From the Eastern Vascular Society

Open conversion after failed endovascular aneurysm repair is increasing and its 30-day mortality is higher than that after primary open repair

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ABSTRACT

Background: Endovascular aneurysm repair (EVAR) has become the preferred treatment of abdominal aortic aneurysms (AAAs). Recent studies have demonstrated that cases of EVAR failure repair and subsequent open conversion have increased. The aim of the present study was to evaluate the national trend of annual cases and assess the 30-day outcomes of conversion to open repair after failed EVAR compared with primary open repair.

Methods: The National Surgical Quality Improvement Program database was queried for relevant Current Procedural Terminology and International Classification of Diseases, Ninth and Tenth Revision, codes to identify patients who had undergone conversion to open repair or primary open repair of nonruptured AAAs from 2009 to 2018. The annual trend of cases was assessed, and the perioperative outcomes of both procedures were compared. Multivariable logistic regression analyses were conducted to identify independent perioperative factors associated with mortality.

Results: Of the 9635 patients with nonruptured AAAs included in the present analysis, 9250 had undergone primary repair and 385 had required open conversion. During the 10-year period, the annual number of cases of open conversion had steadily increased and that of primary repair had decreased. The incidence of postoperative complications was similar between both groups, except for cardiac arrest, which had occurred more frequently in the open conversion group. The 30-day mortality was higher in the open conversion group than in the primary group (9.6% vs 3.9%; $P < .0001$). Open conversion was also independently associated with higher odds of death (adjusted odds ratio [OR], 2.1; 95% confidence interval [CI], 1.8-2.4; $P < .0001$). When the average mortality in both groups was compared between the first and last 5 years, no difference was found (open conversion: 9.8% vs 9.5% [$P = 1.00$]; primary repair: 3.6% vs 4.2% [$P = .19$]). Other perioperative factors independently associated with mortality included increased age (OR, 1.8; 95% CI, 1.5-2.1; $P < .0001$), American Society of Anesthesiologists class ≥III (OR, 2.7; 95% CI, 1.1-6.6; $P = .029$), insulin-dependent diabetes (OR, 2.0; 95% CI, 1.2-3.3; $P = .005$), chronic obstructive pulmonary disease (OR, 1.4; 95% CI, 1.1-1.8; $P = .006$), the presence of dyspnea at rest (OR, 3.3; 95% CI, 1.8-6.1; $P < .0001$), and a high preoperative hematocrit (OR, 0.94; 95% CI, 0.93-0.97; $P < .0001$).

Conclusions: Open conversion to treat nonruptured AAAs after failed EVAR was independently associated with higher mortality. Also, the annual cases of open conversion have continued to increase without any significant changes in postoperative mortality. This highlights the danger of open conversion and stresses the need for better solutions to prevent and manage EVAR failure. (J Vasc Surg 2022;76:1502-10.)

Keywords: Endovascular aneurysm repair; Nonruptured abdominal aortic aneurysm; Open conversion; Postoperative complications; Risk factors

Endovascular aneurysm repair (EVAR) has changed the management of abdominal aortic aneurysms (AAAs) since its advent in 1991.[1] It has become the first-line repair modality for 70% to 80% of patients with nonruptured AAAs,[2,3] with recent expansion to the treatment of ruptured AAAs.[4] This has resulted from its demonstrated advantages in short- and mid-term morbidity and mortality compared with primary open repair.[5] However, in the

