivariate regression analyses.

Statistical Analysis

Continuous variables were expressed as means (± standard deviations) or as medians (±interquartile ranges) if they were not normally distributed. Means were compared using unpaired *t*-tests or analysis of variance. Discrete variables were expressed as counts and percentages, and χ^2 tests used to compare proportions. Because the NSQIP database records all patients over 90 years of age as ''90+,'' age calculations were performed using 90 as the presumed age for all patients in this age group. Univariate and multivariate logistic regression analyses were performed to obtain unadjusted and adjusted odds ratios (ORs) for nonhome DC. We adjusted for age, comorbidities, perioperative factors, and the American Society of Anesthesiologists (ASA) class in the multivariate regression model. Body mass index (BMI) was divided into the following categories: underweight (<19 kg/m^2), normal BMI (19–25 kg/m^2), overweight (25–30 kg/m^2), obese (30–35 mg/m^2), and morbidly obese (>35 kg/m^2). Perioperative variables were included in the model for nonhome DC if they demonstrated statistical significance in the univariate regression analysis and did not contain greater than 10% missing observations. Of these, variables were excluded from the final model if they were associated with $P > 0.10$ in the multivariate model. Model assumptions were evaluated using the variance inflation factors associated with each variable to check for multicollinearity. The overall model fit was obtained using the c-statistic and the Hosmer–Lemeshow goodness-of-fit test. The final multivariate models were built for all elective vascular surgery operations first including only preoperative factors and then assessing effect modification by adding the occurrence of postoperative complications in the model for nonhome DC. Complete case analysis was performed to minimize selection bias secondary to missing observations. The statistical analysis was done using Intercooled STATA version 12 (StataCorp LP, College Station, TX).

RESULTS

Baseline Characteristics

The cohort included 15,843 home-dwelling patients with a mean age of 69.7 ± 10.4 years. Women represented 35.2% of the cohort. Nonhome DC was seen in 1,177 patients (7.4%) overall. Of these, 454 (2.9%) patients were discharged to rehabilitation, 658 (4.1%) patients were discharged to SNFs, and the rest (0.4%) to others/nonspecified. Mean and median mFI was 0.2 ± 0.1 and 0.18 ± 0.1 (range 0–0.73), respectively. Table I describes the salient demographic information, comorbidities, and periprocedural variables in the cohort. It further compares these characteristics in home DC and nonhome DC disposition patients. Patients who did not return home postoperatively were older, more frail, and had a higher burden of comorbidities. Patients discharged to a skilled or rehabilitation facility were more likely to have open procedures, a higher serum creatinine, a lower

Table I. Demographics, comorbidities, and periprocedural information for cohort, by DC disposition

