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Original Article

Early outcomes of treatment selections for infrarenal abdominal aortic aneurysms: The first five year experience of a single center

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Abstract

Aim: We examined the criteria governing patient selection in contemporary practice in cases of infrarenal abdominal aortic aneurysm (AAA) treated electively or urgently in our Cardiovascular Surgery Clinic (CVSC).
Material and Methods: From January 2019 to January 2024, we retrospectively evaluated infrarenal AAA patients treated either electively or urgently with Open Surgical Repair (OSR) or standard Endovascular Aortic Repair (EVAR) at our CVSC. The primary endpoints are distribution of AAA patients by treatment modality, early morbidity and mortality. The secondary endpoints were intensive care unit (ICU) duration and length of hospital stay (LOS).
Results: A total of 332 patients received EVAR (Group 1), including 296 elective cases, while 90 patients underwent OSR (Group 2), with 66 being elective. Early mortality rates were significantly lower in the EVAR group (1.3% for elective and 27.8% for emergent) compared to the OSR group (6.1% for elective and 54.2% for ruptured cases, p=0.001). Major postoperative complications occurred in 12.5% of elective EVAR patients and 39.4% of elective OSR patients (p=0.001), while in ruptured cases, the rates were 11.1% and 58.3%, respectively (p=0.001). Comparisons of ICU duration and LOS also favored EVAR (p=0.001).
Conclusion: EVAR offers a survival benefit in the early period compared to OSR. The choice of treatment should be tailored to the patient's comorbidities, preferences, and the vascular surgeon's expertise. Advanced aortic centers with hybrid operating rooms (HOR) and specialized CVSCs should aim for optimized patient outcomes and cost-effectiveness in our country.

Keywords: Endovascular aneurysm repair, abdominal aorta aneurysm, mortality

INTRODUCTION

The first modern open surgical repair (OSR) of infrarenal abdominal aortic aneurysm (AAA) was performed in 1951, and nearly 40 years later, Endovascular Aortic Repair (EVAR) was presented [1-3]. EVAR was first dedicated to high-risk surgical patients and then spread worldwide with its less invasiveness and early success. In today's endovascular era, endovascular procedures remain the first-line treatment strategy for all anatomically suitable patients [4-6].

Several Randomized Controlled Trials (RCTs), including EVAR-1, DREAM, and OVER trials, have been conducted to compare the outcomes of EVAR with open surgical intervention. These trials consistently demonstrated the initial advantages of EVAR in terms of early mortality and morbidity. However, long-term follow-up spanning 2–4 years has revealed a loss of these advantages [7-9]. These RCTs have faced criticism because

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they use older-generation endografts. Innovative technological improvements and new-generation devices seemed to surpass the complications and long-term limitations of older devices. Furthermore, the cumulative expertise of physicians in this field has continued to evolve. The available data indicate that endovascular repair is linked to lower 30-day all-cause mortality in the perioperative period and a substantial decrease in perioperative morbidity when contrasted with open surgery [7-9].

In contemporary cardiovascular surgery, rapid patient turnover has emerged as a pivotal consideration, particularly within the context of the demanding clinical workload experienced in many healthcare settings, as in our country. Therefore, treatment of choice for infrarenal AAA patients was shifted from OSR to EVAR. Patient preference is also an important factor and is almost always on the less invasive side. Invasive Cardiology and/or Interventional Radiologists were only serving the endovascular treatment of choice. Only Cardiovascular surgeons may contribute to all treatment choices most suitable for the patient whether endovascular, open surgical, or medical.

In the current study, we aimed to appreciate the evolved criteria governing patient selection in contemporary practice alongside the initial outcomes of both procedures in patients diagnosed with elective or urgent infrarenal AAA treated at our Cardiovascular Surgery Clinic (CVSC). Our particular emphasis lies in evaluating the current standards.

