Utility of aortic cuffs in converting initially ineligible patients due to unfavorable neck anatomy into successful candidates for endovascular aortic aneurysm repair: A Case Series.

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ABSTRACT

Endovascular repair of the abdominal aortic aneurysm has been established as a successful alternative to open surgical repair, provided that the criteria necessary for such an approach are fulfilled. Anatomic criteria include suitable diameter, length, and angle of the aneurysm proximal neck. We present three cases in which patients were initially ineligible for endovascular repair because of unfavorable neck anatomy but in whom the use of aortic cuffs allowed for successful endograft placement and aneurysm exclusion.

CASE SERIES

INTRODUCTION

Endovascular aneurysmal repair (EVAR) of the abdominal aorta was first described as an alternative to open surgical repair in 1991 by Parodi et al. (1) and Volodos et al. (2) as a means to successfully exclude infrarenal aortic aneurysms. This technique is now widely practiced, and more than 20,000 EVAR procedures are performed every year in the United States, a number that represents approximately 40% of all abdominal aortic aneurysm (AAA) repairs (3). In EVAR, access is gained through an incision in the femoral artery and insertion of a catheter. Anigography is used to insert a graft with an alloy exoskeleton in a collapsed state. The graft is then deployed and expanded to fit the aorta.

EVAR represents an alternative to open surgical repair in patients who cannot undergo standard surgical procedures because of a number of reasons, including increased age as well as co-morbid conditions such as cardiac, pulmonary, and renal disease. Other advantages of EVAR are that it is less invasive and is less expensive than conventional open repair. Also, several large trials have demonstrated that elective endovascular aortic aneurysm repair is associated with lower perioperative morbidity and mortality rates than open surgical repair (1.2% 30-day postoperative mortality for EVAR, compared with 4.8% for open repair), particularly in patients with significant pre-existing co-morbidities (4,5). EVAR has also been associated with shorter hospital stays, decreased blood loss, and fewer transfusion requirements when compared with open surgical repair.

Unfortunately, the ability to utilize the endovascular approach is limited by a multitude of stringent aortic and iliac anatomic criteria that must be met, depending on the type of endograft deployed. These criteria have been defined by the American College of Cardiology/American Heart Association (ACC/AHA) 2005 Practice Guidelines for the management of patients with peripheral arterial disease. Favorable anatomic characteristics include proximal neck angulation less than 60 degrees, proximal neck length greater than 15 mm, and infrarenal proximal neck diameter less than 28 mm (6). Proximal neck angulation is defined as the angle formed between the line that transects the normal aorta proximal to the aneurysm and the line that transects the long axis of the aneurysm. Proximal neck length can be defined as the length of normal aorta proximal to the aneurysm measured from the inferior portion of the renal artery to the most superior extent of the aneurysm. Proximal neck diameter is the length of normal aorta proximal to the aneurysm in the horizontal plane measured from the inferior portion of the renal artery to the most superior extent of the aneurysm (Figure 1,2).

We present three patients who were initially ineligible for endovascular aortic aneurysm repair because of unfavorable neck anatomy (proximal neck angulation greater than 60 degrees, proximal neck length less than 15 mm, infrarenal proximal neck diameter greater than 28 mm) but who were successfully treated with a Powerlink endograft (Endologix; Irvine, CA) via the use of aortic cuffs. An aortic cuff is an extension device used to achieve complete seal at the proximal aortic neck in the event of suboptimal seal following initial endograft placement. Suboptimal seal may result when space is persistent between the upper end of the graft material and the aorta at the level of the proximal landing zone, with blood between the wall of the neck and the outside of the graft. This suboptimal seal is treated by insertion of an aortic cuff cranial to the endograft itself (Figure 3). The use of aortic cuffs is a valuable technique for dealing with problematic aortic aneurysm necks and expands the number of potential patients eligible for endovascular aortic aneurysm repair (7).

CASE DESCRIPTIONS

Case 1: An 81-year-old woman with medical co-morbidities including coronary artery disease, hypertension, hypercholesterolemia, and chronic obstructive pulmonary disease was referred for endovascular management of an asymptomatic 5.1-cm infrarenal abdominal aortic aneurysm. The aneurysm was not seen on a computed tomography (CT) study performed three years earlier.

The preoperative CT demonstrated a sharply angulated proximal neck of 70 degrees and a short proximal neck length of 10 mm (Figure 4,5), rendering the patient ineligible by standard criteria. An aortic cuff was utilized to compensate for the short aneurysm neck length and allow for placement of a Powerlink endograft. A Powerlink endograft was chosen because of operator familiarity and greater institutional experience with this device over other kinds of endografts. Under general anesthesia, bilateral femoral access was obtained by surgical femoral cutdown with subsequent placement of a 25-16-120 Powerlink endograft (25 represents the diameter of the proximal neck in mm, 16 represents the diameter of the iliac limb in mm, and 120 represents the length of the endograft in mm). Subsequently, an Endologix (Irvine, CA) 25-75 (25 represents the diameter of the aortic cuff in mm, and 75 represents the length of the cuff in mm) aortic cuff was placed, as planned to compensate for the short proximal neck length. Angiography demonstrated a type I endoleak (an endoleak is simply the persistence of blood flow around the endograft within the aneurysm sac, and a type I endoleak usually indicates an incomplete seal at either the proximal or distal attachment site); and consequently an overlapping Endologix (Irvine, CA) 25-55 aortic cuff extension was deployed to seal the endoleak (Figure 6). The completion angiogram showed no evidence of further endoleak. Follow-up angiogram (Figure 7) and CT scan (Figure 8,9) 1 year after the procedure demonstrated a patent endograft with no endoleak.

