ORIGINAL ARTICLE

SURVIVAL, SHORT AND LONG-TERM OUTCOMES OF OPEN AND ENDOVASCULAR SURGICAL REPAIR OF UNRUPTURED INFRARENAL ABDOMINAL AORTIC ANEURYSMS

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Abstract

Introduction: *Endovascular Aortic Repair (EVAR) has become the standard management of Unruptured Infrarenal Abdominal Aortic Aneurysm (UIAAA); however, current evidence is limited and uncertain in our environment compared to Open repair. Our study aimed to determine the survival, short and long-term outcomes of EVAR vs. Open in a Peruvian cohort of UIAAA.*

Methods: *A single-center observational, analytical, longitudinal study using a retrospective registry of 251 patients treated (EVAR=205 vs Open=46) for UIAAA from 2000 to 2017. Variables considered were baseline, comorbidities, type of treatment, short-term (<30 days) and long-term (<5 years) outcomes, postoperative mortality according to the Vascular Quality Initiative (VQI) Risk Score, survival curves including reoperation-free rate and according to size (<65 mm vs. >65 mm) of long-term UIAAA. All variables were grouped according to the treatment performed (EVAR vs. Open) and we used the descriptive, multivariate, Cox regression, and Kaplan-Meier survival statistical analyses.*

Results: *251 UIAAA were evaluated and the mean age was 74.5 years [±13.32], smoking, family members with UIAAA, and previous abdominal surgery were the main antecedents. Diabetes mellitus 2 was the main comorbidity; more than 50% of patients with UIAAA had diameters greater than 65 mm (p=0.021). The calculated mortality (VQI) was Open=2.21% vs. EVAR=1.65%. The outcomes in short-term were mortality (Open=2.92% vs. EVAR=0%; p=0.039), blood transfusion >4 Units (Open=72.68% vs. EVAR=17.39%; p=0.021) and overall hospital stay (Open=14 vs. EVAR=5 days; p=0.049. A reduction in mortality (HR 0.76, 95% CI, 0.62-0.96, p=0.045) and readmission for aneurysmal rupture was identified for EVAR (HR 0.81, 95% CI, 0.79-0.85, p=0.031). In long-term outcomes, mortality (Open=3.41% vs. EVAR=19.56%; p=0.047), aneurysmal rupture (Open=0% vs. EVAR 13.04%; p=0.032) and reinterventions (Open=2.43% vs. EVAR=10.86%; p=0.002). An 86% risk of mortality (HR 1.86, 95% CI, 1.32-2.38, p=0.039) and elevated risk of readmission for aneurysmal rupture was identified for EVAR (HR 2.21, 95% CI, 1.98-2.45, p=0.028). At 5 years, survival for Open=93.67% vs. EVAR=80.44% (p=0.043), reintervention-free survival for Open=89.26% vs. EVAR=47.82% (p=0.021), survival for treated IUAAA <65 mm for Open=95.77% vs. EVAR=63.63% (p=0.019) and >65 mm for Open=92.53% vs. EVAR=85.71% (p=0.059).*

Conclusion: *EVAR has shown better short-term benefits and survival than Open management; however, the latter still prevails in the long term in our Peruvian UIAAA cohort. Further follow-up studies are required to demonstrate the long-term benefit of EVAR in our population.*

Keywords: *Abdominal aortic aneurysm; Endovascular; EVAR; Open; Survival; Follow-up.*

INTRODUCTION

Unruptured Infrarenal Abdominal Aortic Aneurysm (UIAAA) is a cardiovascular pathology that is associated with a series of hemodynamic changes of flow and pressure, conditioning its progressive growth and risk of rupture[1]. It has a prevalence in the male population of 1.3% (55-64.9 years), 9.1% (65-74.9 years), 16.8% (75-84.9 years) and 22% (>85 years) (1, 2). Likewise, in the female population, it is 0.4%, 2%, 3.9%, and 6.2% in the age range previously described[2]. Progressive UIAAA growth is associated with a proportional risk of rupture of 0.3% and >7% for diameters

<40 mm and >50 mm, respectively[1,2]. Due to this risk's high morbidity and mortality rate, open or endovascular surgical treatment (EVAR) has been recommended for UIAAA exceeding 50 and 55 mm in diameter in women and men, respectively[3]. In recent years, with the advent of innovative endovascular repair techniques, EVAR has become the procedure of choice of UIAAA, due to its lower perioperative mortality and fewer associated complications than the open approach[1,3]. However, some published studies, such as the EVAR Trial and others, have described survival data and perioperative benefits as superior to the standard open approach during only the first three years after surgery and after that were similar or lower than the open cohort[4,6].

Therefore, our work aimed to determine the survival, short- and long-term outcomes of open and endovascular surgical repair of UIAAA, and to assess whether the recently reported results reflect real-world practice in Peru's largest cohort of reported cases.

METHODS

Design, Population, and Sample Size

A retrospective, analytical, observational, and longitudinal study was performed. We analyzed 251 patients with UIAAA evaluated by the Vascular and Endovascular Surgery Department of the Edgardo Rebagliati Martins National Hospital, Peru, from January 2000 to January 2017. All patients with a diagnosis of UIAAA, treated surgically by open or endovascular repair, and with survival records and long-term results during the described period were enrolled in the study.

Data Collection and Study Variables

The primary source of information was the electronic medical records through the Patient Registration Information System (PRIS). The latter allowed us to initially identify all patients seen by our department with the code (ICD-10) I71.4 or/and with the designation "Abdominal aortic aneurysm, without mention of rupture". The data was collected retrospectively and longitudinally, selected, and organized according to the chronology of hospital care for five years after surgical treatment of UIAAA. Likewise, data collection was complemented with telephone calls to verify patients' current health status and survival during the study period. The main variables considered were comorbidities, type of UIAAA treatment (open vs. EVAR), perioperative outcomes or short-term (<30 days) and long-term (<5 years), postoperative mortality with the Vascular Quality Initiative (VQI) risk score, survival curves including reoperation-free rate and survival according to UIAAA size at five years. The choice of the type of treatment of UIAAA was under the decision of a multidisciplinary medical evaluation that assessed the patient's age, physical

