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REVIEW PAPERS

EVALUATION OF THE PERIOPERATIVE RISK FACTORS IN PATIENTS WITH THE ABDOMINAL AORTA ANEURYSM – LITERATURE REVIEW

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Progressive expansion of population over 70 years of age results in increased number of patients diagnosed with abdominal aorta aneurysm (AAA). These patients have also other comorbidities that can significantly affect the perioperative risk and therefore surgical treatment of AAA carries a relatively high risk of complications.

Perioperative risk assessment scales

According to recommendation of EUROSTAR (European Collaborators on Stent–Graft Techniques for Abdominal Aortic Aneurysm Repair), the recommended conventional assessments of surgical risk in patients diagnosed with AAA include: American Society of Anesthesiologists classification (ASA) and a numerical scale prepared by Society for Vascular Surgery and International Society for Cardio-Vascular Surgery (SVS/ISCVS) (1). A five-point classification of physical patient condition according to ASA (2) is an evaluation system most commonly used before the anesthesia in the practical setting (tab. 1). It does not evaluate the risk of anesthesiological management, but allows comparison of final outcome of anesthesia and surgical treatment basing on predetermined and conventional criteria. It includes patient age and type and severity of comorbidities (3). Basing on this scale, average risk of perioperative death until day 7 after the surgical procedure, was established for particular risk groups: I – 0.06%, II – 0.47%, III – 4.39%, IV – 23.48%, V – 50.77% (4). Patients with symptomatic AAA fall into group IV and with ruptured AAA – to group IV/V.

SVS/ISCVS scale, recommended by EUROSTAR, includes significant risk factors such as: hypertension, ischemic heart disease, diabetes mellitus, respiratory insufficiency, renal failure, carotid artery stenosis, hyperlipidemia, cigarette smoking and determines their severity on 0-3 scale (tab. 2).

Table 1. ASA classification to assess operative risk related to major complications or death of a patient during or immediately after anesthesia (2)

Risk group	Description of physical condition of a patient
I	healthy patent without any physiological, biochemical or mental abnormalities
II	a patient with mild systemic disorder, subjects below 6 months of age or over 75 years of age
III	a patient with a serious systemic disease that limits his fitness and daily activity
IV	a patient with an extreme systemic disorder that is a constant threat to life
V	a patent with multiorgan failure, in extremely poor condition, who is very likely to die within the next 24 hours irrespective of undergoing surgical treatment or not, e.g. a patient with a ruptured aorta aneurysm

Table 2. Surgical risk scale according to SVS/ISCVS (1)

Risk factors	Points			
	0	1	2	3
Diabetes mellitus	none	onset at mature age, does not require insulin therapy	ponset at mature age, on insulin therapy	childhood onset
Cigarette smoking	nonsmoker	does not smoke but has smoked within the past 10 years	smokes < 1 pack daily	smokes > 1 pack daily
Arteria hypertension	none	controlled on 1 medication	controlled on 2 medications	controlled on > 2 medications or uncontrolled
Serum lipids	normal	slight elevation, controlled on diet alone	hyperlipidemia type II, III or IV, requires low fat diet	requires diet and drugs
Ichemic hart disease	asymptomatic, normal ECG	history of myocardial infarction >6 months ago or only in ECG	stable coronary artery disease, controlled cardiac arrhythmias	unstable coronary artery disease, poorly controlled cardiac arrhythmias, myocardial infarction < 6 months
Carotid artery stenosis	no stenosis	asymptomatic stenosis	a history of TIA or stroke without neurological deficit	a history of stroke with neurological deficit
Renal failure	creatinine < 1.5 mg/dL, clearance > 50 ml/min	creatinine 1.5-3 mg/dL, clearance 30-50 ml/min	creatinine 3-6 mg/dL, clearance 15-30 ml/min	creatinine > 6 mg/dL, clearance <15 ml/min or dialyses or post kidney transplantation
Respiratory insufficiency	asymptomatic, normal chest X-ray, spirometry 80-100% predicted values	moderate dyspnea, low grade parenchyma changes in chest X-ray, spirometry 65-80% predicted values	between 1 and 3	pulmonary hypertension orb VC <1.85 l, FEV_1 <1.2 l, MVV <28 l/min., pCO_2 >45 mm Hg, required oxygen therapy

TIA – transient ischemic attack, VC – vital capacity of lungs; FEV_1 – forced expiratory volume in one second; MVV – maximal voluntary ventilation; pCO_2 – CO_2 partial pressure in arterial blood

The perioperative risk rises with number of points related to severity of these risk factors (5).

