**Analysis of aortic area/height ratio in patients with**

**thoracic aortic aneurysm and type A dissection**

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**Abstract**

**Objectives:** Significant proportions of aortic dissections occur at aortic diameters <5.5 cm. By indexing aortic area to height and correlating with absolute aortic diameter, we sought to identify those aneurysm patients with aortic diameters <5.5 cm who do not meet current size thresholds for surgery, yet with corresponding abnormal indexed aortic areas >10 cm2/m, are at increased risk of aortic complications.

**Methods:** Indexed aortic areas were calculated at three aortic locations in 187 aneurysm and 66 dissection patients operated between 2010-2016 at our tertiary aortic centre. Proportions of patients with indexed aortic area >10 cm2/m, mean indexed aortic areas corresponding to aortic diameters <4.0 cm, 4.0-4.5 cm, 4.5-5.0 cm, 5.0-5.5 cm and >5.5 cm, and mean aortic diameters corresponding to indexed aortic areas 10-12 cm2/m, 12-14 cm2/m and >14 cm2/m were determined.

**Results:** Proportions of patients with abnormal indexed aortic areas were similar in both groups. 49.1% of aneurysm patients with aortic diameters 4.5-5.0 cm, and 98.5% with aortic diameters 5.0-5.5 cm had abnormal indexed aortic areas. Out of 207 separate aneurysms with indexed aortic areas >10 cm2/m between the mid-sinus and mid-ascending aorta, only 139 (69.5%) would warrant surgery according to existing guidelines.

**Conclusions:** Using the indexed aortic area, we identified a significant proportion of patients with thoracic aortic aneurysms who are at increased risk of aortic complications, despite current aortic guidelines not endorsing surgical intervention in this group. Our data suggests the indexed aortic area may be useful in pre-operative risk evaluation and as a criterion for surgery.

**Keywords:** aneurysm; aortic dissection; aorta

**Introduction**

The aortic cross-sectional area/patient height ratio (πr2/h, cm2/m) has been validated in the stratification of mortality risk in patients with a tricuspid aortic valve and dilated aorta [1]. First proposed by Svensson and colleagues, this indexed measurement accounts for the greater risk of aortic complications associated with larger aortic dimensions in shorter patients, whilst incorporating the exponential risk of dissection or rupture with increasing aortic size [2]. Indexed aortic root area >10 cm2/m has been shown to have significant independent prognostic value in patients with tricuspid aortic valve and concomitant aortopathy, compared to a non-indexed aortic diameter [1]. The same study showed that a significant proportion (44% of 771 patients) with aortic root diameter 4.5 – 5.5 cm had an abnormally high aortic root/height ratio; 78% of patients in this sub-group died, although mortality could not be directly attributed to aortic dissection or rupture [1].

These findings highlight that the cohort of patients with aortic size less than the thresholds mandating surgery in current established guidelines, and in whom the cross-sectional aortic area/height ratio exceeds 10 cm2/m, represents an opportunity for early, proactive intervention to prevent potentially fatal aortic dissection. This strategy would theoretically prevent 95% of acute aortic dissections in a Marfan population [2].

The relationship between aortic diameter and indexed cross-sectional aortic area has not been fully ascertained in patients presenting with isolated thoracic aortic aneurysms and those with acute type A aortic dissection. In this study, we sought to determine (i) the indexed aortic area (IAA) in patients with thoracic aortic aneurysms and acute type A aortic dissection at different aortic locations, (ii) the proportion of at-risk aneurysm patients with IAAs >10 cm2/m and (iii) the relationship between IAAs >10 cm2/m and corresponding aortic diameters in aneurysm patients.

**Materials and Methods**

**Definitions**

For the purpose of this study, an aortic root or ascending aortic diameter ≥4 cm was considered aneurysmal. Post-operative renal dysfunction was defined as a new requirement for haemofiltration or haemodialysis following surgery. In-hospital mortality was defined as death during the same hospital admission.

**Study Populations**

We performed a retrospective observational study on all consecutive adult patients undergoing first-time surgery for thoracic aortic aneurysm (aneurysm group) or acute type A aortic dissection (dissection group) between 2010-2016 at St George’s Hospital, London. Patients were assigned to the aneurysm group based on echocardiographic, contrast-enhanced computed tomography (CT) or contrast-enhanced magnetic resonance imaging (MRI) demonstrating an aortic root or ascending aorta ≥4 cm in diameter. Patients with an aortic root/ascending aorta approaching 4 cm in dimension and co-existing connective tissue disease were also included in the aneurysm group. Patients admitted to our service with acute type A dissection, confirmed on contrast-enhanced CT, comprised the dissection group. Patients for whom relevant pre-operative imaging had not been performed within the preceding year, and in whom aortic root/ascending aortic replacement was performed for procedural complications in the absence of pre-operative aortic aneurysm or dissection, were excluded.