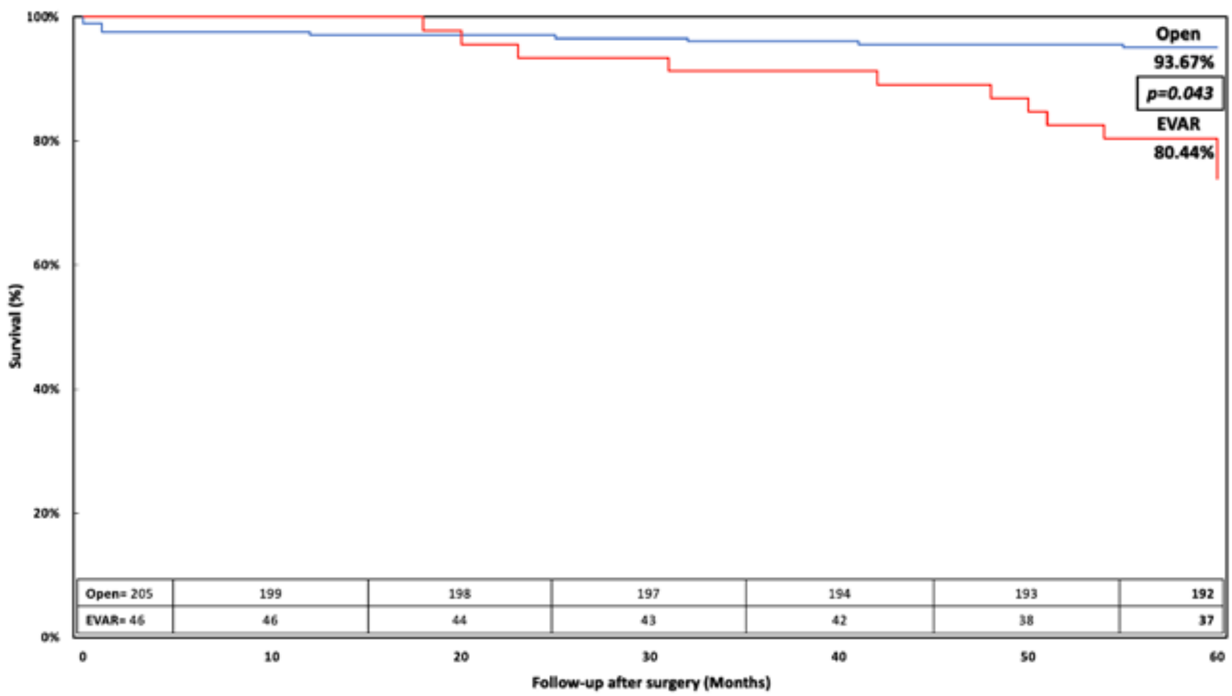

Figure 1 *5-year adjusted survival of patients with UIAAA treated Open and EVAR according to Kaplan-Meier analysis.*

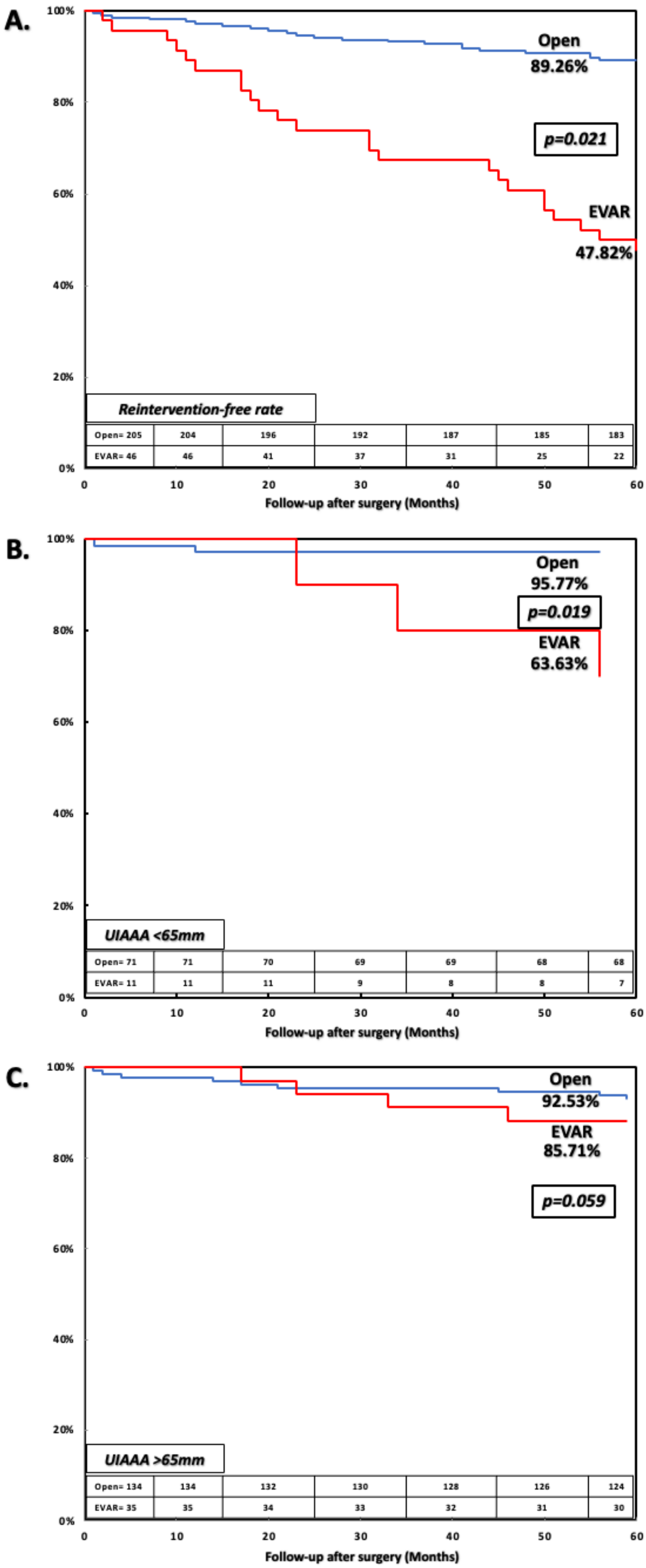

Figure 2 *A. 5-year adjusted freedom from reintervention rate of UIAAA treated Open and EVAR according to Kaplan-Meier analysis.*
B-C. 5-year adjusted survival of UIAAA <65 mm and >65 mm treated Open and EVAR according to Kaplan-Meier analysis.

