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# Ascending Aortic Diameter at the Time of Dissection and its Relationship with Body Mass Index and Body Surface Area

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Research Article

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**Keywords:** Ascending aortic diameter; Ascending aortic dissection; Body surface area; Body mass index

## ABSTRACT

**Objective:** During our experience in aortic dissection surgery, we noticed that the dissected aortic diameter in usual is less than 55 mm. So we designed this research to find the mean diameter of the ascending aorta at the time of dissection and any relation between the diameter of the dissected aorta and body mass index/body surface area.

**Methods:** We have studied the patients who had undergone urgent operations for ascending aortic dissection in our centre from March 2014 to July 2021. The total number of patients was 62. All the patients were investigated for the size of the aortic root, arch, and ascending, descending aortic diameter. Valvular disease, operative surgical procedure, total Cardiopulmonary Bypass (CPB), cross-clamp, and Total Circulatory Arrest (TCA) were also recorded. Body Surface Area (BSA) and Body Mass Index (BMI) were calculated from the height and weight of the patients.

**Results:** Most of the patients were males, and the average age of all the patients was 59.23 ± 11, 74 (61.5) years. The average diameter of the ascending aorta was 51.23 ± 7.75 (50). BSA was 1.9 ± 0.19 (1.89) $m^2$ while BMI was 26.93 ± 4.2 (26.15) $kg/m^2$. There was no significant correlation between BSA/BMI and ascending aortic size at the time of dissection.

**Conclusion:** The mean ascending aortic diameter at dissection time is about 50 mm. The 55 mm aortic size maybe not is the certain borderline for elective surgery. There is no direct relationship between the dissected ascending aortic diameter and BSA or BMI.

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## INTRODUCTION

Aorta is the main arterial vessel of the body that supplies all the organs with oxygenated blood. It may dilate at any segment, developing an aneurysm when expanded by at least 50% of its average diameter [1]. The aneurysmatic segment carries a high risk of dissection or rupture, which threatens life seriously. The incidence of ascending aortic dissection is 5-30/1 million/year. Most of the dissection cases occur between 50-65 years of age. Young people with tissue disease have a higher risk of dissection earlier. Males are 2-3 times more likely to have aortic dissection than females [2]. Most patients present with chief complaints of severe chest pain that strikes the back between the two scapulas. Other signs of ischemia may also present inconsistency on examination in the upper/lower extremities, arterial blood pressure, deficit or absence of pulse, diastolic murmur on auscultation can be found.

Ascending aortic dissection has a high mortality rate despite advanced surgical techniques and instruments. While the mortality of the patients who reached the emergency department was >30%, the patients who had undergone operations still have mortality around 20-30%. The highest mortality rate occurs in acute aortic dissection in the first ten days. Untreated patients have a mortality risk of about 23% in the first 6 hours, 50% in the first 24 hours, and 68% in the first week [3]. The contrast-enhanced CT-Scan is one of the best methods to demonstrate aortic dissection and shows the anatomy of the aorta and its branches. The body mass index is a measurement that is based on a person's height and weight. The BMI is calculated by dividing the body weight by the square of the height, and it is expressed in kilogrammes per square metre (kg/m2) since weight is measured in kilogrammes and height is measured in metres. A table or chart that presents BMI as a function of mass and height using contour lines or colours for different BMI categories—and may use other units of measurement—can be used to calculate BMI. As well as the aortic root, ascending, arch, and descending aorta measurements can be done quickly. 3D reconstruction form of CT angiography has 100% specificity and sensitivity in the diagnosis of dissection [4,5]. In elective cases of ascending aortic aneurysm, it is recommended by the international guidelines to replace aneurysmatic segment with synthetic graft when its diameter becomes greater than 55 mm and between 40 to 50 mm in connective tissue disease patients [6,7].

Usually, People who are elderly than 75 years old have ascending aorta with an aortic size of 41-42 mm (23.2 mm/m$^2$) in males and 36-37 mm (19.5 mm/cm$^2$) in females [8]. On the other hand, most of the dissected aortas diameters are less than 55 mm, as we noticed during our operations. Therefore, we decided to study the most aortic diameter seen at dissection time and whether there is any relationship between ascending aortic diameter at the time of dissection and patients' Body Mass Index (BMI)/Body Surface Area (BSA).

## MATERIAL AND METHODS

From March 2014 to July 2021, we studied more than a hundred cases of the operated dissected ascending aortas in our center. Unfortunately, many of the patients' data were not complete, so only 62 patients were involved in our study. 46 (74.2%) were males and 16 (25.8%) were females Figure 1.

