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ORIGINAL SCIENTIFIC REPORT

Open Repair of AAA in a High Volume Center

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Abstract

Objective To assess results of open repair (OR) of AAA in a single high volume center.

Methods We analyzed prospectively collected data of 450 patients who underwent elective OR of AAA at the Clinic for Vascular and Endovascular Surgery of the Serbian Clinical Centre in the period between January 2013 and September 2014.

Results Postoperative death occurred in seven patients (1. 55%) during the first 30 postoperative days. The mortality was caused by: uncontrolled bleeding-1, acute myocardial infarction-1, ischemic colitis-2, MOFS-2, sepsis due to infection and dehiscence of laparotomy wound-1. Coronary artery disease (OR 3.89; CI 0.85–17.7; $p = 0.0058$), postoperative acute myocardial infarction (OR 29.9; CI 2.56–334.95; $p = 0.0053$), chronic renal failure (OR 7.5; CI 1.35–8.5; $p = 0.0073$), colonic necrosis (OR 88.2; CI 4.77–1629.69; $p = 0.0026$), occlusion of the both hypogastric arteries and the inability to preserve at least one hypogastric artery (OR 17.4; CI 1.99–178.33; $p = 0.0230$), aortobifemoral reconstruction (OR 9.06; CI 1.76–46.49; $p = 0.016$), significant perioperative bleeding (>2 L) (OR 7.32; CI 1.31–10.79; $p = 0.0001$), hostile abdomen (OR 5.25; CI 1.3–21.1; $p = 0.0055$), inflammatory aneurysm (OR 13.99; CI 2.88–65.09; $p = 0.0002$), supraceliac aortic cross-clamping (OR 18.7; CI 3.8–90.6; $p = 0.0003$), prolonged aortic cross-clamping (>60 min) (OR 14.25; CI 2.75–64.5; $p = 0.0003$), the intraoperative hypotension (OR 6.61; CI 0.71–61.07; $p = 0.0545$), the prolonged operation (>240 min) (OR 8.66; CI 0.91–81.56; $p = 0.0585$) and complete dehiscence of the laparotomy (OR 44.1; CI 3.39–572.78; $p = 0.0396$) increased the 30-day mortality in our study.

Conclusions Early mortality after open repair of AAA in high volume center might be very low due to experienced multidisciplinary team. Centralized open aortic surgery might be solution for effective treatment of patients with unsuitable anatomy or for young patients with long life expectancy.

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Introduction

In the developing era of endovascular surgery, it is almost impossible to find a paper on an open repair (OR) of abdominal aortic aneurysms (AAA) [1]. The aim of this paper is to determine whether OR of AAA, performed in a high volume center, is a safe, durable procedure and whether it is even more comparable to EVAR.

Official data of Statistical Office of the Republic of Serbia show that population of Serbia account 7 132 578 people, at January 1, 2015. Age structure: 14,3% are under 14 years old, 68,3% are between 15 and 64 years old and 17,4% are older than 65 years.

There are three major centers for Vascular Surgery in Serbia: Clinic for Vascular and Endovascular Surgery—Clinical Centre of Serbia, Clinic for Vascular Surgery-Institute for Cardio-vascular Disease Dedinje and Clinical for Vascular surgery-Clinical Centre of Vojvodina. Besides these two centers, there are seven small centers that have been organized at general hospitals and have been used just for diagnostics, small procedures and emergencies that cannot be transferred to these two centers. The total number of treated AAA in Serbia is 750–800 per year.

Clinic for Vascular and Endovascular Surgery, Clinical Centre of Serbia, Belgrade, is the oldest clinic for vascular surgery in region of former Yugoslavia, with tradition more than 100 years [2], so we have very good training of our multidisciplinary teams (surgical, anesthesiologists, critical care, nursing teams); based on our experience in combination with contemporary knowledge [3, 4], we created our Serbian guidelines for AAA. In this document, we present all necessary details about repair of AAA [5]. Before 2009, vascular surgery training was organized by scheme 5+2 (general+vascular surgery training), and since 2009 vascular surgery training is organized by scheme 0+5 (general+vascular end endovascular surgery training). Anesthesiologist, preoperative assessments, ICU and intensivist, nurses on the wound are organized according to Serbian guidelines for AAA [5].

Methods

This is a retrospective analysis of prospectively collected data of 450 patients who underwent elective OR of AAA at the Clinic for Vascular and Endovascular Surgery of the Serbian Clinical Centre in the period between January 1, 2013, and September 20, 2014.