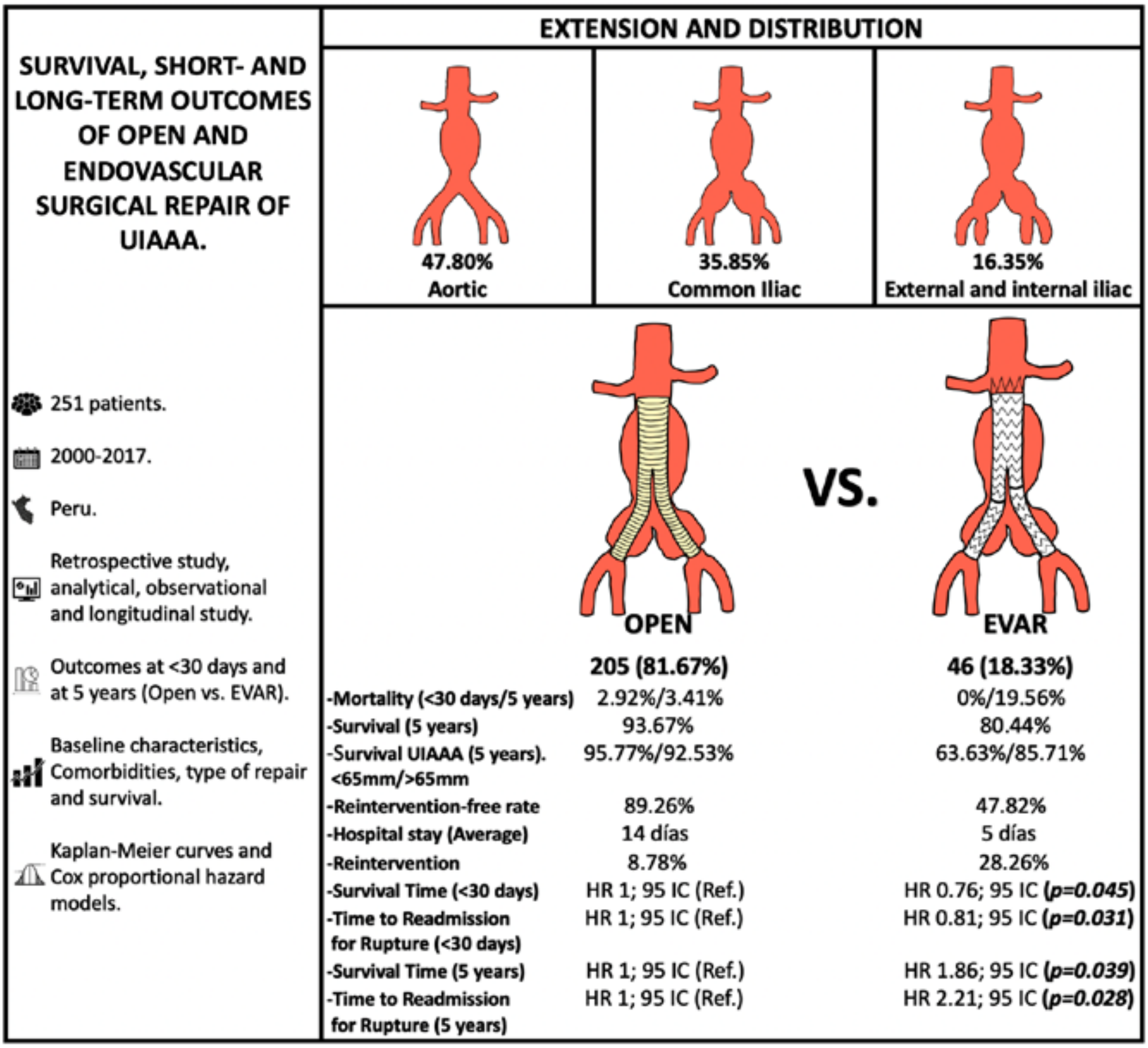

Figure 3 *Highlights of survival, short and long-term outcomes of Open and EVAR surgical repair of UIAAA.*

condition or frailty, comorbidities, the presence or not of a hostile abdomen, characteristics of the UIAAA (size, length, diameters, neck, angulations, and vascular accesses), short and long term survival, and finally the patient's decision about his condition was also considered.

Statistical Analysis

Categorical variables were presented as frequencies and percentages, and continuous variables as median ± Interquartile Ranges (IQR) with the Chi-Square Test. Propensity scores were evaluated using logistic regression models comparing open surgical vs. EVAR treatment of UIAAA and were found to overlap adequately by plotting the scores according to study groups. We used weighted Kaplan-Meier estimates and Cox proportional hazard models to compare data on reintervention, rupture, and 5-year survival, and with this analysis, we sought to stratify the mortality risk of patients treated with EVAR vs. Open (Reference). The standard error was <0.1 at five years for all outcomes, and all patients who died during the survival analysis were censored. Data collection, tabulation, and analysis were performed with the statistical program Stata, version 16 (StataCorp LLC, College Station, Texas) for Windows version 10. Statistical results were considered significant at $p<0.05$.

Ethical Aspects

The study protocol was approved by the Department of Thoracic and Cardiovascular Surgery and the Ethics Committee of the Edgardo Rebagliati Martins National Hospital [HNERM145-2022/009]. The guidelines proposed by the Declaration of Helsinki were followed, data confidentiality was respected, and informed consent was not required due to the type of retrospective study.

RESULTS

A total of 251 UIAAA were evaluated, 81.67% were surgically repaired open, and 18.33% with EVAR. The mean age for both groups was 73 and 76 years; the male gender predominated with 69.75% vs. 67.39%, respectively (Table 01). The main preoperative medications were statins (80.48% vs 69.56%) and aspirin (72.68% vs 63.04%); likewise, smoking history (77.21% vs 30. 43%), relatives with Abdominal Aortic Aneurysm (AAA) (19.30% vs 23.91%) and previous abdominal surgery (15.12% vs 47.82%) obtained statistically significant values (p=0.021, 0.032 and 0.004, respectively). The main comorbidities identified in both groups were Diabetes Mellitus 2 (47.31% vs 52.17%), hypertension (39.51% vs 32.60%), and dyslipidemia (23.90% vs 39.13%). More than 50% of patients with UIAAA presented diameters more significant than 65 mm for both Open repair (65.37%) and EVAR (76.09%) (p=0.021); likewise, most of them extended mainly to the aortic region proper (46.82% vs. 52.17%) and towards common iliac (35.12% vs. 39.13%). Mortality calculated according to VQI at 30 days was 2.21% for the open approach and 1.65% for EVAR (Table 01).

