# Vascular ultrasonography for follow-up of endovascular repair of abdominal aorta aneurysms

## *Ultrassonografia vascular no seguimento da correção endovascular do aneurisma da aorta abdominal*

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## Abstract

**Background:** There is little information available on follow-up of abdominal aortic aneurysm patients treated with endovascular repair using vascular ultrasonography in Brazil or on how it compares with the results of angiotomography. Since ultrasonography is an examination that is risk-free, inexpensive and widely available, it is a very attractive method. In this study we attempted to evaluate the sensitivity and specificity of vascular ultrasonography for follow-up of these patients by comparing the method with angiotomography. **Materials and methods:** We conducted a prospective study from June 2012 to May 2013. We examined patients followed-up at the endovascular surgery clinic run by the University Hospital of Londrina after endovascular repair of abdominal aortic aneurysms. All patients underwent angiotomography for follow-up and were also examined using simple abdominal X-rays and vascular ultrasonography. **Results:** A total of 30 patients were analyzed, with a mean age of 73 years and a mean aneurysm diameter of 6 cm. Four endoleaks were detected. Vascular ultrasonography achieved sensitivity of 75% and specificity of 96% for classification of these endoleaks, in comparison with angiotomography. **Conclusions:** Vascular ultrasonography is an excellent primary method for evaluation and post-surgical follow-up of patients treated with endovascular repair of abdominal aorta aneurysms. However, when ultrasonography detects problems or is difficult to accomplish, it should be supplemented with a more specific investigation for diagnostic confirmation.

**Keywords:** aortic aneurysm; ultrasonography; endoleaks.

## Resumo

**Contexto:** As informações sobre o seguimento de pacientes submetidos à correção endovascular de aneurisma de aorta abdominal com ultrassonografia vascular no Brasil são escassas, bem como sua comparação com os resultados obtidos com a angiotomografia. Na medida em que a ultrassonografia é um exame sem riscos, de baixo custo e de grande disponibilidade, esta se torna um método bastante atraente. Na presente pesquisa, procuramos avaliar a sensibilidade e a especificidade da ultrassonografia vascular (USV) no acompanhamento desses pacientes, comparando este método com a angiotomografia. **Materiais e métodos:** Realizamos estudo prospectivo durante o período de junho de 2012 a maio de 2013. Para tanto, examinamos pacientes acompanhados pelo Ambulatório de Cirurgia Endovascular do Hospital Universitário de Londrina pós-correção endovascular de aneurisma de aorta abdominal. Todos os pacientes haviam sido submetidos à angiotomografia para acompanhamento e foram também avaliados através da radiografia abdominal (raio x simples) e da ultrassonografia vascular. **Resultados:** Foram analisados 30 pacientes, com média de idade de 73 anos, com diâmetro médio do aneurisma de 6 cm, detectando-se quatro vazamentos endovasculares. Na avaliação desses vazamentos endovasculares, a ultrassonografia vascular obteve uma sensibilidade de 75% e uma especificidade de 96%, em relação à angiotomografia. **Conclusão:** A ultrassonografia vascular é um excelente método primário na avaliação e no acompanhamento pós-cirúrgico de pacientes submetidos à correção endovascular do aneurisma da aorta abdominal (AAA). No entanto, em caso de alteração ultrassonográfica ou dificuldade na realização do exame, uma investigação mais específica deve ser realizada para confirmação diagnóstica.

**Palavras-chave:** aneurisma aórtico; ultrassonografia; vazamento endovascular.

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## INTRODUCTION

Endovascular aneurysm repair, introduced by Parodi[1,2] in 1991, is an option that is widely used for open surgical repair in patients with aneurysms of the abdominal aorta (AAA). The technique was developed in order o avoid expansion and rupture of the aneurysm, by placement of an endoprosthesis within the aneurysm sac, forming a channel for blood to flow through.[1,2] Compared with conventional surgery, endovascular repair offers low rates of perioperative mortality and morbidity, but requires rigorous surveillance for the rest of the patient's life because of a relevant incidence of long-term complications, such as endovascular leakage (endoleaks), aneurysm growth, structural failures, graft migration, thrombosis, occlusion of branches and infections.[1,3-5]

