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Frailty Among Veterans Undergoing Abdominal Aortic Aneurysm Repair

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Background: Frailty is a known risk factor for adverse outcomes following surgery and affects at least 3 of every 10 US Veterans aged 65 years and older. We designed a study to characterize the association between frailty and complications after endovascular aneurysm repair (EVAR) compared to open aneurysm repair (OAR) at our regional Veterans Affairs Medical Center.

Methods: Veterans who underwent either OAR or EVAR at our institution between January 1, 2000 and December 31, 2020 were identified. We examined medical history, procedure characteristics, perioperative complications, and frailty as measured by the 5-factor modified frailty index (mFI-5). Frailty was defined as an mFI-5 score $\geq$2. Primary endpoints were postoperative complications, duration of surgery, and length of hospital stay. Tests of association were performed with *t*-test and chi-squared analysis.

Results: Over the 21-year period, we identified 314 patients that underwent abdominal aortic aneurysm (AAA) repair with 115 (36.6%) OAR and 199 EVAR (63.4%) procedures. Patients undergoing EVAR were older on average (72.1 years vs. 70.2 years) and had a higher average mFI-5 compared to the open repair group (1.49 vs. 1.23, $P = 0.036$). When comparing EVAR and OAR cohorts, patients undergoing OAR had a larger AAA diameter (6.5 cm, standard deviation [SD]: 1.5) compared to EVAR (5.5 cm, SD: 1.1 $P < 0.0001$). Fewer frail patients underwent OAR ($n = 40$, 34.8%) compared to EVAR ($n = 86$, 43.2%), and frail EVAR patients had higher AAA diameter (5.8 cm, SD: 1.0) compared to nonfrail EVAR patients (5.3 cm, SD 1.2), $P = 0.003$. Among OAR procedures, frail patients had longer operative times (296 min vs. 253 min, $P = 0.013$) and higher incidence of pneumonia (17.5% vs. 5.3%, $P = 0.035$). Among frail EVAR patients, operative time and perioperative complications including wound dehiscence, surgical site infection, and pneumonia were not significantly different than their nonfrail counterparts. Overall, frail patients had more early complications ($n = 55$, 43.7%) as compared to nonfrail patients ($n = 48$, 25.5%, $P = 0.001$). OAR patients had higher rates of postoperative complications including wound dehiscence (7.0% vs. 0.5%, $P = 0.001$), surgical site infections (7.0% vs. 1.0%, $P = 0.003$), and pneumonia (9.6% vs. 0.5%, P=<0.0001). Open repair was also associated with overall longer average intensive care unit stays (11.0 days vs. 1.6 days, $P < 0.0001$) and longer average hospitalizations (13.5 days vs. 2.4 days, $P < 0.0001$).

Conclusions: Our findings demonstrate that frailty is associated with higher rates of adverse outcomes in open repair compared to EVAR. Patients who underwent open repair had higher

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rates of wound dehiscence, surgical site infection, and pneumonia, compared to those undergoing endovascular repair. Frailty was associated with larger AAA diameter in the EVAR cohort and longer operative times, with higher frequency of postoperative pneumonia in the OAR cohort. Frailty is a strong risk factor that should be considered in the management of aortic aneurysms.

INTRODUCTION

As the population of the United States ages, the proportion of individuals aged 65 years and older is rising and is expected to comprise 25% of the general population by 2060.[1] These individuals account for approximately 40% of all surgical procedures annually and are at higher risk of adverse surgical outcomes.[2] One contributing factor to this is frailty which is a known risk factor for adverse health care outcomes including disability, morbidity, and mortality.[3]

Frailty is 1 way of quantifying health status in the geriatric population. It is conceptualized as an age-related cumulative decline in multiple physiological systems and is closely associated with adverse surgical outcomes. Compared with older adults in the general population, American Veterans represent a high-risk population for the onset of frailty as they are predominately older, have larger proportions of racial-ethnic minorities, lower socioeconomic status, lower levels of formal education, and higher prevalence of chronic physical and mental conditions.[4–6] Recent studies in Veteran populations have revealed frailty prevalence over 20% and an association with increased all-cause mortality.[3,7,8]

