

# Short-term outcomes of endovascular repair of abdominal aortic aneurysm, including ruptured cases

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## Abstract

**Introduction:** Endovascular aneurysm repair as a minimally invasive alternative has become a commonly used surgical method for treating patients with abdominal aortic aneurysm (AAA).

**Aim:** To analyze short-term outcomes of endovascular treatment of AAA patients, including ruptured cases.

**Material and methods:** From 2010 to 2015, 247 patients with AAA were treated using the endovascular aneurysm repair technique. A short-term analysis was conducted – up to 30 days after surgery. It included 236 patients with planned surgery and 11 operated on in emergency mode, due to ruptured AAA.

**Results:** Rates of short-term mortality and re-interventions among patients undergoing planned surgery were 2.5% and 4.2%, respectively. Surgical complications occurred in 18 (7.6%) patients, with the most common being thrombosis and blockage of the stent graft (2.5%). Systemic complications were found in 19 (8%) planned cases, with the most common being arrhythmias (1.7%). In patients with ruptured AAA, short-term mortality was 36.4%, while re-interventions were performed in 3 (27.3%) patients. Rates of surgical and systemic complications for ruptured AAA were 45.4% and 72.7%, respectively.

**Conclusions:** The AAA patients undergoing endovascular aneurysm repair showed relatively low short-term mortality. However, larger groups of patients with ruptured AAA are required in order to assess the outcomes in this sub-population.

**Key words:** abdominal aortic aneurysm, short-term outcomes, endovascular aneurysm repair.

## Introduction

Endovascular stent graft implantation as an alternative to open conventional surgery is becoming a commonly used therapeutic method for abdominal aortic aneurysm (AAA). Worldwide, the endovascular technique is used in 43–74% of patients treated because of AAA [1–3]. The relatively low invasiveness of the endovascular method allows the procedure to be performed under local anesthesia, with less trauma and less perioperative pain. The potential benefits of the endovascular method also include

shorter hospitalization and a reduction in the rates of perioperative complications and mortality [3–7].

Despite potential benefits, the minimally invasive method is associated with more frequent re-interventions, resulting mainly from the occurrence of a leak. The latter fact causes that the advantage of perioperative results decreases during long-term follow-up [8–11]. The cost of equipment needed to carry out endovascular surgery is higher than the cost of performing an open conventional operation. However, taking into account the much lower invasiveness of the endovascular method, such repair of

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AAA may prove to also be a viable treatment for economic reasons [3, 12].

## Aim

A database of patients with AAA who underwent endovascular repair was created in the Department of Vascular Surgery and Angiology at the Brothers of Mercy St. John of God Hospital in Krakow. In this study, we have analyzed short-term outcomes to evaluate occurrence of complications of the endovascular technique within 30 days after this minimally invasive repair. The short-term observation included mortality, surgical and systemic complications, and re-interventions in patients subject to treatment for elective and ruptured AAA.

## Material and methods

Between 2010 and 2015, 247 patients with AAA underwent endovascular repair in the Department of Vascular Surgery and Angiology at the Brothers of Mercy St. John of God Hospital in Krakow. All data for patients and treatment results were recorded in the hospital's MLS MedicAll computer system and in Microsoft Office Excel software. Among the patients analyzed, there were 236 planned interventions, while 11 patients were subject to emergency operations due to a ruptured AAA. The patient's qualification for endovascular repair was based primarily on the anatomy of the AAA, age and general condition of the patient. Prior to the operation, basic biochemical blood tests and echocardiography were performed, and the risk of perioperative mortality was determined using the P-Possum scale. In the case of pre-surgical imaging diagnostics, all of the patients were subjected to computed tomography angiography (angio-CT) of the abdominal aorta, using a 32-row spiral AQUILION 32 CT scanner manufactured by Toshiba. According to the angio-CT imaging, patients were qualified for intervention based on diameter of the AAA above 5–5.5 cm, widening diameter over 0.5–1.0 cm per year or features of ruptured AAA. Some of the patients also suffered from thoracic aortic aneurysms and aneurysms of the iliac artery that were subjected to simultaneous treatment during the same procedure.

All repairs were performed in the Endovascular Therapy Unit of the hospital, using dedicated radiological equipment (Philips). Local or subarachnoid anesthesia was used in the majority of the patients

treated electively, with a few cases of general anesthesia. All patients with ruptured AAA were treated under general anesthesia. Stent grafts were deployed using systems of various manufacturers, including Zenith COOK, Endurant Medtronic, Excluder Gore, Jotec E-tegra, and others.

