Research Article

Appearance of Aortic Polymer-Filled Stent Grafts in CT Angiography

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Abstract

Nellix and Ovation stent grafts are new generation prostheses that utilize polymer technology to treat abdominal aortic aneurysms. The use of polymers in stent grafts aims to increase the number of eligible patients that can be treated by an endovascular approach and to reduce complications of unsuccessful exclusion of the aortic sac from systemic circulation. Knowledge of both normal structure and normal CT appearance of polymer stent grafts is critical for appropriate assessment of treatment efficacy in patients with abdominal aortic aneurysms and for detection of possible complications.

Keywords: Angio-CT; Nellix; Ovation; Aortic aneurysm; Aortic prosthesis; Polymer prosthesis

Introduction

Nellix and Ovation stent grafts are new generation prostheses used for treating abdominal aortic aneurysms. The use of polymers is another step in the evolution of aortic prostheses and is aimed at extending the number of eligible patients that can be treated by an endovascular approach as well as at reducing the complications of an unsuccessful exclusion of the aortic sac from the systemic circulation. Knowledge of the specific structure of the above-mentioned stents and their changing appearance will help avoid diagnostic mistakes. Based on follow-up CT studies after implantation of both Nellix and Ovation stents, we present their normal structure and possible diagnostic pitfalls.

Nellix Stent Graft

The Nellix stent graft is used to exclude an abdominal aortic aneurysm from circulation. It is usually located infrarenally and consists of two chromium cobalt balloon-expandable stents that are covered with polytetrafluoroethylene (ePTFE) and surrounded by two polyurethane endobags. The stents contain 4-mm segments combined together. The first segments on the distal and proximal ends are not covered with ePTFE. The upper margins of the endobags are attached to the lower margins of the first stent segments. The length of the stent is chosen on a case-by-case basis so that the proximal end is located just below the origin of the lowest arising renal artery and the distal ends lie in the undistended parts of the iliac arteries to ensure blood flow to the pelvis and lower extremities. The stents expand on two balloons, each 10 mm in diameter, with nominal pressure (7 atm). The technique of filling the endobags with polymer has two steps. Initially, the endobags are filled with saline until a pressure of 180 atm is reached, then the saline is aspirated back and the endobags are filled with an equal volume of polymer while the internal pressure of the endobags is continuously monitored. The polymer used is polyethylene and it is administered in two separate solutions, achieving the desired consistency once they are mixed and prepared for administration. During application of the polymer, the stents expand on the balloons.

CT scan was obtained postoperatively. Informed consent was obtained from patients who participated in each examination. The following points were made. The density of the polymer in the endobags is intermediate between the density of soft tissue and contrasted blood in the aorta in arterial phase due to the presence of a contrast agent. The density of the polymer, and therefore its appearance in CT scans, will evolve over time. During the first days after implantation, the density is approximately 150 HU, gradually diminishing to 70-80 HU at 1-6 months post-implantation [1]. In their study in 68 patients, Karthikesalingam et al. found polymer density in the range of 148-176 HU shortly after implantation, which significantly decreased to 72-88 HU after 3 months [1]. On further observation at 6 and 9 months, no statistically significant difference in the density of the polymer was observed [1]. The density of the polymer in both endobags is usually homogenous, however, in rare cases, it may display asymmetry due to the uneven distribution of the contrast agent. Decreasing density of the polymer is associated with diffusion of the contrast agent to the periphery, according to the osmotic gradient, which results in its peripheral accumulation with the external wall of the endobag resulting in hyperdensity [2]. Endobag hyperdensity may hamper assessment of endoleak when the structure of the prosthesis is unknown. For proper evaluation, it is advised to assess the image between no contrast and the arterial phase. Endoleak at the upper

margin of stent graft attachment is associated with the presence of contrasted blood between the aortic wall and the outer wall of the prosthesis or between the two endobags. Other types of endoleak are not different from those present after implantation of classic bifurcated grafts in endovascular aneurysm repair (EVAR). A particular diagnostic pitfall described by De Souza et al. is suspecting aortic dissection while in fact the medial adjacent walls of the endobags imitate dissected intima of the aorta [3].