Other variables considered included cardiovascular risk factors (hypertension, hypercholesterolaemia, diabetes mellitus, smoking), as well as pulmonary disease, peripheral vascular disease, chronic kidney disease, connective tissue disease, previous transient ischaemic attack/stroke, ventricular function, aortic valve cusp configuration and aortic valvular regurgitation. Prospectively-collected demographic, clinical and operative data was manually retrieved from our institution's computer database and cross-referenced with medical records. Local ethical approval (equivalent to institutional review board) was granted for this retrospective study.

**Imaging Review**

The most recent pre-operative aortic scans were retrospectively reviewed in multi-planar CT and/or MRI modalities for each patient. Maximum cross-sectional aortic diameters were measured using the inner edge-to-inner edge method in coronal and sagittal views in a plane perpendicular to the direction of blood flow at three aortic locations: the mid-point of the sinuses of Valsalva, the sino-tubular junction, and the mid-ascending aorta (at the level of the pulmonary artery bifurcation) [3]. The largest aortic diameter was used for analysis when multiple measurements were generated. For patients presenting with dissection, diameter measurements included both true and false aortic lumens. All imaging was reviewed by a single clinician with cross-checking of a randomly-selected 10% sample by two experienced cardiovascular radiologists to ensure concurrence in measurement technique and reproducibility.

**Outcome Measures**

Cross-sectional area at each aortic location was calculated using the formula π x r2,where r represents the aortic radius, for patients in aneurysm and dissection groups. This was divided by patient height to determine a ratio of the aortic cross-sectional area to height (indexed aortic area). The median IAA at each of the three aortic locations was calculated for both groups, and the proportion of at-risk patients with IAA >10 cm2/m identified for each aortic location. IAAs at the mid-sinus, sino-tubular junction and mid-ascending aortic locations were categorised into three subgroups (10-12 cm2/m, 12-14 cm2/m and >14 cm2/m) and the mean aortic diameter corresponding to each range was calculated. In addition, patients in the aneurysm group were assigned to one of five subgroups (<4.0 cm, 4.0-4.5 cm, 4.5-5.0 cm, 5.0-5.5 cm or >5.5 cm) depending on aortic diameter at mid-sinus, sino-tubular junction and mid-ascending aortic locations. IAAs were analysed for all patients within the subgroups to calculate the mean IAA at each aortic location for each size subgroup.

**Statistical Analysis**

Statistical analysis was performed using SPSS software (SPSS Inc, Chicago, Illinois, USA). Summary statistics are presented as percentages for categorical variables, and medians and inter-quartile ranges, or means ± standard deviations, for continuous variables. Univariable analyses of categorical and continuous variables were performed using Chi-square and Fisher’s Exact tests. The distribution of continuous variables was assessed for normality with the Shapiro-Wilk Test, and continuous variables were compared between groups using the Mann-Whitney U test. A *p* value <0.05 was considered statistically significant.

**Results**

**Study Populations**

Out of 218 aneurysm patients and 75 dissection patients undergoing surgical repair between 2010-2016 at our institution, 187 patients and 66 patients, respectively, were eligible for analysis. The pre-operative characteristics of both groups are shown in Table 1. 25/187 patients (13.4%) in the aneurysm group were diagnosed with MRI scanning, whereas all patients with dissection underwent CT imaging. Being a tertiary aortic centre, patients with inherited aortopathies are closely monitored within established surveillance programmes and offered early prophylactic surgery. Within the aneurysm group, 20 patients (10.7%) had Marfan syndrome, with an additional 5 (2.67%) having other connective tissue diseases. The dissection group included 6 patients (9.09%) with Marfan syndrome and one patient (1.52%) with other connective tissue disease. Patients in the aneurysm and dissection groups were followed up for a median 337 and 470 days, respectively.

**Mortality**

There was no significant difference in mortality between the aneurysm (10/187, 5.3%) and dissection (7/66, 10.6%) groups (*p*=0.139) during the follow-up period.

