PERIOPERATIVE OUTCOME FOLLOWING OPEN SURGICAL REPAIR OF SYMPTOMATIC NON-RUPTURED ABDOMINAL AORTIC ANEURYSM

PERIOPERATIVNI ISHOD NAKON OTVORENOG HIRURŠKOG LEČENJA SIMPTOMATSKE NERUPTURIRANE ANEURIZME ABDOMINALNE AORTE

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Abstract

Introduction. Symptomatic non-ruptured abdominal aortic aneurysm represents an intermediate clinical entity between elective aneurysms and ruptured disease. This study aimed to compare perioperative outcomes and the incidence of acute kidney injury incidence between patients undergoing open surgical repair for symptomatic versus asymptomatic abdominal aortic aneurysms. **Material and Methods.** This retrospective cohort study included 178 patients who underwent open surgical repair for infrarenal abdominal aortic aneurysm between January 2021 and January 2023. Patients were classified as symptomatic (n = 60) if they presented with abdominal or back pain, limb ischemia without rupture, and as asymptomatic (n = 118) if treated electively. Demographic characteristic, comorbidities, intraoperative parameters, and postoperative outcomes were analyzed. **Results.** Symptomatic patients had a significantly larger mean aneurysm diameter compared with asymptomatic patients (74.5 vs. 64.2 mm; p < 0.001). Overall postoperative complications occurred more frequently in symptomatic patients (28.3% vs. 9.3%; p = 0.001), particularly cardiac complications (10% vs. 2.5%; p = 0.032). The length of hospital stay was significantly longer in the symptomatic group (10.1 vs. 8.4 days; p = 0.004). The incidence of postoperative acute kidney injury did not differ significantly between groups (31.7% vs. 27.1%; p = 0.53). However, preoperative chronic kidney disease and anemia were strong predictors of postoperative acute kidney injury. Thirty-day mortality was higher in symptomatic patients (8.3% vs. 3.4%) although the difference did not reach statistical significance (p = 0.40). **Conclusion.** Symptomatic non-ruptured abdominal aortic aneurysm is associated with larger aneurysm size, higher complication rates, and prolonged hospitalization. Nevertheless, open surgical repair can be performed with acceptable outcomes in specialized centers.

Key words: Aortic Aneurysm, Abdominal; Vascular Surgical Procedures; Treatment Outcome; Postoperative Complications; Risk Factors; Acute Kidney Injury; Renal Insufficiency, Chronic

Sažetak

Uvod. Simptomatska nerupturirana aneurizma abdominalne aorte predstavlja intermedijarni klinički entitet između elektivne i rupturirane bolesti. Ova studija je uporedila perioperativne ishode i incidenciju akutnog bubrežnog oštećenja između pacijenata koji su podvrgnuti otvorenoj hirurškoj reparaciji simptomatske u odnosu na asimptomatsku aneurizmu abdominalne aorte. **Materijal i metode.** Ova retrospektivna kohortna studija uključila je 178 pacijenata koji su podvrgnuti otvorenoj hirurškoj reparaciji infrarenalne aneurizme abdominalne aorte između januara 2021. i januara 2023. godine. Pacijenti su klasifikovani na one sa simptomima (simptomatski) (n = 60), ako su se prezentovali sa bolom ili ishemijom udova bez rupture, i na one bez simptoma (asimptomatski) (n = 118) ako su lečeni elektivno. Analizirani su demografski podaci, komorbidoteti, intraoperativni parametri i postoperativni ishodi. **Rezultati.** Simptomatski pacijenti imali su značajno veći srednji dijametar aneurizme (74,5 naspram 64,2 mm, p < 0,001). Ukupne postoperativne komplikacije javljale su se češće kod simptomatskih pacijenata (28,3% naspram 9,3%, p = 0,001), posebno kardijalne komplikacije (10% naspram 2,5%, p = 0,032). Bolničko lečenje bilo je značajno duže u simptomatskoj grupi (10,1 naspram 8,4 dana, p = 0,004). Incidencija akutnog bubrežnog oštećenja nije se značajno razlikovala između grupa (31,7% naspram 27,1%, p = 0,53). Međutim, preoperativna hronična bubrežna bolest i anemija bile su snažni prediktori postoperativnog akutnog bubrežnog oštećenja. Tridesetodnevni mortalitet bio je viši u grupi sa simptomima (8,3% naspram 3,4%) ali nije dostigao statističku značajnost (p = 0,40). **Zaključak.** Simptomatska nerupturirana aneurizma abdominalne aorte povezana je sa većom veličinom aneurizme, višom stopom komplikacija i produženom hospitalizacijom. Otvorena hirurška reparacija može se izvoditi sa prihvatljivim ishodima u specijalizovanim centrima.