In some cases, the presence of gas bubbles inside the endobags is possible, which can be introduced accidentally during the initial filling of the endobag with saline or during the application of the polymer. On CT scans, gas bubbles are visible directly after the procedure, however, they should not be visible during further observations [2]. Because of the lower osmotic load of the paraaortic tissues, gas diffuses through the endobag wall outside and may be substituted by extracellular fluid. McWilliams et al. found gas bubbles in the prosthesis in 8 out of 29 patients within 1 month after the procedure [4]. Karthikesalingam et al. visualized gas bubbles on CT scans performed immediately after the procedure in all 68 patients [1]. Within 3 months, gas bubbles were still visible in only 2 out of 68 patients, while after 6 months, they were not found in any patient [1]. Certainly, the frequency of this phenomenon is related to the experience of the specialist performing the procedure, as well as the learning curve. In light of those data, the presence of gas in the endobag lumen within the first 3 months following implantation should not be attributed to infection. In sites previously filled with gas, the endobag wall may collapse. In one study, a collapsing endobag wall was found in 12 out of 29 patients [1]. The consequences of this phenomenon are unknown, however a collapse of considerable volume may produce space for type II endoleak. This complication was not found in any of the cases in the previously-mentioned study.

Immediately after a stent graft implantation, the diameter of the aneurysmal sac is similar to its initial size, however, in some cases it may increase by 1-2 mm in response to the pressure produced by the endobags in the sac [1]. Also, due to the same mechanism, intraluminal thrombus in the sac can dislocate, causing a decrease in thickness of this layer [2]. In the long term, the aneurysmal sac may constrict in response to thrombus absorption, however, its extent is much lesser than in the case of patients receiving standard prostheses (EVAR). If no thrombus is present, the aneurysmal sac adheres to the endobags and does not constrict.

In very rare cases, it is possible for the aneurysm to rupture during implantation, creating retroperitoneal hematoma, which in turn may make parts of the prosthesis bulge outside the aortic lumen. A similar situation can occur when managing an already ruptured aneurysm.

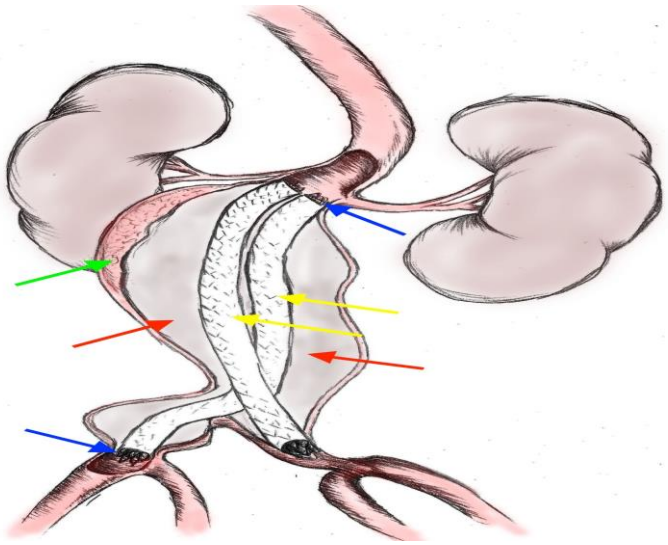

Figure 1: Schematic drawing of Nellix stent graft. Two stents forming flow channels and coated with ePTFE (yellow arrows) are surrounded by two polymer-containing endobags (red arrows). The proximal and distal stent segments are neither covered with ePTFE nor with polymer endobag (blue arrows). The thrombus is in the aneurysmal sac (green arrow).

