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The evaluation of the postoperative course in patients operated due to abdominal aortic aneurysm as urgent or elective procedure

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ABSTRACT:

Introduction: The patients with the aortic abdominal aneurysym of 55 mm in diameter are qualified to surgery. There are open repair (OR) by means of the vascular prosthesis implantation or the less invassive endovascular method by means of the stentgraft implantation through femoral arteries incision (EndovascularAorticRepair – EVAR).

Aim: The aim of the study was the evaluation of the postoperative course in patients operated due to aortic abdominal aneurysm and the evaluation of the impact of the surgical method on the short-time results.

Material and methods: 124 patients operated due to abdominal aortic aneurysm in Dept of Surgery of 4th Military Hospital in Wroclaw in 2014 were enrolled into the study: 53 patients with OR, 53 patients with EVAR, and 19 patients with ruptured aneurysm.

Results: Mortality was 0% in EVAR and 6% in OR and 39% in ruptured aneurysm. Time of hospital stay was 5.8 days in EVAR vs 10 days in OR. The stay in ICU was 0% in EVAR vs 13% in OR. Blood transfusion was 9.4% in EVAR vs 66% in OR. Time of postoperative analgesia was 27 h in EVAR vs 76.8 h in OR. Cardio-respiratory decompensation was 1.9% in EVAR vs 7.6% in OR. Renal insufficiency was 2% in EVAR vs 9% in OR. The lower rate of organ complications was in EVAR. The ruptured aneurysm presented the most complicated postoperative course: hospital stay of 11.4 days, ICU stay of 78%, blood transfusion of 100%, painkillers of 136 hours, cardio-respiratory decompensation of 81% and renal insufficiency of 69%.

Conclusions: The method of treatment, the conditions of the admision and the type of surgery influenced the postoperative course. The elective EVAR patients presented both the 0% of mortality and the lightest postoperative course. The ruptured abdominal aortic aneurysms operated as an emergency had the most complicated postoperative course.

KEYWORDS: abdominal aortic aneurysm, cracked aneurysm, endovascular method, open method

INTRODUCTION:

Incidence of abdominal aortic aneurysm in a population amounts to 2-6% as demonstrated in post-mortem studies. Caucasian elderly men are at particularly high risk of developing the disease, as its prevalence reaches 10% in the seventh decade of life [1, 2, and 3]. In 60% of cases rupture is the first symptom of aortic aneurysm. It is a life-threatening state with mortality exceeding many times that of patients undergoing elective surgery. Hence, prophylactic measures have been implemented in high-risk groups of patients. Studies demonstrated a relationship between the size of an aneurysm and the risk of rupture [4]. The risk of rupture of an aneurysm less than 4 cm in diameter is negligible. For aneurysms with a diameter of 4-5 cm it amounts to 0.5-5%, 5-6cm - 3-15%, and for large aneurysms exceeding 7 cm in diameter the risk reached 20-50% per year. This condition affects 3% of men between 60 and 65 years, 6% aged 66-75 and 9% over the age of 75 [4].

According to the definition, aortic aneurysm is a dilatation of an artery by 50% relative to its proper diameter. Diagnosis of abdominal aortic aneurysm requires relating the size of the diseased fragment of a vessel to the healthy one. An aneurysm may be formed in any vessel, although it is most frequently located in the abdominal aorta below the level of renal arteries (90% of cases) [5, 6].

Locally, abdominal aortic aneurysms are caused by vascular wall pathology resulting in increased vessel diameter and aneurysm formation. Damage to microvessels supplying arterial wall and subsequent aortic injury is not without significance. Factors facilitating progression and, in consequence, rupture of an aneurysm include patient age, untreated hypertension, smoking, alcohol abuse, COPD, large aneurysm diameter, bacterial infections, systemic diseases and genetic disorders [5, 7].

They may reach large sizes. Palpable, pulsating abdominal mass is a frequent diagnostic symptom. Medical history, physical examination, abdominal ultrasound and angio-CT of the aorta and its branches are the fundamental modalities enabling the diagnosis of abdominal aortic aneurysm.

Constant, bursting abdominal pain that may radiate to the lumbar region, pulsating abdominal mass, hypotension, tachycardia, fainting are alarming manifestations of abdominal aortic aneurysm [8, 9]. It is a sign of aneurysm rupture that requires urgent angiosurgical intervention [10, 11]. Aortic aneurysms may be treated conservatively or through intervention [1, 12, and 13]. Conservative management is recommended in patients that do not absolutely require or qualify for surgery.