Ključne reči: aneurizma abdominalne aorte; vaskularne hirurške procedure; ishod lečenja; postoperativne komplikacije; faktori rizika; akutno oštećenje bubrega; hronična bubrežna insuficijencija

Introduction

Abdominal aortic aneurysm (AAA) is a progressive degenerative disease of the aortic wall characterized by chronic inflammation, extracellular matrix degeneration, and gradual dilatation of the vessel. With the increasing use of ultrasound and other imaging modalities, most AAAs are currently detected

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Abbreviations

AAA	– abdominal aortic aneurysm
AKI	– acute kidney injury
AsAAA	– asymptomatic abdominal aortic aneurysm
CI	– confidence interval
CKD	– chronic kidney disease
CMP	– cardiomyopathy
COPD	– chronic obstructive pulmonary disease
CRF	– chronic renal failure
DM	– diabetes mellitus
eGFR	– estimated glomerular filtration rate
EVAR	– endovascular aneurysm repair
HLP	– hyperlipoproteinemia
HTA	– arterial hypertension
KDIGO	– Kidney Disease: Improving Global Outcomes
OR	– odds ratio
OSR	– open surgical repair
SAAA	– symptomatic non-ruptured abdominal aortic aneurysm
SD	– standard deviation
MACE	– Major Adverse Cardiac Events
MGS/MGS-2	– Melbourne Group Scale
MARE	– Major Adverse Respiratory Events

incidentally. These patients are predominantly asymptomatic (AsAAA) and are managed according to established size- and risk-based clinical guidelines [1–3].

However, a subset of patients present with abdominal, back, or flank pain, distal embolization, or signs of local compression without radiological evidence of rupture. These symptomatic non-ruptured aneurysms (SAAA) represent an intermediate yet clinically important category between elective aneurysms and urgent presentations such as ruptured AAA [4–6]. Several studies suggest that the onset of new symptoms may indicate aneurysm instability, rapid expansion, or impending rupture, and may therefore be associated with worse perioperative outcomes compared with AsAAA [4,5,7].

Open surgical repair (OSR) remains a fundamental treatment modality for AAA, particularly in patients with unfavorable anatomy for endovascular aneurysm repair, in younger individuals, and in centers with strong expertise in open vascular surgery [1,8,9]. Although outcomes after elective OSR have been extensively studied, evidence regarding perioperative risk in patients with SAAAs remains less consistent. Large cohort studies have identified symptomatic presentation as an independent predictor of perioperative morbidity and mortality. However, most previously published studies combine symptomatic and ruptured aneurysms, analyze heterogeneous populations undergoing both open and endovascular repair, or lack detailed intraoperative and postoperative data required for accurate risk stratification [4–6].

Acute kidney injury (AKI) represents one of the most clinically significant postoperative complications following AAA repair. It occurs in up to one-third of patients undergoing open repair and is strongly associated with increased short-term morbidity, prolonged intensive care unit stay, the need for renal replacement therapy, and increased long-term mortality. Patients with SAAA may be particularly susceptible to renal injury due to hemodynamic instability, microembolization, higher transfusion requirements, or more complex surgical exposure. Although several studies have evaluated AKI following elective or ruptured AAA repair [10–13], few have specifically examined whether symptomatic presentation itself increases the risk of postoperative renal dysfunction in patients undergoing OSR. This represents an important knowledge gap, as AKI substantially affects both early and long-term outcomes after aortic surgery.

