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Early and Long-term Outcome after Open Surgical Suprarenal Aortic Fenestration in Patients with Complicated Acute Type B Aortic Dissection

Z. Szeberin [a,*], E. Dósa [a], M. Fehérvári [a], C. Csobay-Novák [a], N. Pintér [b], L. Entz [a]

[a] Department of Vascular Surgery, Cardiovascular Centre, Semmelweis University, Budapest, Hungary
[b] Department of Cardiology, Cardiovascular Centre, Semmelweis University, Budapest, Hungary

WHAT THIS PAPER ADDS

This study presents the largest cohort of patients with complicated acute type B aortic dissection treated by open surgical suprarenal aortic fenestration (OSSAF) in a single center. It is important to compare new methods (e.g. stentgraft implantation) with established techniques, but there is a lack of data in the literature about the OSSAF. Late death is frequently related to aortic rupture in patients undergoing OSSAF; therefore new techniques, such as endograft coverage of the primary entry tear are welcome, to try to avoid this complication.

Objectives: The purpose of this retrospective cohort study was to determine the early and long-term mortality and morbidity as well as to reveal risk factors influencing the long-term prognosis in patients with complicated acute type B aortic dissection (CABAD) undergoing open surgical suprarenal aortic fenestration (OSSAF).
Methods: Fifty-two patients with CABAD, defined as (impending) rupture, acute enlargement of the false lumen, malperfusion, and/or unrelenting back pain or uncontrollable hypertension despite maximum medical therapy were treated with by surgical repair between 2002 and 2008. Ten patients with (impending) rupture had aortic graft replacement, while 42 (33 men, mean age 55 ± 11 years) had OSSAF. Follow up visits were scheduled at 1, 3–6 and 12 months after the surgery and annually thereafter. Clinical examination and computed tomography angiography findings were investigated at baseline and at subsequent visits.
Results: The indications for OSSAF were acute enlargement of the false lumen in four (10%), malperfusion in 17 (40%) (11 lower extremity [26%], 6 visceral [14%]), and unrelenting back pain or uncontrollable hypertension in 21 cases (50%). The 30 day mortality was 21.4% (2 multiple organ failure, 2 heart failure, 3 pneumonia, 1 intestinal necrosis, 1 major hemorrhage). The mean follow up was 84 ± 40 months. The 5 year survival was 70.6%. Eight patients (19%) died during the follow up period (6 aortic ruptures, 2 myocardial infarctions). None of the patients became paraplegic after the surgery. Further surgery or stenting was indicated in nine cases (21%).
Conclusions: OSSAF has been performed with an acceptable early mortality and low paraplegia rate, but late mortality is frequently related to aortic rupture. Stentgraft coverage of the primary entry tear decreases late aortic related deaths, but suprarenal fenestration remains an option for cases not suitable for endovascular techniques.

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INTRODUCTION

Acute type B aortic dissection is a potentially life threatening condition with a high mortality rate. The treatment of acute type B aortic dissection can be conservative (e.g. antihypertensive therapy, pain management), surgical (e.g. aortic graft replacement, surgical flap fenestration, extra-anatomic bypass), endosurgical (e.g. interventional flap fenestration, true lumen stenting, catheter based reperfusion, stentgraft implantation), or a combination of these methods.[1] Each treatment has its own indications, contraindications, benefits, and risks. Although minimally invasive techniques have increased in the last decade, there is still a role of open surgical repair for the following reasons: (a) the endosurgical instruments and devices are not available in all centers, (b) the number of skilled interventionists remains small, and (c) endosurgery is not necessarily more cost-effective than surgical reconstructions.[2,3]

Replacement by aortic graft has been the most widely used open surgical procedure for complicated acute type B aortic dissections.[4] Until 2008 the least invasive treatment of complicated acute type B aortic dissection was the open surgical suprarenal aortic fenestration in patients without

* Corresponding author. Z. Szeberin, Department of Vascular Surgery, Cardiovascular Centre, Semmelweis University, Városmajor Street 68, 1122 Budapest, Hungary.
E-mail address: szeberin.zoltan@kardio.sote.hu (Z. Szeberin).
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rupture or impending rupture at the authors' institution. Open surgical aortic fenestration has two main advantages over aortic graft replacement: first, it saves the patients' life by correcting obstruction of the visceral aortic branches and, second, it allows preservation of intercostal arteries, thus reducing the risk of paraplegia.[5] With the exception of some smaller studies,[5–9] no comprehensive data have been published on early or long-term outcomes of open surgical suprarenal aortic fenestration in patients with complicated acute type B aortic dissection. Therefore, the purpose of this retrospective study was to determine the early and long-term results of open surgical suprarenal aortic fenestration as well as to describe the risk factors associated with the long-term prognosis.