This study does not include more than 192 patients with AAA that have been admitted to our clinic in this period. Thirty-five patients with a short life expectancy due to advanced age, incurable neoplasm, in correctable severe heart and pulmonary diseases were not treated in case of absent symptoms. Thirty patients that were at high risk of open surgery with suitable anatomy were treated with endovascular means. GDP—gross domestic product per capita for Serbia—is 10.642 US dollars per year, and total expenditure for health is 10,4%. That is the most important reason why we are not able to perform more EVAR procedure, and why we use EVAR in very specific cases [6].

More than 128 patients who were treated urgently due to ruptured or symptomatic AAA were excluded from analysis (Fig. 1). The mortality rate of AAA in our center is 32%. The fact that there were 128 ruptures for this period is a consequence of lack at the primary care coverage and absence of screening program.

Indication for OR was asymptomatic AAAs occurred with a diameter of at least 5.5 cm for males and 5.0 for females (based on contemporary knowledge [3, 4] and our experience about AAA [5] in the women we think that measure of 5 cm of AAA should be a limit and indication for repair) or rapid growth as on 6-monthly duplex scans. The primary examination included ultrasound assessment of the abdominal aorta by high-resolution B-mode ultrasound. In order to confirm AAA with 4.5 cm or more, MDCT angiography was used prior to OR.

A preoperative resting 12-lead ECG and echocardiography have been performed for all patients undergoing open AAA repair within 30 days of the planned treatment. Noninvasive stress testing or coronary angiography was performed for patients with a history of three or more clinical risk factors. This is particularly employed at patients with coronary artery disease (CAD), chronic heart failure (CHF), cerebrovascular disease (CVD), diabetes mellitus (DM), unknown or unfavorable functional capacity MET<4 [4, 5, 7–9]. Previous myocardial revascularization (PTCA or CABG) was performed at patients with an active ST elevation, unstable angina, stable angina with LM stenosis or triple vessels disease, stabile angina with double vessels disease that includes LAD. If an AAA rupture risk was low considering its diameter, elective OR AAA was performed 4–6 weeks after implantation of the bare-metal stent or CABG or 12 months after the drug-eluting stent implantation. Patients with a history of symptomatic COPD or abnormal pulmonary function studies have been treated with bronchodilators for at least two weeks prior to AAA repair. Patients with hostile abdomen were treated by OR in case of unsuitable anatomy.

No or minor renal dysfunction included patients with serum creatinine below 110 μmol/L, while severe renal dysfunction included serum creatinine above 400 μmol/L, also including patients undergoing dialysis or those with renal transplant.

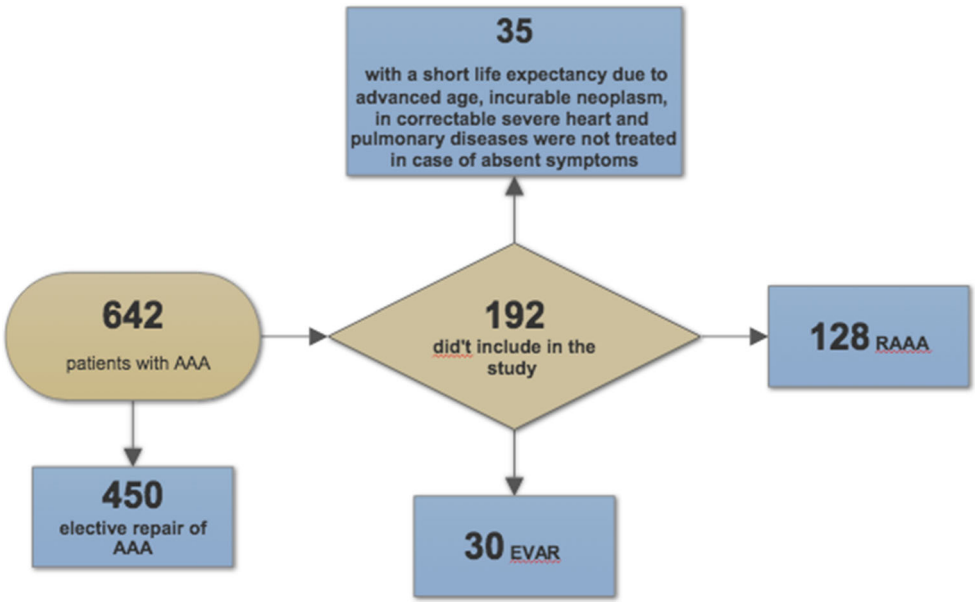

Fig. 1 Flow diagram for treatment for all AAA at our institution for observed period