According to recommendations of American College of Cardiology and American Heart Association (ACC/AHA), AAA patients require particularly meticulous preoperative assessment (ECG, echocardiography, possible coronary angiography and pharmacological treatment). Even patients undergoing surgical treatment for non-cardiac causes, are at high risk of cardiovascular complications during the perioperative period. The degree of risk depends on type and setting of surgical treatment, type of anesthesia, presence of clinical cardiovascular disorders, general health. According to New York Heart Association (NYHA), endovascular procedures are moderate risk procedures, while procedures involving aorta are high risk procedures (6).

In 1977 Goldman et al. proposed a multifactorial method of assessment of risk of postoperative cardiovascular complications in patients undergoing surgical treatment for non-cardiac causes, basing on such data as: age, setting of surgical treatment, type of surgical treatment, history of myocardial infarction, presence of cardiac arrhythmias and poor general condition of a patient (7).

Nine years later, Goldman's criteria were modified by Detsky who added degrees of severity of ischemic heart disease and pulmonary edema (8).

Hardman et al., on the basis of retrospective studies conducted in 1985-1993 in 154 patients treated for ruptured abdominal aorta aneurysm, identified five independent preoperative risk factors: age over 76 years, anemia with Hb <9 g/dL, history of loss of consciousness, myocardial ischemia in ECG and serum creatinine >1.4 mg/dl (tab. 3). According to Hardman et al., these risk factors are major determinants and may be helpful in deciding whether to qualify a patient to surgical treatment due to ruptured AAA. Occurrence of at least three of these factors is associated with 100% risk of death despite surgical treatment (tab. 4) (9).

Table 3. Hardman scale – independent factors of perioperative risk (9)

Risk factors	Points
None	0
Age >76 years	1
Anemia (Hb <9 g/dL)	1
History of loss of consciousness	1
Myocardial ischemia (in ECG)	1
Creatinine concentration > 1.4 mg/dL	1

Table 4. Relationship between total points and level of risk of death according to Hardman (9)

Total points	Risk of death (%)
0	16
1	37
2	72
3	100
4	100
5	100

In 1994 Samy at al. proposed assessment of death risk according to Aneurysm Score (GAS) (tab. 5). Mortality risk can be assessed basing on such data as: age, shock at admission, presence of ischemic heart disease, cerebrovascular disease, renal failure (10). Numerous studies indicate that this scale is currently sued and recommended for estimating the risk of death in high risk patients, in particular with ruptured AAA, undergoing open or endovascular surgical procedure (11, 12).

Other tools of assessment of risk of early mortality include: POSSUM (Physiological and Operative Severity Score for enUmeration of Mortality) (tab. 6) (13) and VBHOM (Vascular Biochemistry and Haematology Outcome Models) (14). Despite publications concerning practical aspect of these scales, attempts of their routine use to predict treatment outcome of AAA patients raise controversies (15, 16, 17).

Markar et al. proposed use of a numerical scale of risk assessment of pulmonary complications (PPRI – Post-operative Pneumonia Risk Index) for patients undergoing surgical treatment for AAA. This scale includes the following factors: patient age and general health, type of surgical procedure, type of anesthesia, presence of COLD, loss of body weight more than 10% over 6 months before the surgical procedure, chronic steroid therapy, serum urea concentration, episodes of brain ischemia, cigarette smoking, alcohol abuse (tab. 7) (18, 19).