Regarding short-term outcomes, perioperative mortality was 2.92% vs 0% (p=0.039) for the open and EVAR group, respectively; likewise, higher use of blood transfusion (72.68% vs 17.39%, p=0.021), overall hospital stay (14 vs five days, p=0.049) and ICU more than 48 hours (27.31% vs. 17.39%, p=0.028) were identified predominantly in the first group. The main indication for reintervention was postoperative bleeding (6.34%) and endoleak (10.86%) for the open group and EVAR subsequently (p=0.049). The open approach presented the highest incidence of increased Cr (43.41%) and hemodialytic support (11.70%) (p=0.028) over EVAR. Regarding long-term outcomes, mortality was 3.41% vs 19.56% in favour of the open approach (p=0.047) and with a higher incidence of rupture (13.04%, p=0.032) of UIAAA surgically treated with EVAR. The main complication was endoleak I (19.56%, p=0.048), and the highest incidence of reinterventions was for the EVAR group (10.86%, p=0.002) (Table 02). Regression analysis for short-term outcomes according to UIAAA repair type showed a 24% reduction in mortality (HR 0.76, 95% CI, 0.62-0.96, p=0.045) and 19% reduction in readmission for aneurysmal rupture for EVAR (HR 0.81, 95% CI, 0.79-0.85, p=0.031). A risk of mortality (HR 1.58, 95% CI, 1.21-1.83, p=0.029) for UIAAA >65mm. A 19% risk reduction in mortality (HR 0.81, 95% CI, 0.76-0.91, p=0.026) and 41% risk reduction in readmission for aneurysmal rupture (HR 0.59, 95% CI, 0.41-0.67, p=0.017) for treated women. Increased risk of death of 32% for treated patients older than 75 years (HR 1.32, 95% CI, 1.28-1.48, p=0.042), 45% and 93% for patients treated with UIAAA extending to common iliac (HR 1.45, 95% CI, 1.32-1.67, p=0.048) and external and internal (HR 1.93, 95% CI, 1.76-2.29, p=0.017), respectively. The latter group also had an 81% higher risk of readmission for aneurysmal rupture (HR 1.81, 95% CI, 1.56-2.01, p=0.042). Mortality risk of 82% (HR 1.82, 95% CI, 1.76-2.01, p=0.032) and 95% (HR 1.95, 95% CI, 1.87-2.21, p=0.049) of readmission for aneurysmal rupture in patients treated with EVAR and endoleak (Table 03).

Regression analysis for long-term outcomes according to a type of UIAAA repair showed an 86% risk of mortality (HR 1.86, 95% CI, 1.32-2.38, p=0.039) and 121% risk of readmission for aneurysmal rupture for EVAR (HR 2.21, 95% CI, 1.98-2.45, p=0.028). An 85% and 93% mortality risk for patients with UIAAA with extension into common iliac (HR 1.85, 95% CI, 1.78-2.11, p=0.037) and external and internal (HR 1.93, 95% CI, 1.82-2.19, p=0.040), respectively; likewise, the latter group showed a 118% risk of readmission for aneurysmal rupture (HR 2.18, 95% CI, 1.99-2.56, p=0.020).

Mortality risk of 131% (HR 2.31, 95% CI, 2.01-2.46, p=0.018) in patients treated with EVAR and endoleak (Table 03). Kaplan-Meier analysis showed a 5-year survival of 93.67% vs. 80.44% for open and EVAR treatment, respectively (p=0.043); likewise, the 5-year reintervention-free rate was 89.26% vs. 47.82% (p=0.021) for both groups. According to the size of treated UIAAA, 5-year survival for those <65 mm was 95.77% (Open) and 63.63% (EVAR) (p=0.019); likewise, for those >65 mm, it was 92.53% (Open) and 85.71% (EVAR) (p=0.059) (Figure 01-02).

DISCUSSION

Our study is the first Peruvian cohort and one of the largest in Latin America, consisting of 251 patients diagnosed with UIAAA and undergoing surgical treatment (Open vs. EVAR) (Figure 03). Age is a factor that influences the response to treatment of UIAAA, and it described that in a population of octogenarian patients, there was greater survival at one year with EVAR but without statistically significant differences at five years compared to open surgery[4-7]. Regarding the gender of the patients, some studies, such as the meta-analysis published by Liu et al. showed higher mortality in the female gender treated with EVAR and a higher rate of acute ischemic complications in the lower extremities (5%), renal (24%) and cardiac (11%) affections, suggesting the hypothesis that these outcomes would be related to the smaller arterial vascular diameters reported in this gender[8].

Among the factors associated with AAA and its complications associated with surgical reparation, it is worth mentioning that obesity is one of the factors that is associated with more significant development of AAA, being considered a negative predictor when the BMI >25 kg/m2, likewise according to recent guidelines of the Society for Vascular Surgery, mention that obesity should favour a retroperitoneal approach in the case of open surgery and that it makes percutaneous access difficult in the case of EVAR[9]. We described a significant association between patients with a family history of AAA, smoking, and those with previous abdominal surgery, which some authors consider. The main relevant antecedents in this population of patients are also described in Latin America[10,11]. Among comorbidities, type 2 diabetes mellitus, poorly controlled or without metformin, hypertension, and dyslipidemia have been considered as the main cardiovascular risk factors; likewise, a great diversity of studies has demonstrated their strong association with AAA (OR 3.4, 95%CI, 2.6-3.9, p=0.034) and worse outcomes (OR 1.7, 95%CI, 1.2-2.3, p=0.003) over time translated into morbimortality[1,8,11-13]. According to the VQI initiative, the estimated 30-day mortality after the surgical treatment chosen for AAA (Open or EVAR) should not exceed 5% as standard, and we had estimated ideal mortality of 2.21% in patients treated by open surgery and 1.65% in those who underwent endovascular treatment. These estimated rates have been similarly reported in various studies around the world; however, in reality, they are not always extrapolated and a clear example is our work that presents mortality data slightly higher and above those projected for the Open group mainly (2. 92% vs 2.21%) and the EVAR (0% vs. 1.65%), setting the basis and background with data from our population, being comparative to more extensive studies such as the systematic review by George A. Antoniou et al. who identified mortality rates exceeding 2.5% for both groups (p=0.048)[9, 11, 14].

The short and long-term results obtained are very similar to other studies. Thus, a meta-analysis showed the main advantage in perioperative survival was found for EVAR vs Open (p<0.001); however, this advantage does not go beyond 2 years[15]. Likewise, some other studies report all-cause mortality rates without statistically significant differences at 2 years (p=0.09), 4 years (p=0.58), and 6 years (p=0.88)[16, 17]; however, in a randomized study, it was seen that the postoperative survival advantage with EVAR was significant during the first 3 years and from year 4 to year 8 it was more significant for the Open group[16]. He also reported that after 8 years, survival was again higher for EVAR, although none of these trends was significant[16]. A critical aspect assessed is that despite the low perioperative mortality, the long-term mortality of those patients designated by surgeons as unfit for Open was relatively high in patients undergoing elective EVAR, probably due to their risk of death secondary to their medical frailty[17]. The designation of unfit for hostile abdomen did not confirm any additional risk after EVAR; however, it is essential to highlight that unfit patients are more likely to have cardiopulmonary complications (p<0.001) and, therefore a higher short and long-term mortality (p<0.001)[3, 7, 9]. This associated mortality is significantly higher if we compare patients ineligible for Open medical comorbidities than only those for the hostile abdomen[16,17]. Siribumrungwong et al. saw that the 30-day mortality rate did not differ significantly for Open vs. EVAR (p=0.145), while the EVAR group, like our work, had less blood loss (<500 ml), shorter operative times (<370 min) and shorter hospital stay (±4-6 days), but higher reoperation rates (18%) (p=0.018)[5, 8, 18].

