ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA
VOL. LXII, N 1, 50 SECTIO D 2007

Department of Interventional Radiology and Neuroradiology, Department of Vascular Surgery
Medical University of Lublin

MONIKA MIAZGA, ANNA DRELICH-ZBROJA, TOMASZ JARGIEŁŁO,
ANDRZEJ WOLSKI, WITOLD ŻYWICKI,
MAŁGORZATA SZCZERBO-TROJANOWSKA

Endoleaks after endovascular abdominal aortic aneurysms repair – types and imaging

In the United States, a ruptured abdominal aortic aneurysm (AAA) is the 10^{th} leading cause of death in patients over 55 years of age (6). The risk of rupture is directly related to aneurysmal size, with a 5%–10% annual risk for aneurysms measuring between 5 and 6 cm. The initial successful open surgical repair of AAA took place approximately 55 years ago. Open surgical repair carries substantial morbidity and a mortality rate ranging between 1% and 7% (6). An alternative treatment option for the repair of AAA is endovascular stentgraft placement. First successful percutaneous transfemoral stent placement in a human was reported in 1991. Endovascular AAA repair is considered an accepted alternative to standard open surgery. This method of treatment relies on the exclusion of the aneurysm sac from arterial pressure/blood flow to reduce the pressure within it and therefore prevent the fatal complication of rupture. When compared with open surgical repair, endovascular stent placement has been shown to decrease the incidence of systemic complications, the 30-day mortality rate, and intensive care unit and hospitalization times (3). There are several unique complications that may occur after stent placement. Complications include graft thrombosis (3%–19%), kinking and migration (!8%), peripheral embolization leading to organ or limb ischemia (4%–7%) or aortic dissection (2%) (10). The most commonly identified complication that occurs after endovascular grafting is endoleak. Endoleaks are defined as areas of persistent blood flow outside the lumen of the endograft after endovascular aortic aneurysm repair, either within the aneurysm sac or within connected vascular segments bypassed by the graft (13). The incidence of endoleaks ranges from 5% to 65% (5). In current clinical practice, endoleaks that occur during the perioperative (30-day) period are termed *primary endoleaks*. Those that occur after successful endovascular repair and after the 30-day window are termed *secondary endoleaks*. Endoleaks are classified into four types. Type I endoleaks are the result of flow around the proximal (type IA) or distal (type IB) ends of an endograft. Primary type I endoleaks can result from malposition of the stent-graft during placement of the device, from underdilatation of the graft material at the time of implantation, or from an error in preprocedure planning, when the endograft diameter that has been selected is smaller than required. They can also occur as a result of an angulated proximal neck, short or noncilcular attachement zones, and mural thrombus or severe calcification within the attachment zones. Secondary type I endoleaks are caused by aneurysm remodeling or dilatation of the native arterial wall. Type II endoleaks are caused by continued perfusion of the aneurysm sac via retrograde flow through patent aortic side branches, such as lumbar, sacral, gonadal, accessory renal, or inferior mesenteric arteries. This type is the most common, occurring in up to 24% of patients and is unrelated to the type or configuration of the stent-graft used (8). Less common are type III endoleaks, which occur at rate of less than 1%. Type III endoleaks arise from a defect within the graft. This flow can be a disjunction between modular components (type IIIA), or a hole in the fabric of the graft (type IIIB). Type III endoleaks are very graft-specific and can be serious because they are invariably associated with a sudden elevation of intrasac pressure. Type IV endoleaks are the result of graft fabric porosity. This type of endoleak typically resolves within the first week and is of no clinical consequence by itself. Type III and IV are rarer than types I and II. Type I and type III endoleaks are associated with an increased risk of rupture of the aneurysm and should be corrected, preferably by endovascular means. If endovascular repair is not possible, then open conversion should be considered. Those cases of aneurysm enlargement in which no cause is identified by imaging modalities have been classified as endotension or type V endoleak (9,14,15). A pressure transmission through thrombus at the attachment site has been proposed as the cause of the aneurysm enlargement. Another hypothesis is that a very low flow endoleak is present and is not depictable with standard imaging modalities, since it allows rapid blood clot formation (14). The treatment of type V endoleak is controversial.

