# Relationship between access side used to deliver the main body of bifurcated prostheses for endovascular aneurysm repair and speed of cannulation of the contralateral limb

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***Objectives:*** **To examine the relationship between the orientation of the iliac arteries in infrarenal aortic aneurysms and its effect on the cannulation of the contralateral limb of a bifurcated stent graft system (SGS) used for endovascular aneurysm repair (EVAR).**

***Methods.*** **This is a retrospective review of prospectively collected data in 100 consecutive patients treated with EVAR using the Zenith device (Cook Medical Inc., Bloomington, Indiana, USA). We collected data on reciprocal orientation between the origins of the common iliac arteries (OOCIA) on an axial plane, the common femoral artery (right or left) used to deliver the main body of the SGS (access side), and the cannulation time of the contralateral limb. The latter was defined as the time elapsed between the introduction of the selective catheter in the contralateral iliac artery to the time of successful cannulation of the contralateral limb of the SGS. Using an Aquarius workstation (v. 3.5; TeraRecon Inc, San Mateo, Calif), the OOCIA was measured establishing the center of the origin of the right and left common iliac arteries and joining them using a straight line. A horizontal line was then drawn through the origin of the right common iliac artery. The angle created by these two lines was defined as "zero," "positive," or "negative." We examined the relations between cannulation time, access side, and OOCIA using *t* tests and a multivariate regression analysis.**

***Results:*** **In 84 patients, the origin of the right common iliac artery was in an anterior position compared with the left; in 16, the origin of the right and left were on the same horizontal line; and the right common iliac artery was posterior in none of the patients. The main body of the prosthesis was delivered using the left femoral artery in 52 patients and the right in 48. When all patients were considered, cannulation time was shorter when the main body of the bifurcated prosthesis was delivered through the left femoral artery (9.3 ± 5.8 minutes vs 15.4 ± 7.2 minutes, $P < .0001$). This effect was more pronounced when only patients with the left common iliac artery located posteriorly were examined (9.3 ± 5.80 minutes vs 16.4 ± 7.6 minutes, $P < .0001$). There was no correlation between increasing negativity of the OOCIA angle and cannulation time, regardless of access side.**

***Conclusion:*** **We have shown that in patients with infrarenal aortic aneurysms, the origin of the right iliac artery is often anterior compared with the left and that cannulation time of the contralateral limb is shorter when the main body of the prosthesis is delivered from the left. (J Vasc Surg 2010;51:33-7.)**

Endovascular abdominal aneurysm repair (EVAR) has become a standard of care, and an estimated 40% to 70% of all elective aneurysms are treated with this technique.[1-5]

Approximately 90% of all EVAR utilize a bifurcated configuration consisting of a stent-graft system (SGS), which includes a main body and leg extensions.[6] When the body of the bifurcated device is deployed, the limbs are placed above the aortic bifurcation and extensions are added, landing in the iliac arteries. Some bodies of SGS have limbs of equal lengths (ANACONDA; Vascutek, Inchinnan, Renfrewshire, Scotland). Other bodies have one long ipsilateral limb that lands in the iliac artery, requiring only one contralateral limb extension (Talent; Medtronic Inc, Minneapolis, Minn; Excluder; W. L. Gore & Associates, Newark, Del) and others have the ipsilateral limb longer than the contralateral (eg, Zenith; Cook Medical Inc, Bloomington, Ind). In addition, the length of the body of an SGS may be short or long. For all devices, except for the ANACONDA, one crucial step is the selective cannulation of the contralateral limb in order to introduce the limb extension (Fig 1). The distance between the contralateral limb of the SGS and the aortic bifurcation depends on the type of prosthesis: those with long bodies (eg, Zenith) have a shorter distance compared with those with short bodies (eg, Excluder, Talent).