Covariates	All (n = 15,843)	Home DC (n = 14,666)	Nonhome DC (n = 1,177)	P value
Mean age, years (±SD)	69.7 (±10.4)	69.4 (±10.3)	73.9 (±10.1)	<0.001
Mean BMI, kg/m^2 (±SD)	28.1 (±6.0)	28.2 (±6.0)	27.5 (±6.1)	<0.001
Female gender	5,581 (35.2%)	5,070 (34.6%)	511 (43.4%)	<0.001
ASA classification				
No or mild disturbance (1−2)	1,305 (8.3%)	1,273 (8.7%)	32 (2.7%)	<0.001
Severe disturbance (3)	11,900 (75.6%)	11,124 (76.4%)	776 (66.4%)	
Life threatening or moribund (4−5)	2,529 (16.1%)	2,168 (14.9%)	361 (30.9%)	
Chronic obstructive pulmonary disease	2,218 (14.0%)	1,994 (13.6%)	224 (19.0%)	<0.001
Myocardial infarction within 6 months	159 (1.0%)	131 (0.9%)	28 (2.4%)	<0.001
Previous percutaneous coronary intervention, cardiac surgery, or angina	5,137 (32.4%)	4,736 (32.3%)	401 (34.1%)	0.21
History of congestive heart failure	137 (0.9%)	111 (0.8%)	26 (2.2%)	<0.001
Diabetes mellitus requiring medication	4,666 (29.5%)	4,234 (28.9%)	432 (35.7%)	<0.001
Hypertension requiring medication	13,171 (83.1%)	12,151 (82.9%)	1,020 (86.7%)	0.001
Previous revascularization, amputation, rest pain, or gangrene	4,516 (28.5%)	3,963 (27.0%)	553 (47.0%)	<0.001
History of cerebrovascular disease	2,228 (14.1%)	1,961 (13.4%)	267 (22.7%)	<0.001
History of end-stage renal disease	334 (2.1%)	267 (1.8%)	67 (5.7%)	<0.001
Functional dependence	557 (3.5%)	409 (2.8%)	148 (12.6%)	<0.001
Weight loss >10% body weight within 6 months	77 (0.5%)	64 (0.4%)	13 (1.1%)	0.002
Current smoker	5,618 (35.5%)	5,262 (35.9%)	356 (30.3%)	<0.001
Chronic steroid use	495 (3.1%)	436 (3.0%)	59 (5.0%)	<0.001
Mean preoperative serum creatinine, mg/dL (±SD)	1.19 (±1.0)	1.17 (±0.9)	1.4 (±1.3)	<0.001
Mean preoperative hematocrit (±SD)	39.6 (±5.1)	39.8 (±5.0)	37.1 (±5.7)	<0.001
Mean operative time, min (±SD)	148.9 (±92.5)	143.5 (±87.8)	216.8 (±119.4)	<0.001
Open repair	11,101 (70.1%)	10,144 (69.2%)	957 (81.3%)	<0.001
Mean mFI (±SD)	0.2 (±0.1)	0.2 (±0.1)	0.25 (±0.1)	<0.001
Frailty, defined as mFI ≥ 0.25	5,914 (37.3%)	5,255 (35.8%)	659 (55.9%)	<0.001

SD, standard deviation.
Continuous variables are expressed as mean ± SD and categorical variables are reported in total number of observations with associated percentage (%) by column in parentheses.

Table II. Postoperative outcomes for the cohort, stratified by procedure type

Procedure	N	30-Day morbidity (%)	30-Day Major Morbidity (%)	Nonhome DC (%)	Mean LOS, days (SD)
EVAR	2,402	17.7	6.6	6.0	2.6 (3.2)
Open AAA repair	729	71.1	19.1	19.1	9.2 (7.9)
Infrainguinal bypass	3,113	34.3	15.2	16.1	5.8 (11.9)
Suprainguinal bypass	1,326	40.9	16.1	11.9	6.5 (11.9)
Peripheral EV interventions	2,222	10.8	7.8	3.3	1.9 (8.8)
Carotid stenting	118	10.2	4.2	1.7	1.9 (2.8)
CEA	5,933	8.3	5.3	2.7	2.2 (10.9)
Total	15,843	20.8	9.3	7.4	3.6 (10.2)

EV, endovascular; LOS, length of stay; SD, standard deviation.
Major morbidity: Clavien−Dindo class IV complications or above.

preoperative hematocrit, and suffered recent weight loss. Interestingly, smokers had a lower likelihood of nonhome DC as compared with nonsmokers ($P < 0.001$).

Thirty-Day Outcomes

Table II displays the postoperative outcomes stratified by procedure type including 30-day morbidity,

Table III. Occurrence of nonhome DC [*n* (% of total)], stratified by diagnosis, procedure type, and frailty: unadjusted OR of nonhome DC in frail as compared with nonfrail patients