**Mean Aortic Diameter**

Table 2 shows the mean aortic diameter for aneurysm and dissection groups according to aortic location. All acute type A aortic dissections occurred at mean aortic diameters <5.5 cm between the aortic root and mid-ascending aorta.

**Indexed Aortic Areas**

Table 3 shows the median IAAs, and Figure 1 the overall distribution of IAAs, for aneurysm and dissection groups categorised according to aortic location. These were largest at the mid-ascending aorta, where the 10 cm2/m cut-off was exceeded, followed by those at the mid-sinus level where values approached abnormal levels. Median IAAs were not significantly different between groups at any aortic location.

**Indexed Aortic Areas >10 cm2/m**

Numbers of patients with IAAs exceeding 10 cm2/m are shown in Table 4. The results reflect the fact that the IAA can exceed 10 cm2/m at several aortic locations in a given patient. The highest IAA was found at the mid-ascending aorta location, where 56.7% of aneurysm group patients, and 60.6% of dissection group patients, had abnormally high IAAs. At the mid-sinuses, 39.6% of aneurysm group patients and 25.8% of dissection group patients had IAAs >10 cm2/m.

**Mean Indexed Aortic Areas Corresponding to Aortic Diameter in Aneurysms**

Figure 2 demonstrates the mean IAA for patients with aortic diameters <4.0 cm, 4.0-4.5 cm, 4.5-5.0 cm, 5.0-5.5 cm and >5.5 cm at mid-sinus, sino-tubular junction and mid-ascending aortic locations. The mean IAA is shown to increase linearly with increasing aortic diameter as expected. Importantly, abnormally high mean IAAs first emerge at aortic diameters of 4.5-5.0 cm. The mean IAA is 11.9 cm2/m at an aortic diameter of 5.0-5.5 cm, and 17.3 cm2/m at >5.5cm.

Table 5 shows the proportion of patients with IAAs >10 cm2/m according to aortic diameter. No patients with aortic diameters <4.0 cm had an abnormal IAA exceeding 10 cm2/m. Within the 4.0-4.5 cm subgroup, only 1/108 (0.9%) patients had an abnormal IAA. Abnormal IAAs were noted in 57/116 (49.1%) patients in the 4.5-5.0 cm subgroup, rising to 67/68 (98.5%) patients in the 5.0-5.5 cm subgroup, and 72/72 (100%) patients in the >5.5 cm subgroups.

**Relationship Between Indexed Aortic Areas and Aortic Diameter in Aneurysms**

Patients with an IAA >10 cm2/m (the at-risk population) at mid-sinus, sino-tubular junction and mid-ascending aortic locations, were categorised into groups with IAA ranges 10-12 cm2/m, 12-14 cm2/m and >14 cm2/m. There were 74 patients, 20 patients and 106 patients who at mid-sinus, sino-tubular junction and mid-ascending aorta location, respectively, had IAAs >10 cm2/m. The mean of the corresponding aortic diameters for each range was then calculated (Table 6).

A considerable 84.3% of patients with an IAA >10 cm2/m based on mid-sinus measurements had a mean aortic diameter below the current 5.5 cm threshold for surgical intervention. Similarly, at the sino-tubular junction, some 62.9% of patients with an abnormal IAA had a mean aortic diameter <5.5 cm. At the mid-ascending aortic location, 58.8% of the at-risk patients with an abnormally high IAA had a mean aortic diameter <5.5 cm.

Only 139 patients (69.5%) out of the entire cohort of 200 patients who have an IAA >10 cm2/m between the mid-sinus of Valsalva and mid-ascending aorta would be eligible for surgical intervention for the aortic root/ascending aorta on the basis of existing guidelines.

**Discussion**

We performed a retrospective observational study to assess the correlation between aortic diameter and IAA in 187 patients with thoracic aortic aneurysm and 66 patients with acute type A dissection. Our study population was limited solely to those patients presenting to us for surgical management of diseased aortas. Of course, there may be a very large group of patients undergoing surveillance for mild proximal aortic dilatation, in whom the IAA may exceed 10 cm2/m, but who have not yet been selected for surgical intervention based on traditional aortic size criteria, or who have not undergone acute dissection.

We noted that dissected aortas had mean aortic root/mid-ascending diameters <5.5 cm on presentation (Table 2). Considering that the diameter of an acutely-dissected aorta will likely increase compared to its pre-dissected state, with haematoma expansion and resultant separation of the aortic wall layers, this suggests that the <5.5 cm mean diameter of the dissected aortas seen in our group would have been even smaller prior to the dissection event [4].