Case 2: A 78-year-old man with a past medical history significant for carotid stenosis, prostate cancer, glaucoma, and macular degeneration was found on CT to have a 5-cm infrarenal abdominal aortic aneurysm after an asymptomatic pulsating abdominal mass was found on routine physical exam (Figure 10,11). The proximal aortic neck was angulated to 40 degrees, with a 29-mm proximal neck diameter, 10 mm below the renal artery level (Figure 12). The proximal aortic neck length measured 10 mm (Figure 12). A standard 28-16-140 Powerlink endograft was deployed, followed by a 36-73 Zenith aortic cuff to stabilize the short proximal aortic neck length and wide proximal aortic neck diameter. A Zenith aortic cuff was used because these generally have larger proximal cuff widths than other aortic cuffs and can better stabilize large proximal neck diameters (8). Repeat angiography following aortic cuff placement showed a persistent but mild proximal type I endoleak (Figure 13). Therefore, a P 5010 Palmaz stent (Cordis; Miami Lakes, FL) was placed at the proximal neck to better appose the endograft to the aortic wall. A completion angiogram showed no further endoleak. One-year follow-up CT also demonstrated no endoleak (Figure 14,15).

Case 3: A 61-year-old woman with a past medical history of coronary artery disease, chronic obstructive pulmonary disease, diabetes mellitus II, hypertension, and hypercholesterolemia was referred for an infrarenal aortic aneurysm that had expanded 1.5 cm in a 1-year interval. A CT angiogram (CTA) demonstrated an infrarenal aneurysm measuring 5 cm in diameter (Figure 16) with a short, angulated (70 degrees), complex dumbbell-shaped proximal neck, measuring 31 mm in diameter and 10 mm in length (Figure 17,18). A 28-16-140 Powerlink endograft was initially placed followed by a Zenith 36-73 infrarenal aortic cuff. A Zenith aortic cuff was used for the same reason as in case two (i.e., to achieve optimal seal for a wide proximal aortic neck diameter). A completion angiogram (Figure 19) demonstrated no endoleak.

DISCUSSION

Endovascular techniques for repair of infrarenal abdominal aortic aneurysms have rapidly evolved since the early 1990s (1,2) and are now relatively common worldwide. The various eligibility criteria, limitations of endovascular aneurysm repair, as well as the devices used, have been extensively published (8,9,10,11). However, much less has been written specifically about the use of aortic cuffs and EVAR in patients who do not meet standard criteria dictated by the 2005 ACC/AHA practice guidelines.

Our experience suggests that aortic cuffs can be successfully used in conjunction with standard endografts in treating patients who are initially ineligible by standard criteria. Other institutions have also successfully treated patients with difficult infrarenal aortic aneurysm neck anatomy with aortic cuffs in conjunction with standard endografts (12,13,14,15). Specifically, Qu et al. described experience with the Endologix Powerlink endograft in EVAR with patients who had short and angulated proximal aortic necks. In that study, 54 patients had proximal aortic neck lengths measuring between 11 and 15 mm, 26 patients had proximal aortic neck lengths measuring <10 mm, and 37 patients had proximal aortic angulations >60 degrees. All 117 of these patients were treated with an Endologix Powerlink endograft as well as an aortic cuff. The technical success rate was reported as 97.4% (114/117 patients), with a 30-day mortality of 1.7 % (2/117 patients). Qu et al. concluded that the use of the Endologix Powerlink endograft device along with an aortic cuff proved safe and effective in treating patients with short and angulated proximal aortic necks for EVAR (13).

Aburahma et al. reported in July 2009 on correlation of aortic neck length to early and late outcomes in EVAR patients (14). Patients were assigned to three categories: those who had aortic neck lengths greater than or equal to 15 mm (group 1), those with neck lengths between 10 and 15 mm (group 2), and those with neck lengths less than 10 mm (group 3). In that study, proximal type I endoleaks occurred in 12% of patients in group 1, 42% of patients in group 2, and 53% of patients in group 3 ($P < .001$). Furthermore, proximal aortic cuffs were needed to seal these type I endoleaks in 10% of patients in group 1, 38% of patients in group 2, and 47% of patients in group 3 ($P < .0001$). Aburahma et al. concluded that EVAR could be used for patients with short aortic necks; however, it was associated with a significantly higher rate of early type I endoleaks, resulting in an increased use of proximal aortic cuffs for sealing the endoleaks (14). Both the Aburahma et al. and Qu et al. studies, as well as our case series, demonstrate the utility of aortic cuffs in successfully treating patients who do not meet standard criteria set forth by ACC/AHA guidelines based on unfavorable proximal neck anatomy.