MATERIAL AND METHODS

This study followed the Declaration of Helsinki, and the study design and protocol underwent review and approval by the Institutional Review Board (TABED 1-24-569). During January 2019 and January 2024 for five years, we retrospectively evaluated infrarenal AAA patients electively or urgently operated by OSR or standard EVAR primarily. Patient demographics, perioperative variables, and early outcomes were recorded from the hospital database. Any patient experiencing associated procedures like distal bypass, advanced skilled endovascular technique, or hybrid procedures were excluded. EVAR revisions with endovascular techniques due to endoleak, migration, or late open surgical conversions were not included in this patient cohort. All patients had a preoperative computed tomography angiography (CTA). Since 2019, 332 patients have been treated with standard EVAR (Group 1), 296 in elective manner, and 36 ruptured cases in emergency manner. For OSR (Group 2), there were 90 patients of which 66 cases were elective and 24 were ruptured infrarenal AAA and operated in an emergency manner. Late conversion of failed EVAR cases were excluded. The cases performed by any other clinic or a combination of clinics were excluded. This study included only the outcomes of primary EVAR or OSR for elective or ruptured infrarenal AAA at our CVSC.

All patients underwent endovascular surgery by the same Cardiovascular Surgeon team in an angiography suite; however, there were four different clinical teams for open surgery in our clinic. At the time interval of our study, two main abdominal endografts were available: Medtronic Endurant™ II (Medtronic, Santa Rosa, CA, USA) and Lifetech Ankura™ Abdominal Stent Graft Lifetech, Shenzhen, China) in our national market. Both endografts were used in this study. For OSR, Knitted tubes or bifurcated Dacron Grafts (InterGard; Intervascular, La Ciotat, France), JOTEC Vascular Prosthesis (JOTEC GmbH, Hechingen, Germany) were used.

Preoperative CTA was conducted for all patients. Measurements were derived from 3D reconstructions of CTA images using a dedicated 3D vascular imaging system (RadiAnt DICOM viewer v2021.2(64 bit)). It was our clinical routine to check the coronary angiography (CAG) of the patients who would enter an OSR except for those with urgent rupture. For EVAR patients, CAG was only performed on symptomatic patients. Only routine electrocardiography and transthoracic echocardiography were performed.

All patients underwent evaluation by a multidisciplinary council comprising cardiologists and cardiovascular surgeons to determine the final treatment decision; however, for patients with ruptured infrarenal AAA, urgent EVAR was performed if anatomically suitable, while open surgical repair (OSR) was selected otherwise.

The primary endpoints were the distribution of infrarenal AAA patients according to treatment modalities in both elective and urgent manners and the early morbidity and mortality of both treatments. Secondary endpoints were intensive care unit (ICU) period, and length of hospital stays (LOS).

Surgical technique: The procedures were mostly performed under general anesthesia, occasionally with spino-epidural and/or local anesthesia. Both femoral arteries were surgically prepared. For pigtail catheterization, a 7F sheath was placed in the contralateral femoral artery. Following the administration of 70 units/kg of systemic heparin and an activated clotting time (ACT) over 200 seconds, the pigtail catheter was subsequently advanced into the aorta and positioned around the anatomical level corresponding to the first and second lumbar vertebra. The procedure was terminated with complementary angiography. The procedure was considered technically successful if there was no type 1 and/or type 3 endoleak on the completion of angiography.

In emergency cases for OSR, retroperitoneal or transperitoneal approaches were chosen according to the surgeon’s preference and experience. All procedures were performed under general anesthesia.

Our surveillance protocol consists of Color Doppler Ultrasound (CDUS) and CTA evaluation. In instances where clinical necessity was warranted, the surveillance algorithm was customized on an individual basis [10].