In all patients that have undergone prolonged anti-platelet therapy, thrombocyte function was preoperatively determined by an emendated aggregometry method (platelet aggregation testing measures the ability of various agonists to platelets to induce in vitro activation and platelet-to-platelet activation. Classically Born aggregometry uses platelet-rich plasma [PRP], but whole-blood aggregometry can be also used. In the Born aggregometer, PRP is stirred in a cuvette at 37 °C and the cuvette sits between a light course and a photocell. When an agonist is added, the platelets aggregate and absorb less light and so the transmission increases and this is detected by the photocell). [10] Obesity was considered if body mass index was higher than 30 kg/m. Hypertension was defined if blood pressure values were higher than 140/90 mmHg during hospital stay, or if a patient was under medical antihypertensive therapy. Patients were considered diabetics if they were already receiving medical therapy.

Demographic characteristics, risk factors and comorbidity of patients are shown in Table 1.

Intraoperative factors

All surgical procedures were carried out under general anesthesia using anterior transperitoneal approach. Due to the technical challenges of adequate surgical exposure and aortic control, as well as a period of obligatory renal and/or visceral ischemia and increased cardiac stress as a consequence of suprarenal or supraceliac clamping, repair of juxtarenal AAA is more complex and associated with increased perioperative morbidity and mortality risk. When extension of aneurysmal disease to the juxtarenal level is recognized from the preoperative CT scan, modifications of operative strategies regarding approach and clamp placement must be considered. Depending on situations we use next strategies: a left flank extended retroperitoneal approach or anterior approach with transcrural supraceliac, suprarenal, interrenal clamping which is combined with temporary resection or mobilization of left renal vein (that is most common situation) and medial visceral rotation. As we mentioned earlier, we used transperitoneal approach. The exact site of proximal aortic clamp placement is determined by anatomy with principal emphasis on extent of aneurysmal and associated aortic atherosclerotic disease. The proximal graft anastomosis is then performed just below the renal artery origins. We perform renal artery bypass grafting or reimplantation in juxtarenal AAA repair just in case of co-existent renal artery disease [11–13]. To minimize time of visceral ischemia by moving the clamp from supraceliac to suprarenal position, also we try to minimize the time of renal ischemia by creating proximal anastomosis as soon as possible, and we do not use any type of renal protection.

Degenerative aneurysm was found in 324 (94.2%) patients, while 26 (5.8%) had inflammatory aneurysm. Our indication for reattachment of IMA was poor back bleeding from the IMA associated with history of prior colon resection (6 cases) or with inability to preserve anterograde flow at the list one hypogastric artery. Detailed intraoperative factors are presented in Table 2.

Ethical Committee of Serbia Clinical Center has approved this study, and the patients gave informed consent to participate in the study.

Table 1 Baseline characteristics of the population

	Number	%
Gender	450	100.0
Men	396	87.8
Women	54	12.2
Age (years)		
Range	42–85	
Mean	66.27 (SD = 7.24)	
<50	3	1.0
50–59	90	20.0
60–69	210	46.0
70–80	138	31.0
>80	9	2.0
Arterial hypertension	316	70.1
Dyslipidemia	194	43.0
Obesity	65	14.44
Cigarette smoking	383	85.1
Hostile abdomen	49	10.8
Coronary artery diseases	117	25.9
Previous PTCA/CABG	72	16.0
Heart rhythm disorder	38	8.4
COPD	61	13.5
Chronic renal insufficiency	50	11.1
POAD	78	17.3
Previous peripheral arterial reconstruction	18	4.0
Carotid artery disease		
Nonsignificant carotid stenosis (<75%)	221	49.0
Carotid artery occlusion	5	1.1
Previous CEA/CAS	34	7.5

Statistical analysis was performed with Statistic 5.0 software and Microsoft Excel 7.0. Normal distribution was tested with Shapiro–Wilk's W test. Continual variables were presented with mean value ± standard deviation (SD) or with number (n) and percentage (%) in case of categorical variables. Statistical significance between the groups was tested with t test for independent variables or Mann–Whitney U test as nonparametric test. Categorical variables were tested with Pearson's Chi-square test. Difference was considered statistically significant if $p < 0.05$.

Results

Postoperative death occurred in seven patients (1. 55%) during the first 30 postoperative days. One patient died during the surgery due to massive, uncontrolled blood loss with prolonged hypotension. In other six cases, the cause of death was acute myocardial infarction-1 (14.28%), ischemic colitis-2 (28.6%), multiorgan failure syndrome-3 (43.2%) and sepsis-1 (14.28%).