Taken together, the current literature suggests that symptomatic non-ruptured AAAs represent a distinct and clinically relevant subgroup with potentially worse perioperative and long-term outcomes, yet high-quality evidence focusing specifically on open surgical repair remains limited. A clearer understanding of how symptomatic presentation influences postoperative complications, acute kidney injury, and survival is essential for optimizing patient selection, perioperative risk counseling, and management strategies.

The objective of this study was to compare perioperative outcomes, the incidence of acute kidney injury, and short-term survival in patients undergoing open surgical repair for symptomatic non-ruptured versus asymptomatic abdominal aortic aneurysms over a three-year period in a high-volume vascular surgery center. Additionally, the study aimed to identify independent predictors of postoperative morbidity, mortality, and renal dysfunction, with particular emphasis on variables associated with symptomatic presentation.

Material and Methods

This retrospective cohort study included 178 patients who underwent open surgical repair (OSR) for abdominal aortic aneurysm (AAA) at the University Clinical Center of Vojvodina, Serbia between January 2021 and January 2023. Of these, 60 patients underwent surgery for symptomatic non-ruptured abdominal aortic aneurysm (SAAA), while 118 patients received elective treatment for asymptomatic abdominal aortic aneurysm (AsAAA). Patients were classified as having SAAA if they presented with abdominal, back, or groin pain attributable to the aneurysm, or limb ischemia, without radiologic or intraoperative evidence of rupture. Asymptomatic patients underwent elective repair based on aneurysm size or documented aneurysm growth. Baseline demographic and clinical variables, aneurysm characteristics, intraoperative parameters, and postoperative outcomes were extracted from electronic and paper records of the institutional medical registry at the

University Clinical Center of Vojvodina. The following preoperative variables were collected: age, sex, aneurysm diameter, comorbidities: arterial hypertension (HTA), cardiomyopathy (CMP), chronic obstructive pulmonary disease (COPD), hyperlipoproteinemia (HLP)], diabetes mellitus (DM), and chronic kidney disease (CKS), cigarette smoking, estimated glomerular filtration rate (eGFR), hemoglobin level, and presenting symptoms.

The following intraoperative and postoperative parameters were recorded:

– Surgical technique (interposition of Dacron tube graft, aortobiiliac bypass, or aortobifemoral bypass)
– Intraoperative blood loss (ml)
– Duration of surgery (minutes)
– Treatment outcome
– Postoperative complications were defined as local or systemic complications occurring during hospitalization or within 30 days after surgery. Cardiac complications were defined according to Major Adverse Cardiac Events (MACE) criteria and included: acute myocardial infarction, new-onset cardiac arrhythmia requiring treatment, acute heart failure, and cardiac death. Pulmonary complications were defined according to Major Adverse Respiratory Events (MARE) criteria using the Melbourne Group Scale (MGS/MGS-2). These included: respiratory failure requiring supplemental oxygen or mechanical ventilation beyond baseline, pneumonia (new radiological infiltrate accompanied by fever, purulent sputum, or positive microbiological culture), atelectasis requiring bronchoscopy or physiotherapy, pleural effusion requiring drainage, and pneumothorax.
– Acute kidney injury (AKI) defined according to KDIGO criteria, and the need for renal replacement therapy
– Duration of hospitalization
– Overall survival (30-day mortality)

All procedures were performed in the operating rooms of the University Clinical Center of Vojvodina and the Emergency Center in Novi Sad. Surgical interventions were carried out collaboratively by vascular surgeons and anesthesiologists, and all patients underwent general endotracheal anesthesia. Following surgery, patients were transferred to the Intensive Care Unit and subsequently to the Department of Vascular and Endovascular Surgery. After clinical stabilization and recovery, patients were discharged with prescribed medications and scheduled follow-up visits.