When analyzing an octagenarian population, Banno et al. described that 30-day mortality and death rates (Open vs. EVAR) during follow-up were similar, with no advantage of one technique over the other; however, the incidence of perioperative complications was higher in the Open group than in EVAR (56. 7% vs. 14.8%, p<0.001) and these were mainly gastrointestinal (23.4%), renal (49.1%) and neurological (21.5%) and associated to vascular access (19.6%) for the second group (19). Regarding postoperative mortality of UIAAA, some researchers described stroke (16%) and AMI (11%), but without significant differences (p<0.079); likewise, postoperative renal complications (39%) were primarily associated with the Open approach, similar to those reported in our study[15]. Postoperative renal function during the first 30 days of AAA treatment was evaluated and described a reduction in glomerular filtration rate and an increase in RIFLE score predominantly in the Open group, 33% vs. EVAR, 17%; p<0.027[11,20]. We report that the long-term rupture and reintervention rate was more associated with EVAR, coinciding with that described by Lederle et al. (35%) because patients in this group underwent secondary endovascular procedures to treat a series of complications headed by endoleaks (19%) and AAA ruptures (6%)[16]. Rahim et al. reported in their work that when reviewing several studies addressing only secondary aneurysmal rupture and reintervention after primary repair, they found statistically significant differences in favour of the Open group over the EVAR (8.4% vs 21.2%, p<0.038)[21]. A 15-year survival study of patients treated with EVAR in a center in Denmark, showed that 27.8% presented some endoleak at 95 days after EVAR (IQR= 90-106 days), of which 60% belonged to type II, 81.25% required some endovascular intervention, and this conditioned the survival rates to be lower than 15 years compared to the cohort of patients without endoleak (81.1% vs. 93.5%, p=0.05%). 25% required some endovascular intervention, which conditioned the survival rates to be lower at 15 years compared to the cohort of patients without endoleak (81.1% vs. 93.5%, p=0.02)[22]. We report similar results with a 32.60% incidence of endoleak and, of which 60% were of type I, mainly; this is why we highlight the importance of periodic follow-up in the short and long term with imaging studies to identify and, if necessary, treat endoleaks, follow up the aneurysmal sac and determine the need for reinterventions, which could range between 18%-90%[22].

Research conducted in 12.7-year follow-up in patients treated surgically for AAA and observed that after 0-6 months after randomization, a period considered to be short term according to their work, the EVAR group had a 66% reduction in mortality (HR 0.47, 95%CI, 0.23-0.93, p=0.031), a result much higher than ours of only 24% (HR 0.76, 95%CI, 0.62-0.96, p=0.045), probably due to differences in sample size and operational definition of "short term" (23). Likewise, in the evaluation of long-term survival, Patel et al. reported that beyond 8 years of follow-up, the open repair had a mortality risk of 25% (HR 1.25, 95%CI, 1.10-1.56, p=0.048), whereas we describe an estimated 86% risk of mortality for EVAR (HR 1.86, 95%CI, 1.32-2.38, p=0.048), whereas we describe an estimated 86% risk of mortality for EVAR (HR 1.86, 95%CI, 1. 32-2.38, p=0.039) over open, indicating to us that this could be related to the multiple comorbidities previously described in our study and probably to the learning curve in endovascular AAA repair, the latter because this option has recently become available in our setting[1, 17, 23]. We have obtained data different from the worldwide casuistry on the female sex and its relationship with mortality (HR 0.81, 95% CI, 0.76-0.91, p=0.026) and readmission for aneurysmal rupture (HR 0.59, 95% CI, 0.41-0.67, p=0.017); Charlton-Ouw KM et al. observed that a predictive factor for EVAR failure due to off-label use was female sex (p=0.001) because they were more likely to have insufficient proximal neck size (21.9%) and excessive iliac limb size (12.4%), conditioning a series of short and long-term complications on EVAR[4, 7, 24].

Some investigators described long-term survival stratified by age for 18 years, identifying that EVAR was associated with a 37% mortality risk reduction in the cohort aged 80 years or older (HR 0.63, 95%CI, 0.46-0.86, p=0.004); concluding with better outcomes of EVAR in the older cohort compared to open repair[25]. About our findings, we can mention an increased risk of mortality of 32% in the long term for treated patients older than 75 years with both techniques (HR 1.32, 95% CI, 1.28-1.48, p=0.042) because 81.67% of our population belonged to the Open group and this generates an additional 33% risk of complications in patients older than 75 years[19, 23].

A study of 30,074 patients treated with EVAR, of whom 40% showed regression of the aneurysmal sac in the first year, 35% were unchanged, and 25% persisted in their growth. The main factors that conditioned this last outcome were age with a cumulative risk per decade (OR 1.07, 95%CI, 1.01-1.13, p=0.02), AAA <5cm (OR 1.37, 95%CI, 1.21-1.55, p=0. 01) and CKD (OR 1.15, 95%IC, 1.05-1.25, p=0.01) and endoleaks with an additional 23% long-term mortality risk than predicted in patients treated with EVAR (OR 1.23, 95%IC, 1.10-1.37, p=0.001)[26]. The latter data is much lower than that reported in our work with a 131% risk (HR 2.31, 95% CI, 2.01-2.46, p=0.018) of mortality for the EVAR group with the presence of some type of endoleak. The expansion of the aneurysmal sac (OR 2.3, 95% CI, 2.0-2.7, p=0.001) or its invariability over time (OR 3.1, 95% CI, 2.7-3.5, p=0.001) have been associated with the development of new endoleak as described by Thomas F. X. O'Donnell et al. On the other hand, also among the factors certainly protective of aneurysmal sac growth are ex-smoking patients (OR 0.86, 95%CI, 0.76-0.96, p=0.01) and the use of statins (OR 0.83, 95%CI, 0.75-0.91, p=0.001)[26].

Our Kaplan-Meier analysis has shown that postoperative mortality before 2 years was higher in patients undergoing open surgery compared to EVAR; however, the long-term survival trajectory decreased significantly in the latter group of patients (Figure 1). Notably, this phenomenon was more noticeable for those patients with UIAAA <65mm (Figure 2 B and C), which may be explained by the higher rupture and operative risks associated with larger diameter UIAAA, making survival due to factors other than the surgical technique used[16-19]. These findings are consistent with previous clinical trials[27-29], which have evidenced the efficacy and safety of endovascular repair in the short and mid-term; the results of studies such as Endovascular Aneurysm Repair Trial 1 (EVAR-1) and Open Versus Endovascular Repair (OVER) showed that 30-day mortality was significantly lower in patients undergoing EVAR compared to open surgery (EVAR I, 1. 6% vs 4.6% and OVER, 0.5% vs 3.0%), as well as shorter intensive care unit (<48 hours) and hospital (~4-6 days) stay[25,26].