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long term, the durability of EVAR has remained challenged by aneurysm- and graft-related complications such as endoleaks and stent graft migration. These complications have resulted in an increased need for aortic-based reinterventions, especially when used for patients with unsuitable anatomy or outside the instructions for use (IFU) for the devices.[6,7] Although reintervention can usually be performed successfully using an endovascular technique such as arterial embolization and graft extension or relining, conversion to open repair can be required in 0.4% to 22% of cases.[8,9] Open conversion is associated with unique technical challenges, including difficult dissection, vascular control, and graft explantation.[10] Furthermore, patients presenting after failed EVAR could represent a high surgical risk cohort, given that open surgery was avoided initially as the primary treatment option for some of these patients. Although recent studies have reported an increasing incidence of open conversion, conclusions regarding its perioperative outcomes have remained conflicting.[11-14] Therefore, the aim of the present study was to evaluate the current trend of annual cases and assess the 30-day outcomes of nonurgent conversion to open repair after failed EVAR compared with those of primary open repair of nonruptured AAAs. Furthermore, a multivariable regression model was used to identify the risk factors associated with mortality in this cohort.

ARTICLE HIGHLIGHTS

- **Type of Research:** A retrospective analysis of prospectively collected data from the National Surgical Quality Improvement Program
- **Key Findings:** The results from the present study of 9625 patients have demonstrated that cases of conversion to open repair after failed endovascular aneurysm repair increased and cases of primary open repair had decreased from 2009 to 2018. The patients in the open conversion group had had higher odds of death within 30 days after surgery compared with the primary repair group. The odds of death were even greater for older patients and those with a higher American Society for Anesthesiologists classification, chronic obstructive pulmonary disease, insulin-dependent diabetes, or dyspnea at rest. Despite the increase in open conversion, no change was found in the associated mortality over time.
- **Take Home Message:** The incidence of open conversion after failed endovascular aneurysm repair of nonruptured abdominal aortic aneurysms had not only increased but was also associated with increased mortality.

METHODS

Data source. We used data from the National Surgical Quality Improvement Program (NSQIP) database for the present study. The NSQIP is a quality improvement initiative developed by the American College of Surgeons as a risk-adjusted surgical outcomes database. As of 2022, about 700 hospitals were participating, both nationally and internationally, from which standardized and validated perioperative data are prospectively collected from a random sample of patients by dedicated surgical clinical reviewers.[15,16] More than 200 variables are collected in the database in the following categories: preoperative characteristics (eg, demographics, comorbidities, and laboratory tests, if applicable), intraoperative data points, and postoperative outcomes.[17] The postoperative outcomes are collected for 30 days after the procedure and include the following categories: overall mortality, overall complications, cardiac complications, cerebrovascular complications, pulmonary complications (eg, pneumonia, prolonged intubation [>48 hours after the procedure], unplanned intubations, pulmonary embolism, venous thrombosis), bleeding and transfusion, renal dysfunction, and surgical site infections (eg, superficial, fascia, and deep organ space infections).[17,18] Additional outcomes include readmission and return to the operating room. The database is devoid of any protected health information because all entered data have been de-identified. Therefore, institutional review board approval and patient informed consent were not required for the present study.

Patient identification. All patients who had undergone nonurgent conversion to open repair after failed EVAR or primary open repair of nonruptured AAAs from January 2009 to December 2018 were included in the present study. The International Classification of Diseases (ICD), 9th and 10th Revision, codes (ICD-10 codes, I71.4, I71.9; and ICD-9 codes, 441.4 and 441.9) were used to query the NSQIP database for patients with a postoperative diagnosis of a nonruptured AAA. These patients were divided into two groups according to the procedure used. The procedures were identified using the Current Procedural Terminology (CPT) codes, including CPT codes 35081 (repair of abdominal aorta), 35091 (repair involving visceral vessels), 35102 (repair involving iliac vessels) for primary open repair of nonruptured AAAs and 34830 (conversion with tube prosthesis), 34831 (conversion with aorto-bi-iliac prosthesis), 34832 (conversion with aortobifemoral prosthesis) for open conversion after failed EVAR. The CPT codes for conversion also encompassed attempted EVAR in the case of acute conversion. Therefore, the study cohort was considered a combination of acute and late conversion because we could not discriminate between the two. The patients were identified from both the general and the vascular-targeted NSQIP participant use file.

