ANALYSIS OF EARLY AND DISTANT RESULTS FOLLOWING ENDOVASCULAR REPAIR OF THE DESCENDING AND ABDOMINAL AORTA

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The aim of the study was to analyze early and distant results following thoracic descending and abdominal aorta stentgraft implantations.

Material and methods. During the period between 2000 and 2006, 20 stentgrafts were implanted into the thoracic descending aorta and 114 into the abdominal aorta.

Results. The initial technical success was obtained in 85.71% of cases considering the descending aorta and 89.47% in case of the abdominal aorta. The initial clinical success was obtained in 85.71% and 84.21%, respectively. In 5% of descending aortic operations the branching of the left subclavian artery was covered. Early mortality in case of descending aortic operations amounted 4.76%, while that after abdominal aortic operations – 0.88%. After the implantation of abdominal aortic stentgrafts, 2.63% of early conversions were performed because of aneurysmal rupture, and 1.75% of distant conversions, due to prosthesis inflammation. After abdominal aortic operations, 2.63% of patients required reconstructive operations, due to arterial injury at the site of the approach. After the implantation of descending aortic stentgrafts, early type 1 endoleaks were observed in 10% of cases. After the implantation of abdominal aortic stentgrafts, primary endoleaks were observed in 11.4% of cases: type 1 – 7.02%, type 2 – 3.51%, type 3 – 0.88%. Following the implantation of abdominal aortic stentgrafts, 1.75% of patient’s demonstrated symptoms of colon ischemia, while 0.88% – kidney ischemia. After abdominal aortic operations secondary endoleaks were observed in 7.01% of cases: type 1 – 2.63%, type 2 – 1.75%, type 3 – 2.63%.

Conclusions. 1. The implantation of stentgrafts is a safe and effective method considering the treatment of descending aortic injuries, dissections and ruptures. 2. The implantation of stentgrafts enables to obtain satisfactory results in the treatment of abdominal aortic aneurysms, considering high-risk patients. 3. The significant number of complications and their heterogeneity might be responsible for the limited indications towards stentgraft implantations. The above-mentioned method should be performed in case of patients, where classical operations are connected with an increased risk of complications.

Key words: stentgraft, complications, abdominal aortic aneurysm, thoracic descending aorta aneurysm, descending aortic dissection

In 1991, Parodi et al. (1) were the first to describe the use of stentgrafts in the treatment of abdominal aortic aneurysms (AAA), while Volodos et al. (2) described the implantation of stentgrafts in the treatment of thoracic descending and abdominal aorta aneurysms. With sur-
gical experience, improved stentgrafts, data obtained from longer observation periods, clinical registry results (3, 4), and multicenter investigations (5-9), indications towards endovascular treatment of dissections (10), aneurysms (11) and injuries (12) of the descending and abdominal aorta are being determined (13, 14, 15). Data analyses evaluated the place of endovascular operations in the treatment of rupturing, ruptured and inflammatory abdominal aortic aneurysms (16, 17, 18). Recently, stentgrafts are being implanted in case of penetrating aortic ulcers (19, 20). In Poland, the first report concerning the implantation of a bifurcated stentgraft into the abdominal aorta was published in 1999 (21). Results considering intravascular treatment of descending aortic aneurysms were described in 2001 (22), while that of chronic dissection in 2002 (23). Thus far, Polish authors from five centers published treatment results concerning the use of stentgrafts in case of pathological conditions of the aorta, both in Polish and foreign literature (24-32).

The aim of the study was to analyze early and distant results following thoracic descending and abdominal aorta stentgraft implantations.