The average age of the patients was 59.2 years with a median age of 59.2 (min 22–max 84) Figure 2.

We recorded aortic root, ascending arch, and descending aortic diameter at the time of dissection. Besides the measurements of the aortic segments, we studied the other parameters that may be concerning the aortic dissection. Body Surface Area (BSA) and Body Mass Index (BMI) were calculated. We have checked out the ascending aorta diameter from the CT-Scan and Echo; there was ± 3 mm between both methods.

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We recorded our results according to the results of the CT-Scan. The possibility of a relation between BSA and BMI with the size of the dissected aorta was one of the points that encouraged us to start this study.

**Figure 1.** Pie chart of the gender distribution. **Note:** (■) Male; (■) Female

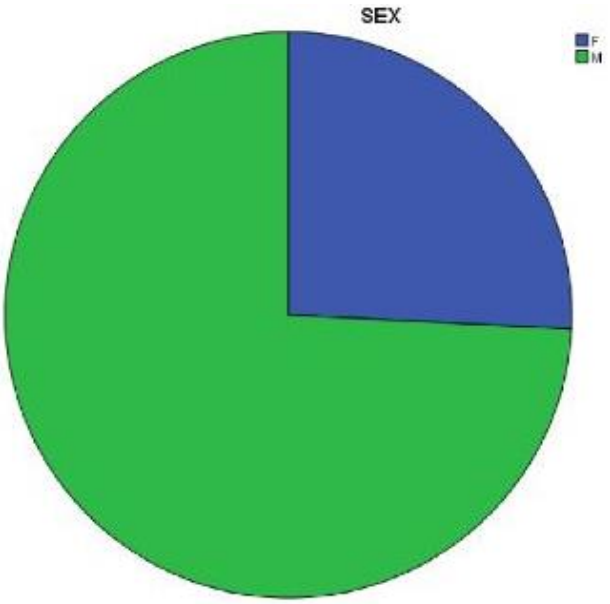
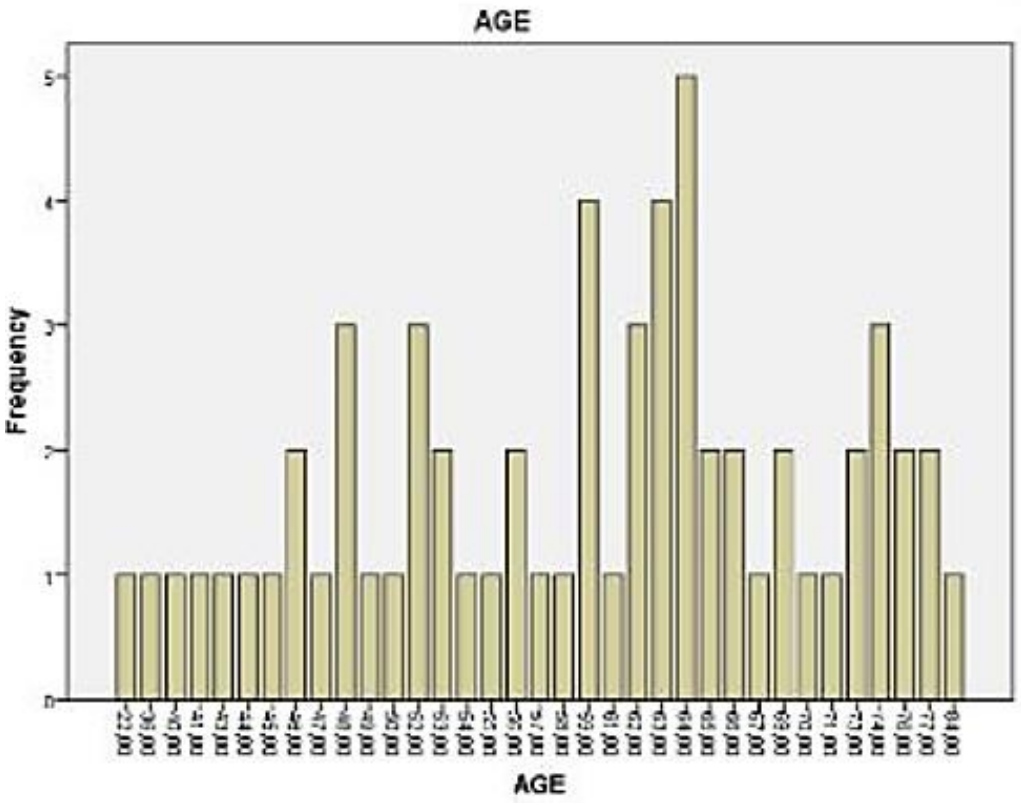



