Up to the early 1990s, the only alternative treatment to open surgery was watchful waiting in combination with controlling blood pressure [2]. In 1991, Parodi et al. [8] in Argentina and Volodus et al. in the Ukraine [9] first reported on Endovascular Aneurysm Repair (EVAR) using a stent-graft. In this procedure, the surgeon places the endovascular prosthesis into the aorta by the femoral or iliac arteries. Compared with conventional open surgery, EVAR has proved to be a less invasive procedure with shorter procedure duration, reduced blood loss and a shorter hospital stay [10]. Patients usually go home within three days of treatment as opposed to a week or more with the conventional treatment.

A meta-analysis of three randomized clinical trials [11 - 13] showed a 30-day mortality rate of 1.6%. That is significantly lower than the 30-day mortality rate of 4.7% for open repair. In addition, there is a lower incidence of perioperative pulmonary complications, hemorrhage, graft infection and colonic ischemia associated with EVAR [14].

Today, the EVAR procedure, developed and refined over the past eighteen years, offers a minimally invasive alternative for repairing abdominal aortic aneurysms [15]. A critical element in assessing the need for, performing and following up on any endovascular procedure is good imaging.

Endovascular abdominal aortic aneurysm repair using the Veradius with flat detector

Clinical applications

The abdominal aortic aneurysm (AAA) is a common condition, with a prevalence of up to 8.9% in men and up to 2.2% in women [1, 2]. As the natural course for aortic aneurysm is one of irreversible expansion, growth of the aneurysm will continue until the aorta eventually ruptures. Most patients with ruptured AAAs die before they arrive at a hospital or before it is possible to perform surgery [3]. Survival rates for emergency AAA repair are between 10% and 25% [4]. Ruptured abdominal aneurysms account for 1.3% of deaths in men older than 65 years [5].

Abdominal aortic aneurysms usually display no symptoms. Often, doctors only detect an AAA during a routine medical examination for some other complaint. Once found, if the aneurysm is larger than 5 cm, is growing by more than 1 cm a year, or is causing pain, then surgery is often the only choice for the patient. There is as yet no definite identified cause for the condition. Other than atherosclerosis, other factors associated with AAA disease are [6]:

• being a male
• smoking
• high blood pressure
• family history of AAA.

Previously, once the need for surgical intervention was determined, the only surgical choice available was open abdominal surgery. First introduced by Dubost et al. in 1952 [7], open aortic surgery has evolved and become the gold standard for treatment of AAAs. The technique does, however, involve laparotomy with the need for temporary aortic cross clamping to allow placement of an aortic graft over the area of the aneurysm.

Most AAA patients are elderly, often in the poor physical condition that accompanies old age. Thus there is severe morbidity and mortality associated with the open surgery technique.

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Today, the EVAR procedure, developed and refined over the past eighteen years, offers a minimally invasive alternative for repairing abdominal aortic aneurysms [15]. A critical element in assessing the need for, performing and following up on any endovascular procedure is good imaging.

At the University Medical Center (UMC) in Utrecht, the Netherlands, the Veradius mobile C-arm with flat detector has been undergoing extensive clinical evaluation. In the Department of Vascular Surgery, this new system is already proving to be a valuable tool in advancing the endovascular repair of abdominal aortic aneurysms.
Veradius with flat detector

The Veradius is a next generation of the versatile mobile C-arm system in which a thin, flat detector replaces the conventional image intensifier (Figure 1). The flat detector frees up valuable space and provides several advantages over the conventional image intensifier technology, including:

- a higher dynamic range, able to differentiate a larger range of grayscale values to provide clearer images with better contrast
- no distortion due to the earth’s magnetic field when rotating the C-arm, because of the direct digital conversion of X-rays
- no pincushion distortion, because the convex image intensifier input screen is replaced by a truly flat detector.

The Veradius is equipped with a stand monitor that allows the operator to position the flat detector easily and accurately, saving valuable X-ray dose and time.

Method

At the UMC, patients are mainly under general or epidural anesthesia during the EVAR procedure. The individual patient’s physiology or preference determines the choice of anesthesia. The patient’s anatomy, especially in the case of obese patients, can also affect the ability to image the aneurysm area clearly. Experience to date indicates that the Veradius with flat detector is having a positive effect on improving imaging during the EVAR procedure.

The procedure involves inserting the stent-graft, often called an endograft, in through the femoral artery. From there the surgeon guides the stent-graft up through the iliac artery to the site of the aneurysm. The stent-graft consists of a tube of polyester (Dacron®) or PTFE material supported by a metal skeleton frame. Stent-grafts are now available in various sizes and lengths to allow for different patient anatomies and aneurysm sizes. Usually the caudal end of the stent-graft is bifurcated to allow placement across the iliac arch as a preventive measure against stent-graft migration.

The stent-graft must cover the aorta interior wall correctly and exclude any further flow into the aneurysm sac, while ensuring that there is no obstruction of the renal or iliac arteries. The interior wall of the stent-graft then acts as an artificial lumen, taking the pressure off the aneurysm sac, the contents of which will thrombose in time.

The stent-graft is compressed into a sheath for delivery, which is removed once the stent-graft is in the correct placement area. The skeleton metal frame, in trying to revert to full size, gives firm fixation without the need for sewing. Precise placement of the stent-graft before deployment is therefore essential.

