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Endovascular treatment of aortic aneurysm by endoprosthesis

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Aortic endoprosthesis are divided according to its shape, site of application, and construction material. Regarding the shape, there are tubular, unilateral and bifurcational endoprosthesis. Tubular are used mostly for treatment the thoracic aneurysms, and less for treatment of the abdominal aneurysms. For exclusion of abdominal aneurysm the bifurcational prosthesis is mostly used. Aortic endoprostheses are made of metallic support and prosthethic part. Supportive elements are made of stainless steel or nitinol, while the prosthetic part is made of dacron or PTFE. Metallic part of prosthesis attaches prosthesis to healthy part of aorta, above and below aneurysm, like sutures. It expands and gives support to the prosthesis. The procedure is precisely described for thoracic and abdominal aortic aneurysms. We describe the possible complications and the mechanism of leakage and its diagnosis. In the study are presented two cases of patients with aneurysm of thoracic aorta and one case with abdominal aorta, successfully treated in our Institution. The follow-up results after 2 years, in the patients with thoracic aortic aneurysm, and 6 months follow up in the patient with abdominal aortic aneurysm showed no signs of clinical or imaging complications. In conclusion, we were trying, on the basis of our experiences and results that have been recently published, to evaluate this method of treatment.

Key words: aortic aneurysm; blood vessel prosthesis

Introduction

Aortic endoprosthesis is used for exclusion of aortic aneurysm in abdominal and descending part of thoracic aorta. It is indicated as an alternative treatment to operation in high risk patients. It is introduced into aorta through delivery catheter system from femoral artery. First report about successfully treated aortic aneurysm of abdominal aorta was given by Benko in 1986.[1] The first results of treatment in human beings were published in 1991 and 1994.[2,3] The first placement of endoprosthesis in Slovenia was performed in 1994, under the American professor (prof. dr. Keller) supervision.[4] It was performed by ourselves in two patients with thoracic aneurysm in 1998 and in one patient with abdominal aneurysm one year later.

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Types of endoprostheses

Endoprostheses are divided according to shape, site of application and construction material. We define tubular (Figure 1a), unilateral and bifurcational (Figure 1b) prosthesis by shape. Endoprosthesis for descending part of thoracic aorta is tubular (Figure 1a), big, with diameter of 34-40 mm and 50 mm long or otherwise made by special order. It is made of self-expanding metallic support (Figure 2a) and prosthesis from dacron (Figure 1a).[3,4] Endoprostheses for abdominal aorta are tubular, unilateral or bifurcational (Figure 1b). They are made of Palmaz sent and dacron or PTEF [2,5] prothesis or Gianturco or nitinol self-expanding sent and dacron prosthesis.[3,4,6] Palmaz prosthesis is expanded with balloon catheter, others are self- expanding.[2,5] Tubular type is used for exclusion of aneurysm, which is 15-20 mm away from bifurcation. Bifurcational or unilateral type is used when aneurysm reaches bifurcation or one or both iliac arteries (Figure 1b). Tubular measure 22-30 mm, bifurcational 22-35 mm, iliac artery part 10-18 mm.