Procedure	*N*	Nonhome DC (%)	Prevalence frailty (%)	Nonhome DC		Unadjusted OR (95% CI)
				Frail	Nonfrail	
AAA						
EVAR	2,402	145 (6.0%)	542 (22.6%)	43 (7.9%)	102 (5.5%)*	1.5 (1.0–2.1)
Open AAA repair	729	139 (19.1%)	150 (20.6%)	48 (32.0%)	91 (15.7%)*	2.5 (1.7–3.8)
Peripheral arterial disease						
Infrainguinal bypass	3,113	500 (16.1%)	1,532 (49.2%)	331 (21.6%)	169 (10.7%)*	2.3 (1.9–2.8)
Suprainguinal bypass	1,326	158 (11.9%)	498 (37.6%)	93 (18.7%)	65 (7.9%)*	2.7 (1.9–3.8)
Peripheral EV interventions	2,222	73 (3.3%)	961 (43.3%)	44 (4.6%)	29 (2.3%)*	2.0 (1.3–3.3)
Carotid artery stenosis						
Carotid stenting	118	2 (1.7%)	47 (39.8%)	2 (4.3%)	0 (0%)	–
CEA	5,933	160 (2.7%)	2,184 (36.8%)	98 (4.5%)	62 (1.7%)*	2.8 (2.0–3.9)
Total	15,843	1,177 (7.4%)	5,933 (37.5%)	659 (11.1%)	518 (5.2%)*	2.3 (2.0–2.6)

EV, endovascular.
*$P < 0.05$ for each procedure type comparing nonhome DC risk in frail patients with nonfrail.

Table IV. Adjusted odds ratios [ORs (95% CI)] obtained from the multivariate logistic regression analysis for 30-day nonhome DC

Independent variable	Preoperative factors only	Pre- and perioperative factors
	Model 1[a]	Model 2[b]
Frailty (mFI >0.25)	1.6 (1.4–1.8)	1.6 (1.3–1.8)
Endovascular procedure	0.45 (0.4–0.5)	0.6 (0.5–0.7)
Female gender	1.2 (1.0–1.4)	1.3 (1.1–1.5)
Age in years (reference 65 and younger)		
65–75	1.6 (1.3–1.9)	1.8 (1.5–2.2)
75–85	2.5 (2.0–3.0)	2.9 (2.4–3.6)
85 and above	5.0 (3.9–6.5)	7.1 (5.4–9.3)
ASA class	1.8 (1.6–2.1)	1.5 (1.3–1.7)
End-stage renal disease	1.9 (1.1–3.3)	2.1 (1.2–3.8)
Preoperative hematocrit	0.96 (0.95–0.97)	0.97 (0.96–0.99)
Preoperative chronic steroid use	1.4 (1.0–1.9)	1.4 (1.0–2.0)
History of hemi/paraplegia	1.8 (1.4–2.5)	2.2 (1.6–3.0)
Preoperative recent transfusion	3.0 (1.6–5.5)	2.0 (1.0–3.8)
Preoperative wound infection	3.5 (2.9–4.1)	2.7 (2.3–3.2)
Local or regional anesthesia (reference general)	–	0.85 (0.7–1.0)
Operative time (hr)	–	1.26 (1.2–1.3)
Occurrence of a postoperative complication	–	3.9 (3.4–4.5)

Model c-statistic and goodness of fit: [a]$c = 0.76$, $P = 0.4$; [b]$c = 0.84$, $P = 0.01$.

major morbidity, nonhome DC, and length of stay. The traditional 30-day end points of major morbidity (as defined in Methods section) were the highest in open AAA repair (19.1%), followed by suprainguinal bypass (16.1%) and then infrainguinal bypass (15.2%). CEA had the lowest risk of death and complications. The risk of nonhome DC was also the highest in the open AAA repair group with around one-fifth (19.1%) of previously home-dwelling patients being discharged to a skilled facility or nursing home. Open peripheral arterial disease (PAD) bypasses also had substantial proportion of nonhome DC where 12% and 16% of supra- and infrainguinal bypass patients did not DC to home. Despite the minimally invasive nature of EVAR procedures, 6% of the patients did not return home after surgery. Peripheral endovascular interventions and CEA both had a nonhome DC rate around 3.3%, while carotid stents had the lowest nonhome DC rate of 1.7%. The peripheral endovascular interventions and carotid stents had the highest use of nongeneral anesthesia with 55% of peripheral vascular interventions and 75% of the carotid stents done under local or monitored anesthesia care sedation.

