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The challenge of gate cannulation during endovascular aortic repair: A hypothesis of simplification

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ABSTRACT

Aim: One of the technical problems which can be encountered during the endovascular repair (EVAR) of abdominal aortic aneurysms, is represented by the challenge of cannulation of the contralateral gate after the opening of the main body of the endograft, especially in case of tortuous aorta-iliac anatomy. Aim of this work is to propose a hypothesis of simplification, verifying the possibility to maximize the area available for the cannulation of the contralateral gate by simulating an oblique distal end of the leg of the most used devices, without affecting the correct sealing between the main body and the iliac extension.
Methods: Data about the contralateral gate of the main body of endografts most used for EVAR were analyzed. The elliptical sectional area resulting from the simulation of the oblique cut was calculating with some geometric formulas. Then the gain of "disposable area" for the cannulation of the contralateral gate was calculated as a percentage of the elliptical area resulting in maximum distal oblique cut, with respect to the nominal circular area of the base.
Results: The only endografts which could undergo an oblique cut without losing the sealing between the main body and the contralateral limb were the Incraft, the Treovance and the Ovation, for which it would be possible to obtain a surface gain up to 84%, 22.8% and 14.4% respectively (being 9.8% in case of Ovation with the main body 29 and 34). A simulation of oblique cut was also performed on the endografts which currently do not allow to do so without a loss of sealing, assuming to lengthen the contralateral gate of an arbitrary measure of 10 mm. In these cases, the percentage of surface gain was greater for endoprostheses which had a smaller diameter of the contralateral leg.
Conclusions: The oblique cut of the contralateral gate allowed a gain of the surface available for the cannulation, however it was not applicable to all models of currently available endoprostheses, unless of a loss of sealing between the main body and the contralateral iliac limb.

Introduction

The endovascular repair of abdominal aortic aneurysms (EVAR) has now emerged as a safe and effective alternative to open surgery, with some advantages of the former over the latter including a lower perioperative mortality and morbidity and, not least, a reduction of the operative time [1].

One of the technical problems which can be encountered intraoperatively when EVAR is performed using modular graft, is represented by the challenge of cannulation of the contralateral gate after the opening of the main body, especially in case of tortuous aorta-iliac anatomy [2]. This problem may lead to a lengthening of the operative time and to the need to use more material with increasing costs and increased risk of vascular access complications. In fact, when contralateral cannulation gate is challenging, an alternative vascular access may be advocated, such as the brachial [3] or the contralateral femoral artery via crossover technique.

To overcome this problem some endografts have been equipped with devices that facilitate the cannulation of the contralateral gate [4,5]. Some other endoprostheses instead require no more contralateral gate cannulation [6,7].

In most of the devices used for EVAR however the contralateral leg is cannulated through a free gate that has a circular section due to a cut which is perpendicular to the major axis of the graft itself.

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The hypothesis

Aim of this work is to propose a hypothesis of simplification, verifying the possibility to maximize the area available for the cannulation of the contralateral gate by simulating an oblique distal end of the leg of the most used devices, without affecting the correct sealing between the main body and the iliac extension.

Materials and methods

The most used endografts for the endovascular treatment of abdominal aortic disease were analyzed, with the exception of those presenting particular devices which already aim to facilitate the cannulation the contralateral gate.

For each device, the technical brochure was analyzed, with particular attention to the technical specifications of the main body's contralateral gate. In particular, data analyzed were the distal diameter of the gate, the length of the contralateral gate of the main body and the minimum overlapping needed between the gate and the contralateral iliac extension to ensure optimal sealing between the prosthetic modules (Table 1).

In fact, the extent of the shortening that would result to the oblique cut of the gate cutting instead of the circular one, takes into account the minimum overlapping suggested by the instruction for use to ensure a proper sealing between the modular pieces.

Given the minimum overlapping between the gate and the iliac extension, the maximum value of shortening was obtained (s), from which, knowing the diameter (2r), the maximum α angle of executable oblique cutting was obtained (Fig. 1).