The first group consists of patients with aneurysms less than 5 cm in diameter. Statistical analyses indicate that surgical risk exceeds the risk of death due to aneurysm rupture. The second group inclu-

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des extremely ill patients with, e.g. cardiorespiratory failure, renal failure, with end-stage neoplastic disease and aneurysm morphology precluding intravascular treatment. Eradication of risk factors for aneurysm progression and rupture is indicated in both groups of patients. Smoking cessation, avoiding physical exertion, treatment of hypertension and hyperlipidemia are absolutely necessary. Blood pressure and cardiac output-lowering agents as well as statins are recommended as well as constant control of aneurysm size and progression with imaging (ultrasound, CT) [5, 8].

Patients with aortic aneurysm size exceeding 5.5 cm are referred for elective interventional treatment. In such cases the risk of rupture is higher than perioperative hazard. Surgical repair of abdominal aortic aneurysms may be of two kinds depending on their morphology, patient age and clinical condition as well as the need for urgent or elective intervention. We may consider classic open surgery involving implantation of vascular prosthesis in place of the aneurysm (open repair - OR) or treatment with minimally-invasive intravascular stentgraft implantation through femoral artery incision or puncture (Endovascular Aortic Repair – EVAR) [1, 12, 13]. Each type of procedure carries a risk of numerous specific complications [10, 14]. Up to 70-80% of patients without ischemic heart disease and 50-60% of patients without the condition survive five years. Among patients who did not qualify for surgery survival amounts to 20% [10]. Postoperative prognosis depends largely on patient age, general condition, comorbidities and treatment method.

AIM

The goal of this work was to assess condition of patients undergoing abdominal aortic aneurysm repair in the perioperative period and to determine the impact of treatment method on early outcome.

MATERIAL AND METHODS

Study subjects consisted of patients undergoing surgical treatment for abdominal aortic aneurysm at the Department of Surgery of the 4th Military Clinical Hospital in Wroclaw in 2014.

We distinguished 3 groups of patient in our study group:

- 53 patients treated with open repair – OR (10 F, 43M);
- 53 patients subject to endovascular treatment - EVAR (12F, 41M);
- 19 patients undergoing urgent surgery due to aneurysm rupture (4 F, 15M).

Study involved a comparison of patient groups divided depending on basic anthropometric features, disease parameters, postoperative course and the outcome of abdominal aortic aneurysm repair.

Statistical analysis of collected data was conducted using STATISTICA software. Characterization of study groups was performed by presenting percentage distributions of qualitative variable variants, while for quantitative variables by means of measures of position – arithmetic mean and median, as well as measures of variability – standard deviation and range. Comparisons of distributions of qualitative and quantitative variables among the study groups were performed with univariate chi-square test and Kruskal-Wallis test. Multiple comparisons were done after determining statistically significant differences in distributions of the above-mentioned variables. The level of statistical significance assumed for the entire analysis was established at 0.05.

RESULTS

Analysis of sex distribution in study groups did not reveal statistically significant differences in contrast to the analysis of age distribution: patients treated with EVAR were older compared to those managed with OR (median age 76 vs. 67 years, $P < 0.001$) (Tab. I).

Mean diameter of abdominal aortic aneurysm treated with EVAR amounted to 59 mm and was significantly lower than in patients undergoing OR (59 mm vs. 65 mm, $P = 0.009$) and patients operated on due to ruptured aneurysm (59 mm vs. 68 mm, $P = 0.003$). Earlier treatments within abdominal cavity were noted significantly more often among patients treated with EVAR, i.e. in 51% of patients compared to 23% of subjects managed with OR ($P = 0.003$) (Tab. II). None of the patients treated surgically had undergone such a procedure.

Internal carotid artery revascularization was performed in patients treated with OR, EVAR or operated for aneurysm rupture in, respectively, 19%, 11% and 6% of cases, without statistical differences between compared patient groups (Tab. II).

