DOI: http://dx.doi.org/10.48305/arya.2022.16298.2518

Short and one-year outcome of endovascular aortic repair (EVAR) for abdominal aortic aneurysms (AAAs)

Alireza Khosravi[1], Ali Eghbal[2], Mohammad Kermani-Alghoraishi[3], Mohaddeseh Behjati[4], Javad Shahabi[5], Asieh Mansouri[6]

short communication

Abstract

BACKGROUND: Endovascular aortic repair (EVAR) of abdominal aortic aneurysms (AAAs) has been marked as standard practice during the past decades. We aimed to investigate the short- and long-term outcomes of EVAR in patients with AAAs in Isfahan, Iran. .

METHOD: This retrospective study conducted on 50 patients with AAAs who have undergone EVAR procedure consequently in four different hospitals (Chamran hospital, Asgarieh hospital, Sepahan hospital and Saadi hospital) in Isfahan, Iran, between 2017 to 2020. We followed patients for one year and recorded short-term and one-year outcome include Endoleak, Aorta-iliac expansion, and mortality in hospital records during one year and telephone follow up. Data was entered in SPSS (ver.25) and analyzed with Univariate Linear Regression and Chi-Square Test.

RESULTS: The mean age of participants was 66.6±11.7 years old, in which 88%(n=44) of them were male. Elective EVAR was performed in 88% of patients. Regarding the complications one year after EVAR, endoleak and CIN (contrast-induced nephropathy) were occurred in 6%(n=3) and 6%(n=3) of patients, respectively. We also reported the rate of in-hospital mortality and one-year mortality as 2%(n=1) and 8%(n=4), respectively. Univariate regression analysis revealed no significant difference regarding one-year mortality in patients who underwent EVAR. In patients who underwent spinal anesthesia in comparison with general and regional anesthesia before EVAR, there were lower rate of vascular complications [0% (n=0) versus 23.5% (n=4) and 20.0% (n=2), P=0.053], level of blood urea nitrogen (BUN) [9.8 ± 13.9 versus 17.0 ± 13.1 and 14 ± 6.2, P=0.031] and creatinine (Cr) [0.6±1.1 versus 1.1±0.6 and 1.3±0.5, P=0.005], respectively.

CONCLUSION: Desirable short- and long-term outcomes as expected, combined with a reduction in hospital length of stay and mortality and one-year mortality allowed EVAR to become the favorable therapeutic strategy for AAAs in Iran especially in high-risk patients. Lower rate of vascular complications, ICU length of stay and lower level of BUN and Cr were observed using spinal anesthesia in patients who underwent EVAR in our centers.

Keywords: Abdominal aortic aneurysm; Endovascular aortic repair; Treatment outcome

Date of submission: 2021-Sep-15, ***Date of acceptance:*** 2022-Apr-17

Introduction

Abdominal aortic aneurysms (AAAs) occurred mostly among men aged more than 65 years old in developing countries [1]. Its exact prevalence is unknown, but varied between 1-8.9% in different

How to cite this article: Khosravi A, Eghbal A, Kermani-Alghoraishi M, Behjati M, Shahabi J, Mansouri A. **Short and one-year outcome of endovascular aortic repair (EVAR) for abdominal aortic aneurysms (AAAs).** ARYA Atheroscler 2022; 18(5): 2518.

1- Professor, Hypertension Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran
2- Isfahan Cardiovascular Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran
3- Assistant professor, Interventional Cardiology Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran
4- Cardiac Rehabilitation Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran
5- Heart Failure Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran
6- Assistant Professor, Hypertension Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran
Address for correspondence: Asiye Mansouri; Assistant Professor, Hypertension Research Center, Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran ; Email: mansouri.arn@gmail.com

