

Original Research

Minimally Invasive Endovascular Intervention in Emergent and Urgent Thoracic Aortic Pathologies: Single Center Experience

NIKOLAOS SARATZIS, NIKOLAOS MELAS, ATHANASIOS SARATZIS, JOHN LAZARIDIS, DIMITRIOS KISKINIS

1st Department of Surgery, Aristotle University of Thessaloniki, Papageorgiou General Hospital, Thessaloniki, Greece

Key words:
Endovascular,
thoracic aorta, blunt
trauma,
symptomatic
thoracic aortic
aneurysm.

Introduction: We report mid-term results from the endovascular treatment of acute thoracic aortic pathologies in a single center.

Methods: We retrospectively interrogated our clinical database and identified the following patients who were treated for an acute thoracic aortic pathology during a 3-year period (January 2003 to February 2006) with the deployment of a thoracic endograft: 8 male patients diagnosed with a thoracic aortic pseudoaneurysm and/or a thoracic aortic disruption following blunt chest trauma; 1 male patient with a large mobile mural thrombus of the descending thoracic aorta; 1 patient with an aortobronchial fistula; and 8 patients with a symptomatic descending thoracic aortic aneurysm.

Results: Complete exclusion of the lesion was achieved in all patients. No procedure-related deaths occurred. Postoperative complications included one case of a distal type 1 endoleak, repaired with re-intervention and deployment of an extension graft, and 1 case of moderate graft kinking without further complications.

Conclusion: The endovascular treatment of acute thoracic aortic pathologies is technically feasible and safe. Early and intermediate results are promising.

Manuscript received:
October 12, 2007;
Accepted:
April 3, 2008.

Address:
Athanasios Saratzis

9A Farmaki St.
552 36 Thessaloniki,
Greece
e-mail:
a_saratzis@yahoo.gr

Thoracic aortic pathologies pose a challenge for cardiovascular and interventional specialists. Thoracic aortic aneurysms, Stanford type B dissections, penetrating ulcers, traumatic aortic tears, and aortobronchial fistulae are all potentially morbid entities that are usually treated with open surgical repair. Even with the advent of cardiopulmonary bypass, profound hypothermia, circulatory arrest, spinal cord protection and intensive care unit (ICU) support,¹ the operative mortality rates for open repair have been reported to range from 8% to 20% for elective cases and up to 60% following aortic rupture.¹⁻⁴ The endoluminal treatment of those pathologies is a minimally invasive alternative with promising early clinical results. The long-term efficacy of

this treatment option, though, has not yet been proven. This is a retrospective report of our department's experience in a tertiary hospital from the endovascular exclusion of acute thoracic aortic pathologies over a medium-term follow up. Written informed consent was obtained in all cases, as was approval from the Institutional Review Board.

Methods and results

Aortic rupture

Eight male patients (mean age 29 years, range 19-43 years) were admitted between January 2003 and January 2006 following blunt thoracic aortic trauma. Diagnosis was based on plain chest X-rays, spiral

computed tomography (CT) of the chest, aortography and transesophageal echocardiography (TEE). All imaging modalities were utilized in all patients, except TEE, which was only used for diagnosis in 5 cases. Five patients were diagnosed with a thoracic aortic pseudoaneurysm secondary to thoracic aortic disruption. Three patients were diagnosed with acute thoracic hematomas and a hemopneumothorax due to disruption of the thoracic aorta. All subjects suffered from major concomitant injuries: multiple bone fractures (8), rib cage fractures (2), abdominal hematomas (7), and pulmonary contusions (7). The rupture of the thoracic aorta was situated at the level of the aortic isthmus in all cases.

The repairs were performed with the deployment of the EndoFit (LeMaitre Vascular, Burlington, MA, USA) stent-graft. In 2 cases the procedure was delayed (<48 hours) because of inadequate stabilization of the patient's general condition. Complete exclusion of the disruption and the pseudoaneurysm was achieved in all cases. In a single case we deployed a second cuff because of a secondary endoleak (distal type 1) detected on the intraoperative completion angiography. The dimensions of the endografts used were as follows: proximal diameter 38-42 mm, distal diameter 36-40 mm, length 12-16 cm. In 2 patients the left subclavian artery was occluded in order to achieve adequate graft affixation. In the remaining subjects, all aortic arch branches remained intact.