According to Geller SC,[6] follow-up with imaging studies after endovascular repair should assess three major parameters: (1) aneurysmal diameter; (2) detection and classification of endoleaks, and (3) detection of morphological changes to endoprostheses. Graft occlusion, infection and other potential complications should be assessed.[4] Angiotomography has become considered the gold-standard imaging technique for investigating all of these complications,[1] but some studies over recent years have demonstrated an increased risk of radiation-induced cancer and nephropathy caused by the contrast after repeated exposures to tomography.[7,8]

In response to these findings, many researchers have proposed substituting tomography for follow-up of these patients with other imaging methods, including vascular ultrasonography (USV), with or without contrast. This is relatively inexpensive and is an attractive option for postoperative surveillance, since it is also a noninvasive diagnostic method that is generally available.[9-11] Several different studies have therefore been conducted to compare the precision of vascular ultrasonography with that of angiotomography for classification of endoleaks.[12-14] The objective of this study was to determine the correlation, sensitivity and specificity of the ultrasonography method, with relation to angiotomography, for measurement of aneurysm diameter, identification of tortuosity and for detection and classification of endoleaks.

## MATERIALS AND METHODS

### Study design

The study was conducted from June 2012 to May 2013, while under consideration by the Ethics Committee, which gave its approval. All patients treated with endovascular repair of abdominal aortic aneurysms (AAA) and seen at the Endovascular Surgery Clinic of the University Hospital in Londrina were enrolled. The postoperative follow-up protocol included angiotomography, ultrasonography and abdominal X-ray after 1, 6 and 12 months, during the first year, and annually thereafter. Patients who did not comply with the follow-up protocol or whose USV and angiotomography were not conducted within 30 days of each other were excluded.

### X-ray protocol

Simple abdominal X-rays, anteroposterior projection, were taken of all patients in follow-up after endovascular repair of abdominal aortic aneurysms. The X-rays were taken to check for morphological changes to the endoprostheses, such as fractures, tortuosity or displacement of segments.

### Ultrasonography protocol

Vascular ultrasonography scans were conducted in mode B, with color, spectral analysis and power mode, of the whole abdominal aorta and the iliac arteries, using an ESAOTE 3-5MHz convex abdominal transducer, for all patients in follow-up after endovascular repair of abdominal aortic aneurysms. Ultrasound scans were conducted after 8 hours' fasting, with appropriate intestinal preparation and 40 drops of dimethicone every 8 hours, starting on the day before the examination. All examinations were conducted by the same Vascular Surgeon, qualified in Vascular Echography. These examinations were conducted in order to evaluate the diameter of aneurysms and patency of endoprostheses, and to identify and classify any endoleaks. These were assessed by aneurysm measurements in anteroposterior and lateral projections, and by detection of blood flow outside of the endoprosthesis using Doppler.

### Tomography protocol

Angiotomography was conducted on patients in follow-up according to our routine protocol, as follows: full abdominal angiotomography in three steps, first without contrast; then with 100-120 mL of contrast, and once more (late) 180 seconds after injection of the contrast, using a 16-channel tomography machine and 1.25 mm abdominal and pelvic slices. These scans were also used to detect and classify any endoleaks present, identified by contrast seen outside of endoprostheses, to evaluate anteroposterior and lateral aneurysm diameter measurements, and to check for patency and structural changes to endoprostheses visible on three-dimensional reconstructions. In order to avoid interference from the ultrasonographic examination, a different examiner, also qualified, was responsible for this procedure and only conducted angiotomography for this study. Patients with a history of allergy and/or renal failure were duly prepared with antiallergic drugs and corticosteroids and given adequate hydration before and after examinations.

### Statistics

Comparisons of mean size of aneurysm on USV and angiotomography were accomplished by calculating coefficients of variation. The coefficient of variation was determined by dividing the standard deviation of the difference between the two measurements by the mean of means of the study population. Pearson's correlation coefficient was used to determine the degree of agreement between USV and angiotomography.

