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Endovascular Repair of Abdominal Aortic Aneurysm does not Improve Early Survival versus Open Repair in Patients Younger than 60 Years[☆,☆☆] CME

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WHAT THIS PAPER ADDS

- Multiple randomised trials have demonstrated lower perioperative mortality after endovascular aneurysm repair (EVAR) compared to open surgical repair (OSR) for infrarenal abdominal aortic aneurysms (AAAs). The median age of the patients in these trials was more than 70 years. We compared EVAR ($n = 369$) and OSR ($n = 282$) in patients younger than 60 years of age in terms of 30-day mortality (EVAR = 1.1%; OSR = 0.4%; $P = 0.22$) using the National Surgical Quality Improvement Program (NSQIP) data set. These contemporary results demonstrate similar peri-procedural mortality rate after OSR and EVAR in patients younger than 60 years of age. Our data can aid in the informed consent process of younger patients with AAA. All patients should be educated about the advantages and disadvantages of EVAR; some would prefer the upfront morbidity risk of open surgery to avoid the late consequences of EVAR, while others would not.

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ABSTRACT

Objectives: Multiple randomised trials have demonstrated lower perioperative mortality after endovascular aneurysm repair (EVAR) compared to open surgical repair for infrarenal abdominal aortic aneurysms (AAAs). However, in these trials the mortality advantage for EVAR is being lost within 2 years of repair and the patients evaluated are relatively older with no study specifically comparing EVAR and open repair for patients younger than 60 years of age.
Design: A retrospective analysis of prospectively collected data.
Materials and methods: Patients younger than 60 years of age who underwent EVAR and open surgical repair for elective infrarenal AAA were identified from the 2007–09 National Surgical Quality Improvement Program (NSQIP) – a prospective database maintained at 237 centres across the United States. Univariate and multivariate analyses were performed.
Results: Of the 651 patients, 369 (56.7%) underwent EVAR and 282 (43.3%) underwent open repair. Thirty-day mortality for EVAR and open repair were 1.1% and 0.4%, respectively. This was not significantly different on univariate ($P = 0.22$) as well as multivariate ($P = 0.69$) analysis after controlling for other co-morbidities. On multivariate analysis, body mass index, history of stroke and bleeding disorder prior to surgery were associated with a higher 30-day mortality after AAA repair (combined open and EVAR).
Conclusions: These contemporary results demonstrate that the 30-day mortality rate after open repair is similar to that after EVAR in patients younger than 60 years with infrarenal AAA.
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Parodi's landmark paper in 1991 on endovascular aneurysm repair (EVAR) marked a paradigm shift in abdominal aortic aneurysm (AAA) repair.[1] Since then, multiple randomised prospective multicentre trials have demonstrated lower perioperative mortality after EVAR compared to open infrarenal AAA repair.[2–4] These findings have been further corroborated in population-based studies.[5] The immediate perioperative advantages of the endovascular approach are, however, lost with time. Follow-up data from the randomised trials have shown equivalent mortality after open and endovascular approaches by 2 years, with the merging of the mortality curves related to late deaths in the EVAR cohort.[3,6–8] EVAR has also been shown to have a significantly higher re-intervention rate.[6,8] Further, graft-related complications after EVAR necessitate multiple routine follow-up computed tomographic scans with the associated radiation exposure, which could be an issue for the younger patients.

The trials and population studies demonstrating lower perioperative mortality after EVAR compared to open AAA repair had patients with a median age over 70 years. Due to their relatively advanced age, these patients would be at a higher perioperative risk after open surgery compared to the less invasive EVAR.[9–11] Previous studies have not compared EVAR to open AAA repair in relatively younger patients. We hypothesised that in patients younger than 60 years in age, perioperative outcomes after open surgical repair would not be inferior to EVAR. Further, given the higher mortality rates associated with EVAR beyond the perioperative period,[6,8] open repair may be associated with a lower overall mortality in comparison to EVAR. We used the multicentre (237 hospitals as of 2009), prospective, National Surgical Quality Improvement Program (NSQIP) data sets to compare 30-day outcomes after open and endovascular elective infrarenal aortic aneurysm repair in patients younger than 60 years.