However, the advantage of such survival is lost after 2 or 3 years of follow-up; in addition, we showed that the reintervention rates were significantly higher in patients who underwent EVAR (Figure 2A), mainly due to endoleaks I (19.56%) and offsetting the early benefits of this technique by lower durability[28, 29]. Being recognized as a significant disadvantage for EVAR the graft-related complications such as endoleaks, recognized as an independent predictor of aneurysmal sac expansion in more than 32% of cases, which in turn correlate significantly with late mortality (5.2%, p=0.011) (30-32). Overall, the data consistently show that, although EVAR offers reduced short-term postoperative mortality (<2.6%, p=0.033), this survival benefit is not maintained in the long term and is associated with a substantially higher rate of reinterventions at follow-up over time (26%, p=0.001), pointing to late failure with endograft and a higher rupture rate compared to open surgery (11.5% vs. 2.3%, p=0.048)[24-26, 32].

CONCLUSION

Endovascular treatment of UIAAA in our Peruvian cohort has shown better morbimortality and survival rates within the first two years compared to the open approach; however, this therapeutic superiority decreases with 5-year follow-up, and the open technique becomes the best option over EVAR. It is, therefore, necessary to stratify the risk associated with treatment and the estimated life expectancy of patients with UIAAA, allowing the best form

Table 1 **Baseline and clinical characteristics of the UIAAA study population**

CHARACTERISTICS	UIAAA TREATMENT (N=251)				
	OPEN		EVAR		*p*
	N=205	%=81.67	N=46	%=18.33	
Age (Years), Average (IQR)	73 (65.2-77.8)		76 (69.8-79.3)		0.057
Gender					
Male	143	69.75	31	67.39	0.089
Female	62	30.25	15	32.61	
Race					
Mestizo	157	76.58	35	76.08	
White	31	15.12	7	15.21	0.167
Black	12	5.85	3	6.52	
Other	5	2.45	2	2.19	
BMI (kg/m2)					
<18.5 (Desnutrition)	15	7.31	5	10.86	0.046
≥ 30 (Obesity)	78	38.04	19	41.30	
Preoperative medication					
Statins	165	80.48	32	69.56	
Aspirin	149	72.68	29	63.04	0.092
Corticosteroids	54	26.34	12	26.08	
Smoking	138	67.31	14	30.43	0.021
Family history of AAA	39	19.30	11	23.91	0.032
Previous abdominal surgery	31	15.12	22	47.82	0.004
Comorbidities					
Diabetes Mellitus 2	97	47.31	24	52.17	
Hypertension	81	39.51	15	32.60	
Dyslipidemia	49	23.90	18	39.13	
COPD	56	27.31	15	32.60	0.079
AMI	34	16.58	11	23.91	
GFR <30 ml/min	29	14.14	10	21.73	
Stroke	18	8.78	12	26.08	
Diameter UIAAA (mm)					
<65 mm	71	34.63	11	23.91	0.021
>65 mm	134	65.37	35	76.09	
Distal aneurysmal extension					
Aortic	96	46.82	24	52.17	
Common Iliac	72	35.12	18	39.13	0.090
External and internal iliac	37	18.06	4	8.7	
Estimated mortality (VQI)	2.21%	(1.94-2.89)	1.65%	(1.15-1.99)	0.075

IRQ= Interquartile Range; BMI= Body Mass Index; AAA= Abdominal Aortic Aneurysm; COPD= Chronic Obstructive Pulmonary Disease; AMI= Acute Myocardial Infarction; GFR= Glomerular Filtration Rate; UIAAA= Unruptured Infrarenal Abdominal Aortic Aneurysm; VQI= Vascular Quality Initiative.

Table 2 **Short- and Long-Term outcomes of UIAAA patients treated with open approach and EVAR.**

OUTCOMES	UIAAA TREATMENT (N=251)				
	OPEN		EVAR		*p*
	N=205	%=81.67	N=46	%=18.33	
SHORT-TERM (<30 Days)					
Perioperative mortality	6	2.92	0	0	0.039
Blood transfusion (>4 Units)	189	72.68	8	17.39	0.021
Hospital Stay (Days), Mean (IRQ)	14 (11.5-16.2)		5 (3.9-8.2)		0.049
ICU stay >48 hours	56	27.31	8	17.39	0.028
Complications					
Pneumonia	42	20.48	9	19.56	0.188
Reintervention					
Postoperative bleeding	13	6.34	1	2.17	
Aneurysmal rupture	0	0	2	4.34	0.049
Endoleak	0	0	5	10.86	
AMI	14	6.82	2	4.34	0.078
Cardiac arrest	9	4.39	1	2.17	0.190
Acute renal dysfunction					
Increased Cr >2 mg/dl	89	43.41	7	15.21	0.028
Hemodialysis	24	11.70	4	8. 69	
SSI	7	3.41	1	2.17	0.102
Septic shock	4	1.95	0	0	0.890
Hypovolemic shock	7	3.41	2	4.34	0.134
Ischemic colitis	11	5.36	1	2.17	0.067
Stroke	12	5.85	3	6.52	0.083
Lower limb ischemia	4	1.95	1	2.17	0.205
Venous thrombosis and pulmonary	14	6.82	4	8. 69	0.271
Embolism					
Urinary tract infection	32	15.60	2	4.34	0.039
Postoperative Delirium	15	7.31	3	6.52	0.876
LONG-TERM (30 DAYS-5 YEARS)					
Late mortality	7	3.41	9	19.56	0.047
Complications					
UIAAA rupture	0	0	6	13.04	0.032
Endoleak					
IA	0	0	9	19.56	
IB	0	0	2	4.34	
IIA	0	0	2	4.34	0.048
IIB	0	0	1	2.17	
V	0	0	1	2.17	
Reintervention	5	2.43	5	10.86	0.002
Graft and endoprosthesis infection	2	0.9	0	0	0.140
Stroke	5	2.43	3	6.52	0.107
CKD	13	6.34	5	10.86	0.231

IRQ= Interquartile Range; ICU= Intensive Care Unit; AMI= Acute Myocardial Infarction; SSI= Surgical Site Infection; UIAAA= Unruptured Infrarenal Abdominal Aortic Aneurysm; CKD= Chronic Kidney Disease.