A plain X-ray and a CT scan of the chest (Figure 1) obtained within 10 days after the repair confirmed secure graft affixation and the absence of graft-related complications. The thoracic hematomas had decreased substantially in size. The pseudoaneurysms were excluded successfully and remained stable in

terms of diameter throughout the follow up. The patients remained hospitalized in the ICU until their overall condition was stabilized and remained under monthly follow up, including a full clinical and neurological assessment as well as a chest CT scan, until the 6th postoperative month. The patients remained under close follow up every 3 months after the 6th postoperative month. No procedure-related deaths occurred. No cardiac or peripheral vascular complications were observed within 20 months' (range 14-24 months) follow up.

Thoracic aortic aneurysms

Eight male patients (mean age 71 years) with a symptomatic (intense continuous chest pain) descending thoracic aortic aneurysm were admitted to our department between January 2003 and July 2005 for endovascular repair. The diagnosis was dependent on chest CT scans and CT angiography. The median maximal aneurysmal diameter was 6.8 cm (range 5.2-7.4 cm). All subjects were ASA (American Society of Anesthesiologists) grade III or above (severe systemic disturbance or above) and therefore at high surgical risk.⁵ The patients' comorbidities included the following: arterial hypertension (8), coronary artery disease (6), diabetes mellitus (1), hyperlipidemia (8), previous or current smoking habits (8), chronic obstructive pulmonary disease (2), and previous acute myocardial infarction (6). The EndoFit thoracic stent-graft was deployed in all cases. Complete aneurysm exclusion was feasible in all subjects (Figures 2, 3) and was verified on the intraoperative completion angiography and on the postoperative chest CT scans obtained within 10 days after the procedure. A single stent-

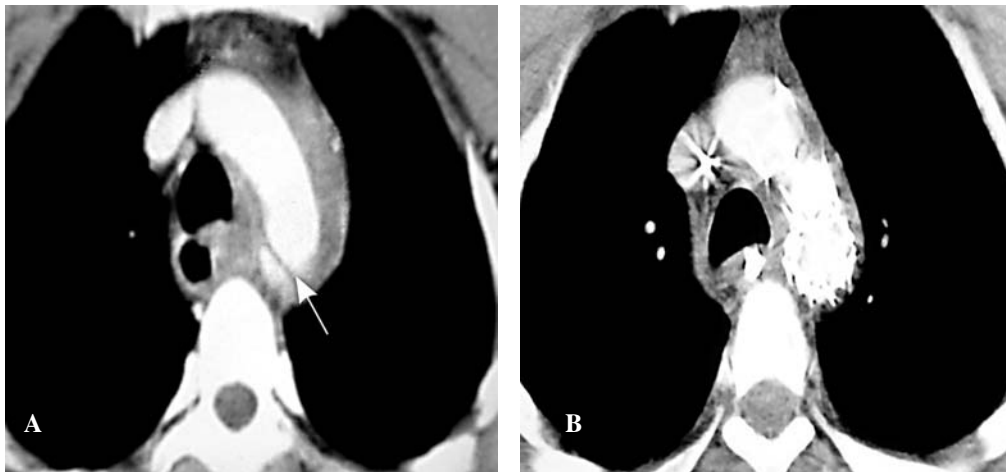


Figure 1. Preoperative (A) and postoperative (B) chest CT of a patient with aortic rupture due to blunt trauma. Notice the ruptured aorta, the para-aortic hematoma, the aortic flap (arrow) and the successful exclusion of the lesion with the deployment of the endo-graft.



Figure 2. Preoperative (A) and postoperative (B) plain chest X-ray scans depicting a descending thoracic aortic aneurysm and secure graft positioning without any signs of graft kinking or migration.

graft was deployed in 3 cases. The deployment of a second graft was necessary in the remaining patients, allowing 4 cm of overlap, in order to achieve complete aneurysm exclusion. The origin of the left subclavian artery and the other aortic arch branches were not obstructed in any case.

The mean follow up was 26 months and the patients were evaluated at the 1st, 6th, and 12th postoperative month, and annually thereafter. The postoperative CT scans were compared to the preoperative images to determine the sac volume and diameter. No patient was lost to follow up. No procedure-related deaths occurred. Reduction of the maximal aneurysmal diameter was seen in 4 cases, whereas the diameter remained steady in the other patients. A distal type I endoleak of unknown etiology was detected on the chest CT (1st postoperative month) in a single patient. No graft-related complications had been detected perioperatively or during the operation. It was repaired with re-intervention and deployment of an extension graft. The patient was free of other vascular or neurological complications. Graft migration, graft infection, paraplegia, cerebral or distal embolization, renal impairment or any other procedure-related complications did not occur.