Considering comorbidities, arterial hypertension was present significantly more often in patients treated with EVAR compared to OR (92% vs. 74%, $P = 0.010$) (Tab. III). Renal failure was identified preoperatively in half of patients treated surgically for aortic aneurysm rupture, which constituted a significantly higher proportion compared to patients treated with EVAR (50% vs. 13%, $P = 0.001$) or OR (50% vs. 15%, $P = 0.003$) (Tab. III). Diabetes and cardiovascular comorbidities predominated among patients managed for aneurysm rupture (respectively: 50% and 83%), but were not significantly more prevalent than in the remaining two groups. Smoking was more frequent among patients treated with OR compared to EVAR (77% vs. 43%, $P < 0.001$) and patients operated on due to aneurysm rupture (77% vs. 33%, $P = 0.001$) (Tab. III). Alcohol abuse was not a factor differentiating between study groups.

POSTOPERATIVE COURSE

Mean duration of surgery for abdominal aortic aneurysm was the highest for ruptured aneurysms due to its catastrophic nature, and amounted to 2 hours and 15 minutes. EVAR procedures were the least time-consuming and significantly shorter than other types of surgery (OR: median 1h30' vs. 1h55', $P = 0.002$; ruptured aneurysm: median 1h30' vs. 2h15', $P < 0.001$) (Tab. III).

Recovery period defined as length of hospital stay (Tab. III) and necessity of hospitalization in an intensive care unit (ICU) was least burdensome for patients treated with endovascular method. None of the patients undergoing EVAR required intensive therapy, while such a need was identified in 13% of patients managed with OR and as much as 78% of patients treated for aneurysm rupture ($P < 0.001$).

Tab. I. Group characteristics of patients treated with open repair (OR), endovascular repair (EVAR) and undergoing surgery for ruptured aneurysm.

STUDY GROUP		OR	EVAR	RUPTURED ANEURYSM	P
NUMBER		53	53	19	
Sex, n (%)	Female	10 (18.9%)	12 (22.6%)	4 (22.2%)	0.884
	Male	43 (81.1%)	41 (77.4%)	15 (77.8%)	
Age (years), X±SD Median (range)		67.6 ±6.1 67 (52–85)[a]	73.4 ±10.4 76 (42–90)[a]	71.8 ±9.3 70 (50–86)	<0.001
Height (cm), X±SD Median (range)		173.0 ±8.4 174 (150-190)	169.4 ±9.2 170 (150-186)	171.4 ±6.5 170 (160–182)	0.179
Weight (kg), X±SD Median (range)		79.7 ±12.9 80 (37–106)	81.0 ±16.9 78 (40–124)	82.9 ±9.6 80 (67–100)	0.606
BMI (kg/m²), X±SD Median (range)		26.6 ±3.7 26.3 (16.4–35.3)	28.1 ±4.7 27.8 (19.4–38.3)	28.3 ±3.3 27.8 (23.2–34.6)	0.206
BMI, n (%)	<25 kg/m²	19 (35.9%)	15 (28.3%)	3 (17.7%)	0.338
	≥25 kg/m²	34 (64.1%)	38 (71.7%)	15 (82.3%)	

X – mean; SD – standard deviation; BMI – Body Mass Index; a – P < 0.005 for multiple comparisons.

Tab. II. Diagnosis of abdominal aortic aneurysm and surgical treatments among patients managed with open repair (OR), endovascular repair (EVAR) and undergoing surgery for ruptured aneurysm.

STUDY GROUP		OR	EVAR	RUPTURED ANEURYSM	P
NUMBER		53	53	19	
Abdominal aortic aneurysm size (mm), X±SD Median (range)		73.5±21.3 65 (47–111)[a]	60.5±10.0 59 (48–100)[a,b]	72.1±28.4 68 (9–20)[b]	0.001
Previous abdominal surgery, n (%)	Yes	12 (22.6%)	41 (77.4%)	15 (77.8%)	0.003
	No	41 (77.4%)	27 (50.9%) 26 (49.1%)	- -	
Carotid revascularization, n (%)	Yes	10 (18.9%)	6 (11.3%)	1 (5.9%)	0.315
	No	43 (81.1%)	47 (88.7%)	16 (94.1%)	

X – mean; SD – standard deviation; a, b – P < 0.005 for multiple comparisons.