**Figure 2**. Bar graph of gender distribution.



The data of the ejection fraction of the left ventricle, the degree of the valvular pathology, if present were collected from Echocardiography (Echo). Co-morbidities such as Coronary Artery Disease (CAD), Chronic Obstructive Pulmonary Disease (COPD), Arterial Hypertension (HTN), diabetes Miletus (DM), Peripheral Artery Disease (PAD), and smoking were carried into attention while preparing this study. We obtained the time of cardiopulmonary bypass, cross-clamp, and total circulatory arrest during the operation from Perfusionists records. Mortality and post-discharge follow-up period were investigated too.

**Surgical intervention:** All the patients with dissected ascending aorta were operated on urgently without regarding the diameter of the aorta. Under general anesthesia, operations started *via* median sternotomy. In some patients, aortic cannulation was done firstly *via* the right subclavian artery or femoral artery. In others, after sternotomy, aortic cannulation was performed at the proximal side of the innominate artery if not dissected. The decision of the operative procedure type was taken according to the dissection type, distension, the diameter of the aortic root, arch, and the degree of the aortic valve insufficiency (if present).

Some patients had undergone the Button Bentall procedure, while the others had only isolated ascending aortic graft replacement. Some patients had hemi-arch or total arch besides ascending aortic replacement/Button Bentall. Teflon felt was used in all proximal anastomosis except in button Bentall, where conduit grafts were used. In some patients, there was a need to enter total circulatory arrest, while in others, mainly those who underwent isolated ascending aortic replacement, moderate hypothermia was enough. The dissected aortic segments were replaced by synthetic grafts, mainly Dacron® (28-30 mm).

**Statistical analysis:** We performed all our statistical analyses using SPSS 25.0 (IBM SPSS Statistics 25 software (Armonk, NY: IBM Corp.). Continuous variables were defined by the mean ± standard deviation, median (minimum-maximum values), and categorical variables were defined by number and percent. Kolmogorov Smirnov test was used for the determination of normal distribution. Spearman correlation analysis was performed to investigate the relationships between continuous variables. Statistical significance was determined as p<0, 05.

## RESULTS

Most of the patients were males (n=46, 74.2%), while females were 16 in number (25.8%). The mean age of all patients was 59.2 (min 22–max 84) years old. The age peak was seen at 64 age's (Figure 2).

Twenty-eight patients were operated on by ascending aortic graft replacement, 23 ascending aorta+hemiarch/total arch replacement, while 11 patients had the Button Bentall procedure.

The mean size of all dissected ascending aorta was 51.23 ± 7.75 mm; the median was 50 mm (min 35–max 77 mm). At the same time, the mean size of the root, arch, and descending aorta were 41.9 ± 7.9 (42), 38.4 ± 7.3 (38), 35.4 ± 7.9 (42) mm, respectively. To find if there is any relation between the size of the aorta at dissection time and BSA-BMI we collected the data of all the patients' height and weight and calculated BSA and BMI. The average height of all the patients was 170.8 ± 8.2, median (172.5) (min 150-max 190) cm, while the weight was 78.6 ± 13.9, median (79) (min 45–max 125) kg. According to those results, the mean BSA was 1.9 ± 0.19 (1.89), (min 1.36-max 2,41) $m^2$ and BMI 26,93 ± 4,2 (26.15), (min 18.8–max 38,6) $kg/m^2$. The results showed that most of the patients were overweight, and their body surface area was normal in males and high in females.

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At the same time, we collected the echocardiography data, mainly the degree of the cardiac valves deficiency and the left ventricular Ejection Fraction (EF%).

Most of the patients had second-degree Aortic Insufficiency (AI) (min 0–max 4). In contrast, mitral and tricuspid valvular insufficiency was one degree on average for most of the patients, and the average EF was 55%. In addition, intraoperative total cardiopulmonary bypass, cross-clamp, and total circulatory arrest times were recorded. Their mean times were 181, 105 and 27 minutes, respectively. Survived patients were followed up in our center. According to our outpatients' record system, the average of the control period was 12.3 ± 17.8 (min 0–max 73) months. The most critical point that took our attention was the average diameter of the dissected ascending aorta; it was about 50 mm and not above 55 mm Table 1.

