

# Technical note: ultrasonography evaluation of aortic aneurysms treated with endoprosthesis

*Nota técnica: avaliação ultrassonográfica de aneurismas da aorta tratados com endopróteses*

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### Abstract

Aortic aneurysms treated with endovascular techniques may develop endoleaks. In addition to anatomic location, these endoleaks should be classified based on the type of blood flow. We describe the types of blood flow into the endoleaks as detected by Doppler ultrasonography: in-and-out flow as a "pseudoaneurysm", channel flow through the aneurysm, and direct flow into the aneurysm. Endoleaks may be intermittent and actually be endoseepage, detected by aneurysmal growth without an apparent inflow. Ultrasound virtual histology is suggested to detect endoseepage. Relative quantity and location of blood/liquid in the aneurysm can be detected by evaluating pixel brightness of the ultrasonographic B-mode image. Such anatomofunctional information allows for quantitative follow-up and emphasizes the risk of an endoleak with direct flow into the aneurysm.

**Keywords:** aortic aneurysm; endovascular procedures; endoleak; ultrasonography.

### Resumo

Aneurismas da aorta tratados com endopróteses podem desenvolver *endoleaks*. Esses *endoleaks* devem ser classificados com base nos tipos de fluxo, além da localização anatômica. Enfatizamos tipos de fluxo dos *endoleaks* detectados pela ultrassonografia com Doppler: fluxo entra-e-sai como "pseudoaneurisma", fluxo de canal e fluxo direto. Ao se notar a possibilidade de *endoleaks* intermitentes, salientamos o conceito de *endoseepage* detectáveis por crescimento de dimensões sem fluxo entrante aparente. Sugerimos o uso da histologia virtual ultrassonográfica para detecção de infiltrações. Quantidade relativa e localização de sangue ou líquido dentro do saco aneurismático pode ser detectado pela avaliação dos níveis de brilho da ultrassonografia modo B. Essa informação permite um seguimento compreensivo do aneurisma tratado com endoprótese e salienta o risco maior de um *endoleak* de fluxo direto entrante no aneurisma.

**Palavras-chave:** aneurisma aórtico; procedimentos endovasculares; endoleak; ultrassonografia.

### Introduction

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Aortic aneurysms treated with endoprosthesis may develop endoleaks<sup>1,2</sup>. An endoleak is a leak of blood flow, or prosthesis, or a branch of the aorta into the aneurysm. They have been classified according to their anatomical location<sup>3</sup>. This technical note emphasizes the hemodynamics of endoleaks' flow, describes the concepts of endoseepage and intermittent endoleak, and summarizes the technique of intravascular ultrasound virtual histology (IVUS-VH) for the detection of blood or fluids, acute, subacute or fibrotic thrombi inside the aneurysm.

### Endoleak flow types

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Endoleaks have been identified with at least three types of flow:

1. similar to that of a pseudoaneurysm;
2. channel flow through the aneurysm;
3. direct flow into the aneurysm.

#### *Pseudoaneurysm flow*

Figure 1 shows the flow of an endoleak into a pseudoaneurysm inside an aortic aneurysm treated with

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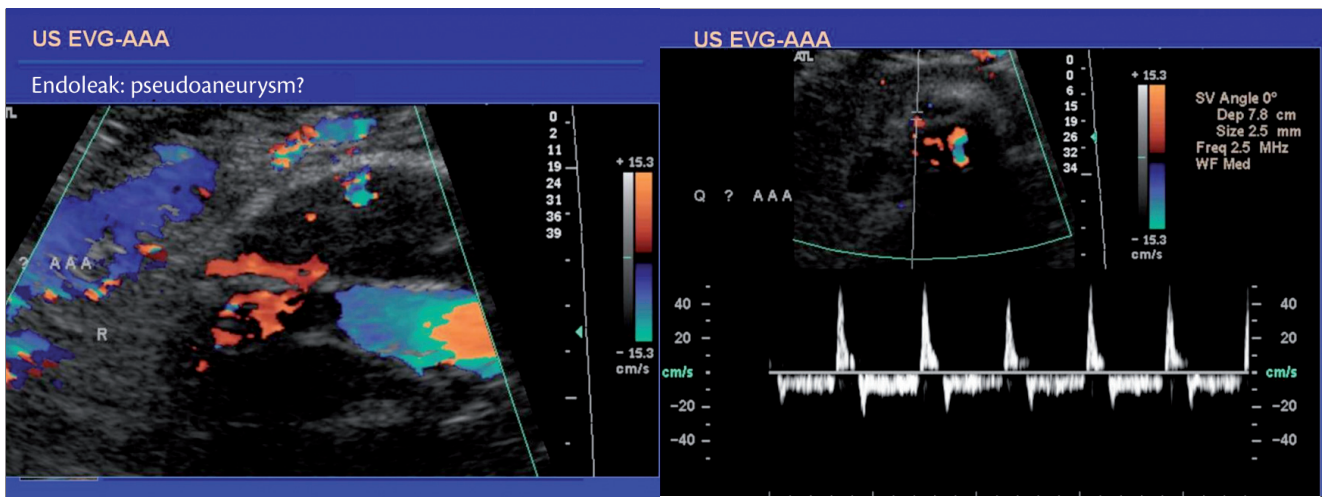
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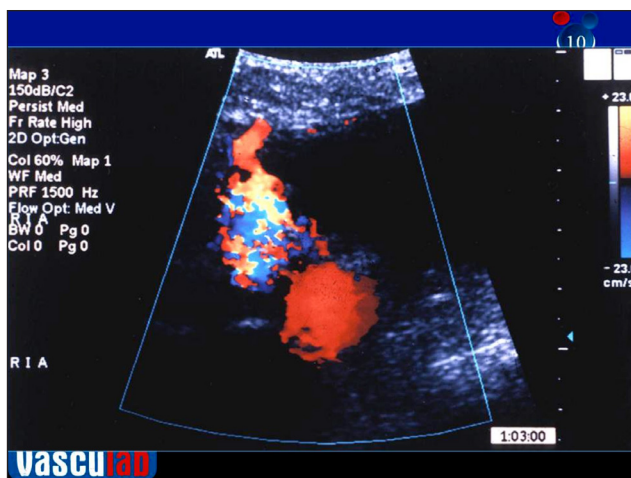
endoprosthesis. The flow into the pseudoaneurysm is characterized as in- and outflow. This type of endoleak does not seem to contribute with increase in the diameter or volume of the treated aneurysm. Occasionally, the pseudoaneurysm may thrombose and occlude. However, thrombosis of the pseudoaneurysm does not guarantee the closure of the endoleak. The flow can change direction, creating a new pseudoaneurysm in other area of the aneurysm. Periodic monitoring of this type of endoleak is recommended, even if the first pseudoaneurysm has been closed. This type of endoleak may be intermittent.