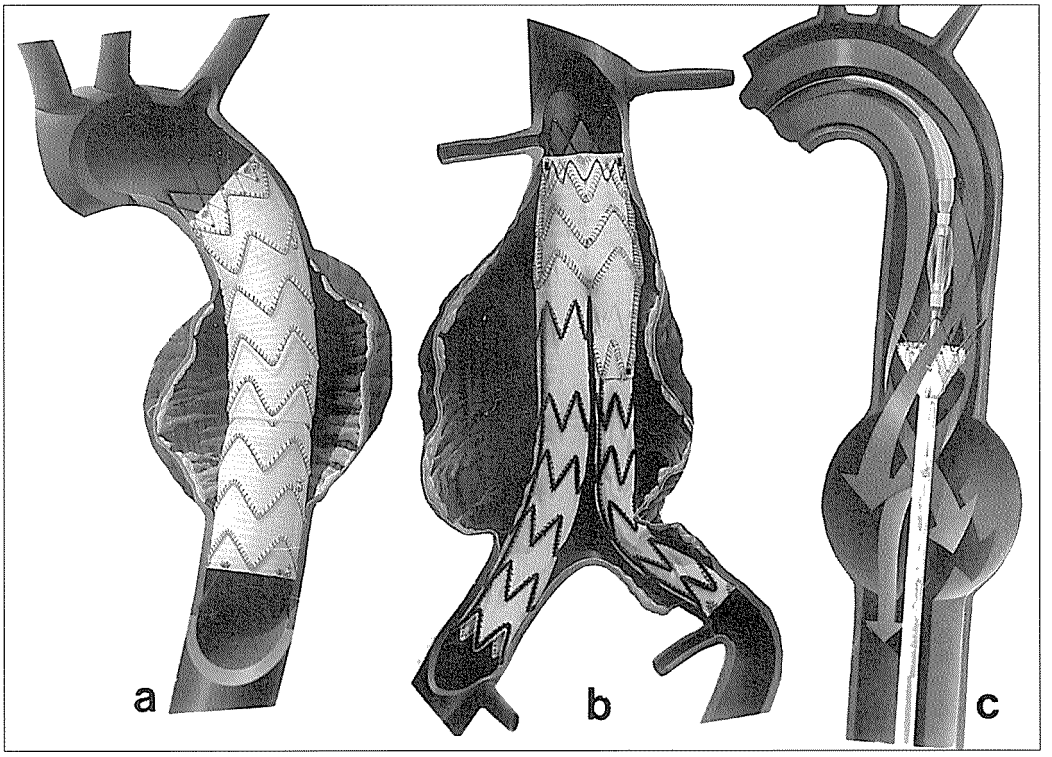

Figure 1. Schematic figure of tubular and bifurcational endoprosthesis and one of the delivery systems. A) Tubular endoprosthesis from dacron and nitinol crosses the aneurysm of descendent thoracic aorta. Endoprosthesis crosses the edges of dacron prosthesis to enlarge the attachment segment with aortic wall. B) Bifurcational endoprosthesis crosses the abdominal aneurysm, bifurcation and iliac arteries. Aortic neck between renal arteries and aneurysm is short, attachment site is enlarged by uncovered part of endoprosthesis, which goes over right renal artery orifice. Left part of endoprosthesis is introduced separately, through left common femoral artery. C) Delivery system with endoprosthesis is introduced over guide-wire, it is narrower in the front part and flexible to ease the introduction over stenosis and edges. Endoprosthesis is released with quick pulling down of outside catheter at chosen site. Latex balloon placed over endoprosthesis to improve its attachment to aortic wall above and bellow aneurysm.