PATIENTS AND METHODS

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Semmelweis University Ethics Committee.

Patient population

Between January 1, 2002, and December 31, 2008, 52 patients with complicated acute type B aortic dissection requiring aortic surgery were admitted to the department. Of these patients, 10 with rupture or impending rupture had aortic graft replacement, while the other 42 were treated by open surgical suprarenal aortic fenestration. The procedures were performed at the Vascular Surgery Department of Semmelweis University (Budapest, Hungary).

Definitions

Aortic dissection was classified as type B according to the Stanford classification if the dissected aorta did not involve the ascending aorta. The aortic dissection was considered acute if the dissection presented within 2 weeks of the initial onset of symptoms. The term complicated dissection was defined as rupture or impending rupture, acute enlargement of the false lumen $\geq$5 mm, malperfusion (loss of adequate blood supply to visceral organs or lower extremities due to compression of the true aortic lumen or branch vessel obstruction [either static or dynamic]), and/or unrelenting back pain or uncontrollable hypertension despite maximum medical therapy.[10] Unrelenting back pain was defined as pain persisting despite opioid therapy at maximum recommended doses if not present in the clinical history before the onset of dissection. Uncontrollable hypertension was defined as hypertension persisting despite treatment with more than three different classes of antihypertensive therapy at maximum recommended or maximum tolerated doses if not present in the clinical history before the onset of dissection.[11]

Pre-procedural protocol

The pre-procedural work up included clinical data collection (symptoms, risk factors, which have been described in detail previously[12] and medical history), physical examination, blood studies (complete blood count, serum chemistry, cardiac marker assays, plasma fibrin degradation product and fibrinogen assays, D-dimer assay, smooth muscle myosin heavy chain assay), chest X-ray interpretation, and assessment of the diseased aorta and its branches with transesophageal echocardiography, computed tomography (CT) angiography, or magnetic resonance imaging. All patients had a 12 lead electrocardiogram. The patients' heart rate and systolic blood pressure were under control; intravenous beta blockers were used as first line therapy, with a target heart rate of 60 bpm and a target systolic blood pressure of 100–120 mmHg. For those in whom beta blockers were ineffective or contraindicated, a calcium antagonist was used. If the blood pressure was not adequately controlled with beta blockers, vasodilators were added. All patients received appropriate medications for their pain; narcotics and opiates were the preferred agents.

Open surgical aortic fenestration procedure

The surgical procedure was performed under general anesthesia without left heart bypass. Patients were placed in a right oblique supine position and a standard left thoracoabdominal incision was made. After cutting through the diaphragm, the descending aorta was prepared for clamping and incision from distal thoracic level to the bifurcation. Heparin (100 IU/kg) was administered intravenously prior to the supraceliac clamping, which was used for proximal aortic control. A posterolateral longitudinal aortotomy was performed. The dissected intimal flap was resected from the aorta and the ostia of the affected visceral branches of the abdominal aorta (celiac trunk, superior mesenteric artery, and/or renal arteries). If thrombus was present in the false lumen at this level, it was also removed. Then the remaining intimal layer was fixed down with a running suture. This way a single barreled distal aortic lumen was left behind with a double lumen descending thoracic aorta and an endarterectomized short aortic segment at the ostium of the visceral branches of the abdominal aorta (Fig. 1). The aortotomy was closed with a running 3/0 or 4/0 Prolene suture.

Follow up

Follow up visits were scheduled at 1, and 3–6 and 12 months after the surgery, and annually thereafter. The postprocedural work up included clinical data collection, physical examination, and assessment of the aorta by CT angiography. The cause of death was determined by autopsy in all cases.