The method of endoleak detection is equally important. It is necessary to have a method that is highly sensitive and specific, inexpensive, reproducible, and that carries little risk to the patient. Although direct measurement of the sac pressure would be the ideal, this is not a practical method at present. As a result, many imaging studies are and have been evaluated for endoleak detection, including ultrasound, contrast angiography, and magnetic resonance angiography. In most centers contrast-enhanced CT angiography has remained the golden standard for the routine detection and follow-up of endoleaks (4). Abdominal plain film radiographs are excellent for evaluating device malfunction, such as kinks, breaks, modular disconnection, tilting or migration; however, there is no role for it in endoleak detection. Contrast angiography has long been considered the modality of choice for arterial imaging. Two reasons preclude its routine use for endoleak detection. First, it is an invasive technique. Second, because it is a projectional imaging modality, overlap of structures can often obscure the visualization of an endoleak. The apperance of endoleaks during angiography is similar to CT. Generally, contrast will be seen outside the confines of the stent-graft and within the aneurysm sac or its adjacent branches. Large leaks may be obvious, and smaller leaks, which are often clearly shown on CT, may not be visualized at the time of angiography. Contrast angiography, however, can often be of great benefit in determining the cause of small endoleaks (12). Whereas contrast angiography has changed very little in recent years, advances in magnetic resonance (MR) imaging technology have substantially improved the quality of MR angiography. Its advantages include the lack of ionizing radiation and multiplanar capability. Unfortunately, metallic clips or hardware related to stent-grafts can produce considerable magnetic susceptibility artifacts, which is not a problem with some of the other imaging modalities, such as CT angiography. Also, branch vessels are often not clearly visualized because of the artifact from metal related to the endograft or from calcified plaques. At present, MR imaging has a limited role in the routine poststent-graft implantation imaging of endoleaks. Currently, CT angiography is considered the gold standard for the detection and evaluation of AAAs as well as for surveillance after endovascular repair. Acquisition of volumetric data allows for the evaluation of calcified and tortuous aortas, branch vessels and adjacent structures. The administration of intravenous contrast allows the visualization of true and false lumen flow channels, slow perigraft flow around aortic stent-graft, graft limb thrombosis, and intramural hematomas. In addition, the aneurysm sac diameter can be accurately measured and compared with previous studies (11). Patients undergo CT scanning 1 month, 6 months, 1 year and annually after endovascular procedure. Recognized limitations of serial CT angiographic examinations include repeated radiation exposure, the need to use intravenous contrast material with potential risk of allergy and nephrotoxicity, the relatively high cost and the impossibility of depicting the velocity or direction of the blood flow causing the endoleak. Ultrasound examinations with the use of Doppler options have been widely used for surveillance of AAA for many years. It is well established and the procedure of choice for noninvasive imaging of the aorta. It offers the advantages of wide availability, lower cost, no radiation exposure, noninvasiveness, and no nephrotoxicity compared to CTA, MRA and arteriography. Doppler ultrasound examinations can be used for the detection of endoleaks. Ultrasound contrast agents (microbubble-based) seem to substantially increase ultrasound diagnostic accuracy and have been recently applied in several fields (1). In recently published reports, some investigators described the use of ultrasound microbubble-based agents in the detection of endoleaks after endovascular treatment and reported good correlation sensitivity when compared with CT (2). Giannoni at el. suggested that based on enhanced ultrasound examination it is possible to identify endoleaks missed by other imaging techniques in some cases (7). Bendick et al. reported the detection of two endoleaks in contrast-enhanced ultrasound that were not visualized at CT angiography, but that were confirmed at DAS (2). During the period 2004–2006 we assessed the efficacy of contrast enhanced ultrasound in detecting endoleaks to aneurysmal sac in the group of 93 patients who underwent endovascular treatment of AAA. We used Optison as a ultrasound contrast agent. Based of our study we concluded that the use of ultrasound contrast agents increased the diagnostic efficacy of Doppler examinations and allowed for detecting type I endoleaks. However, this examination has minor value in detecting type II endoleaks. From the beginning of 2006 we started to use SonoVue as an ultrasound contrast agent and in the group of 64 patients we diagnosed 5 type II endoleaks based on ultrasound examinations after SonoVue administration, CT showed 6 type II endoleaks in this group of patients. The main advantages of contrast-enhanced ultrasound examinations over CT are the absence of radiation exposure and the avoidance of iodinated contrast agent injection in patients who frequently present reduced renal function. These are important advantages for an imaging procedure which has to be employed in lifelong follow-up, and the latter precludes the risk of allergy and nephrotoxicity associated with iodinated contrast agents. Moreover, contrast-enhanced ultrasound is noninvasive and has a higher temporal resolution (time required to produce an image) and a higher sensitivity to the contrast material than CT. Contrast-enhanced ultrasound examinations allow identification of the blood flow direction and provide information regarding the origin and mechanism of the endoleak.

