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Residual Infrarenal Aortic Neck following Endovascular and Open Aneurysm Repair

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ABSTRACT

Background: The effectiveness of open and endovascular aneurysm repair of aortic abdominal aneurysms (AAAs) can be jeopardised by deterioration of the residual infrarenal neck of the aneurysm.
Objective: The study aims to determine the length of the residual infrarenal aortic segment after endovascular and open aneurysm repair.
Methods: In a multicentre randomised controlled trial comparing open and endovascular AAA repair, 165 patients were discharged after open AAA repair (OR) and 169 after endovascular repair (EVAR). Immediately after the operation, surgeons were asked to enter in the case record form whether the level of their anastomosis after open repair was within or beyond 10 mm of the caudal renal artery. Postoperative computed tomography (CT) scans that were obtained within 6 months after surgery were used for comparative analysis. The distance between the caudal renal artery and the proximal anastomosis of the (endo-) graft was measured using axial CT slices and a standardised protocol. CT images were available and suitable for analysis in 156 (95%) of 165 OR patients and in 160 (95%) of 169 EVAR patients. Data are presented as median (range). Differences were analysed using the Mann–Whitney test.
Results: The distance from the caudal renal artery to the proximal anastomosis was 24 mm (16–30 mm) in the OR group versus 0 mm (0–6 mm) in the EVAR group ($p < 0.0001$, Mann–Whitney). In 140 of 156 (90%) patients, at least 1 cm of untreated infrarenal neck persisted after OR and in 17 of 160 (10%) after EVAR. In 84 of the 156 open repair patients (54%), the surgeon had indicated that the proximal anastomosis was within 10 mm of the caudal renal artery. Only five surgeons (6%) were accurate in this respect.
Conclusion: After open repair, a longer segment of the infrarenal aortic neck is left untreated compared with endovascular repair and this length is underestimated by most surgeons. Long-term studies are required to determine the consequences of this difference.

While the effectiveness of open (OR) and endovascular aortic abdominal aneurysm (AAA) repair can be jeopardised by postoperative changes of the residual infrarenal neck,[1–5] the long-term clinical significance of aortic neck dilatation is still subject to debate.[2,3,6]

In theory, endovascular aneurysm repair (EVAR) allows an (endovascular) anastomosis closer to the renal arteries than after open repair because no infrarenal clamp is required. This leaves a shorter untreated infrarenal segment *in situ* (or none at all) after EVAR as opposed to a residual (clamped) segment after open repair. It has been demonstrated that the infrarenal aorta can dilate after aneurysm repair. This accounts for both the untreated residual infrarenal segment after open repair[7–16] and the endovascular infrarenal sealing zone after EVAR.[1,4,6,17–21]

Especially, when choosing between open and EVAR in relatively young and good-risk patients, durability of EVAR is of utmost importance. It is currently unknown how much residual infrarenal aorta is left *in situ* after open repair in patients who are suitable for EVAR. The objective of this study was to determine the length of the residual untreated infrarenal segment after EVAR and OR in a randomised trial.

Patients and Methods

In the Dutch Randomised Endovascular Aneurysm Management (DREAM) trial, patients suitable for both treatments are randomly allocated to EVAR or OR. The study design has been described

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[d] For the DREAM trial participants (The members of the Dutch Randomised Endovascular Aneurysm Management (DREAM) trial group are listed in Appendix).

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elsewhere.[22] In brief, patients referred to surgery clinics at 24 centres in the Netherlands and four centres in Belgium, who had received a diagnosis of an AAA of at least 5 cm in diameter and who were considered suitable candidates for both techniques, were randomly assigned to undergo OR or EVAR after giving written informed consent. A patient's suitability for EVAR was primarily determined by means of endograft-dependent anatomical criteria. A patient's suitability for open repair was determined by an internist or a cardiologist. Patients who needed to undergo emergency aneurysm repair were excluded from the study, as were patients with inflammatory aneurysms, anatomical variations, connective tissue disease, a history of organ transplantations or a life expectancy of less than 2 years. The study was performed according to the principles of the Declaration of Helsinki, and the institutional board of each participating hospital approved the protocol. The exposure and aneurysm repair technique used for open repair was at the surgeon's discretion. The intended position of the endovascular or conventional graft was directly beneath the lowest renal artery. Computed tomography (CT) scans were obtained within 6 months after surgery.

