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A Multicentre Study of Abdominal Aorta Diameters in a Turkish Population

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The aim of this study was to determine the normal values for aortic diameters and the prevalence of aortic dilatation in a mixed Turkish population. Between March 1998 and May 2000, patients who were undergoing abdominal ultrasonography examination for pathologies not involving the aorta, in three different cities, were enrolled into the study prospectively. The anterior posterior aortic diameters were measured at the subdiaphragmatic and aortic bifurcation levels using ultrasonography. A total of 596 patients were included (302 females, 294 males). The mean age was 48 ± 16 years (range, 6 – 88 years). The mean aortic diameter in the whole group was 19.0 ± 3.9 mm (10 – 45 mm) at the subdiaphragmatic level and 15.7 ± 3.6 mm (9 – 65 mm) at the aortic bifurcation level. The mean subdiaphragmatic aortic diameter was 18 ± 3 mm in females and 19 ± 4 mm in males. The mean aortic diameters at the bifurcation level was 15 ± 3 mm in females and 16 ± 4 mm in males. An aortic bifurcation diameter > 30 mm was encountered in 0.67% of the population. This ratio increased to 1.8% in patients over 55 years of age, regardless of sex. A subdiaphragmatic aorta diameter above 30 mm was observed in 1.2% of the population. In patients over the age of 55 years, this ratio increased to 2.7% (3.6% in males and 1.9% in females). In this national study, the subdiaphragmatic aortic diameters were similar to mean values reported in the world literature. The mean aortic bifurcation diameters were generally lower when compared with the literature, which may be due to difficulties in standardization of the measurements. Aneurysmal dilatation rates in this study also conform to those reported in studies conducted in other countries. Considering the significant number of patients with aneurysmal dilatation of the aorta in the elderly population, we believe it would be prudent to evaluate the aorta in all patients undergoing abdominal ultrasonographic examination.

KEY WORDS: AORTA; ABDOMEN; ULTRASONOGRAPHY; ANEURYSM; DILATATION

Introduction

The prevalence of abdominal aortic aneurysm may reach 3% in patients over 50 years of age, although most patients are unaware of their problem.[1] Another aspect of abdominal aneurysms is the difference in surgical mortality when elective and emergency procedures are compared. Whereas elective surgery has a mortality rate of around 1 – 3%, patients who are admitted to the hospital with a ruptured abdominal aortic aneurysm suffer a mean mortality of 50%.[2] If patients who die without reaching the hospital are also taken into account, the clinical importance of diagnosis of

an aneurysm before rupture is easily comprehended.

Diagnosis in most cases with abdominal aortic aneurysm is made when the patients have an abdominal study performed for unrelated indications.[3] The most frequent study that is performed in these patients is abdominal ultrasonography and the radiologists usually report any unusual dilatation of the aorta that he or she believes has clinical relevance. Although dilatation of the aorta is not unusual, particularly in the elderly population, the true cut-off point for abdominal aortic aneurysm is debated. We planned this study to determine the mean aortic diameters for different age groups and sexes in a mixed Turkish population involving different cities. Another aim was to determine the rate of aneurysmal dilatation in this same population.

Patients and methods

PATIENTS

Male and female patients undergoing abdominal ultrasonographic examination for non-vascular indications, between March 1998 and May 2000, at three different radiology departments in three different cities were involved in this study. Patients with known abdominal aortic pathology were excluded from the study. Age, sex, height, weight and diagnosis were recorded. As the measurements were made during an examination for other reasons and did not entail any additional procedure or risk to the patient, verbal consent was deemed adequate. Privacy of the patients was protected by giving each patient a study number and not recording their identity.

MEASUREMENT OF ABDOMINAL AORTA DIAMETER

The inner abdominal aorta diameters, excluding the thrombus, were measured from the anterior–posterior axis. Two different measurements were taken: subdiaphragmatic measurements at the aortic level, just before the celiac trunk; and aortic bifurcation level measurements taken 1 cm above the aortic bifurcation. An aneurismal dilatation was defined by an aortic diameter ≥ 30 mm.