studies [2, 3]. During the past two decades, the incidence has raised due to population aging, the increase in the number of smokers, and improved diagnostic tools and screening programs [4, 5]. To the best of our knowledge, there is no report about the mortality rate related to aortic aneurysms in Iran, however, rupture of these aneurysms causes about 8000 and 15000 deaths per year in the UK and the USA, respectively [6, 7]. Although some patients have vague symptoms, including back pain or abdominal pain, most AAAs are asymptomatic until rupture, which leads to death in 65-85% of patients [8]. There are various causes of AAAs, in which a few cases are directly caused by trauma, acute/chronic infection (brucellosis and salmonellosis/ tuberculosis), inflammatory diseases (Behçet and Takayasu disease), and connective tissue disorders (Marfan Syndrome, Ehlers-Danlos type IV) [9]. Thus, most cases of AAAs are categorized as non-specific ones [10, 11]. In addition, atherosclerosis and some additional factors such as tobacco smoking, Caucasian race, and familial clustering of AAAs are probably involved in aneurysm development [12-14].
Conventional management of AAA is made through open repair with a mortality rate [13, 15]. During the past three decades the world has witnessed a transition from physician-made devices to industry-made devices with a dramatic improvement in stent-graft technology. Then, endovascular aortic repair (EVAR) of AAAs has been marked as standard practice. It was introduced by Parodi in 1991 consisted of the placement of an endograft across the aneurysm followed by its fixation to the normal aortic and iliac artery walls with stents at both ends to exclude the aneurysm from the circulation [16]. EVAR is more cost-effective in comparison to open surgery [17]. According to a meta-analysis EVAR has lower mortality compared with open surgery [18]. The lower physiological stress of the minimally invasive endovascular approach may be associated with subsequent lower morbidity and mortality rates. However, similar to open repair, EVAR may be associated with respiratory, cardiac, renal, neurologic and hemorrhagic complications, endoleak, stent migration and stent wire fracture [19, 20]. In this study, we aimed to investigate the short- and long-term outcomes of EVAR in patients with AAAs in Isfahan, a referral city for endovascular interventions in the center of Iran. All of these patients who were referred to the referral centers in Isfahan were high risk for open surgical repair.

Methods

This study was conducted on the patients with AAAs who were under treatment with EVAR in 4 hospitals (Chamran hospital, Asgarieh hospital, Sepahan hospital and Saadi hospital) in Isfahan, Iran between 2017 to 2020 consequently. The ethics committee of Isfahan University of medical science approved the study protocol (project number: IR.MUI.MED.REC.1400.017). We have excluded patients who were not followed or who had missing data on their documents. Finally, 50 patients were included in our study. We collected patients' information including age, gender, history of diabetes mellitus (DM), hyperlipidemia (HLP), hypertension (HTN), coronary artery disease (CAD), chronic kidney disease (CKD), cerebrovascular accident (CVA), respiratory disease, revascularization and smoking as well as family history of AAAs and the indication(s) of EVAR from hospital records.

We performed multi-detector cardiac tomography angiography for all patients at 1, 6 and 12 months follow-up We also collected laboratory data such as hemoglobin (Hb), creatinine (Cr) and blood urea nitrogen (BUN) on admission and 72 hours after EVAR from hospital records. The short-term outcomes consisted of the duration of hospitalization, ICU admission and length of stay, pack cell usage, types of EVAR, type of anesthesia (spinal, regional and general), success rate and in-hospital mortality were recorded. We followed patients for 1 year and also recorded long-term outcomes including endoleak, contrast-induced nephropathy (CIN) and one-year mortality. Follow-up was performed by using telephone contact. If the patient's answer was positive on each outcome, he/she was requested to submit the related documents to us. Final confirmation of outcomes was obtained after reviewing the patient's documents by an interventional cardiology fellow.

