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Morphological Differences in the Aorto-iliac Segment in AAA Patients of Caucasian and Asian Origin

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WHAT THIS PAPER ADDS

A considerable number of patients with AAA are ineligible for endovascular treatment because of anatomical characteristics. Selection bias presents a significant limitation in studies published on this topic, in particular in terms of aorto-iliac anatomy of the non-Caucasian population. This is the first multicentre study aiming to provide data on morphological vascular differences between Asian and Caucasian populations. It is hoped that it will provide useful data for future stent graft design, thereby increasing the number of patients suitable for EVAR as well as improving the outcome of the procedure.

Objective: The objective was to quantify aorto-iliac morphology differences between AAA patients of Caucasian and Asian origin. Additionally, the impact of patient demographic characteristics was assessed, which could influence the morphological differences.

Methods: This international multicentre study included two tertiary referral institutions from Europe and one from China. CT scans with 3D reconstruction of 296 patients with infrarenal AAA >5 cm were analysed. Eighteen measurements were recorded from each CT scan and compared between Caucasian and Asian patients.

Results: Caucasian patients had longer common iliac arteries (right: 65.0 vs. 33.1 mm, $p < .001$ left: 65.0 vs. 35.2 mm, $p < .001$), longer aneurysm neck (33.0 vs. 28.4 mm, $p < .001$), greater aneurysm to aortic axis angle (153.0° vs. 142.2°, $p < .001$), and longer combined aorto-iliac length (195.7 vs. 189.2 mm, $p < .001$). However, Asian patients had a longer infrarenal abdominal aorta (152.0 vs. 130.0 mm, $p < .001$), longer AAA (126.2 vs. 93.0 mm), and greater linear distance from renal artery to aorto-iliac bifurcation (143.6 vs. 116.0 mm, $p < .001$). Caucasian patients had a larger inner common iliac artery diameter (right: 16.0 vs. 14.9 mm, $p < .001$, left: 16.0 vs. 15.2 mm, $p < .001$), larger inner exernal iliac artery diameter (right: 9.0 vs. 7.5 mm, $p < .001$ left: 9.0 vs. 7.7 mm, $p < .001$), and larger inner common femoral artery diameter (right: 10.0 vs. 5.9 mm, $p < .001$ left: 10.0 vs. 6.1 mm, $p < .001$). No difference was observed in AAA transverse diameter (62.0 vs. 63.1 mm, $p = .492$).

Conclusion: The results showed that aorto-iliac anatomy in Caucasians differs significantly from Asians, particularly in the length of the common iliac arteries and infrarenal abdominal aorta, and in the transverse diameter of the common, external iliac, and common femoral arteries. Therefore, the exact criteria for stent graft design are dependent on the racial origin of the patient.

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INTRODUCTION

Several large randomised clinical trials have shown that endovascular aneurysm repair (EVAR) has significantly reduced peri-operative mortality and morbidity compared with open repair of abdominal aortic aneurysm (AAA).[1–3] Although EVAR is a less invasive procedure, a considerable number of patients with AAA are not eligible for EVAR because of anatomical characteristics.[4] In addition, challenging anatomical features have been shown to be predictive of adverse outcomes in patients treated by EVAR.[5] Selection bias presents a significant limitation in the published studies, particularly in terms of aorto-iliac anatomy of the non-Caucasian population.[6,7] Hence, more anatomical data are necessary to provide sufficient benchmarks for future stent graft design, thereby increasing the number of patients suitable for EVAR as well as improving the outcome of the procedure.

The objective of this study was to quantify aorto-iliac morphology differences between AAA patients of Caucasian and Asian origin using anatomical measurements obtained from high quality CT imaging with 3D reconstruction. In addition, the impact of patient demographic characteristics was assessed, which could influence the investigated inter-racial morphological differences.