Statistical analysis

Statistical analysis was performed with Prism 6 for Mac OS X (Graph Pad Software, San Diego, CA, USA) and IBM SPSS Statistics for Mac OS X (IBM Corporation, Armonk, NY, USA) statistical software products. Because many of the variables had non-Gaussian distribution, non-parametric tests were applied. The Kaplan–Meier estimate was used for survival analysis. For comparison of the survival curves the Gehan–Breslow–Wilcoxon test and Mantel–Cox test were applied.

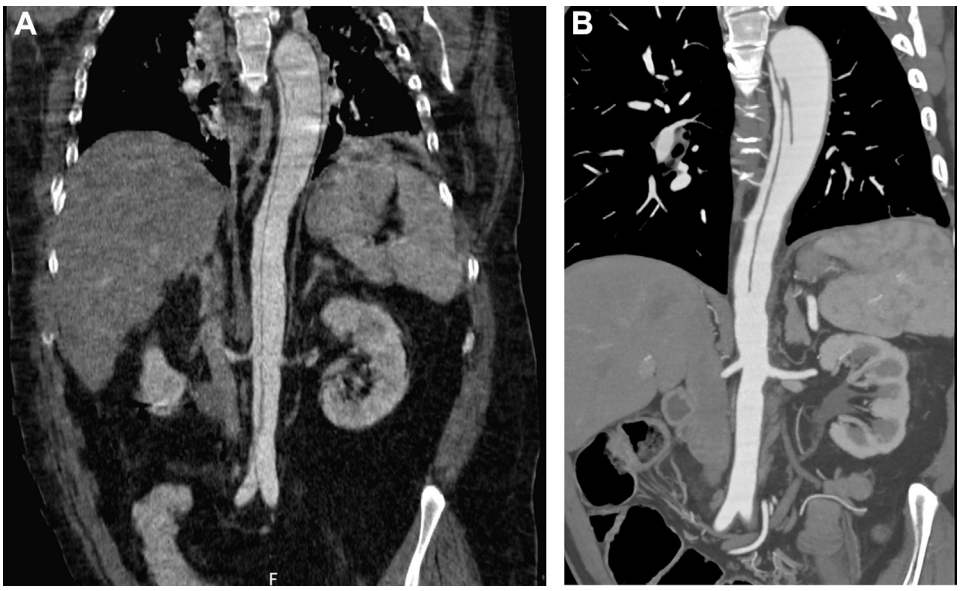


Figure 1. Contrast enhanced coronal computed tomography images show type B aortic dissection before (A) and after open surgical suprarenal aortic fenestration (B).

The Mann—Whitney U test was performed to compare two independent groups. All statistical analyses were two-tailed and $p < .05$ was considered to be significant. Values presented in the text are medians (interquartile ranges, IQR) unless otherwise stated. Fisher's exact test was used to evaluate the possible effect of different variables to all-cause mortality and rupture related mortality.

The reporting of this study conforms to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement.[13]

RESULTS

Patient data

The mean age of the 42 patients (33 men, 9 women) was 55 years (range, 28—84 years). On admission, the major symptoms were chest (36%), back (36%), and abdominal pain (28%). Oxygenation was satisfactory in 37 patients (88%); one (2%) had respiratory distress, and four (10%) were intubated and ventilated. Six patients had a relevant past medical history: five had had prior aortic surgery for type A aortic dissection and one had had cardiac surgery. Atherosclerotic risk factors were smoking in 20 patients (48%), hypertension in 38 (90%), hyperlipidemia in 27 (64%), and diabetes mellitus in two (5%). In one case (2%) the predisposing factor for aortic dissection was Marfan syndrome.