Materials and Methods

Data set

Data were extracted from the 2007, 2008 and 2009 American College of Surgeons NSQIP Participant Use Data Files.[12] These are multicentre, prospective databases with 183 (year 2007), 211 (year 2008) and 237 (year 2009) participating academic and community US hospitals, with data being collected on 136 perioperative variables. NSQIP is a risk-adjusted data collection mechanism that collects and analyses clinical outcomes data. Participating hospitals use their collected data to develop quality initiatives that improve surgical care, with participation being voluntary. In NSQIP, a participating hospital's surgical clinical reviewer (SCR) captures data through 30 days following surgery using a variety of methods, one of which is medical chart abstraction. Events occurring after hospital discharge were identified using comprehensive strategies.[13] In addition to examining inpatient medical records and outpatient patient charts, a minimum of three attempts to contact the patient by telephone or mail are made to ensure accurate documentation of post-discharge events. If no response is obtained, the Social Security Death Index and the National Obituary Archives are queried to investigate the potential of a death. Hospitals are required to provide complete 30-day follow-up on at least 95% of patients.[13]

The data are collected based on strict criteria formulated by a committee. To ensure that the data collected are of a high quality, the NSQIP has developed different training mechanisms for the SCR and conducts an inter-rater reliability audit of participating sites.[12] Inter-rater reliability audits revealed that in 2008 total disagreements were at 1.60% (>140,000 audited fields).[14] The processes of SCR training, inter-rater reliability auditing, data collection and sampling methodology have been previously described in detail.[12]

Patients

Patients younger than 60 years of age undergoing elective open and endovascular repair of infrarenal AAAs were identified from the NSQIP data sets. Preoperative data obtained included demographics, lifestyle, co-morbidity and other variables (Table 1). Complete definitions for all the above-listed variables have been previously published elsewhere.[12]

Outcome

The primary outcome of interest was 30-day mortality. Other outcomes analysed included hospital length of stay, minor morbidity (urinary tract infection or superficial wound infection) and major morbidity. The latter included deep wound infection, organ space infection, wound dehiscence, pneumonia, reintubation, on ventilator >48 h, pulmonary embolus, deep venous thrombosis, renal insufficiency, acute renal failure, stroke, coma, peripheral nerve deficiency, graft/prosthesis failure, cardiac arrest, myocardial infarction, transfusion >4 units packed red blood cells (PRBCs) within 72 h, sepsis, and septic shock or return to the operating room. The NSQIP database captures outcomes through 30 days following surgery, except for hospital length of stay, which is recorded till the patient is discharged.

Sepsis has been defined in NSQIP as systemic inflammatory response syndrome (SIRS) along with a positive blood culture or clinical documentation of purulence or positive culture from any site thought to be causative. SIRS is clinically recognised by the presence of two or more of the following within 48 h prior to surgery: temperature >38 °C or <36 °C; heart rate >90; respiratory rate >20 breaths/min or partial pressure of carbon dioxide in arterial blood ($PaCO_2$) <32 mmHg (<4.3 kPa); white blood cell count >12,000 cells mm^{-3}, <4000 cells mm^{-3}, or >10% immature (band) forms; anion gap acidosis defined as $[Na + K] - [CL + HCO_3$ (or serum) $CO_2] > 16$ or $Na - [CL + HCO_3$ (or serum) $CO_2] > 12$. Reintubation was said to have occurred if a patient was intubated postoperatively once extubated. If the patient returned to the operating room for any reason and was intubated as part of the anaesthesia/surgery, then it was not counted as a reintubation. If a patient self-extubated and had to be reintubated, then also it was not counted as a reintubation. Complete definitions for all the other above-listed variables have been previously published elsewhere.[12]

Statistical analysis

Univariate exploratory analysis was performed using Pearson chi-square test or Fisher's exact test for categorical variables and *t*- or *F*-test for continuous variables. Stepwise multivariate logistic regression was performed to assess risk factors for perioperative morbidity and mortality. Type of aortic repair (open vs. endovascular) was forced into the logistic regression analysis. Both the *C*-statistic and the *P*-value for the Hosmer–Lemeshow goodness of fit test were obtained to determine if there was a satisfactory fit of the model. All statistical analyses were performed using Statistical Analysis System (SAS, version 9.2; SAS Institute, Cary, NC, USA). *P*-value <0.05 was considered as significant.