Statistical Analysis

All data were entered into a database and analyzed using appropriate statistical methods. Continuous variables are presented as mean ± standard deviation (SD) and were compared between groups using the Student's t-test for normally distributed data or the Mann-Whitney U test for non-normally distributed variables. Categorical variables are presented as frequencies and percentages and were compared using the Pearson chi-squared test or Fisher's exact test, as appropriate. Logistic regression analysis was performed to identify independent predictors of postoperative acute kidney injury. Results are reported as odds ratios (OR) with 95% confidence intervals (CI). A p-value < 0.05 was considered statistically significant.

The study was approved by the Ethics Committee of the Faculty of Medicine, Novi Sad, and all procedures were conducted in accordance with the principles of the Declaration of Helsinki.

Results

The study included 178 patients with infrarenal AAA who underwent OSR. Of these, 60 patients (33.7%) underwent surgery in emergency or delayed settings for SAAA, whereas 118 patients (66.3%) underwent elective OSR. Patients with confirmed AAA rupture, aortocaval fistula, or aortoduodenal fistula were excluded from the analysis.

Table 1. Gender, age, and comorbidity distribution of patients with abdominal aortic aneurysm

	SAAA	AsAAA	P value
Number of patients	60	118	-
Male	81.7% (49/60)	81.3% (96/118)	0.96
Average age, years	73.7 years (57-89) SD 6.7	71.9 years (55-85) SD 6.1	0.07
Hypertension	83.3% (50/60)	91.5% (108//118)	0.102
Hyperlipoproteinemia	21.7% (13/60)	11.9% (14/118)	0.085714
Chronic obstructive pulmonary disease	15% (9/60)	27.1% (32/118)	0.781
Diabetes mellitus	36.6% (22/60)	11.9% (14/118)	0.0000001
Cardiomyopathy	18.3% (11/60)	43.7% (56/118)	0.000121
Cigarette use	10% (6/60)	32.2% (38/118)	0.001066
Chronic kidney disease	30% (18/60)	18.6% (22/118)	0.0871
eGFR mL/min/1.73 m^2	102 SD 25.6	105,2 SD 20.3	0.356
Size of aneurysm, mm	74.5 mm SD 15.7	64.2 mm SD 9.8	0.0000000293

The majority of patients in both groups were male (SAAA: 81.7%; AsAAA 81.3%), with no statistically significant difference in sex distribution between the groups **(Table 1).**

The mean age was slightly higher in the SAAA group compared with the AsAAA group, although this difference did not reach statistical significance (SAAA: 73.7 years, SD 6.7; AsAAA: 71.9 years, SD 6.1; p = 0.07). The oldest patient was 89 years old, and the youngest was 55 years old.

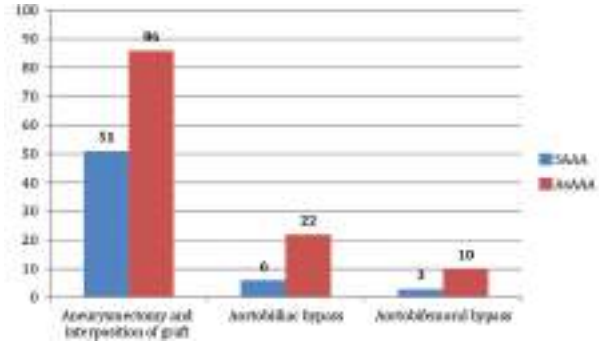
The mean aneurysm diameter was 74.5 mm (SD 15.7) in the SAAA group and 64.2 mm (SD 9.8) in the AsAAA group. Patients treated for SAAA had significantly larger aneurysms (p < 0.001).