Tab. III. Comorbidities and substance use among patients managed with open repair (OR), endovascular repair (EVAR) and undergoing surgery for ruptured aneurysm

STUDY GROUP		OR	EVAR	RUPTURED ANEURYSM	P
NUMBER		53	53	19	
Diabetes, n (%)	Yes	12 (22.6%	13 (24.5%)	9 (50.0%)	0.066
	No	41 (77.4%)	40 (75.5%)	9 (50.0%)	
Arterial hypertension, n (%)	Yes	39 (73.6%)[a]	49 (92.4%)[a]	17 (94.4%)	0.012
	No	15 (26.4%)	4 (7.6%)	1 (5.6%)	
Cardiovascular comorbidities, n (%)	Yes	35 (66.0%)	38 (71.7%)	15 (83.3%)	0.373
	No	18 (34.0%)	15 (28.3%)	3 (16.7%)	
Renal failure, n (%)	Yes	8 (15.1%)[a]	7 (13.2%)[b]	9 (50.0%)[a,b]	0.002
	No	45 (84.9%)	46 (86.8%)	9 (50.0%)	
Smoking, n (%)	Yes	41 (77.4%)[a,b]	23 (43.4%)[a]	6 (33.3%)b	<0.001
	No	12 (22.6%)	30 (56.6%)	12 (66.7%)	
Alcohol abuse, n (%)	Yes	9 (17.3%)	8 (15.1%)	-	0.175
	No	43 (82.7%)	45 (84.9%)	18 (100%)	

X – Mean; SD – standard deviation; a, b – P < 0.005 for multiple comparisons.

Hemoglobin levels before and after surgery were the lowest among patients operated on due to aneurysm rupture (P < 0.001 and P = 0.001, respectively), which was also reflected by a higher number of perioperative transfusions (P < 0.001) (Tab. IV). In the remaining groups hemoglobin levels before and after the procedure were similar, although open repair was associated with a higher number of blood transfusions (P < 0.001).

Preoperative creatinine levels were the highest among patients operated on due to aneurysm rupture, although the difference was not statistically significant. Postoperatively, there was a statistically significant difference in creatinine levels among patients managed with OR and those treated for aneurysm rupture (median 0.94 mg/dL vs. 1.58 mg/dL, P = 0.017) (Tab. IV).

Body temperature was significantly higher in the group operated after aneurysm rupture compared to the group treated with EVAR (median 38.0oC vs. 36.8oC, P = 0.020) (Tab. IV).

Tab. IV. Postoperative course in patients managed with open repair (OR), endovascular repair (EVAR) and undergoing surgery for ruptured aneurysm