Statistical analysis

We used IBM SPSS Statistics25 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp) for data analysis. Quantitative and qualitative variables are presented by mean ± standard deviation (SD) and number (percentage), respectively. Normality assumption was checked using Kolmogorov-Smirnov test and Normal quantile-quantile plot, simultaneously. We used Wilcoxon test for comparison of changes in laboratorial findings from the time of admission to 72 hours after admission. Comparison of qualitative

and quantitative variables between three groups of anesthesia was performed using Chi-square and KrusKal-Wallis H tests, respectively. Moreover, we used logistic regression to identify determinants of one-year mortality in patients with AAA who were under EVAR. The P-value < 0.05 was considered statistically significant.

Results

We recruited 50 patients with AAAs who underwent EVAR. Patients' characteristics are presented in Table 1. As shown, these patients were middle aged and dominantly male. Frequency of smoking and medical history of diabetes mellitus, hypertension, hyperlipidemia, coronary artery disease and revascularization was remarkable while medical history of chronic artery disease, chronic kidney disease and family history of aortic aneurysms was relatively low.

The majority of patients underwent elective EVAR without any symptoms. The mean±SD duration of hospitalization was 4.1±3 days. Pack cell was administrated for about half of patients during or after the procedure. Regular and Chimney EVAR were performed in 47 (94%) and 3 (6%) of patients, according to vessel anatomy, respectively. The success rate of the EVAR procedure was 100% (n=50). General, spinal and regional anesthesia were performed in 17 (34%), 23 (46%) and 10 (46%) of the patients who underwent EVAR. Regarding the complications one year after EVAR, endoleak and CIN were occurred in 3 (6%) and 3 (6%) of patients, respectively. We also reported the in-hospital and one-year mortality as 1 (2%) and 4 (8%), respectively. In-hospital mortality was duo to late hemorrhage and DIC from open femoral arteriotomy. No patient developed myocardial infarction (MI), arrhythmia, thrombosis, ischemia and infection after EVAR in our survey (Table 2).

Laboratory data are represented in table 3. Although BUN changed significantly during the 72 hours after EVAR, the differences between Cr level on admission and 72 hours after admission was not statistically significant (P-vale>0.05).

To determine predictors of one-year mortality, we used logistic regression analysis. Since the findings derived from univariate logistic regression analysis were non-significant, we did not perform further multiple logistic regression (Table 4).

The results of comparing different variables between patients who underwent EVAR via General, spinal and regional anesthesia are presented in Table 5. As displayed, Frequency of vascular complications, mechanical ventilation, duration of hospitalization, duration of ICU admission and one-year mortality and mean BUN 72 hours after EVAR was lower in spinal and regional anesthesia groups compared with general anesthesia group. On the other hand, CIN and mean of creatinine 72 hours after EVAR was lower in general anesthesia group. However, these

Table 1. Characteristics of patients with AAA who were under EVAR, 2017-2020, Isfahan- Iran

Variables	N = 50
Age (years)	66.6 (11.7)
Gender	
Male	44 (88%)
Female	6 (12%)
Past medical history	
Diabetes mellitus	12 (24%)
Hypertension	26 (52%)
Hyperlipidemia	33 (66%)
Coronary artery disease	14 (28%)
Chronic kidney disease	1 (2%)
Cerebrovascular accident	4 (8%)
Respiratory disease	0 (0%)
Revascularization	31 (62%)
Smoking	20 (40%)
Family history of aortic aneurysms	7 (14%)

Continuous and categorical variables are displayed as Mean (Standard Deviation) and Number (percentage)
AAA: Abdominal Aortic Aneurysms, EVAR: Endovascular Aortic Repair

Table 2. Short-term and one-year outcomes of patients with AAA who were under EVAR, 2017-2020, Isfahan- Iran

Variables	Mean (SD) or Number (percentage)
Indication	
Elective (diameter more than 5.5 cm)	44 (88%)
Urgent (symptomatic)	6 (12%)
Duration of hospitalization (days)	4.1 (3)
Duration of ICU admission (days)	0.3 (.6)
Pack cell usage	29 (58%)
Plan	
Regular EVAR	47 (94%)
Chimney EVAR	3 (6%)
Anesthesia	
General	17 (34%)
Spinal	23 (46%)
Regional	10 (20%)
Proglide usage	10 (20%)
Success rate	50 (100%)
Endoleak	1 (2%)
Aorta-iliac expansion	23 (46%)
Contrast-induced nephropathy	3 (6%)
In-hospital mortality	1 (2%)
1-year mortality	4 (8%)

