review

Diagnostic imaging, indications and measurements for the treatment of aortic aneurysm by endoprosthesis

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Background. *This paper presents imaging diagnostics of an aneurysm of the aorta, indications, common contraindications and measurements for the construction and selection of an endoprosthesis. The examination using ultrasound is the most handy and economically justifiable method for detecting an aneurysm of the aorta, for monitoring asymptomatic aneurysms as well as patients having undergone an operation or those with an endoprosthesis. Another examination to visualise the aortic aneurysm is CT with or without contrastive medium. The plan for treating an aneurysm can be made with the help of a DSA, helical CT angiography and/or MRA. DSA shows well the lightness of the aneurysm and the aorta, as well as the changes inside of it, large arteries close to the aneurysm and the condition of pelvic arteries for the selection of the approach. The helical CT angiography and MRA in two or three dimensional reproduction in several directions enable an accurate measurement of an aneurysm, the aorta diameter above and below the aneurysm, and the evaluation of the quality of its wall.*

Conclusions. *The indication areas for endoprosthesis are aneurysms of the abdominal aorta and those of the descending part of thoracic aorta. The treatment with endoprosthesis as a less invasive method is indicated in patients who risk a number of complications and even high mortality when treated surgically. Endoprosthesis is made of metal stent and prosthesis. The stent attaches the endoprosthesis to the unaffected part of the aorta above and below the aneurysm, it sets the stent asunder and provides support. The prosthesis is made of Dacron synthetic fabric, which has very good properties for this purpose such as small compliance, porosity, permeability and extensibility. The endoprosthesis is introduced into the aorta through a catheter system with the help of a special guide wire. The entering point is surgically opened common femoral or iliac artery.*

Key words: aortic aneurysm-diagnosis-therapy; tomography, x-ray computed; magnetic resonance angiography; angiography, digital subtraction; blood vessel prosthesis

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Introduction

Aortic aneurysms are consequences of atherosclerosis, inflammatory and degenerative changes in the aortic wall and posttraumatic changes of its wall. It is most commonly found in abdominal aorta, followed by the ascendent part of thoracic aorta and aortic arch, and less frequently in descendent aorta. The frequency of aneurysms, especially abdominal, is growing.[1,2] The reason for this is probably higher life expectancy and wider use of ultrasound and CT diagnostics.

Aneurysms are classified as asymptomatic and symptomatic. Symptomatic and very large asymptomatic lesions with the weakened vessel wall are life-threatening, the others being followed for enlargement. The treatment is by means of a surgical repair, lately being replaced by the percutaneous insertion of endoprosthesis[3,4] without actually opening the thorax or abdominal wall. This, less invasive approach, is becoming increasingly popular as alternative method, opposed to a surgical treatment of descending part of thoracic aorta and abdominal aorta. To be successful, it is very important to exactly plan the procedure, and various imaging techniques play a major role in it.

Imaging diagnostics

Aneurysms are most commonly found at ultrasound examination and native x-ray films. Especially ultrasound is very useful as the primary method for the detection of abdominal aneurysms. With ultrasound, it is possible to assess the extent of the aneurysm, and the presence of the thrombus in it or near it. Doppler US enables the evaluation of the remaining flow rate, its direction and quality. Ultrasound is most suitable for the follow-up of asymptomatic aneurysms and of postoperative assessment, having a very high cost-benefit as well.[5]

Aneurysms of thoracic aorta are usually found accidentally at chest radiograms or CT; less frequently it is specifically looked for due to dissection, local rupture, local pressure or haemorrhage. On chest films, it is often indistinguishable from expansive mediastinal lesions. In case of localised haemorrhage, a chest film demonstrates a local mediastinal widening or a pleural effusion. Diagnosis can be confirmed by an transthoracic or transoesophageal ultrasound examination, the latter being more reliable and accurate. It demonstrates aneurysm, dissection of the aortic wall, thrombus in the lumen or in surrounding tissues. The next diagnostic modality is CT with and without contrast material, defining aneurysms of thoracic and/or abdominal aorta, its wall, possible haemorrhage, thrombosis and contrast extravasation. It also delineates aorta above and below the affected segment.