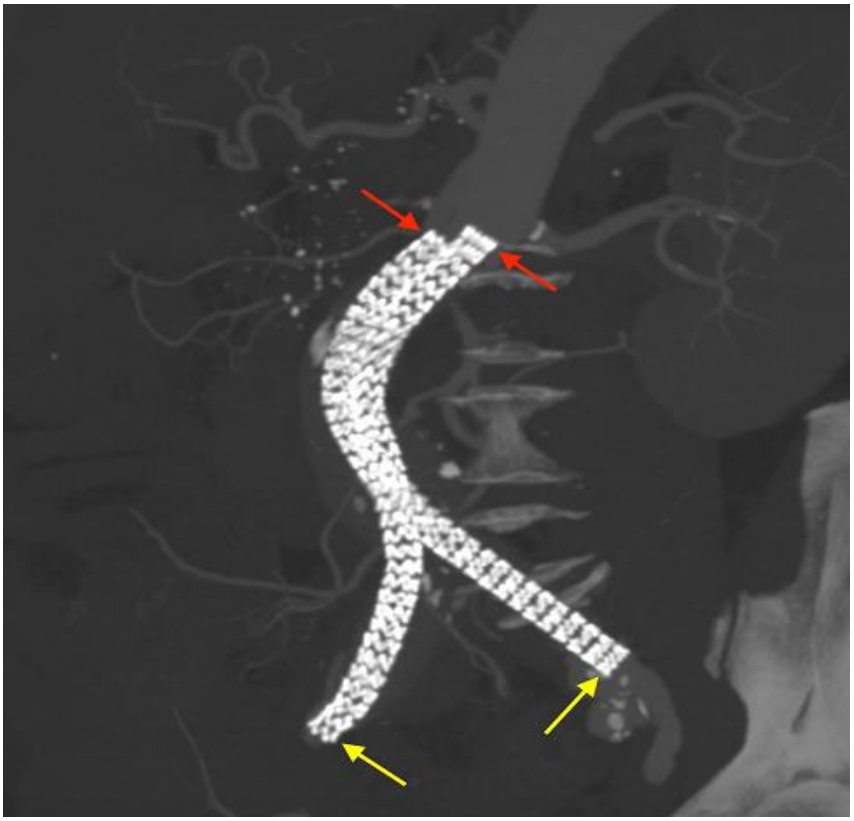

Figure 2: MIP reconstruction of angio-CT in a cross-sectional view. Two stents containing 4-mm segments combined together are visible. Proximal segments (red arrows) and distal segments (yellow arrows) are neither covered with ePTFE nor with polymer endobag.

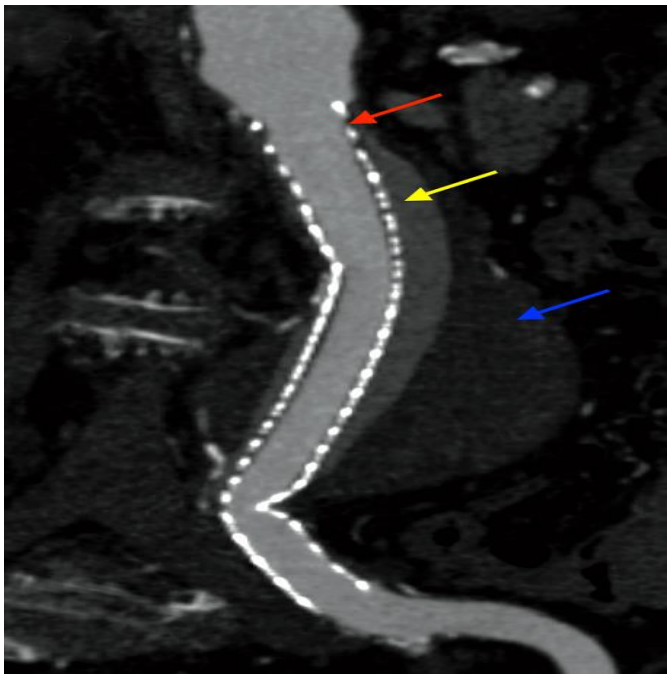

Figure 3: MIP reconstruction of angio-CT in a sagittal view. The density of the polymer-containing endobag (yellow arrow) is intermediate between the contrasted blood and the thrombus in the aneurysmal sac (blue arrow). The polymer-containing endobag is attached to the bottom edge of the first stent segment (red arrow).