Injuries to adjacent organs were noticed in 6 (1.33%) cases. There was one ureteral, one small bowel and 4 splenic injuries. The ureteral injury (transection) was found at patient with inflammatory AAA. This injury was repaired immediately by end-to-end anastomosis with additional protective insertion of double-J stent. Small bowel injury developed during laparotomy at patient with previous surgery, and that lesion was repaired by segmental resection and anastomosis. In all four cases, splenic injury resulted from excessive retraction. In these cases, suprarenal [1] and supraceliac aortic cross-clamping [4] was used. In all our cases with splenic injury immediate splenectomy has been performed.

Postoperative hemorrhage that required reintervention resulted from patent medial sacral artery-2, adhesions between liver and aneurysmal wall at patient who underwent previous surgery-1, intraoperatively unrecognized iliac vein injury-1, intraoperatively unrecognized splenic injury-1, muscular injury at the site of abdominal drainage-1 and unknown reason-1. All hemorrhages were solved successfully with no consequences.

During the first 30 postoperative days, out of 12 patients who were reoperated due to acute lower limbs ischemia, distal anastomosis was at aortic bifurcation, iliac or femoral artery in 4, 6 and 2 patients, respectively. Cause of ischemia was femoral artery embolism, limb thrombosis of the bifurcated graft, iliac artery thrombosis and popliteal aneurysm thrombosis-1 in 5, 3, 3 and 1 patient, respectively. After immediate reintervention, all extremities were salvaged without consequences. Complications that occurred in first 30 days are presented in Table 3.

Factors influencing outcome of AAA open repair

Among 49 patients who had hostile abdomen, in 3 (6.12%) of them, OR of AAA resulted in lethal outcome during the first 30 postoperative days. In patients with hostile abdomen who died, intra-abdominal organ lesion did not occur intraoperatively. Presence of hostile abdomen was statistically significant in regard to death outcome after the surgical treatment (OR 5.25; CI 1.3–21.1; $p = 0.0055$). Other factors that increased 30-day mortality are presented in Table 4.

Discussion

According to papers published from 1988 to 2002, the 30-day mortality after elective OR of AAA ranged from 3.5 to 9.2% [14–22]. Majority of authors found that 30-day

Table 2 Intraoperative factors

Intraoperative factor	Number	%
Pathology of AAA	450	100.0
Inflammatory	26	5.8
Degenerative	424	94.2
Proximal aortic cross-clamping position		
Infrarenal	383	85.3
Interrenal	29	6.5
Suprarenal	16	3.6
Supraceliac	21	4.7
Procedure with left renal vein		
No	348	77.3
Mobilization	67	14.9
Temporary transection and reanastomosis	35	7.8
Proximal aortic cross-clamping duration (minutes)		
<10	5	1.1
10–20	174	38.8
20–30	170	37.9
30–40	75	16.7
40–50	20	4.4
>60	5	1.1
Inferior mesenteric artery		
Occluded	113	25.1
Good retrograde flow	301	66.7
Poor retrograde flow	26	5.8
Reimplantation	9	2.0
Hypogastric arteries		
Both patent	396	88.4
Saved anterograde flow through both hypogastric arteries	339	85.06

Table 3 Distribution of complications that occurred after AAA open repair

Complication	Number	%
Hemorrhage	7	1.6
Ischemia of the lower limbs	12	2.7
Laparotomy wound dehiscence	3	0.7
Ischemic colitis	2	0.4
Lesions of the intra-abdominal organs	2	0.4
Superficial wound infection	12	2.7
Acute myocardial infarction	4	0.9
Stroke	3	0.7
Prolonged artificial ventilation	2	0.4
Ischemic colitis	2	0.4
Paraplegia	2	0.4
DVT	2	0.4
Acute renal insufficiency	2	0.4

mortality rate after OR of AAA was inversely correlated with hospital volume and surgical experience [15, 16, 18, 22–32]. Among the lowest reported is 30-day mortality rate of 1.2% after OR of AAA at Cleveland Clinic from 1989 to 1998 [20]. Thirty-day outcome occurred in 7 (1.55%) patients in our study which is lower in most of the RCTs performed in the last 15 years [32–39].