In our case series, we also demonstrated that cuff use is not limited to a single aortic cuff, because other devices and various combinations may be necessary and can serve the equivalent purpose to a standard aortic cuff, depending on the scenario. In Case 1, two overlapping Endologix aortic cuffs were necessary because of a proximal type I endoleak after deployment of the first cuff. In Case 2, a Zenith aortic cuff was initially placed, but because of a Type I endoleak it was followed by reinforcement at the same level with a P 5010 Palmaz stent that has great radial strength in order to achieve an optimal aneurysm neck seal. In Case 3, a single Zenith aortic cuff proved to be sufficient.

Our case series of three patients also highlights the fact that EVAR in patients with unfavorable proximal neck anatomy is not without risk. In two of our three cases, placement of an initial aortic cuff was complicated by the development of a type I endoleak, indicating incomplete exclusion or incomplete seal of the aneurysm. Aburahma et al. also demonstrated that the group of patients with aortic neck length of less than 10 mm had the greatest frequency of type I endoleaks, whereas the group of patients with aortic neck length greater than or equal to 15 mm had the least frequency of type I endoleaks. The risk of endoleak in initially ineligible patients by standard criteria undergoing EVAR should not be overlooked as a limitation to the procedure.

Aside from type I endoleaks, three other types of endoleaks may occur during EVAR, in addition to the potential for endotension. A type II endoleak, the most common type of endoleak complicating EVAR, refers to retrograde flow from collateral vessels, particularly from the lumbar arteries or inferior mesenteric artery (16). A type III endoleak arises from a defect in the graft, which can result from a disjunction between components of the graft or even a hole in the fabric of the graft. A type IV endoleak refers to flow through the graft presumed to be associated with graft wall porosity and is usually self limited and resolves spontaneously within 1 month (16). Endotension, which is not considered a type of endoleak, is simply persistent or recurrent pressure on the endograft (16).

CONCLUSION

In conclusion, the use of aortic cuffs represents a useful approach for endovascular repair of abdominal aortic aneurysms with complex, large-diameter, short-length, or excessively angulated aneurysm necks. The availability of an increased variety of aortic cuffs, which in our cases included an Endologix aortic cuff, Zenith aortic cuff, and Palmaz P 5010 stent, may allow more patients to benefit from the endovascular method of aneurysm repair, particularly those who are otherwise not candidates for open surgical repair. The presence of endoleak in initially ineligible patients by standard criteria undergoing EVAR should not be overlooked as a limitation to the procedure. Much more data on long term outcomes are needed before aortic cuffs can be used as a standard procedure in patients initially ineligible for EVAR.

TEACHING POINT

For patients who are not good candidates for open surgical repair of an AAA, EVAR represents a less invasive and less expensive alternative. In addition, for those patients who would benefit from an EVAR but do not meet the stringent practice guidelines described by the 2005 ACC/AHA, aortic cuffs can be a useful adjunct that can help seal off leaks.

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FIGURES

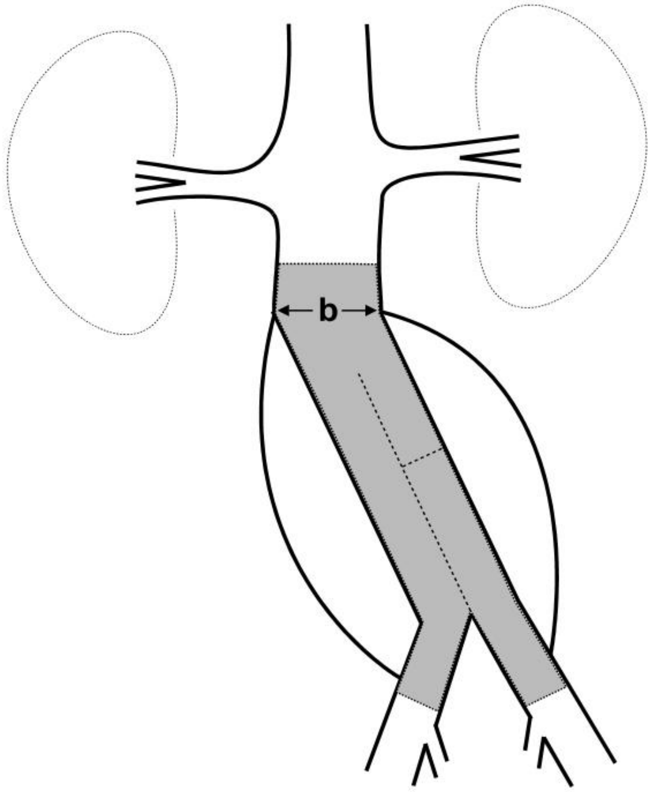

Figure 1: Schematic diagram representing an infrarenal abdominal aortic aneurysm. Here, b represents the proximal neck diameter or the length of normal aorta proximal to the aneurysm in the horizontal plane measured from the inferior portion of the renal artery to the most superior extent of the aneurysm.