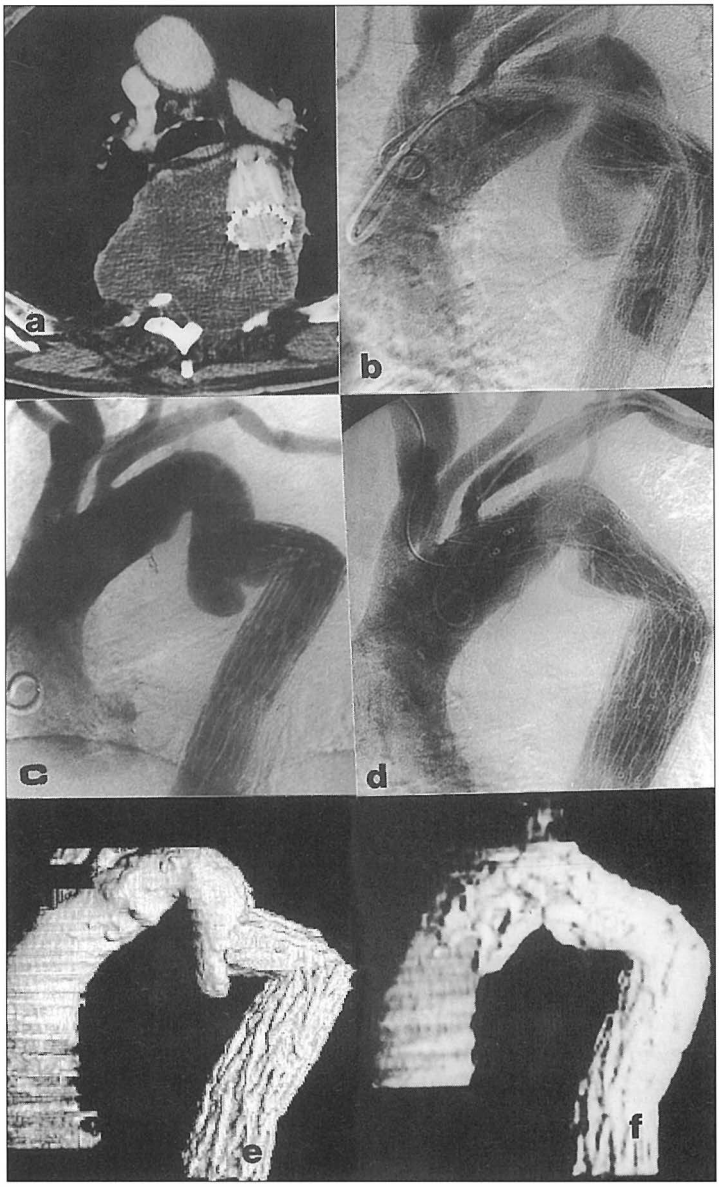

Figure 2. Late complication of endoprosthesis treatment in thoracic aorta and its cure. A) Transversal slice on spiral CTA shows bending of endoprosthesis with leakage into big aneurysm, which eroded thoracic spine segments. B) DSA of thoracic aorta in LAO shows movement and bending of prosthesis towards aneurysm, widened aorta over endoprosthesis and leakage to aneurysm. C) 3D reconstruction of spiral CTA in LAO projection confirms angiography. D) Introduction of delivery system with endoprosthesis over bending and curves as also highly positioned aortic arch towards subclavian artery, after which there is attachment site of new endoprosthesis. It is achieved with guide-wire, which is pulled through brachiocephalic and axillary artery out and additionally firmed. E) New endoprosthesis reaches up to left subclavian artery orifice and down to straight part of pre-existing endoprosthesis (marks shaped as no.8). Bending of endoprosthesis is sufficiently corrected, leakage is not obtained any more. F) Spiral-CTA in 3D reproduction shows good position of endoprosthesis, correction of bending and no leakage.

Procedure performance

Endoprosthesis for the thoracic aorta is introduced in general anaesthesia with intubation and ventilation. Catheter is placed into pulmonary artery and tube is placed into oesophagus for US control. Angiography catheter is introduced into ascendent aorta through one of brachial or axillary arteries for DSA control. Patient is given antibiotic protection, with cephalosporin application every 4 hours for 8 times. In Standford, USA [3], the procedure is performed on operation table, permeable for X-rays. Patient is sterile washed and placed in a way that immediate sternotomy can be performed, if necessary. In Slovenia procedure is performed on X-ray table in intervention radiology room, additionally prepared for this procedure. We have stand-by surgery team with extracorporeal equipment prepared. We are working under fluoroscopy and DSA control. Control angiography is performed at the beginning, to obtain the starting position. The surgeon prepares the femoral artery, on the site of arteriotomy we do the puncture of common femoral artery and introduce the guiding-wire (type »J« 0,035 inches, 260 cm long), with greater stiffness and better support. The front part, i.e. the softer part, is introduced into the ascending aorta. The patient receives 5000 I.E. heparin i.v. Through arteriotomy site, introducing sheath with haemodynamic valve is implanted over the guiding-wire. Sheath is placed on plastic dilator for support during the introduction. The choice of length and diameter of the sheath depends on aortic width, position of aneurysm and size and construction of the prosthesis. The front part of the sheath is placed over aneurysm, or otherwise over the site where the endoprosthesis will be released (Figure 1c). Endoprothesis is placed inside short catheter, from which it is introduced into sheath by using pushing catheter and placed at its edge. Introduction and precise positioning is controlled by DSA (Figure 2d). Endoprosthesis is released by holding pushing-catheter in a position and quickly pulling sheath down (Figure 1a,c). Endoprothesis is according to its self-expanding mechanism pressed against aortic wall and so excludes the aneurysm from the blood flow. Displacement of endoprosthesis during the procedure is disabled by lowering of aortic pressure to 50-60 mmHg for short time. Control DSA shows the exclusion of the aneurysm. After the catheter's removal the surgeon sutures the arterial opening and the operation site. Shorter iliac part may become longer with additional endoprosthesis, percutaneously introduced on the same side. For aneurysm exclusion, which reaches bifurcation and iliac arteries tubular endoprosthesis with distal narrowing can be used, it is placed deep into iliac artery and contralateral side is closed by embolisation. Limb vascularisation is provided by femoro-femoral by by-pass. Endoprosthesis for abdominal aorta is usually placed in local or spinal anaesthesia.