**Channel flow**

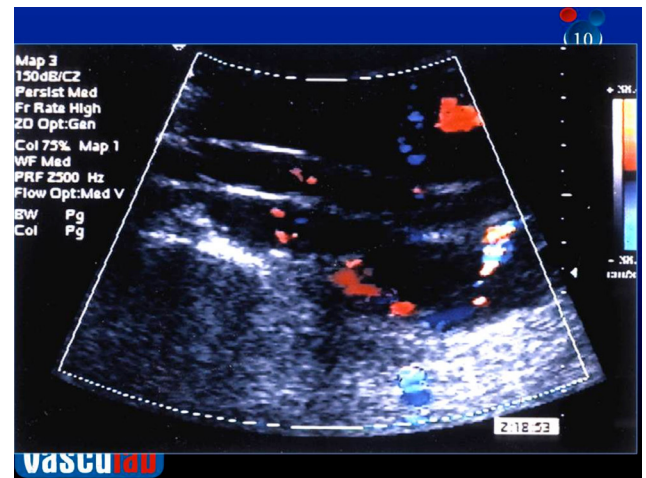
Figure 2 shows a blood flow channel inside the aortic aneurysm treated with endoprosthesis. This channel may have varied sources of blood flow, such as the endoprosthesis itself, or a branch of the aorta or the iliac arteries. The drainage of this channel also varies, but it is generally found at a branch of the aneurysm. This channel is apparently restricted by a chronic thrombosed tissue, that is, a blood thrombus in various stages of fibrosis. The blood leakage from the channel into the aneurysm depends on the type of tissue around this false lumen. Apparently, this type of



**Figure 1.** Endoleak of aortic aneurysm treated with endoprosthesis. Blood in- and outflow similar to that of a pseudoaneurysm inside the aneurysm.



**Figure 2.** Endoleak of aortic aneurysm treated with endoprosthesis. Channel flow inside the aneurysm.



**Figure 3.** Endoleak of aortic aneurysm treated with endoprosthesis. Direct blood flow inside the aneurysm. The high speed shows aliasing – light color at the end of the prosthesis.

endoleak does not dramatically affect the diameter or volume of the treated aneurysm. However, it is this type of endoleak is thought to be more dangerous than the endoleak similar to that of a pseudoaneurysm. A closer follow-up is recommended in such cases.

### Direct flow

Figure 3 shows a direct flow of endoleak into the aneurysm sac. This type of endoleak is classified as high-risk. The volume of blood drained into the aneurysm may quickly rupture the aneurysm wall. This aneurysm ruptured two hours after the ultrasound and, as a consequence, the 93-year-old patient, who was not candidate for revascularization, died. The vascular surgeon should be informed immediately in case of endoleak direct flow shown at ultrasonography.

### Endoseepage

Diameter measurements illustrate cases of endoseepage. The continuing growth of 2 cm in diameter per year of an aneurysm is equivalent to 0.05 mm per day or 0.002 mm per hour. It is not well established whether endoseepage can be identified by any modern flow measurement technique. The concept of endoseepage was then created for aneurysms that grow in size without an apparent source of blood flow.