Pre-operative imaging findings

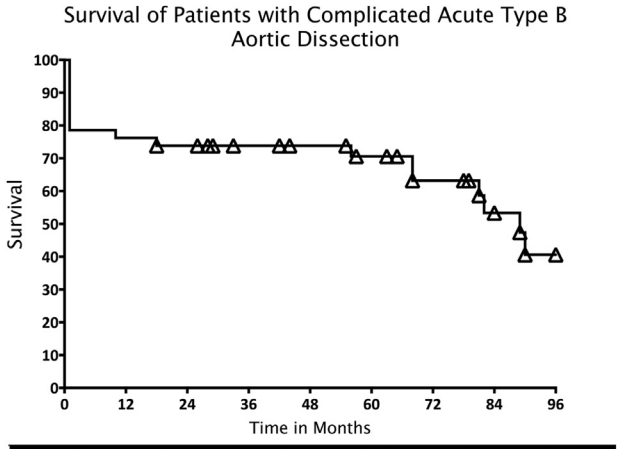
The pre-operative chest X-ray was unremarkable in 20 cases (47%). Mediastinal widening was found in 15 patients (36%) and pleural effusion in seven (17%). The mean largest descending aortic diameter on CT or MR angiogram was 54.23 $\pm$ 2.92 mm. The entry site of dissection was at the left subclavian artery in 12 (28%), in the descending thoracic aorta in 28 (67%), and in the abdominal aorta in two cases (5%). Celiac trunk involvement was seen in two patients (5%), superior mesenteric artery involvement in six (14%), renal artery involvement in five (12%), and a combination of two or three in six (14%). The re-entry dissection site was located above the aortic bifurcation in 28 cases (67%) and below the aortic bifurcation in 14 (33%). At the time of diagnosis, the false lumen was patent in 29 patients (69%), partially thrombosed in 11 (26%), and completely thrombosed in two (5%).

Surgery and early post-operative period (within 30 days)

Indications for surgery was acute enlargement of the false lumen in four (10%), malperfusion in 17 (40%) (11 lower extremity [26%], six visceral [14%]), and unrelenting back pain or uncontrollable hypertension in 21 cases (50%). The operations were performed within 14 days of admission. The average aortic clamp time was 36 $\pm$ 8 min, while the average length of the operation was 169 $\pm$ 44 min. The estimated blood loss was quite variable (1343—3665 ml). The average length of the hospital stay was 11 $\pm$ 4 days.

None of the patients became permanently paraplegic after the surgery. The 30 day mortality was 21.4% (Fig. 2). The cause of death was multiple organ failure and heart failure in two (22%), pneumonia in three (33%), and bowel ischemia in one (11%). In one case (11%) there was severe retroperitoneal hemorrhage, the aortic suture line was checked for leaks, additional stitches were placed, and splenectomy was performed because of unintended injury to the spleen. But despite all the efforts, the patient died on the eighth post-operative day due to a major hemorrhage.

Further surgery or stenting was needed in seven patients (17%): one of them underwent a femoro-femoral crossover bypass, another had a retroperitoneal hematoma evacuation, and in the third a retroperitoneal hematoma evacuation followed by right femoral fenestration, followed by a femoral thrombectomy and a right leg fasciotomy were performed. One patient required iliac artery stenting.



Follow up Time	Numbers at Risk	Percent Surviv. (95% CI)
30 days	33	78.5% (68.9–94.2)
1 year	32	73.3% (62.6–89.3)
2 years	30	73.3% (62.6–89.3)
5 years	20	70.6% (59.0–87.3)
7 years	9	53.3% (37.1–73.0)
8 years	3	40.6% (21.2–60.9)

Figure 2. Kaplan—Meier survival curve shows all cause mortality.

One underwent nephrectomy because of thrombosis of the left renal artery and infarction of the kidney. Five patients (12%) required temporary dialysis; two only briefly due to successful renal artery stenting.

Follow up period

The mean follow up was 84 ± 40 months. Eight patients (19%) died during follow up; four patients died in the first 5 years and four thereafter (Fig. 2). The cause of death was aortic rupture in five cases (63%) and acute myocardial infarction in two (25%). In one patient (12%), 9 years after surgical aortic fenestration, a large aortic aneurysm (diameter 65 mm), requiring surgery, developed just below the left subclavian artery. The patient underwent aortic aneurysm resection, but subsequently died of aortic rupture. In another patient total aortic arch replacement was carried out successfully 6 years after surgical aortic fenestration because of a large aneurysm (diameter 55 mm) involving the aortic arch. None of the patients required permanent dialysis.

Risk factors, past medical history, baseline, and 2 year follow up parameters of patients with late aortic rupture are summarized in Table 1. Except for one patient, these patients did not come back for check up 2 years following surgery. Indications for surgery were malperfusion in one (17%) case and unrelenting back pain or uncontrollable hypertension in five (83%). On admission, the descending aortic diameter was ≥40 mm in half, and the false lumen was patent in all cases. At 2 years, there was only one patient with ≥5 mm increase in the descending aortic diameter, and the false lumen remained patent in all cases (Table 1).