A standardised protocol was applied to assess the quality of the CT images: for instance, the CT-table position in mm was required. All CT images, on conventional film or in digital format, were reviewed to measure the residual infrarenal neck. Intra-observer variability tends to be smaller than inter-observer variability.[23] Therefore, all data were measured by one physician. In case the level of the anastomosis was not obvious, a second measurement was obtained by another physician, blinded to the first measurement, to arrive at a mean value. Both physicians were well experienced in measuring aortic dimensions from computed tomography angiography (CTA) scans in EVAR patients. The distance between the caudal renal artery and the proximal anastomosis was measured using axial CT slices.

Subsequently, the obtained lengths of the residual infrarenal aorta were categorised into six classes (0–5, 6–10, 11–15, 16–20, 21–25, >25 mm).

Immediately after the operation, surgeons were asked to enter in the case record form whether the level of their anastomosis after open repair was within or beyond 10 mm of the caudal renal artery. All surgeons were well experienced in performing vascular and endovascular surgery; however, their self-assessment skills were unknown.

Differences between treatment groups were evaluated with the use of the Mann–Whitney *U* test for continuous variables and Fisher's exact test for proportions. All reported *p*-values are two-sided and are not adjusted for multiple testing.

Results

Between November 2000 and December 2003, 351 patients were randomly assigned to undergo either OR or EVAR. Of the 351 randomised patients, six patients did not undergo surgery (four declined and two died preoperatively). During the first part of the trial, 10 patients died in the hospital after surgery. A total of 165 patients were discharged after open AAA repair (OR) and 169 after EVAR. Seven patients died within the first year, while four patients had renal dysfunction and did not undergo CT within the first 6 months after aneurysm repair. One CT was not performed with intravenously contrast. Two CTs lacked slice thickness. One CT was damaged, and three patients did not receive CT for unknown reasons.

Therefore, CT images were available and suitable for analysis in 156 of 165 (95%) OR patients and in 160 of 169 (95%) EVAR patients. There were no differences in baseline characteristics (age, gender and mean aneurysm size) between EVAR and OR (Table 1). The SVS/ISCVS risk factor score did not differ significantly except for tobacco use.

Table 1
Baseline characteristics.

	OR (156)	EVAR (160)	*p*-value
Age-yr	69 ± 6.6	70 ± 6.7	0.13
Male sex –no. (%)	141 (90%)	149 (93%)	0.38
SVS/ISCVS risk factor score (%moderate or severe)			
Diabetes Mellitus	16 (10%)	15 (9%)	0.83
Tobacco Use	80 (52%)	102 (64%)	0.02
Hypertension	85 (54%)	93 (58%)	0.51
Cardiac Disease	69 (44%)	65 (41%)	0.75
Renal Disease	12 (8%)	12 (8%)	0.59
Maximum diameter-mm (Mean ± SD)	60.3 ± 8.6	60.6 ± 8.9	0.95

Fig. 1 shows the lengths of the infrarenal segment after OR and EVAR. The median distance from the caudal renal artery to the proximal anastomosis was 24 mm (interquartile (IQ) range = 16–30 mm) in the OR group and 0 mm (IQ range = 0–6 mm) in the EVAR group ($p < 0.0001$, Mann–Whitney). The distances as categorised into six length classes are depicted in Table 2. In 140 of 156 (90%) patients, at least 1 cm of untreated infrarenal neck persisted after OR and in 17 of 160 (10%) after EVAR.

In 84 of the 156 patients (54%), the surgeon had indicated the proximal anastomosis was within 10 mm of the caudal renal artery. Only five surgeons (6%) were accurate in this respect. Of the 94% surgeons whose estimation had been incorrect, the median distance of their anastomosis to the renal artery was 23 mm (IQ range 16–28 mm).

Of the 72 surgeons who had indicated that their proximal anastomosis was not within 10 mm of the caudal renal artery, 69 (96%) were correct. The median distance of their anastomosis to the renal artery was 30 mm (IQ range 20–36).

In the OR group, about one-fourth of the patients at risk 5 years after randomisation had a CT scan; of these 34 patients, two (5.8%) had a para-anastomotic aneurysm.