Frailty and Nonhome Discharge

Frailty had a significant impact on likelihood of nonhome DC in the cohort of previously home-dwelling patients with over twice the odds in frail patients as compared with the nonfrail [unadjusted ORs 2.3, 95% confidence interval (CI) 2.0–2.6, $P < 0.05$]. This association of frailty and nonhome DC was consistent across procedure subtypes as shown in Table III. The highest risk of nonhome DC with frailty was seen in open AAA repair patients where more than a third of the frail patients (32%) were not able to return home postsurgery as compared with 16% in the nonfrail (unadjusted OR 2.5, 95% CI 1.7–3.8, $P < 0.05$). PAD bypasses also had a strong association of frailty and nonhome DC with almost a fifth of the suprainguinal (19%) and infrainguinal (21.6%) frail patients not able to DC home after surgery (unadjusted OR 2.7, 95% CI 1.9–3.8 and 2.3, 95% CI 1.9–2.8, respectively). Peripheral endovascular interventions also had twice the chance of nonhome DC after surgery in frail patients as compared with nonfrail. Although the absolute numbers for nonhome DC were only 2.7% in the CEA procedure group, the OR was the highest in the frail CEA patients (OR 2.8, 95% CI 2.0–3.9). The lowest OR of nonhome DC comparing frail with nonfrail patients was seen in EVAR patients (unadjusted OR 1.5, 95% CI 1.0–2.1, $P < 0.05$).

Multivariate Logistic Regression Analysis

The significant predictors of nonhome DC are shown in Table IV. Adjusting for other clinical and demographic preoperative factors, frail patients were 1.6 times more likely to have a nonhome DC location after surgery (adjusted OR 1.6, 95% CI 1.46–1.8, $P < 0.01$) compared with the nonfrail patients. Endovascular procedures decreased the odds of nonhome DC by half as compared with the open procedures [adjusted OR 0.45, 95% CI 0.4–0.5, $P < 0.01$] while having a higher hematocrit was also significantly associated with lower odds of nonhome DC [adjusted OR 0.96, 95% CI 0.95–0.97, $P < 0.01$]. Other risk factors for increased odds of nonhome DC were female gender, increasing age, higher ASA class, end-stage renal disease, chronic steroid use, history of hemi/paraplegia, history of recent transfusion, or preoperative wound infection. While significantly associated with nonhome DC in univariate analyses, covariates such as current smoking status, alcohol use, preoperative BMI (categorized into underweight, normal, overweight, obese, and morbidly obese), recent unintended weight loss, bleeding disorder, history of chronic obstructive pulmonary disease, chemoradiation, preoperative creatinine, and so on, were not significant in the final model. A separate model was created including perioperative factors in addition to preoperative risk factors. Among those, type of anesthetic, operative time, and occurrence of a postoperative complication were significant. Having a postoperative complication increased the odds of nonhome DC by 4-fold (adjusted OR 4.1, 95% CI 3.6–4.7, $P < 0.05$). Despite adjustment in the model for postoperative complications, frailty was still a significant independent predictor of nonhome DC in the model with an OR of 1.6 (95% CI 1.4–1.9, $P < 0.05$).

Effect of Frailty and Complications on Nonhome Discharge

The multivariate logistic regression model shows a strong association of frailty as well as occurrence of postoperative complication on the risk of nonhome DC (Table IV). However, frailty itself is a significant predictor of occurrence of complications. Therefore we examine this interaction in detail using stratified analysis (Fig. 1). The frequency of nonhome DC was compared between frail and nonfrail patients after stratification based on complications. In the absence of complications, the risk of nonhome DC in frail patients was 5.5% as compared with 2.75% in nonfrail patients (OR 2.1, 95% CI 1.7–2.5, $P < 0.01$). The incidence of any complication was 21% in the overall cohort and varied by procedure type (Table II). Frailty increased the risk of occurrence of postoperative complication (OR 1.6, 95% CI 1.5–1.7, $P < 0.05$). In the presence of complications, the risk of nonhome DC was much higher especially in the frail patients (27.5%) as compared with the nonfrail (16.5%) (OR 1.9, 95% CI 1.6–2.3, $P < 0.01$). The absolute risk difference was much higher in the presence of complications (∼11%) than in the absence (∼3%) of complications. This increased odds of nonhome DC with frailty was still statistically significant in stratified multivariate analysis by the absence or presence of complications with adjusted OR of 1.7 (95% CI 1.4–2.1) and 1.4 (95% CI 1.1–1.7), respectively. The relative excess risk due to interaction was 1.29 ($P < 0.01$), suggesting that the estimated joint effect of frailty and the occurrence of postoperative complications together