Data and outcomes. Data on the baseline characteristics, intraoperative details, and postoperative outcomes were retrieved and analyzed for both groups. The primary outcomes included the annual trend of both procedures over time and differences in 30-day overall mortality. The secondary outcomes included the differences in postoperative complications and identification of the risk factors associated with mortality.

Statistical analysis. All categorical baseline characteristics were summarized as frequencies and percentages and compared across groups using a χ^2 test of independence. Because of the non-normal nature of biologic data, all numeric predictors and continuous outcomes were summarized as the median and interquartile range and compared across groups using the Mann-Whitney *U* test. Composite outcomes were created by assessing whether any of the sub-outcomes were present for each patient. A binary outcome was created as the presence of any sub-outcome. All binary outcomes were compared across groups using the χ^2 test of independence.

Univariable logistic regression models were used to assess the relationship between the predictors and 30-day mortality. All statistically significant univariable predictors at the α level of 0.05 were included in a multivariable model to predict their relationship with 30-day mortality. Stratified Poisson regression models were created to model the number of cases annually. The model was stratified by primary vs open conversion procedures, with the year used as the predictor. All analyses considered $\alpha = 0.05$, and the results were not adjusted for multiple comparisons. Analyses were conducted using SPSS, version 27 (IBM Corp, Armonk, NY).

RESULTS

Annual trend of cases. Data from 9625 patients (primary open repair, n = 9250; and conversion to open repair, n = 385) were identified and analyzed. During the 10-year study period, the annual number of cases of conversion to open repair had steadily increased and that of primary open repair had decreased (Fig 1). When a stratified Poisson regression model was used to conduct a test of trend over time, we found a statistically significant annual increase in the number of conversions to open repair [exp(β) = 1.06; 95% confidence interval (CI), 1.02-1.10; $P < .0001$] and an annual decline in the number of cases of primary open repair [exp(β) = 0.97; 95% CI, 0.99-0.98; $P < .0001$].

Baseline characteristics. The patients' baseline characteristics are presented in Table I. The patients in the open conversion group were slightly older (72 vs 71 years; $P < .0001$) and more frequently were aged ≥80 years (21% vs 14.1%; $P < .0001$). Both groups were similar in the sex distribution but more Asians were in the open conversion group (5.2% vs 2%; $P < .0001$) than in the primary repair group.

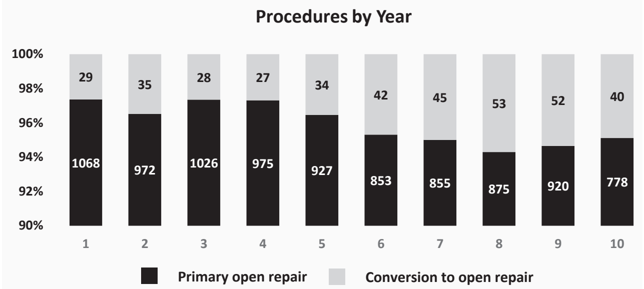

Fig 1. From 2009 to 2018, we found an upward trend in the annual number of cases of conversion to open repair with a downward trend in the number of cases of primary open repair for nonruptured abdominal aortic aneurysms (AAAs).

The baseline comorbidities were mostly similar in both groups, except that more patients in the open conversion group were likely to have dyspnea at rest (1.8% vs 0.9%; $P = .04$). They were also more likely to be classified as having American Society of Anesthesiologists (ASA) class ≥III (97.9% vs 95.2%; $P = .013$) and to have received a preoperative transfusion (2.6% vs 1.2%; $P = .01$) compared with the primary repair group. However, the proportion of smokers in the primary repair group was higher than that in the open conversion group (47% vs 37%; $P < .0001$).

Intraoperative events. Intraoperatively, conversion to open repair was associated with a significantly longer median operative time compared with primary open repair (244 vs 217 minutes; $P < .0001$).