Next, imaging modalities are directed towards the treatment planning. »Gold standard« remains digital subtraction angiography (DSA), which reliably shows aorta, aneurysms and her branches as well as iliac arteries and thus enables the possibility of treatment by stent-graft, the choice of the most appropriate entry site and implant route. DSA only demonstrates the lumen of the vessel and aneurysm. By contrast, CT angiography (CTA) and MR angiography (MRA) enable the visualisation of the aortic and aneurysmal wall, the demonstration of thrombus and the assessment of the flow within the aneurysm.[6,7]

It is important for the assessment of aortic wall quality that the endoprosthesis is firmly and permanently attached to the normal vessel wall, as opposed in the case of attaching it onto the thrombus or diseased aortic wall, where the permanence is not guaranteed. CTA (Figure 1) and MRA are very accurate imaging modalities for the procedure planning, due to the multidirectional view of tree-dimensional reconstructed images. CTA protocol is as follows: 50 rotations with the slice

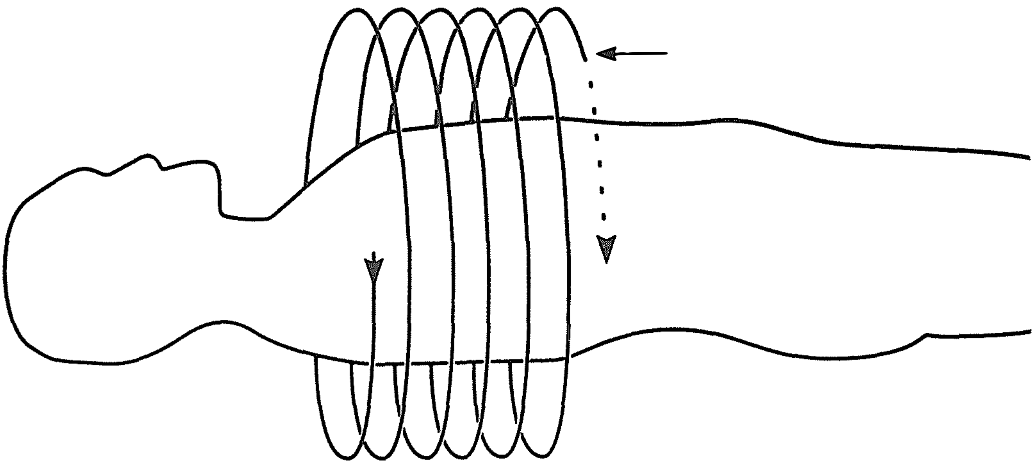

Figure 1. Schematical demonstration of spiral scan, made by x-ray tube during the table movement with the patient during CT angiography (CTA). Arrowhead indicates the scanning direction, and arrow the table direction.

thickness of 5 mm and table speed of 5 mm / sec and the continuous application of contrast material. The primary reconstruction is made with 2 mm interval so that overlapping slices improve the picture quality. Slices can be viewed in cine mode as well, so that the first impression about the endoprosthesis attachment site and the shape and the size of the aneurysm are noted. The exact measures of the width of aorta and the length of the aneurysm are possible on multiplanar reconstructed (MPR) images.[6] The alternative method is MRA, which also enables us to define the upper and the lower extent of aneurysm and its size, shape, thrombus and flow type within it.[7] As with CTA, the exact measurements are possible by MPR. Using different sequences, like two- and three-dimensional time-of-flight, turbo flash, and contrast enhancement, enables the increased diagnostic and prognostic accuracy of MRA.[8]

Indications

Indications for percutaneous treatment of aneurysms by the insertion of endoprosthesis are the same as for the surgical approach, yet the fact, that in contrast with the endoprosthesis insertion, the short- and long-term results of surgery are well known.[9,10] Planned surgical operations on aneurysms of ascendent thoracic and abdominal aorta in younger patients without additional vessel pathology are successful, but less favourable with the aneurysms of a descendent part of thoracic aorta.[10] A less favourable outcome is reported with urgent procedures, reoperations, and operations on the patients with coronary arteries disease, heart, lung or renal failure and other pathological conditions. A surgical treatment is less successful with older patients and severely diseased ones as well. In this part of the indication field, associated with a very high complication rate and high mortality, the insertion of endoprosthesis is becoming increasingly popular despite the lack of definitive long-term results, especially in the abdominal aorta, and carry a relatively high risk of complications. According to numerous reports by the group of authors from Stanford, USA, the insertion of endoprosthesis in the thoracic aorta is the treatment of choice within a definite range of indications.

General contraindications

Contraindications for the insertion of aortic endoprosthesis are i.e. sepsis, coagulopathies, contraindicated systemic anticoagulant protection during the procedure, inflamed aneurysm, extreme tortuosity and stenosed or occluded iliac arteries and/or terminal aorta. Patients with severe lung dysfunction need ventilatory support during the procedure.

