DOI: https://doi.org/10.2298/SARH211229067M
UDC: 616.136-007.64

ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Open surgical conversion and management of patients with ruptured abdominal aortic aneurysm after previous endovascular aneurysm repair

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SUMMARY

Introduction/Objective The objective was to present the results and technical considerations from high-volume center when performing late open surgical conversion (LOSC) after endovascular aneurysm repair (EVAR) in ruptured abdominal aortic aneurysm (RAAA) patients.

Methods This was a single center retrospective study. LOSC was performed whenever eventual endovascular reintervention failed, was not feasible due to hostile anatomy and unavailability of specific endograft materials, or when patient was hemodynamically unstable necessitating emergent surgery.

Results All previously implanted EVARs had bimodular configuration with suprarenal fixation. Total endograft explantation was performed in 40% of patients. Hospital mortality was 20%. Both patients who died had total endograft explantation with supraceliac clamp lasting more than 30 minutes. 30-day mortality was 30%, with one more patient who died from pulmonary embolism after hospital discharge and two hospital deaths were due to myocardial infarction.

Conclusion LOSC due to RAAA after previous EVAR carries greater mortality for the patient, suggesting multifactorial impacts on the outcome. The appropriate choice of surgical method and technical success are of ultimate importance, with total graft explantation having negative impact on patient's survival.

Keywords: ruptured abdominal aortic aneurysm (RAAA); endovascular aneurysm repair (EVAR); late open surgical conversion (LOSC)

INTRODUCTION

Most of the stent-graft failures are managed with secondary endovascular techniques (aortic or iliac endograft extensions, embolization, and endograft relining). However, late open surgical conversion (LOSC) may sometimes be the only available option to repair a failing endovascular aneurysm repair (EVAR) [1, 2].

The incidence of ruptured abdominal aortic aneurysm (RAAA) after EVAR is low, and estimated to be 0.9% [3]. Nowadays, the incidence may be even higher than previously reported, because of the follow-up delays during COVID-19 pandemic.

In the previous multicentric study we already reported that morbidity and mortality rates for LOSC after EVAR are generally higher than in standard open elective or semi-elective circumstances [4, 5]. Currently, insufficient data are available in the latest European Society for Vascular and Endovascular Surgery guidelines on the Management of Abdominal Aorto-iliac Aneurysms to recommend a particular strategy when performing LOSC in RAAA setting, and surgeon's preference still plays a major role [6].

That is why the objective of this paper is to present the results and technical considerations from high-volume center when performing LOSC after EVAR in RAAA patients, that might help vascular surgeons when dealing with this challenging condition.

METHODS

This was a single center retrospective study. A total of 236 elective EVARs were performed between January 2010 and January 2020. Ten patients were operated due to ruptured aneurysm following EVAR, however in five patients previous EVAR was performed in other hospitals. LOSC was performed whenever eventual endovascular reintervention failed, was not feasible due to hostile anatomy and unavailability of specific endograft materials, or when a patient was hemodynamically unstable needing urgent surgery.

Computerized tomography angiography was performed in all patients to determine the extent and anatomy of the RAAA. All procedures were performed in a fully equipped operating room including intraoperative cell saving system, under the general anesthesia. All patients were treated by experienced vascular surgeons proficient at both open and endovascular surgery.

Received • Примљено: December 29, 2021
Revised • Ревизија: June 19, 2022
Accepted • Прихваћено: July 2, 2022
Online first: July 8, 2022

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Following data were collected and analyzed: demographics (age and sex), baseline clinical characteristics (presence of hypertension, diabetes mellitus, coronary artery disease, chronic obstructive pulmonary disease, chronic renal insufficiency, hostile abdomen, time from EVAR to LOSC), endovascular reinterventions before LOSC (type of stent-graft, previous endovascular attempt to correct the culprit lesion, indication for LOSC), operative data (surgical approach, site of aortic cross-clamping (ACC), type of reconstruction, total blood loss, number of allogenous blood transfusion), as well as postoperative data such as complications, in-hospital and 30-day mortality.

To assess for normal distributions, we used Shapiro–Wilk test. All results were expressed as arithmetic mean (X) ± standard deviation for normally distributed variables and as median and lower and upper interquartile range for non-normally distributed variables. Categorical variables were presented as absolute and relative frequencies.