Postoperative complications. In terms of the postoperative complications, only cardiac arrest requiring resuscitation was found to have occurred more frequently in the open conversion group than in the primary repair group (5.5% vs 2.2%; $P < .0001$). The occurrence of other complications such as wound infection, sepsis, stroke, cerebrovascular accident, bleeding, transfusion requirement, myocardial infarction, pneumonia, pulmonary embolism, renal insufficiency, renal failure, and a return to the operating room were all similar in both groups. The hospital length of stay was also similar between both groups (Table II).

Thirty-day mortality. The 30-day mortality was significantly higher in the open conversion group than that in the primary repair group (9.6% vs 3.9%; $P < .0001$; Table II). When the average mortality in both groups was compared between the first and last 5 years of the study period, we found no differences (open conversion: 9.8% vs 9.5% [$P = 1.00$]; primary repair: 3.6% vs 4.2% [$P = .19$]; Fig 2). After adjusting for possible confounders in a multivariable logistic regression analysis, conversion to open repair was independently associated with a greater odds of death compared with primary open repair (OR, 2.2; 95% CI, 1.5-3.2; $P < .0001$). This finding remained

Table I. Demographics and comorbidities (n = 9635)

Variable	Primary open repair (n = 9250)	Conversion to open repair (n = 385)	*P* value
Age, years	71 (65-76)	72 (67-78)	<.0001
Age group, years			<.0001
<50	109 (1.2)	5 (1.3)	
50-59	841 (9.1)	27 (7)	
60-69	3191 (34.5)	106 (27.5)	
70-79	3808 (41.2)	166 (43.1)	
≥80	1301 (14.1)	81 (21)	
Sex			.5325
Female	2388 (25.8)	94 (24.4)	
Male	6855 (74.2)	291 (75.6)	
Race			
Asian/Pacific Islander	189 (2)	20 (5.2)	<.0001
Black/African American	470 (5.1)	22 (5.7)	
White	7004 (75.7)	294 (76.4)	
Unknown/other	1587 (17.2)	49 (12.7)	
ASA class ≥III	8794 (95.2)	376 (97.9)	.013
Preoperative BUN, mg/dL	17 (13-22)	17 (14-21)	.6963
Preoperative creatinine, mg/dL	1 (0.9-1.2)	1 (0.8-1.2)	.517
Preoperative hematocrit, %	41 (37.7-44)	40 (36.1-44)	.0066
Preoperative PTT	29.4 (27-32.2)	29.3 (27.1-32)	.7511
Preoperative INR	1 (1-1.1)	1 (1-1.1)	.0741
Preoperative WBC count, K/μL	7.5 (6.3-9)	7.3 (5.8-8.9)	.0051
Smoking[a]	4324 (46.7)	141 (36.6)	<.0001
Obesity	2570 (27.8)	99 (25.7)	.374
Functional status			.371
Independent	9038 (97.7)	373 (96.9)	
Partial and total dependence	194 (2.1)	11 (2.9)	
Unknown	18 (0.2)	1 (0.3)	
Insulin-dependent diabetes	235 (2.5)	8 (2.1)	.5706
History of COPD	1805 (19.5)	69 (17.9)	.4395
History of CHF	115 (1.2)	3 (0.8)	.4173
History of renal failure	36 (0.4)	2 (0.5)	.6894
Renal failure requiring dialysis	71 (0.8)	5 (1.3)	.2484
Preoperative transfusion	107 (1.2)	10 (2.6)	.0114
Dyspnea			.0489
None	7672 (82.9)	328 (85.2)	
At rest	82 (0.9)	7 (1.8)	
On moderate exertion	1496 (16.2)	50 (13)	
Preoperative weight loss	128 (1.4)	7 (1.8)	.4774
Steroid use	270 (2.9)	17 (4.4)	.0905

ASA, American Society of Anesthesiologists; *BUN,* blood urea nitrogen; *COPD,* chronic obstructive pulmonary disease; *INR,* international normalized ratio; *PTT,* partial thromboplastin time; *WBC,* white blood cell.
Data presented as median (interquartile range) or number (%).
[a]Smoking within 1 year of surgery.

unchanged after an inverse propensity score-weighted analysis (OR, 2.15; 95% CI, 1.8-2.4; $P < .0001$; Fig 3).