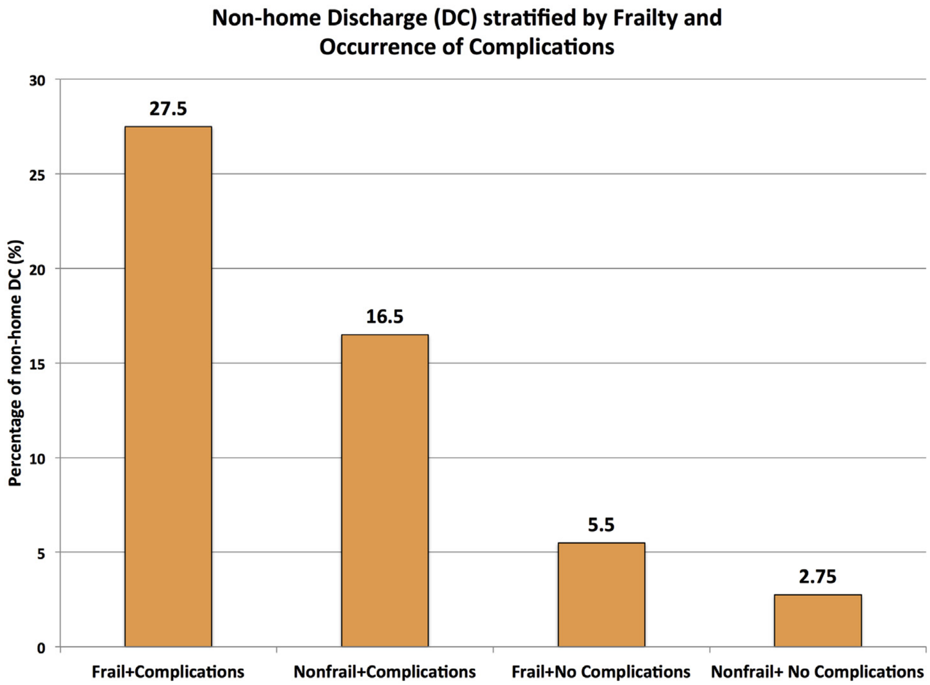

Fig. 1. Nonhome DC stratified by frailty and occurrence of complications.

on nonhome DC was greater than the sum of the estimated effects of frailty alone and complications alone confirming a positive interaction on the additive scale. We also created an interaction term between frailty and occurrence of any complications and introduced that in the multivariate model instead. Frail patients with no complications were at 1.7 times higher odds of not returning home after a vascular procedure (adjusted OR 1.66, 95% CI 1.4–2.0, $P < 0.01$) compared with nonfrail patients with no complications (reference group). Nonfrail patients with complications were at 4.2 times higher odds of nonhome DC (adjusted OR 4.17, 95% CI 3.4–5.1, $P < 0.01$), while frail patients with complications had the highest risk of not returning home (adjusted OR 6.1, 95% CI 5.0–7.5, $P < 0.01$).

DISCUSSION

Our study is the first to describe the incidence of nonhome DC in home-dwelling elective patients after various vascular surgery procedures using a large contemporary nationally representative database. The risk of nonhome DC is highest in the more invasive procedures of open AAA repair, suprainguinal bypass, and infrainguinal bypass with 23% of them not returning home after surgery. Regardless of the procedure, frailty increases this risk by 2-fold for almost all procedure subtypes. Furthermore, we show the independent effect of preoperative frailty on a higher risk of not returning home after surgery after adjusting for other covariates in a multivariate model. Additionally, frailty has an additive effect on complications that further increase the chance of an unfavorable DC disposition. Clearly, frailty as a definable construct using the mFI has significant implications for DC disposition in our vascular surgical population.