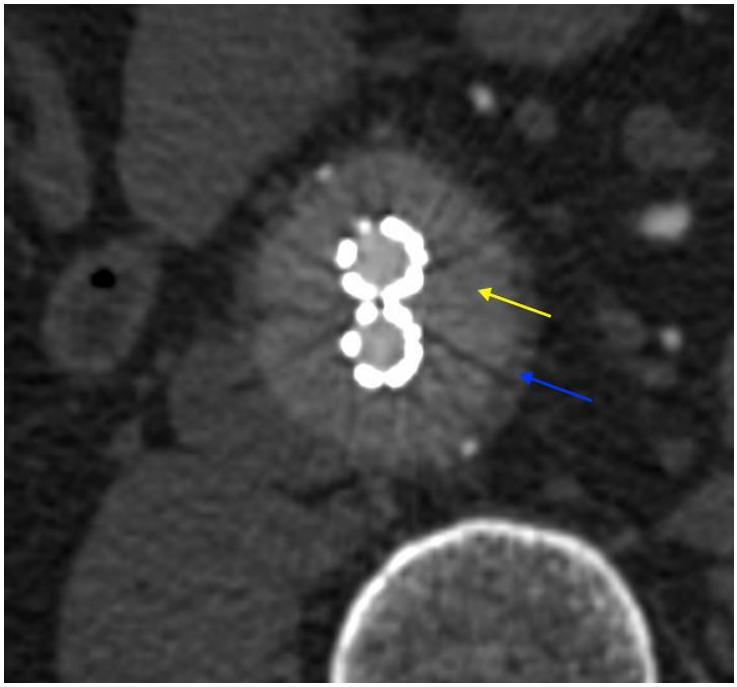

Figure 4: Angio-CT image in a cross-sectional view. The density of the polymer-containing endobag (yellow arrow) is intermediate between the contrasted blood in flow channels and the thrombus in the aneurysmal sac (blue arrow).

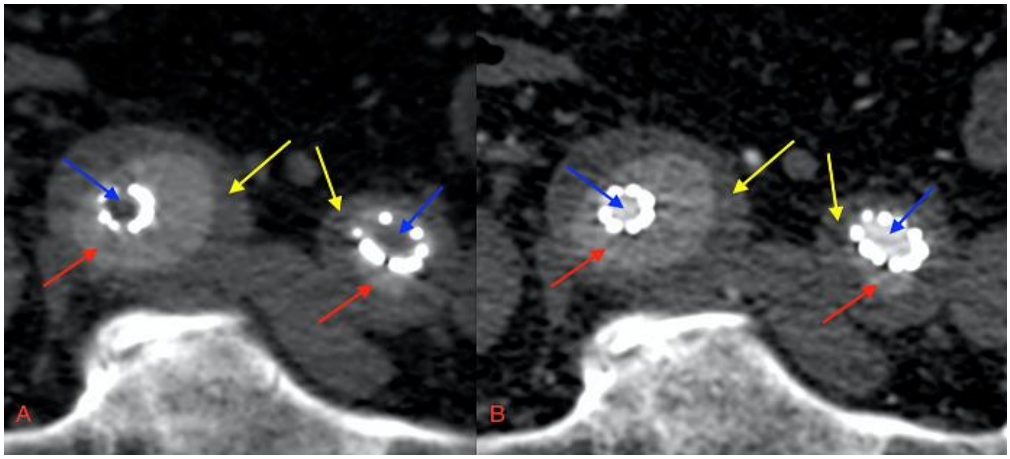

Figure 5: Angio-CT images in a transverse view prior to the administration of contrast medium (A) and in arterial phase (B). Contrasted blood in flow channels is indicated with blue arrows. The hyperdense polymer-containing endobags (red arrows) cannot be interpreted as a endoleak – the comparison of images before (A) and after the administration of contrast medium (B) is helpful. Mural thrombus is indicated with yellow arrows.