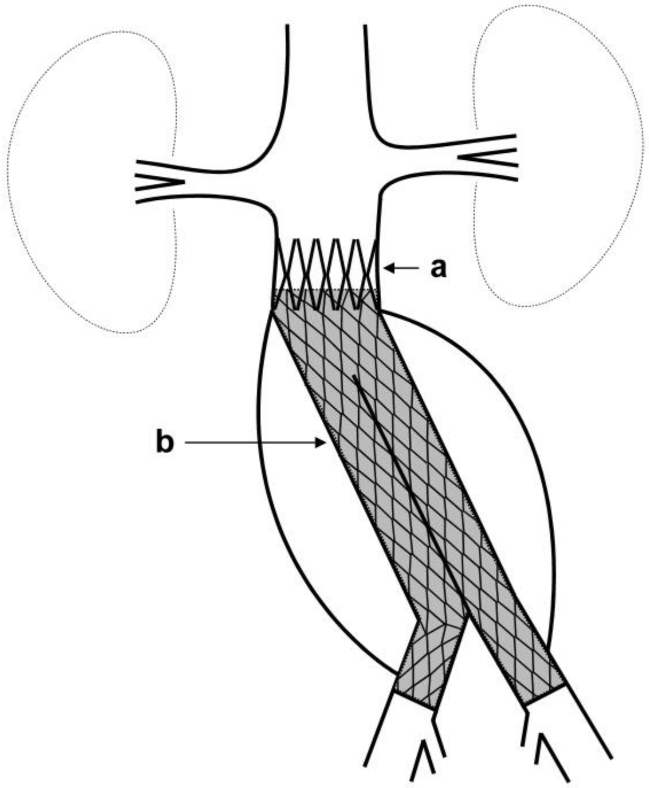

Figure 3: Schematic diagram of an infrarenal aortic aneurysm with successful placement of an endograft (b) and an aortic cuff (a). The aortic cuff is deployed cranial or proximal to the endograft itself to achieve complete seal at the proximal aortic neck in the event of suboptimal seal following initial endograft placement.

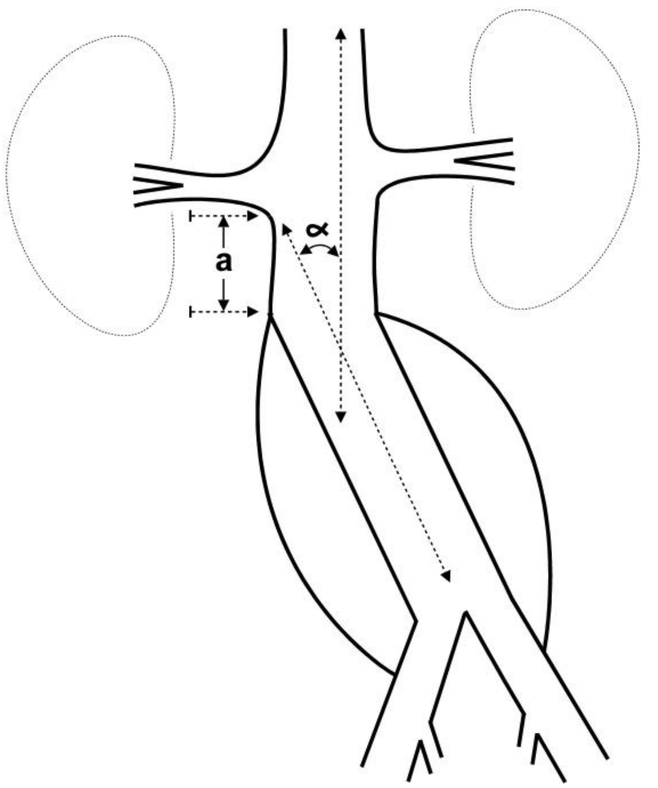

Figure 2 (left): Schematic diagram of an infrarenal abdominal aortic aneurysm. Here, a represents proximal neck length or the length of normal aorta proximal to the aneurysm measured from the inferior portion of the renal artery to the most superior extent of the aneurysm. Proximal neck angulation, depicted as α, is the angle formed between the line that transects the normal aorta proximal to the aneurysm and the line that transects the long axis of the aneurysm.

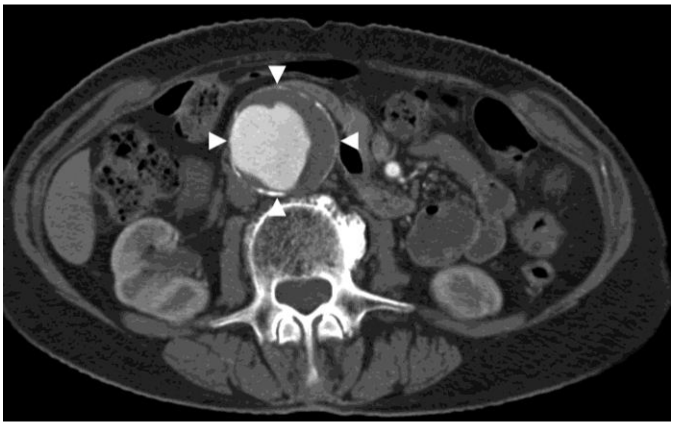

Figure 4: Eighty-one-year-old woman with infrarenal aortic aneurysm. Axial CT in arterial phase (CTA) with the use of 100 mL of Omnipaque 350 intravenous contrast injected at a rate of 4 mL/s shows a 5.1-cm infrarenal aortic aneurysm (arrowheads).