The other perioperative factors associated with a higher odds of mortality on multivariable analysis for the overall cohort were older age (OR, 1.8; 95% CI, 1.5-2.1; $P < .0001$), ASA class ≥III (OR, 2.7; 95% CI, 1.1-6.6; $P = .029$), insulin-dependent diabetes (OR, 2.2; 95% CI, 1.2-3.3; $P = .005$), chronic obstructive pulmonary disease (COPD; OR, 1.4;

Table II. Postoperative outcomes (n = 9635)

Variable	Primary open repair (n = 9250)	Conversion to open repair (n = 385)	*P* value
Total operation time, minutes	217 (168-287)	244 (175-320)	<.0001
Hospital LOS, days	7 (6-10)	7 (5-10)	.4855
Stroke/CVA	82 (0.9)	6 (1.6)	.1745
Cardiac arrest requiring resuscitation	205 (2.2)	21 (5.5)	<.0001
Transfusion			.4798
Postoperative	34 (0.4)	0 (0)	
Intraoperative	5118 (55.3)	216 (56.1)	
Cardiopulmonary complications	1585 (17.1)	78 (20.3)	.1119
Pneumonia	661 (7.1)	37 (9.6)	.0676
Reintubation	617 (6.7)	28 (7.3)	.643
Pulmonary embolism	53 (0.6)	2 (0.5)	.8914
Failure to wean	871 (9.4)	43 (11.2)	.2502
Myocardial infarction	298 (3.2)	17 (4.4)	.1968
Renal complications	589 (6.4)	29 (7.5)	.3607
Renal failure	374 (4)	20 (5.2)	.2636
Renal insufficiency	237 (2.6)	9 (2.3)	.7844
Wound complications	392 (4.2)	17 (4.4)	.8654
Superficial incisional SSI	151 (1.6)	7 (1.8)	.7786
Deep incisional SSI	52 (0.6)	4 (1)	.2279
Organ/space SSI	81 (0.9)	3 (0.8)	.8419
Wound disruption	136 (1.5)	5 (1.3)	.7836
Sepsis	230 (2.5)	11 (2.9)	.6482
Any complication			.200
0	3359 (36.3)	131 (34.0)	
1	3890 (42.1)	156 (40.5)	
≥2	2001 (21.6)	98 (25.5)	
Return to OR ≤30 days	824 (8.9)	43 (11.2)	.1288
30-Day mortality	360 (3.9)	37 (9.6)	<.0001

CVA, Cerebrovascular accident; *LOS,* length of stay; *OR,* operating room; *SSI,* surgical site infection.
Data presented as median (interquartile range) or number (%).

95% CI, 1.1-1.8; $P = .006$), and the presence of dyspnea at rest (OR, 3.3; 95% CI, 1.8-6.1; $P < .0001$). In contrast, a high preoperative hematocrit (OR, 0.95; 95% CI, 0.93-0.97; $P < .0001$) was associated with a decreased odds of mortality (Fig 3).

DISCUSSION

Principal findings

Analysis of 10-year data from the NSQIP database of patients with nonruptured AAAs treated with either nonurgent conversion to open repair after failed EVAR or primary open repair without prior EVAR demonstrated that the annual number of cases of conversion to open repair had increased and the number of cases of primary open repair had decreased. Furthermore, the patients who had required open conversion had been older and frailer. Although the incidence of postoperative complications were mostly similar between both groups, the patients in the open conversion group had had higher odds of death within 30 days after surgery compared with that for the primary group. The odds of death were even higher if the patients were older or had had a higher ASA class, COPD, insulin-dependent diabetes, or dyspnea at rest. However, despite the increased number of cases of open conversion, we found no change in the associated mortality over time.