Statistical analysis: Statistical analysis was conducted using SPSS for Windows version 20.0 software (SPSS Inc., Chicago, IL, USA). Group variables were assessed for normal distribution using both visual methods (histograms, probability plots) and analytical methods (Kolmogorov-Smirnov test). Continuous variables were presented as mean±standard deviation (SD) for normally distributed data and compared with the student t test. Categorical variables were expressed as numbers and percentages. Demographic characteristics and perioperative variables were compared using the Fisher exact test and chi-square test. The factors for early mortality were investigated with univariate and multivariate logistic regression analyses. A p-value less than 0.05 was considered statistically significant and 95% Confidence interval limits were given.

RESULTS

A total of 422 patients underwent primary infrarenal AAA surgery, comprising 296 elective, 36 ruptured patients in Group 1 (EVAR), and 66 elective, 24 ruptured patients in Group 2 (OSR). In the total patient cohort, male patients were in the majority (391 patients - 92.6%). For the elective patient cohort, in Group 1, 88.5% of the patients were in American Society of Anesthesiologists (ASA) 3-4 status (262 patients) whereas it was only 37.9% of the patients (25 patients) in Group 2 (p=0.01).

The preoperative data for the patient's cohort are presented in Table 1. The mean age of patients undergoing EVAR was 72.3±11.5 years, compared to 65.1±8.6 years for those in Group 2 (p=0.04). For elective cases (362 patients), 81.8% of the patient population was endovascularly treated while it was 60% for the ruptured aneurysms. A significant difference in aneurysm diameter was observed, with a mean of 59.1 mm for EVAR and 64.7 mm for OSR (p=0.04). Preoperative renal insufficiency was comparable between the two groups. Additionally, in the preoperative data, only frailty and a higher ASA status were significantly associated with EVAR (p=0.01).

Table 1. Preoperative characteristics of the patients

	EVAR (n) (%)	OSR (n) (%)	Total (n) (%)	SS (p)
Elective cases	296 (81.8)	66 (18.2)	362	
Urgent ruptured infrarenal AAA cases	36 (60)	24 (40)	60	
Total cases	332 (78.7)	90 (21.3)	422	
Mean age (years old)	72.3±11.5	65.1±8.6	69.7±8.9	0.04*
ASA 2 (only elective patients)	34 (11.5)	41 (62.1)	75 (20.7)	0.02**
ASA 3 (only elective patients)	216 (73)	21 (31.8)	237 (65.5)	0.01**
ASA 4 (only elective patients)	46 (15.5)	4 (6.1)	50 (13.8)	0.04***
Hypertension	214 (64.5)	56 (62.2)	270 (63.9)	NS**
Diabetes mellitus	85 (25.6)	21 (23.3)	106 (25.1)	NS**
Chronic obstructive pulmonary disease	146 (43.9)	22 (24.4)	168 (39.8)	0.05**
Hypercholesterolemia	131 (39.5)	38 (42.2)	169 (40)	NS**
Coronary artery disease	182 (54.8)	47 (52.2)	229 (54.3)	NS**
Chronic renal failure	38 (11.4)	9 (10)	47 (11.1)	NS**
Previous cerebrovascular event	12 (3.6)	4 (4.4)	16 (3.8)	NS***
Cancer	23 (6.9)	2 (2.2)	25 (5.9)	0.05***
Smoking	214 (64.5)	59 (65.6)	273 (64.7)	NS**

AAA: abdominal aortic aneurysm, ASA: American Society of Anesthesiologists, OSR: open surgical repair, EVAR: endovascular aortic repair, SS: statistically significance, NS: not significant, *: student t test , **: x^2 test, ***: Fisher Exact Test

The procedure was carried out with the administration of general anesthesia in 384 patients (91%). Sedation and loco-regional anesthesia were applied in 9% of patients in Group 1 (38 patients).

The difference in all-cause early mortality between the OSR and EVAR groups was significant, with rates of 6.1% and 1.3% for elective patients, respectively (p=0.001), and 54.2% and 27.8% for emergency cases, respectively (p=0.001). The technical success rate for EVAR was 100%, with no early conversions to open surgery. For ruptured infrarenal AAA cases, in Group 1, two patients suffered from abdominal compression syndrome. One of these patients was opened surgically for a second look, and the other patient died before any procedure was performed because of multiorgan failure (MOF).