Currently, there are multiple proposed methods of assessing frailty that researchers are continuing to evaluate as predictive tools for postoperative outcomes. The 5-factor modified frailty index (mFI-5) has been validated for use as a frailty metric across all surgical subspecialties.[9] Studies have shown that it is highly correlated with the 11-item scale from which it was derived and uses the following 5 criteria: (1) diagnosis of diabetes mellitus; (2) diagnosis of congestive heart failure; (3) diagnosis of hypertension (HTN) requiring antihypertensive medication; (4) diagnosis of chronic obstructive pulmonary disease (COPD) or pneumonia at the time of surgery; and (5) functional dependence classification of ''partially dependent'' or ''completely dependent.'' The scale is scored from 0 to 5 and counts 1 point for each of the previously mentioned criteria. A score of 2 or greater on the mFI-5 is indicative of frailty.[9]

Characterizing the association between frailty and clinical outcomes after abdominal aortic aneurysm (AAA) repair will allow providers to make more informed decisions on surgical approach and identify potentially modifiable risk factors that could be optimized prior to intervention. Thus, the goal of this study is to characterize the association of frailty, measured by the mFI-5, on postoperative outcomes for Veterans undergoing aortic aneurysm repair.

METHODS

This study was a retrospective review of all AAA repair procedures performed at the Veterans Affairs Greater Los Angeles Healthcare System from January 1, 2000 to December 31, 2020. All patients who underwent open aneurysm repair (OAR) or endovascular aneurysm repair (EVAR) for AAA were included. Both emergent and elective cases were included. Emergent procedures were defined as repairs noted as unplanned and emergent in the preoperative vascular surgery note or unplanned repairs performed within 12 hr of an admission through the emergency department.

The study was approved by the local institutional review board and conducted in accordance with their protocol.

Primary and Secondary Outcomes

Primary outcome measures were frailty, measured by the mFI-5 and defined as a score $\geq$2, and perioperative complications. Complications were analyzed by early (within 30 days) and late (after 30 days) as noted in vascular surgery clinic follow-up notes. Early complications included pneumonia, acute renal failure, wound dehiscence, surgical site infection, and postoperative myocardial infarction (MI). Late complications included new or worse claudication, graft infection, emergency department visits, and aneurysm enlargement. Additional data collected included baseline demographics as well as medical comorbidities such as history of MI, coronary artery disease, HTN, and COPD. Secondary outcome measures were operative time, length of hospital and intensive care unit (ICU) stay following procedure, and mortality collected at 30-days, 6-months, 1-year, 5-years, 10-years, and 15-years. Length of stay was calculated from postoperative day 1 to the day of discharge from hospital.

Table I. Cohort demographics and clinical characteristics

Demographics and clinical characteristics	EVAR $n = 199$ (63.4%)	Open $n = 115$ (36.6%)	P-value
Age (years)	72.1 ± 7.5	70.2 ± 8.2	0.035
Gender (Male)	198 (99.5)	115 (100)	0.446
MI	28 (14.1)	20 (17.4)	0.442
CAD	71 (35.7)	52 (45.2)	0.102
HTN	160 (80.4)	98 (85.2)	0.283
COPD	67 (33.7)	22 (19.1)	0.006
Mean Max AAA Diameter (cm)	5.5 ± 1.1	6.5 ± 1.5	<0.0001

CAD, coronary artery disease.

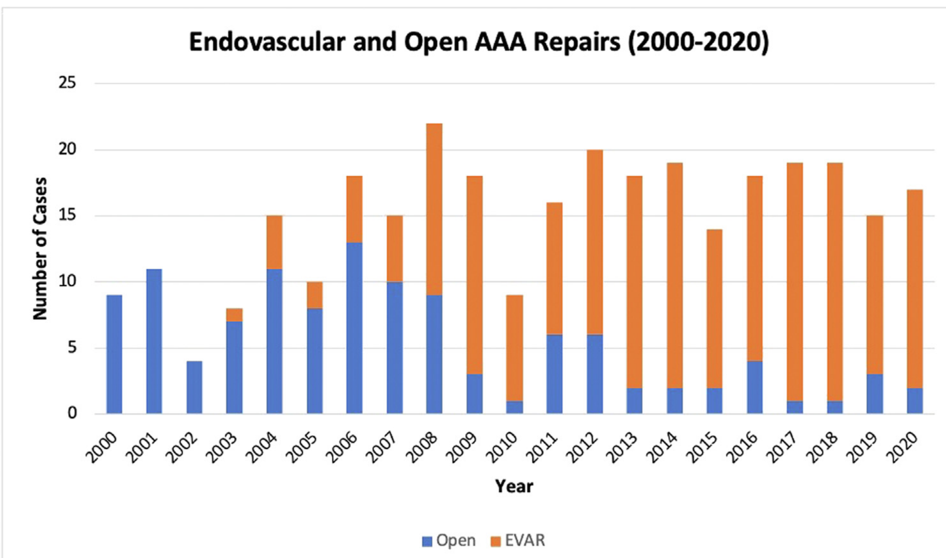

Fig. 1. Breakdown of surgical approach over time.

