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Sex Specific Differences in Abdominal Aortic Aneurysm Morphology Based on Fully Automated Volume Segmented Imaging: A Multicentre Cohort Study and Propensity Score Matched Analysis

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Odd: Sex Specific Differences in Aortic Aneurysm Morphology: A Multicentre Cohort Study

Even: Michal Kawka *et al.*

WHAT THIS PAPER ADDS

This study provides the most comprehensive matched analysis to date of sex specific differences in abdominal aortic aneurysm (AAA) morphology using a fully automated volume segmentation (FAVS) methodology. It demonstrates that women consistently present with more hostile vascular anatomy; shorter, narrower, and more angulated necks and smaller access vessels, even after adjusting for body size and cardiovascular risk. These anatomical disparities significantly reduce endovascular repair suitability. By offering high throughput, reproducible anatomical assessment, FAVS can inform future device development and personalised pre-operative planning, ultimately supporting more equitable care and improved outcomes for women undergoing AAA repair.

Objective: Sex specific anatomical differences may contribute to observed disparities in outcomes and suitability for endovascular aneurysm repair (EVAR) between men and women with abdominal aortic aneurysms (AAAs). This study aimed to assess these differences using fully automated volume segmentation (FAVS) and explore implications for EVAR suitability.

Methods: This was a retrospective, multicentre cohort study of patients undergoing elective AAA repair between 2013 and 2023 in three UK tertiary centres. Pre-operative computed tomography scans were analysed using FAVS software. Demographic and clinical outcome data were obtained from the National Vascular Registry. Propensity score matching (1:4 women:men) was performed, adjusting for age, cardiovascular risk, aortic size index (ASI), treatment modality, and centre. Morphological features and device specific likelihood to meet instructions for use (IFU) were compared by sex.

Results: Of 1 455 eligible patients, 145 women were matched to 580 men. Despite similar ASI and cardiovascular risk profiles, women had statistically significantly narrower, shorter, and more angulated aneurysm necks ($p < .001$), smaller visceral and access vessel diameters, and greater thoracic aorta and thrombus index ($p < .050$). However, no statistically significant differences were found in calcification volume or vessel tortuosity. Women were statistically significantly less likely to meet IFU criteria across proximal, distal, and access vessel parameters ($p < .001$).

Conclusion: FAVS offers a scalable approach to pre-operative anatomical assessment and could guide future device design. Even after adjusting for body size and cardiovascular risk, women with AAA exhibit distinct vascular morphology that adversely impacts EVAR suitability. The development of low profile, durable stent grafts and strategies targeting hostile neck anatomy are critical to improving EVAR access and outcomes for women.

Keywords: Abdominal aortic aneurysm, CT, EVAR, Fully automated volume segmentation, Sex differences

INTRODUCTION

Abdominal aortic aneurysm (AAA) morphology impacts both repair strategies and patient outcomes for open and endovascular aneurysm repair (EVAR).[1] In light of this, stent graft manufacturers' EVAR instructions for use (IFU) specify anatomical parameters of the proximal and distal landing zones, and access vessels within which stent grafts are appropriate to use.[2] For both sexes, AAA repair conducted outside stent graft IFU, particularly for the proximal seal zone, is associated with a higher rate of graft related adverse events, including re-intervention, endoleak, sac growth, secondary rupture, limb occlusion, graft migration, and aneurysm related mortality.[3,4] Performing standard EVAR outside IFU may have a greater detrimental effect for women than men, possibly helping to explain the observed sex disparity in AAA repair outcomes.[5] Women are half as likely to meet IFU criteria for EVAR[6–8] and are treated outside IFU twice as often.[9] The fact that a greater proportion of women than men fail to meet IFU criteria at the time of AAA repair is partially explained by sex specific differences in AAA morphology.[6,10]

Operative planning for aortic repair relies on computed tomography angiography (CTA) to evaluate vessel diameter, angulation, thrombus, and calcification burden.[11] Such manual measurements remain prone to substantial inter- and intra-observer variability and are also labour intensive, especially when quantifying thrombus burden on every slice.[12] In contrast, fully automated volume segmentation (FAVS) techniques have demonstrated rapid, reproducible, and accurate measurement of diameters and volumes on CT and magnetic resonance imaging. FAVS utilises computational neural networks and has previously been used in oncology, ophthalmology, and gastroenterology, amongst others.[13] FAVS has recently gained interest in the vascular community and has already been successfully applied to tracking sac regression after EVAR, as well as providing volumetric quantification of thrombus.[14–16] It is reproducible, with similar results to standard semi-automated measurement techniques, and is less time consuming. FAVS could help clarify sex based anatomical differences and identify whether these are independent of differences in cardiovascular risk factors and underlying anatomical variation in size between men and women. FAVS could also enable individualised care pathways (through assessment of neck morphology, iliac vessel size, and access route suitability) and assist in decision-making for AAA repair by leveraging automated three dimensional (3D) reconstructions, which are crucial considerations highlighted in the 2024 European Society for Vascular Surgery (ESVS) AAA guidelines.[17]

The primary aim of this study was to use FAVS of CTA imaging to investigate sex specific anatomical differences in AAA morphology, when adjusting for aortic size index (ASI), severity of cardiovascular disease, risk factors, and medication. The secondary aim was to evaluate the sex specific differences in the proportion of aneurysms that would have met IFU criteria across a range of EVAR devices commonly used in the UK.