Discussion

This is the first study to compare the length of the remaining, untreated infrarenal neck after EVAR and OR in a randomised controlled trial. This study demonstrates that after OR a longer segment of infrarenal neck is left untreated than after EVAR. This length is underestimated by most surgeons and could have a negative impact on the long-term durability of OR.

Conversely, endoleak and endograft migration can occur after EVAR particularly with continuing dilatation of the infrarenal aortic neck.[1,4,5,17,20]

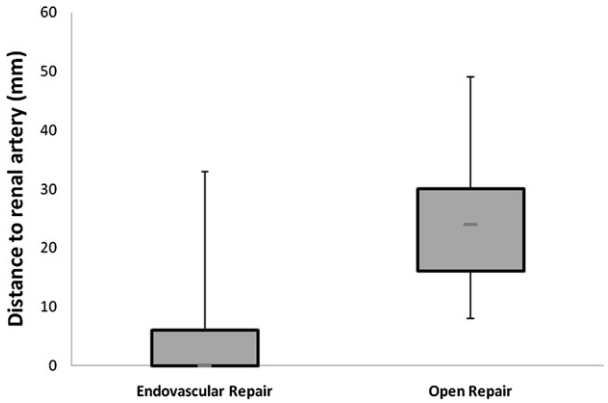

Figure 1. Median distance from caudal renal artery to proximal anastomosis of the graft displayed with boxplots. Boxes are displayed as interquartile ranges and error bars are minimum and maximum values.

Table 2
Length of the residual infrarenal aorta.

Categories according to distances (mm)	OR (N)	EVAR (N)
0–5	6 (4%)	116 (73%)
6–10	10 (6%)	27 (17%)
11–15	18 (12%)	10 (6%)
16–20	28 (18%)	3 (2%)
21–25	37 (24%)	4 (3%)
>25	57 (37%)	0
Total	156	160

Both aorto-enteric fistulas and para-anastomotic aneurysms are complications of open aortic surgery. Several strategies to deal with these complications are associated with high morbidity and mortality.[12,24]

Considering increase of life expectancy and the ongoing discussion on whether or not to treat young and low-risk patients with EVAR, long-term durability is of utmost importance.

Long-term follow-up of the infrarenal aortic neck after open aneurysm repair shows a dilatation of 0.5 mm annually.[8,9,14] This dilatation may jeopardise long-term results of both open and endovascular abdominal aortic aneurysm repair. To identify patients at risk of developing proximal neck dilatation, several predictive risk factors have been shown. Patients with large aortic aneurysm necks, large abdominal aneurysms or circumferential aortic neck thrombus are prone to develop aortic neck enlargement after EVAR of the infrarenal AAA.[25]

Traditional teaching of OR dictates creation of the proximal anastomosis immediately distal to the renal arteries; however, this objective can only be achieved using suprarenal clamping. Theoretically, this technique uses the best quality wall (pararenal), and it would prevent long-term complications from continued aneurysmal dilatation of the infrarenal aorta. This study proves it is difficult for a surgeon to assess the correct position of the graft; only 6% of the 84 surgeons were correct in their estimation of whether the graft was within 10 mm of the caudal renal artery.

Our study consists of a unique set of patients with long infrarenal necks as they were all considered suitable for EVAR. One might argue that current OR patients all lack a suitable neck and that juxtarenal aneurysm repair is more appropriate in these patients. Our study does indicate that the placement of an infrarenal neck leaves at least 1 cm of native aorta *in situ*, prone to further dilatation.

Other studies indicate that drug treatment might play an essential role in developing AAA and thus might have the potential to attenuate or slow the process of aortic neck dilatation as well.[26,27]

In the OR group, about one-fourth of the patients at risk 5 years after randomisation had a CT scan; of these 34 patients, two (5.8%) had a para-anastomotic aneurysm. In future study designs comparing EVAR to OR of AAAs, long-term CT scan follow-up is warranted.

Conclusion

After open repair, a longer segment of the infrarenal aortic neck is left untreated compared with EVAR, and the length of this segment is underestimated by most surgeons. Whether this underestimation results in more long-term problems at the proximal aortic neck is subject to further study.