MATERIAL AND METHODS

During the period between 2000 and 2006, 21 stentgrafts were implanted in patients with thoracic descending aorta pathologies, and 114 stentgrafts considering patients with abdominal aorta pathologies. Table 1 presented demographic data and presence of concomitant diseases. The ejection fraction (EF) considering patients planned for abdominal aortic stentgraft implantations ranged between 28-73% (median – 55%). Prior to abdominal aortic stentgraft implantation, 31 (27.19%) patients underwent a laparotomy, including 11 (9.65%)-more than one. In the group of patients subjected to descending aorta stentgraft implantations, 16 (76.19%) were in class 1 and 2, while 5 (23.81%) in class 3 and 4, according to the ASA classification. In case of patients subjected to abdominal aorta stentgraft implantations, 47 (41.23%) were in class 1 and 2, while 67 (58.77%) in class 3 (59 pts – 51.75%) and 4, according to the ASA classification. Table 2 demonstrated descending aorta stentgraft implantation indications. The diameter of the thoracic descending aorta in patients subjected to surgery, due to aneurysm or dissection ranged between 50 and 66 mm (median – 60 mm). Table 3 presented indications for endovascular abdominal aortic repair. The diameter of abdominal aortic aneurysms ranged between 50 and 92 mm (median – 58 mm). Operations were performed by a team of interventional radiologists and vascular surgeons at the Department of Radiology. Suprădural anesthesia was used during 16 (76.19%) thoracic descending aorta, and 98 (85.96%) abdominal aorta operations. After uncomplicated descending aorta stentgraft implantation, patients were subjected to early postoperative contrast computer tomography examinations, followed by an examination every six months during the initial year, and once every 12 months, thereafter. After uncomplicated abdominal aorta stentgraft implantation,
ultrasound examinations were performed during the early postoperative period, and after six months, followed by computer tomography every 12 months.

RESULTS

Early results

106 (92.98%) aorto-biiliac, 7 (6.14%) simple aortic, and one (0.88%) aorto-iliac (femoro-femoral anastomosis) stentgrafts were implanted into the abdominal aorta. Considering one patient with a thoracic descending aorta aneurysm the stentgraft was anastomosed to the common iliac artery, due to the small diameter of the femoral artery. In the remaining 20 cases the femoral arteries were prepared on one side followed by percutaneous injection on the opposite side.

Prior to abdominal aortic stentgraft implantation, both femoral arteries were prepared in 97 (85.09%) patients. The mean duration of a non-complicated descending aorta stentgraft implantation amounted to 2.05 hours, while in case of the abdominal aorta – 2.5 hours. Four (19.05%) patients after thoracic descending aorta operations required blood transfusions, while 15 (13.16%) after abdominal aortic operations. Mean hospitalization after uncomplicated stentgraft implantation amounted to 11 days in case of thoracic descending aortic operations, and 6 days in case of abdominal aortic operations.

Mortality in case of descending aorta stentgraft implantation amounted to 4.76%, while that after abdominal aortic operations – 0.88%. Deaths were connected with multiorgan failure and digestive tract bleeding. In one case (4.76%), due to difficulties in introducing the leader into both canals of the dissected aneurysm the procedure was abandoned. In one case (0.88%) of abdominal aortic stentgraft implantation conversion to classical surgery was required, due to aneurysmal rupture of the iliac artery. After abdominal aortic stentgraft implantations, five (4.38%) patients presented with fever of unknown etiology, and three (2.63%) with arterial injury requiring surgical intervention. Table 4 showed early complications connected with the presence of stentgrafts.

Acute lower limb ischemia was connected with the translocation of the aorto-biiliac stent, and occlusion of its leg. After thoracic descending aorta stentgraft implantation, two (10%) type 2 endoleaks were observed. Both cases required the implantation of an additional segment and balloon angioplasty during the same hospitalization. After abdominal aorta stentgraft implantation primary endoleaks were observed in 13 (11.4%) cases. Considering the eight primary endoleaks, four healed spontaneously. Two endoleaks were treated following the implantation of an additional segment and balloon angioplasty during the same hospitalization. Two of four primary type 2 abdominal aorta endoleaks were treated by means of sur-
Two of three type 1 endoleaks were treated by means of implantation of an additional stentgraft segment, while one subjected to conservative treatment remained present. In spite of sealing two type 2 endoleaks by means of balloon angioplasty, one remained present. Both type 3 endoleaks were removed following the implantation of an additional stentgraft segment. After a 12-month postoperative observation period we noted reduction in the diameter of the aneurysmal sac by at least 5 mm in 57.14% of AAA cases, and increased diameter in 17.86% of patients. 40% patients from the latter group were diagnosed with primary, secondary or persistent endoleaks.