Risk of treatment of ruptured AAA

In 1954 Gerbode did a first successful surgical treatment of ruptured abdominal aorta aneurysm (20). According to some centers of vascular surgery, mortality in this group of patients, undergoing conventional surgical procedure, is still high and on average reaches 50% (21, 22). Due to availability of endovascular treatment of ruptured AAA, average mortality rate has been greatly reduced and amounts to 24% (23, 24). Basing on 5-year studies in 178 AAA patients, Sharif et al. determined risk of death basing on score on Hardman scale. Average patient age was 73.9 years and mortality was 57.3%. Despite much higher average mortality rate (57.3%) as compared to Hardman studies (39%), 100% risk of death occurred only in patients in whom at least four of five risk factors coexisted. Age and a history of myocardial infarction were the most potent determinants of mortality until day 30 after the procedure (25). Studies by Karkos et al. also supported utility of Hardman scale as a prognostic tool for early mortality in patients undergoing endovascular treatment for ruptured AAA. Occurrence of a single risk factor was associated with 21% risk of death, while occurrence of three or more risk factors was associated with 78% risk of death (26). Correlation between mortality rates within 30 days and one year after the surgical procedure depending on patient age was presented by Rigberg et al. as a result of retrospective analysis of three patient groups: those undergoing elective conventional procedure for AAA, those operated due to ruptured AAA and general population. Mortality rate for patients in the age range 70-79 years within one year after the surgical treatment was 9.5% in the first group, 55.5% in the second group and 4.4% in the third one. Mortality rate in patients undergoing surgical treatment for AAA is markedly higher than in the general popula-

Table 5. GAS scale – assessment of risk of death (10)

Risk factors	Points
Age	number of years
Shock	17
Ischemic hart disease	7
Cerebrovascular disease	10
Renal failure	14

Table 6. POSSUM scale – early risk of death calculator (13)

Physiological parameters	1	2	4	8	Points
Age (in years)	<61	61-70	>70		
Cardiovascular	no pathology	diuretics, digoxin, drugs for coronary artery disease or hypertension	peripheral edema, warfarin, borderline cardiomyopathy	elevated JVP, cardiomegaly	
Respiration	no dyspnea	post-exercise dyspnea, mild COLD	limited dyspnea, moderate COLD	resting dyspnea, pulmonary fibrosis/ densities in chest X-ray	
ECG	normal	atrial fibrillation, hart rate 60-90 bpm	other arrhythmias, Q waves, ST/T changes		
Systoli pressure (mm Hg)	110-130	100-109 or 131-170	>170 lub / or 90-99	<90	
Hart rate (bpm)	50-80	81-100	101-120	<40 lub / or >120	
Hemoglobin (g/dl)	13-16	11,5-12,9 or 16,1-17	10-11,4 lub / or 17,1-18	<10 lub / or >18	
White blond cell count (10^3/µl)	4-10	10,1-20 or 3,1-4	>20 lub / or <3		
Urea (mmol/l)	<7,6	7,6-10	10,1-15	>15	
Sodium (mmol/l)	>135	131-135	126-130	<126	
Potassium (mmol/l)	3,5-5	3,2-3,4 or 5,1-5,3	2,9-3,1 lub / or 5,4-5,9	<2,9 or >5,9	
Glasgow scale (in points)	15	12-14	9-11	<9	
Parameters of the procedure	1	2	4	8	Points
Procedure type	minor procedure	moderate procedure	major procedure	major, complex procedure	
Number of procedures	one	two	more than two		
Intraoperative blond loss (ml)	<100	101-500	501-999	>1000	
Peritoneal contamination	no contamination	mild contamination	focal suppurative site	alimentary contents, pus or blood	
Malignancy	not malignant	only primary lesion	malignant with involvement of lymph nodes	malignant with metastases	
Setting of the procedure	elective	urgent	urgent (within 2 hours)		

tion (27). Basing on Glasgow Aneurysm Score, Leo et al. investigated risk of Heath in 114 patients with ruptured AAA. Mortality rate in a group above 85 points on GAS scale was 88.9% (28). Italians studies by Antonello et al., conducted between 1988 and 2005, enrolled patients with symptomatic AAA undergoing conventional surgical treatment, in whom utility of GAS scale as a tool for assessment of death risk was confirmed. Postoperative mortality rate was 2.9% in patients with GAS < 90 points and 50% in patients with GAS > 90 points (29). However Tambyraja et al. published a paper that cast doubt over practical utility of this scale. They obtained lower mortality rate (37%) over two years in one hundred of patients with ruptured abdominal aorta aneurysm and average age of 73 years despite very high risk according to GAS scale (30).