The short-term outcomes, including mortality, surgical and systemic complications, and re-interventions, were recorded within the 30-day period after the repair. As the anticipated outcomes differ markedly between planned and emergency interventions, the short-term results were analyzed separately for these two groups of patients.

## Statistical analysis

The Mann-Whitney *U* test and the  $\chi^2$  test were used where appropriate to compare the distribution of individual variables between AAA patients treated in planned and emergency settings. *P*-value < 0.05 was considered statistically significant in a two-tailed analysis. Statistical analysis was performed using the Statistica 12 software package (StatSoft Polska).

## Results

The study population consisted mostly of male elderly patients with numerous co-morbidities. The risk of perioperative mortality calculated according to the P-Possum score was significantly lower in patients with elective AAA repair. The median hemoglobin level was significantly lower in patients with ruptured AAA (10.8 g/dl, IQR: 7.4–14.4) compared to elective patients with AAA (13.4 g/dl, IQR: 12.0–14.4) (Table I).

Based on the angio-CT imaging, the median AAA diameter was 59 mm (IQR: 54–64.7) in unruptured cases and 60 mm (IQR: 58.5–76.5) in ruptured cases. Clinical manifestations of AAA were recorded in 45 (19.1%) elective patients. No significant differences in the median duration of surgery and the median length of hospitalization were noted between the patients with unruptured and ruptured AAA (Table II).

In 236 patients undergoing planned interventions, short-term mortality was 2.5% and surgical complications occurred in 18 (7.6%) patients. Thrombosis and blockage of the stent graft with acute ischemia of the lower limb was reported in 6 (2.5%) patients. In 6 cases leaks occurred – type I (3 patients) and type II (3 patients) – whereas 4 (1.7%) and 2 (0.8%) patients respectively had an infection of the

**Table I.** Demographic and clinical-pathological characteristics of the studied group of patients

Parameter	Unruptured abdominal aortic aneurysm	Ruptured abdominal aortic aneurysm	P-value
Number of patients	236	11	
Age [years] median (IQR)	75 (69–80)	71 (65.5–76.5)	0.196*
Male/female, n (%)	204 (86.4)/32 (13.6)	10 (90.9)/1 (9.1)	0.690†
Comorbidities, n (%):			
General arteriosclerosis	84 (35.6)	6 (54.5)	0.035†
Blood hypertension	127 (53.8)	5 (45.4)	0.587†
Ischemic heart disease	122 (51.6)	5 (45.4)	0.686†
Heart valve disorders	17 (7.2)	2 (18.2)	0.182†
Arrhythmia	37 (15.6)	1 (9.1)	0.554†
Diabetes mellitus	47 (19.9)	4 (36.3)	0.188†
Chronic renal failure	21 (8.9)	2 (18.2)	0.300†
Lung disease	34 (14.4)	3 (27.3)	0.243†
Thyroid disease	19 (8.0)	1 (9.1)	0.239†
Oncological disease	17 (7.2)	0 (0)	0.345†
Nicotine addiction, n (%)	61 (25.8)	3 (27.3)	0.916†
Ejection fraction (%), median (IQR)	55 (43–60)	50 (47–55)	0.910*
P-Possum mortality (%), median (IQR)	15 (9.2–22.3)	28 (23.5–32.6)	0.044*
Hemoglobin [g/dl], median (IQR)	13.4 (12–14.4)	10.8 (7.4–14.4)	0.045*
Urea [mmol/l], median (IQR)	7.7 (6–9.7)	11.1 (6.5–16.3)	0.007*
Creatinine [mmol/l], median (IQR)	95 (79–121.7)	105 (85–131.7)	0.098*

\*Mann-Whitney test; † $\chi^2$  test.

wound in the groin and bleeding from the wound in the groin. Systemic complications in short-term follow-up occurred in 19 (8%) patients undergoing elective AAA repair. The most common were arrhythmia (1.7%), myocardial infarction (1.3%), exacerbation of ischemic heart disease (1.3%) and pneumonia (1.3%). Ten (4.2%) patients required re-interventions after elective endovascular treatment (Table III).