METHODS

Study design and setting

This was an observational, retrospective cohort study conducted in three UK tertiary vascular centres. All adult patients aged > 50 years and receiving primary open or EVAR for intact (elective or non-ruptured, symptomatic) infrarenal or juxtarenal AAA at participating centres from 1 January 2013 to 1 July 2023 were included. Juxtarenal AAA was defined as an aneurysm with neck < 4 mm, according to the ESVS definition.[17] Pre-operative CT imaging was extracted from participating centres. Patient demographic information, comorbid status, and indication for surgery were obtained locally from contemporaneously collected UK National Vascular Registry (NVR) records. Pre-existing variables are defined within the UK

NVR data dictionary (https://www.vsqip.org.uk/resource/nvr-data-dictionary/; accessed 14 March 2025) and the OPCS Classification of Interventions and Procedures (OPCS-4) (https://classbrowser.nhs.uk/#/book/OPCS-4.10; accessed 14 March 2025). Exclusion criteria were: (1) insufficient CT imaging quality to enable automated segmentation (> 1 mm slices) or lack of CT imaging within 1 year of operation; (2) ruptured aneurysm, aorto-iliac occlusive disease as an indication for treatment, penetrating aortic ulcer, dissection, or suprarenal AAA; (3) secondary AAA repair; and (4) patients with insufficient clinical data to enable risk stratification (e.g., lack of data regarding comorbid status).

Derived variables for this study included: ASI = AAA diameter/body surface area (cm/m^2); and adherence to IFU parameters for the AAA neck (proximal landing zone), common iliac artery (CIA) (distal landing zone), and external iliac artery (EIA) measurements (access vasculature) for each approved stent graft on the market (Supplementary Table S1). Since NVR data do not include details of device use, assessment of IFU adherence of the specific graft implanted was not possible. Instead, 14 commonly used devices were selected, and each of the scans was assessed for manufacturer's IFUs on a device by device basis, regardless of the repair received in real life. This was automatically performed using code prepared in R, which compared specific components of IFU criteria of each stent graft with measurements generated via FAVS. Following this, parameters were grouped into the three categories, as above, to allow for granular assessment of vessel specific sites of where deviations from IFU occurred. Assessment of validity and correction and or completion of missing clinical data fields were locally performed by a member of the direct care team during clinical data extraction and pseudonymisation. Pseudonymisation included removal of identifiable data from DICOM (Digital Imaging and Communications in Medicine) files prior to transfer for FAVS, with local care teams maintaining a secure key, allowing clinical outcomes to be matched with imaging data.

Fully automatic segmentation software was provided by PRAEVAorta (Nurea; https://nurea-soft.com/; accessed 14 March 2025), which has received CE (European Conformity) marking (class IIb). A sample output of the software can be seen in Figure 1. Use of PRAEVAorta for FAVS has been shown to be fast and reproducible for evaluation of the infrarenal aorta. It has been validated on external datasets using both pre- and post-operative CTA, and has been shown to have a Dice similarity coefficient > 0.90 between the software and semi-automatic segmentations.[15,16] No manual measurements were conducted; all measurements used were those generated via FAVS. Quality assurance for automatic imaging segmentation was conducted in three stages by members of the research team, who are vascular specialists. Firstly, pre-operative scans were assessed to confirm aneurysm extent and intact pre-operative status. Secondly, each 3D reconstruction was also visually inspected to ensure accurate identification of the aorta, access vessels, and visceral branches as part of segmentation quality control. Lastly, missing measurement data and outlying values were assessed, with subsequent exclusion of cases that demonstrated failure of adequate segmentation (> 10% of missing data fields) and inaccurate neck or access vessel identification.

Outcome measures

Primary outcome measures were vascular morphology: neck morphology (e.g., diameter, length, suprarenal angle, infrarenal angle); and visceral (renal, coeliac, and superior mesenteric artery) and access vessel diameters (CIAs, internal iliac arteries, EIAs). Additionally, tortuosity index, calcification volume, wall thrombus index, and thrombus volume were measured for all abovementioned vessels and the neck. Wall thrombus index was calculated as a proportion of thrombus volume compared with total volume of the vessel at the level measured. Finally, maximum CIA stenosis was measured. Diameters were taken as outer to outer wall measurements, unless stated otherwise, for selected variables (e.g., lumen diameter). Secondary outcomes included within IFU for proximal landing zone, distal landing zone, and vascular access.

Statistical analysis

Data are presented as median with interquartile range (IQR) or number (%). Statistical analyses were conducted using R statistical software version 4.2.3 (R Foundation for Statistical Computing, Vienna, Austria). A list of packages and detailed statistical analysis can be found in Supplementary Table S2. In brief, missing data patterns were explored with assessment of the associations between missing variables, patient sex, and repair modality.[18,19] Clinical variables with insufficient data quality (defined as > 25% missing data) were excluded from further analyses. Imputation of missing data was performed using a k nearest neighbours approach with comparison of original and imputed data.[20,21] Nearest neighbour propensity score matching was then used to enable adjusted sex comparison for thrombus burden and vascular morphology.[22] Following matching, quality was confirmed through examination of covariate balance.[21,23] Distributions of propensity scores were also compared for women and unmatched and matched men. Standard parametric and non-parametric testing was then used to assess for sex differences in the pre-specified variables of interest, with a p value of $< .05$ considered statistically significant. Pre-planned sensitivity analysis for EVAR only cases was conducted for IFU compliance. *Post hoc* sensitivity analysis for infrarenal AAA cases was also conducted to assess anatomical differences.