AAA: abdominal aortic aneurysms, EVAR: endovascular aortic repair, SD: standard deviation

Table 3. Laboratory findings in patients with AAA who were under EVAR, 2017-2020, Isfahan- Iran

Variables	At admission	72 hours after admission	P-value
Hemoglobin	11.6 (4.7)	-	-
Creatinine	1 (0.4)	0.9 (0.6)	0.566[a]
Blood urea nitrogen	19.5 (9.6)	13 (9.8)	<0.001[a]

[a] Results obtained by Wilcoxon test
Values are Mean (Standard Deviation)

Table 4. Predictors of one-year mortality (univariate logistic regression) in patients with AAA who were under EVAR , 2017-2020, Isfahan- Iran

Variables	Univariate analysis		
	Exp(β)	95% CI	P-value
Age	1.04	0.45-1.14	0.41
Gender (ref: male)	2.73	0.24-31.5	0.42
Diabetes Melitus	3.60	0.45-28.8	0.23
Hyperlipidemia	1.60	0.15-16.7	0.69
Hypertension	0.92	0.11-7.07	0.50
Coronary	0.85	0.08-8.89	0.90
Smoking	1.56	0.20-12.0	0.67
Blood Urea Nitrogen	0.97	0.88-1.08	0.58
Creatinine	1.35	0.14-13.0	0.80
Indication (ref:elective)	2.73	0.24-31.5	0.42
Anesthesia (ref:general)/spinal	0.34	0.03-4.11	0.40
Anesthesia (ref:general)/regional	0.83	0.07-10.5	0.89
Vascular complication	2.73	0.22-31.5	0.42 [a]
Duration of ICU admission (days)	2.30	0.71- 7.47	0.17 [a]
Duration of Hospitalization (days)	1.33	0.99-1.79	0.06 [a]

AAA: abdominal aortic aneurysms, EVAR: endovascular aortic repair, ICU: intensive care unit.
P-value <0.05 was considered significant

Table 5. Comparison of patients with AAA who were under EVAR with general, spinal or regional anesthesia, 2017-2020, Isfahan- Iran

Variables	Anesthesia			P-value
	General (n=17)	Spinal (n=23)	Regional (n=10)	
Vascular complications	4(23.5)	0(0)	2(20.0)	0.053[a]
Endoleak	1(5)	1(4)	1(10.0)	0.821[b]
CIN	1(5.9)	2(8.7)	0(0)	0.627[a]
Mechanical ventilation	4(23.5)	3(13.0)	1(10.0)	0.837[a]
One-year mortality	2(11.8%)	1(4.3%)	1(10.0%)	0.671[a]
Age	66 (12)	69(17)	64(3)	0.563[b]
Duration of Hospitalization (days)	3(5)	4(2)	5(4)	0.664[b]
Duration of ICU admission (days)	0(1)	0(0)	0(0)	0.040[b]
BUN (72 hours after EVAR)	17.0(13.1)	9.8(13.9)	14.0(6.2)	0.031[b]
Creatinine (72 hours after EVAR)	1.1(0.6)	0.7(1.1)	1.3(0.5)	0.005[b]

AAA: abdominal aortic aneurysms, EVAR: endovascular aortic repair, CIN: contrast-induced nephropathy ICU: Intensive Care Unit, BUN: blood urea nitrogen.
Continuous and categorical variables are displayed as Mean (Standard Deviation) and Number (percentage), respectively.
[a] results obtained by chi-square test
[b] results obtained by Kruskal-Wallis test
P-value <0.05 was considered significant

differences were significant just for duration of ICU admission, BUN and creatinine 72 hours after EVAR.