## RESULTS

Between June 2012 and May 2013, a total of 62 patients were examined using the follow-up protocol for endovascular AAA repair. Three of these patients had been treated for endovascular AAA repair in 2010, 11 in 2011, 13 in 2012 and three in 2013. The remaining 32 patients were excluded because they had not complied with the follow-up protocol and did not have their ultrasonography and angiotomography scans close enough in time.

The sample comprised 25 men (84%) and five women (16%), with a mean age of 73 years (56-84). Hypertension, smoking and diabetes were the most common comorbidities. On angiotomography, the diameter of abdominal aneurysms found after endovascular repair ranged from 3.0 to 10.5 cm, with a mean of 5.8 cm. Aneurysms of iliac arteries were also identified by angiotomography in nine patients, 30% of cases, five of which (17% of the total) were bilateral.

Analysis of the abdominal X-rays found tortuosity of the endoprosthesis structure in just one patient, without any significant hemodynamic alterations when viewed on vascular ultrasonography (Figure 1). No X-rays showed structural fractures or disconnections.

With relation to USV findings, four endoleaks were identified in the 30 patients examined, two type IA and two type II. When compared with angiotomography, which also found four endoleaks, three USV-detected leaks were confirmed. In just one angiotomography a leak was identified that had not been diagnosed using ultrasonography. Therefore, the statistical analysis resulted in sensitivity and specificity for endoleaks of 75% and 96% respectively, and positive predictive and negative predictive values of 75% and 96%. However, we did not observe the same relationship for classification of endoleaks, since the classification only coincided in one case; the other three cases were two misclassifications and one false positive.

Only one of the USV examinations detected abnormalities on the spectral analysis. In this case, angiotomography confirmed the ultrasonographic diagnosis of occlusion of the external branch of a sandwich graft in the iliac arteries (Figure 2). This represents sensitivity and specificity of 100%, despite the small sample.

We observed a variation of three millimeters between aneurysmal diameters measured on ultrasonography and the equivalent angiotomography measurements, with a strong positive linear correlation (Table 1).

## DISCUSSION

Serial X-rays are useful in follow-up of endovascular AAA treatment for assessment of structural changes, especially when interest lies in detection of fractures and kinking of abdominal endoprostheses.[15] These X-rays are simple and inexpensive to obtain and are widely available. Additionally, their sensitivity for detection of graft migration is similar to that offered by computed tomography,[15] although an understanding of

**Figure 1.** Standard abdominal X-ray showing tortuosity of an endoprosthesis branch.

endoprosthesis construction and the placement of radiopaque markers is indispensable for correct assessment and interpretation of these X-rays.[16,17] However, X-rays are subject to two important limitations: they cannot be used to measure aneurysm diameter nor to detect endoleaks.

On the other hand, USV can be used both for monitoring of aneurysm diameters for screening for endoleaks after endovascular AAA repair.[3,4] Additionally, USV is convenient, noninvasive, inexpensive and portable, does not involve radiation exposure and does not need contrast. However, there is a relatively higher rate of interobserver and intraobserver variability with ultrasonography than with angiotomography,[18] but this variability is no larger than 4 mm, on average.[19] Additionally, ultrasonography is also able to provide a better approximation to the true perpendicular diameter of an abdominal aortic aneurysm, since it is not affected by the angle of the aorta, which impacts on tomography results at angles greater than 25°.[20]

Endoleaks can be detected by ultrasound using color spectral analysis to show blood flow. While published specificity rates for detection of endoleaks with Doppler ultrasonography are high (89%-97%),[21] the sensitivity and diagnostic power of Doppler US for detecting endoleaks is still debatable, when compared with angiotomography.[11,22-30] Some studies,[11,22-25] such as one conducted by Collins et al.,[11] have reported 85% positive predictive values, whereas others[26-30] found ultrasonography to be less sensitive than tomography, as was the case of Ashoke et al.,[30] who observed sensitivity of 70% in their study. In our study, four patients had endoleaks that were identified using angiotomography. Three of these were clinically significant type IA leaks and all three were also identified by USV, while the single case of type II endoleak, which was not expanding, was not detected by USV (Table 2). It can therefore be concluded that although USV does not offer a relatively high degree of sensitivity, as has been reported in other studies, it does offer adequate sensitivity for identifying endoleaks and indicating their treatment, without impacting on the quality of care.