Aortobronchial fistula

A 79-year-old male patient was admitted with hemoptysis and anemia. Magnetic resonance angiography disclosed a thoracic aortic aneurysm that had ruptured into the left bronchus (aortobronchial fistula). During hospitalization, he developed hemoptysis which eventually progressed to hemorrhagic shock and dyspnea, requiring endotracheal intubation. The patient's impaired condition made open surgical repair dangerous and endovascular exclusion of the fistula was decided upon once informed consent had been obtained. The repair was possible with the deployment of an EndoFit thoracic stent-graft (diameter 40 mm, length 16 cm). The completion angiography and the postoperative scans indicated complete exclusion of the aneurysm and the absence of endoleak or other device-related complications. The 30-day follow up was uneventful and the postoperative plain chest X-rays disclosed good graft positioning, without kinking or migration. Five months later he was clinically re-evaluated and was found to be in good overall condition. Seven months postoperatively the patient was diagnosed with an abdominal aortic aneurysm, but refused further intervention. The pa-

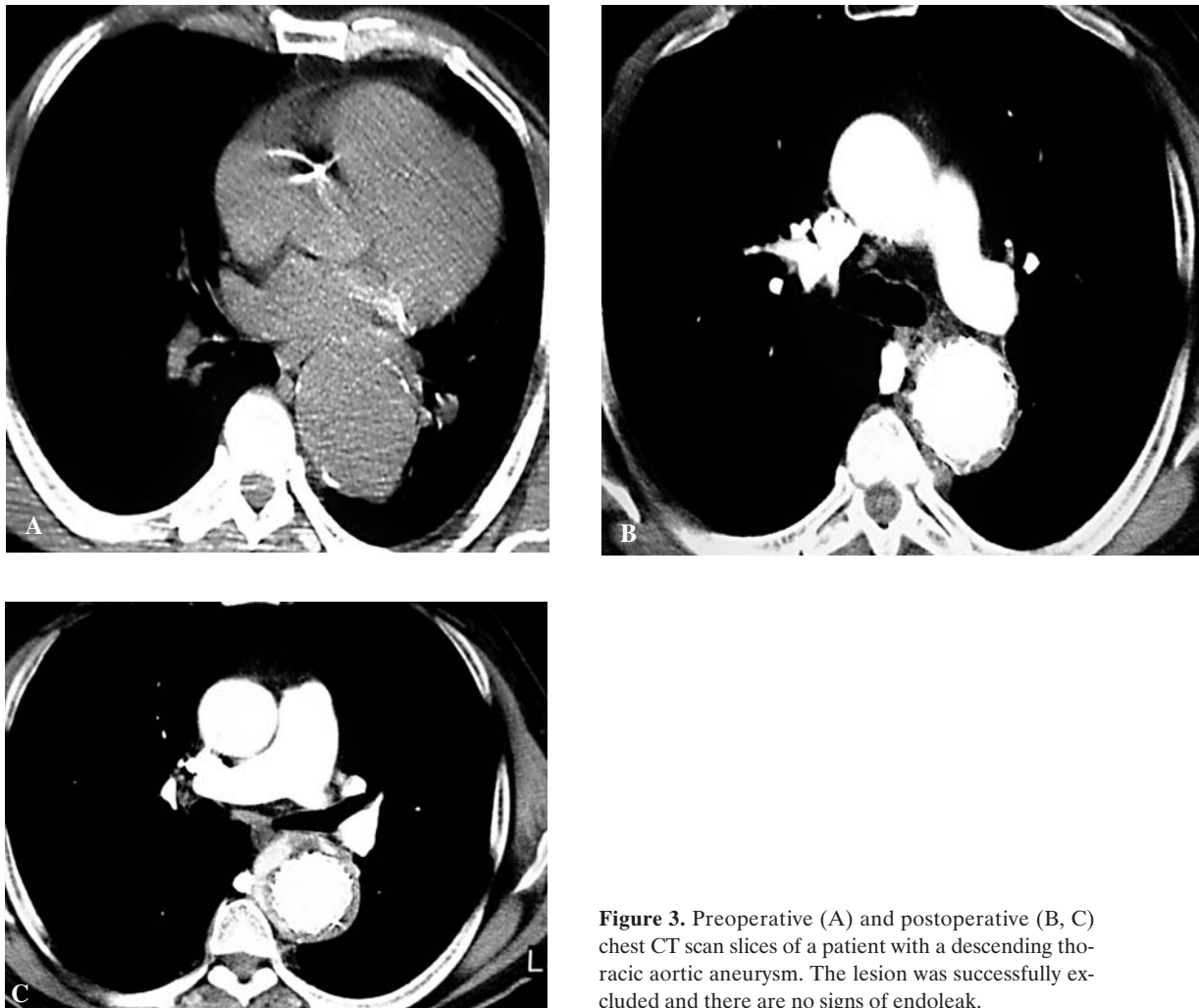


Figure 3. Preoperative (A) and postoperative (B, C) chest CT scan slices of a patient with a descending thoracic aortic aneurysm. The lesion was successfully excluded and there are no signs of endoleak.

tient died 2 years postoperatively due to non procedure-related causes.

Thoracic aortic thrombi

A 63-year-old male patient was admitted with acute abdominal pain and vomiting. Clinical examination disclosed diffuse mild tenderness without a palpable abdominal mass or other signs indicative of an aneurysm. The patient's history included intermittent claudication (Fontaine grade II) within the last week, arterial hypertension and eczema of the upper limbs. An abdominal CT scan disclosed multiple visceral infarcts (a spleen infarct and bilateral renal infarcts, a small liver infarct and occlusion of the left common iliac and right superficial femoral artery). Digital subtraction angiography disclosed an adjacent filling defect arising from the aortic arch, opposite to the origin of the left subclavian artery. The patient's cardio-