Baseline characteristics and comorbidities are presented in **Table 1.** The most common comorbidity in both groups was arterial hypertension (HTA) (SAAA: 83.3%, AsAAA 91.5%; p = 0.10). Diabetes mellitus (DM) was significantly more prevalent in the SAAA group (36.6% vs. 11.9%, p < 0.001), whereas cigarette smoking (10% vs. 32.2%, p = 0.001) and cardiomyopathy (CMP) (18.3% vs. 43.7%, p<0.001) were more common in the AsAAA group. Chronic kidney disease (CKD) was present in 30% of SAAA patients and 18.6% of AsAAA patients (p = 0.0871).

All patients underwent open surgical repair. Aneurysmectomy with interposition of a Dacron tube graft was the most frequently performed procedure in both groups (SAAA: 85%, 51/60; AsAAA: 72.9%, 86/118), followed by aortoiliac bypass (SAAA: 10%, 6/60; AsAAA: 18.6%, 22/118) and aortobifemoral bypass (SAAA: 5%, 3/60; AsAAA: 8.5%, 10/118) **(Graph 1).**

Perioperative blood loss and operative duration were comparable between groups **(Table 2)**. Mean intraoperative blood loss was 1159 ml (SD 662) in the SAAA and 1112 ml (SD 673) in the AsAAA (p = 0.65). Mean operative time was 147 minutes (SD 37) in the SAAA and 144 minutes (SD 49) in the AsAAA (p = 0.68).

Total postoperative complications were significantly more frequent in the SAAA group (28.3% vs. 9.3%, p = 0.001), particularly cardiac complications (10% vs. 2.5%, p = 0.032). Pulmonary complications (10% vs. 3.3%, p = 0.071) and local complications (5% vs. 2.5%, p = 0.39) did not differ significantly between the groups.



Graph 1. Applied surgical techniques

Acute kidney injury (AKI) occurred in 31.7% of SAAA patients (19/60) and 27.1% of AsAAA patients (32/118), with no statistically significant difference between the groups (p = 0.53). However, postoperative AKI was significantly more frequent in patients with preoperative CKD (73% vs. 20%, p < 0.001) and in those with preoperative anemia (69% vs. 22%, p < 0.05). Preoperative CKD (OR 10.5, 95% CI 4.0-27.5) and anemia (OR 9.5, 95% CI 3.5-22.5) were strong predictors of postoperative AKI.

The length of hospital stay was significantly longer in the SAAA group (mean 10.1 days, SD 3.7) compared to the AsAAA group (mean 8.4 days, SD 3.6; p = 0.004). This difference likely reflects the higher complication rate and the need for preoperative stabilization in symptomatic patients.

Thirty-day mortality was higher in the SAAA group (8.3%, 5/60) than in the AsAAA group (3.4%, 4/118), although this difference did not reach statistical significance (p = 0.40).

Discussion

Abdominal aortic aneurysm (AAA) remains a major cause of cardiovascular morbidity and mortality worldwide, with an estimated prevalence of 2–8% in men older than 65 years. Women tend to experience

Table 2. Comparative analysis of intraoperativly and postoperatively monitored parameters

	SAAA	AsAAA	P value
Intraoperative blood lose	1159 ml SD 662 ml	1112 ml SD 673 ml	0.65
Duration of surgery	147 min SD 37 min	144 min SD 49 min	0.68008
Postoperative complications	28.3% (17/60)	9.3% (11/118)	0.00122
Local complications	5% (3/60)	2.5% (3/118)	0.392
Cardiac complications	10% (6/60)	2.5% (3/118)	0.03191
Pulmonary complications	10% (6/60)	3.3% (4/118)	0.070911
Acute kidney injury	31.7% (19/60)	27.1% (32/118)	0.528508
Hospital stay	10.1 days SD 3.7	8.4 days SD 3.6	0.003958
30 day mortality	8.3% (5/60)	3.4%(4/118)	0.3976

aneurysm rupture at smaller diameters and generally have poorer clinical outcomes compared with men [1,2].

Despite significant improvements in screening programs and elective repair, ruptured AAA continues to be associated with extremely poor prognosis, with overall mortality exceeding 80%, largely due to prehospital deaths. Even with emergency surgery is performed, perioperative mortality remains high [1, 14–16]. Consequently, ruptured AAA accounts for approximately 1–2% of all deaths in men older than 65 years in Western countries.