Table 1
Preoperative and intraoperative characteristics.

Category	Preoperative/Intraoperative variable		Open repair	EVAR	*P*-value
			N (%)		
Total			282 (100)	369 (100)	
Cardiac	Angina within 1 month	Yes	3 (1.1)	10 (2.7)	0.14
	Cardiac surgery prior	Yes	39 (13.8)	62 (16.8)	0.30
	Congestive heart failure	Yes	2 (0.7)	7 (1.9)	0.20
	Myocardial infarction (within 6 months)	Yes	3 (1.1)	4 (1.1)	0.98
	Percutaneous coronary intervention prior	Yes	57 (20.2)	92 (24.9)	0.16
Circulatory	Bleeding disorder	Yes	20 (7.1)	39 (10.6)	0.13
	PAD	Yes	21 (7.5)	20 (5.4)	0.29
	Rest pain in lower extremity	Yes	7 (2.5)	6 (1.6)	0.44
	Wound (Open)	Yes	4 (1.4)	6 (1.6)	0.83
General	Age (Median) in years (Inter-quartile range)		56 (53–58)	56 (54–58)	0.004
	ASA Class	1	14 (5.0)	12 (3.3)	0.33
		2	74 (26.3)	118 (32.0)	
		3	155 (55.2)	190 (51.5)	
		4	37 (13.2)	49 (13.3)	
		5	1 (0.4)	0	
	BMI (Median) in kg/m^2 (Inter-quartile range)		29.0 (25.7–33.3)	30.0 (26.0–33.9)	0.049
	Corticosteroid use (chronic)	Yes	3 (1.1)	18 (4.9)	0.006
	Diabetes mellitus	On insulin	22 (7.8)	20 (5.4)	0.41
		On medication	16 (5.7)	18 (4.9)	
	Functional status	Partially dependent	9 (3.2)	7 (1.9)	0.41
		Totally dependent	2 (0.7)	1 (0.3)	
	Hypertension	Yes	215 (76.2)	280 (75.9)	0.92
	Prior operation within 30 days	Yes	4 (1.4)	5 (1.4)	0.95
	Race	American Indian	1 (0.4)	2 (0.5)	0.41
		Asian/Pacific Islander	1 (0.4)	2 (0.5)	
		Black	21 (7.5)	29 (7.9)	
		Hispanic	9 (3.2)	5 (1.4)	
		Unknown	15 (5.3)	31 (8.4)	
		White	235 (83.3)	300 (81.3)	
	Sex	Male	227 (80.5)	335 (90.8)	0.0002
		Female	55 (19.5)	34 (9.2)	
	Transition (admitted from)	Home	273 (96.8)	359 (97.3)	0.37
		Acute care	8 (2.8)	8 (2.2)	
		Chronic care	1 (0.4)	0	
		Others	0	2 (0.5)	
	Weight loss > 10% within 6 months	Yes	4 (1.4)	12 (3.3)	0.13
Laboratory	Albumin	Abnormal	21 (7.5)	33 (8.9)	0.60
		Normal	123 (43.6)	148 (40.1)	
		Unknown	138 (48.9)	188 (51.0)	
	Creatinine	Abnormal	23 (8.2)	33 (8.9)	0.94
		Normal	251 (89.0)	326 (88.4)	
		Unknown	8 (2.8)	10 (2.7)	
	Haematocrit	Abnormal	43 (15.3)	46 (12.5)	0.16
		Normal	234 (83.0)	308 (83.5)	
		Unknown	5 (1.8)	15 (4.1)	
	Platelets	Abnormal	40 (14.2)	64 (17.3)	0.23
		Normal	236 (83.7)	291 (78.9)	
		Unknown	6 (2.1)	14 (3.8)	
	Prothrombin time	Abnormal	61 (21.6)	76 (20.6)	0.93
		Normal	137 (48.6)	179 (48.5)	
		Unknown	84 (29.8)	114 (30.9)	
	Partial thromboplastin time	Abnormal	27 (9.6)	36 (9.8)	0.99
		Normal	167 (59.2)	219 (59.4)	
		Unknown	88 (31.2)	114 (30.9)	
	White blood cell count	Abnormal	41 (14.5)	45 (12.2)	0.28
		Normal	235 (83.3)	309 (83.7)	
		Unknown	6 (2.1)	15 (14.1)	
Neurologic	Hemiplegia	Yes	3 (1.1)	3 (0.8)	0.74
	Stroke with neurologic deficit	Yes	8 (2.8)	10 (2.7)	0.92
	Stroke without neurologic deficit	Yes	7 (2.5)	11 (3.0)	0.71
	Transient ischaemic attack	Yes	8 (2.8)	19 (5.2)	0.14
Renal	On dialysis preoperatively	Yes	1 (0.4)	11 (3.0)	0.01
Respiratory	Chronic obstructive pulmonary disease	Yes	37 (13.1)	59 (16.0)	0.31
	Dyspnoea	At rest	1 (0.4)	7 (1.9)	0.07
		On moderate exertion	52 (18.4)	84 (22.8)	
Social	Alcohol intake within last 2 weeks	Yes	23 (8.2)	32 (8.7)	0.81
	Smoking within past year	Yes	202 (71.6)	231 (62.6)	0.02