DISCUSSION

Due to penetrating aortic ulcers (PAU), two (9.52%) patients required planned stentgraft implantations to the thoracic descending aorta, and one (0.88%) to the abdominal aorta, which accounted for 2.22% of all endovascular procedures. Apart from the well-known indications considering stentgraft implantations, such as aneurysms, trauma, and dissections, the above-mentioned have been recently implanted in case of penetrating ulcers. Accor-

Table 4. Early complications

<table>
<thead>
<tr>
<th></th>
<th>Thoracic descending aorta (n=20)</th>
<th>Abdominal aorta (n=114)</th>
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<tbody>
<tr>
<td>Stentgraft translocation</td>
<td>1 (0.88%)</td>
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<tr>
<td>Stentgraft leg impatency</td>
<td>3 (2.63%)</td>
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<tr>
<td>Aneurysmal rupture</td>
<td>2 (1.75%)</td>
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<td>Endoleak</td>
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<tr>
<td>- typ 1 / type 1</td>
<td>2 (10%)</td>
<td>3 (2.63%)</td>
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<tr>
<td>- typ 2 / type 2</td>
<td>2 (10%)</td>
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<tr>
<td>- typ 3 / type 3</td>
<td>1 (0.88%)</td>
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<tr>
<td>Total</td>
<td>2 (10%)</td>
<td>16 (14.03%)</td>
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Table 5. Distant complications

<table>
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<th>Abdominal aorta (n=114)</th>
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<tr>
<td>Stentgraft translocation</td>
<td>1 (0.88%)</td>
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<tr>
<td>Stentgraft leg impatency</td>
<td>2 (1.75%)</td>
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<tr>
<td>Stentgraft inflammation</td>
<td>2 (1.75%)</td>
<td></td>
</tr>
<tr>
<td>Death due to multiorgan failure</td>
<td>2 (10%)</td>
<td>2 (1.75%)</td>
</tr>
<tr>
<td>Mechanical obstruction after hybrid surgery</td>
<td>1 (0.88%)</td>
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<tr>
<td>Endoleak</td>
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<tr>
<td>- typ 1 / type 1</td>
<td>3 (2.63%)</td>
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<tr>
<td>- typ 2 / type 2</td>
<td>2 (1.75%)</td>
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<tr>
<td>- typ 3 / type 3</td>
<td>3 (2.63%)</td>
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<tr>
<td>Total</td>
<td>2 (10%)</td>
<td>16 (14.03%)</td>
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Analysis of early and distant results following endovascular repair of the descending and abdominal aorta

According to Batt et al. (19), surgical procedures in case of PAU are indicated in 3.4% of cases. Penetrating ulcers are more common in the descending aorta (76-89%), in comparison to the abdominal aorta (11-24%). In 33 (72%) of the 46 described patients surgical procedures were performed, due to PAU complications: false aneurysm, rupture and intramural hematoma. The intramural hematoma occurs more often in case of the abdominal aorta, in comparison to the thoracic aorta (42% vs 9%). Peripheral embolism and aneurysms occur more often in patients with descending aorta penetrating ulcers (28% vs 9% and 46% vs 28%). Rupture was observed in 20% of PAU cases, considering the descending aorta, and in 38% of abdominal aorta cases (p>0.01). Perioperative mortality amounted to 2%.

According to the recommendations presented by Chaikoff et al. (33), we calculated the percentage of primary technical success, which amounted to 85.71% in case of patients after stentgraft implantation to the thoracic descending aorta, and 89.47% considering the abdominal aorta. The index of primary clinical success in case of the descending and abdominal aorta amounted to 85.71% and 84.21%, respectively. Literature data demonstrated the technical success amounting to 89.79-98% after stentgraft implantation to the descending aorta (4, 10), while in case of the abdominal aorta the technical and clinical success amounted to 92% and 98%, respectively (34, 35). One of the factors responsible for the decreased percentage of clinical success was the occurrence of early complications, connected with the learning curve. According to Boult et al. (34), factors influencing lack of technical success were as follows: AAA neck flexure angle >45°, short neck, and large diameter of the aneurysmal sac. Factors influencing lack of clinical success were as follows: AAA neck flexure angle >45°, reduced size of the aneurysmal sac during the observation period, advanced patient age, and large diameter of the AAA sac before the endovascular procedure.

Considering our patient group, mortality after thoracic descending aorta stentgraft implantation amounted to 4.76%, while that after abdominal aorta implantation – 0.88%. According to literature data mortality in case of patients subjected to stentgraft implantation, due to Stanford B type dissection ranged between 6.7-16% (10, 36, 37), while that after endovascular procedures on the thoracic descending aorta – 19% (11). After endovascular procedures considering patients with AAA, mortality ranged between 0.6 and 5.8% (3, 4, 13, 15, 34, 35).

In one case (4.76%) the narrow femoral artery rendered impossible the introduction of the stentgraft into the thoracic descending aorta, which required transient access from the vascular prosthesis anastomosed to the iliac artery. Similar procedures were performed by other authors, using the transient access through the iliac arteries and abdominal aorta (11, 22, 24, 27, 37).