The occurrence of postoperative complications was markedly lower with EVAR compared to OSR (p=0.01). In terms of Major Adverse Cardiovascular Events (MACE=perioperative death, stroke, myocardial infarction), there was a statistically significant difference in the elective patient cohort (EVAR (1.3%) vs OSR (10%)) (p=0.01). Table 2 presents the postoperative complications.

Table 2. Postoperative data of all patient groups

30 day – early outcomes	e-EVAR (n=296)	e-OSR (n=66)	P value	r-EVAR (n=36)	r-OSR (n=24)	P value
Early mortality	4 (1.3%)	4 (6.1%)	**0.001*** **	10 (27.8%)	13 (54.2%)	**0.001*** **
Major complications	37 (12.5%)	26 (39.4%)	**0.001** **	4 (11.1%)	14 (58.3%)	**0.001*** **
Cardiac complications	1 (0.3%)	12 (18.2%)	**0.001** **	1 (2.8%)	4 (16.7%)	**0.03*** **
Pulmonary complications	1 (0.3%)	10 (15.1%)	**0.001*** **	1 (2.8%)	7 (29.2%)	**0.001*** **
Renal complications	33 (11.1%)	4 (6.06%)	NS***	2 (5.5%)	3 (12.5%)	NS***
Leg occlusion	2 (0.6%)	0	NS***	0	0	NS***
Minor complications	28(9.5%)	14 (21.2%)	**0.05** **	5 (13.9%)	4 (16.7%)	NS***
Revisions	3 (1.3%)	6 (12.1%)	**0.001*** **	1 (2.8%)	2 (8.3%)	**0.03*** **
Incisional complications	25 (8.4%)	8 (12.1%)	NS**	4 (11.1%)	2 (8.3%)	NS***
Mean ICU period (hour)	3.8±1.4	22.3±9.5	**0.001***	28.5±12.6	62.4±18.1	**0.001***
Mean hospital stay (day)	3.4±0.6	7.6±4.1	**0.001***	7.3±2.9	15.7±7.4	**0.001***

ICU: intensive care unit, EVAR: endovascular aortic repair, OSR: open surgical repair, e: elective, r: ruptured, NS: not significant; *: student t test, **: x^2 test, ***: Fisher Exact Test

Univariate and multivariate analyses revealed that hematocrit levels below 20% significantly predicted early mortality within the ruptured cohort (p=0.04). In contrast, age and gender did not show statistically significant associations, suggesting that demographic factors alone did not account for the observed differences in outcomes. Table 3 presents the early mortality factors.

Table 3. Early mortality factors for ruptured cohort (Univariate-multivariate analysis)

	Univariate logistic regression			Multivariate logistic regression		
Factors	**HR**	**CI 95%**	**P**	**HR**	**CI 95%**	**P**
Hct (<20%)	58.3	5.22-651.6	0.001	89.13	4.09-1904	0.04
Age (>70 years)	8.2	0.6-3.41	0.440	7.5	0.32-21.03	0.82
Female gender	4.3	0.44-6.1	0.780	3.6	0.08-9.23	0.68
CAD	1.1	0.27-5.03	0.830	0.41	0.03-5.78	0.51
HT	0.52	0.12-2.32	0.400	1.19	0.09-15.82	0.89
CRI	5.14	0.71-37.1	0.105	6.53	0.44-96.98	0.17
COPD	0.292	0.52-1.646	0.292	1.09	0.08-14.02	0.94

The table displays the results of multivariate and univariate logistic regression analyses assessing the impact of factors on early mortality in the first column; the predictors are presented along with their p-values and the bounds of the 95% confidence interval (CI); Hct <20%, CAD: coronary artery diseases, HT: hypertension, CRI: chronic renal insufficiency, COPD: chronic obstructive pulmonary diseases

In Group 1, Post-implantation Syndrome (PIS) was observed in 114 patients (34.3%) while 58 patients (64.4%) experienced PIS in Group 2. We defined PIS as White Blood Cell (WBC) elevation (>12.0 10^9/L), elevation in CRP levels (>5 mg/L), and fever (>37.5°C).