Discussion

Generally, we found that one-year mortality among patients who underwent EVAR was 8%. In the current study, women were significantly less likely to meet the criteria for EVAR procedure. This finding was similar to Erben et al. study [21]. The proportion of females to males in our survey could show this fact.

Despite the endoleak is a common complication [22], the endoleak formation occurred in 3 patients after a one-year follow-up and was less reported compared to some previous reports which observed endoleak complication in approximately one-fourth of patients [23]. Besides. the reaserchers had no report of rupture in the one-year follow-up after EVAR. In a population-based, retrospective cohort study that has compared 6100 patients underwent EVAR and 11583 patients underwent open surgery, there was not significant difference between two groups in terms of rupture [24]. The most common complications after EVAR in current studies were aneurysm expansion, rupture and endoleak formation that can occur even after a successful procedure [25]. Endoleak is defined as a blood flow inside the aneurysm sac external to the stent graft. The aneurysm sac communicates with the systemic circulation through a variety of mechanisms, but the most common way is the reversal of flow through aortic branch vessels which then empty into the aneurysm sac [26].

One of the advantages of EVAR was short-term hospitalization length as seen in previous studies [27]. Our data demonstrating the approximate mean duration of hospitalization of 4 days is consistent with these studies. The overall one-year mortality was 8% in our study in-hospital mortality was 2% which was due to complications of open surgery. Beck et al. reported 5.8% one-year mortality after EVAR in their study [28]. In another study by Lieberg J et al., 30-day, 90-day and 5-year mortality rate of patients underwent elective AAAs were 0.9%, 2.6%, and 32%, respectively [29]. Bush RL et al. have also demonstrated lower one-year mortality in EVAR vs. open repair of AAAs (8.7% vs 12.1%, p = 0.018) [30].

Furthermore, we observed significant differences regarding vascular complications, duration of ICU length of stay and BUN and Cr levels at 72 hours after EVAR between three groups of anesthesia. It has been proven that local anesthesia is safe and may decrease recovery times and medical morbidity compared to general and regional anesthesia [31]. To best of our knowledge, this is the first study which reveals these relationships in cases who undergo EVAR. But in our study, no advantage for an anesthetic technique could be demonstrated by evaluation of one-year mortality. Parra et al. were

also unable to show any difference in mortality rate using different anesthesia techniques [31]. The absence of such advantages could be attributed to the small number of participants in each studied anesthesia group in our study.

Conclusion

Desirable short- and long-term outcomes as expected, combined with a reduction in hospital length of stay and one-year mortality allowed EVAR to become the favorable therapeutic strategy for AAAs in Iran. Lower vascular complications and limited ICU length of stay were also observed using spinal compared to general and regional anesthesia in patients who underwent EVAR in our center. Additionally, spinal anesthesia was associated with lower BUN and Cr level at 72 hours post EVAR. To best of our knowledge, this is the first study which reveals these relationships.

Acknowledgment

This research was supported by Isfahan University of Medical Science (project number: 54421). The ethics committee of Isfahan University of medical science approved the study protocol (project number: IR.MUI.MED.REC.1400.017). We thank our colleagues from Cardiovascular Research Institute who provided insight and expertise that greatly assisted the research.