Annual trend of cases over time

Although the findings of a decreasing number of cases of nonurgent primary open repair and an increasing number of cases of nonurgent conversion to open repair of nonruptured AAAs were interesting, they seem expected and, to some extent, self-explanatory. Worldwide, EVAR has become the dominant form of elective AAA repair since its advent in 1991.[1-3] Also, with the continuous

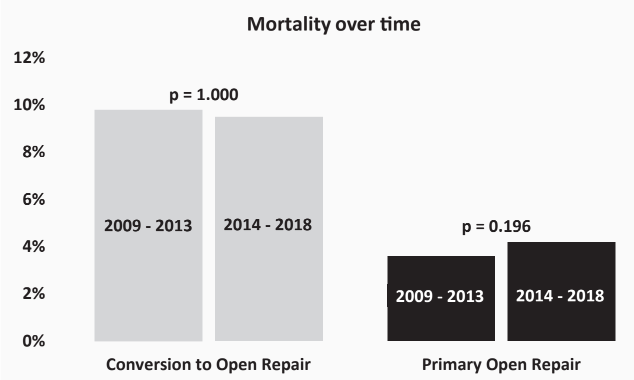

Fig 2. No difference was found in the average mortality between the two groups when the first and last 5 years were compared.

innovation and advancement of EVAR technology (eg, fenestrated devices), surgeons have been able to go beyond previous boundaries and chose to use EVAR for patients with more complex anatomy and clinical situations.[19] The expansion in indication and increased usage of EVAR would, therefore, be expected to result in less use of primary open repair, hence, the declining cases over time.

Additionally, because the number of patients undergoing EVAR has been increasing, it should not be surprising that the number of cases of open conversion after failed EVAR will also be increasing. This finding is in alignment with the results of several other studies.[11-14,20] Although EVAR has been proved to be beneficial in the short term, the durability of EVAR has remained challenged by the occurrence of aneurysm- and device-related complications resulting in the need for aortic-based reintervention in the long term.[6,7,21] Although most of the reinterventions can be performed successfully with the available endovascular options, some patients will still require conversion to open repair.[8,9] The reported incidence of open conversion was 1.9% in 2010 and 5.4% in 2018.[12,22] The possible explanations for this increment include the increased adoption of EVAR in younger age groups, its use for patients with complex and unsatisfactory anatomy, and its increased use outside the device manufacturers' IFU. It has been reported that IFU violation will occur in 38% to 68% of EVAR cases and is associated with increased adverse events and reintervention.[6,7,23] Therefore, our finding of an increasing number of cases of open conversion and its association with worse outcomes raises concerns regarding patient selection for the initial AAA repair. One finding from the present study was the proportion of Asians noted in the open conversion group compared with the primary repair group (5.2% vs 2%; $P < .0001$). This was relatively high, given that only 2.5% of EVAR cases were for Asian patients, according to a NSQIP study.[24] Asian patients have been reported to have more challenging aortoiliac anatomy (shorter aneurysm neck and common iliac artery, torturous infrarenal aorta, and smaller external iliac artery) compared with patients of other races, posing technical difficulties for EVAR.[25] This might have contributed to an increased risk of graft failure, resulting in more Asians requiring open conversion.

Outcomes

Intraoperative details. The average operation time for conversion to open repair was longer than that for primary open repair. Similar results have been reported by other studies.[26,27] Open conversion is understandably a complex procedure associated with unique challenges. These include the presence of periaortic inflammation, active endoleaks, and the endograft and possibly other associated secondary endovascular devices, such as coils and extension cuffs. All of these can increase the difficulty of dissection and the establishment of adequate vascular control and graft explantation.[9,28]

Postoperative complications. Although the patients in the open conversion group were older and frailer at baseline and had had longer operation times, the occurrence of major postoperative complications remained similar in both groups. The exception was cardiac arrest requiring resuscitation, which had occurred more frequently in the open conversion group. In contrast, Ultee et al[13] reported a higher complication rate in the open conversion group compared with the primary repair group. Although they had also used data from the NSQIP database, the study period was relatively old and the divergences noted could have resulted from recent advancements and improvements in perioperative monitoring and treatment. The extent of endograft explantation (total vs partial) performed in the open conversion procedure has also been linked to the incidence of postoperative complications, with partial explantation more favorable than total explantation, especially when repair was not indicated for infection.[29,30] However, we did not obtain data regarding the extent of explantation performed and, therefore, could not comment with certainty whether the observed difference was related to the explantation extent.