Regulatory aspects and ethical approval

The project was approved by the Health Research Authority (HRA) and Health and Care Research Wales (HCRW) (IRAS: 292985, REC: 21/HRA/0498) and was sponsored by Imperial College London (UK). Data processing agreements and research services agreement were agreed by Nurea (company number RCS Bordeaux 841437411 00017, France) and Imperial College of Science, Technology and Medicine, who acted as sponsor for the study. DICOM data were pseudonymised by local care teams through removal of patient identifiable/personal metadata and replacement with a study identification number. All data for the project were securely stored on a password protected, General Data Protection Regulation compliant, secure cloud server owned by Imperial College London, or on encrypted hard drives stored in a locked location at Imperial College London. Pseudonymised DICOM data were securely transferred to Nurea's server for FAVS, following which an output report was created and DICOM data were deleted. Nurea was not party to any identifiable, sensitive, or personal data. This study was conducted according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) and REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) guidelines for observational studies (Supplementary Table S3).[24,25]

RESULTS

Demographics, risk factors, and nearest neighbour propensity score matching

A total of 2 001 patients were initially screened for eligibility, with 1 655 being eligible prior to image segmentation. An additional 200 cases did not have imaging with sufficient quality for segmentation and were excluded (all of which had > 10% missing data). A total of 1 455 patients at the three centres met all inclusion criteria and had CTA imaging of sufficient quality for analysis. Of these, 452 patients (40 women and 412 men) underwent open repair and 1 003 patients (105 women and 898 men) underwent EVAR (Fig. 2). The proportion of juxtarenal AAA amongst men (59/1 310, 4.5%) and women (6/145, 4.1%) was comparable ($p = .84$).

Prior to matching, women were older (median age 76.30 years [IQR 70.90, 81.60] *vs.* 74.30 years [IQR 69.00, 79.80]; $p = .017$), were less likely to have ischaemic heart disease (24.1% [35/145] *vs.* 33.1% (433/1 310); $p = .037$), were more likely to have chronic obstructive pulmonary disease (37.9% [55/143] *vs.* 23.6% [309/1 310]; $p < .001$), were more likely to be a current smoker (27.1% [39/145] *vs.* 20.4% [267/1 310]; $p = .025$), and were less likely to be on a statin at the time of repair (71.7% [104/145] *vs.* 80.7% [1 057/1 310]; $p = .015$).

On average, women had smaller AAA diameters (median 59.89 mm [IQR 53.75, 64.39] *vs.* 62.89 mm [IQR 59.25, 68.84]; $p = .001$), but a larger ASI (median 3.29 [IQR 2.91, 3.80] *vs.* 3.11 [IQR 2.82, 3.56]; $p = .004$), and were more often coded as a symptomatic AAA (13.3% [19/145) *vs.* 6.3% [82/1 310]; $p = .030$). Following matching (145 women:580 men), the standardised mean difference was < 0.1 for all covariates of interest (Supplementary Fig. S1).

Assessment of sex difference in vascular morphology using fully automatic volume segmentation

Women with an AAA had narrower, shorter, more angulated necks ($p < .001$). Mean vessel diameters were consistently smaller for visceral branches, access vasculature, and internal iliac arteries ($p < .001$). Women were not observed to have a statistically significantly greater CIA stenosis percentage, and there was no statistically significant evidence of increased vessel tortuosity for women, but rather a suggestion that men may have slightly more tortuous access vasculature. Overall calcification volumes were also not statistically significantly different for women and men. Findings were consistent in cohorts matched using ASI and within unmatched cohorts (Table 1; Supplementary Table S4). These findings were consistent when juxtarenal AAAs were removed on *post hoc* sensitivity analysis (Supplementary Table S5).

Women also had a statistically significantly greater wall thrombus burden index within the thoracic aorta (4.91 [IQR 3.68, 7.98] *vs.* 4.42 [IQR 2.93, 7.44]; $p = .029$) and coeliac artery (6.06 [IQR 3.11, 11.05] *vs.* 4.55 [1.89, 8.34]; $p < .001$), despite consistently lower thrombus volumes compared with men overall (Table 2). There were no statistically significant differences between thrombus wall index in the remaining vessels analysed. Findings were consistent when cohorts were matched using ASI and within unmatched cohorts (Table 2; Supplementary Table S6).

Assessment of sex difference in instructions for use using fully automatic volume segmentation

Women were statistically significantly less likely to meet stent graft IFU for proximal landing zones, distal landing zones, and access vessel diameters ($p < .001$) (Table 3). The difference was most pronounced for proximal seal zone (i.e., neck) and access vessels, whilst the absolute differences were small for distal seal zone (Fig. 3). This was consistent on sensitivity analysis selecting for cases that underwent EVAR (n = 1 003) (Supplementary Table S7).

DISCUSSION

After accounting for cardiovascular risk factors and normalising for ASI, the abdominal aneurysm necks of women remained more angulated and shorter. This, combined with smaller access vessels, meant that fewer of them met official device IFU. This finding concurs with previously published Vascular Quality Initiative data[26,27] and also reinforce the ESVS 2024 guidelines call for individualised care pathways and highlight the need for sex specific thresholds in decision-making for AAA, supporting the recommendation to consider sex as a critical modifier in surveillance and treatment planning.[17] Therefore, developing devices or techniques that address hostile neck anatomy could expand EVAR eligibility for women and improve their outcomes following repair.[26] Such innovations would likely also benefit non-Caucasian ethnic groups, who show similarly high rates of hostile necks and the same sex based differences.[28] The use of propensity matching and ASI normalisation in this study showed that these hostile neck features are inherent in women, and not simply secondary to other risk factors.