Statistical Analysis

Frailty, operative details, and postoperative outcomes were stratified by frailty status (mFI-5 ≥ 2 vs. < 2). Descriptive statistics were calculated, including mean with standard deviation for normally distributed variables, and chi-squared tests were used to compare categorical variables. A P-value <0.05 was considered significant.

RESULTS

Over the 21-year period, we identified 314 patients that underwent AAA repair who met inclusion criteria. One hundred fifteen (36.6%) procedures were done via an open approach and 199 (63.4%) were EVAR procedures. The average age was 72.1 ± 7.5 in the EVAR cohort and 70.2 ± 8.2 in the open cohort with the vast majority of patients being male (Table I). The EVAR cohort had significantly more patients with COPD, 34% ($n = 67$) compared to 19% ($n = 22$) in the open group, $P = 0.006$. Additionally, patients undergoing open repair had a higher AAA diameter (6.5 cm ± 1.5) compared to EVAR (5.5 cm ± 1.1), $P < 0.0001$. Breakdown of surgical approach over time demonstrated a trend from more open surgery to more endovascular surgery (Fig. 1).

Analysis of frailty using the mFI-5 within the 2 groups revealed that patients undergoing EVAR had an average higher frailty scores (1.49 ± 1.10) compared to open group (1.23 ± 1.04), $P = 0.036$. A higher proportion of EVAR patients classified as frail (43%, $n = 86$), vs. less than 35% ($n = 40$) in the open group, $P = 0.14$.

Table II. Operative characteristics

Operative characteristics	EVAR (n = 199)			Open (n = 115)		
	Non-frail (n = 113)	Frail (n = 86)	P-value	Non-frail (n = 75)	Frail (n = 40)	P-value
AAA diameter (cm)	5.3	5.8	0.003	6.46	6.66	0.5
Operative time (min)	145	158	0.276	253	296	0.013
ICU length of stay	1.5	1.6	0.733	11.3	10.1	0.785
Hospital length of stay	2.1	2.7	0.118	13.6	13.3	0.947

Table III. Early and late postoperative complications

Postoperative complications	EVAR (n = 199)		Open (n = 115)	
	Nonfrail (n = 113)	Frail (n = 86)	Non-frail (n = 75)	Frail (n = 40)
Early Complications				
Pneumonia	0	1	4	7
Acute renal failure	4	1	3	3
Wound dehiscence	1	0	8	0
Surgical site infection	0	1	5	3
Embolus (PE, Stroke)	4	5	0	0
Other (hematoma)	2	1	1	3
Postoperative MI	0	0	0	2
Total	11	9	21	18
Late Complications				
New/worse claudication	5	11	4	2
Graft infection	1	1	1	0
ED visit	1	4	6	0
AAA enlargement	18	12	1	1
Graft migration	0	1	0	0
Total	25	29	12	3

PE, pulmonary embolism; ED, emergency department.

Data on operative characteristics showed that frail EVAR patients had higher AAA diameter (5.8 cm) compared to nonfrail EVAR patients (5.3 cm), $P = 0.003$ (Table II), while there was not a significant difference in diameter between the nonfrail and frail patients undergoing open repair. The operative time was significantly longer for frail patients (296 min) treated with open repair than their nonfrail counterparts (253 min), $P = 0.013$. Hospital and ICU length of stay were similar between the frail and nonfrail patients undergoing both EVAR and open repair.

Table III displays the examination of postoperative complications which was categorized by early (within 30 days) and late (greater than 30 days postoperative). We observed no difference in rates of early complications within 30 days among frail and nonfrail patients undergoing EVAR. In the open repair cohort, a higher proportion of frail patients had early complications. However, this was not a statistically significant difference. Comparing all patients, those that were frail had a higher proportion of complications (n = 59, 47%) than nonfrail patients (n = 69, 37%), $P = 0.069$.

There were no significant differences in mortality when comparing all frail and nonfrail patients regardless of operative approach (Table IV). Additionally, when comparing the EVAR to open approach stratified by frail and non-frail, our mortality findings were not statistically significant (Table V). However, we found that while EVAR patients survived well into the 10 to 15 postoperative year, open approach patients had significant mortality at 30 days, and none survived past 5 years.