Characteristics intrinsic to the design of the SGS and anatomical features of the aneurysm, including angulation, orientation of the aortic bifurcation, and iliac tortuosities may render cannulation of the contralateral limb difficult. The size of the aneurysm and the presence or absence of

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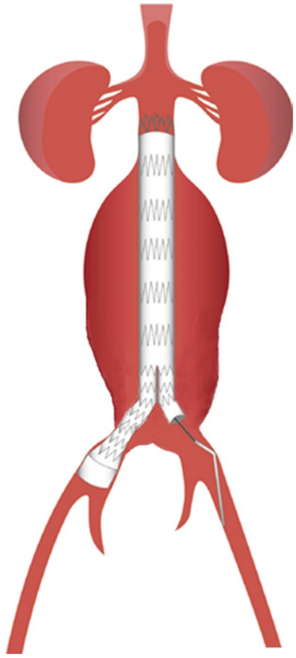

**Fig 1.** Cannulation of the contralateral limb of a bifurcated endovascular stent graft system.

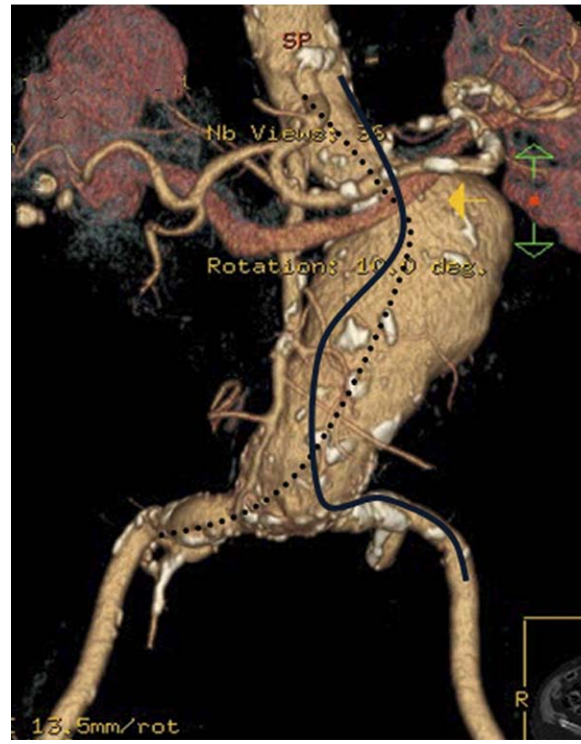


**Fig 2.** "C" configuration (dotted line) and "S" configuration (solid line) describing the neck-to-aneurysm and aneurysm-to-iliac arteries angulations.

mural thrombus can further complicate this step of the procedure. In addition, the orientation and position of the contralateral limb of the SGS within the aneurysm sac influences the ease of contralateral limb cannulation. Endovascular therapists often intentionally orient the contralateral limb of the SGS according to the specific patient anatomy using an anterior, lateral, or posterior gate placement or crossing the limbs of the SGS all together.

The objective of this work is to identify anatomical and technical factors that facilitate cannulation of the contralateral limb. We specifically examined the relationship between access side for the delivery of the main body of the bifurcated prosthesis, orientation of the aortic bifurcation, and speed of cannulation of the contralateral limb.

## METHODS

We undertook a retrospective review of 100 consecutive patients presenting for endovascular repair of abdominal aortic aneurysms (AAA) to a tertiary endovascular center between September 2006 and February 2008. All procedures were planned by the senior author (CSC) using a Zenith bifurcated prosthesis. With this endovascular stent graft system, the main body was always chosen to place the short contralateral limb 5 mm to 10 mm proximal to the aortic bifurcation, therefore placing the ipsilateral long limb within the lumen of the ipsilateral common iliac artery. When delivering the main body, it was oriented in such a way that the contralateral short limb was placed 30 degrees to 60 degrees anteriorly compared with the ipsilateral. During the study period, the right femoral artery was chosen as a default for access of the main body, unless other criteria suggested otherwise: (1) a specific access side was preferred if the combination of iliac, aneurysm-to-neck, and neck-to-aneurysm angulations drew an imaginary line with a "C" configuration, rather than an "S" (Fig 2); (2) stenosis or small diameter of the iliac system prevented passage of the delivery system; (3) the side that allowed the easiest rotation of the delivery system was usually preferred; (4) considerations regarding the distance lowest renal artery-to-aortic bifurcation and length of the body of the stent graft system suggested the selection of one side rather than the other.