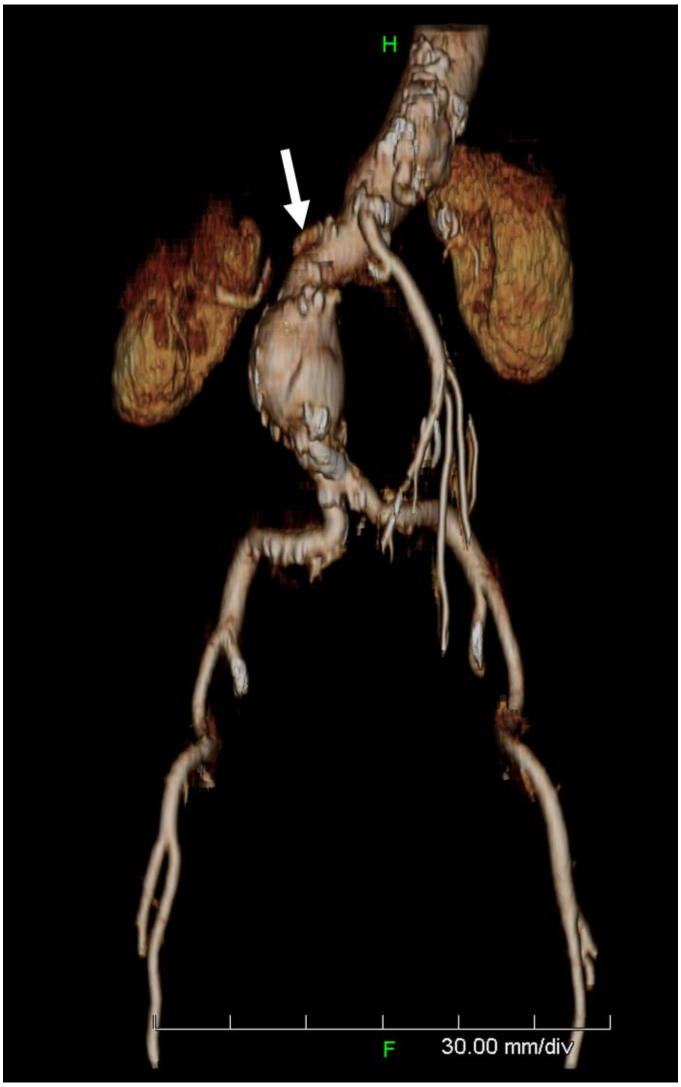

Figure 5: Eighty-one-year-old woman with infrarenal aortic aneurysm. Volume-rendered 3D image from pre-repair CT study demonstrates infrarenal abdominal aortic aneurysm with proximal neck angulation of 70 degrees and 10-mm proximal neck length (arrow).

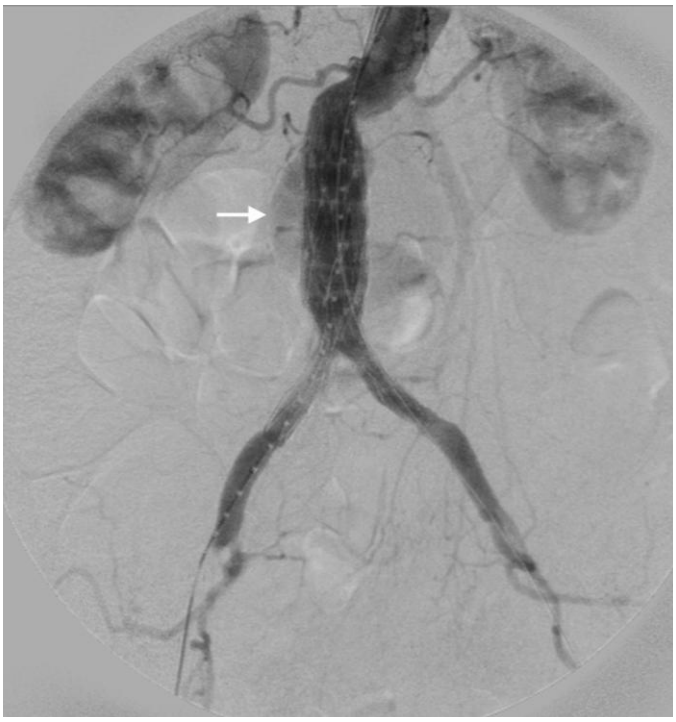

Figure 6: Eighty-one-year-old woman with infrarenal aortic aneurysm. Intraoperative angiogram with use of 150 mL of Omnipaque 300 intravenous contrast demonstrates a type I endoleak (arrow) with contrast filling the aneurysm sac proximally.