This study demonstrated that FAVS can be used to enable large scale, comparative assessment of vascular morphology for women and men with AAA. Anatomical parameters were uniformly assessed across all patients and sites, enhancing the reliability of sex based comparisons. Moreover, FAVS successfully evaluated additional features that are impractical to manually measure in large cohorts, notably the total thrombus and calcification volume within the aneurysm sac and along the iliac arteries. These volumetric assessments provide a more nuanced picture of atherosclerotic disease burden than subjective grading. In the future, FAVS with integrated IFU assessment may be leveraged in clinical workflows to assist surgeons by quickly identifying patients who are borderline eligible for EVAR and might need alternative management strategies. In a previously published study, FAVS ranged from

27 seconds to four minutes per patient, compared with five minutes to 80 minutes for manually corrected methods, to generate equally feature rich datasets.[15]

When men and women were matched on all other characteristics, women did not show more atheromatous disease burden (e.g., calcification volume, CIA stenosis) or tortuous vessels than men, contrary to preliminary findings, indicating that sex differences are selective to certain anatomical features. Women had a significantly higher thrombus volume index in the thoracic aorta and coeliac trunk, hinting at potential differences in disease biology that warrant further investigation, which is currently being conducted in this dataset, looking at thromboembolic complication rates. Higher thrombus rate in the thoracic aorta was of particular interest, as aortic thrombus could be dislodged due to wire manipulations during EVAR. Moreover, women were less likely to be on a statin at the time of repair ($p = .015$), potentially suggesting their association with thrombus formation. This may help explain why women face more thromboembolic complications after AAA repair, such as heart, kidney, bowel, or leg ischaemia.[29,30]

Further analyses may benefit from software development to increase accuracy and capabilities. For example, analysis of sex differences in thrombus morphology was limited to volumetric assessment in this study, while further in depth analyses may be complemented by using qualitative scoring mechanisms and quantitative assessment of surface irregularity and thrombus density, fluid dynamics assessment, as well as other thrombo-radiomic texture features.[31,32]

On matched analysis, adjusting for body size and cardiovascular risk factors, access vessels were consistently smaller for women. It is therefore logical that lower profile devices, designed to accommodate smaller vessels with greater flexibility, can increase the proportion of patients suitable for EVAR. This is consistent with the ESVS 2024 guidelines that advocate for the use of newer generation, low profile stent grafts to accommodate challenging iliac anatomy.[17] These are already more frequently used for women and may narrow the sex specific gap in short term outcomes.[27,33,34] However, their long term strength durability remains uncertain, with the Zenith low profile graft having been shown to have a higher rate of conversion to open surgery within 1 year (5% *vs.* 0.31%; $p = .030$).[35] Careful device, continuous device innovation, and follow up therefore remain critical. The lowest profile device analysed had a minimum EIA diameter of 5 mm (corresponding to 15 F); additional analysis of the current data suggested that if a 12 F device existed, it would decrease the percentage of IFU access violation from 29.5% to 8.0%, and if a 9 F device existed, that would result in a further reduction to 3.2% (Supplementary Table S8).

However, low profile devices alone do not resolve the challenge of hostile proximal neck anatomy, which was also significantly more prevalent among women in the current cohort. In such cases, additional adjuncts may be necessary to improve proximal fixation and sealing. For example, endoanchors have demonstrated utility in securing short or angulated necks and may serve as a bridge between standard EVAR and more extensive and or complex solutions.[36] In patients with profoundly hostile neck morphology, fenestrated endovascular aneurysm repair (FEVAR) may offer improved sealing and durability by providing a longer seal zone and precise targeting of visceral branches.[37] However, access to FEVAR is limited in many centres and often delayed due to planning complexity and custom manufacturing of endografts. Alternatively, open surgical repair remains a definitive solution for challenging necks, but it carries a well-documented increased peri-operative risk in women, particularly in terms of early mortality and respiratory complications.[38] This underscores a critical dilemma: whether to accept higher upfront surgical risk or to pursue complex endovascular strategies with long term surveillance burdens. The findings of this study suggest that sex specific anatomical assessment should be central to this decision-making.

Additionally, proactive preparation of the access vessels (via iliac angioplasty or surgical conduits) could help overcome access vessel limitations, especially given the consistent anatomical limitations demonstrated in this cohort, more commonly in women. Evidence from thoracic endovascular aortic repair (TEVAR) and arch device deployment supports the role of aggressive access management to minimise access related complications and improve technical success rates.[39] Extrapolating from this experience, a tailored strategy that includes routine pre-operative access planning and a lower threshold for adjunctive iliac interventions may help overcome sex specific barriers to EVAR and expand endovascular applicability in women without defaulting to open repair. These access modifying strategies, used judiciously, could contribute to more equitable outcomes by offsetting anatomical disadvantage.

In alignment with the UK-COMPASS trial findings, the current study demonstrated that a significant proportion of patients, particularly women, do not meet standard EVAR IFU across a range of commonly used devices.[40] This was especially evident for proximal landing zone and access vessels, which, as discussed above, could promote consideration of alternative or adjunctive management strategies for those aneurysms with hostile anatomy. By applying propensity matching and ASI normalisation, this study showed that these morphological barriers are not merely artefacts of body size but represent inherent anatomical sex differences. This supports the call in UK-COMPASS for reconsideration of IFU thresholds and for more inclusive device designs that reflect the morphological diversity of real world patients.