Measurements

The aortic endoprosthesis is chosen individually for each patient on the basis of different diagnostic modalities, like chest radiograph, DSA, CTA and/or MRA. Chest radiograph is used to define the presence of pathology. DSA is used to assess the relations of aneurysms towards the aortic arch and great neck vessels in the upper part and celiac trunk in the lower part of descendent thoracic aorta; it also demonstrates intercostal and pelvic vessels as well. In the cases of abdominal aneurysms, the relations toward renal and iliac arteries are demonstrated. We use the calibrated catheter with measuring units, enabling us to measure the luminal diameter, as the vessel width is not a fixed constant at DSA and all units do not have associated measuring devices. CTA and/or MRA are very important for the accurate assessment of the diameter of aorta and the length of aorta above and below the aneurysm, where the stent-graft is to be inserted. The aortic length and the length of aneurysm can be different in each projection. Abdominal aneurysm and aorta above and below the lesion can produce different angles, as well as the overbifurcational aneurysm can deform the pelvic arteries angles (Figure 2). In these cases, CTA and MRA are invaluable tools to avoid the mismeasurements due to multidirectional views in three dimensions. With these multidirectional modalities, it is possible to determine the angle of bending for easier planning of treatment and to choose the most appropriate therapy. The length of unaffected segment cranially and caudally from the aneurysm should be at least 15 mm, as most of the endoprostheses have 10 mm of uncovered metallic parts for the increased longitude of the contact area with the aortic wall. It has been shown that the uncovered part of endoprosthesis does not significantly interfere with the flow through the vessels, even if it is partially inserted over them.[11,12] This is useful in cases, in which the distance between the aneurysm and renal or subclavian arteries is less than 15 mm.

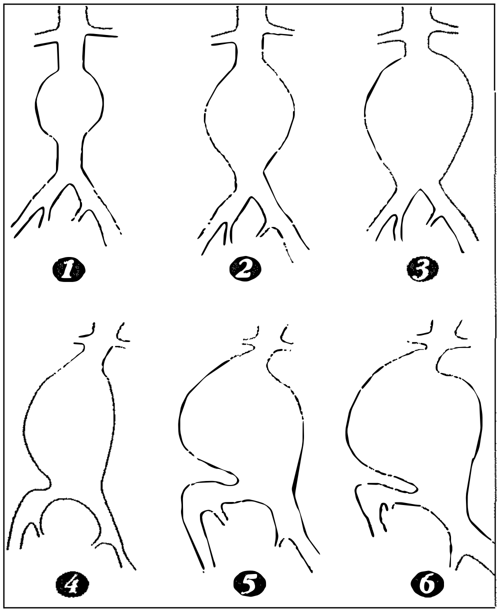

Figure 2. Morphology of the aneurysm in different stages.

Description of endoprosthesis

The aortic endoprosthesis is made of metal stent and prosthesis. A metal stent is often used for supporting the vessel wall at endoluminal dilation at the site of stenosis.[13] It is also used in the case of the endoprosthesis insertion for its fixation towards the vessel wall, instead of sutures, and so the blood flow through the aneurysm is excluded, as well as the danger of a rupture. It sets the endoprosthesis asunder and provides it support. The stent can be of the same length or longer than the prosthesis itself. It is usually made of stainless steel or nitinol, in the first case being made on the basis of Gianturco or Palmaz stent,[3,4,11] and in the second case on the basis of thermical memory processed nitinol (mixture of nickel and titanium). Stents of this material are designed at 500°C, but during the cooling they are compressed to the lower diameter. At the body temperature it regains its former shape. Palmaz-type endoprosthesis is packed and pressed to the balloon part of the catheter, and after the release it is expanded by the same balloon to the final diameter. Other types are self-expandable, being expanded immediately after the release. Stainless steel endoprostheses expand like the spring coils, while the nitinol ones on the basis of thermal memory. Usually, the self-expandable type of endoprosthesis is being used, and it attaches itself by means of the radial pressure, forcing it to the width of two millimetres greater than aorta.

The prosthesis is made of Dacron synthetic fabric, industrially named polyethylene terephtalate (PET), which has very good properties for this purpose such as small compliance, porosity, permeability and extensibility. Inside, it is impregnated with collagen, gelatin, or albumin in order to reduce its thrombogeneity. The prosthesis is attached to the stent at many sites with 6-0 polypropylene sutures.

The endoprosthesis is introduced into the aorta through a catheter system, the width of which ranges from 17 to 27 F, depending on the size and structure of the prosthesis. The size of device is depending upon the width of aorta, the extent of pathology to be treated, and upon the quality and amount of the material used for the planned endoprosthesis. The catheter insertion systems are alike, yet every manufacturer has its special properties. All are equipped with the insertion catheter into which we insert the endoprosthesis or it is already inserted into it. It is introduced in the aorta with the use of vascular sheath or without it. Without sheath, the insertion catheter is being applied with the help of a special guide wire, measuring 0,0035 inches and 260 cm long. The entering point is surgically opened common femoral or iliac artery.

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