Imaging findings during the follow up

Twenty-six of 33 patients had serial CT angiogram scans. The average increase in descending aortic diameter measured on CT angiogram was 4 ± 2 mm/year. A positive correlation was noted between the pre-operative maximum descending aortic diameter and the diameter measured during follow up ($r = .484$, $p = .035$). Retrograde extension was seen in two patients (5%). Between the first and the last follow up examination, the false lumen status changed from patent to partially thrombosed in eight patients (19%).

Factors examined for all-cause mortality and late aortic rupture-related mortality

The following variables were examined: female gender, age ≥55 years, smoking, hypertension, hyperlipidemia, diabetes mellitus, prior aortic or cardiac surgery, acute enlargement of the false lumen on admission, malperfusion on admission, unrelenting back pain or uncontrollable hypertension on admission, descending aortic diameter ≥40 mm on admission, entry site at the level of the left subclavian artery, re-entry site below the aortic bifurcation, multiple visceral branch involvement, and patent false lumen on admission. However, no association was found between any of these variables and all cause mortality or late aortic rupture related death.

DISCUSSION

Thirty day survival was approximately 79% at 30 days and 71% at 5 years after open surgical suprarenal aortic fenestration in patients with complicated acute type B aortic dissection. The most common cause of late death was aortic rupture.

There is no perfect cure for complicated acute type B aortic dissection. Open aortic surgery can be a treatment of choice when endovascular interventional procedures are not available, have failed, or are contraindicated. Complicated acute type B aortic dissection can be managed surgically in several different ways. In the absence of rupture or impending rupture, surgical fenestration is favored over direct aortic graft replacement, and is the most commonly performed open surgical procedure in patients with complicated acute type B aortic dissection in our institute, because in cases of fenestration there is no need for cardiopulmonary bypass or other shunt maneuvers. The longitudinal aortotomy was initiated above the level of the renal arteries in all patients in the study. The suprarenal approach (longitudinal aortotomy) allows visualization of the ostia of the celiac trunk, and the mesenteric and renal arteries better than the infrarenal approach (transverse aortotomy).[5—9] The second argument in favor of suprarenal longitudinal aortotomy is if the false lumen is filled with thrombus, paravisceral aortic thrombectomy can be accomplished more easily.[5—9] To the best of the authors' knowledge, this paper presents the outcome of a retrospective study evaluating the largest number of patients who have been treated with open surgical suprarenal aortic fenestration.

The most feared complication of both open surgical and endosurgical aortic procedures is paraplegia.[9,14—18] In this study none of the patients became paraplegic due to surgery.

Table 1. Risk factors, past medical history, baseline and 2 year follow up parameters of patients with late aortic rupture.

Variable	Patient no. 1	Patient no. 2	Patient no. 3	Patient no. 4	Patient no. 5	Patient no. 6
Risk factors/past medical history						
Gender	Male	Male	Male	Female	Female	Male
Age (years)	49	70	48	59	47	38
Smoking	Yes	No	No	No	Yes	Yes
Hypertension	Yes	Yes	Yes	Yes	Yes	Yes
Hyperlipidemia	No	Yes	No	Yes	No	No
Diabetes mellitus	No	No	No	No	No	No
Prior aortic or cardiac surgery	No	No	No	No	No	No
Baseline parameters						
Indication for surgery	Unrelenting back pain or uncontrollable hypertension	Unrelenting back pain or uncontrollable hypertension	Unrelenting back pain or uncontrollable hypertension	Malperfusion	Unrelenting back pain or uncontrollable hypertension	Unrelenting back pain or uncontrollable hypertension
Maximum descending aortic diameter (mm)	34	42	42	44	34	26
Entry site	Left subclavian artery	Descending thoracic aorta	Descending thoracic aorta	Left subclavian artery	Left subclavian artery	Descending thoracic aorta
Re-entry site	Above the aortic bifurcation	Above the aortic bifurcation	Above the aortic bifurcation	Above the aortic bifurcation	Above the aortic bifurcation	Above the aortic bifurcation
False lumen	Patent	Patent	Patent	Patent	Patent	Patent
Parameters at 2 years						
Maximum descending aortic diameter (mm)	34	42	43	44	39	27
Retrograde extension	No	No	No	No	No	No
False lumen	Patent	Patent	Patent	Patent	Patent	Patent
Survival time (months)	109	56	89	62	59	49
Autopsy						
Site of rupture	Descending thoracic aorta	Descending thoracic aorta	Descending thoracic aorta	Descending thoracic aorta	Descending thoracic aorta	Descending thoracic aorta

The risk of paraplegia is known to be low in cases of surgical aortic fenestration because, as opposed to aortic graft replacement and stentgraft implantation, the intercostal arteries are not permanently excluded from the circulation.