Table 3 **Cox regression analysis of survival time and time to readmission for UIAAA treated**

VARIABLES	SHORT-TERM (<30 DAYS)					
	SURVIVAL TIME			TIME TO READMISSION FOR RUPTURE		
	HR	95% IC	p	HR	95% IC	p
UIAAA Repair Type						
Open	1.00 (Reference)			1.00 (Reference)		
EVAR	0.76	0.62-0.96	0.045	0.81	0.79-0.85	0.031
Diameter UIAAA (mm)						
<65 mm	1.00 (Reference)			1.00 (Reference)		
>65 mm	1.58	1.21-1.83	0.029	1.34	1.11-1.48	0.067
Gender						
Male	1.00 (Reference)			1.00 (Reference)		
Female	0.81	0.76-0.91	0.026	0.59	0.41-0.67	0.017
Age (Years)						
<70	1.00 (Reference)			1.00 (Reference)		
>70	1.32	1.28-1.48	0.042	0.95	0.89-1.13	0.095
Alteration in BMI						
No	1.00 (Reference)			1.00 (Reference)		
Yes	1.87	1.68-2.11	0.039	1.29	1.01-1.34	0.048
Distal aneurysmal extension						
Aortic	1.00 (Reference)			1.00 (Reference)		
Common Iliac	1.45	1.32-1.67	0.048	1.38	1.28-1.42	0.059
External and internal iliac	1.93	1.76-2.29	0.017	1.81	1.56-2.01	0.042
Endoleak (EVAR)						
No	1.00 (Reference)			1.00 (Reference)		
Yes	1.82	1.76-2.01	0.032	1.95	1.87-2.21	0.049
Renal Disease						
No	1.00 (Reference)			1.00 (Reference)		
Yes	1.24	1.01-1.45	0.081	1.39	1.15-1.63	0.459
Surgical reintervention						
No	1.00 (Reference)			1.00 (Reference)		
Yes	1.83	1.78-1.99	0.089	1.60	1.32-1.98	0.087

VARIABLES	LONG-TERM (30 DAYS-5 YEARS)					
	SURVIVAL TIME			TIME TO READMISSION FOR RUPTURE		
	HR	95% IC	p	HR	95% IC	p
UIAAA Repair Type						
Open	1.00 (Reference)			1.00 (Reference)		
EVAR	1.86	1.32-2.38	0.039	2.21	1.98-2.45	0.028
Diameter UIAAA (mm)						
<65 mm	1.00 (Reference)			1.00 (Reference)		
>65 mm	1.58	1.39-1.79	0.178	1.63	1.48-1.87	0.089
Gender						
Male	1.00 (Reference)			1.00 (Reference)		
Female	0.79	0.65-0.81	0.059	0.96	0.84-1.32	0.096
Age (Years)						
<70	1.00 (Reference)			1.00 (Reference)		
>70	1.22	1.15-1.32	0.069	1.14	0.98-1.21	0.182
Alteration in BMI						
No	1.00 (Reference)			1.00 (Reference)		
Yes	1.92	1.81-2.20	0.041	1.39	1.14-1.66	0.058
Distal aneurysmal extension						
Aortic	1.00 (Reference)			1.00 (Reference)		
Common Iliac	1.85	1.78-2.11	0.037	2.01	1.96-2.25	0.091
External and internal iliac	1.93	1.82-2.19	0.040	2.18	1.99-2.56	0.020
Endoleak (EVAR)						
No	1.00 (Reference)			1.00 (Reference)		
Yes	2.31	2.01-2.46	0.018	1.98	1.87-2.21	0.050
Renal Disease						
No	1.00 (Reference)			1.00 (Reference)		
Yes	1.09	0.83-1.21	0.189	1.02	0.81-1.21	0.198
Surgical reintervention						
No	1.00 (Reference)			1.00 (Reference)		
Yes	1.10	0.95-1.22	0.087	1.19	0.98-1.23	0.083

BMI= Body Mass Index; UIAAA= Unruptured Infrarenal Abdominal Aortic Aneurysm of repair to be chosen, improving this population's quality of life and survival. However, although our results are similar to those of other populations studied, more research is needed with a larger population, more years of follow-up, and considering more variables that could reveal many future findings related to the surgical treatment of UIAAA.