logical evaluation (including transthoracic cardiac ultrasound) was normal and thrombophilia screening tests were also negative. Spiral CT of the chest and CT-angiography disclosed a mural lesion of the thoracic aorta at the distal end of the aortic arch and the proximal descending aorta. During hospitalization, the patient experienced intense pain originating from the left hypochondrium, combined with fever and an elevated white blood cell count. A new spiral CT (abdomen and chest) disclosed new spleen infarcts and an increase of the hypodense areas in both kidneys. TEE disclosed a large mobile mural thrombus of the descending thoracic aorta, adherent to a calcified, protruding atherosclerotic plaque (diagnosis: aortic penetrating ulcer with mural thrombus). Prompt intervention was decided upon with the deployment of a thoracic endograft (EndoFit thoracic stent-graft: diameter 40 mm, length 18 cm). The lesion was successfully covered, without any thrombus dislodgement

during deployment. Plain X-ray and chest CT disclosed good graft positioning during the 30 days' follow up, which was uneventful. The patient remains in good overall condition 2.5 years after the intervention, without any indications of peripheral vascular complications.

Device details

The EndoFit (LeMaitre Vascular, Burlington, MA, USA) thoracic aortic stent-graft was deployed in all cases. The device is composed of self-expanding nitinol stents, encapsulated in two layers of ePTFE (polytetrafluoroethylene). Each stent of the main covered portion is separated from the others. The bare proximal stent is connected to the covered part with two solid steel bars. The bare proximal stent offers enhanced proximal affixation without the need to obstruct the blood flow to the left subclavian artery (Figure 4). The graft comes loaded on a cartridge and is deployed without any release wires, simply by retracting the introducing sheath.

The device is available in the following sizes: proximal diameter 30-42 mm, distal diameter 30-42 mm, length 12-20 cm. A 15-20% oversizing is applied proximally to ensure adequate graft affixation and minimize the risk of migration and/or endoleak. In case a second graft is necessary to fully cover the lesion, this is deployed using 4 cm of overlap.