Risk of treatment of asymptomatic AAA

Literature indicates that an average early mortality rate (up to day 30 after the procedure) in patients with asymptomatic AAA undergoing conventional procedure is 4 – 5%, while for endovascular procedures it is 1 – 2% (31, 32). Long term follow-up indicated similar mortality in these both groups of patients, while patients undergoing endovascular procedures had number of complications increased by three fold (33). Baas et al. studied 345 patients undergoing an elective open surgery (n = 174) and endovascular procedure (n = 171) and analyzed mortality risk within 30 days and 2 years after the surgical treatment with GAS scale. Results were comparable in both these groups and supported utility of this scale (34). However it must be emphasized that this

Table 7. PPRI scale – assessment of risk of pulmonary complications (18, 19)

Risk factors	Points
Type of surgical procedure	
AAA surgery	15
Toracosurgical procedure	14
Procedure involving abdominal cavity	10
Procedure involving neck	8
Neurosurgical	8
Vascular excluding AAA and CNS	3
Age	
80 or more years	17
70-79	13
60-69	9
50-59	4
Daily activity	
Complete dependence in daily activities	10
Partial dependence in daily activities	6
Loss of > 10% of body weight during the past 6 months	7
COLD	5
Poor reaction to stimuli	4
General anesthesia	4
Cerebrovascular accident	4
Serum urea concentration	
<8 mg/dL	4
22-30 mg/dL	2
>30 mg/dL	3
Blood transfusion> 4 units	3
Surgical procedure in an emergency setting	3
Chronic steroid therapy	3
Cigarette smoking during the past year	3
Alcohol drinking during the past 2 weeks	2

scale seems to be a particularly valuable prognostic tool for perioperative mortality in patients undergoing endovascular procedures, who are usually at higher preoperative risk. A study by Urbonavicious et al., conducted in Lithuania in 1999-2003, was a detailed analysis of perioperative risk factors in one hundred patients with asymptomatic or symptomatic AAA. Basing on preoperative assessment including: ASA scale, medical and cardiac status of the patient, ECG and echocardiography, renal function, and intraoperative assessment including: basic vital signs, blood loss, duration of the surgical procedure as well as postoperative assessment including: respiratory and cardiovascular function, duration of hospitalization after the surgical procedure, categorized patients into three risk groups: low, moderate and high.

They showed that postoperative mortality in these groups was 2.9%, 8% and 44.4%, respectively. The most important risk factors were: age above 75 years, female gender, presence of symptomatic aneurysm, history of myocardial infarction, respiratory insufficiency or renal failure. No statistically significant differences were shown for arterial hypertension, coronary artery disease, overweight or ejection fraction < 40% (35). Higher mortality rate in the mentioned Urbonavicious study probably reflects inclusion of patients with symptomatic aneurysm in the study and a small sample size. Results of a study by Elkouri et al., conducted in 1999 – 2001 in 355 patients undergoing conventional surgical treatment (n = 261) an endovascular treatment (n = 94) were very good. Mortality in both these groups was 1.2% and 0%, respectively. Elary postoperative complication rate (until day 30) differed in both these groups and was 21.8% and 10.6% for cardiac complications and 16.1% and 3.2% for pulmonary complications. Higher rate of non-surgical complications, found in patients undergoing conventional surgical treatment for AAA, seems to be related to required general anesthesia, with a significantly more extensive

surgical trauma, longer duration of the procedure and bigger blood loss (36). In 1996 Lawrence et al. published data that indicated that pulmonary complication rate after abdominal surgical procedures was similar to cardiac complication rate (37). Adverse factors related to respiratory system, such as asthma, chronic obstructive lung disease (COLD), pneumonia, cigarette smoking, may increase the perioperative risk (38). Postoperative respiratory insufficiency, requiring respirator therapy, is the most dangerous pulmonary complication. Five to 21% of patients who undergo surgical treatment for AAA, require artificial ventilation in the postoperative period. In 2001 Axelroad et al., basing on multicenter, retrospective studies in 1053 who underwent surgical treatment for AAA, including 25.1% subjects with COLD, among others analyzed the following data: total duration of hospitalization, number of days spent in intensive care units, number of hours of artificial ventilation. 6.9% of patients with COLD required respirator assistance in the postoperative period. This contrasts with a group of patients free of COLD, where only 3.6% required such management. COLD seems to be an important determinant of requirement for postoperative artificial ventilation that prolongs hospitalization and increases cost of treatment of these patients. Furthermore, COLD has been shown not to increase patient mortality or risk of AAA rupture (39). Preoperative assessment of respiratory system identifies high risk patients and allows successful actions to be undertaken: quitting smoking, pharmacological treatment of asthma and COLD, implementation of targeted antibiotic therapy for pneumonia, selection of an optimal anesthesia method, successful treatment of postoperative pain, respiratory rehabilitation that can reduce the risk of complications in this patient group (40). Literature recommends spirometry for any patient undergoing surgical treatment for AAA (41).