Another advantage of USV is its ability to detect the direction of endoleak flow, which cannot easily be investigated using angiotomography. Parent et al.[31] related the Doppler waveform to analysis of type II endoleaks as follows: a 'anterograde and retrograde' pattern was associated with spontaneous resolution, whereas the presence of a monophasic or biphasic waveform was associated with persistent leakage. However, we did not observed this in our study, since two of the three endoleaks correctly identified by ultrasonography, both type IA, were erroneously classified as type II and one was repaired using a

**Table 1.** Correlation between analyses of aneurysm diameter: USV vs. angiotomography.

| Analysis | Result (cm) |
|---|---|
| Mean diameter on ultrasonography | 5.79 |
| Mean diameter on tomography | 5.86 |
| Mean variance | 0.35 |
| Standard deviation | 0.32 |
| Pearson's correlation coefficient | 0.91 |

cm: centimeters.

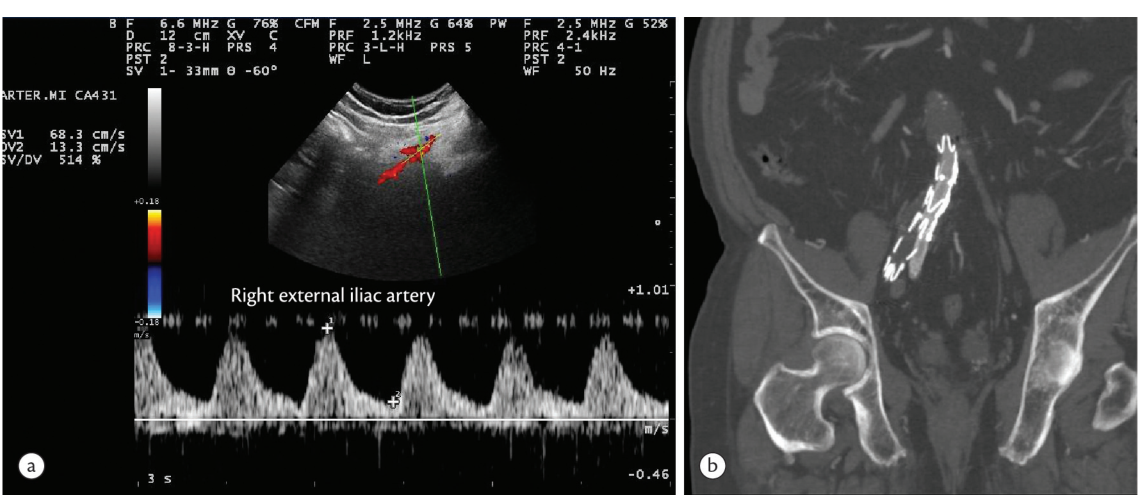


**Figure 2.** (a) Vascular ultrasonography with monophasic flow in right external iliac. (b) Angiotomography with occlusion right external iliac branch.

proximal extension and the other was repaired by embolization (Figure 3). The principal cause of this difference was probably an error of interpretation by the USV examiner.

It is important to point out that for assessment of stenosis or occlusion of the aortoiliac segment, it is arteriography and not angiotomography that is the gold-standard diagnostic method.[32] Additionally, Beeman et al.[33] believe that USV is also more precise than angiotomography for identifying patency and for detecting other problems such as tortuosity and stenoses, since the color flow images combined with analysis of the waveform provide anatomic and hemodynamic data that cannot be acquired using angiotomography. In their study,[33] USV precisely identified all seven cases in which there were problems with graft permeability requiring treatment, which was also the case in our study, since we correctly identified the only case of branch occlusion using USV.