The appropriate graft length was calculated by al-

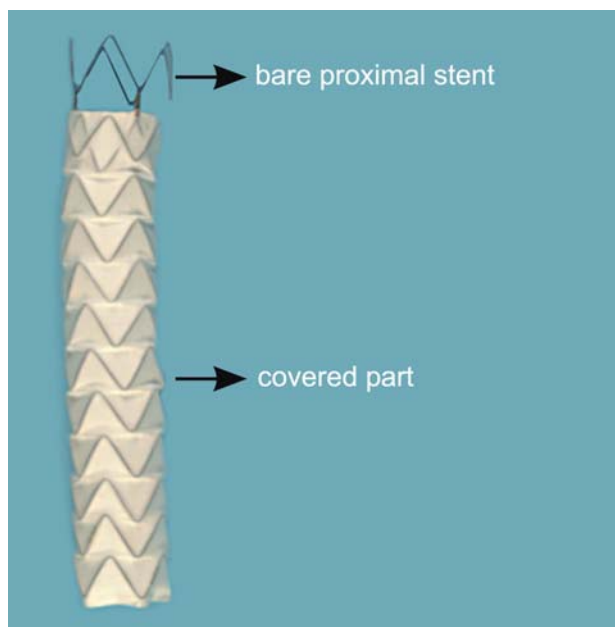


Figure 4. The EndoFit thoracic stent-graft, which was deployed in all cases.

lowing a minimum 1 cm proximal landing zone and a minimum 2 cm distal landing zone.

Technique

All patients had appropriate iliac and femoral artery anatomy that allowed the introduction of the delivery sheaths (as detected on the preoperative digital subtraction angiography or CT angiography scans) and an absence of general contraindications for endovascular repair. None of the patients had impaired renal function. Non-ionic iodinated contrast medium (Iopromide, Ultravist 300, Bayer Schering Pharma AG, Berlin, Germany) was used in all cases.

All procedures took place in a fully equipped operating room under fluoroscopic control, using a portable C-arm (Siremobil 2000, Siemens, Erlangen, Germany). TEE was also available intraoperatively in all cases. Heparin was administered intravenously (5000 IU). The right common femoral artery and the left brachial artery were surgically exposed. A hydrophilic guidewire was then advanced under fluoroscopic control to track the iliac axis. A guiding catheter was inserted over the wire and forwarded up to the ascending aorta. The left brachial artery was catheterized and a 5 Fr sheath was inserted. A hydrophilic guidewire was advanced, serving as a guiding point for the orifice of the left subclavian artery. A 22-24 Fr EndoFit (LeMaitre Vascular, Burlington, MA, USA) hydrophilic introducing sheath with a tapered dilator was inserted over the stiff wire. Fluoroscopic images (aortograms) and TEE were used to ensure accurate proximal and distal positioning. Controlled systemic hypotension (80-90 mmHg) was induced by administering a fast-acting vasodilator (atropine), during graft deployment. Obstruction of the left subclavian artery was avoided, unless the proximal affixation of the graft was not adequate. When possible, only the non-covered part of the endograft was positioned proximal to the origin of the left subclavian artery. Completion angiographies verified the exclusion of the lesion and the absence of endoleak or other device-related complications. Clopidogrel (75 mg daily) was administered postoperatively and continued as a lifelong anti-platelet treatment, according to our Department's protocol for all patients undergoing endovascular repair.

Discussion

Acute thoracic aortic pathologies, such as thoracic

aortic aneurysms, penetrating atherosclerotic ulcers⁶ and aortic dissections, are potentially morbid entities with an increasing incidence.⁷ These pathologies, if left untreated, usually lead to aortic expansion and ultimately death. The annual risk of rupture, dissection, or death in a patient with a thoracic aneurysm (measuring 6 cm in diameter) is over 14%.⁸ The diagnosis of untreated type B aortic dissections is more benign, with branch ischemia constituting the most devastating complication. Penetrating ulcers and traumatic aortic tears are rare, but mortality rates are reported to be as high as 90%, if left untreated.⁹⁻¹¹

Traditional open surgical repair for acute thoracic aortic aneurysms (aortic graft replacement via a left thoracotomy) has been found to improve survival rates substantially compared to medical treatment.¹² Operative mortality rates range from 8% to 20% (elective cases), rising to 60% following aneurysmal rupture.^{7,13-15} Procedure-related morbidity includes renal, intestinal and spinal cord ischemia.^{14,16,17} Traumatic aortic rupture has also traditionally been treated with open surgical repair. A large proportion of these patients, though, present with severe co-morbidities (including visceral, extensive orthopedic or intracranial hemorrhage) that make open surgery manipulations dangerous or impossible.