Current guidelines advocate prophylactic aortic replacement at absolute aortic diameters of 4.5-5.5 cm in tricuspid and bicuspid aortic valves, or 4.0-4.5 cm with inherited aortopathies, such as Marfan and Ehlers-Danlos syndromes [3]. However, 40% of patients presenting with type A aortic dissection have an aortic diameter <5 cm, at which size 15% of patients with Marfan syndrome, who have the highest lifetime risk of aortic dissection, will undergo dissection or rupture [4-6]. Loss of aortic elastic tissue in bicuspid-valve related aneurysms means dissection risk in this patient population is not dissimilar to those with Marfan syndrome [2,7]. This questions the true prognostic value of the absolute aortic diameter, and emphasises the need for optimal timing of surgical intervention, especially in those patients under surveillance who do not meet established size criteria for surgery, but may still be at significant risk of dissection. Additionally, utilisation of absolute aortic diameter in existing guidelines fails to account for size, height and gender differences in aortic dimensions, as well as the irregular elliptical shape of the aorta.

More recently, there has been greater emphasis on indexing aortic cross-sectional area to patient height for dissection and mortality risk stratification in dilated aortas with both bicuspid and tri-leaflet aortic valves [1,2,5]. An IAA >10 cm2/m has been determined as a cut-off value after which prophylactic aortic root with or without ascending aortic replacement is advocated for curative potential and thus to improve long-term survival [1].­­­­­­­­

In the present study, we found that median IAAs were comparable between groups from the mid-sinus to the mid-ascending aorta (Table 3). Median IAAs exceeded the critical 10 cm2/m point at the ascending aortic location, suggesting that aneurysm patients may be at risk of dissection once an IAA of 10 cm2/m is exceeded. Based on measurements at the mid-ascending aorta, over half of patients (106/187) in the aneurysm group were shown to be at risk with IAAs >10 cm2/m; the same was true for over a third (74/187) of aneurysm patients based on mid-sinus measurements (Table 4).

We showed that between 57.8 - 84.3% (Table 6) of our study population (depending on the aortic location considered) who were at increased risk of aortic complications according to IAAs, would not have been eligible for aortic surgery according to contemporary guidelines. A previous observational study found an abnormally high IAA in 44% of patients with aortic root diameters at 4.5-5.5 cm [1]. In our study, 124/184 (67.4%) patients with aortic diameters 4.5-5.5 cm were found to have abnormally high IAAs (Table 5). Thus, the present study confirms that a significant proportion of patients with aortic diameters that do not reach the size criteria recommended for elective aortic aneurysm surgery have an abnormal IAA, indicating their increased risk of aortic complications.

Emergency surgery for acute type A dissection aims to prevent the potentially fatal complications of aortic rupture, acute aortic regurgitation, pericardial tamponade, acute coronary occlusion, stroke and limb and organ ischaemia. With improving understanding of the underlying pathophysiology, enhanced recognition with modern imaging modalities, prompt referral to cardiothoracic services and accruing surgical experience, survival rates in acute aortic syndrome have gradually improved in recent years. Hospital mortality has been reported at 10-25% in the current era across all ages [5,8]. Elective aortic root and/or ascending aortic replacement carries an even lower operative risk at experienced centres with a high-volume case output [9]. This emphasises the importance of accurately identifying at-risk individuals with thoracic aortic aneurysms for prophylactic surgery.

The purpose of this isolated retrospective observational study was not to determine a novel size threshold for the selection of patients for aortic surgical intervention. Rather, we aimed to elucidate the less well-studied association between absolute aortic diameter and IAA. It is now well-recognised that aortic dissection may occur in a significant cohort of patients at aortic diameters less than the 5.5 cm proposed for surgical repair [2,5,6]. Considering this, and in conjunction with the present study's findings that IAA is abnormally increased in 67.4% of patients with aortic diameter 4.5-5.5 cm (Table 5), rendering them at higher risk of aortic complications, we suggest that an IAA >10 cm2/m should be considered as a potential risk factor in thoracic aortic disease, and be further evaluated as a criterion for aortic surgery. Large-scale prospective multi-centre registries with accurate long-term follow-up of outcomes are needed to clarify the prognostic value of the IAA in varied surgical populations, including bicuspid and tri-leaflet aortic valves, as well as Marfan's syndrome, which confers the greatest dissection risk. This would ideally afford patients at risk of aneurysm-related dissection or rupture the chance for potentially curative surgery, and at lower operative risk when performed at dedicated, high-volume aortic centres [9-12].