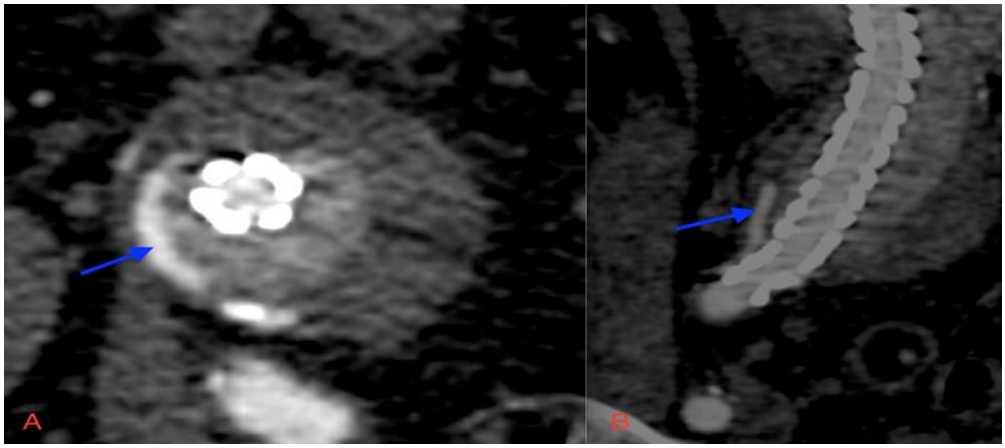

Figure 6: Angio-CT images in transverse (A) and sagittal (B) views. Endoleak is apparent within the distal fixation of the graft (IB type). Contrasted blood flows back into the aneurysmal sac between the mural thrombus and polymer-containing endobag (blue arrows).

Ovation Stent Graft

The Ovation endograft has a trimodular design consisting of the main body and two iliac limbs. The main body includes a suprarenal nitinol stent with anchors to achieve active fixation to the aortic wall and a low-permeability polytetrafluoroethylene (PTFE) graft, which, unlike other devices, is not supported by a metallic endoskeleton [5]. The main body is 80 mm long and designed as one 50-mm long cylinder that splits into two 30-mm long legs [5]. Proximal anchoring is provided by a unique system of two rings filled with polymer [5]. Their shape adapts to the aneurysmal neck

and, depending on the presence of thrombi or calcifications, it takes an irregular shape. The iliac limbs consist of highly flexible nitinol stents covered with PTFE. The original sealing mechanism allows sealing in infrarenal necks as short as 7 mm.

On CT scans, those polymer rings display intermediate density between soft tissue and contrasted blood in the aorta, similar to endobags in Nellix stent grafts. The awareness of stent graft structure allows for proper evaluation of the upper attachment and the exclusion of possible endoleak of contrasted blood into the aneurysmal sac. For proper distinction between hyperdense rings and hyperdense blood, it is useful to compare images before and after administration of contrast agent.

Diagnostic problems may also arise from the presence of the atypical main body of the endograft which is not supported by the metallic endoskeleton. At this level, the covering is composed solely from PTFE, which is practically invisible in the phase after administration of contrast agent. The assessing physician may have a false impression of stent graft detachment because only the suprarenal nitinol stent and iliac limbs are supported by a metallic endoskeleton.