Informed consent for the procedure was obtained from all conscious patients. In those with distracted consciousness or intubated prior to admission due to aortic rupture, consent for surgery was obtained from family members. The study was approved by the institutional committee on ethics and was conducted according to the principals of the Helsinki Declaration.

RESULTS

The mean patient's age was 76 ± 6.86 years, the majority were males (87.5%), had coronary artery disease (62.5%), 50% of them had chronic renal failure and 25% had chronic obstructive pulmonary disease. All previously implanted EVARs had bimodular configuration with suprarenal fixation (five Endurant® and three Zenith®). The most common culprit for the development of RAAA was type Ia endoleak (50%) and the mean interval from initial EVAR until rupture was 48 ± 24.43 months. Previous endovascular attempt to correct the underlying endoleak was attempted in 40% of patients (Table 1).

Median laparotomy was performed in all patients. For proximal bleeding control supraceliac aortic clamp was applied in all patients. Total endograft explantation was performed in four (40%) patients. An aortobiiliac bypass was performed in the majority of patients (80%), with mean proximal clamp duration of 29.1 ± 7.9 min, mean total operative time of 179 ± 63 minutes and mean blood loss of 3417 ± 992 milliliters.

Hospital mortality was 20%. Both patients who died had total endograft explantation with supraceliac clamp lasting more than 30 minutes. Two patients developed transmural colon ischemia needing colectomy, while one had additional surgical bleeding requiring reintervention. 30-day mortality was 30%, with one patient who died from pulmonary embolism after hospital discharge, while two in-hospital deaths were due to myocardial infarction. From four patients who underwent total endograft explantation, two died (50%).

When comparing patients with total and partial graft explantation (Table 2), there was no significant major cardiovascular risk profile difference. The proximal clamping time as well as total operation duration seemed to be longer in patients who had total graft explantation implying the overall increased complexity when whole stent graft is explanted. Both myocardial infarctions occurred in total explantation group which led to the fatal outcome.

Table 1. Baseline data, indications, type of repair and postoperative outcomes

Baseline characteristics		Intraoperative variable	
Age	76.2 ± 6.05	Median laparotomy	10 (100%)
Male	9 (90%)	Total endograft explantation	4 (40%)
Hypertension	10 (100%)	Type of reconstruction	
Diabetes mellitus	5 (50%)	Graft interposition	2 (20%)
Coronary artery disease*	6 (60%)	All bypass	8 (80%)
COPD	3 (30%)	Proximal supraceliac clamp	100 (100%)
Renal failure	6 (60%)	Proximal clamp duration (min)	29.1 ± 7.9
Hostile abdomen**	2 (20%)	Total operative time	179 ± 63
Interval from EVAR to LOSC (months)	48 ± 24.43	Blood loss (ml)	3417 ± 992
EVAR*-related data		Postoperative outcome	
Type of endograft		Hospital mortality	2 (20%)
Endurant®	7 (70%)	30-day mortality	3 (30%)
Zenith®	3 (30%)	Surgical bleeding	1 (10%)
Suprarenal fixation	10 (100%)	Wound infection	1 (10%)
Previous endovascular reintervention	4 (40%)	Dialysis	1 (10%)
Indication for LOSC		Colon ischaemia	2 (20%)
Type Ia endoleak	6 (60%)	Acute limb ischaemia	1 (10%)
Type Ib endoleak	1 (10%)	Acute coronary syndrome	2 (20%)
Type III endoleak	2 (20%)	Stroke	0 (0%)
Stent-graft migration	1 (10%)	Prolonged ventilation (more than 48h)	3 (30%)

COPD – chronic obstructive pulmonary disease; EVAR – endovascular abdominal aortic aneurysm repair; LOSC – late open surgical conversion; AII – aortobiiliac bypass; *coronary artery disease was defined as presence of angina pectoris or previous myocardial infarction, percutaneous coronary intervention or coronary artery bypass; **hostile abdomen was defined as previous major abdominal surgery or radiation

Table 2. Baseline data, indications, type of repair and postoperative outcomes for patients who had total and partial stent-graft explantation