This study had several limitations. Firstly, although the use of FAVS enabled detailed examination of a large cohort of patients, necessary selection of patients with CTAs of sufficient quality may have incurred some unavoidable bias, which may affect generalisability, although this is unlikely to have affected women and men differently. In addition, it is possible that those with more complex vascular morphology (e.g., severe iliac stenosis) may have failed segmentation, leading to subsequent exclusion from analyses. The software did not allow for more in depth analysis of neck conicity or suprarenal angle, as well as not providing common femoral artery diameter measurements, although this should be enabled in the future as the software is improved. Analyses were further limited by the granularity of clinical data. For example, although NVR data capture is standardised, the paucity of complete records regarding stent graft used, endoleaks, and technical success precluded evaluation of these data; specifically, it was not possible to accurately determine whether women in this cohort were less likely to receive an EVAR within IFU. In addition, the study reported data from three high volume centres with considerable expertise in AAA repair, and so the adverse effect of hostile vascular morphology on AAA repair outcomes may have been mitigated by advanced operative techniques and high quality of care. This analysis did not include patients turned down for repair, of which women present a higher proportion, and so was unable to assess sex differences in the likelihood of receiving EVAR.[6,41]

Conclusion

FAVS can be successfully utilised to investigate sex specific anatomical differences in AAA. Women with AAA exhibit distinct vascular morphology compared with men, despite adjusting for cardiovascular risk factors and normalising for ASI, most notably more angulated, shorter necks and smaller access vessels. Continued development of hostile neck solutions and durable low profile devices is therefore essential to expand EVAR eligibility for women. Furthermore, larger patient cohorts and advances in FAVS software will be critical to unravel how these sex specific anatomical differences influence outcomes after AAA repair, including thromboembolic complications.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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APPENDIX A: SUPPLEMENTARY DATA

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Figure 1. Sample of the output from the PRAEVAorta software, including standard endovascular aneurysm repair (EVAR) measurements and volumetric assessments of select regions of the aorta. A Full 3D reconstruction based on pre-operative computed tomography scan. B Infrarenal aorta segmentation reconstruction and measurements. C Full pre-operative measurement protocol for EVAR planning. D Single region segmentation.

Figure 2. Flow diagram demonstrating patient selection for the study of sex specific differences in abdominal aortic aneurysm (AAA) morphology based on fully automated volume segmentation. CT = computed tomography; EVAR = endovascular aneurysm repair.

Figure 3. Comparison of likelihood of meeting endovascular aneurysm repair (EVAR) instructions for use (IFU) criteria for women and men with abdominal aortic aneurysm following matching for cardiovascular risk factors and aortic size index.

Table 1. Comparison of vascular morphology for women (*n* = 145) and men (*n* = 580) using measurements generated using fully automated volume segmentation following propensity score matching for cardiovascular risk factors and aortic size index.

Measurement	Women (*n* = 145)	Men (*n* = 580)	*p* value
Neck measurements			
Neck diameter – mm	22.55 (20.38, 25.68)	24.64 (22.50, 27.71)	<.001
Maximum neck diameter – mm	27.72 (25.10, 31.97)	30.09 (27.50, 33.98)	<.001
Minimum neck diameter – mm	20.80 (18.97, 23.30)	22.83 (20.71, 25.54)	<.001
Neck length – mm	23.79 (13.79, 33.74)	29.73 (17.67, 41.54)	<.001
Infrarenal neck angle – °	35.72 (27.70, 47.26)	33.57 (25.89, 42.87)	.015
Vessel diameters			
Coeliac artery – mm	6.50 (5.39, 7.35)	7.08 (6.20, 8.07)	<.001
Superior mesenteric artery – mm	5.80 (4.83, 6.72)	6.90 (6.10, 7.74)	<.001
Left renal artery – mm	4.55 (3.71, 5.34)	4.93 (4.25, 5.64)	<.001
Right renal artery – mm	4.13 (3.55, 4.89)	4.68 (4.02, 5.29)	<.001
Left CIA – mm	11.90 (10.33, 13.47)	14.32 (12.73, 17.22)	<.001
Right CIA – mm	12.66 (10.81, 15.58)	14.75 (13.10, 17.43)	<.001
Left EIA – mm	7.35 (6.53, 7.98)	9.18 (8.16, 10.14)	<.001
Right EIA – mm	7.34 (6.46, 7.86)	9.11 (8.11, 10.04)	<.001
Left IIA – mm	6.47 (5.33, 7.96)	7.70 (6.53, 9.11)	<.001
Right IIA – mm	6.77 (5.85, 8.10)	7.77 (6.66, 9.07)	<.001
Maximum CIA stenosis			
Right CIA – %	13.40 (9.63, 20.20)	13.66 (9.95, 18.10)	.61
Left CIA – %	11.21 (7.95, 16.80)	11.34 (8.13, 16.27)	.93
Tortuosity index			
Thoracic aorta	1.19 (1.02, 1.34)	1.21 (1.03, 1.30)	.81
Neck	1.01 (1.00, 1.02)	1.01 (1.00, 1.02)	.47
Coeliac artery	1.04 (1.01, 1.11)	1.04 (1.01, 1.09)	.69
Superior mesenteric artery	1.05 (1.02, 1.10)	1.04 (1.01, 1.08)	.037
Left renal artery	1.11 (1.04, 1.23)	1.09 (1.04, 1.18)	.33
Right renal artery	1.12 (1.06, 1.19)	1.11 (1.06, 1.18)	.093