Aneurysm size, in particular its diameter, is another prognostic factor that affects the risk (42, 43). During five-year follow-up, Hallin et al. published data related to the risk of aneurysm rupture depending on its diameter. Over one year, small aneurysms (with up to 4 cm in diameter) increased their diameter by 2-4 mm, moderate aneurysms (with 4-5 cm in diameter) – by 2-5 mm, while large aneurysm (over 5 cm in diameter) increased their diameter by 3-7 mm. The risk of rupture after 5 years of follow-up was 2%, 10%, and 22%, respectively (44). Independent researchers, Mofidi and Solberg, came to controversial conclusions related to relationship between growth of an aneurysm and patient gender. They found the aneurysms to increase their size faster in woman, which probably may lead to higher rupture risk than in men (45, 46). Thomson, publishing his data in 2009 from several years of screening studies, came to opposite conclusions (47). Recently other, often neglected risk factors in AAA patients, have been emphasized in the literature: postoperative stress (48) and disorders of nutrition, in particular obesity (49).

Precise determination of perioperative risk in patients diagnosed with AAA is impossible due to numerous variable prognostic factors. Preliminary qualification to a high risk group allows for optima patent preparation to a surgical procedure and selection of adequate surgical treatment that may result in reduction of risk of complications and reduction of mortality. Current literature data indicate a clear trend toward reduction of mortality rate in patients from high perioperative risk groups due to progress in surgical technique and anesthesiology, associated with AAA treatment.

REFERENCES

1. Eurostar Data Registry Centre Progress Report Abdominal aortic aneurysms 2004; 1-29.
2. American Society of Anesthesiologists. New classification of physical status. *Anesthesiology* 1963; 24: 111.
3. *Keats AS*: The ASA classification of physical status – a recapitulation. *Anesthesiology* 1978; 49: 233-36.
4. *Owens WD, Felts JA, Spitznagel EL*: ASA physical status classifications: a study of consistency of ratings. *Anesthesiology* 1978; 49: 239-43.
5. *Brewster D, Cronenwett JL, Hallet JW* et al.: Guidelines for the treatment of abdominal aortic aneurysms. *J Vasc Surg* 2003; 37: 1106-17.
6. *Eagle KA, Berger PB, Calkins H* et al.: ACC/AHA guideline update for perioperative cardiovascular