**Table 1.** Mean, median, and (minimum-maximum) values of the collected patients' values.

| Parameter | Mean ± S.D | Med | (min-max) |
|---|---|---|---|
| Age (year) | 59.23 ± 11.74 | 61.5 | (22-84) |
| Ascending Aorta (mm) | 51.23 ± 7.75 | 50 | (35-77) |
| Descending Aorta (mm) | 35.35 ± 8.44 | 33.5 | (25-70) |
| Aortic Root (mm) | 41.87 ± 7.89 | 42 | (29-70) |
| Aortic Arch (mm) | 38.42 ± 7.26 | 38 | (23-57) |
| height (cm) | 170.81 ± 8.21 | 172.5 | (150-190) |
| weight (kg) | 78.63 ± 13.91 | 79 | (45-125) |
| BSA ($m^2$) | 1.9 ± 0.19 | 1.89 | (1.36-2.41) |
| BMI ($kg/m^2$) | 26.93 ± 4.2 | 26.15 | (18.8-38.6) |
| Total CPB (minutes) | 193.32 ± 78.28 | 181 | (94-496) |
| Cross Clamp (minutes) | 120.63 ± 55.17 | 105.5 | (42-334) |
| TCA (minutes) | 31.11 ± 24.34 | 27 | (0-120) |
| EF (%) | 53.23 ± 6.47 | 55 | (30-65) |
| AI (degree) | 1.74 ± 1.17 | 2 | (0-4) |
| MI (degree) | 1.03 ± 0.81 | 1 | (0-3) |
| TI (degree) | 1.24 ± 0.86 | 1 | (0-3) |
| Control period (months) | 12.29 ± 17.83 | 3 | (0-73) |

**Abbreviations**: BSA: Body Surface Area; BMI: Body Mass Index; CPB: Cardio Pulmonary Bypass; TCA: Total Circulatory Arrest; EF: Ejection Fraction; AI: Aortic Insufficiency; MI: Mitral Insufficiency; TI: Tricuspid Insufficiency

Mortality was 35.5% (n=22) of all the patients. There were 18 males (29.3%) and 4 (6.2%) females who passed intraoperatively or during the postoperative following few days. The other characteristics of the patients have been summarized in where we can see that the 88, 7% (n=55) of the patients had hypertension (HTN), 61.3% (n=38) Diabetes Miletus (DM), and 48.4% (n=30) were smokers Table 2.

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**Table 2.** Co-morbidities of the patients associated with ascending aortic dissection.

| | Frequency | Percent |
|---|---|---|
| Asthma | 1 | 1.6 |
| CAD | 15 | 24.2 |
| COPD | 1 | 1.6 |
| PAD | 2 | 3.2 |
| HTN | 55 | 88.7 |
| DM | 38 | 61.3 |
| hepatıtıs | 1 | 1.6 |
| Goitre | 2 | 3.2 |
| Cigarettee | 30 | 48,4 |
| Soft tissue disese | 2 | 3.2 |
| Bıcuspid aorta | 2 | 3.2 |

**Abbrevations**: CAD: Coronary Artery Disease; COPD: Chronic Obstructive Pulmonary Disease; PAD: Peripheral Artery Disease; HTN: Arterial Blood Hypertension; DM: Diabetes Mellitus

When we performed our statistical analysis, we correlated our parameters to find any significant relation if present. Also, there was no correlation between the size of the dissected ascending aorta and BSA or BMI. However, there is a strong positive relation between ascending aortic size and aortic root (P=0.001) and aortic arch size (P=0.003). On the other hand, BSA and BMI do not correlate with any parameter, except BSA negatively correlates with age Table 3.