Table 1 (*continued*)

Category	Preoperative/Intraoperative variable		Open repair	EVAR	*P*-value
			N (%)		
Total			282 (100)	369 (100)	
Intraoperative	Bifurcated graft	Yes	141 (50.0)	321 (87.0)	<0.0001
	Intraoperative PRBC transfusion in units (median)		1	0	<0.0001
	Type of anaesthesia	Regional	3 (1.1)	49 (13.3)	<0.0001
		General	279 (98.9)	320 (86.7)	
	Anaesthesia time in minutes (median)		317	198	<0.0001
	Operative time in minutes (median)		226	129	<0.0001

EVAR – Endovascular aortic repair; ASA – American Society of Anesthesiologists; BMI – Body mass index; PAD – Peripheral arterial disease with history of previous amputation/revascularization; PRBC – Packed red blood cells.

Results

Demographics, co-morbidities and therapy characteristics

A total of 10,251 patients underwent AAA repair in the 2007–09 NSQIP data. Of these, 651 patients (the study population) were under 60 years of age. Two-hundred and eighty-two of these patients underwent open aortic repair, while 369 patients underwent EVAR. Median age was 56 years for both the open and EVAR group of patients. Patients undergoing EVAR were more commonly males (90.8% vs. 80.5%; $P = 0.0002$) and dialysis dependent (3.0% vs. 0.4%; $P = 0.01$). There were no differences between the two groups in terms of ASA class, diabetes, functional status, respiratory, cardiovascular and neurologic co-morbidities (Table 1). Fifty percent of the open repairs were 'tube grafts'. Bifurcated prosthesis was used for the majority of the EVARs (87.0%), while an aorto-aortic tube prosthesis was used in 10.6% of cases and an aortouniiliac or aortounifemoral prosthesis was used in 2.4% of the cases.

Outcomes

The 30-day mortality rate after open aortic repair was 0.4% ($n = 1$), while it was 1.1% ($n = 4$) after EVAR. This was not significantly different on univariate ($P = 0.22$) as well as multivariate ($P = 0.69$) analyses after controlling for other co-morbidities (Table 2).

The data demonstrate that the single patient who died after open repair required a return to the operating room where he apparently died due to unknown causes on postoperative day (POD) 1. Of the four patients who died after EVAR, the first died on POD 14 due to development of pneumonia and septic shock. The patient had required a return to the operating room and had developed postoperative renal failure and failure to wean from ventilator within 48 h of surgery. The second patient died on POD 14, probably due to renal and respiratory failure. This second patient had also required a return to the operating room and developed postoperative renal failure and failure to wean from ventilator within 48 h of surgery. The third patient died on POD 15, due to postoperative septic shock after requiring a return to the operating room, reintubation and cardiac arrest. The last patient died on POD 15 from postoperative septic shock after requiring reintubation.

Body mass index (BMI), stroke with neurological disorder and bleeding disorder were significantly associated with 30-day mortality on both univariate and multivariate analyses (Table 2). Rest pain in lower extremities, open wound, American Society of Anesthesiologists' (ASA) class,[15] abnormal creatinine and abnormal platelets were significant ($P < 0.05$) on univariate but not on multivariate analysis.