The reported 30 day mortality rate (21.4%) is similar to the early mortality rates that can be found in other open surgical studies (16.7—29%),[9,14,15] but slightly worse than the mortality rates of aortic stentgraft implantation (0—17%).[14—16,19] In this study the 5 year survival rate was 70.6%, which is similar to the surgical and endosurgical survival rates published in the literature (60.9—82.6% and 61—84%, respectively).[14,16,19—21] The most common cause of death was aortic rupture during the follow up period. Unfortunately, except for one patient, these patients did not come back for check up 2 years following surgery. In all cases autopsies were performed to determine the cause of death. The site of rupture was remote from the initial repair in all patients and the dissected aorta was aneurysmal. This draws attention to the biggest drawback of this technique. If surgery successfully resolves the malperfusion syndrome, usually no abnormality can be seen at the site of "endo-aortectomy" on the follow up CT angiograms. But aneurysmal dilatation, especially of the aortic arch and/or descending thoracic aorta, commonly develops: sometimes slowly, often over several years, sometimes quickly, over a few months. The rate of aneurysm growth depends on the aortic diameter on admission; a positive correlation was found between the pre-operative maximum descending aortic diameter and the diameter measured during the follow up. Although it was not investigated, pre-existing comorbidities (e.g. Marfan syndrome) and patient attitude (e.g. whether he/she takes the prescribed antihypertensive medications or not) surely contribute to the formation of aneurysms in patients with aortic dissection.

Covering the primary entry tear by an endovascular approach seems to be a good option to reduce the high mortality related to late aortic expansion; however, it needs to be proven.[22] Until now, except the INSTED-XL trial, which showed an improved 5 year aorta specific survival and delayed disease progression after stentgraft implantation, no other prospective, randomized studies are available.[23] So, the possible effect of the endovascular method in preventing aortic rupture is promising, but further trials are required.

The limitations of the present study leave some of the findings incomplete. First, patients were retrospectively enrolled into the study and the results represent experience acquired in a single institution with a limited number of patients. Second, owing to the retrospective nature of patient selection, complete follow up data were not available for all patients.

CONCLUSION

Surgical suprarenal aortic fenestration can be accomplished with low paraparesis and acceptable early mortality rates. Late deaths are often related to thoracic aortic rupture; therefore, these patients require close observation in order to increase the chances of early diagnosis and proper treatment of a dilated and weakened, rupture prone aortic segment. Stentgraft coverage of the primary entry tear may decrease the late aortic related deaths, but suprarenal fenestration means an alternative open surgical method for those cases that are not suitable for endovascular methods.