The measurements were made by six different radiologists using three different ultrasonography machines (Siemens Elegra, Erlangen, Germany; Toshiba UIPS 240A, Tochigi Ken, Japan; Toshiba SSH 140A Tochigi-Ken, Japan).

STATISTICAL ANALYSIS

Data are expressed as mean ± SD. Statistical analysis was performed using Student's *t*-test and the variance analysis (ANOVA) tests. Correlation coefficients were calculated using Pearson's coefficient. SPSS software (version 8.0) was used for all analyses.

Results

PATIENTS

A total of 596 patients (302 female, 294 male) were involved in this study. The mean age was 48 ± 16 years (range, 6 – 88 years). The mean ages for the female and male patients were 47 ± 16 years and 48 ± 15 years, respectively (P = 0.529). Grouped by age, there were: 18 patients (10 females, eight males) under 15 years old; 40 (21 females, 19 males) between 15 and 24 years old; 114 (52 females, 62 males) between 25 and 39 years old; 205 (102 females, 103 males) between 40 and 54 years old; 167 (79 females, 88 males) between 55 and 69 years old; and 52 (28 females, 24 males) over 70 years old.

The mean weight of the patients was 69 ± 12 kg (range, 23 – 100 kg). The mean weights for the females and males were 67 ± 12 kg and 71 ± 12 kg, respectively (P < 0.001). The mean height was 165 ± 8 cm (range, 126 – 188 cm).

The mean height for females was 163 ± 7 cm and for males, 167 ± 8 cm ($P < 0.001$).

AORTIC DIAMETER MEASUREMENTS

The mean aortic diameter in the whole group at the subdiaphragmatic level was 19.0 ± 3.9 mm (range, 10 – 45 mm). At the aortic bifurcation level, the mean aortic diameter was 15.7 ± 3.6 mm (range, 9 – 65 mm). The mean subdiaphragmatic diameters in females and males were 18 ± 3 mm and 19 ± 4 mm, respectively, and aortic bifurcation diameters were 15 ± 3 mm and 16 ± 4 mm, respectively ($P < 0.001$). In patients over

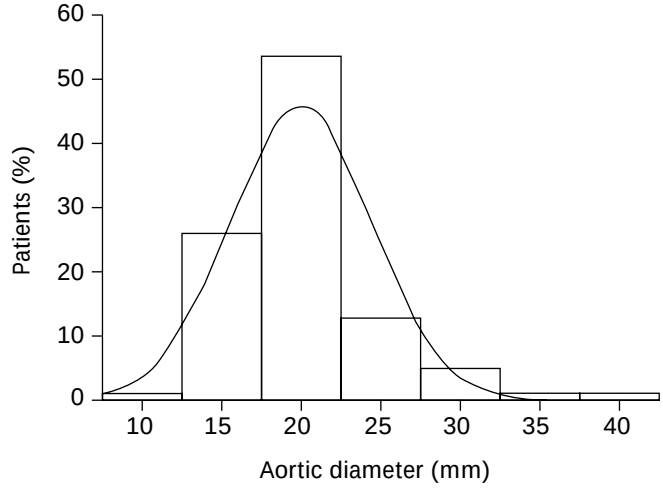


FIGURE 1: Subdiaphragmatic aortic diameter of 107 female patients over 55 years of age who had undergone abdominal ultrasonographic examination for non-vascular indications (mean, 19.9; SD, 4.4)