**Table 3.** Correlations among patients' parameters.

| | Spearman's rhocorrelation | AGE | ROOT | ASCEN. | ARCH | DESC. | BSA | BMI | AI | EX |
|---|---|---|---|---|---|---|---|---|---|---|
| AGE | Correlation Coefficient | 1.000 | -.166 | .138 | .180 | .124 | -.267 | -.045 | -.184 | -.044 |
| | p | . | .198 | .284 | .162 | .335 | .036 | .728 | .152 | .732 |
| ROOT | Correlation Coefficient | -.166 | 1.000 | .399 | .343 | .028 | .164 | .159 | .394 | .357 |
| | p | .198 | . | .001 | .006 | .827 | .202 | .218 | .002 | .004 |
| ASCEN. | Correlation Coefficient | .138 | .399 | 1.000 | .373 | -.079 | .004 | .067 | .221 | -.067 |
| | p | .284 | .001 | . | .003 | .544 | .974 | .607 | .085 | .605 |
| ARCH | Correlation Coefficient | .180 | .343 | .373 | 1.000 | .360 | .041 | .114 | .063 | .063 |
| | p | .162 | .006 | .003 | . | .004 | .749 | .376 | .627 | .625 |
| DESC. | Correlation Coefficient | .124 | .028 | -.079 | .360 | 1.000 | -.060 | .022 | -.125 | -.082 |
| | p | .335 | .827 | .544 | .004 | . | .641 | .863 | .333 | .525 |
| BSA | Correlation Coefficient | -.267 | .164 | .004 | .041 | -.060 | 1.000 | .578 | -.135 | .008 |
| | p | .036 | .202 | .974 | .749 | .641 | . | .000 | .296 | .948 |
| BMI | Correlation Coefficient | -.045 | .159 | .067 | .114 | .022 | .578 | 1.000 | -.104 | .053 |
| | p | .728 | .218 | .607 | .376 | .863 | .000 | . | .421 | .684 |
| AI | Correlation Coefficient | -.184 | .394 | .221 | .063 | -.125 | -.135 | -.104 | 1.000 | .375 |
| | p | .152 | .002 | .085 | .627 | .333 | .296 | .421 | . | .003 |
| EX | Correlation Coefficient | -.044 | .357 | -.067 | .063 | -.082 | .008 | .053 | .375 | 1.000 |
| | p | .732 | .004 | .605 | .625 | .525 | .948 | .684 | .003 | . |

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Patients with large roots also had strong positive correlations with aortic arch (P=0.006), aortic valve insufficiency (P=0.002), and mortality (P=0.004); However, mortality has increased in direct proportion with total CPB time (P=0.000) and cross-clamp time (P=0.002) Table 4.

**Table 4**. Correlations among ascending aortic diameter, co-morbidities, CPB, cross-clamp, TCA times, and mortality.

| | Spearman's rhocorrelation | ASCEN. | Total CPB | Cros Clmp | TCA | HTN | DM | Smoking | EX |
|---|---|---|---|---|---|---|---|---|---|
| ASCEN. | Correlation Coefficient | 1.000 | .116 | .110 | -.079 | .188 | .078 | -.033 | -.067 |
| | p | . | .368 | .394 | .543 | .143 | .547 | .802 | .605 |
| Totalcpb | Correlation Coefficient | .116 | 1.000 | .818 | .214 | -.060 | -.084 | .124 | .463 |
| | p | .368 | . | .000 | .095 | .644 | .515 | .335 | .000 |
| CrosClmp | Correlation Coefficient | .110 | .818 | 1.000 | .218 | -.118 | -.133 | .159 | .381 |
| | p | .394 | .000 | . | .088 | .360 | .302 | .218 | .002 |
| TCA | Correlation Coefficient | -.079 | .214 | .218 | 1.00 | .023 | .122 | -.007 | .215 |
| | p | .543 | .095 | .088 | . | .860 | .347 | .955 | .093 |
| HTN | Correlation Coefficient | .188 | -.060 | -.118 | .023 | 1.00 | .135 | .141 | -.055 |
| | p | .143 | .644 | .360 | .860 | . | .295 | .273 | .671 |
| DM | Correlation Coefficient | .078 | -.084 | -.133 | .122 | .135 | 1.00 | -.092 | -.033 |
| | p | .547 | .515 | .302 | .347 | .295 | . | .477 | .796 |
| CİGAR. | Correlation Coefficient | -.033 | .124 | .159 | -.007 | .141 | -.092 | 1.00 | .226 |
| | p | .802 | .335 | .218 | .955 | .273 | .477 | . | .077 |
| EX | Correlation Coefficient | -.067 | .463 | .381 | .215 | -.055 | -.033 | .226 | 1.000 |
| | p | .605 | .000 | .002 | .093 | .671 | .796 | .077 | . |

## DISCUSSION

Ascending aortic dissection types A (Stanford classification) or type I and II (DeBakey classification) is a serious vascular pathology that needs urgent management [9]. The aneurysmatic ascending aorta tends to perforate in direct proportion with the size of the aorta. The risk increases when aortic diameter rises more than 55 mm in sporadic patients. Thus, in such patients, 55 mm, and in connective tissue disease patients, 40-50 mm is enough for elective surgery, unless there is a rapid expansion of the aorta, or the patients will undergo cardiac surgery for pathology. We had only two patients with connective tissue disease and two patients with the bicuspid aortic valve. When ascending aortic dissection occurs, surgical management should be done regardless of the size of the aorta. We have noticed that most of the dissected aorta we had repaired is less than 55 mm in diameter.