All patients with thrombosis and blockage of the stent graft with acute ischemia of the lower limb required re-interventions. In 5 cases femorofemoral bypass surgery was carried out, and 1 patient was subject to thrombectomy of the left and right branch of a stent graft, with angioplasty and implantation of a stent in the right branch of a stent graft. In all patients with type I leak during short-term observation, re-intervention was also performed, which consisted of stent graft reimplantation. Patients with type II leak and infection of the wound in the groin did not require any surgical intervention. In 1 patient with bleeding from the wound in the groin, a surgical revision of the

wound was performed, with hemostasis and hematoma evacuation, while in the case of 1 patient conservative treatment and compression were applied.

In patients with ruptured AAA, short-term mortality was 36.4%. Surgical and systemic complications in this group occurred in 45.4% and 72.7% of patients, respectively. The most common surgical complications were leaks, which occurred in 3 patients. Re-interventions were carried out in 3 (27.3%) patients (Table III).

In patients with type I and III leaks, reimplantation of the stent grafts took place, while in the case of the patient with intestinal necrosis left hemicolectomy and colostomy were performed. In patients with type II leak and infection of the wound in the groin, no surgical intervention was required.

## Discussion

In Poland, the endovascular method is the only treatment alternative for conventional open sur-

**Table II.** Characteristics of abdominal aortic aneurysm (AAA) and perioperative features of the implanted stent graft

Parameter	Unruptured abdominal aortic aneurysm	Ruptured abdominal aortic aneurysm	P-value
Number of patients	236	11	
AAA diameter [mm], median (IQR)	59 (54–64.7)	60 (58.5–76.5)	0.657*
Symptomatic AAA, yes/no, n (%)	45 (19.1)/191 (80.9)	11 (100)/0 (0)	< 0.001 <sup>†</sup>
Additionally, aneurysm of iliac arteries, n (%):			
Right common iliac artery	58 (24.6)	3 (27.3)	0.839 <sup>†</sup>
Left common iliac artery	52 (22)	3 (27.3)	0.683 <sup>†</sup>
Right external iliac artery	1 (0.4)	0 (0)	0.829 <sup>†</sup>
Right internal iliac artery	7 (2.8)	1 (9.1)	0.262 <sup>†</sup>
Left external iliac artery	0 (0)	0 (0)	
Left internal iliac artery	14 (5.9)	0 (0)	0.406 <sup>†</sup>
Additionally, thoracic aorta aneurysm, n (%)	3 (1.2)	0 (0)	0.707 <sup>†</sup>
Anesthesia, n (%):			
Local	105 (44.5)	0 (0)	0.004 <sup>†</sup>
Subarachnoid	86 (36.4)	0 (0)	0.013 <sup>†</sup>
General	45 (19.1)	11 (100)	< 0.001 <sup>†</sup>
Operation time [min], median (IQR)	105 (88.7–125.0)	110 (105–130)	0.937*
Type of implanted stent graft, n (%):			
Zenith COOK	69 (29.3)	1 (9.1)	0.147 <sup>†</sup>
Endurant Medtronic	78 (33.1)	9 (81.8)	0.001 <sup>†</sup>
Excluder Gore	36 (15.2)	0 (0)	0.161 <sup>†</sup>
Jotec E-tegra	47 (19.9)	1 (9.1)	0.375 <sup>†</sup>
Other	6 (2.5)	0 (0)	0.592 <sup>†</sup>
Covering of external iliac arteries, yes/no, n (%)	87 (36.9)/149 (63.1)	4 (36.4)/7 (63.6)	0.973 <sup>†</sup>
Volume of administered Optiray contrasting agent [ml], median (IQR)	110 (97.5–132.5)	130 (110–150)	0.688*
Hospitalization [days], median (IQR)	6 (4–8)	7 (5–9)	0.090*

\*Mann-Whitney test; <sup>†</sup>χ<sup>2</sup> test.

gery of AAA patients due to technical problems and a long learning curve associated with laparoscopic procedures and the high costs of the robotic system. In the current study, the short-term outcomes were analyzed in patients with elective and ruptured AAA subject to endovascular treatment between 2010 and 2015. The basic parameters proving the efficiency of the endovascular repair, such as mortality, surgical and systemic complications and re-interven-

tions, were examined up to 30 days after interventions.