References

1. Sakalihasan N, Michel JB, Katsargyris A, Kuivaniemi H, Defraigne JO, Nchimi A, et al. Abdominal aortic aneurysms. Nat Rev Dis Primers 2018; 4(1): 34.
2. Gianfagna F, Veronesi G, Tozzi M, Tarallo A, Borchini R, Ferrario MM, et al. Prevalence of Abdominal Aortic Aneurysms in the General Population and in Subgroups at High Cardiovascular Risk in Italy. Results of the RoCAV Population Based Study. Eur J Vasc Endovasc Surg 2018; 55(5): 633–9.
3. Lindholt JS, Diederichsen AC, Rasmussen LM, Frost L, Steffensen FH, Lambrechtsen J, et al. Survival, Prevalence, Progression and Repair of Abdominal Aortic Aneurysms: Results from Three Randomised Controlled Screening Trials Over Three Decades. Clin Epidemiol 2020; 12: 95–103.
4. Jahangir E, Lipworth L, Edwards TL, Kabagambe EK, Mumma MT, Mensah GA, et al. Smoking, sex, risk factors and abdominal aortic aneurysms: a prospective study of 18 782 persons aged above 65 years in the Southern Community Cohort Study. J Epidemiol Community Health 2015; 69(5): 481–8.
5. Summers KL, Kerut EK, Sheahan CM, Sheahan MG. Evaluating the prevalence of abdominal aortic aneurysms in the United States through a national screening database. J Vasc Surg 2021; 73(1): 61–8.
6. Karthikesalingam A, Holt PJ, Vidal-Diez A, Ozdemir BA, Poloniecki JD, Hinchliffe RJ, et al. Mortality from ruptured abdominal aortic aneurysms: clinical lessons from a comparison of outcomes in England and the USA. Lancet 2014; 383(9921): 963–9.
7. Karthikesalingam A, Vidal-Diez A, Holt PJ, Loftus IM, Schermerhorn ML, Soden PA, et al. Thresholds for Abdominal Aortic Aneurysm Repair in England and the United States. N Engl J Med 2016; 375(21): 2051–9.
8. Erhart P, Hyhlik-Dürr A, Geisbüsch P, Kotelis D, Müller-Eschner M, Gasser TC, et al. Finite element analysis in asymptomatic, symptomatic, and ruptured abdominal aortic aneurysms: in search of new rupture risk predictors. Eur J Vasc Endovasc Surg 2015; 49(3): 239–45.
9. Anagnostakos J, Lal BK. Abdominal aortic aneurysms. Prog Cardiovas Dis 2021; 65: 34–43.
10. Forneris A, Kennard J, Ismaguilova A, Shepherd RD, Studer D, Bromley A, et al. Linking Aortic Mechanical Properties, Gene Expression and Microstructure: A New Perspective on Regional Weakening in Abdominal Aortic Aneurysms. Front Cardiovasc Med 2021; 8: 631790.
11. Ribeiro T, Ferreira RS, Catarino J, Vieira I, Correia R, Bento R, et al. Aneurisma Da Aorta Abdominal Complicado De Fístula Aorto-Cava Primária-Experiência Institucional E Revisão Da Literatura. Angiologia e Cirurgia Vasc 2021; 17(1): 20–6.
12. Kuivaniemi H, Ryer EJ, Elmore JR, Tromp G. Understanding the pathogenesis of abdominal aortic aneurysms. Exp Rev Cardiovasc Ther 2015; 13(9): 975–87.
13. Ullery BW, Hallett RL, Fleischmann D. Epidemiology and contemporary management of abdominal aortic aneurysms. Abdom Radiol 2018; 43(5): 1032–43.
14. Erhart P, Cakmak S, Grond Ginsbach C, Hakimi M, Böckler D, Dihlmann S. Inflammasome activity in leucocytes decreases with abdominal aortic aneurysm progression. Int J Mol Med 2019; 44(4): 1299–308.
15. van Schaik TG, Yeung KK, Verhagen HJ, de Bruin JL, van Sambeek MR, Balm R, et al. Long-term survival and secondary procedures after open or endovascular repair of abdominal aortic aneurysms. J Vasc Surg 2017; 66(5): 1379–89.
16. Parodi JC, Palmaz JC, Barone HD. Transfemoral Intraluminal Graft Implantation for Abdominal Aortic Aneurysms. Ann Vasc Surg 1991; 5(6): 491–9.
17. Canning P, Tawfick W, Whelan N, Hynes N, Sultan S. Cost-effectiveness analysis of endovascular versus