It is possible that Doppler examinations with the use of contrast agents may replace CT as a primary long-term follow-up imaging modality for most patients after endovascular repair of AAA. If abnormalities are detected on ultrasound examinations, then further evaluation of the endovascular graft and aneurysm should be performed with CT.

REFERENCES

1. Barr R.: Seeking consensus: contrast ultrasound in radiology. Eur. J. Radiol., 41, 207, 2002.
2. Bendick P. J. et al.: Efficacy of ultrasound scan contrast agents in the noninvasive follow-up of aortic stent-grafts. J. Vasc. Surg., 37, 381, 2003.
3. Bosch J. L. et al.: Endovascular versus open surgical elective repair of infrarenal abdominal aortic aneurysm: predictors of patient discharge and destination. Radiology, 220, 576, 2001.
4. Chan C. L. H. et al.: Endoleaks following conventional open abdominal aortic aneurysm repair. Eur. J. Vasc. Endovasc. Surg., 19, 313, 2000.
5. Corriere M. A. et al.: Endoleak following endovascular abdominal aortic aneurysm repair:

implications for duration of screening. Ann. Surg., 239, 800, 2004.
6. Finlayson S. R. et al. : Should endovascular surgery lower the threshold for repair of abdominal aortic aneurysms? J. Vasc. Surg., 29, 973, 1999.
7. Giannoni M. F. et al. : Contrast-enhanced ultrasound imaging for aortic stent-graft surveillance. J. Endovasc. Ther., 10(2), 208, 2003.
8. Gorich J.: Treatment of leaks after endovascular repair of aortic aneurysms. Radiology, 215, 414, 2000.
9. Lin P. H. et al.: Delayed aortic aneurysm enlargement due to endotension after endovascular abdominal aortic aneurysm repair. J. Vasc. Surg., 38, 840, 2003.
10. Mita T. et al.: Complications of endovascular repair for thoracic and abdominal aortic aneurysms: an imaging spectrum. RadioGraphics, 20, 1263, 2000.
11. Resnikoff M. et al.: Fate of the excluded abdominal aortic aneurysm sac. Long-term follow up of 831 patients. J. Vasc. Surg., 24, 851, 1996.
12. Srinivas T., Powell A.: Imaging of endoleaks. Techniques in Vasc and Intervent Radiol., 4, 208, 2001.
13. White G. H et al.: Endoleak as a complication of endoluminal grafting of abdominal aortic aneurysms: classification, incidence, diagnosis and management. J. Endovasc. Surg., 4, 152, 1997.
14. White G. H. et al.: What are the causes of endotension? J. Endovasc. Ther., 8, 454, 2001.
15. White G. H. et al.: Endotension: an explanation for continued AAA growth after successful endoluminal repair. J. Endovasc. Surg., 6, 308, 1999.

SUMMARY

Endovascular AAA repair is considered an accepted alternative to standard open surgery. There are several complications that may occur after stent-graft placement. The most commonly identified complication is endoleak. The incidence of endoleaks ranges from 5% to 65%. Endoleaks are classified into four types. Many imaging studies are and have been evaluated for endoleak detection, including ultrasound, contrast angiography, and magnetic resonance angiography. In most centers contrast-enhanced CT angiography has remained the golden standard for the routine detection and follow-up of endoleaks. In our opinion, there are some advantages of contrast-enhanced ultrasound examinations over CT in detection of endoleak and this method can replace CT as a primary follow-up imaging after AAA endovascular repair in the future.

Zaciek po śródnaczyniowym leczeniu tętniaków aorty brzusznej – typy i obrazowanie

Śródnaczyniowe leczenie tętniaków aorty brzusznej to uznana alternatywa dla metody chirurgicznej. Po implantacji stent-graftu mogą wystąpić powikłania, pośród których najczęstszy jest zaciek. Występuje on z częstością od 5% do 65%. Są cztery typy zacieków. Do rozpoznawania zacieku wykorzystywano i nadal wykorzystywane są różne techniki obrazowania, takie jak ultrasonografia, angiografia tomografii komputerowej czy angiografia rezonansu magnetycznego. W wielu ośrodkach angiografia tomografii komputerowej uznawana jest za złoty standard w rutynowym monitorowaniu po zabiegu i rozpoznawaniu zacieku. Naszym zdaniem ultrasonografia z wykorzystaniem środków kontrastujących wykazuje kilka istotnych korzyści w rozpoznawaniu zacieku w porównaniu z tomografią komputerową. Metoda ta może w przyszłości zastąpić tomografię komputerową w diagnostyce zacieku.