All cannulations of the contralateral limb of the main body of the SGS were done by the right-handed senior author (CSC) positioned on the right side of the patient. The most common selective catheter used was a 5-F Kumpe catheter and a Terumo glidewire. According to the circumstances, however, other selective catheters were also used (Vanchie catheters 1-4, C2 or VS1 catheters). When time and anatomic difficulties prevented retrograde cannulation, an up-and-over technique was used, cannulating the contralateral limb from the ipsilateral side using a VS1 catheter and a glidewire and retrieving the glidewire from the contralateral side using an EN snare from Angiotech.

Anatomical measurements were obtained using a 64-slice computerized tomography (CT) scanner and post-processing done with the Aquarius workstation v. 3.5 (TeraRecon Inc, San Mateo, Calif). Institutional research

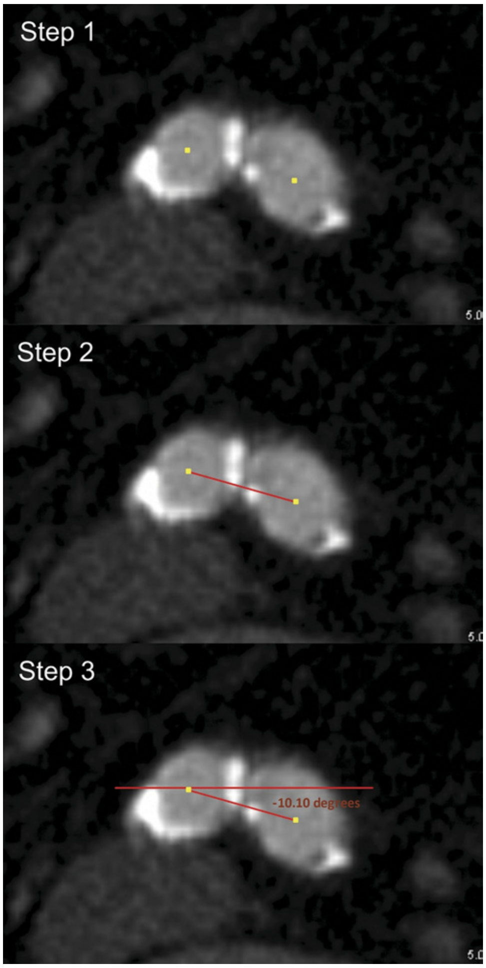


**Fig 3.** Calculation of the angle between the right and left common iliac artery (CIA) in the axial plane. Step 1: Defining the center of the right and left CIAs; step 2: A line is drawn to connect the origins of the CIAs; step 3: A horizontal line is drawn through the origin of the right CIA, and the angle is measured.

ethics board approval was obtained and requirement for individual consent waived.

We collected the following data: reciprocal orientation between the origins of the common iliac arteries (OOCIA) on an axial plane; the side (right or left) of the common femoral artery used to deliver the main body of the bifurcated prosthesis (access side); and the cannulation time of the contralateral limb, which was collected prospectively in all patients. The OOCIA was measured from CT images in a three-step process. First, we established the center of the origin of the right and left common iliac arteries and joined them using a straight line. A horizontal line was then drawn through the origin of the right common iliac artery. Finally, the angle created by these two lines was measured using the "angle" function of the TeraRecon software and defined as "zero," "positive," or "negative" (Fig 3). A zero angle indicated that the origins of the iliac arteries in an axial plane were both located on the horizontal line drawn through the origin of the right common iliac artery or within ±5° based on an estimated degree of error measurement. A negative angle represented a left common iliac artery anatomically posterior to the right, while a positive angle identified the opposite orientation. Access side was ascertained through a review of operative records of each individual patient. Cannulation time in minutes was measured intraoperatively from the time the selective catheter was inserted in the contralateral iliac system to the time successful cannulation of the limb of the body was confirmed by a Pigtail catheter, spinning freely within the graft.

Since no patients were identified with a "positive" OOCIA angle, for analysis purposes, patients were divided into two groups according to the access side and stratified according to a "negative" or "zero" OOCIA angle.

Data were entered into a database by two independent investigators and verified by the senior vascular surgeon (CSC) to reduce error. Disagreements were resolved by consensus. Patients who underwent EVAR with aorto-uni configuration and those treated for isolated iliac artery aneurysms were excluded from the study.