STUDY GROUP		OR	EVAR	RUPTURED ANEURYSM	P
NUMBER		53	53	19	
Length of hospital stay (days), X±SD Median (range)		10.0±2.9 10 (6–18)[a]	5.8±1.6 5 (4–10)[a,b]	11.4±8.2 9.5 (1–23)b	<0.001
Hospitalization in the ITU, n (%)	Yes	7 (13.2%)[a,c]	-[a,b]	15 (77.8%)[b,c]	<0.001
	No	46 (86.8%)	53 (100%)	4 (22.2%)	
Procedure duration (h), X±SD Median (range)		1.59±38 1.55 (55–3.35)[a]	1.37±39 1.30 (40-4.50)[a,b]	2.27±48 2.15 (1.25-4.30)b	<0.001
Hemoglobin before the procedure (g/dL), X±SD Median (range)		13.5±1.5 13.4 (10.2–16.2)[a]	13.8±1.7 13.8 (9.6–17.5)[b]	9.1±1.8 9.0 (6.1–13.0)[a,b]	<0.001
Hemoglobin after the procedure (g/dL), X±SD Median (range)		11.4±1.8 11.5 (7.3–15.1)[a]	11.6±1.6 11.5 (8.2–16.1)[b]	9.6±1.7 9.9 (6.0–12.6)[a,b]	0.001
Creatinine before the procedure (mg/dL), X±SD Median (range)		1.055±0.326 1.01 (0.41–1.81)	1.055±0.269 1.01 (0.53–1.93)	1.721±1.219 1.20 (0.66–4.61)	0.062
Creatinine after the procedure (mg/dL), X±SD Median (range)		1.269±1.212 0.94 (0.47–7.29)	1.133±0.308 1.10 (0.43–1.77)[a]	2.083±1.426 1.58 (0.64–4.70)[a]	0.015
Number of perioperative transfusions, n (%)	0	18 (34.0%)[a,c]	48 (90.6%)[a,b]	-[b,c]	<0.001
	1-5	30 (56.6%)	3 (5.6 %)	2 (11.1%)	
	6-10	4 (7.5%)	2 (3.8%)	15 (77.8%)	
	11-15	1 (1.9%)	-	2 (11.1%)	
Number of reoperations, n (%)	0	44 (83.0%)	51 (96.2%)	15 (83.3%)	0.204
	1	8 (15.1%)	2 (3.8%)	3 (16.7%)	
	2	1 (1.9%)	-	-	
Altered mental status after the procedure, n (%)	Yes	7 (13.7%)	4 (7.6%)	2 (11.1%)	0.593
	No	44 (86.3%)	49 (92.4%)	16 (88.9%)	
Temperature after the procedure (oC), X±SD Median (range)		37.13±0.65 37.0 (36.0-38.6)	37.13±0.61 36.8 (36.1-38.6)[a]	37.63±0.71 38.0 (36.4-38.6)[a]	0.023
Analgesia in the perioperative period, n (%)	Yes	50 (98.0%)	52 (98.1%)	17 (100%)	0.847
	No	1 (2.0%)	1 (1.9%)	-	
Duration of analgesia (h), X±SD Median (range)		76.8±30.5 72 (12-154)[a]	27.1±20.5 24 (12-96)[a,b]	136.0±73.2 120 (24-240)[b]	<0.001
Cardiorespiratory failure after the procedure, n (%)	Yes	4 (7.6%)[b]	1 (1.9%)a	13 (81.3%)[a,b]	<0.001
	No	49 (92.4%)	52 (98.1%)	3 (18.7%)	
Normal diuresis, n (%)	Yes	48 (90.6%)[b]	52 (98.1%)[a]	5 (31.3%)[a,b]	<0.001
	No	5 (9.4%)	1 (1.9%)	11 (68.7%)	
Anuria, n (%)	Yes	5 (9.4%)[b]	1 (1.9%)[a]	11 (68.7%)[a,b]	<0.001
	No	48 (90.6%)	52 (98.1%)	5 (31.3%)	
Death, n (%)	Yes, During surgery	-	-	1 (5.6%)	<0.001
	Yes, After surgery	3 (5.7%)[b]	-[a]	7 (38.9%)[a,b]	
	No	50 (94.3%)	53 (100%)	10 (55.5%)	

X – Mean; SD – standard deviation; a, b, c – P<0.005 for multiple comparisons.

Perioperative analgesia was administered in almost all patients regardless of the type of performed procedure, but duration of treatment was significantly shorter in patients treated with EVAR compared to open repair OR (median 24h vs. 72h, P < 0.001) and surgery for aneurysm rupture (median 24h vs. 120h, P < 0.001) (Tab. IV).

Nearly all patients treated with EVAR (98%) and OR (91%) had normal diuresis in contrast to about one third of patients (31%) operated on due to aneurysm rupture (EVAR: 98% vs. 31%, P < 0.001; OR 91% vs. 31%, P < 0.001) (Tab. IV.).

Renal failure (anuria) was observed in the majority of patients treated for aneurysm rupture (69%), extremely rarely in patients undergoing endovascular treatment (2%) and sporadically with open repair (9%) (EVAR: 2% vs. 69%, P < 0.001; OR: 9% vs. 69%, P < 0.001).

Cardiorespiratory instability affected as much as 81% of patients treated for aneurysm rupture, reflecting the severe, life-threatening nature of the disease, while in the remaining groups its frequency did not exceed 10% (P < 0.001).

Complications requiring surgical re-intervention in patients undergoing EVAR, OR or treated for aneurysm rupture involved, respectively, 4%, 17% and 17% of patients; the differences were not considered statistically significant.

Proportions of patients presenting with altered mental status after surgery ranged from 8% to 15% and did not differ significantly between the study groups. There was one death during the procedure – a patient operated on due to aneurysm rupture. Over the follow-up period the percentage of deaths among patients with aneurysm rupture reached 39%, which was considered significantly higher in statistical analysis compared to mortality in EVAR or OR, which were not associated with any deaths or sporadically ended in death (EVAR: 0% vs. 39%, $p < 0.001$; OR: 6% vs. 39%, $p < 0.001$) (Tab. IV.).