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REFERENCES

1. Behrendt CA, Sedrakyan A, Rieß HC, Heidemann F, Kölbel T, Petersen J, Debus ES. Short-term and long-term results of endovascular and open repair of abdominal aortic aneurysms in Germany. J Vasc Surg. 2017;66(6):1704-1711.e3.
2. Schmitz-Rixen T, Böckler D, Vogl TJ, Grundmann RT. Endovascular and Open Repair of Abdominal Aortic Aneurysm. Dtsch Arztebl Int. 2020;117(48):813-819.
3. Chaikof EL, Dalman RL, Eskandari MK, Jackson BM, Lee WA, Mansour MA, Mastracci TM, Mell M, Murad MH, Nguyen LL, Oderich GS, Patel MS, Schermerhorn ML, Starnes BW. The Society for Vascular Surgery practice guidelines on the care of patients with an abdominal aortic aneurysm. J Vasc Surg. 2018;67(1):2-77.e2.
4. United Kingdom EVAR Trial Investigators, Greenhalgh RM, Brown LC, Powell JT, Thompson SG, Epstein D, Sculpher MJ. Endovascular versus open repair of abdominal aortic aneurysm. N Engl J Med. 2010;362(20):1863-71.
5. Johal AS, Loftus IM, Boyle JR, Heikkila K, Waton S, Cromwell DA. Long-term survival after endovascular and open repair of unruptured abdominal aortic aneurysm. Br J Surg. 2019;106(13):1784-1793.
6. de Guerre LEVM, Dansey K, Li C, Lu J, Patel PB, van Herwaarden JA, Jones DW, Goodney PP, Schermerhorn ML. Late outcomes after endovascular and open repair of large abdominal aortic aneurysms. J Vasc Surg. 2021;74(4):1152-1160.
7. Scallan O, Novick T, Power AH, DeRose G, Duncan A, Dubois L. Long-term outcomes comparing endovascular and open abdominal aortic aneurysm repair in octogenarians. J Vasc Surg. 2020;71(4):1162-1168.
8. Liu Y, Yang Y, Zhao J, et al. Systematic review and meta-analysis of sex differences in outcomes after endovascular aneurysm repair for infrarenal abdominal aortic aneurysm. J Vasc Surg 2020; 71: 283–96.
9. Varkevisser RRB, O'Donnell TFX, Swerdlow NJ, Liang P, Li C, Ultee KHJ, Pothof AB, De Guerre LEVM, Verhagen HJM, Schermerhorn ML. Fenestrated endovascular aneurysm repair is associated with lower perioperative morbidity and mortality compared with open repair for complex abdominal aortic aneurysms. J Vasc Surg. 2019;69(6):1670-1678.
10. Trooboff SW, Wanken ZJ, Gladders B, Columbo JA, Lurie JD, Goodney PP. Longitudinal Spending on Endovascular and Open Abdominal Aortic Aneurysm Repair. Circ Cardiovasc Qual Outcomes. 2020;13(5):e006249.
11. Bluro IM, Garagoli F, Fiorini NB, Rabellino JM, Chas JG, Domenech A, Kotowicz V, Pizarro R. Resultados a cinco años de la reparación electiva del aneurisma de aorta abdominal infrarrenal en un hospital universitario de Argentina [Five-year outcomes of elective infrarenal abdominal aortic aneurysm repair at a university hospital in Argentina]. Arch Cardiol Mex. 2022;92(2):222-229.
12. Schmitz-Rixen T, Böckler D, Vogl TJ, Grundmann RT. Endovascular and Open Repair of Abdominal Aortic Aneurysm. Dtsch Arztebl Int. 2020;117(48):813-819.
13. Li B, Khan S, Salata K, Hussain MA, de Mestral C, Greco E, Aljabri BA, Forbes TL, Verma S, Al-Omran M. A systematic review and meta-analysis of the long-term outcomes of endovascular versus open repair of abdominal aortic aneurysm. J Vasc Surg. 2019;70(3):954-969.e30.
14. Antoniou GA, Antoniou SA, Torella F. Editor's Choice - Endovascular vs. Open Repair for Abdominal Aortic Aneurysm: Systematic Review and Meta-analysis of Updated Perioperative and Long Term Data of Randomised Controlled Trials. Eur J Vasc Endovasc Surg. 2020;59(3):385-397.
15. AlOthman O, Bobat S. Comparison of the Short and Long-Term Outcomes of Endovascular Repair and Open Surgical Repair in the Treatment of Unruptured Abdominal Aortic Aneurysms: Meta-Analysis and Systematic Review. Cureus. 2020; 12(8): e9683.
16. Lederle FA, Kyriakides TC, Stroupe KT, Freischlag JA, Padberg FT, Matsumura JS, et al. Open versus Endovascular Repair of Abdominal Aortic Aneurysm. N Engl J Med. 2019; 380:2126-2135.
17. Chang H, Rockman CB, Jacobowitz GR, Ramkhelawon B, Cayne NS, Veith FJ, et al. Contemporary Outcomes of Endovascular Abdominal Aortic Aneurysm Repair in Patients Deemed Unfit for Open Surgical Repair. J Vasc Surg. 2021;73(5):1583-1592.e2.
18. Siribumrungwong B, Kurita J, Ueda T, Yasui D, Takahashi KI, Sasaki T, et al. Outcomes of abdominal aortic aneurysm repairs: Endovascular vs open surgical repairs. Asian J Surg.

2022;45(1):346-352.
19. Banno H, Sugimoto M, Sato T, Ikeda S, Kawai Y, Tsuruoka T, et al. Endovascular Aneurysm Repair Compared With Open Repair Does Not Improve Survival in Octogenarians. Circ J. 2021; 85:2166 – 217.
20. Rai A, Salehi MG, Rezaei M, Zaebi E, Sobhiyeh M. Comparison of renal function after Endovascular Aneurysm Repair and Open Aneurysm Repair in patients treated with abdominal aortic aneurysm below the renal artery. J Vasc Nurs. 2021;39(2):39-42.
21. Rahim AA, Ibrahim R, Yao L, Khalf A, Ismail M. Incidence of secondary rupture after abdominal aortic aneurysms (endovascular vs. open surgical repair). Ann Med Surg. 2021; 9;70:102831.
22. Andersen RM, Henriksen DP, Mafi HM, Langfeldt S, Budtz-Lilly J, Graumann O. A Long-Time Follow-Up Study of a Single-Center Endovascular Aneurysm Repair (Evar) Endoleak Outcomes. Vasc Endovascular Surg. 2018;52(7):505-511.
23. Patel, R. , Sweeting, M. J. , Powell, J. T. , Greenhalgh, R. M., & EVAR trial investigators. Endovascular versus open repair of abdominal aortic aneurysm in 15-years' follow-up of the UK endovascular aneurysm repair trial 1 (EVAR trial 1): a randomised controlled trial. Lancet. 2016;388(10058):2366-2374
24. Charlton-Ouw KM, Ikeno Y, Bokamper M, Zakhary E, Smeds MR, participants. G. Aortic endograft sizing and endoleak, reintervention, and mortality following endovascular aneurysm repair. J Vasc Surg. 2017 ;74(1519-1526.):5.
25. Varkevisser RRB, Carvalho Mota MT, Swerdlow NJ, et al. Long-term age-stratified survival following endovascular and open abdominal aortic aneurysm repair. J Vasc Surg. 2022;S0741-5214:22.
26. O'Donnell TFX, Deery SE, Boitano LT, Siracuse JJ, Schermerhorn ML, Scali ST, Schanzer A, Lancaster RT, Patel VI. Aneurysm sac failure to regress after endovascular aneurysm repair is associated with lower long-term survival. J Vasc Surg. 2019;69(2):414-422.
27. Greenhalgh R M, Brown L C, Kwong G P, Powell J T, Thompson S G; EVAR trial participants.Comparison of endovascular aneurysm repair with open repair in patients with abdominal aortic aneurysm (EVAR trial 1), 30-day operative mortality results: randomised controlled trial Lancet 2004364(9437):843–848.
28. Lederle F A, Freischlag J A, Kyriakides T C et al. Outcomes following endovascular vs open repair of abdominal aortic aneurysm: a randomized trial. JAMA. 2009;302(14):1535–1542.
29. Lederle F A, Freischlag J A, Kyriakides T C et al. Long-term comparison of endovascular and open repair of abdominal aortic aneurysm. N Engl J Med. 2012;367(21):1988–1997.
30. Dangas G, O'Connor D, Firwana B et al. Open versus endovascular stent graft repair of abdominal aortic aneurysms: a meta-analysis of randomized trials. JACC Cardiovasc Interv. 2012;5(10):1071–1080.
31. Deery SE, Ergul EA, Schermerhorn MLVascular Study Group of New England, et al; Aneurysm sac expansion is independently associated with late mortality in patients treated with endovascular aneurysm repair. J Vasc Surg 2018;67(01):157–164
32. Blackstock CD, Jackson BM. Open Surgical Repair of Abdominal Aortic Aneurysms Maintains a Pivotal Role in the Endovascular Era. Semin Intervent Radiol. 2020;37(4):346-355.