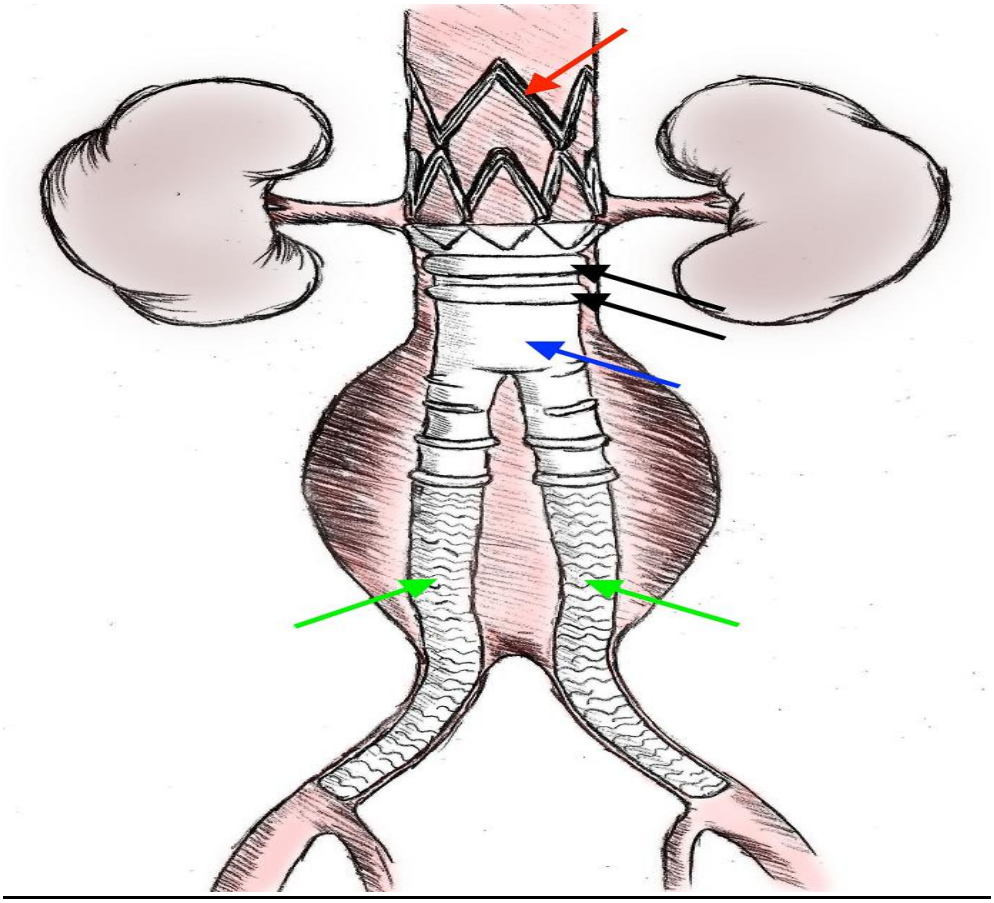

Figure 7: Schematic drawing of Ovation stent graft. The suprarenal fixation is not covered with PTFE (red arrow). The two polymer rings sealing the area of proximal fixation are indicated with black arrows. The main body is covered with PTFE and does not contain metallic endoskeleton (blue arrow). The iliac limbs of the stent graft are covered with PTFE and contain metallic endoskeleton (green arrows).

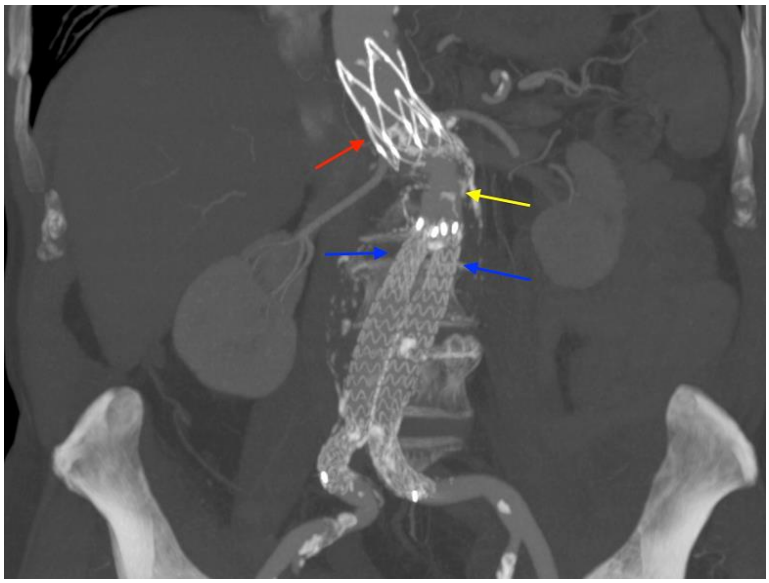

Figure 8: MIP reconstruction of angio-CT in a cross-sectional view. The suprarenal fixation-free flow segment is not covered with PTFE (red arrow). The main body does not contain metallic endoskeleton (yellow arrow). This image cannot be interpreted as disconnection of stent graft elements. Stent graft iliac limbs are indicated with blue arrows.