evaluation for noncardiac surgery – executive summary: a report of the American College of Cardiology/American Heart Association task force on practice guidelines (committee to update the 1996 guidelines on perioperative cardiovascular evaluation for noncardiac surgery). *Circulation* 2002; 105 (10): 1257-67.
7. *Goldman L, Caldera DL, Nussbaum SR* et al.: Multifactorial index of cardiac risk in noncardiac surgical procedures. *N Eng J Med* 1977; 297: 845-50.
8. *Detsky AS, Abrams HB, McLaughlin JR* et al.: Predicting cardiac complications in patients undergoing noncardiac surgery. *J Gen Intern Med* 1986; 1: 211-19.
9. *Hardman DTA, Fisher CM, Patel M* et al.: Ruptured abdominal aortic aneurysm: who should be offered surgery? *J Vasc Surg* 1996; 23: 123-29.
10. *Samy AK, Murray G, MacBain G* et al.: Glasgow Aneurysm Score. *Cardiovasc Surg* 1994; 2: 41-44.
11. *Visser JJ, Williams M, Kievit J* et al.: Prediction of 30-day mortality after endovascular repair or open surgery in patients with ruptured abdominal aortic aneurysms. *J Vasc Surg* 2009; 49: 1093-99.
12. *Rix T, Bates T*: Pre-operative risk scores for the prediction of outcome in elderly people who require emergency surgery. *World J Emerg Surg* 2007; 2: 16-26.
13. *Copeland GP*: The POSSUM system of surgical audit. *Arch Surg* 2002; 137: 15-19.
14. *Tang T, Walsh SR, Prytherch DR* et al.: VBHOM, a data economic model for predicting the outcome after open abdominal aortic aneurysm surgery. *Br J Surg* 2007; 94: 717-21.
15. *Patterson BO, Holt PJ, Hinchliffe R* et al.: Predicting risk in elective abdominal aortic aneurysm repair: a systematic review of current evidence. *Eur J Vasc Endovasc Surg* 2008; 36: 637-45.
16. *Tang TY, Walsh SR, Prytherch DR* et al.: POSSUM models in open abdominal aortic aneurysm surgery. *Eur J Vasc Endovasc Surg* 2007; 34: 499-504.
17. *Kodama A, Narita H, Kobayashi M* et al.: Usefulness of POSSUM Physiological score for the Estimation of Morbidity and Mortality Risk after elective abdominal aortic aneurysm repair In Japan. *Circ J* 2011; 75: 550-56.
18. *Arozullah AM, Khuri SF, Henderson WG* et al.: Development and validation of a multifactorial risk index for predicting postoperative pneumonia after major noncardiac surgery. *Ann Intern Med* 2001; 135: 847-57.
19. *Markar SR, Walsch SR, Griffin K* et al.: Assessment of a Multifactorial Risk Index for Predicting Postoperative Pneumonia after abdominal aortic aneurysm repair. *Vascular* 2009; 17: 36-39.
20. *Gerbode F*: Ruptured aortic aneurysms – a surgical emergency. *Surg Gynecol Obstet* 1954; 98: 759.
21. *Greco G, Egorova N, Anderson PL* et al.: Outcomes of endovascular treatment of ruptured abdominal aortic aneurysms. *J Vasc Surg* 2006; 43: 453-59.
22. *Hinchliffe RJ, L. Bruijstens L, MacSweeney ST* et al.: A randomised trial of endovascular and open surgery for ruptured abdominal aortic aneurysm-results of a pilot Study and lessons learned for future studies. *Eur J Vasc Endovasc Surg* 2006; 32: 506-13.
23. *Rayt HS, Sutton AJ, London NJ* et al.: A systematic review and meta-analysis of endovascular repair (EVAR) for ruptured abdominal aortic aneurysm. *Eur J Vasc Endovasc Surg* 2008; 36: 536-44.
24. *Sadat U, Hayes PD, Kullar PJ* et al.: An emergency EVAR service reduces mortality in ruptured abdominal aortic aneurysms. *Eur J Vasc Endovasc Surg* 2009; 37: 189-93.
25. *Sharif MA, Arya N, Soong CV* et al.: Validity of the Hardman index to predict outcome in ruptured abdominal aortic aneurysm. *Ann Vasc Surg* 2007; 21: 34-38.
26. *Karkos CD, Karamanos D, Papazoglou KO* et al.: Usefulness of the Hardman index In predicting outcome after endovascular repair of ruptured abdominal aortic aneurysms. *J Vasc Surg* 2008; 48: 788-94.
27. *Rigberg DA, Zingmont DS, Mc Gory ML* et al.: Age stratified, perioperative, and one-year mortality after abdominal aortic aneurysm repair: A statewide experience. *J Vasc Surg* 2006; 43: 224-29.
28. *Leo E, Biancari F, Nesi F* et al.: Risk-scoring methods in predicting the immediate outcome after emergency open repair of ruptured abdominal aortic aneurysm. *Am J Surg* 2006; 192: 19-23.
29. *Antonello M, Lepidi S, Kechagias A* et al.: Glasgow Aneurysm Score predicts the outcome after emergency open repair of symptomatic, unruptured abdominal aortic aneurysms. *Eur J Vasc Surg* 2007; 33: 272-76.
30. *Tambyraja AL, Fraser SC, Murie J* et al.: Validity of the Glasgow Aneurysm Score and the Hardman Index in predicting outcome after ruptured abdominal aortic aneurysm repair. *Br J Surg* 2005; 92: 570-73.
31. *Schermerhorn ML, O'Maley AJ, Jhaveri A* et al.: Endovascular vs. open repair of abdominal aortic aneurysms in the medicare population. *N Engl J Med* 2008; 358: 464-74.
32. *Giles KA, Pomposelli F, Hamdan A* et al.: Decrease in total aneurysm-related deaths in the era of endovascular aneurysm repair. *J Vasc Surg* 2009; 49: 543-51.
33. *Greenhalgh RM, Powell JT*: Endovascular repair of abdominal aortic aneurysm. *N Engl J Med* 2008; 358: 494-501.
34. *Baas A, Janssen K, Prinssen M* et al.: The Glasgow Aneurysm Score as a tool to predict 30-day and 2-year mortality in the patients from the Dutch Randomized Endovascular Aneurysm Management trial. *J Vasc Surg* 2008; 47: 277-81.
35. *Urbonavicius S, Vorum H, Urbonaviciene G* et al.: Predictors of post-operative mortality following treatment for non-ruptured abdominal aortic aneu-