DC disposition after major surgery is an important patient-centered outcome that has not been well studied, especially in the vascular patient population. To put our findings in perspective, Dolansky et al.[33] have shown that approximately 30% of patients with myocardial infarctions, 25% with heart failure, 11% with coronary artery bypass surgeries, and 20% with valve surgeries are not discharged home. Our study shows that vascular surgery patients undergoing major vascular procedures have very comparable rates of nonhome DC with 19% of open AAA, 16% of suprainguinal bypasses, and 15% of infrainguinal bypasses not returning home. Moreover with an increasingly aging population more often having surgical procedures, these rates are likely to increase. In our cohort patients, 10% of 75–85 years old patients (adjusted OR 2.5, 95% CI 2.0–3.0) and 18.4% of 85 years and older patients (adjusted OR 5.0, 95% CI 3.9–6.5) did not DC home, respectively, as compared with 4.6% of nonhome DC rate in patients under 65 years of age. DC to a nonhome setting is associated with increased mortality and readmissions.[4–14] In our cohort, there was a 6-fold higher post-DC mortality (3% vs. 0.5%, $P < 0.001$) and twice the unplanned readmission risk (9.9% vs. 4.7%, $P < 0.001$) at 30 days in patients who were not discharged home. This may be a function of the underlying patient frailty versus decline in physical and cognitive function after DC to nonhome setting. Cook et al.[4] showed only 50% survival at 2 years after DC to an extended care facility versus DC to home, in a longitudinal follow-up study of patients who underwent surgical intensive care admission. Legner et al.[5] showed a 4-fold higher mortality for patients discharging to skilled care versus those returning home after major abdominal surgery. Nonhome DC is also associated with a higher risk of readmission after colectomy[7] and joint replacement.[9,14] The DC destinations of patients not returning home include short-term rehabilitation centers, SNFs, or long-term acute care (LTAC) hospitals. Each of these carry very different prognosis for returning home, dying, or being committed to a longer term nursing facility.[4,5] In a study of cardiac surgery patients, Edgerton et al. showed that patients discharged to an extended care facility frequently do not return to their prior living situation. They had a low likelihood (55%) of returning to independent living, and at 1 year postoperatively, only 50% were alive and in their own home. The fate is worst for those who require LTAC with only 30.8% being alive and at home at 1 year in contrast to 95% of patients discharged home alive at 1 year.[10] Mallinson et al. show that only 73% of patients were discharged back to home after inpatient rehabilitation or SNF care after hip fracture repair and a significant portion continue to require home health services for limited mobility and poorer self-care. Around 25% of the patients who went to rehabilitation services ended up requiring other disposition destinations including skilled care.[34] Another study on Medicare beneficiaries with hip fractures showed that 10% of patients discharged to rehabilitation ended up dying or in a custodial nursing home by 120 days after DC[35] highlighting that DC to rehabilitation facility is not a ''benign'' event and can lead to institutionalization or prolonged stay away from home. More invasive vascular surgery procedures such as aortic aneurysm and open bypasses could potentially have similar risks with patients discharged to rehabilitation or SNFs, especially frail patients. However, there are no long-term studies on vascular patients and their post-DC transitions of care.