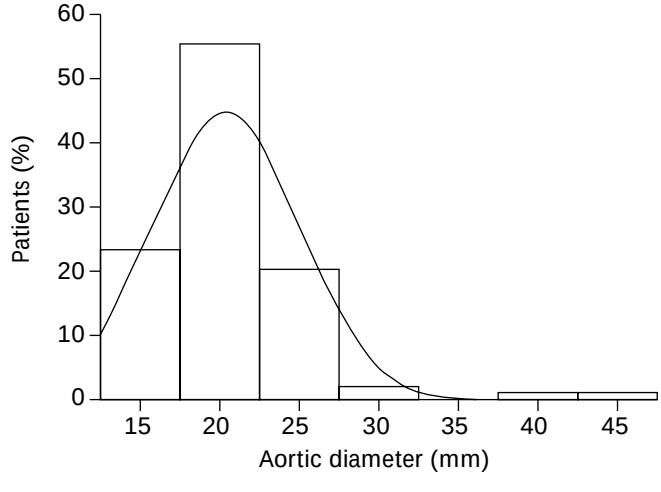


FIGURE 2: Subdiaphragmatic aortic diameters in 112 male patients over 55 years of age who had undergone abdominal ultrasonographic examination for non-vascular indications (mean, 20.4; SD, 4.6)

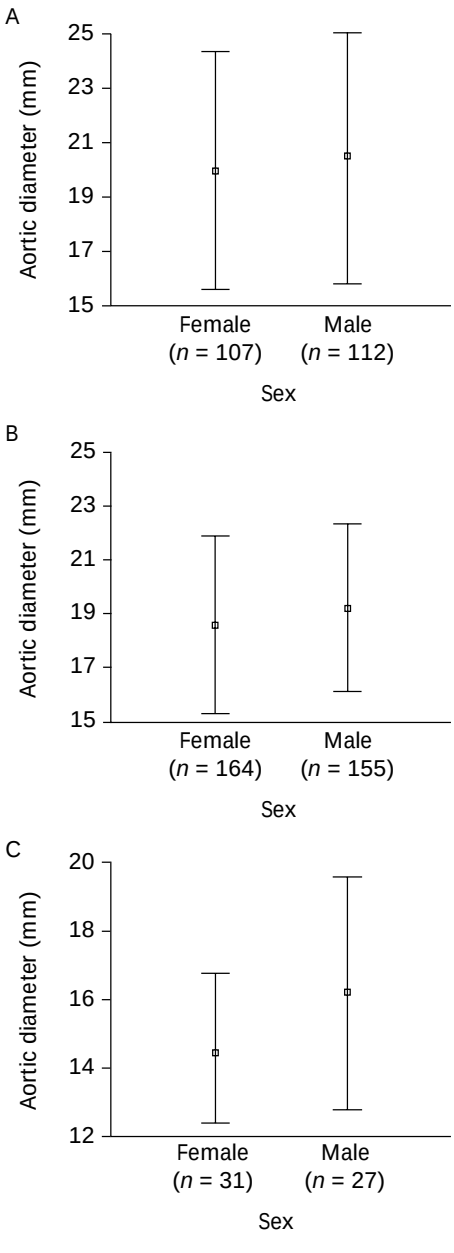


FIGURE 3: Subdiaphragmatic aortic diameter in patients (A) over 55 years of age, (B) between 25 and 55 years of age and (C) under 25 years of age, who had undergone abdominal ultrasonographic examination for non-vascular indications. Data are shown as mean ± SD

55 years of age, the subdiaphragmatic aorta diameters varied between 10 – 40 mm in females (Fig. 1) and 14 – 45 mm in males (Fig. 2). At the subdiaphragmatic level, mean aortic diameters in females and males were: 19.9 ± 4.4 mm and 20.4 ± 4.6 mm, respectively, in patients over the age of 55 (Fig. 3A)**;** 18.6 ± 3.3 mm and 19.2 ± 3.1 mm, respectively, in patients between 25 and 55 years of age (Fig. 3B); and 14.6 ± 2.2 mm and 16.2 ± 3.4 mm, respectively, in patients below 25 years of age (Fig. 3C). The mean aortic diameters at both the subdiaphragmatic and aortic bifurcation level according to sex and age groups are presented in Table 1.

CORRELATION BETWEEN AGE, HEIGHT AND AORTIC DIAMETER

Aortic diameter showed significant correlation with age ($P < 0.001$), height ($P < 0.001$) and weight in females ($P < 0.001$). In males, there was a significant correlation between aortic diameter and age ($P < 0.001$) and height ($P = 0.001$), but not with weight (Table 2).