For Group 1 and Group 2, the mean ICU time was 3.8±1.4 hours and 22.3±9.5 hours respectively for elective patients. Additionally LOS for elective patients in Group 2 was 7.6±4.1 days, compared to only 3.4±0.6 days for elective EVAR patients. The treatment of choice for elective or urgent cases in terms of years is illustrated in Figure 1.

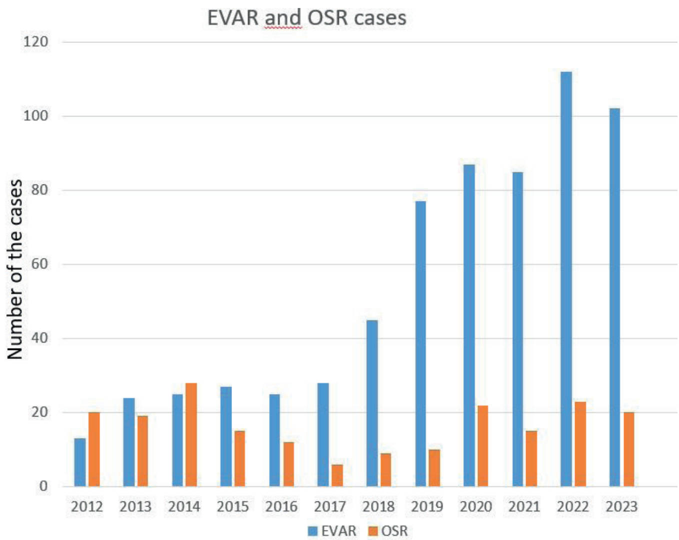

Figure 1. The distribution of patients in the OSR and EVAR groups over the years

DISCUSSION

Since the 1990s, endovascular entities have changed the practice paradigm of a vascular surgeon. Veith declared a percentage of 90 to 95% of all infrarenal AAA treatments in an endovascular manner as his prescience about the future of vascular surgery in 2016 for the next ten years [11]. With the technological developments and experience with newer generation endografts, this prediction seems close and real. EVAR is nowadays the gold standard for all anatomically suitable patients except young ones in our clinic. The increase in the ratio of EVAR to OSR over the years, which we revealed in our previous study [4], is also seen in Figure 1. We reported that 39.4% of infrarenal AAA patients underwent EVAR in 2012, compared to 84.5% today, coinciding with a reduction in early mortality from a rate of 2.1% between 2012 and 2018 to 1.3% between 2019 and 2024. Consequently, EVAR has emerged as a credible alternative to traditional open surgical techniques offering the potential for minimally invasive treatment with reduced perioperative morbidity and mortality to frail patient cohorts with faster patient turnover. For ruptured infrarenal AAA groups, only 60% of patients experienced EVAR. Inadequacies in material resources and facility capabilities may necessitate a preference for open surgery, despite the potential advantages offered by EVAR in certain contexts.

In our study, regarding the elective patients; the higher risk patient group was in Group 1. The proportion of patients classified as ASA Class 3-4 was significantly higher in the EVAR group at 88.5%, compared to 37.9% in the OSR group (p=0.01). ASA classification may be useful for decision-making in treatment choice for providing endovascular advantages to frail patient groups [12]. When early mortality was compared for elective patients, it was 1.3% for EVAR and 6.1% for OSR (p=0.01). Hemodynamic status during admission was similar for both groups.