open repair of abdominal aortic aneurysm in a high-volume center. J Vasc Surg 2019; 70(2): 485–96.
18. Burgers LT, Vahl AC, Severens JL, Wiersema AM, Cuypers PWM, Verhagen HJM, et al. Cost-effectiveness of Elective Endovascular Aneurysm Repair Versus Open Surgical Repair of Abdominal Aortic Aneurysms. Eur J Vasc Endovasc Surg 2016; 52(1): 29–40.
19. Aridi HND, Locham S, Nejim B, Ghajar NS, Alshaikh H, Malas MB. Indications, risk factors, and outcomes of 30-day readmission after infrarenal abdominal aneurysm repair. J Vasc Surg 2018; 67(3): 747-758.e7.
20. Hicks CW, Alshaikh HN, Zarkowsky D, Bostock IC, Nejim B, Malas MB. Intensive care unit admission after endovascular aortic aneurysm repair is primarily determined by hospital factors, adds significant cost, and is often unnecessary. J Vasc Surg 2018; 67(4): 1091-1101.e4.
21. Erben Y, Bews KA, Hanson KT, Rocha-Franco JAD, Money SR, Stone W, et al. Female Sex is a Marker for Higher Morbidity and Mortality after Elective Endovascular Aortic Aneurysm Repair: A National Surgical Quality Improvement Program Analysis. Ann Vasc Surg 2020; 69: 1–8.
22. Major M, Long GW, Eden CL, Studzinski DM, Callahan RE, Brown OW. Long-term outcomes and interventions of postoperative type 1a endoleak following elective endovascular aortic aneurysm repair. J Vasc Surg 2022; 75(1): 136-143.e1.
23. Quinn AA, Mehta M, Teymouri MJ, Keenan ME, Paty PSK, Zhou Y, et al. The incidence and fate of endoleaks vary between ruptured and elective endovascular abdominal aortic aneurysm repair. J Vasc Surg 2017; 65(6): 1617–24.
24. Salata K, Hussain MA, de Mestral C, Greco E, Aljabri BA, Mamdani M, et al. Comparison of Outcomes in Elective Endovascular Aortic Repair vs Open Surgical Repair of Abdominal Aortic Aneurysms. JAMA Network Open 2019; 2(7): e196578.
25. Ramaiah VG, Thompson CS, Rodriguez-Lopez JA, DiMugno L, Olsen D, Diethrich EB. Endovascular Repair of AAA Rupture 20 Months after Endoluminal Stent-Grafting. J Endovasc Ther 2001; 8(2): 125–30.
26. Wible BC, Walker TG. Diagnostic imaging: interventional procedures. Elsevier Health Sciences 2017.
27. Rutherford RB, Krupski WC. Current status of open versus endovascular stent-graft repair of abdominal aortic aneurysm. J Vasc Surg 2004; 39(5): 1129–39.
28. Beck AW, Goodney PP, Nolan BW, Likosky DS, Eldrup-Jorgensen J, Cronenwett JL. Predicting 1-year mortality after elective abdominal aortic aneurysm repair. J Vasc Surg 2009; 49(4): 838–44.
29. Lieberg J, Pruks LL, Kals M, Paapstel K, Aavik A, Kals J. Mortality After Elective and Ruptured Abdominal Aortic Aneurysm Surgical Repair: 12-Year Single-Center Experience of Estonia. Scand J Surg 2018; 107(2): 152–7.
30. Bush RL, Johnson ML, Collins TC, Henderson WG, Khuri SF, Yu HJ, et al. Open Versus Endovascular Abdominal Aortic Aneurysm Repair in VA Hospitals. J Am Coll Surg 2006; 202(4): 577.
31. Parra JR, Crabtree T, McLafferty RB, Ayerdi J, Gruneiro LA, Ramsey DE, et al. Anesthesia technique and outcomes of endovascular aneurysm repair. Ann Vasc Surg 2005; 19(1): 123–9.