The contralateral leg of the main body has the shape of a straight circular cylinder. Applying the oblique distal cut, the contralateral leg would become a cylinder with oblique section, as shown in Fig. 2. Given the radius (r), the nominal length (b) and the length obtained after the maximum practicable shortening (a), some geometric formulas were applied, as shown in Fig. 2, in order to calculate:

- Total cylinder Area (TA),
- Lateral cylinder Area (LA),
- Circular Area of the base ($CA = \pi r^2$), that is the circular distal area of the contralateral leg with the cut which is perpendicular to the major axis of the leg itself.

Table 1
Technical features of the main body's contralateral leg of analyzed endografts.

Endograft	Distal diameter (mm)	Length (mm)	Minimum overlapping (mm)	Maximum shortening, s(mm)
INCRAFT	11	37	20	17
ZENITH LP	11	14	14	0
ZENITH FLEX	12	14	14	0
TREOVANCE	14	30	20	10
E-TEGRA	13	30	30	0
E-VITA ABDOMINAL XT	14	30	30	0
EXCLUDER C3	13	30	30	0
TALENT ABDOMINAL	14	30	30	0
ENDURANT II	14 12 (main body 23)	30	30	0
OVATION	9 11 (main body 29, 34)	35	30	5

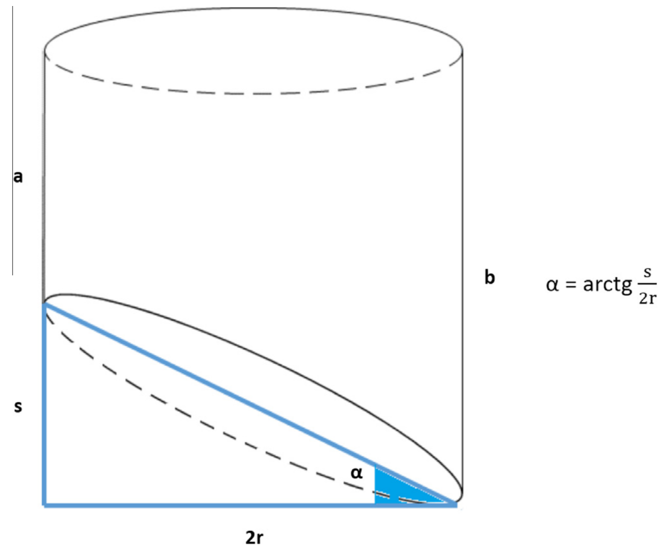

Fig. 1. Trigonometric formula for the calculation of the maximum α angle of oblique executable cutting; a = the minimum overlapping between the gate and the iliac extension, s = the maximum value of shortening, 2r = the diameter.

Subtracting the lateral Area and the circular Area to the total Area, the elliptical sectional area resulting from the oblique cut (XA) was calculated: $XA = TA - LA - CA$.

Then, the gain of "disposable area" for the cannulation of the contralateral gate was calculated as a percentage of the elliptical area resulting in maximum distal oblique cut, with respect to the nominal circular area of the base: $\%\ Gain = (100 * XA/CA) - 100$.

Evaluation of the hypothesis and results

The oblique cut theoretically could be always applicable. However, as reported in Table 1, from the technical point of view the oblique cut was not applicable to all models of currently available endoprostheses, unless of a loss of sealing between the main body and the contralateral iliac limb. The only endografts which could undergo this change were the Incraft and the Treovance, for which it would be possible to obtain a surface gain up to 84% and 22.8% respectively, as reported in Table 2. Even the endoprosthesis Ovation can afford to make this change, although this would lead to a lower percentage gain.

A simulation of oblique cut was also performed on the endografts which currently do not allow to do so without a loss of sealing, assuming to lengthen the contralateral gate of an arbitrary measure of 10 mm. As reported in Table 3, the percentage of surface gain was greater for endoprostheses which had a smaller diameter of the contralateral leg. In particular, with the Cook Zenith LP, up to 35% of surface gain would be obtained.

Consequences of the hypothesis and discussion

One of the technical problems that may arise during EVAR is a challenging cannulation of the contralateral gate of the endograft [2], especially in case of tortuous aorto-iliac anatomy. In fact, the cannulation of the contralateral gate often requires the ability to capture a small circular space (maximum 1.5 cm^2) that sometimes lies gaping in a huge aneurysm sac. Then we must not forget that the movement of the gate cannulation takes place in a three-dimensional space, but is displayed in two dimensions. No data in the literature exist about the average time of cannulation of the contralateral gate, but in our experience in case of challenging