Statistical analysis was conducted using SPSS v.16.0 (Chicago, Ill). Continuous variables are expressed as mean ± standard deviation and categorical variables as percentages. Continuous variables were compared with unpaired two-tailed Student's $t$ tests. Multivariate regression analysis was conducted using cannulation time as the dependent variable and OOCIA angle and access side (right or left) as independent variables. Patients defined as having a "zero" degree angle were excluded because of collinearity. A $P$ value less than .05 was considered statistically significant.

## RESULTS

In 84 patients, the origin of the right common iliac artery was anterior to the left (negative angle), and in 16, it was in the same horizontal line (zero-degree angle). The cannulation time in the two groups of patients was not statistically different (12 ± 7.4 minutes and 12.7 ± 5.7 minutes, respectively, $P = .762$).

The main body of the prosthesis was delivered using the left femoral artery in 52 patients and the right in 48. The average cannulation time was 9.3 ± 5.8 minutes (shortest, 1 minute; longest, 32 minutes) and 15.4 ± 7.2 minutes (shortest, 3 minutes; longest, 41 minutes), respectively ($P < .0001$). Analysis of the relative orientation of the iliac arteries demonstrated that the origin of the right common iliac artery was anterior with respect to the left (yielding a negative angle) in 84 patients (−28 ± 13 degrees). In 16 patients, the origin of the right and left common iliac arteries were on the same horizontal line (yielding a zero degree angle). None of the patients presented with a positive angle, which would have denoted a configuration with the origin of the left common iliac in an anterior position.

In the group of patients with a negative angle (right iliac anterior to the left), the main body of the bifurcated endoprosthesis was delivered from the left femoral artery in 51 cases (61%) and from the right femoral artery in 33 (39.3%). The cannulation time in those accessed from

**Table.** Multivariate regression analysis of using cannulation time as a dependent variable and angle of the common iliac arteries and access side as independent variables

| *Predictor variables* | β | *Standard error* | *Confidence interval* | *Statistical significance* |
|---|---|---|---|---|
| Constant | 15.461 | 1.695 | −10.689 to −4.372 | $P < .0001$ |
| Angle | 0.044 | 0.059 | 12.088 to 18.835 | $P = .458$ |
| Access side | −7.530 | 1.587 | −2.73 to 0.161 | $P < .0001$ |

$R^2 = 0.227$.

the left was 9.3 ± 5.8 minutes (shortest, 1 minute; longest, 32 minutes) and in those accessed from the right was 16.4 ± 7.6 minutes (shortest, 7 minutes; longest, 41 minutes) ($P < .0001$).

In the zero-angle group, 15 patients were accessed from the left, and one was accessed from the right femoral artery. The cannulation time was 13.1 ± 5.7 (shortest, 3 minutes; longest, 21 minutes) and 7 minutes, respectively ($P = .3$).

Excluding those patients with the origin of the iliac arteries with zero-degree angle, multivariate analysis showed that there is no correlation between increasing negativity of the angle (ie, with greater anterior position of the origin of the right common iliac artery) and cannulation time ($P = .458$) regardless of the access side. Right access side was associated with a longer cannulation time ($P < .0001$) (Table).