With the advent of endovascular stent-grafts many cardiovascular interventionalists embraced the idea of repairing descending thoracic aortic pathologies while avoiding thoracotomy and aortic cross-clamping.¹⁸ Volodos was the pioneer in 1991.^{16,17} Ever since, numerous reports have proven the feasibility and efficacy of the endoluminal exclusion of descending thoracic aortic aneurysms, Stanford type B dissections, and aortic tears.¹⁹⁻⁴⁴ The advantages of the endovascular approach are many: avoidance of major thoracic or thoraco-abdominal incisions, decreased need for general anesthesia, shorter operative time, minimal blood loss and need for transfusions, lack of aortic crossclamping, avoidance of cardiopulmonary bypass, decreased postoperative pain, shorter hospital and ICU stay, and faster recuperation.¹⁸ Thirty-day mortality rates have been reported between 0% to 25%.¹⁹⁻⁴⁴ Morbidity ranges from 0 to 25%, with most centers reporting rates below 10%. Paraplegia is not a common complication in most series, including the patients in our report.¹⁹⁻⁴⁴ This may be attributed to the avoidance of aortic clamping and/or extracorporeal circulation, minimal blood-loss during the stenting procedure, decreased operative time and the fact that

the orifice of the aortic branches remains intact. Khojnehzad et al⁴ recently identified a series of factors that may contribute to spinal cord ischemia during thoracic aortic endografting. These include the following: obesity, increased intraoperative blood loss, vascular embolization, aneurysm as an underlying pathology, the use of an iliac conduit, and coverage of the hypogastric artery. These risk factors for ischemia may be markers of a tenuous collateral blood supply to the spinal cord. In contrast, open surgery is often complicated by paraplegia, with rates ranging from 8% to 30%.^{2,3} The potential complications of descending thoracic aortic grafting are as follows: intraoperative stroke, endoleak, graft migration, fracture or collapse, graft infection, and sac pressurization.

Intraoperative stroke can be prevented by excluding patients with excessive arch atheromatous disease from endovascular treatment. Complicated maneuvers during sheath introduction and graft deployment should also be avoided. In this series we did not experience any intraoperative strokes or other major intraoperative neurological events.

As far as device complications are concerned (graft migration, collapse, fracture and infection) the interventionalist's experience in the use of the endograft and the choice of the appropriate device are crucial. A minimum 1 cm proximal landing zone and a minimum 2 cm distal landing zone combined with an amount of oversizing (depending on the device) should offer adequate affixation. Proximal endograft collapse is a potential complication of oversizing, but we did not encounter any such event in this series. In the case of a short proximal landing zone, the left subclavian artery can be occluded with the added risk of upper limb ischemia, which requires strict postoperative follow up. The graft that was deployed in this group incorporates a bare proximal stent that enhances affixation without obstructing the aortic arch branches. In cases where the lesion has not been successfully excluded the deployment of a second cuff should adequately resolve the problem. In this series we applied 4 cm of overlapping when a second cuff was required. Endoleak can be avoided by applying an adequate amount of proximal oversizing, provided that the measurements of the lesion have been carefully obtained. If an endoleak is detected during follow up, the deployment of a giant bare Z-stent or secondary deployment of an endoluminal cuff should resolve the problem. We did not observe graft fracture, collapse or major kinking in this patient group.

Conclusion

The endovascular treatment of thoracic aortic emergencies, such as aortic rupture, acute descending thoracic aortic aneurysms and aortobronchial fistulas is technically feasible and the mid-term results in this series appear promising.