Our experience

We treated 3 patients with aortic aneurysm in our Institution, two patients with aneurysm in descendent part of thoracic aorta and one with abdominal aneurysm. In patients with thoracic aortic aneurysm the indication for treatment was a high risk for operation procedure. A patient with abdominal aortic aneurysm choosed this treatment as an easier procedure after having two open heart surgeries. In the first case, it was pseudoaneurysm, which caused hoarseness and in the second case due to the late complication with deformation of endoprosthesis and internal leakage (Figure 2a,b,c) after 2 treatments of percutaneous placement of endoprosthesis.

Results

Treatment with endoprosthesis is successful in cases where there is no leakage into aneurysm, where there is narrowing of aneurysm or no longer growth of it. In the cases of leakage the procedure is unsuccessful, and it is also the same, if aneurysm grows, even without obvious leakage. If aneurysm does not become smaller, even without leakage, we should state that aneurysm is not excluded, except if it is very calcified. In the cases where aneurysm stays the same (or grows bigger) with leakage present, there is quite a risk of its rupture.

Complications

Possible complications are divided by Dietrich[8] into 3 groups: complications during introduction, local/vascular and distant/systemic complications.

- Complications due to introduction are caused by missapproach, displacement of endoprosthesis, endoprosthesis' collapse, deformation and thrombosis.
- Local/vascular complications are: aneurysm rupture, leakage, stenosis of endoprosthesis, occlusion of renal arteries or subclavian artery, ileofemoral injury, embolism and bleeding.
- Distant/systemic complications: microembolisations, multisystemic failure, renal or cardiac failure, myocardial infarction, arrhythmia, stroke or transient vascular disturbance.

Endoprothesis can cause vascular disturbance of spinal cord and so transient or permanent paraparesis. The most frequent complication is leakage of blood at the site of attachment into aortic wall either above or bellow aneurysm. Leakage can be early or late. Causes of early leakage can be due to endoprosthesis or aortic wall. Endoprosthesis can bend or detach from the attachment site, its size or shape can be unsuitable or it can incompletely expand or be misplaced.

Aortic neck can be short, too wide or covered with recent thrombus or atheroma, so endoprosthesis is attached to a wounded neck. Small, fresh bleeding usually stops spontaneously in few weeks. If leakage is present after 3 months, and the patient is not coagulopath, we have to treat it. The leakage will persist if there is inflow and outflow in the aneurysm with a pressure difference. This kind of leakage does not stop spontaneously and risk of aneurysm's rupture persists. Blood flow direction in the aneurysm can flow from the upper to lower site of leakage (Figure 3a), from upper or lower to side branches (Figure 3b) or from lower to side branch-