Considering our patients, three (2.63%) early conversions to open surgery were necessary: one because of iliac artery aneurysm rupture during the operation and two because of AAA rupture during the postoperative period. Two (1.75%) late conversions were performed, due to stentgraft inflammation. Considering literature data the percentage of early conversions after abdominal aorta stentgraft implantations ranged between 0.6 and 6%, while in case of late conversions, between 2.15 and 23.6% (3, 4, 34, 35, 38, 39). The most common cause of early conversion was connected with vessel tortuosity and significant iliac artery stenosis, which rendered impossible the introduction, implantation, opening and anchorage of the stentgraft. Thus, in case of “difficult anatomical conditions” of the iliac arteries, numerous authors (38, 39) recommend to withdraw from endovascular intervention or implant a transient vascular prosthesis conduit. The most common causes of late conversions are as follows: translocation of stentgrafts, separation of stentgraft elements and integument continuity disruption in case of older models. This leads towards stentgraft insufficiency, which was manifested by the development of endoleaks, as well as aneurysm enlargement or rupture.

In case of one of our patients (5%) the branching of the left subclavian artery was covered by a stentgraft, considering the patient with thoracic descending aortic dissection, type Stanford B. The above-mentioned seems necessary in 26-55% of cases, without significant and long-lasting cerebral blood flow disturbances and upper extremity vascularization (4, 24, 26, 36, 37).

Complications connected with vascular system access requiring surgical intervention were...
observed in three (2.63%) cases after abdominal aortic stentgraft implantation. All patients presented with common femoral artery injuries. Surgery consisted in femoral artery reconstruction using a patch from the saphenous vein. Complications following reconstructive operations, due to arterial rupture or occlusion were observed in 6.1-9.68% of cases, according to literature data (4, 11).

Early type 1 endoleaks were observed in two (10%) cases following thoracic descending aorta stentgraft implantations. According to literature data type 1 endoleaks occur in 22.58%, type 2 in 12.9%, and type 3 in 6.45% of cases (11).

After abdominal aortic stentgraft implantations, primary endoleaks were observed in 13 (11.40%), and secondary endoleaks in 8 (7.01%) patients. According to other authors the frequency of primary type 1 endoleaks ranged between 2.27-5.4%, type 2 endoleaks between 4.4-10%, and type 3 endoleaks between 1.5-1.9% (3, 4, 24, 34). Spontaneous closure of primary endoleaks and surgical management are responsible for their decreased number. According to EUROSTAR data (4) the percentage of endoleaks disclosed during the initial control examination (10.9%) is lower, in comparison to angiographic data obtained at the end of the operation (16.32%) (type 1: 2.9% vs 4.2%, type 2: 7.2% vs 10%, type 3: 1.6% vs 1.9%). After an 18-month observation period endoleaks were noted in 9.6% of cases, including type 1 – 2%, type 2 – 7.3%, and type 3 – 1.1%. Primary endoleaks usually close spontaneously (24, 34). According to the RETA registry, persistent type 1 endoleaks were connected with aneurysmal rupture in 21% of cases (3). Persistent and secondary endoleaks usually require surgical intervention (24, 34). According to the EUROSTAR registry (40) and Van Marrevijk et al. (41) the percentage of interventions (trans-abdominal, post-anatomical and endovascular) was higher in case of patients with endoleaks.

Considering our patients the endoleaks were treated conservatively or by means of endovascular methods. After abdominal aortic stentgraft implantation, both balloon interventions in case of early and distant type 2 endoleaks proved ineffective. In case of endovascular procedure failure, considering patients with persistent type 2 endoleaks with concomitant aneurysmal sac enlargement, Ferrari et al. (42), and Verhoeven et al. (43) recommended AAA sac opening, removal of the clot and underpinning of the bleeding retrograde vessels.

Four (3.51%) of our patients demonstrated early acute lower limb ischemia symptoms, due to thrombosis of the stentgraft leg. According to literature data, early occlusion of the stentgraft leg was observed in 0.68-2.27% of cases (4, 24).

Three (2.63%) patients were diagnosed with distant acute lower limb ischemia, due to brachial thrombosis and stentgraft translocation. According to literature data distant occlusion of the stentgraft leg was observed in 2.27-2.67% of cases (24, 44).