The 30-day major morbidity rates were 18.8% ($n = 53$) and 9.2% ($n = 34$) for open aortic repair and EVAR, respectively. This was significantly different on both univariate ($P = 0.0004$) and multivariate (odds ratio 2.74; 95% confidence interval: 1.66–4.50; $P < 0.0001$) analyses (Table 3). COPD, hypertension, smoking within 1 year of surgery and weight loss >10% prior to surgery were also significantly associated with 30-day morbidity on both univariate and multivariate analyses (Table 3). Site of attachment ('tube' vs. bifurcated repair), female gender, BMI, dependent functional status, congestive heart failure (CHF), open wound, anaesthesia time and operative time were significant ($P < 0.05$) on univariate but not on multivariate analysis.

Among major morbidities, significantly higher rates of postoperative sepsis, deep wound infection, greater than 4 units red blood cell transfusion, renal insufficiency, reintubation and failure to wean from ventilator within 48 h of surgery were seen after open repair ($P < 0.05$; see Table 4). The median (lower quartile–upper quartile) lengths of stay after open repair and EVAR were 6 (5–8) and 2 (1–3) days, respectively ($P < 0.0001$).

Discussion

Currently in the United States, 60% of the aortic aneurysms are repaired by endovascular techniques, and this number is increasing every year.[16] The widespread use of the endovascular approach is largely due to its decreased perioperative morbidity and mortality in comparison to open repair. The Comparison of Endovascular Aneurysm Repair with Open Repair in Patients with Abdominal Aortic

Table 2
Variables associated with postoperative mortality in the stepwise logistic regression analysis.

Parameter	Adjusted ODDS ratio	95% Wald confidence interval
Open vs. endovascular aortic repair	0.62	0.06–6.72
Body mass index per kg/m^2 of increase	1.18	1.05–1.33
History of stroke with neurologic deficit	37.04	2.24–500.0
Bleeding disorder prior to surgery	15.87	1.68–142.86

C-statistic – 0.83.

Table 3
Variables associated with postoperative morbidity in the stepwise logistic regression analysis.

Parameter	Adjusted ODDS ratio	95% Wald confidence interval
Open vs. endovascular aortic repair	2.74	1.66–4.50
Chronic obstructive pulmonary disease	2.36	1.34–4.17
Hypertension	2.84	1.39–5.82
Smoking within 1 year of surgery	1.96	1.11–3.45
Weight loss >10% within six months of surgery	4.93	1.63–14.71

C-statistic – 0.73.

Table 4
Postoperative characteristics.

Postoperative variables		Open repair	EVAR	*P*-value
		N (%)		
Total		282 (100)	369 (100)	
Major Complications				
Cardiac	Cardiac arrest	1 (0.4)	1 (0.3)	0.85
	Myocardial infarction	3 (1.1)	2 (0.5)	0.45
Circulatory	Postoperative PRBC transfusion > 4 Units	3 (1.1)	0	0.047
Graft	Graft/prosthesis failure	3 (1.1)	7 (1.9)	0.39
Infection	Organ space infection	2 (0.7)	0	0.11
	Sepsis	10 (3.6)	3 (0.8)	0.01
	Septic shock	3 (1.1)	3 (0.8)	0.74
Neurologic	Coma	0	0	–
	Nerve deficit	1 (0.4)	0	0.25
	Stroke	1 (0.4)	1 (0.3)	0.85
Renal	Acute renal failure	4 (1.4)	3 (0.8)	0.46
	Renal insufficiency	3 (1.1)	0	0.047
Respiratory	Pneumonia	8 (2.8)	5 (1.4)	0.18
	Reintubation	12 (4.5)	5 (1.4)	0.02
	Ventilator > 48 h	15 (5.3)	6 (1.6)	0.01
Return to operating room	Return to operating room	22 (7.8)	21 (5.7)	0.28
Venous thromboembolism	Deep venous thrombosis	4 (1.4)	2 (0.5)	0.25
	Pulmonary embolism	2 (0.7)	0	0.11
Wound	Deep wound infection	3 (1.1)	0	0.047
	Wound dehiscence	6 (2.1)	2 (0.5)	0.07
Any major morbidity		53 (18.8)	34 (9.2)	0.0004
Minor Complications				
	Superficial wound infection	7 (2.5)	6 (1.6)	0.44
	Urinary tract infection	7 (2.5)	5 (1.4)	0.29
Other Postoperative Parameters				
Number of days from operation to death, median (lower quartile–upper quartile)		1 (1–1)	14.5 (14–15)	0.0002
Length of stay in days, median (lower quartile–upper quartile)		6 (5–8)	2 (1–3)	<0.0001
Mortality		1 (0.4)	4 (1.1)	0.22