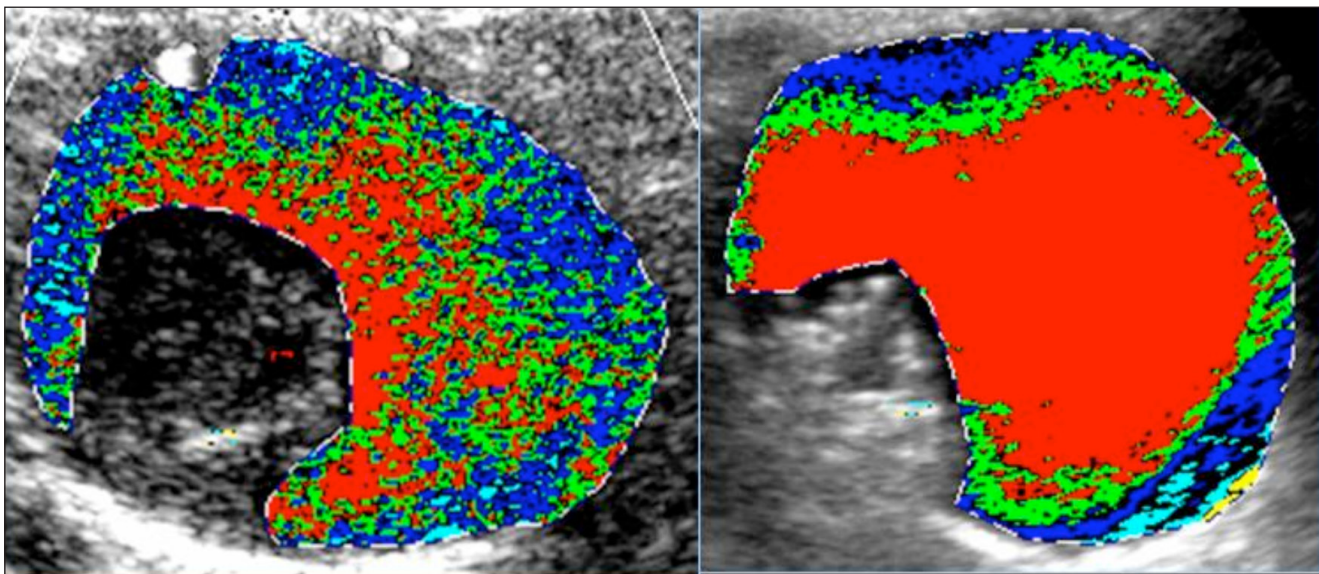
### Intermittent endoleak

Some studies suggest that Doppler flow ultrasound is more accurate than radiographic techniques used to detect endoleaks, while other studies show the other way around<sup>4-6</sup>. In general, ultrasonography has detected more endoleaks than computed tomography scan; the low positive predictive value of ultrasonography can be analyzed as CT scan false-negative result.

Another explanation for these discrepancies is that these techniques were not performed simultaneously, and that the endoleak could be intermittent. An intermittent endoleak could explain the contradictory results, the change in direction of the pseudoaneurysm-like endoleaks in follow-up, or the growth of the aneurysm dimensions without an apparent source of endoleak. Monitoring of the dimensions, diameter and even of the volume parallel to the flow is recommended.

### Ultrasound-virtual histology

Figure 4 shows two Ultrasound-virtual histology images of aneurysms treated with endoprosthesis. This technique has artificial color brightness levels of the B-mode ultrasound imaging<sup>7-10</sup>. The image shows regions with echoes similar to blood, lipids, muscle, fiber and calcium. In the case of aortic aneurysms, it would be interpreted as blood or fluid, recent thrombus or thrombi in various stages of



**Figure 4.** Ultrasound-virtual histology (IVUS-VH) imaging of the aortic aneurysm treated with endoprosthesis. The red, green, blue, dark-blue and light-blue stains represent blood, lipids, muscles and fibers.

fibrosis. Based on intravenous studies, the acute thrombus would generate images similar to lipids (green stain in Figure 4); the subacute thrombus would tend to appear in bright blue<sup>8,9</sup>.

The virtual histology technique creates a range of brightness in the B-mode ultrasound imaging. Usually, these images have 256 levels of brightness. In these applications, the blood (or what appears in black) is zero in the scale. The adventitia (or what is in white at the prosthesis) is 200 in the scale. Blood, lipids, muscle, fiber, and calcium have echoes in the intervals 0-4, 8-26, 41-76, 112-196 e 211-255<sup>7</sup>.

Evaluation of endoleaks, endoseepage and dimensions is recommended in periodic follow-up of aneurysms with hypochoic regions defined by B-mode virtual histology imaging.

## Conclusions

Simple analysis of ultrasound B-mode imaging or the complex processing of the image using the technique of Ultrasound-virtual histology can identify hypochoic regions inside the aneurysm treated with endoprosthesis. Duplex and Doppler ultrasound imaging can show the location and type of endoleak flow. The results of these imaging techniques can be used to determine the follow-up of the aneurysm or the need for emergency care of an aneurysm with direct-flow endoleak.

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