To ensure correct placement, the procedure is carried out under fluoroscopic control. With a conventional image intensifier, the convex input screen produces pincushion distortion at the edge of the image field (Figure 2). When the area of interest is confined to the center of the image this is not a problem. However, the EVAR procedure requires a large distortion-free image, because undistorted estimates of the distance between the renal arteries and the proximal part of the stent-graft, and between the distal part and the iliac arteries, are needed to assure correct placement.
occlusion. With the improved image quality provided by the Veradius, the stent-graft can now be positioned as close as 1 mm to the renal artery, making it possible to treat patients who previously could not undergo the EVAR procedure because of the proximity of the aneurysm to the renal artery.

The medical personnel have noted that using Veradius with the flat detector also improves communication in the operating room. This is because it is less obtrusive and so does not block eye contact between members of the operating team. Now, for example, it is possible for the surgeon to see clearly the anesthetist stationed at the head end of the patient. This aids communication at the most critical stage of the procedure, so that the anesthetist can control the patient’s breathing while the stent-graft is being maneuvered into exactly the right position.

Conclusions

In the future, the ageing population is expected to lead to a rise in the number of patients presenting with AAA. Endovascular repair

Here the flat detector has a distinct advantage over the convex input screen of the image intensifier, as there is no pincushion distortion, so that distances can be estimated equally well at the center or at the periphery of the image field. This means that it is no longer necessary to reposition the C-arm to ensure that the region of interest is in the center of the field of view. Consequently, the procedure is faster and, as fewer images are required, there is an overall saving in X-ray dose and the quantity of contrast agent needed.

A further advantage using the Veradius is that the clear, sharp digital images make it easier to identify anatomical structures, the stent-graft, and the radiopaque markers on the sheath and catheter, contributing to greater confidence and a faster operating procedure.

Most stent-grafts are placed in the area between the renal arteries and the iliac arch. With the conventional image intensifier the image quality is insufficient to allow a stent graft to be placed closer than 2-3 mm to the lowermost renal artery, in order to avoid the risk of partial or total occlusion. With the improved image quality provided by the Veradius, the stent-graft can now be positioned as close as 1 mm to the renal artery, making it possible to treat patients who previously could not undergo the EVAR procedure because of the proximity of the aneurysm to the renal artery.

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Conclusions

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The flat detector has no pincushion distortion.
techniques will need to be constantly improved to meet the increased demand. New stent-graft designs will allow treatment of patients who are now excluded because of physiology, age or aneurysm location. In addition, imaging techniques need to be improved to meet the imaging requirements of these new developments.

The Veradius mobile C-arm with flat detector is an example of this improvement in imaging technology. Designed to give excellent quality at low X-ray dose, the flat detector has several advantages over image intensifiers. The flat detector has a wider dynamic range, providing improved brightness and contrast, and fewer distortion artifacts.

The clearer, sharper images give the vascular surgeon working with AAA cases greater confidence and freedom to select and use new stent-graft designs. As a result, more patients will undergo less invasive procedures, with the consequent decrease in risk, and an improved quality of life.

Over the last decade, EVAR has gained increased worldwide application for the treatment of abdominal aortic aneurysms. In comparison with the open surgery, EVAR is significantly less invasive and the outcome of the first randomized trials supports the use of EVAR in patients.

In the future, new stent graft technologies will probably extend the application and durability of EVAR. The first results with fenestrated grafts are promising for patients with short aneurysm necks, and with the use of these, migration rates are expected to be lower. In all cases, image quality will continue to play a key role in the success of AAA treatments, and the Philips Veradius with flat detector appears to be an important step in this direction.

Case studies

Case 1
An abdominal ultrasound examination revealed an asymptomatic saccular abdominal aortic aneurysm in a 73-year-old male patient who had presented with an unrelated complaint. The anatomy of the aneurysm was judged to be suitable for endovascular repair.

A bifurcated stent-graft was inserted via the left femoral artery, and positioned with the stent still retracted just below the renal arteries. A control angiogram was made (Figure 3a) to check the stent-graft position before deployment. The radiopaque markers indicate the proximal end of the covered part of the stent-graft.

After deployment of the bare stent, the second limb of the bifurcated stent-graft was inserted and deployed. The result of the procedure is shown in Figure 3b. The aneurysm is fully excluded by the bifurcated graft, while the renal and internal iliac arteries remain patent, as planned.

Case 2
An 85-year-old male patient presented with an asymptomatic abdominal aortic aneurysm. The anatomy of the aneurysm was judged to be suitable for endovascular repair.
Figure 4. Case 2. An asymptomatic saccular abdominal aortic aneurysm in an 85-year-old male patient.

Figure 4a. Positioning the proximal part of the stent-graft.

Figure 4b. Deployment of the right and left limbs of the bifurcated stent-grafts.

Figure 4c. Because the longest available stent-graft was too short for this patient, the right limb was extended with an extensor cuff.

Figure 4d. Final angiogram showing satisfactory exclusion of the aneurysm.
The main body of the bifurcated stent-graft was inserted via the right femoral artery and the proximal part of the stent-graft was placed in the desired position (Figure 4a).

Because the lumen of the aorta was rather narrow (the aneurysm was filled with thrombus) the vascular surgeon decided to cannulate the short left limb first, before deployment of the right limb of the stent graft. Then, both the right and left limbs of the bifurcated graft were deployed (Figure 4b). Because the longest available stent-graft was too short for this patient, the right limb was extended with an extensor cuff (Figure 4c). Figure 4d shows the final angiogram with satisfactory exclusion of the aneurysm.

References