DISCUSSION

Our results corroborated the data presented in literature. Mean age of treated patients (67 years) as well as sex distribution (3:1 male predominance) were in line with that reported in meta-analyses [1, 2, 15]. Obtained results also pointed to significant differences regarding age of patients referred for different procedures. Patients managed with EVAR were older, with mean age of 73.4 years. Surgical mortality is a key parameter determining the effectiveness of a given treatment method. Numerous publications unequivocally demonstrated significantly lower mortality in patients undergoing endovascular treatment in contrast to patients treated with open repair. Pifaretti et al. analyzed the outcomes of 311 patients treated over the years 2000-2005, reporting 17% mortality among patients treated with classic surgery and 6% among patients managed with endovascular techniques. Siracuse et al. reported significantly lower mortality, 1.5-0.5%. Thomas et al. included in the analysis 632 patients and found 1.6% mortality in the group of patients treated with EVAR and 6.7% mortality among patients treated with OR [16]. These results are similar to those obtained by our group (EVAR 0%, OR 5.7%). In our material the mortality associated with aortic rupture was 38.9%, while according to other authors in such cases the mortality reaches 70-90% [17].

In our study, blood transfusions were significantly less frequent in patients treated with endovascular methods (only 10%) compared to patients treated with classic surgery (66%). All of our patients treated for ruptured aneurysm required blood transfusions, which is consistent with numerous domestic and international reports [18, 19, 15, 20, and 21].

Length of hospital stay was another studied parameter. In our material, hospitalization time was significantly shorter among patients managed with EVAR compared to patients treated with OR, amounting to 5.8 days vs. 10 days, respectively. Patients treated due to aortic aneurysm rupture required the longest hospitalization (11.4 days), which is consistent with literature [19, 20, and 21].

Many authors indicate that after open repair, significantly more patients require hospitalization in an intensive care unit (ICU). Piffaretti et al. demonstrated the need for intensive medical care in 27% of patients treated with EVAR and 7% of patients after OR. In our material 0% patients treated with EVAR and 13.2% of patients undergoing OR required such a management. Moreover, in our study we showed that as much as 77.8% of patients treated for ruptured abdominal aortic aneurysm had to be transferred to ITU.

Literature reports of elevated body temperature associated with EVAR [21] were not corroborated in our material. Mean body temperatures in EVAR, OR and ruptured aneurysm groups were almost identical and amounted to 37.13°C, 37.13°C, and 37.63°C, respectively.

There was, however, a significantly reduced need for analgesic agents among patients undergoing endovascular treatment compared to those treated with open repair or those with aneurysm rupture. In the EVAR group analgesia was used in the first postoperative day, in the OR group in the first three days, and in the group with ruptured aneurysms – during the first five days after surgery. It is also in agreement with other literature reports on potential benefits of EVAR [8, 22].

General surgical complications were significantly more common in patients undergoing treatment for ruptured aortic aneurysm compared to subjects managed with intravascular intervention or elective open surgery. Incidence of cardiorespiratory failure amounted to, respectively, 81%, 1.9%, and 7.6%.

Acute renal failure was also significantly more common in patients operated on due to aneurysm rupture (as much as 69%), while EVAR was associated with 2% and open repair with 9% risk of this complication. Such a high incidence of cardiorespiratory instability and renal failure among patients treated surgically for ruptured abdominal aortic aneurysm is associated with an initial extremely severe condition. A significantly lower proportion of such perioperative complications in the EVAR group compared with OR-treated patients in our study group is in agreement with the observations of other authors [15, 18, 19].

Smoking, which by many authors is considered a risk factor [5, 7, 8], in our study group was identified in 77% of subjects treated with OR, 43% of EVAR patients and only 33% of ruptured aneurysms. Differences in individual groups were statistically significant. Low proportion of smokers in the group with ruptured aneurysms could be associated with problems with taking proper medical history during urgent hospital admission.

CONCLUSIONS

EVAR technique is less invasive than OR, as demonstrated by: shorter hospitalization time, no need for ITU stay, less frequent transfusions, reduced need for analgesics, reduced incidence of cardiorespiratory and renal failure, as well as lower incidence of other organ damage. We observed reduced perioperative mortality among patients undergoing elective treatment with EVAR compared to those treated with OR. The highest mortality is associated with urgent surgical procedures to treat aortic aneurysm rupture.

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