## DISCUSSION

In most modular stent graft systems, an important step in the deployment of the graft is the addition of a limb extension through the selective cannulation of the contralateral limb. This step may prove to be difficult and is influenced by many variables including graft characteristics and patient anatomy. Insertion of a limb extension into the ipsilateral side of the main body of the bifurcated prosthesis is straightforward because a guide wire through the main body is already in place. Some manufacturers (Vascutek, Anaconda) build sophisticated systems, which include the use of magnet wires to facilitate the cannulation of the contralateral limb. This approach has limitations since the anatomy of the aortoiliac segment may prevent the meeting of the two magnets. To facilitate cannulation of the contralateral limb, industry experts and surgeons suggest various approaches: different access side for the main body according to patients' anatomy, a specific placement of the contralateral limb along a clockwise position, and use of different selective catheters and wires. We demonstrated that in patients with an infrarenal AAA, the origin of the right common iliac artery is frequently anterior in relation to the left. In our population, the origins of the two arteries could be found in the same plane, but the origin of the left was never in an anterior position. The explanation for this anatomic arrangement may be due to the simultaneous elongation of the aorta, which occurs when an aneurysm develops, and to the anatomic fixation of the right and left iliac arteries to the reciprocal surrounding structures. This particular anatomical arrangement has significance specifically when long-bodied, bifurcated modular prostheses that require cannulation of the contralateral limb (such as the Zenith [Cook] device) are used. We have shown that regardless of the relative degree of the angle of orientation of the iliac arteries, since the left is almost always posterior, delivery of the main body from the left femoral artery is associated with a shorter cannulation time compared with the right. This observation may have important clinical consequences, since it may be used as a criterion in choosing the access side for delivery of the main body when using the Zenith [Cook] device. If there are no other compelling anatomic or pathologic contraindications (tortuosities, stenosis, calcifications, etc), a left side access is associated with shorter cannulation time. This may be particularly important for the endovascular treatment of ruptured aneurysms, to shorten cannulation when time is of the essence. A plausible hypothetical explanation for this finding is that usually the main body of a Zenith SGS is oriented to place the contralateral short limb slightly anterior. Suggested reasons for this orientation are that the limb is less likely to be compressed by the lateral aspect of the wall of the aneurysm, and that the wire exiting from the common iliac artery and entering the aneurysm usually takes an anterior path. If the short limb of the graft is then placed just above the origin of a common iliac artery, which is anterior to the contralateral, the lumen of the short limb and that of the common iliac artery would be in line, facilitating cannulation. Since we have found that the origin of most right common iliac arteries is anterior relative to the left, delivery of the main body from the left side with orientation of the contralateral short limb slightly anterior, would place the gate of the short limb in line with the orifice of the right common iliac artery.

In our group of patients with iliac arteries on the same plane, there was only one in whom the main body was delivered from the right femoral artery, and the cannulation time was shorter compared with those with access from the left. Although no statistical support may be given to this finding due to the small sample size, we speculate, however, that if the iliac arteries are on the same plane, delivery of the main body of the prosthesis and cannulation of the contralateral limb might be easier for a right-handed surgeon when the main body is delivered from the right.

To identify studies addressing the relationship between anatomy, delivery of the main body of the endostent and cannulation time, we searched the EMBASE, CINAHL, MEDLINE and Cochrane databases, using the search terms described in the Appendix (online only) and the files of the senior author. We were unable to identify articles describing the correlation between the anatomy of the aortic bifurcation and the cannulation time of the contralateral limb in endovascular repair of AAAs. To our knowledge, this report is the first attempt to quantify variables that affect cannulation time.

The strengths of this study include: (1) the novel definition of the anatomy of the aortic bifurcation in patients with aortic aneurysms with the finding of the origin of the right common iliac artery being anterior to the left in the vast majority of patients; (2) this is the first study in the literature addressing cannulation time of the contralateral limb, a crucial component of EVAR, and correlating this variable with the anatomy of the aortic bifurcation; (3) data regarding contralateral limb cannulation time were collected prospectively; (4) the anatomy of the aortic bifurcation was a systematically defined and reliably measured using computerized tomography with dedicated post-processing software (TeraRecon); (5) it is a large, continuous and consecutive cohort of patients operated on by a single vascular surgeon (CSC) with specific training and experience in complex infrarenal and fenestrated repairs.

The inference that may be drawn from this work is somewhat limited by the retrospective nature of the study. In particular, the side for access of the delivery system was not chosen at random, but it was chosen by an experienced endovascular surgeon with the specific aim of minimizing cannulation time. This may have biased the results, magnifying the benefit demonstrated by our work. In fact, theoretically in patients in whom the main body was delivered from the right, the cannulation of the contralateral short limb might have been rendered difficult by other anatomic variables not considered in this study (eg, tortuosities and angulations). The comparison between access sides in patients who have left and right iliac arteries on the same plane was weakened by the small sample size. Considering that there was only one patient who had been accessed from the right femoral artery and presented with a zero-angle configuration of the iliac arteries, the advantages of using either access side within this specific patient group cannot be accurately determined.