Many authors have found that female gender is associated with higher operative risk in several population-based studies using administrative data [16, 17, 24, 40]. According to other prospective trials, gender has not been found to be associated with increased operative mortality [14]. Some authors identified advanced age as an independent risk factor for increased mortality [16, 19, 23]. The fact that two-thirds of our populations are under 70 years can be explained that our population is extremely exposed to risk factors for atherosclerosis. Kazmers et al. [14] found difference only between patients who are younger or older than 80. Due to this, older age seemed to be associated with increased risk, but the evidence was not as strong [25, 41]. In the present study, female gender and advanced age did not increase 30-day mortality after OR of AAA.

Incidence of postoperative myocardial infarction in the published literature varies from 2 to even 8% [42]. This study has recorded postoperative acute myocardial infarction in 4 (0.9%) patients. Such low frequency rate in our study is a result of an adequate preoperative cardiological evaluation and patient preparation in accordance with current guidelines. Dedicated anesthesiological team, low intraoperative blood lost and low intraoperative hemodynamic variation must be scientifically invisible factors that are contributing to such a result. Although our study did not demonstrate that previous myocardial revascularization (PTCA or CABG), when indicated, statistically significantly reduces mortality after OR of AAA, we think that it is very important and we advise it routinely to patients who are at lower risk of rupture (AAA diameter 55–65 mm) with unsuitable anatomy for endovascular repair. If the risk of rupture is greater, repair of the AAA has advantage when our first choice is endovascular if it is possible.

An elective OR of AAA is complicated by an acute renal failure in 5–12%, and contributing factors were duration and level of aortic cross-clamping [43]. Our results are different (0.4%). In almost 80% of our patients clamping duration time was less than 30 min. In case of suprarenal clamping, our policy is to use cold manitol solution to perfuse renal arteries after 30 min of clamping. Acute postoperative renal failure did not significantly influence mortality in our study comparing other authors [14, 19, 38, 44, 45]. However, the number in our study is very low for any statistical analysis.

Table 4 Factors influencing outcome of AAA open repair

Factor	Odds ratio	95 % CI	*P* value
Hostile abdomen	5.25	1.3–21.1	0.0055
Coronary artery disease	3.89	0.85–17.7	0.0058
Inflammatory AAA	13.99	2.88–65.09	0.0002
Supraceliac aortic cross-clamping	18.7	3.8–90.6	0.0003
Duration of aortic cross-clamping >60 min	14.25	2.75–64.5	0.0112
Occluded both hypogastric arteries	17.4	1.99–178.33	0.0230
Bifurcated aortobifemoral graft	9.06	7.76–46.49	0.0160
Intraoperative bleeding >2 L	7.32	1.31–10.79	0.0001
Intraoperative hypotension (<100 mmHg)	6.61	0.71–61.07	0.0545
Total operative time >240 min	8.66	0.91–81.56	0.0585
Laparotomy wound dehiscence	44.1	3.39–572.78	0.0396
Colonic necrosis	88.2	4.77–1629.69	0.0026
Acute myocardial infarction	29.9	2.56–334.95	0.0053
Chronic renal failure	7.5	1.35–8.5	0.0073

Despite the fact that the transmural ischemic colitis incidence with wall necrosis after an elective OR AAA is only 1%, it has been affected by mortality of even 70% [19, 39]. Contributing factors are ligation of a patent inferior mesenteric and exclusion of both hypogastric arteries [46]. A prospective randomized trial did not show that routine reimplantation of patent inferior mesenteric artery reduces the incidence of perioperative colonic necrosis, excluding elderly patients and those with increased intraoperative blood loss [47]. At the time of surgery, inferior mesenteric artery is already occluded in 40–50% of cases [47]. Both of the patients that develop colon ischemia that required surgical treatment died. The number of patients is low to drive any conclusions about contributing factors. Delayed diagnosis or already high-risk patients might be the reason for so high mortality in our group.

The reasons for the usage of bifurcated graft are associated iliac aneurysms (20–30% of cases) or aortoiliac occlusive disease. The usage of bifurcated graft, and especially its extension to femoral arteries, increases the incidence of wound infection, graft limb thrombosis and anastomotic aneurysm [47]. In our study, 12 (2.7%) such cases have been registered. It is known that more than 25% of all early arterial reinterventions after OR of AAA are a result of bifurcated graft limb or iliac artery occlusion [4, 5, 7]. This complication was the reason for reoperation in 50% of our patients.

Conclusions

Early mortality after open repair of AAA in high volume center might be very low due to educated and experienced anesthesiological and surgical team. Centralized aortic surgery might be solution for effective treatment of patients with unsuitable anatomy or for young patients with long life expectancy. Education of young vascular surgeon in open aortic surgery is of a vast importance.

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