Parameters	Patients with total stent-graft explantation				Patients with partial stent-graft explantation					
Baseline characteristics	Patient No I	Patient No II	Patient No III	Patient No IV	Patient No V	Patient No VI	Patient No VII	Patient No VIII	Patient No IX	Patient No X
Age	66	81	67	80	73	82	77	79	83	74
Coronary artery disease*	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No
COPD	No	Yes	No	No	No	No	No	No	Yes	Yes
Renal failure	No	No	No	No	Yes	No	Yes	Yes	Yes	Yes
Hostile abdomen**	No	Yes	No	No	No	No	Yes	No	No	No
Preoperative data										
Interval from EVAR to LOSC (months)	13	96	38	23	29	48	72	60	54	47
Type of endograft	Endurant®	Endurant®	Zenith®	Zenith®	Endurant®	Endurant®	Endurant®	Endurant®	Endurant®	Endurant®
Indication for LOSC	Stent-graft migration	Type Ia endoleak	Type III endoleak	Type Ia endoleak	Type Ia endoleak	Type Ib endoleak	Type III endoleak	Type Ia endoleak	Type Ia endoleak	Type Ia endoleak
Operative data										
Proximal clamp duration (min)	46	35	31	32	30	21	19	23	26	23
Type of reconstruction	All bypass	All bypass	Graft interposition	All bypass	All bypass	All bypass	All bypass	All bypass	Graft interposition	All bypass
Total operative time	300	180	210	240	210	170	90	150	110	135
Blood loss (ml)	5200	3200	2700	3300	4300	3000	2400	3200	2800	1600
Postoperative outcomes										
Colon ischaemia	Yes	No	No	No	No	No	Yes	No	No	No
Acute coronary syndrome	Yes	Yes	No	No	No	No	No	No	No	No
Prolonged ventilation (more than 48h)	Yes	No	No	Yes	No	No	No	No	Yes	No
Hospital mortality	Yes	Yes	No	No	No	No	No	No	No	No

COPD – chronic obstructive pulmonary disease; EVAR – endovascular abdominal aortic aneurysm repair; LOSC – late open surgical conversion; All – aortobiiliac bypass; *coronary artery disease was defined as presence of angina pectoris or previous myocardial infarction, percutaneous coronary intervention or coronary artery bypass; **Hostile abdomen was defined as previous major abdominal surgery or radiation

DISCUSSION

Although reported late, RAAA rate after EVAR is low, with the progressive expansion of EVAR, especially to more complex anatomies, frequently outside manufacturer's instructions for use, the need for LOSC is likely to increase, especially during COVID-19 pandemic [1, 7]. In only four of our patients previous endovascular reintervention was attempted, suggesting that better compliance with surveillance protocols would have resulted in elective endovascular or open surgical correction of EVARs.

In our institution, EVAR is mainly performed in patients of advanced age with significant comorbidities making them unfit for open repair. [8] Performing open reintervention that often exceeds the extent of hypothetic primary open repair is an extreme challenge. Although some reports suggest that these patients are less hemodynamically unstable than primary ruptures, our experience is different [1]. All our patients were in severe state of hemorrhagic shock on admission.

In a meta-analytical population of 791 patients treated with LOSC (617 elective and 174 urgent procedures), those treated in an urgent setting had a 10 times higher risk for mortality, suggesting that among various indications for urgent conversion, type I/II endoleak and infection, rupture possibly contributes to a larger extent to this event [4]. This underscore not only the necessity of close surveillance but also the importance of timely LOSC to approach the ideal scenario of avoiding non-elective LOSC because EVAR does not provide significant survival advantage when the aneurysm ruptures [9]. In a single-center cohort evaluating LOSC in the urgent setting, with high proportion of ruptured cases (57%), Perini et al. [10, 11] presented similar results, i.e., the mortality rate was 33%.

Three important technical elements of LOSC are: surgical approach, the level of proximal ACC and the procedure with stent-graft [5]. We advocate transperitoneal approach through midline laparotomy, since this provides adequate proximal and distal bleeding control, and enables fast cardiopulmonary reanimation if necessary. However, this approach could be challenging in patients with hostile abdomen that often-dictates the indication for initial endovascular procedure (two of our patients). In all our RAAA patients regardless of rupture etiology, we use liberal approach to supraceliac ACC. Especially in cases with previous EVAR and suprarenal stent fixation, we think that supraceliac ACC is mandatory. In this manner, the lesion of the metallic skeleton (including perforation) and the dissection through hematoma is avoided. This lowers the chance of retroperitoneal organ lesion, and in case of