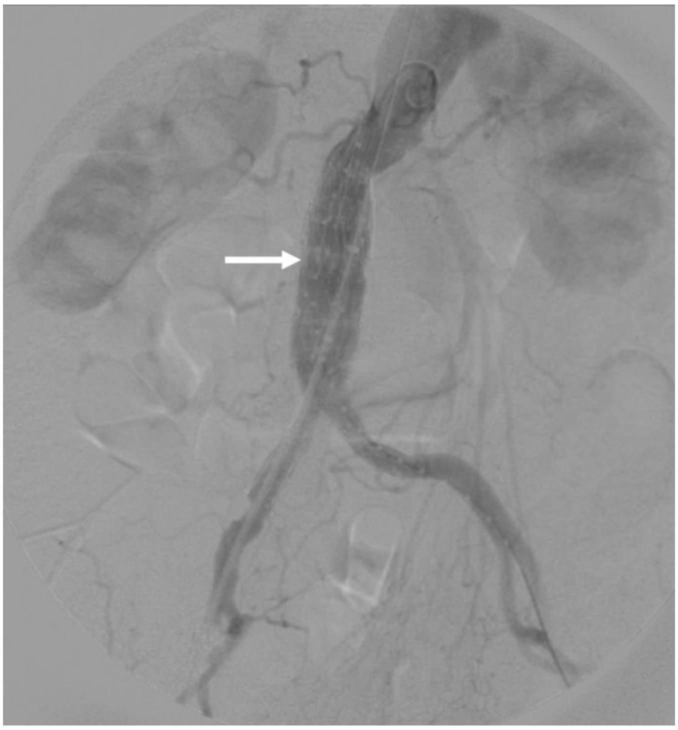

Figure 7: Eighty-one-year-old woman with infrarenal aortic aneurysm. Intraoperative angiogram with use of 150 mL of Omnipaque 300 intravenous contrast demonstrates successful endograft placement with exclusion of the abdominal aortic aneurysm (arrow).

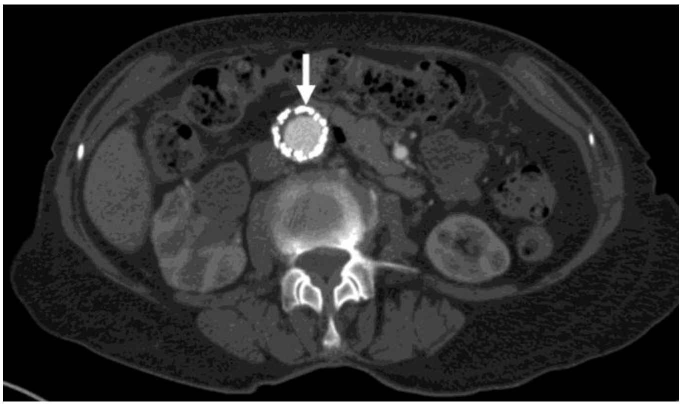

Figure 8: 81-year-old woman with infrarenal aortic aneurysm. Follow-up postrepair intravenous contrast (100 mL of Omnipaque 350 injected at a rate of 4 mL/s) enhanced CT study in arterial phase (CTA) demonstrates successful aneurysm exclusion by the endograft (arrow).

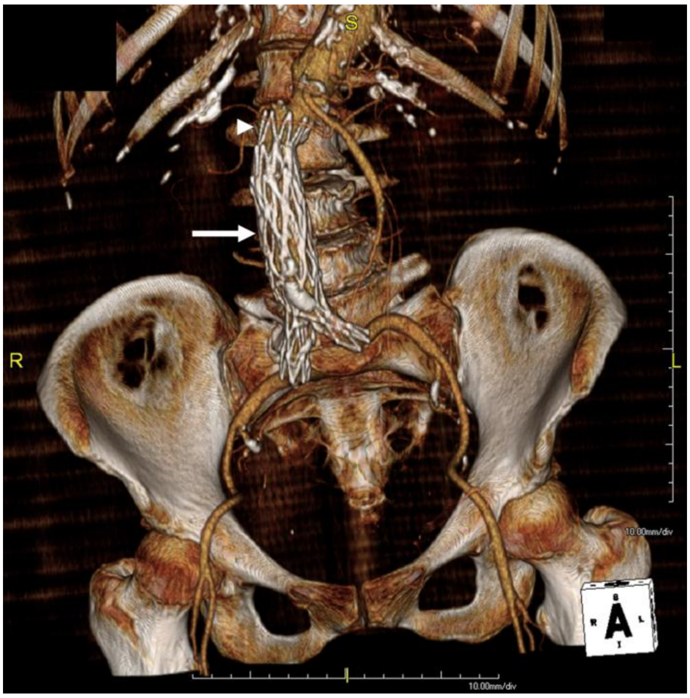

Figure 9: Eighty-one-year-old woman with infrarenal aortic aneurysm. Endograft (arrow) as it appears on a volume-rendered 3D image on a 1-y follow-up CTA examination. Arrowhead points to components of the aortic cuffs.

Figure 10 (right): Seventy-eight-year-old man with infrarenal aortic aneurysm. Axial CT in arterial phase (CTA) with the use of 100 mL of Omnipaque 350 intravenous contrast injected at a rate of 4 mL/s shows a 5-cm infrarenal aortic aneurysm (arrow).