ANEURYSMAL DILATATION

Four patients (two females, two males) had an aortic diameter at the aortic bifurcation level > 30 mm (Table 3). This corresponds to an aneurysmal dilatation rate of 0.67% for the whole population. When only patients above 55 years of age are evaluated, the rate of aneurysmal dilatation rises to 1.8% for the whole population.

Seven patients (two females, five males) had an aortic diameter at the subdiaphragmatic level > 30 mm, corresponding to an aneurysmal dilatation of 1.2% for the whole population. Looking at only the patients who are over 55 years of age, this proportion rises to 2.7% for the whole population, 1.9% for females and 3.9% for males (Table 4).

TABLE 1:
Aortic diameters according to age groups in male and female patients who had undergone abdominal ultrasonographic examination for non-vascular indications

Age group (years)	Sex	Subdiaphragmatic diameter (mm)	*P*-value	Aortic bifurcation diameter (mm)	*P*-value
< 15	F	12.3 ± 1.5	–	10.5 ± 1.5	–
	M	12.4 ± 1.3	0.651	10.7 ± 1.5	0.753
15 – 24	F	15.9 ± 2.0	–	13.1 ± 1.8	–
	M	18.0 ± 2.6	0.014	15.2 ± 2.1	0.005
25 – 39	F	17.2 ± 2.3	–	14.3 ± 1.8	–
	M	18.1 ± 2.9	0.108	15.4 ± 2.0	0.008
40 – 54	F	19.4 ± 2.7	–	15.2 ± 2.2	–
	M	19.4 ± 3.2	0.96	15.9 ± 2.3	0.051
55 – 69	F	20.6 ± 4.7	–	17.1 ± 4.0	–
	M	20.6 ± 3.9	0.907	17.6 ± 6.2	0.538
> 70	F	18.3 ± 2.9	–	16.3 ± 2.6	–
	M	19.7 ± 6.7	0.372	17.0 ± 4.8	0.525

Data are shown as mean ± SD.

COMPARISON BETWEEN CENTRES

Patient groups from the three centres differed in terms of age, body weight, height and aortic diameters. When only patients who were older than 55 years of age were compared between the three centres, the measurements taken using the different ultrasound apparatus did not differ statistically at the subdiaphragmatic level or the aortic bifurcation level.

TABLE 2:
Correlation of subdiaphragmatic and aortic bifurcation level aortic diameters with age, height and weight in patients who had undergone abdominal ultrasonographic examination for non-vascular indications

	Subdiaphragmatic diameter (mm)		Aortic bifurcation diameter (mm)	
	Female	Male	Female	Male
Age CC	0.368	0.291	0.421	0.263
P-value	0.000	0.000	0.000	0.000
Height CC	0.206	0.240	0.317	0.193
P-value	0.000	0.000	0.000	0.001
Weight CC	0.235	0.112	0.348	0.361
P-value	0.000	0.055	0.000	0.060

CC, Pearson's correlation coefficient.

TABLE 3:
Characteristics of four patients with an aortic diameter at bifurcation level > 30 mm

Age (years)	Sex	Height (cm)	Weight (kg)	Subdiaphragmatic diameter (mm)	Aortic bifurcation diameter (mm)
56	M	173	85	34	31
58	M	174	65	40	40
58	F	165	70	39	65
78	F	165	70	45	35

TABLE 4:
Characteristics of seven patients with a subdiaphragmatic aortic diameter > 30 mm

Age (years)	Sex	Height (cm)	Weight (kg)	Subdiaphragmatic diameter (mm)	Aortic bifurcation diameter (mm)
54	M	165	80	32	21
56	F	173	85	34	31
58	M	174	65	40	40
58	M	165	70	39	65
62	M	175	74	31	18
62	F	175	74	32	19
72	M	165	70	45	35