Thirty-day mortality. The mortality rate within 30 days after surgery was significantly higher in the open conversion group than in the primary repair group (9.6% vs 3.9%; $P < .0001$). In the literature, the variation in the reported mortality is significant for nonurgent conversion to open repair, with a range of 0% to 28.5%.[20,31-33] The variation could have been because most of the reported studies had been single-center investigations with small sample sizes, limiting their quality and generalizability. Although our finding of a 9.6% mortality rate in the open conversion group is in line with the results from other larger studies,[13,22] it is in contrast to the findings of a recent pooled meta-analysis. The meta-analysis reported a 30-day mortality rate of 2.8% for nonurgent conversion

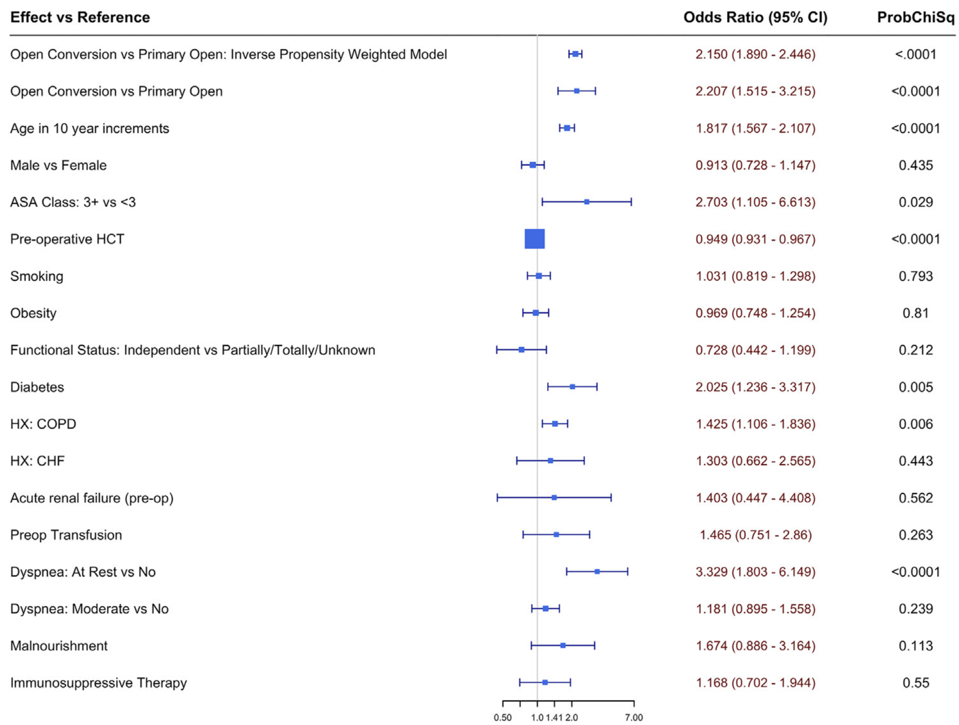

Fig 3. Forest plot demonstrating the results of the multivariable analysis. *ASA,* American Society of Anesthesiologists; *HCT,* hematocrit; *HX: CHF,* history of congestive heart failure; *HX: COPD,* history of chronic obstructive pulmonary disease.

to open repair and concluded that the outcomes of primary open repair and conversion to open repair are comparable.[12] However, the meta-analysis had included only 10 studies with a total of 156 patients. In addition, the investigators reported that the studies were appraised to be of low quality.[12]