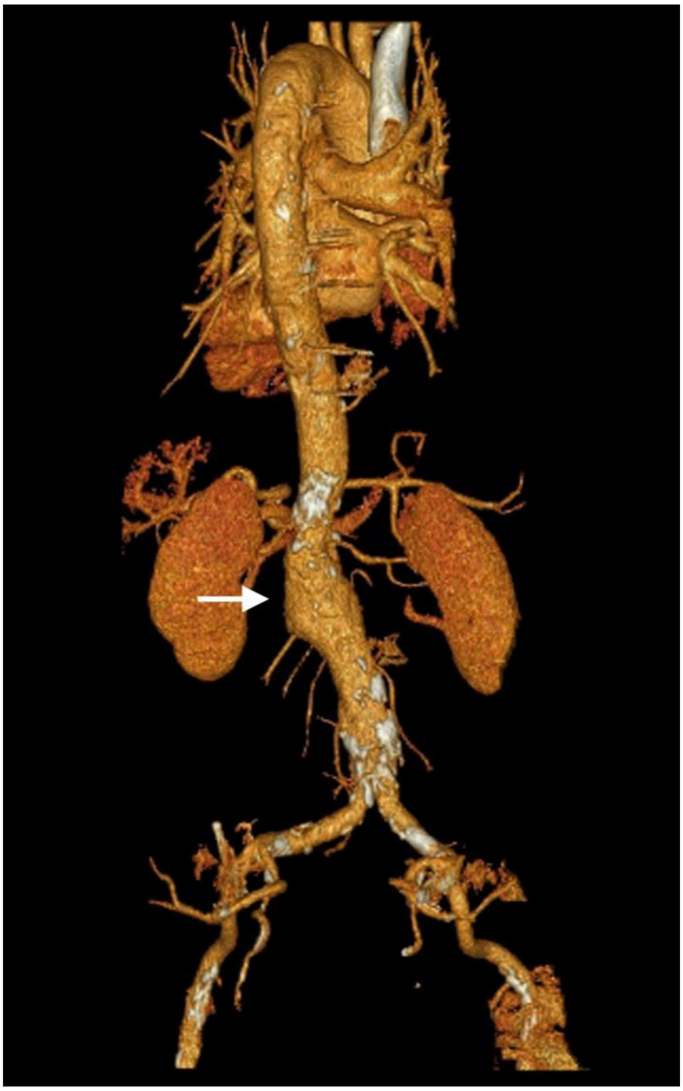

Figure 11: Seventy-eight-year-old man with infrarenal aortic aneurysm. Volume-rendered 3D image from pre-repair CT study demonstrates infrarenal abdominal aortic aneurysm (arrow) with a short 10-mm proximal aortic aneurysm neck with angulation of 40 degrees and diameter of 29 mm.

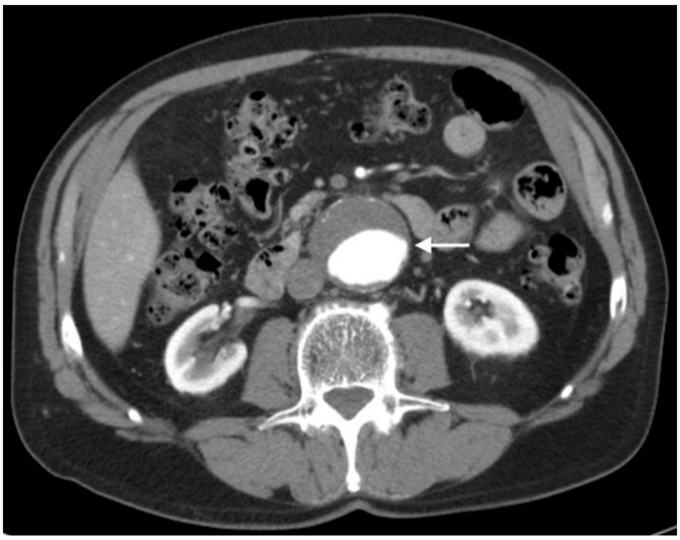

Figure 12: Seventy-eight-year-old man with infrarenal aortic aneurysm. Intraoperative angiogram with the use of 150 mL of Omnipaque 300 intravenous contrast demonstrates a short, 10-mm proximal aortic aneurysm neck with angulation of 40 degrees and diameter of 29 mm (arrows).

Figure 13: Seventy-eight-year-old man with infrarenal aortic aneurysm. Intraoperative angiogram with use of 150 mL of Omnipaque 300 intravenous contrast demonstrates a mild type I endoleak with contrast filling the aneurysm sac (between the 3 arrows).

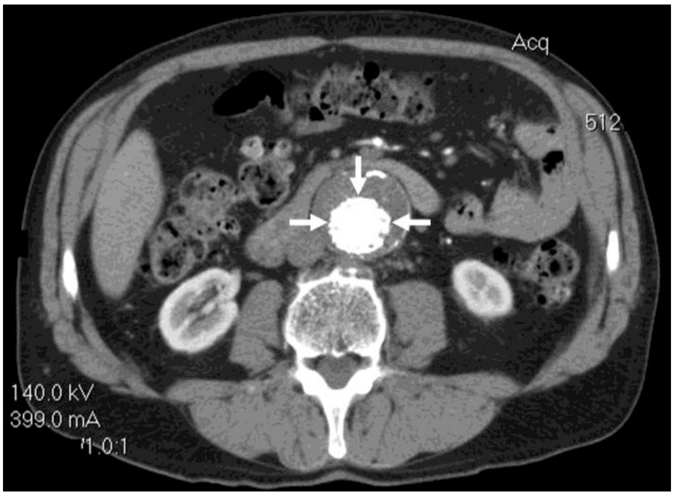

Figure 14: Seventy-eight-year-old man with infrarenal aortic aneurysm. Intravenous contrast-enhanced CTA with use of 100 mL of Omnipaque 350 injected at a rate of 4 mL/s obtained 1-y later reveals isolation of aortic aneurysm sac by the endograft (arrows) with no endoleak.