In case of one (0.88%) patient the stentgraft was implanted at the site of the accessory renal artery occlusion. According to EUROSTAR data (4) the closure of the accessory renal artery was observed in 181 of all 8345 (2.17%) endovascular procedures, considering patients with abdominal aortic aneurysms. Outcomes of accessory renal artery occlusion have no negative influence on kidney functioning, and embolization is not required in case of type 2 endoleak treatment (45).

Two (1.75%) patients after bifurcated stentgraft implantation were diagnosed with colon ischemia. In one of the above-mentioned patients, both internal iliac arteries were occluded, thus, the stentgraft legs were implanted into the external iliac arteries. One patient required Hartmann’s procedure, while conservative treatment in one, proved effective. According to literature data, after AAA endovascular procedures colon ischemia occurred in 0.6-2.9% of cases (3, 4, 46). Many authors consider that the cause of the above-mentioned might be connected with the mobilization of the embolic material from the AAA neck during technically difficult operations (46, 47, 48). There is no evident data that one-sided or both-sided internal iliac artery occlusion might be responsible for colon ischemia. Nevertheless, both-sided internal iliac artery occlusion should be avoided. Zhang et al. (47), recommended colonoscopy in case of patients with potential embolic material localized in the AAA neck, when postoperative peripheral embolism symptoms developed.

Two (1.75%) patients required stentgraft removal, due to inflammation followed by non-anatomical anastomoses. Hartmann’s procedure performed several days after stentgraft im-
planted, because of colon ischemia proved an inflammatory risk factor. The frequency of stentgraft inflammations, according to literature data and Ducasse’s questionnaire (49), ranged between 0.05 and 4% (mean – 0.43%). Mortality after conservative and operative treatment amounted to 36.4% and 14%, respectively. Mortality after non-anatomical and in situ reconstructions amounted to 16% and 5.8%, respectively.

After 12-months of observations, a 5 mm reduction in the AAA diameter was noted in 57.14% of patients, and an increased diameter in 17.86% AAA patients. Australian authors (34) observed an increased percentage of aneurysmal sacs, which decreased during the observation period from 40% after 6 months to 70% after three years. The diameter of 10% of aneurysms increased after three years following stentgraft implantation.

Considering our patients, most complications requiring repeated endovascular and surgical procedures occurred during the initial six months following abdominal aortic stentgraft implantations (fig. 1). According to Boult et al. (34), factors increasing the risk of possible complications and necessity of reintervention after abdominal aortic stentgraft implantations are as follows: presence of concomitant diseases (high ASA class), unsuitable patient for open AAA repair, and large AAA diameter. These factors are evidence of the need to perform endovascular procedures in the treatment of abdominal aortic aneurysms. Thus, patients and surgeons should be conscious of the increased possibility of complications, and necessity to perform following surgical procedures in patients fulfilling the above-mentioned criteria. According to the EVAR 1 trial (5) reinterventions are necessary in 9.8% of patients after endovascular AAA repair, and in 5.8% after classical operations (p=0.02). Hobo and Buth (40) analysed the EUROSTAR registry demonstrating 247 cases of reoperations in 2846 (8.7%) patients after stentgraft implantations, due to abdominal aortic aneurysms.

CONCLUSIONS

1. The implantation of stentgrafts is a safe and effective method, considering the treatment of thoracic descending aorta injuries, dissections and ruptures.
2. The implantation of stentgrafts enables to obtain satisfactory results in the treatment of abdominal aortic aneurysms, considering high-risk patients.
3. The significant number of complications and their heterogeneity might be responsible for the limited indications towards stentgraft implantations. The above-mentioned method should be performed in case of patients, where classical operations are connected with increased risk of complications.

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COMMENTARY

Endovascular treatment of aortic aneurysms is now a well-recognized method. However, the majority of publications mention early results of endovascular treatment, whereas, late results are frequently omitted. The presented study is to my knowledge the first in Polish literature, to treat so extensively and in details, distant results of endovascular treatment of aortic aneurysms using stent-grafts. The above-mentioned is an important contribution in the discussion concerning indications for endovascular treatment.

The Authors analyzing complications did not refer to the type of the stentgraft used. The construction of the stentgraft, its form of fixation (sub- or infrarenal) may have an important influence on the frequency and character of complications. It would also be interesting to determine the influence of the vascular anatomy or the tortuosity of iliac arteries on the occurrence of complications, such as type 1 endoleaks and the occlusion of the stentgraft leg.

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