References

- Cowley RA, Turney SZ, Hankins JR, Rodriguez A, Attar S, Shankar BS. Rupture of thoracic aorta caused by blunt trauma. A fifteen-year experience. *J Thorac Cardiovasc Surg.* 1990; 100: 652-660.
- Sa HJ, Campbell MP, Ferreira ML, Azizzadeh A, Miller CC. Spinal cord protection in descending thoracic and thoracoabdominal carotid aneurysm repair. *Semin Thorac Cardiovasc Surg.* 1998; 10: 41-44.
- Hamilton IN, Hollier LH. Adjunctive therapy for spinal cord protection during thoracoabdominal aortic aneurysm repair. *Semin Thorac Cardiovasc Surg.* 1998; 10: 35-39.
- Khoynezhad A, Donayre CE, Bui H, Kopchok GE, Walot I, White RA. Risk factors of neurologic deficit after thoracic aortic endografting. *Ann Thorac Surg.* 2007; 83: 882-889.
- Rozner MA. The American Society of Anesthesiologists physical status score and risk of perioperative infection. *JAMA.* 1996; 275: 1544.
- Karabinos IK, Papadopoulos A, Kotoulas G, Katritsis D. The natural history of a penetrating atherosclerotic ulcer at the aortic arch. *Hellenic J Cardiol.* 2006; 47: 308-309.
- Clouse WD, Hallett JW Jr, Schaff HV, Gayari MM, Ilstrup DM, Melton LJ III. Improved prognosis of thoracic aortic aneurysms: a population based study. *JAMA.* 1998; 280: 1926-1929.
- Elefteriades JA. Natural history of thoracic aortic aneurysms: indications for surgery, and surgical versus nonsurgical risks. *Ann Thorac Surg.* 2002; 74: 1877-1880.
- Coady MA, Rizzo JA, Hammond GL, Peirce JG, Kopf GS, Elefteriades JA. Penetrating ulcer of the thoracic aorta: What is it? How do we recognize it? How do we manage it? *J Vasc Surg.* 1998; 27: 1006-1016.
- Kos X, Bouchard L, Otal P, et al. Stent-graft treatment of penetrating thoracic aortic ulcers. *J Endovasc Ther.* 2002; 9: II25-31.
- Cardarelli MG, McLaughlin JS, Downing SW, Borwn JM, Attar S, Grith BP. Management of traumatic aortic rupture: a 30-year experience. *Ann Surg.* 2002; 236: 465-470.
- Crawford ES, DeNatale RW. Thoracoabdominal aortic aneurysm: observations regarding the natural course of the disease. *J Vasc Surg.* 1986; 3: 578-582.
- DeBaakey ME, McCollum CH, Graham JM. Surgical treatment of aneurysms of the descending thoracic aorta: long-term results in 500 patients. *J Cardiovasc Surg.* 1978; 19: 571-576.
- Achneck HE, Rizzo JA, Tranquilli M, Elefteriades JA. Safety of thoracic aortic surgery in the present era. *Ann Thorac Surg.* 2007; 84: 1180-1185.
- Svensson LG, Crawford ES, Hess KR, Coselli JS, Sa. HJ. Experience with 1509 patients undergoing thoracoabdominal aortic operations. *J Vasc Surg.* 1993; 17: 357-370.
- Parodi JC, Palmaz JC, Barone HD. Transfemoral intraluminal graft implantation for abdominal aortic aneurysms. *Ann Vasc Surg.* 1991; 5: 491-499.
- Volodos NL, Karpovich IP, Troyan VI, et al. Clinical experience of the use of self-fixing synthetic prostheses for remote endoprosthetics of the thoracic and abdominal aorta and iliac arteries through femoral artery and intraoperative endoprostheses for aorta reconstruction. *Vasa Suppl.* 1991; 33: 93-95.
- Anagnostopoulos-Tzifa A. Management of aortic coarctation in adults: endovascular versus surgical therapy. *Hellenic J Cardiol.* 2007; 48: 290-295.
- Bortone AS, Schena S, Mannatrizio G, et al. Endovascular stent-graft treatment for diseases of the descending thoracic aorta. *Eur J Cardiovasc Thorac Surg.* 2001; 20: 514-519.
- Ehrlich M, Grabenwoeger M, Cartes-Zumelzu F, et al. Endovascular stent graft repair for aneurysms on the descending thoracic aorta. *Ann Thorac Surg.* 1998; 66: 19-25.
- Mitchell RS, Miller DC, Dake MD, Semba CP, Moore KA, Sakai T. Thoracic aortic aneurysm repair with an endovascular stent graft: the "first generation". *Ann Thorac Surg.* 1999; 67: 1971-1974.
- Temudom T, D'Ayala M, Marin ML, et al. Endovascular grafts in the treatment of thoracic aortic aneurysms and pseudoaneurysms. *Ann Vasc Surg.* 2000; 14: 230-238.
- Grabenwoeger M, Hutschala D, Ehrlich MP, et al. Thoracic aortic aneurysms: treatment with endovascular self-expandable stent-grafts. *Ann Thorac Surg.* 2000; 69: 441-445.
- Taylor PR, Gaines PA, McGuinness CL, et al. Thoracic aortic stent grafts - early experience from two centers using commercially available devices. *Eur J Vasc Endovasc Surg.* 2001; 22: 70-76.
- Greenberg R, Resch T, Nyman U, et al. Endovascular repair of descending thoracic aortic aneurysms: an early experience with intermediate-term follow-up. *J Vasc Surg.* 2000; 31: 147-156.
- Bortone AS, Schena S, Mannatrizio G, et al. Endovascular stent-graft treatment for diseases of the descending thoracic aorta. *Eur J Cardiovasc Thorac Surg.* 2001; 20: 514-519.
- White RA, Donayre CE, Walot I, et al. Endovascular exclusion of descending thoracic aortic aneurysms and chronic dissections: Initial clinical results with the AneuRx device. *J Vasc Surg.* 2001; 33: 927-934.
- Won JY, Lee DY, Shim WH, Chang B, Park SI, Yoon CS. Elective endovascular treatment of descending thoracic aortic aneurysms and chronic dissections with stent-grafts. *J Vasc Interv Radiol.* 2001; 12: 575-582.
- Cambria RP, Brewster DC, Lauterbach SR, et al. Evolving experience with thoracic aortic stent graft repair. *J Vasc Surg.* 2002; 35: 1129-1136.
- Thompson CS, Gaxotte VD, Rodriguez JA, et al. Endoluminal stent grafting of the thoracic aorta: initial experience with the Gore Excluder. *J Vasc Surg.* 2002; 35: 1163-1170.
- Totaro M, Mazzei G, Marullo AGM, Neri E, Fanelli F, Miraldi F. Endoluminal stent grafting of the descending thoracic aorta. *Ital Heart J.* 2002; 3: 366-369.
- Najibi S, Terramani TT, Weiss VJ, et al. Endoluminal versus open treatment of descending thoracic aortic aneurysms. *J Vasc Surg.* 2002; 36: 732-737.
- Criado FJ, Clark NS, Barnatan MF. Stent graft repair in the aortic arch and descending thoracic aorta: a 4-year experience. *J Vasc Surg.* 2002; 36: 1121-1128.
- Herold U, Piotrowski J, Baumgart D, Eggebrecht H, Erbel R, Jakob H. Endoluminal stent graft repair for acute and chronic type B aortic dissection and atherosclerotic aneurysm of