Within this clinical spectrum, symptomatic non-ruptured AAA (SAAA) represents a distinct and clinically important category positioned between elective asymptomatic aneurysms and ruptured disease. Previous studies have demonstrated that SAAA is associated with perioperative mortality and complication rates that are intermediate between these elective and ruptured AAA, highlighting its unique risk profile and the need for focused evaluation [17].

In the present study, patients with SAAA tended to be older than those undergoing elective repair, although the difference did not reach statistical significance. Similar observations have been reported by Mroczek et al. [18] and De Martino et al. [19], although some studies found no significant age difference [5]. As expected, maximum aneurysm diameter was significantly larger in the symptomatic group, a finding consistently reported in the literature [18–23].

With regard to comorbidities, diabetes mellitus was more prevalent in the SAAA group, whereas cardiomyopathy and active smoking were more frequently observed in asymptomatic patients, possibly reflecting surveillance-driven diagnosis in these high-risk individuals. These findings contrast with some studies reporting higher smoking rates and greater prevalence of cardiomyopathy among patients with SAAA [5,7, 18,19], which may reflect cohort differences. Arterial hypertension was the most common comorbidity in both groups, underscoring its well-established role in AAA pathogenesis [5,7,18,19,24].

From a surgical perspective, aneurysmectomy with interposition of a tube graft represented the most frequently performed procedure in both groups. Consistent with previous reports [5,6,19,24], operative duration and intraoperative blood loss did not differ significantly between the groups, suggesting that symptomatic presentation alone does not necessarily increase technical complexity during open surgical repair.

Despite comparable intraoperative parameters, hospital stay was significantly longer in the SAAA group, likely reflecting both the higher postoperative complications, as well as the need for preoperative hospitalization for diagnostic evaluation and hemodynamic stabilization.

Thirty-day mortality was slightly higher in the SAAA group, although the difference did not reach statistical significance. This observation indicated that OSR of symptomatic non-ruptured AAA can be performed with acceptable early survival in specialized centers, which is consistent with findings from previous studies [6,7,16–19,24]. Nevertheless, overall postoperative complications occurred significantly more frequently in SAAA patients, in agreement with reports by Soden et al. [5], Mroczek [18], and Chandra et al. [6]. Other studies [18] suggested better outcomes with EVAR overall, although these differences likely reflect varying institutional experience.

In our cohort, cardiac complications were more frequent among patients with SAAA, consistent with the increased cardiovascular stress associated with symptomatic disease [18,19]. In contrast, pulmonary and local complications did not differ significantly between the groups.

Importantly, the incidence of AKI did not differ significantly between SAAA and AsAAA groups. However, postoperative AKI was strongly associated with preoperative CKD (OR 10.5, 95% CI 4.0–27.5) and preoperative anemia (OR 9.5, 95% CI 3.5-22.5). These findings indicate that baseline renal dysfunction and reduced oxygen-carrying capacity represent major vulnerabilities in patients undergoing open AAA repair. These results are consistent with several studies demonstrating that preoperative CKD and reduced eGFR (< 60 mL/min/1.73 m^2) are independent predictors of postoperative AKI, regardless of repair technique used [20–22,25–27].

Conclusion

In this retrospective cohort study, symptomatic non-ruptured aortic aneurysms were significantly larger and associated with higher postoperative complication rates and prolonged hospitalization compared with asymptomatic aneurysms. However, 30-day mortality and the incidence of acute kidney injury did not differ significantly between the two groups. Preoperative chronic kidney disease and anemia emerged as the strongest predictors of postoperative acute kidney injury, regardless of symptomatic status. These findings emphasize the critical importance of preoperative risk stratification and optimization of renal function. Overall, open surgical repair of symptomatic non-ruptured abdominal aortic aneurysm can be performed with acceptable outcomes in high-volume centers, particularly when supported by careful patient selection and comprehensive perioperative management strategies.

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