In this study, 62 patients with dissected ascending aorta had been included and investigated for the size of ascending, root, arch, and descending aorta besides calculating BSA and BMI. In addition, other parameters like the age, sex, type of the surgical procedure, time of total CPB, cross-clamp and total circulatory arrest, the presence of the valvular disease, mortality, and follow-up period for the survived patients had been taken into account. The mean age of all the patients was 61 (59.2 ± 11,7), with a peak at 64 years. Many studies have similar results [10,11]. Most of our patients were male (n=46, 74.2%), while females were only 16 (25.8%). The distribution of the patients according to their gender in our study is slightly different from some studies. In 2019 year, a study was done on a large population of type A dissection patients (3380), which showed the males were 2164 (63%) and females were 1234 (37%). However, in general, men are at higher risk of aortic dissection than women [12]. The average diameter of the dissected ascending aortas was 50 mm. This result was similar to an extensive study done in 2007 over 591 patients presented with type A aortic dissection. The authors emphasized that most patients had a dissected aorta with an aortic diameter <55 mm. All the patients in our study were investigated preoperatively with contrast-enhanced CT-Scan, and Echocardiography (Echo). However, we noticed no relationship between BSA/BMI and dissected ascending aortic diameter (Table 4). Instead, BMI showed that most of the patients were overweight, and the BSA was average for males and increased in female patients. Among the significant relations that we noticed; the relationship between the aortic root size and aortic valve insufficiency, mortality besides ascending aortic and arch size, which goes side by side together. The average size of the root was 39.0 ± 5.1 (42) mm in our patients, while it was around 40 mm in other studies [13]. Intraoperatively total CBP and cross-clamp time were found affecting the rate of mortality in direct proportion. The degree of hypothermia associated with TCA was about 24°C - 28°C when the arterial cannulation was applied *via* the right subclavian area and around 18°C when the cannulation was performed *via* the femoral artery. Our mortality rate was significant. Twenty-two patients (35.5%) died intraoperatively or within the first few days postoperatively (1-3 days). The male mortality rate was 81.8%, while the female's mortality rate was 18.2% of all mortalities (Table 2). This high mortality rate may be due to the delay in bringing the patient to our center from the other cities and to the delay of diagnosis. According to a study done in 2018, among 282 patients who were operated on for type A dissection, only 51 patients (18%) died [14]. Other studies for type A dissection showed the mortality rate was 12-35% [15,16].

When we studied the relationship between the sizes of the ascending, root, and descending aorta with mortality in perspective of the associated co-morbidities (HTN, DM, and smoking), we have not found any significant relationship between them. Blood hypertension was found in 55 patients (88.7%), but the statistical analysis showed no significant correlation between HTN and the size of the aorta at the time of dissection. Nevertheless, we can see through different researches that HTN is highly associated with aortic aneurysms and plays a significant

role in the pathophysiology of the aneurysms [17, 18, 19]. On the other hand, we noticed from our experience that most patients with dissected aorta have hypertension, so the first management is always to take their blood pressure under control while preparing them for the operation.

## CONCLUSION

In sporadic ascending aortic aneurysms, the diameter of ≥ 55 mm, maybe not be a suitable predictor for elective surgery. Most of the dissected ascending aortic diameter was around 50 mm in size, while the aortic root size was around 42 mm at dissection time. BSA and BMI do not have any direct relation with ascending aortic diameter. The mean BMI showed overweight in all patients. Males were within normal BSA, and females had an increased BSA value. Operative mortality increased when the aortic root size, aortic valve insufficiency, CPB, and cross-clamp time increased.

## LIMITATIONS OF THE STUDY

Our study population was small in number. Larger populations are needed for further studies. We have chosen only the patients who have complete data for our study and excluded the others

## DECLARATION OF CONFLICTING INTERESTS

The authors declared no conflicts of interest concerning the authorship and/or publication of this article.

## FUNDING

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## DATA AVAILABILITY STATEMENT

The authors confirm that all data underlying the findings are fully available without restriction, deposited in our university hospital patients' Database, and available from the authors on request.

## ETHICS COMMITTEE APPROVAL

The institutional ethics committee approved the study, and the principles of the Helsinki Declaration conducted it. The approval had been taken on 05.10.2021 under the approval number (E-60116787-020-113792) from Pamukkale university-Faculty of Medicine/Ethics Committee/Denizli/TURKEY.

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