EVAR – Endovascular aortic repair; PRBC – packed red blood cells.
Graft/prosthesis failure – Mechanical failure of an extracardiac graft or prosthesis including myocutaneous flaps and skin grafts requiring return to the operating room, interventional radiology, or a balloon angioplasty within 30 days of the operation.

Aneurysm (EVAR 1), Dutch Randomised Endovascular Aneurysm Management (DREAM) and the Veterans Affairs Open versus Endovascular Repair (OVER) trials showed significantly better 30-day mortality after EVAR.[2–4] The DREAM trial showed better 30-day morbidity after EVAR; the OVER trial did not study 30-day morbidity, but showed similar 1-year morbidity, while the EVAR 1 trial also did not specifically study 30-day morbidity. Recently published, long-term data from these trials, show that over time the mortality benefit disappears, with patients having equivalent long-term survival with both interventions.[6,8] The mortality curves merged in the first year in the DREAM trial,[7] between the first and second years in the EVAR 1 trial,[17] and at 2 years in the OVER trial.[3] The long-term data also showed that the rates of graft-related complications and reinterventions were significantly higher with EVAR. Furthermore, the ACE (Anevrysme de l'aorte abdominale: Chirurgie versus Endoprothese) trial published last year, comparing open repair and EVAR in low- to moderate-risk patients (categories 0–2 according to the co-morbidity score of the Society for Vascular Surgery/American Association for Vascular Surgery) showed no difference between the two groups with respect to 30-day or 3 year morbidity and mortality.[18] In the EVAR group, however, reintervention was significantly higher, with a trend towards a higher aneurysm-related mortality.

The results of the ACE trial suggest that the superior perioperative outcomes seen after EVAR compared to open repair in the DREAM, EVAR 1 and OVER trials are probably related to patient co-morbidities and associated risk for open surgery. The OVER trial used the RAND surgical risk score, with only 53% patients categorised as low risk for surgery. Patients in EVAR 1 or DREAM trial may have been at a higher risk for open repair because risk assessment was left to the individual centre's evaluation. In the ACE trial, by restricting the patients to those with low and medium risk based on the Society of Vascular Surgery co-morbidity score, the perioperative advantage of EVAR over open repair was lost.

In the present study, 30-day mortality rates for open repair and EVAR in patients under 60 years of age were 0.4% and 1.1%, respectively. These rates are comparable to those from the ACE trial (0.6% and 1.3%). The 30-day mortality rates for open repair in the EVAR 1 trial, DREAM trial and OVER trial (3.0–4.6%) were higher than those seen in the present study, while the mortality rates for endovascular repair were similar (0.5–1.6%). The difference after open repair seen in the present study compared to the EVAR 1, DREAM and OVER trials is probably due to the lower age in the NSQIP data with associated decrease in co-morbidities, as the median age of patients in the DREAM, EVAR 1 and OVER trials was around 70 years. Age has been previously shown to be associated with higher perioperative mortality, especially after an abdominal incision.[9–11] The congruity in 30-day outcomes between our data and those from the ACE trial suggests a possible similarity in the overall risk profiles of the participants in the two studies. Both sets of patients were low to moderate risk – based on age in our study and Society of Vascular Surgery co-morbidity score in the ACE trial.

Females have been previously reported to have a higher risk for complications after AAA repair.[19,20] In the cohort of patients we studied (less than 60 years old undergoing AAA repair) we did not find female gender to be significantly associated with 30-day mortality or morbidity on multivariate regression analysis.