**Limitations**

This is a retrospective observational study with inherent potential for associated selection bias. However, since our tertiary institution is a referral centre for acute type A aortic dissection, patients submitted to aortic surgery at other tertiary cardiac centres would share similar characteristics, namely aortic diameter and IAA, to those in our population. Despite examining all-comers submitted to thoracic aortic aneurysm or dissection surgery over a pre-defined time period, our study population did not comprise large numbers of patients with inherited aortopathies or bicuspid aortic valves, since these are monitored closely in established surveillance programmes and selected for early surgery. Thus the results of our analysis may be transferable to other major aortic centres in non-aortopathy populations. We utilised the formula π x r2 for aortic area calculations which may be less suitable for eccentric aortic shapes where a planimetry technique may be more appropriate [1]. Finally, whilst the results of the present study suggest IAA >10 cm2/m may be useful as a risk factor in thoracic aortic disease, validation of the IAA in comparative analyses would be required prior to its adoption in pre-operative risk evaluation.

**Conclusions**

This study confirms that a large proportion of patients with thoracic aortic aneurysms have IAAs >10 cm2/m corresponding to absolute aortic dimensions that do not satisfy contemporary guideline criteria for aortic surgical intervention, despite being at increased risk of aortic complications. This cohort of patients may benefit from undergoing earlier surgery performed at high-volume centres with special aortic expertise, and at more conservative aortic size ranges, which need verification in larger prospective studies with extended follow-up.

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**Conflict of Interest Statement:** The authors declare that they have no conflicts of interest to declare.

**Figure Legends**

**15-01-18 Fig 1.tifFigure 1:** Distribution of indexed aortic areas in aneurysm group (left-sided bars) and dissection group (right-sided bars) according to aortic location

**Figure 2:** Mean indexed aortic area corresponding to aortic diameter in aneurysms

**Table 1: Pre-operative patient characteristics**

|  |  |  |  |
| --- | --- | --- | --- |
| Characteristic | Aneurysm Group  N = 187 | Dissection Group  N = 66 | *p*-value |
| Age (years) | 63 (52-73) | 66 (51-73) | 0.77 |
| Male | 127 (67.9) | 45 (68.2) | 0.97 |
| BMI | 27 (24-30) | 27 (25-29) | 0.67 |
| Logistic EuroSCORE | 5.58 (2.17-9.17) | 8.86 (4.23-14.0) | 0.001 |
| NYHA class |  |  | <0.001 |
| I | 75 (40.1) | 50 (75.8) |  |
| II | 79 (42.2) | 8 (12.1) |  |
| III | 33 (17.6) | 8 (12.1) |  |
| Hypertension | 109 (58.3) | 35 (53.0) | 0.46 |
| Hypercholesterolaemia | 60 (32.1) | 11 (16.7) | 0.017 |
| Smoking | 84 (44.9) | 18 (27.3) | 0.022 |
| Pulmonary disease | 14 (7.49) | 6 (9.09) | 0.68 |
| CKD stage |  |  | <0.001 |
| 1 | 75 (40.1) | 15 (22.7) |  |
| 2 | 89 (47.6) | 28 (42.2) |  |
| 3 | 20 (10.7) | 21 (31.8) |  |
| 4 | 2 (1.07) | 1 (1.52) |  |
| 5 | 1 (0.53) | 0 (0.00) |  |
| Pre-operative dialysis | 1 (0.53) | 1 (1.52) | 0.45 |
| TIA / CVA | 19 (10.2) | 9 (13.6) | 0.40 |
| Previous MI | 13 (6.95) | 5 (7.58) | 0.79 |
| Peripheral vascular disease | 11 (5.88) | 0 (0.00) | 0.07 |
| LV function |  |  | 0.10 |
| Good | 153 (81.8) | 61 (92.4) |  |
| Moderate | 30 (16.0) | 5 (7.58) |  |
| Poor | 4 (2.14) | 0 (0.00) |  |
| RV function |  |  | <0.001 |
| Good | 176 (94.1) | 50 (75.8) |  |
| Moderate | 9 (4.81) | 15 (22.7) |  |
| Poor | 1 (0.53) | 0 (0.00) |  |
| Aortic valve cuspidity |  |  | <0.001 |
| Unicuspid | 3 (1.60) | 0 (0.00) |  |
| Bicuspid | 70 (37.4) | 1 (1.52) |  |
| Tricuspid | 113 (60.4) | 65 (98.5) |  |
| Quadricuspid | 1 (0.53) | 0 (0.00) |  |
| Marfan syndrome | 20 (10.7) | 6 (9.09) | 0.71 |
| Other connective tissue disease | 5 (2.67) | 1 (1.52) | 0.59 |
| Aortic regurgitation | 133 (71.1) | 45 (68.2) | 0.65 |
| Pericardial effusion | 4 (2.14) | 21 (31.8) | <0.001 |
| Cardiac tamponade | 0 (0.00) | 8 (12.1) | <0.001 |
| Aortic rupture | 0 (0.00) | 3 (4.55) | 0.017 |
| Pre-operative ventilation | 0 (0.00) | 2 (3.03) | 0.07 |
| Cardiogenic shock | 0 (0.00) | 4 (6.06) | 0.004 |
| Mesenteric ischaemia | 0 (0.00) | 1 (1.52) | 0.26 |
| Site of intimal tear |  |  |  |
| Aortic root |  | 28 (42.4) |  |
| Sino-tubular junction |  | 3 (4.55) |  |
| Ascending aorta |  | 21 (31.8) |  |
| Other |  | 13 (19.7) |  |