rysm. *Current Controlled Trials in Cardiovasc Medicine* 2005; 6-14.
36. *Elkouri S, Gloviczki P, McKusick MA* et al.: Perioperative complications and early outcome after endovascular and open surgical repair of abdominal aortic aneurysms. *J Vasc Surg* 2004; 39: 497-05.
37. *Lawrence VA, Dhanda R, Hilsenback SG* et al.: Risk of pulmonary complications after elective abdominal surgery. *Chest* 1996; 110: 744-50.
38. *Smetana GW*: Preoperative pulmonary evaluation. *N Engl J Med* 1999; 340 (12): 937-44.
39. *Axelroad DA, Henke PK, Wakefield TW* et al.: Impact of chronic obstructive pulmonary disease on elective and emergency abdominal aortic aneurysm repair. *J Vasc Surg* 2001; 1: 72-76.
40. *Lawrence VA, Cornell JE, Smetana GW*: Strategies to reduce of postoperative pulmonary complications after noncardiothoracic surgery: systematic review for the American College of Physicians. *Ann Intern Med* 2006; 144: 596-608.
41. *Mitchell CK, Smoger SH, Pfeifer MP* et al.: Multivariate analysis of factors associated with postoperative pulmonary complications following general elective surgery. *Arch Surg* 1998; 133: 194-98.
42. *Noszczyk W, Stryga W, Woźniak W*: Tętniaki aorty brzusznej. W: Noszczyk W (red.) Chirurgia tętnic i żył obwodowych. Wyd. 2. Wydawnictwo Lekarskie PZWL, Warszawa 2007; 706-27.
43. *Szmidt J*: Tętniaki. W: Szmidt J, Kużdżał J (red.) Podstawy chirurgii. Wyd. 2. Medycyna Praktyczna; Kraków 2009, 1200-16.
44. *Hallin A, Bergqvist D, Holmberg L*: Literature review of surgical management of abdominal aortic aneurysm. *Eur J Vasc Endovasc Surg* 2001; 22: 197-04.
45. *Mofidi R, Goldie V, Kelman J* et al.: Influence of sex on expansion rate of abdominal aortic aneurysm. *Br J Surg* 2007; 94: 310-14.
46. *Solberg S, Singh K, Wilsgaard T* et al.: Increased growth rate of abdominal aortic aneurysms in women. The Tromso Study. *Eur J Vasc Endovasc Surg* 2005; 29: 145-49.
47. *Thompson A, Cooper J, Ashton H* et al.: Growth rates of small abdominal aortic aneurysms correlate with clinical events. *Br J Surg* 2010; 97: 37-44.
48. *Li Z, Sadat U, U-King-Im J* et al.: Association between aneurysm shoulder stress and abdominal aortic aneurysm expansion: a longitudinal follow-up study. *Circulation* 2010; 122: 1815-22.
49. *Johnson ON, Sidawy AN, Scanlon JM* et al.: Impact of obesity on outcomes after open surgical and endovascular abdominal aortic aneurysm repair. *J Am Coll Surg* 2010; 210 (2): 166-67.

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