MATERIALS AND METHODS

This international multicentre study included two tertiary referral institutions from Europe and one tertiary referral institution from China. The study was conducted with the approval of the local institutional ethics committees. Over a 2 year period (from March 2012 to March 2014), medical records from 296 consecutive patients diagnosed with an infrarenal abdominal aortic aneurysm (AAA) $>$ 5 cm, were obtained and analysed. To avoid selection bias, only pre-operative CT scans were used regardless of later treatment type (open surgery or endovascular treatment). Moreover, for patients with multiple CT scans, only the most recent CT scan before any intervention (in cases in which intervention had occurred) were identified and retained. Each CT scan was reviewed and a pre-specified set of measurements was recorded by three experienced vascular specialists (IB, GO, ZJ). CT examinations were performed using the following imaging modality: GE 64 VCT Lightspeed, helical mode, tube voltage 140–180 KV, tube current 300 mAs, CTDI Vol 14 mGy, rotation time 0.32, pitch 0.7, slice collimation 0.6 mm, acquisition 64 $\times$ 0.625 mm, slice width 1.5 mm in retro-reconstruction (European medical centre 1); GE 64 VCT Lightspeed, helical mode, tube voltage 80–140 KV, tube current 300 mAs, CTDI Vol 14 mGy, rotation time 0.32, pitch 0,7, slice collimation 0.6, acquisition 64 $\times$ 0.625 mm, slice width 1.5 mm in retro-reconstruction (European medical centre 2), SIEMENS 64 VCT Lightspeed, helical mode, tube voltage 120 KV, tube current 140 mAs, CTDI Vol 10.74 mGy, rotation time 0.33s, pitch 1.2, slice collimation 1.0 mm, acquisition 64 $\times$ 0.6 mm, slice width 1 mm in retro-reconstruction (Asian medical centre). Routine 3 dimensional (3D) centre line reconstruction programs (Osirix, 3mensio, Aquarius NET Thin Client, TerRecon Inc) were used for accurate morphological measurement.[8] The intra-observer variability of the measurements was tested by a repeated measurement in 15 randomly selected patients at each medical centre (supplementary material, Supplement 4). Before the study was initiated, a pre-study training course was conducted to test and optimise inter-observer variability. During the training course, several randomly chosen CT scans were presented separately to each investigator. For patient measurements that were inconsistent between investigators, CT images were re-presented, and joint reading was carried out until consensus was reached.

The following 18 measurements were recorded: M1, greatest outer diameter of AAA neck just below the lowest renal artery; M2, greatest inner diameter of AAA neck just below the lowest renal artery; M3, aneurysm neck length; M4, greatest outer diameter of AAA neck just above the aneurysm sac; M5, angle between aneurysm and aortic axis; M6, length of infrarenal abdominal aorta; M7, greatest outer diameter of AAA; M8, linear renal artery to aorto-iliac bifurcation distance; M9, inner diameter of the left common iliac artery (distal landing zone); M10, length of the right common iliac artery; M11, length of the left common iliac artery; M12, inner diameter of the right common iliac artery (distal landing zone); M13, inner diameter of the left external iliac artery; M14, inner diameter of the right external iliac artery; M15, inner diameter of the left common femoral artery; M16, inner diameter of the right common femoral artery. To obtain combined aorto-iliac length (M17), the sum of infrarenal abdominal aortic length (M6) and length of the averaged common iliac artery in each patient (M6+(M10 + M11)/2) was calculated. The averaged common iliac artery length was calculated for each patient from the sum of the length of the left and the right common iliac arteries divided by two. The AAA length (M18) was calculated by subtracting the length of aneurysm neck (M3) from length of infrarenal abdominal aorta (M6) (M18 = M6-M3). Aneurysm neck was defined as the distance between the lower edge of the lowest renal artery and the beginning of the aneurysm sac.[9] When no clear transition between aneurysm neck and aneurysm sac could be defined, the distal end of the neck was defined by aortic diameter change of $>$10%.[10,11] A graphical explanation of the measurements recorded in the study is displayed in Fig. 1.

After obtaining all datasets from investigators, data verification was performed by local data coordinators. The preliminary statistical analysis of datasets collected from two European medical centres did not reveal any variance. Thus, these data were joined and compared with the Asian population in further analysis. The distributions of continuous variables were examined for normality by visual histogram inspection, calculation of the skewness coefficient, and using Kolmogorov–Smirnov test of normality. If the assumption of normality was met, statistically significant differences between Asian and Caucasian patients were evaluated using Student *t* test. However, if the assumption