## CONCLUSION

We have shown that in patients with infrarenal aortic aneurysms, the origin of the right iliac artery is often anterior compared with the left and that cannulation time of the contralateral limb is shorter when the main body of the prosthesis is delivered from the left. In the absence of other contraindications, delivery of the main body from the left may shorten the operating time and improve efficiency during EVAR.

## AUTHOR CONTRIBUTIONS

Conception and design: CC
Analysis and interpretation: WD, MK, MP, CC
Data collection: WD, MK, CC
Writing the article: WD, MK, CC
Critical revision of the article: WD, MK, MP, CC
Final approval of the article: WD, MK, MP, CC
Statistical analysis: WD, MK, CC
Obtained funding: N/A
Overall responsibility: CC

## REFERENCES

1. Lee WA, Carter JW, Upchurch G, Seeger JM, Huber TS. Perioperative outcomes after open and endovascular repair of intact abdominal aortic aneurysms in the United States during 2001. J Vasc Surg 2004;39:491-6.
2. Anderson PL, Arons RR, Moskowitz AJ, Gelijns A, Magnell C, Faries PL, et al. A statewide experience with endovascular abdominal aortic aneurysm repair: rapid diffusion with excellent early results. J Vasc Surg 2004;39:10-9.
3. Dillavou ED, Muluk SC, Makaroun MS. Improving aneurysm-related outcomes: nationwide benefits of endovascular repair. J Vasc Surg 2006;43:446-51.
4. Dillavou ED, Muluk SC, Makaroun MS. A decade of change in abdominal aortic aneurysm repair in the United States: Have we improved outcomes equally between men and women? J Vasc Surg 2006;43:230-8.
5. Brewster DC, Jones JE, Chung TK, LaMuraglia GM, Kwolek CJ, Watkins MT, et al. Long-term outcomes after endovascular abdominal aortic aneurysm repair: the first decade. Ann Surg 2006;244:426-38.
6. Endovascular aneurysm repair versus open repair in patients with abdominal aortic aneurysm (EVAR trial 1): randomised controlled trial. Lancet 2005;365:2179-86.

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*Additional material for this article may be found online at www.jvascsurg.org.*

**Appendix, online only**

**Search Strategy:**
*The Cochrane Library (All databases up to Issue 1, 2009)*

#1 (aneurysm) and (abdominal) and (aortic)
#2 (access) and (cannulat*)
#3 (endovascular)
#4 (#1 AND #2 AND #3)
#5 (iliac artery) or (iliac bifurcation) or (aortic anatomy)
#6 (#2 AND #5)

*EMBASE (1980 to 2009 Week 14)*

#1 exp Aortic Aneurysm, Abdominal/or Aneurysm/or aneurysm.mp.
#2 cannulat*.mp.
#3 1 and 2
#4 exp Aortic Aneurysm, Abdominal/or endovascular repair.mp. or exp Vascular Surgical Procedures/or exp Stents
#5 3 and 4
#6 exp Stents/or exp Iliac Artery/or exp Aorta, Abdominal
#7 5 and 6

*Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) (1950 to Present)*

#1 exp Aortic Aneurysm, Abdominal/or Aneurysm/or aneurysm.mp. (83149)
#2 cannulat*.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (14035)
#3 1 and 2 (537)
#4 exp Aortic Aneurysm, Abdominal/or endovascular repair.mp. or exp Vascular Surgical Procedures/or exp Stents/(114222)
#5 3 and 4 (171)
#6 exp Stents/or exp Iliac Artery/or exp Aorta, Abdominal/(56459)
#7 5 and 6 (30)
#8 limit 7 to (English language and humans) (27)

*CINAHL*

#1 TX aneurysm and TX abdominal and TX aortic
#2 TX cannulat*
#3 TX access
#4 (TX access) and (S2 and S3)
#5 ("endovascular repair") or (MH "Grafts")
#6 (("endovascular repair") or (MH "Grafts")) and (S1 and S5)
#7 ((("endovascular repair") or (MH "Grafts")) and (S1 and S5)) and (S4 and S6)
#8 TX iliac artery and TX iliac bifurcation
#9 (TX iliac artery and TX iliac bifurcation) and (S4 and S8)