Previous research performed in our former hospital [13] reported that early mortality rate of OSR was 43.3% for ruptured AAA, which remained alarmingly high in the current study at 54.2% even though more than 20 years have passed. However, the anatomically harder cases were directed to OSR and there was no centralization for open surgical repair initially. Randomized controlled trials (RCTs) have shown comparable rates of early mortality between EVAR and OSR; however, real-world experiences tend to favor EVAR in terms of early mortality, hospital stay, and ICU stay durations and so do the current guidelines [14-21]. Meta-analysis of 136 studies concluded statistical significance for early hospital mortality of 24.5% for EVAR versus 37.8% for OSR (p<0.001). For OSR, hospital volume was an important mortality factor [22]. In case of instability, balloon control may be essential to control hemorrhage. For unstable patients, aortic balloon occlusion was recommended for both techniques. Meta-analysis reported the need for aortic balloon occlusion in 14,1% of the patients [23]. In our patient cohort, balloon occlusion was performed in 6 patients who had ruptured infrarenal AAA.

In our study, hematocrit levels of <20% appeared to be a significant predictor of early mortality in the rupture cohort (p=0.04). This finding is not surprising, as low hematocrit levels suggest more extensive bleeding and prolonged hemorrhage, increasing the risk of cardiac ischemia due to inadequate oxygen delivery.

When the choice of treatment is the main issue, the patient side is another important factor. According to the sociocultural level of the patient, there may be some expectations or priority requests. The less invasive nature of the endovascular treatments is attractive. Our mission is to give information about the unique pros and cons of each treatment option. According to our patient questionnaire study, the patients were obeying the final decision of the surgeon in charge over 95% [24].

Cardiovascular surgery encompasses a comprehensive spectrum of treatment modalities for patients with aneurysmal disease, ranging from medical management to interventional procedures or traditional OSR. Conventional OSR remains a cornerstone of treatment for certain patients, particularly young ones and patients with complex anatomical features. In our daily practice, involving the infrarenal AAA patients, we encounter an increasing number of late conversions to open surgery (LOCS) of failed EVARs. Nearly 30% of patients will undergo reintervention at 10 years [25]. In the current study, only two patients who had their first procedure in our hospital experienced LOCS. However, we operated on 16 patients who had failed EVAR and LOCS. Therefore, we may conclude that medical centers not performing OSR for infrarenal AAA should not perform elective EVARs. For urgent cases, the restriction will not be logical.

OSR for AAA represents a high-risk procedure associated with hormonal and metabolic stress, leading to the systemic inflammatory response (SIR) caused by surgical trauma and aortic cross-clamping. In contrast, EVAR seems to offer less extensive incisions and tissue manipulation. The underlying mechanisms may be different; however, both treatment modalities have similar results in this topic [26]. In our study, PIS was observed in 114 patients (34.3%) in Group 1, while 58 patients (64.4%) in Group 2 experienced PIS.

Faster patient turnover, less invasive nature, and successful early outcomes force medical health providers to perform procedures more in an endovascular fashion.

There are some limitations in our study. First of all, it is a retrospectively designed single-center experiment. Also the patient cohort was small for further recommendations. Every country and medical center has its own realities depending upon experiences and habits of daily practices and our center was built from the combination of five different hospitals. Therefore, operational experience may vary and it takes time to build up an aortic centralisation.

CONCLUSION

EVAR has a certain survival benefit in the early period when compared to OSR. The ultimate decision regarding the type of treatment should be tailored to the patient's specific comorbidities, preferences, and the experience of the vascular surgeon in charge. Cardiovascular Surgery is the only clinic that may perform all treatment choices and must be the leading clinic for the final treatment of choice for enhanced patient longevity, superior long-term success and cost-effectiveness.

Ethics Committee Approval: The study design and protocol underwent review and approval by Ankara Bilkent City Hospital No. 1 Medical Research Scientific and Ethical Evaluation Board (TABED 1-24-569).

Patient Consent for Publication: Not necessary for this manuscript.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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