Infrarenal aorta	1.11 (1.08, 1.16)	1.08 (1.06, 1.12)	<.001
Left CIA	1.07 (1.03, 1.14)	1.08 (1.03, 1.15)	.82
Right CIA	1.05 (1.03, 1.10)	1.07 (1.03, 1.13)	.005
Left EIA	1.12 (1.08, 1.20)	1.16 (1.11, 1.23)	<.001
Right EIA	1.16 (1.10, 1.25)	1.19 (1.12, 1.28)	.010
Left IIA	1.12 (1.06, 1.20)	1.11 (1.06, 1.21)	.92
Right IIA	1.10 (1.05, 1.19)	1.10 (1.04, 1.18)	.34
Calcification volume – cm^3 *			
Neck	0.04 (0.01, 0.17)	0.05 (0.01, 0.21)	.28
Left renal artery	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)	.56
Right renal artery	0.00 (0.00, 0.01)	0.00 (0.00, 0.00)	.015
Left CIA	0.21 (0.09, 0.42)	0.24 (0.09, 0.46)	.32
Right CIA	0.25 (0.10, 0.48)	0.29 (0.11, 0.54)	.20
Left IIA	0.05 (0.00, 0.12)	0.05 (0.00, 0.17)	.29
Right IIA	0.03 (0.00, 0.11)	0.03 (0.00, 0.10)	.90

Data are presented as median (interquartile range). CIA = common iliac artery; EIA = external iliac artery; IIA = internal iliac artery; AAA = abdominal aortic aneurysm.

* Calcification data are presented for vessels where segmentation was successful (i.e., for > 90% of scans).

Table 2. Comparison of wall thrombus index and thrombus volumes using measurements generated using fully automated volume segmentation for women (*n* = 145) and men (*n* = 580) following propensity score matching for cardiovascular risk factors and aortic size index.

Parameter	**Women (*n* = 145)**	**Men (*n* = 580)**	***p* value**
Wall thrombus index			
Thoracic aorta	4.91 (3.68, 7.98)	4.42 (2.93, 7.44)	.029
Visceral aorta	30.02 (21.34, 42.83)	29.70 (19.73, 40.78)	.40
Neck	16.28 (11.71, 20.96)	15.77 (12.11, 21.45)	.68
Coeliac artery	6.06 (3.11, 11.05)	4.55 (1.89, 8.34)	.001
Superior mesenteric artery	4.98 (1.72, 11.08)	4.35 (1.89, 7.72)	.066
Left renal artery	5.96 (2.05, 11.03)	6.80 (2.18, 13.75)	.325
Right renal artery	4.66 (1.51, 8.24)	4.70 (1.44, 10.08)	.90
Infrarenal aorta	49.22 (34.66, 61.76)	49.65 (33.50, 60.79)	.56
Left CIA	22.29 (16.70, 32.66)	22.60 (16.56, 31.01)	.76
Right CIA	25.08 (18.18, 35.22)	24.84 (18.41, 33.80)	.57
Left EIA	7.38 (4.26, 13.52)	7.46 (4.29, 12.67)	.655
Right EIA	8.27 (4.26, 15.23)	8.09 (4.46, 13.20)	.70
Left IIA	15.59 (6.54, 24.91)	15.79 (8.18, 24.36)	.62
Right IIA	12.49 (5.38, 23.14)	12.62 (6.03, 22.32)	.99

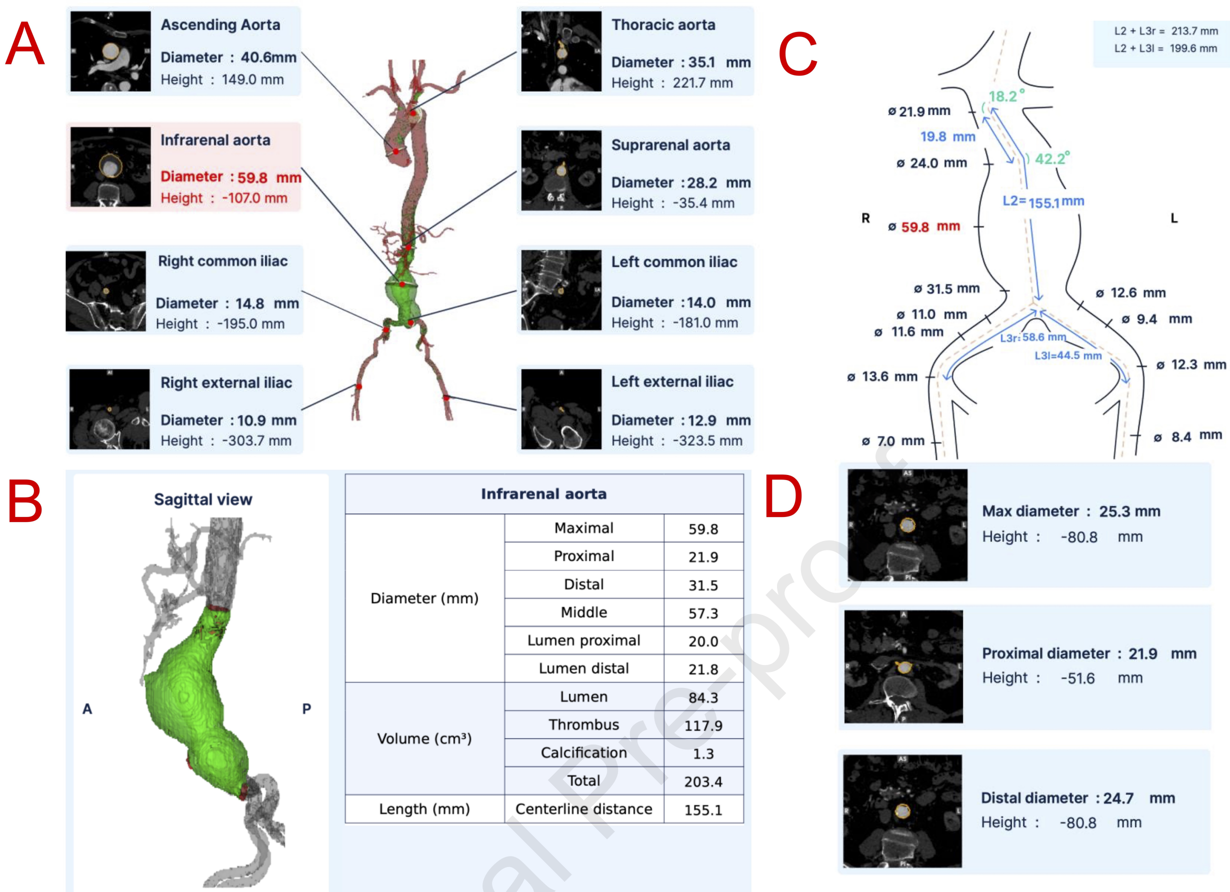
Data presented as median (interquartile range). CIA = common iliac artery; EIA = external iliac artery; IIA = internal iliac artery.