- the thoracic aorta. *Eur J Cardiothorac Surg.* 2002; 22: 891-897.
35. Chabbert V, Otaï P, Bouchard L, et al. Midterm outcomes of thoracic aortic stent-grafts. *J Endovasc Ther.* 2003; 10: 494-504.
 36. Fattori R, Napoli G, Lovato L, et al. Descending thoracic aortic diseases: stent-graft repair. *Radiology.* 2003; 229: 176-183.
 37. Scharrer-Pamler R, Kotsis T, Kapfer X, Gorich J, Orend KH, Sunder-Plassmann L. Complications after endovascular treatment of thoracic aortic aneurysms. *J Endovasc Ther.* 2003; 10: 711-718.
 38. Lamme B, de Jonge IC, Reekers JA, de Mol BA, Balm R. Endovascular treatment of thoracic aortic pathology. *Eur J Vasc Endovasc Surg.* 2003; 25: 532-539.
 39. Lepore V, Lonn L, Delle M, Mellander S, Radberg G, Risberg B. Treatment of descending thoracic aneurysms by endovascular stent grafting. *J Cardiovasc Surg.* 2003; 18: 436-443.
 40. Krohg-Sorensen K, Hafsahl G, Fosse E, Geiran OR. Acceptable short-term results after endovascular repair of diseases of the thoracic aorta in high risk patients. *Eur J Cardiothorac Surg.* 2003; 24: 379-387.
 41. Lambrechts D, Casselman F, Schroeyers P, De Geest R, D'Haenens P, Degrieck I. Endovascular treatment of the descending thoracic aorta. *Eur J Vasc Endovasc Surg.* 2003; 26: 437-444.
 42. Ellozy SH, Carrocio A, Minor M, et al. Challenges of endovascular tube-graft repair of thoracic aortic aneurysm: midterm follow-up and lessons learned. *J Vasc Surg.* 2003; 38: 676-683.
 43. Czerny M, Cejna M, Hutschala D, et al. Stent-graft placement in atherosclerotic descending thoracic aneurysms: midterm results. *J Endovasc Ther.* 2004; 11: 26-32.
 44. Melissano G, Tshomba Y, Civilini E, Chiesa R. Disappointing results with a new commercially available thoracic endograft. *J Vasc Surg.* 2004; 39: 124-130.