Due to the low invasiveness, less trauma and perioperative pain, as well as shorter hospitalization time and faster return to full fitness, the endovascular technique is becoming the preferred treatment for AAA patients worldwide [1–7]. In a UK study, AAA patients undergoing planned endovascular treatment were found to have low rates of short-

**Table III.** Short-term observation after endovascular treatment of the studied group of patients

Short-term observation (up to 30 days after operation)	Unruptured abdominal aortic aneurysm	Ruptured abdominal aortic aneurysm	P-value <sup>†</sup>
Number of patients	236	11	
Mortality, n (%)	6 (2.5)	4 (36.4)	< 0.001
Surgical complications, n (%):	18 (7.6)	5 (45.4)	< 0.001
Type I leak	3 (1.3)	1 (9.1)	0.045
Type II leak	3 (1.3)	1 (9.1)	0.045
Type III leak	0 (0)	1 (9.1)	< 0.001
Thrombosis and stent graft blockage with acute ischemia of a lower limb	6 (2.5)	0 (0)	0.592
Bleeding from wound in the groin	2 (0.8)	0 (0)	0.759
Infection of wound in the groin	4 (1.7)	1 (9.1)	0.089
Intestinal necrosis	0 (0)	1 (9.1)	< 0.001
Systemic complications, n (%):	19 (8.0)	8 (72.7)	< 0.001
Arrhythmia	4 (1.7)	2 (18.2)	< 0.001
Myocardial infarction	3 (1.3)	1 (9.1)	0.045
Exacerbation of coronary heart disease	3 (1.3)	1 (9.1)	0.045
Pneumonia	3 (1.3)	2 (18.2)	< 0.001
Exacerbation of chronic renal failure	2 (0.8)	1 (9.1)	0.015
<i>Clostridium difficile</i> infection	2 (0.8)	0 (0)	0.759
Infection of the urinary tract	2 (0.8)	1 (9.1)	0.015
Re-interventions, n (%)	10 (4.2)	3 (27.3)	< 0.001

<sup>†</sup> $\chi^2$  test.

term mortality and complications – 0% and 12%, respectively. However, the study was conducted in young patients with a low perioperative risk [13]. Prospective randomized controlled trials including the elderly population also showed low short-term mortality in elective patients with AAA after stent graft implantation (0.5–1.7%) [14–17]. The short-term mortality in patients undergoing planned surgery in the current study was 2.5%. Gnus *et al.* reported mortality of 1.5%, while Ziaja *et al.* and an Asian study did not show short-term mortality in patients with AAA after elective endovascular aneurysm repair. What is worth mentioning, Morisaki *et al.* conducted a study on an elderly population over 80 years of age on average [7, 18, 19]. In the analysis conducted by Schermerhorn *et al.*, patients undergoing a planned endovascular operation due to AAA showed decreasing short-term mortality

during long-term follow-up from 4.9% to 2.4%. The latest global multicenter report for this group of patients comparing the two periods 2005–2009 and 2010–2013 indicated a decrease of mortality rate from 1.5% to 1.1% [20–22].

Short-term mortality in ruptured AAA in US reports was 25.9–44.1% [3, 5, 20]. In this study, short-term mortality for this group of patients was 36.4%. Similar mortality rates (35.4%) were shown by a randomized controlled trial in Europe, while Raats *et al.* reported a perioperative mortality rate of 30% [9, 20]. Other European reports on this group of patients show short-term mortality rates of 21.6–46.3% [6, 23, 24]. The lowest short-term mortality for patients with ruptured AAA after endovascular aneurysm repair is reported by a Dutch publication – 20% [25]. In the latest Italian study for endovascular treatment involving AAA-ruptured patients, there was a signif-

icant difference in short-term mortality for men and women, 22.2% and 40%, respectively. Tan *et al.* reported a relatively high rate of the analyzed parameter after endovascular treatment of ruptured AAA in the elderly – 41% [26, 27].

In this study, we conducted an analysis of the short-term results of AAA treatment using the endovascular method, in the case of both scheduled and emergency interventions. The large number of patients (236) included in the study allows for a reliable assessment of the endovascular method for scheduled repair. On the other hand, there is a relatively low number of patients (11) with ruptured AAA in the analysis. In addition, there are no middle- or long-term observations in the study, which would allow, *inter alia*, an assessment of the incidence of late surgical re-interventions.

## Conclusions

The short-term therapeutic outcomes obtained in patients operated both in scheduled and emergency mode due to ruptured AAA are similar to the results of global reports on this subject. In patients with AAA provided with planned treatment, short-term mortality was 2.5%, while world reports mention 0–4.9% [7, 13–21]. Short-term mortality in patients with emergency surgery due to the AAA rupture was 36.4%, and in the case of global reports it was 20–46.3% [3, 5, 6, 9, 22–27].

## Conflict of interest

The authors declare no conflict of interest.

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