Discussion

Abdominal aortic aneurysm presents a significant cause of death in the elderly population. Statistical analysis of deaths in England and Wales have shown that ruptured aortic aneurysms account for 1.7% of deaths in men between the ages of 65 and 79 years.[1,4] Recent studies have shown an increasing trend for these rates and have prompted screening of asymptomatic elderly patients for the presence of an abdominal aortic aneurysm. A study by Scott *et al.*[3] of 753 patients between the ages of 65 and 80 years has revealed a prevalence of 2.7% for an abdominal aorta diameter above 3.5 cm. Other population-based studies have shown an aneurysm prevalence of around 2% for patients above the age of 60.[1,3 – 5] In our study, 1.8% of the patients above the age of 55 had an abdominal aorta above 3.0 cm at the aortic bifurcation level. If subdiaphragmatic level measurements are taken into account, this ratio increases to 2.7% in the general population and 3.6% in the male population. These aneurysm rates conform to population-based studies from other countries.[1,3]

This study was based on measurements made using abdominal ultrasonography. Computerized tomography is less user-dependent and more objective compared with ultrasonography, and is not affected by intestinal gas. However, ease of use and lower cost makes ultrasonography valuable

as a screening test. In a study by Lederle *et al.*,[6] variability in aortic diameters measured with both computerized tomography and ultrasonography was analysed in 258 patients. They reported a difference of < 0.2 cm in 44% of patients and a difference of > 0.5 cm in 33% of patients. Ultrasonographic measurements showed a mean diameter 0.27 cm less than computerized tomographic measurements. This difference did reach statistical significance, although a difference of < 3 mm in most patients may not have a great clinical importance.

In this study, the mean aortic diameters at the aortic bifurcation level were measured as 15 ± 3 mm in females and 16 ± 4 mm in males. In a similar study by Ouriel *et al.*,[7] infrarenal aortic diameters were measured as 19 mm in females and 23 mm in males. In another study, by Brivady *et al.*,[8] where the inner diameters of the infrarenal abdominal aorta was measured in atherosclerotic patients, the mean diameters were 16 ± 4 mm in females and 20 ± 7 mm in males. This difference in reported diameters of the infrarenal aorta and the results obtained in our study may stem from the difference in the level at which the measurements were taken. Measurements at the aortic bifurcation level can be more difficult as this area is more prone to interference from intestinal gas, and diameter measurements are more difficult to standardize and reproduce. The results obtained at the subdiaphragmatic level in our study conform to most reports.

Smaller body size can be another factor that may result in lower figures in our study. The mean height of 163 ± 7 cm in females and 167 ± 8 cm in males is generally lower than those reported in Western data. However, a study of patients in Saudi Arabia by Al Zahrani *et al.*[9] reported a mean suprarenal aortic diameter of 18 ± 2 mm which conforms to both the measurements reported in Western studies and to our own investigation. This similarity in upper aortic level measurements leads us to believe that the lower than normal aortic bifurcation level measurements may be erroneous. We hypothesize that ultrasonographic measurements taken at the subdiaphragmatic level may represent aortic diameters more realistically.

All of the aneurysms diagnosed in this study can be considered as small aortic aneurysms. The clinical importance of small aortic aneurysms is still not well defined. In a study based on autopsies of hospital deaths, the ratio of rupture for small (4.1 – 5 cm) aneurysms was reported as 23.4%.[6] However, in a population-based study carried out in Rochester, MN, USA, Nevitt *et al.*[10] reported a rupture rate of 0% in aneurysms < 5 cm in diameter compared with 25% in aneurysms > 5 cm in diameter.

The annual rate of expansion was defined by Nevitt *et al.*[10] as 0.21 cm. In contrast, Delin *et al.*[11] reported a similar expansion rate for both small aneurysms and those > 6 cm. Katz *et al.*[2] calculated a rupture rate per 100 patient years of 0 for aneurysms < 4 cm, 3.3 for aneurysms between 4 cm and 4.9 cm and 14.4 for aneurysms ≥ 5 cm. Neither of the latter two studies were population-based and they were both performed using a limited number of patients. As we have encountered aneurysmal dilatation rates similar to those reported elsewhere, we believe deaths due to aneurysmal rupture may also have a similar prevalence in our society.

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