Identification of preoperative frailty using simple standardized measures has shown a lot of promise in predicting morbidity and mortality postsurgery in recent surgical literature.[19–24] The impact of frailty on nonhome DC is not only mediated by the direct lack of functional reserve in frail patients but also by the occurrence of more complications in that subgroup, as we have shown in our analysis that frail patients with complications had 6-fold higher risk of not returning home as compared with nonfrail patient with no complications. Frailty and functional status have been shown to be associated with nonhome DC in other surgical specialties including trauma, gynecology, and thoracic operations.[25,36,37] In the era of value-based care and assessment of patient satisfaction, there is growing evidence that patients' perceptions of their care are highly influenced by their expectations surrounding the intervention.[38,39] A short assessment scale, like mFI, provides a rapid frailty screening measure to a surgeon or other healthcare professionals to use in the office during surgical planning and consent. There are more in-depth web-based surgery-specific risk prediction models available; however, they are cumbersome to use and are validated in only subspecialties of patients thus limiting their generalizability. Frailty assessment allows discussion in broader terms of postoperative expectation and can assist patient counseling and postoperative disposition planning as it compares their risk with a nonfrail group and allows for easier extrapolation of standard surgical risks. It can also aid in healthcare resource utilization because the process of arranging for nonhome DC is a challenging task involving a multidisciplinary effort from providers, nurses, case managers, social workers, occupational and physical therapists, and the patient's family being actively involved. Lack of foresight in determining DC disposition is often associated with prolonged hospitalization. Frailty assessment can guide planning of nonhome DC much earlier and even prior to surgery with the patient and family preferences.

The limitations of our study include the retrospective nature of the national database, use of chart review by nurse abstractors, and only a 30-day follow-up from the operation. Also the participation in the NSQIP database is voluntary and may not be a true representation of national estimates. Despite these limitations, the NSQIP database provides a large sample size for our study encompassing all major vascular surgical subtypes in the analyses. The data also lack information on return to home after skilled facility DC or nursing home placement, limiting our ability to comment on length of stay at these rehabilitation sites. Frailty is measured by using a modified scale (mFI) combining physical, cognitive, and functional frailty domains. However, the data does not have other metrics of frailty like gait speed or grip strength. The mFI therefore relies on a model of accumulating deficits and has been shown to have construct validity in the NSQIP database[32] and has been shown in geriatric literature to have robust discrimination as compared with the Fried frailty phenotype.[16] However, the mFI has not been validated in a head to head comparison with the full Canadian Study of Health and Aging-frailty index. We also demonstrated that preoperative steroid use and significant weight loss were significant predictors of nonhome DC in the multivariate regression model, although the absolute number of patients with the presence of these variables was low in the cohort (3% and 0.5%, respectively). Another limitation of our study is the inability to explore social determinants of nonhome DC. There could be unmeasured factors such as availability of social support and physical barriers at home that preclude return to home after surgery. Future studies are needed to elucidate the influence of social factors on nonhome DC in frail vascular patients as well as the ability of these patients to return home following rehabilitation versus commitment to an institutional facility.

In summary, nonhome DC disposition is fairly high in the vascular surgical patient population. The risk of nonhome DC markedly increased by frailty regardless of procedure. Overall, 23% of frail patients undergoing elective open major vascular surgical interventions like aneurysms and bypasses do not return home after surgery. The association of 2-fold increased risk of nonhome DC for frail patients as compared with nonfrail holds true for endovascular interventions as well. Frailty additionally increases the risk of nonhome DC by its association with occurrence of postoperative complications. As frailty is easily measured in the preoperative elective setting,[40] it has the potential to be a useful tool in preoperative planning, setting treatment expectations and goals of care for patients and caregivers while optimizing healthcare resource utilization for vulnerable vascular surgical patients. Further study is needed into post-DC transitions of care in vascular patients and their ability to return home and to independent functional status.

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APPENDIX A
COMPONENTS OF NSQIP MFI DERIVED FROM THE CSHA FRAILTY INDEX

NSQIP
Preoperative functional health status—partially or totally dependent
Impaired sensorium
Diabetes mellitus—noninsulin or insulin
History of severe chronic obstructive pulmonary disease or current pneumonia
Congestive heart failure within 30 days before surgery
History of myocardial infarction within past 6 months before surgery
History of angina, percutaneous coronary intervention, or cardiac surgery
Hypertension requiring medication
History of transient ischemic attack
Cerebrovascular accident or stroke with neurologic deficit
History of rest pain, gangrene, amputation, or revascularization for peripheral vascular disease