Other limitations of duplex ultrasonography include its operator dependency, inter-patient physical variations and the need for intestinal preparation.[4] However, improvements in ultrasonography technology and techniques can improve and increase its diagnostic power. Contrast mediums, for example, have been developed that can overcome some of the limitations of ultrasonography.[34] Ultrasonography contrasts are noninvasive, easy to handle, well-tolerated and, apparently, increase the sensitivity of ultrasonography. Use of ultrasonography contrasts significantly improves sensitivity for detection of endoleaks,[35-37] particularly in cases of endotension, which is obscured in angiotomography, but can be seen with the aid of contrast.[36,37]

Additionally, using simple X-rays combined with USV as the primary imaging method for patient follow-up after endovascular repair of abdominal aortic aneurysms could also reduce the radiological risks associated with angiotomography.[38] The endovascular procedure and serial lifelong angiotomography involve a substantial ionizing radiation load, in addition to the fact that angiotomography requires administration of iodine-based contrast agents that are associated with nephrotoxic effects.[39] Nevertheless, it is known that ultrasonography can also suffer from a series of limitations. In obese patients with inadequate intestinal preparation, the abdominal examination can be limited by an inappropriate acoustic window.[4] However, the limited sample of 30 cases and the short observation period notwithstanding, this study observed low variability in aneurysm sac dimensions with a strong correlation coefficient, and also a low number of false negative results, just one in fact, which had no clinical significance since the aneurysm did not exhibit significant growth.

**Table 2.** Correlations for patients with endoleaks: USV × angiotomography.

| Patient | Dmt aneurysm USV | Type of endoleak | Dmt aneurysm CT | Type of endoleak | |
|---|---|---|---|---|---|
| Patient 1 | 5.8 | IA | 6 | No leak | False positive |
| Patient 2 | 6.6 | II | 6.9 | IA | |
| Patient 3 | 10.3 | No leak | 10.9 | II | False negative |
| Patient 4 | 7.9 | II | 7.3 | IA | |
| Patient 5 | 10 | IA | 9.8 | IA | |

Dmt: diameter; USV: vascular ultrasonography; TC: computed tomography.

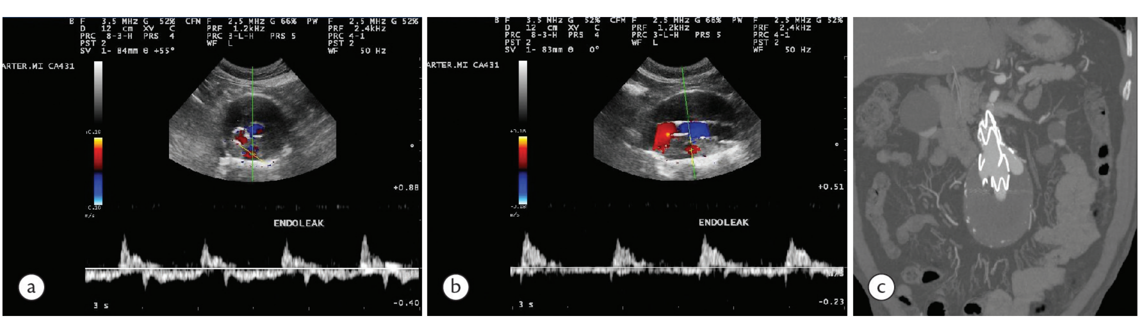


**Figure 3.** (a) Transverse and longitudinal vascular ultrasonography (b) showing type II endoleak. (c) Angiotomography showing type IA endoleak.

## CONCLUSIONS

It is therefore understood that vascular ultrasonography combined with abdominal X-ray could be used as a possible substitute for angiotomography as the primary method for follow-up of patients with aneurysms of the abdominal aorta operated using endovascular techniques. Abdominal X-ray proved to be an excellent supplementary examination for assessing the structure of endoprostheses. Ultrasonography had a high correlation coefficient and low variability when compared with angiotomography for measurement of aneurysm diameter. With regard to endoleaks, vascular ultrasonography identified all clinically significant leaks.

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