Figure 15: 78-year-old man with infrarenal aortic aneurysm. Endograft as it appears on a volume-rendered 3D image on a 1-year follow-up CTA examination (white arrow). Arrowhead shows the aortic cuff, and green arrow points to the Palmaz stent.

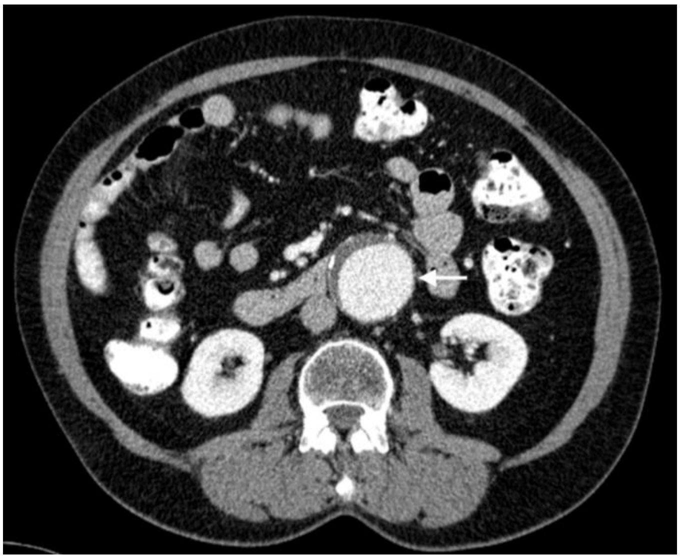

Figure 16: Sixty-one-year-old woman with infrarenal aortic aneurysm. Axial CT in arterial phase (CTA) with use of 100 mL of Omnipaque 350 intravenous contrast injected at a rate of 4 mL/s shows a 5-cm infrarenal aortic aneurysm (arrow).

Figure 17 (bottom left): Sixty-one-year-old woman with infrarenal aortic aneurysm. Volume-rendered 3D images from preprocedure CTA demonstrates complex, short, angulated, and dumbbell-shaped proximal neck (arrow). (Proximal neck angulation of 70 degrees, proximal neck length of 10 mm, and proximal neck diameter of 31 mm).

Figure 18 (bottom right): Sixty-one-year-old woman with infrarenal aortic aneurysm. Volume-rendered 3D images from preprocedure CTA demonstrates complex, short, angulated, and dumbbell-shaped proximal neck (arrow). (Proximal neck angulation of 70 degrees, proximal neck length of 10 mm, and proximal neck diameter of 31 mm.)

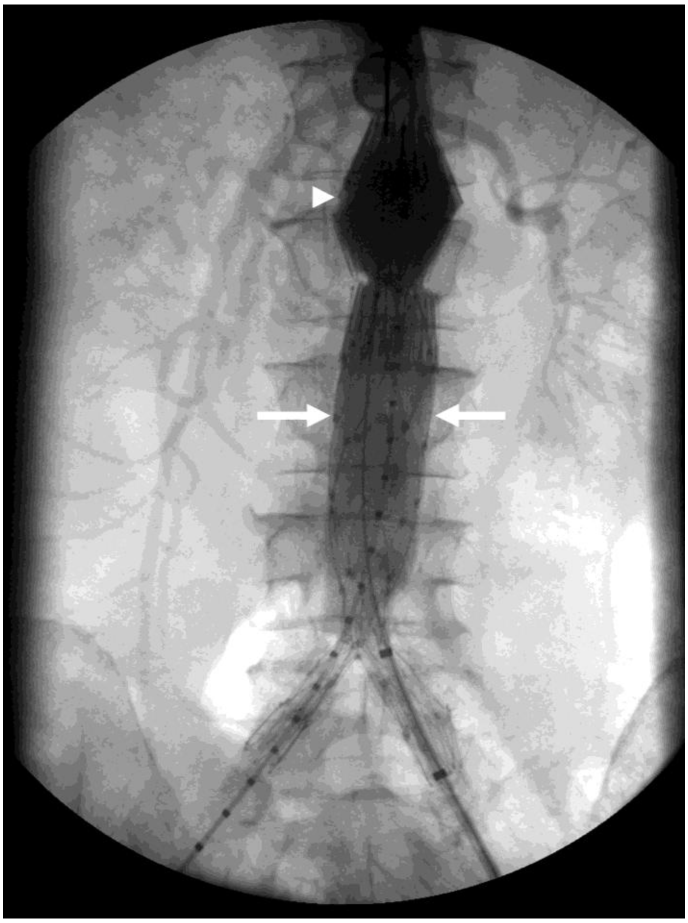

Figure 19: Sixty-one-year-old woman with infrarenal aortic aneurysm. Intraoperative angiogram with the use of 150 mL of Omnipaque 300 intravenous contrast demonstrates successful endograft placement (arrows). Arrowhead points to the aortic cuff.

ABBREVIATIONS

EVAR = Endovascular aneurysmal repair
AAA = Abdominal aortic aneurysm
ACC/AHA = American College of Cardiology/American Heart Association
mm = millimeters
CT = computed tomography
CTA = computed tomographic angiogram
mL/s= milliliters/second

KEYWORDS

Endovascular aortic aneurysm repair; Aneurysm proximal neck anatomy; Aortic cuff