Values are *n* (%) or median (inter-quartile range)

BMI, body mass index; CKD, chronic kidney disease; CVA, cerebrovascular accident; LV, left ventricle; NYHA, New York Heart Association; RV, right ventricle; TIA, transient ischaemic attack

**Table 2: Mean aortic diameter according to aortic location**

|  |  |  |  |
| --- | --- | --- | --- |
| Aortic Location | Aneurysm group  N = 187  n (%) | Dissection group  N = 66  n (%) | *p*-value |
| Mid-sinus | 4.53 ± 0.78 | 4.42 ± 0.82 | 0.13 |
| Sino-tubular junction | 3.87 ± 0.79 | 4.05 ± 1.18 | 0.70 |
| Mid-ascending | 4.97 ± 1.12 | 5.20 ± 1.26 | 0.31 |

Values are mean ± standard deviation

**Table 3: Median indexed aortic areas (cm2/m) according to aortic location**

|  |  |  |  |
| --- | --- | --- | --- |
| Aortic Location | Aneurysm group  N = 187 | Dissection group  N = 66 | *p*-value |
| Mid-sinus | 9.37 (2.67-21.2) | 8.01 (4.04-24.7) | 0.09 |
| Sino-tubular junction | 6.49 (2.03-20.6) | 6.69 (2.77-35.6) | 0.68 |
| Mid-ascending | 10.6 (3.07-41.9) | 11.2 (3.37-36.5) | 0.32 |

Values are median (range)

**Table 4: Patients with indexed aortic area >10 cm2/ma**

|  |  |  |
| --- | --- | --- |
| Aortic Location | Aneurysm group  N = 187  n (%) | Dissection group  N = 66  n (%) |
| Mid-sinus | 74 (39.6) | 17 (25.8) |
| Sino-tubular junction | 20 (10.7) | 13 (19.7) |
| Mid-ascending | 106 (56.7) | 40 (60.6) |

aIndexed aortic area >10 cm2/m can occur at ≥1 aortic location in the same patient.

**Table 5: Proportion of aneurysm patients with indexed aortic area >10 cm2/m according to aortic diameters**

|  |  |
| --- | --- |
| Aortic diameter (cm) | Indexed aortic areas >10 cm2/m  n (%) |
| <4.0 | 0/212 (0.0) |
| 4.0 - 4.5 | 1/108 (0.9) |
| 4.5 - 5.0 | 57/116 (49.1) |
| 5.0 - 5.5 | 67/68 (98.5) |
| >5.5 | 72/72 (100) |

**Table 6: Relationship between mean aortic diameters and indexed aortic area ranges in aneurysms**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Mean aortic diameter (cm) according to aortic location  (n, % of all patients with indexed aortic area >10cm2/m per aortic location) | | |
| Indexed aortic area (cm2/m) | Mid-sinus  N = 74 | Sino-tubular junction  N = 20 | Mid-ascending  N =106 |
| 10-12 | 4.98 (45, 60.0) | 5.04 (9, 42.9) | 4.92 (46, 43.4) |
| 12-14 | 5.46 (18, 24.3) | 5.35 (4, 20.0) | 5.37 (17, 15.4) |
| >14 | 6.25 (11, 14.7) | 6.19 (7, 33.3) | 6.54 (43, 40.6) |

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