The multivariable analysis demonstrated that conversion to open repair was independently associated with a higher odds of death. This finding remained unchanged even after applying inverse-weighted propensity matching to create an equally matched group. A similar association was also reported by Ultee et al.[13] Other factors that were identified to independently increase the odds of death included COPD, insulin-dependent diabetes, a high ASA class, dyspnea at rest, and older age. For every 10-year increment in age, the odds of death were 80% higher. When considering the correlations between the occurrence of complications and mortality, it is important to consider, not only the rate of occurrence, but also the severity.[34] Older age and higher ASA class have been associated with a greater severity of complications and mortality in surgical patients.[35,36] A recent study by Chastant et al[30] showed that most of the patients who had died after conversion to open repair had been 8 years older than those who had survived (84.5 vs 76.5 years). Considering that more patients in the open conversion group were also older and had had dyspnea at rest and a higher ASA class might explain why they had had more than twice the mortality compared with the patients in the primary open repair group, despite a similar rate of major complications. A higher preoperative hematocrit was found to be a protective factor against mortality. These findings further stress the importance of patient optimization and reconditioning before surgery, especially for nonemergent cases.

Finally, a comparison of the average mortality between the first and last 5 study years showed that the mortality in both groups had remained unchanged over time, signifying that conversion to open repair remains a risky procedure and that better solutions are needed to prevent and treat EVAR failure.

Study limitations

We would recommend caution with the interpretation of the results of our study for the following reasons. First, data for patients from both the general (nonvascular-targeted) and vascular-targeted NSQIP dataset were used, limiting the critical evaluation of the technical aspects of the procedures and information on the specific indications for conversion to open repair, both of which could have affected the studied outcomes. Second, given that the CPT codes for conversion also encompass attempted EVAR in the case of acute conversion, cases of acute and late conversion could not be differentiated, making the study cohort a combination of both. Third, it is unclear whether the available CPT codes for open conversion will identify patients who had undergone open aneurysmorrhaphy and sac plication with stent graft preservation; therefore, the conversion group could have included such cases. Fourth, although the NSQIP dataset is compiled by trained dedicated clinical reviewers, the accuracy of the data could not be verified. Fifth, although the NSQIP data are required in prospective fashion, our analysis was retrospective and, therefore, susceptible to missing information. Sixth, the NSQIP dataset comprises clinical practice from multiple institutions and countries; therefore, we could not control for the effect of variations in practice. Finally, the NSQIP database has only recently included readmission data; however, the NSQIP database still does not include information on long-term data, limiting the assessment of late reintervention rates or long-term survival.

Despite these limitations, our study represents one of the most recent and largest collection of data comparing conversion to open repair after failed EVAR with primary open repair and providing important information regarding their trends and outcomes. Given its large sample size and the use of prospective data registry with wide coverage across the United States and internationally, the results are likely more generalizable.

CONCLUSIONS

The results from the present study have demonstrated that conversion to open repair for nonruptured AAAs is associated with increased mortality. The annual number of cases of open conversion have also continued to increase over time without significant changes in associated mortality. This highlights the danger of open conversion and stresses the need for better solutions to prevent and manage EVAR failure. We encourage the consideration of factors such as patient age, preference, surgical risk and tolerance, and anatomy when choosing the optimal treatment method for those with nonruptured AAAs.

AUTHOR CONTRIBUTIONS

Conception and design: MI, QP
Analysis and interpretation: MI, MS, TJ, MM, MA, AS, RR, QP
Data collection: MI, QP
Writing the article: MI, MS, QP
Critical revision of the article: MI, MS, TJ, MM, MA, AS, RR, QP
Final approval of the article: MI, MS, TJ, MM, MA, AS, RR, QP
Statistical analysis: MS
Obtained funding: Not applicable
Overall responsibility: QP
RR and QP contributed equally to this article and share co-senior authorship.

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