DISCUSSION

Frailty in our population of older Veterans undergoing AAA repair is associated with an additional risk of negative postoperative outcomes, particularly with regard to early complications. Those undergoing open repair also had longer operative times which may be due to the increased complexity

Table IV. Postoperative mortality comparing frail and nonfrail patients

Postoperative mortality	Frail ($n = 126$)	Nonfrail ($n = 188$)	P-value
30-day mortality—no. (%)	26 (20.6)	45 (23.9)	0.58
6-month mortality—no. (%)	26 (20.6)	46 (24.5)	0.51
1-year mortality—no. (%)	27 (21.4)	48 (25.5)	0.48
5-year mortality—no. (%)	32 (25.4)	53 (28.2)	0.58
10-year mortality—no. (%)	56 (44.4)	75 (39.9)	0.42
15-year mortality—no. (%)	72 (57.1)	96 (51.1)	0.30

Table V. Postoperative mortality by operative approach stratified by frailty

	EVAR ($n = 199$)			Open ($n = 115$)		
Postoperative mortality	Nonfrail ($n = 113$)	Frail ($n = 86$)	P-value	Non-frail ($n = 75$)	Frail ($n = 40$)	P-value
30-day mortality—no. (%)	0 (0)	0 (0)	-	45 (39.1)	26 (22.6)	0.60
6-month mortality—no. (%)	0 (0)	0 (0)	-	46 (40)	26 (22.6)	0.69
1-year mortality—no. (%)	0 (0)	0 (0)	-	48 (41.7)	27 (23.5)	0.71
5-year mortality—no. (%)	1 (0.9)	0 (0)	-	75 (100)	40 (100)	-
10-year mortality—no. (%)	23 (20.4)	24 (27.9)	0.28	-	-	-
15-year mortality—no. (%)	44 (38.9)	40 (46.5)	0.28	-	-	-

or higher degree of technical difficulty in frail patients. Interestingly, mortality data demonstrate that EVAR patients lived significantly longer than patients who underwent an open approach. This may have led to a lead-time bias in our postoperative outcomes analysis, as EVAR patients did not experience mortality until the 10-year postoperative period, procedure associated complications may not have arisen in our analysis period.

Multiple studies in recent years have supported the effect of frailty on increased complications in vascular surgery patients undergoing AAA repair. Morisaki et al. examined patients undergoing EVAR and found that frail patients defined by the Geriatric Nutritional Risk Index experienced almost 18% more postoperative complications compared to nonfrail patients.[9] Complications they included were endoleaks, vessel occlusion, and surgical complications such as surgical site infection, and renal, cardiac, and respiratory complications.[9] Another study using the mFI-11, the predecessor to the mFI-5, demonstrated that frail patients were almost 2 times more likely to experience severe complications after AAA repair compared to less frail patients.[10] These studies are heterogenous and use various scales to measure frailty, but the overall consensus supports our findings that frailty is associated with worse postoperative outcomes.

Our study has a few limitations, notably, that 1 component of the frailty score, functional status, was not formally documented in the chart. We attempted to increase the accuracy of our estimation by examining numerous notes such as those written by nursing staff, physical therapy notes, and primary care providers around the time of the patient's surgery. Despite this, we may have underassessed frailty as providers occasionally did not document patients' level of functional dependence and our protocol was to assume those patients were functionally independent. Additionally, shortcomings inherent to retrospective design include vulnerability to information bias due to missing data that limit our ability to control for confounding variables.

This is a real-world study among the Veteran population that looked at frailty in patients undergoing AAA repair. Our findings suggest that further investigation into the assessment of frailty is warranted. In the face of improving technology that allows for more endovascular procedures, this study suggests that research comparing open and endovascular management of AAA in frail patients may help guide the choice between surgical approaches.

Overall, our goal is to become more methodical in assessing frailty in our Veteran patients and how it correlates with the risk of perioperative complications.

CONCLUSION

In conclusion, while additional work is required to further characterize frailty in older Veterans, this study suggests that frail patients as identified by the mFI-5 may have worse postsurgical outcomes. The mFI-5 is a quick and simple tool that we were able to apply in a retrospective manner to identify an association between frail status and operative aortic outcomes. Future studies using a Veteran-centric real-time frailty assessment tool may augment surgeon-patient/family communication concerning expected surgical outcomes and also help providers optimize outcomes following AAA repair.

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