In the present study, open repair was associated with a higher risk for postoperative major morbidity. With further analysis of the complications, the differences appear to be in postoperative sepsis, deep wound infection, red blood cell transfusion, renal insufficiency (but not renal failure), reintubation and failure to wean from ventilator within 48 h of surgery. Long-term data from the EVAR 1 and DREAM trials show a higher morbidity for the EVAR group due to aneurysm-related complications and reinterventions.[6,8] Medicare data, on the other hand, showed similar morbidity between open repair and EVAR in the community due to laparotomy-related complications after open surgery.[5] There is no long-term morbidity data published specifically for patients less than 60 years of age who undergo AAA repair. It is possible that due to the relatively longer life span of these patients, they would be at a higher risk for endograft-related complication after EVAR, as well as for laparotomy-related complications after open repair.

Another source of potential morbidity that is not captured in reports of 30-day, and long-term morbidity following EVAR, is radiation exposure. Due to persistence of aneurysm-related morbidities including rupture, in most centres, patients undergo annual surveillance computed tomographic (CT) scans following EVAR.[21] An EVAR programme comprising planning CT, EVAR and surveillance CT at 1, 6 and 12 months, and annually thereafter, equates to a total effective radiation dose of around 145–205 mSv over 5 years, with a single standard post-EVAR surveillance CT angiogram exposing patients to a radiation dose of 20–30 mSv.[21] These numbers are striking when contrasted to the cohort of survivors from the 1945 atomic bombing where the mean radiation exposure was 40 mSv.[22] Exposures to doses between 5 and 125 mSv (mean 34 mSv) were associated with a significant increase in solid cancer mortality. A 50-year-old exposed to 200 mSv has a lifetime attributable cancer risk of 1.03% (1 in 100).[21] Similarly, a large-scale study of 400 000 radiation workers in the nuclear industry (exposed to 20 mSv) also showed a significant association between radiation dose and mortality from cancer.[22] Radiation is a risk factor for developing cancer after a latency period of between 10 and 20 years which is of particular concern for patients under 60 which constitute the study cohort in this report.[23] Few studies have assessed duplex ultrasound imaging as an alternative post-EVAR surveillance modality.[24] Systematic reviews of literature have shown colour duplex ultrasound to have a lower sensitivity (<70%) for endoleak detection, thus making it much less accurate than CT angiogram.[25] Contrast-enhanced ultrasound has a relatively higher sensitivity (77%) and holds promise;[26] however, till its use becomes widespread, CT angiogram remains the gold standard. The radiation risks associated with surveillance CTs following EVAR must be carefully explained to patients to enable a true informed consent.

Our study has several limitations. Variables analysed were limited to those recorded by NSQIP. Despite the data set being fairly comprehensive with more than 50 preoperative variables analysed, information on preoperative stress test, echocardiography, arrhythmia, electrocardiogram and glomerular filtration rate was not available. Anatomic data such as aneurysm diameter and rate of growth, the presence of symptoms, reason for return to the operating room and data on hospital and surgeon volume were also unavailable. Data on postoperative complications such as peripheral and visceral ischaemia, erectile dysfunction and paraplegia were also not available. While history of stroke and bleeding disorder prior to surgery were significantly associated with postoperative mortality, the confidence intervals are wide, which is probably due to the relatively low number of events. While the generalisability of these findings may be restricted to hospitals participating in NSQIP, more than 25% of hospitals across the US where AAA repairs are performed are enrolled in NSQIP.[27] Lastly, NSQIP does not record outcomes beyond 30 days and so evaluation of long-term outcomes using these data is not feasible. It would be ideal to study long-term outcomes; however, given the low number of patients under 60 years of age undergoing AAA repair, and lack of multicentre registries with long-term follow-up, this would be difficult to study.

EVAR has become the approach of choice for the repair of infrarenal AAAs mainly due to lower perioperative mortality when compared to open repair. However, this initial advantage is lost within 2 years of the repair, and long-term data demonstrate that the rates of graft-related complications, reinterventions and radiation exposure are significantly higher with EVAR. The present study identifies a patient group in which EVAR does not have a perioperative mortality advantage over open repair. Our data show that in patients less than 60 years of age, 30-day mortality after open repair is comparable to that after EVAR, with 30-day morbidity being higher. Our data can significantly aid in the informed consent process of younger patients with AAA. All patients should be educated about the advantages and disadvantages of EVAR; some would prefer the upfront morbidity risk of open surgery to avoid the late consequences of EVAR, while others would not.

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Conflict of Interest

None of the authors had any conflicts of interest.

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Ethical Approval

Exempt from IRB as patient data not identifiable and publicly available.

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