Table 3. Comparison of theoretical adherence to instructions for use (IFU) for commonly available devices for women (*n* = 145) and men (*n* = 580) following propensity score matching for cardiovascular risk factors and aortic size index.

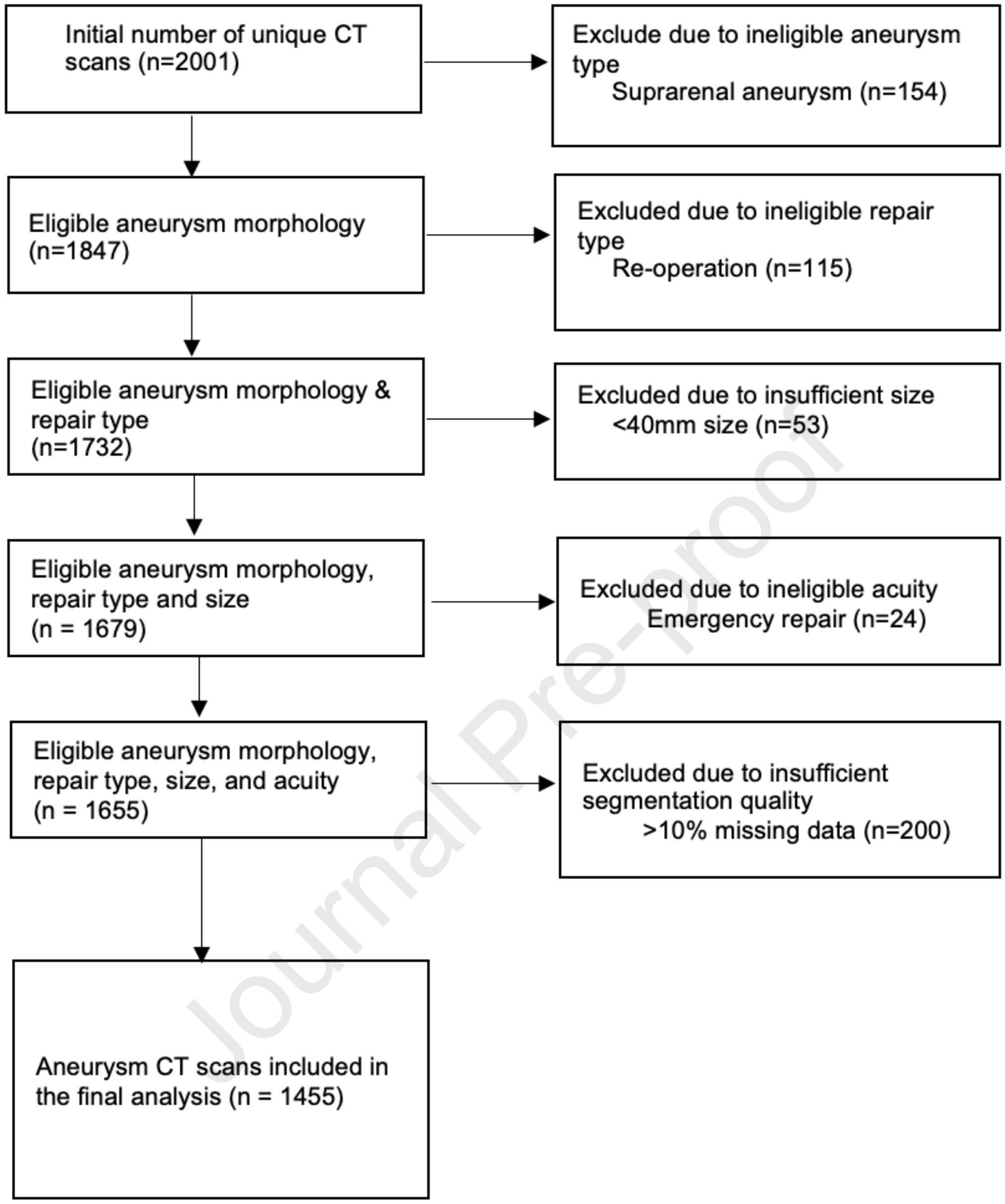
Adherence	**Women (*n* = 145)**	**Men (*n* = 580)**	***p* value**
Within IFU for proximal landing zone			
0 stent grafts	38 (26.2)	104 (17.9)	<.001
1–5 stent grafts	37 (25.5)	134 (23.1)	
6–10 stent grafts	12 (8.3)	39 (6.7)	
≥11 stent grafts	58 (40.0)	303 (52.2)	
Within IFU for distal landing zone			
0 stent grafts	57 (39.3)	225 (38.3)	<.001
1–5 stent grafts	16 (11.0)	93 (16.0)	
6–10 stent grafts	32 (22.1)	104 (17.9)	
≥11 stent grafts	40 (27.6)	158 (27.2)	
Within IFU for vascular access			
0 stent grafts	56 (38.6)	158 (27.2)	<.001
1–5 stent grafts	46 (31.7)	113 (19.5)	
6–10 stent grafts	25 (17.2)	81 (14.0)	
≥11 stent grafts	18 (12.4)	228 (39.3)	