Appendix. DREAM Trial Participants

Steering Committee: D.E. Grobbee, J.D. Blankensteijn, A.A.A. Bak, J. Buth, P.M. Pattynama, E.L.G. Verhoeven, A.E. van Voorthuisen; *Executive and Writing Committee:* J.D. Blankensteijn, R. Balm, J. Buth, P.W.M. Cuypers, D.E. Grobbee, M. Prinssen, M.R.H.M. van Sambeek, E.L.G Verhoeven, A.F. Baas; *Data-Monitoring and Ethics Committee:* M.G. Hunink, J.M. van Engelshoven, M.J.H.M. Jacobs, B.A.J.M de Mol; *Site and Device-Selection Committee:* J.H. van Bockel, R. Balm, J. Reekers, X. Tielbeek, E.L.G. Verhoeven, W. Wisselink; *Data Management:* N. Boekema, L.M. Heuveling I Sikking; *Outcome Adjudication Committee:* M. Prinssen, R. Balm, J.D. Blankensteijn, J. Buth, P.W.M. Cuypers, M.R.H.M. van Sambeek, E.L.G. Verhoeven; *Data Analysis:* J.L. de Bruin, A.F. Baas, J.D. Blankensteijn, M.Prinssen; *Clinical Centers (the number of randomised patients is given in parentheses):* **the Netherlands**: *Catharina Hospital, Eindhoven (94)* — J. Buth, A.V. Tielbeek; *University Medical Center, Utrecht (35)* — J.D. Blankensteijn; *Academic Medical Center, Amsterdam (32)* — R. Balm, J.A. Reekers; *Erasmus Medical Center, Rotterdam (30)* — M.R.H.M. van Sambeek, P. Pattynama; *University Hospital, Groningen (27)* — E.L.G. Verhoeven, T. Prins; *St. Franciscus Gasthuis, Rotterdam (27)* — A.C. van der Ham, J.J.I.M. van der Velden; *Rijnstate Hospital, Arnhem (14)* — S.M.M. van Sterkenburg, G.B. ten Haken; *Leyenburg Hospital, 's-Gravenhage (9)* — C.M.A. Bruijninckx, H. van Overhagen; *Albert Schweitzer Hospital, Dordrecht (8)* — R.P. Tutein Nolthenius, T.R. Hendriksz; *Atrium Medical Center, Heerlen (8)* — J.A.W. Teijink, H.F. Odink; *Medical Center Rijnmond Zuid, Rotterdam (7)* — A.A.E.A. de Smet, D. Vroegindeweij; *Jeroen Bosch Hospital, den Bosch (7)* — R.M.M. van Loenhout, M.J. Rutten; *St. Elisabeth Hospital, Tilburg (5)* — J.F. Hamming, L.E.H. Lampmann; *Maxima Medical Center, Veldhoven (5)* — M.H.M. Bender, H. Pasmans; *Onze Lieve Vrouwe Gasthuis, Amsterdam (5)* — A.C. Vahl, C. de Vries; *Meander Medical Center, Amersfoort (4)* — A.J.C. Mackaay; *Vlietland Hospital, Schiedam (4)* — L.M.C. van Dortmont; *University Medical Center, Nijmegen (4)* — A.J. van der Vliet, L.J. Schultze Kool; *Martini Hospital, Groningen (3)* — J.H.B. Boomsma, H.R. van Dop; *Medical Center Haaglanden, 's-Gravenhage (3)* — J.C.A. de Mol van Otterloo, T.P.W. de Rooij; *Hospital Bernhoven, Oss (3)* — T.M. Smits; *Oosterschelde Hospital, Goes (3)* — E.N. Yilmaz; *Vrije Universiteit Medical Center, Amsterdam (2)* — W. Wisselink, F.G. van den Berg; *Leiden University Medical Center, Leiden (1)* — M.J.T. Visser, E. van der Linden; *University Medical Center, Maastricht (1)* — G.W.H. Schurink, M. de Haan; *Bronovo Hospital, 's-Gravenhage (1)* — H.J. Smeets; **Belgium**: *St. Jozef Hospital, Turnhout (4)* — P. Stabel; *St. Trudo Hospital, St. Truiden (3)* — F. van Elst; *University Hospital, Antwerp (1)* — J. Poniewierski; *University Medical Center, Gent (1)* — F.E.G. Vermassen.

Conflict of Interest/Funding

None.

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