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REFERENCES

1 Hughes GC, Andersen ND, McCann RL. Management of acute type B aortic dissection. *J Thorac Cardiovasc Surg* 2013;**145**: S202—7.
2 Narayan P, Wong A, Davies I, Angelini GD, Bryan AJ, Wilde P, et al. Thoracic endovascular repair versus open surgical repair — which is the more cost-effective intervention for descending thoracic aortic pathologies? *Eur J Cardiothorac Surg* 2011;**40**: 869—74.
3 Karimi A, Walker KL, Martin TD, Hess PJ, Klodell CT, Feezor RJ, et al. Midterm cost and effectiveness of thoracic endovascular aortic repair versus open repair. *Ann Thorac Surg* 2012;**93**: 473—9.
4 Apostolakis E, Baikoussis NG, Georgiopoulos M. Acute type-B aortic dissection: the treatment strategy. *Hellenic J Cardiol* 2010;**51**:338—47.
5 Pradhan S, Elefteriades JA, Sumpio BE. Utility of the aortic fenestration technique in the management of acute aortic dissections. *Ann Thorac Cardiovasc Surg* 2007;**13**:296—300.
6 Elefteriades JA, Hammond GL, Gusberg RJ, Kopf GS, Baldwin JC. Fenestration revisited. A safe and effective procedure for descending aortic dissection. *Arch Surg* 1990;**125**:786—90.
7 Webb TH, Williams GM. Abdominal aortic tailoring for renal, visceral, and lower extremity malperfusion resulting from acute aortic dissection. *J Vasc Surg* 1997;**26**:474—80.
8 Panneton JM, Teh SH, Cherry Jr KJ, Hofer JM, Gloviczki P, Andrews JC, et al. Aortic fenestration for acute or chronic aortic dissection: an uncommon but effective procedure. *J Vasc Surg* 2000;**32**:711—21.
9 Trimarchi S, Jonker FH, Muhs BE, Grassi V, Righini P, Upchurch GR, et al. Long-term outcomes of surgical aortic fenestration for complicated acute type B aortic dissections. *J Vasc Surg* 2010;**52**:261—6.
10 Khoynezhad A, Walot I, Kruse MJ, Rapae T, Donayre CE, White RA. Distribution of intimomedial tears in patients with type B aortic dissection. *J Vasc Surg* 2010;**52**:562—8.
11 Fattori R, Cao P, De Rango P, Czerny M, Evangelista A, Nienaber C, et al. Interdisciplinary expert consensus document on management of type B aortic dissection. *J Am Coll Cardiol* 2013;**61**:1661—78.
12 Dósa E, Hirschberg K, Apor A, Járányi Z, Entz L, Acsády G, et al. Echolucent or predominantly echolucent femoral plaques predict early restenosis after eversion carotid endarterectomy. *J Vasc Surg* 2010;**51**:345—50.
13 von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *PLoS Med* 2007;**4**:e296.

14 Naughton PA, Park MS, Morasch MD, Rodriguez HE, Garcia-Toca M, Wang CE, et al. Emergent repair of acute thoracic aortic catastrophes: a comparative analysis. *Arch Surg* 2012;**147**:243—9.
15 Wilkinson DA, Patel HJ, Williams DM, Dasika NL, Deeb GM. Early open and endovascular thoracic aortic repair for complicated type B aortic dissection. *Ann Thorac Surg* 2013;**96**:23—30.
16 Hanna JM, Andersen ND, Ganapathi AM, McCann RL, Hughes GC. Five-year results for endovascular repair of acute complicated type B aortic dissection. *J Vasc Surg* 2014;**59**:96—106.
17 Pearce BJ, Passman MA, Patterson MA, Taylor SM, Lecroy CJ, Combs BR, et al. Early outcomes of thoracic endovascular stent graft repair for acute complicated type B dissection using the Gore TAG endoprosthesis. *Ann Vasc Surg* 2008;**22**:742—9.
18 Lombardi JV, Cambria RP, Nienaber CA, Chiesa R, Teebken O, Lee A, et al. STABLE Investigators. Prospective multicenter clinical trial (STABLE) on the endovascular treatment of complicated type B aortic dissection using a composite device design. *J Vasc Surg* 2012;**55**:629—40.
19 Ehrlich MP, Rousseau H, Heijmen R, Piquet P, Beregi JP, Nienaber CA, et al. Midterm results after endovascular treatment of acute, complicated type B aortic dissection: the Talent Thoracic Registry. *J Thorac Cardiovasc Surg* 2013;**145**:159—65.
20 Shimokawa T, Horiuchi K, Ozawa N, Fumimoto K, Manabe S, Tobaru T, et al. Outcome of surgical treatment in patients with acute type B aortic dissection. *Ann Thorac Surg* 2008;**86**:103—7.
21 Murashita T, Ogino H, Matsuda H, Sasaki H, Tanaka H, Iba Y, et al. Clinical outcome of emergency surgery for complicated acute type B aortic dissection. *Circ J* 2012;**76**:650—4.
22 VIRTUE Registry investigators. The VIRTUE Registry of type B thoracic dissections—study design and early results. *Eur J Vasc Endovasc Surg* 2011;**41**:159—66.
23 Nienaber CA, Kische S, Rousseau H, Eggebrecht H, Rehders TC, Kundt G, et al. INSTEAD-XL trial. Endovascular repair of type B aortic dissection: long-term results of the randomized investigation of stent grafts in aortic dissection trial. *Circ Cardiovasc Interv* 2013;**6**:407—16.