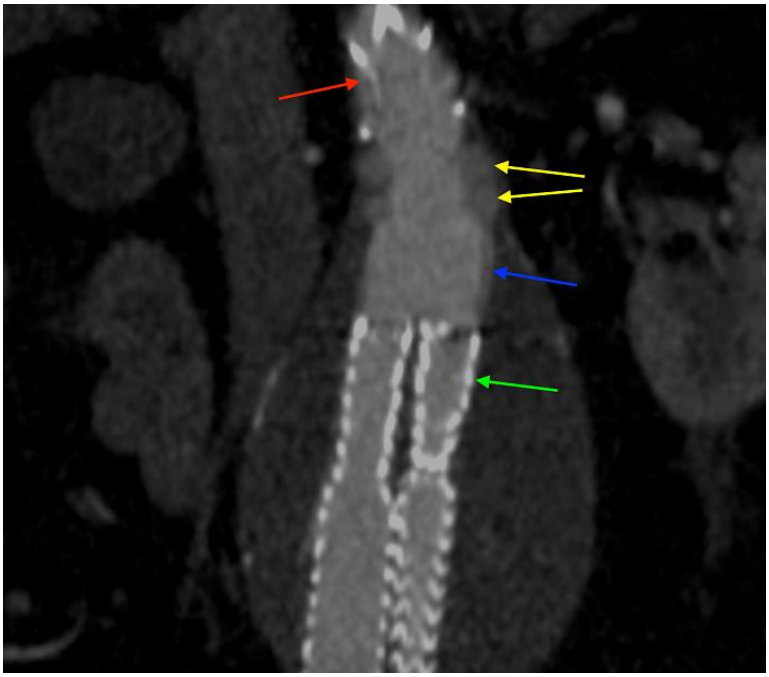

Figure 9: MIP reconstruction of angio-CT in a cross-sectional view. The suprarenal fixation-free flow segment is not covered with PTFE (red arrow). The two polymer rings sealing the area of proximal stent graft fixation are indicated by yellow arrows; their density is intermediate between the contrasted blood in the flow channel and the thrombus in the

aneurysmal sac in arterial phase. The main body is made of PTFE and does not contain metallic endoskeleton (blue arrow). This image cannot be interpreted as disconnection of stent graft elements. Stent graft iliac limbs are indicated by the green arrow.

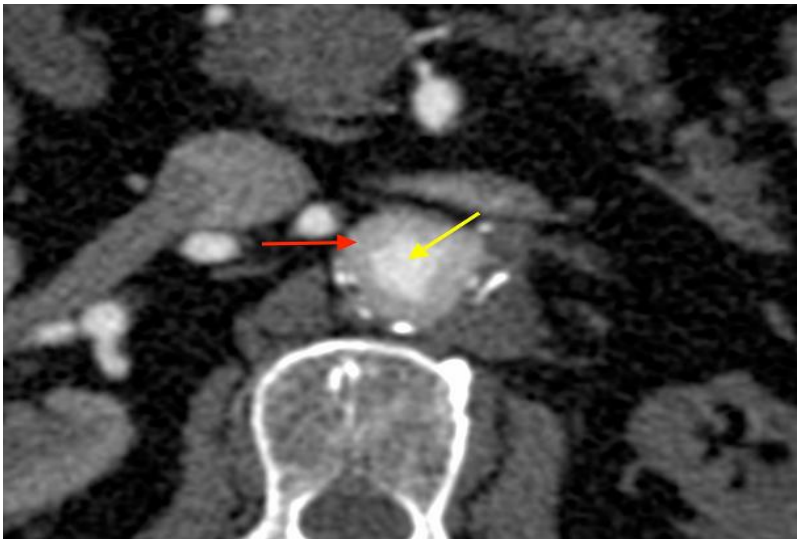

Figure 10: Angio-CT image in a transverse view. A hyperdense polymer ring with a slightly irregular shape adapting to the aneurysmal neck is indicated by the red arrow. The image cannot be interpreted as a endoleak in the area of proximal stent graft anchoring. The density of the polymer ring is intermediate between the contrasted blood in the flow channel (yellow arrow) and surrounding tissues. Images from the phase before the administration of contrast medium may be helpful for proper interpretation of image.

Conclusion

Knowledge of both normal structure and normal CT appearance of polymer stent grafts is critically important for appropriate assessment of treatment efficacy in patients with abdominal aortic aneurysms and for the detection of possible complications.

Compliance with Ethical Standards

None of the authors declared any conflict of interest.

The study has been approved by the local Bioethics Committee (Approval of the Ethics and Surveillance Committee for Research in Human and Animal Sciences at the Central Clinical Hospital of the Ministry of Internal Affairs; No. 54/2016 of 01.06.2016).

The written informed consent for stent graft implantation as well as for performing CT has been obtained from all patients participating in this study.

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