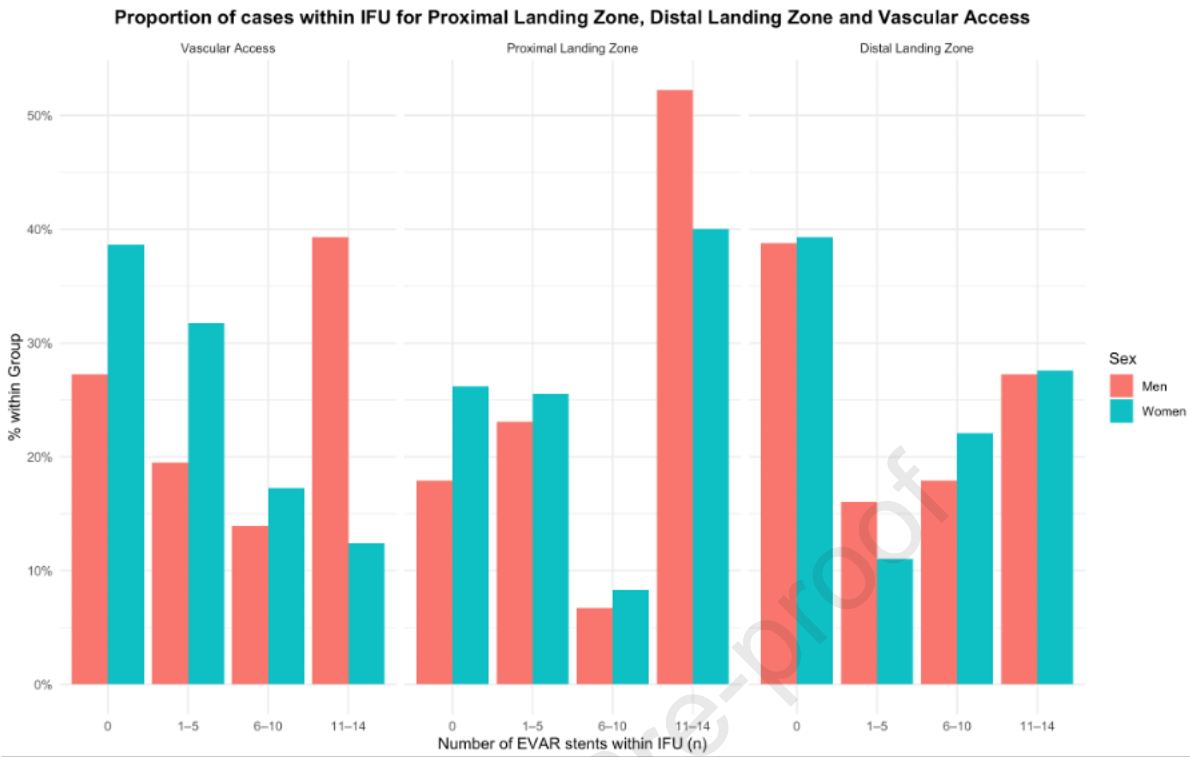
Data are presented as *n* (%). IFU = instructions for use.

Stent graft specifications are presented in Supplementary Table S1.



Infrarenal aorta		
Diameter (mm)	Maximal	59.8
	Proximal	21.9
	Distal	31.5
	Middle	57.3
	Lumen proximal	20.0
	Lumen distal	21.8
Volume (cm³)	Lumen	84.3
	Thrombus	117.9
	Calcification	1.3
	Total	203.4
Length (mm)	Centerline distance	155.1


Initial number of unique CT scans (n=2001)
Exclude due to ineligible aneurysm type
Suprarenal aneurysm (n=154)
Eligible aneurysm morphology (n=1847)
Excluded due to ineligible repair type
Re-operation (n=115)
Eligible aneurysm morphology & repair type (n=1732)
Excluded due to insufficient size
<40mm size (n=53)
Eligible aneurysm morphology, repair type and size (n = 1679)
Excluded due to ineligible acuity
Emergency repair (n=24)
Eligible aneurysm morphology, repair type, size, and acuity (n = 1655)
Excluded due to insufficient segmentation quality
>10% missing data (n=200)
Aneurysm CT scans included in the final analysis (n = 1455)



Proportion of cases within IFU for Proximal Landing Zone, Distal Landing Zone and Vascular Access
Vascular Access
Proximal Landing Zone
Distal Landing Zone
50%
40%
30%
20%
10%
0%
% within Group
0
1–5
6–10
11–14
Number of EVAR stents within IFU (n)
Sex
Men
Women