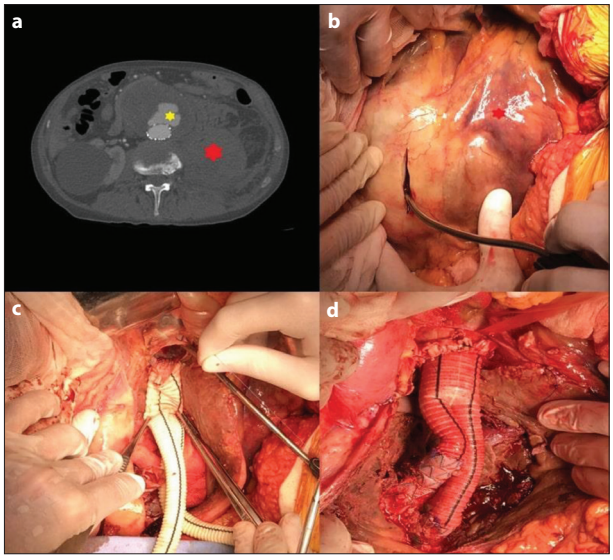

Figure 1. A patient undergoing partial stent-graft explantation: (a) preoperative computed tomography scan where yellow asterix shows type Ia endoleak and the red one retroperitoneal hematoma; (b) intraoperative photo at the moment of aneurysm sac opening after the supracoeliac clamp has been positioned, with red asterix the retroperitoneal hematoma is marked; (c) proximal anastomosis creation using "Bonvini" neo-neck technique; (d) bifurcated bypass presentation at the end of the procedure

hemodynamic instability it provides quick and efficient rise of blood pressure.

The final step is procedure with stent-graft, which includes its complete or partial removal. No clear recommendations exist regarding stent-graft management during open conversion (i.e., complete stent-graft removal *vs.* partial preservation), which is a controversial subject. Our opinion is that total endograft explantation should be avoided in order to perform the simplest reconstruction, especially when there is suprarenal fixation and absence of infection. Total explantation was associated with longer proximal ACC time, more blood loss and more extensive reconstruction (both patients died). Therefore, attempts should be made to partially remove the stent-graft whenever possible, and to perform a proximal suture, as the "neo-neck" technique (Figure 1) [12]. The proximal segment of new anastomosis between preserved stent graft and new graft should include three layers: stent graft, teflon pledgets and aneurysmal wall.

CONCLUSION

Emergent LOSC due to RAAA after previous EVAR carries greater mortality for the patient, suggesting multifactorial impacts on the outcome. This underlines the importance of surveillance after EVAR in order to avoid non-elective LOSC. The appropriate choice of surgical method and technical success are of ultimate importance, with total graft explantation having negative impact on patient's survival.

ACKNOWLEDGMENT

The presented article is a part of a scientific research project (No. 175008) supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

Miroslav Marković and Petar Zlatanović contributed equally to this paper.

Conflicts of interest: None declared.

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Отворена хируршка конверзија и лечење болесника са руптуром анеуризме абдоминалне аорте и претходним ендоваскуларним третманом

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САЖЕТАК

Увод/Циљ Циљ рада је да се прикажу резултати и технички аспекти третмана са отвореном конверзијом после ендоваскуларног третмана код болесника са руптуром анеуризме абдоминалне аорте.

Методе Ово је била уницентрична ретроспективна студија. Отворена конверзија је рађена код претходно неуспелог ендоваскуларног третмана, када он није био могућ због хостилне анатомије и недоступности ендографтова, или када је болесник био толико хемодинамски нестабилан да је захтевао ургентну хирургију.

Резултати Сви претходни ендоваскуларни третмани анеуризме абдоминалне аорте су имали бимодуларну конфигурацију са супрареналном фиксацијом. Тотална експлантација ендографта рађена је код 40% болесника. Хоспитални морталитет је био 30%. Оба болесника која су преминула имала су тоталну експлантацију ендографта са супрацелијачним клемовањем које је трајало дуже од 30 минута. Тридесетодневни морталитет је био 30%, од чега је један болесник преминуо од плућне емболије после отпуста из болнице, а два смртна случаја у болници била су због акутног инфаркта миокарда.

Закључак Отворена конверзија због руптуре анеуризме абдоминалне аорте после претходног ендоваскуларног третмана носи велики морталитет за болеснике. Избор адекватне хируршке методе и технички успех су од највеће важности, при чему потпуна експлантација негативно утиче на преживљавање болесника.

Кључне речи: руптурирана анеуризма абдоминалне аорте; ендоваскуларни третман анеурзиме абдоминалне аорте; отворена конверзија