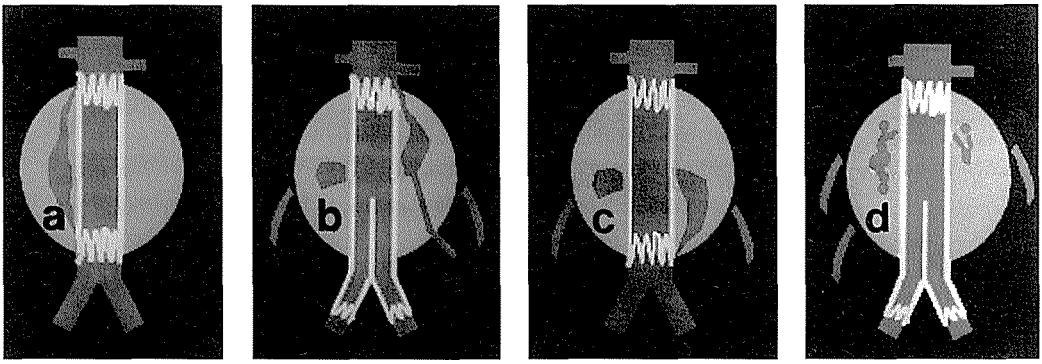

Figure 3. Schematic figure of blood flow direction in leakage into aneurysm. A) Blood flow between upper and lower leakage. B) Blood flow between upper leakage and side branches. C) Blood flow between lower leakage and side branches. D) Blood flow between arterial branches and aneurysm.

es (lumbar, hypogastric, AMI) or between branches and aneurysm itself (Figure 3d). Persistent leakage in aneurysm without outflow persists only if leakage is profound or outflow is not obtained. Late leakage is a complication diagnosed during follow-up of the patient without previous leakage. It is caused by displacement of endoprosthesis (Figure 2 b,c,d), deformation of parts of endoprosthesis, progressive dilatation of aorta at the attachment site. It is the most serious complication of this kind of treatment. Diagnosis and differentiation of leakage is important for its treatment (Figure 2).

Diagnosis of early and late complications

Displacement, deformation, and bending of endoprosthesis is most easily diagnosed by plain film of chest and abdomen in AP and side projection. In comparison with previous films we can evaluate the present state. US, which is relatively cheap and non-invasive method, can evaluate the size of aneurysm: it can be smaller, equal, or bigger. More profound leakage or/and blood flow in the aneurysm can be diagnosed by Doppler US. Small leakage and very small changes at the attachment site are better shown with spiral CTA, with 3 mm thick transversal slices. With spiral CTA a communication between aneurysm and side branches can be obtained, and also the changes in diameter and volume as well as the displacement of aneurysm (Figure 2a,c).[9]

Alternative method is MRA. It shows precise changes in aortic wall, size of aneurysm and thrombus in it.[10] It enables 3 D picture in few directions. Spiral CTA is more reliable for smaller leakage. MRA is in some regards better then CTA -there is no ionisation and nephrotoxic contrast media. MRA is used as a method of choice in treatment of patients before endovascular placement.[10] Ferro material in some endoprosthesis unables further MRA follow-up.

Treatment results, discussion and conclusion

Both our patients with thoracic aortic aneurysm have no clinical problems after 2 years and also our patient with abdominal aneurysm was without symptoms after a year. We found no changes on plain film in position or shape of endoprosthesis. We will perform spiral CTA one year after the procedure, or even sooner in the case of clinical problems or changes found on plain film. In Standford, there were 102 patients with aneurysm of descendent part of thoracic aorta of different aetiology treated between July 1992 and February 1997.[12] The procedure was successfully performed in all cases, 82% survived 35 months. 1,8 % of patients died in the period up to 35 days after the procedure. Nobody died during the procedure, 3,9 % remained paraplegic and 4 % suffered from partial thrombosis of aneurysm. These results are encouraging in comparison with operative treatment, with death rate between 12 %-17 %.[14] The most experienced with abdominal aneurysm intravascular endoprosthesis treatment is Parodi [5,15], but he did not follow up the patients. In large group of 765 patients from 31 European countries the results and complications of abdominal aneurysm treatment with endoprosthesis are published between the period of May 1994 and November 1997. 92 % were treated with bifureational prosthesis, only 8 % with tubular. The treatment was successful in 83 % after 3 months. 3,7 % patients died in the first 30 days. Internal leakage was diagnosed in 14 %, of those 68 % closed spontaneously. The results are comparable with operative.[16]

In conclusion, we can state that treatment of aortic aneurysm with endoprosthesis in descendent part of thoracic aorta is more successful than abdominal aneurysm treatment, especially on long-terms. In some indications it is even more successful than the operative treatment and so it becomes a method of choice for thoracic descendent aortic ane-

urysm. The biggest problem is attachment of endoprosthesis in abdominal aorta to the aortic wall between aneurysm and renal arteries, when this part is too short or weakened.

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