Comparison of Aortic Diameter in Normal Subjects and Patients with Systemic Hypertension

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Background: *Standard aortic root dimensional measurement by the two dimensional echocardiography should be routinely performed in all patients. There is limited data on the normal reference on Thai population.*
Objective: *Aims of this study were 1) to determine the normal reference of aortic root dimension in Thai population and 2) to determine the difference in the aortic root size in patients with hypertension comparing with normal population.*
Material and Method: *We retrospectively reviewed 81 patients who had the transthoracic echocardiographic examinations in our echocardiographic lab and had the aortic root measurement data. The patients with ascending aortic aneurysm, aortic dissection, aortic stenosis and/or regurgitation more than mild in degree, Marfan's syndrome and annuloaortic ectasia were excluded. The echocardiographic data of were collected; the aortic root dimensions at four levels; aortic valve annulus, sinus of Valsava, sinotubular junction and tubular parts. Hypertension was indentified if the patient had the prior diagnosis of hypertension and on antihypertensive medications, or who had blood pressure more than 140/90 mmHg for two or more occasions.*
Results: *Eighty-one patients were enrolled. Sixty patients (74.1%) were diagnosed hypertension. Mean age was 66.9 $\pm$ 11.2 years in hypertensive patients and 49.1 $\pm$ 16.4 years in normotensive patients. Normal reference values based on 95% upper normal limit of aortic valve annulus, sinus of Valsava, sinotubular junction and tubular part were 2.30 (2.21-2.38), 3.56 (3.35-3.77), 2.79 (2.61-2.97), and 3.36 (3.13-3.59), respectively. Patients with hypertension had significant larger sinus of Valsava and tubular part of aortic root than patients with normotension.*
Conclusion: *We reported a normal reference value for aortic root size in Thai population. The aortic root sizes are influenced by hypertensive status, age and gender.*

Keywords: *Aortic root diameter, Hypertension, Normal reference, Echocardiography, Sinus of Valsava, Normotensive*

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Standard aortic root dimensional measurement by the two dimensional echocardiography has been recommended and should be routinely performed in all patients[1]. Prognostic value of aortic root dilation is clearly identified in aortic regurgitation, Marfan's syndrome and aortic dissection. Although the presence of hypertension appears to have effect on aortic root dimension[2], some studies show controversial results[3,4]. The previous studies, regarding to normal value of aortic root size, were mainly conducted in a Western country with a few data in the Asian populations[5-7].

Aims of this study were 1) to determine the normal reference of aortic root dimension in Thai population and 2) to determine the difference in the aortic root size between patients with hypertension and normal population.

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Material and Method

From January 2008 through October 2009, we retrospectively reviewed 81 patients who had transthoracic echocardiographic examinations in our echocardiographic lab and had the aortic root measurement data. The patients with ascending aortic aneurysm, aortic dissection, aortic stenosis and/or regurgitation more than mild degree, Marfan's syndrome and annuloaortic ectasia were excluded. The medical records were reviewed for a medical illness and the echocardiographic parameters. The following echocardiographic data were collected: aortic valve annulus, sinus of Valsava, sinotubular junction and

tubular part. Two-dimensional measurement of the inner edge to the inner edge of each level during end-diastole was used[1] (Fig. 1). We also collected left ventricular (LV) wall thickness, LV dimension, LV ejection fraction using M-mode tracing in left parasternal short-axis view and the biplane Simpson's method, left atrial (LA) volume using the biplane area-length method, mitral inflow velocities and tissue velocity of septal mitral annulus. Blood pressure was determined in all patients before echocardiography, after rest for at least 10 minutes. Hypertension was identified if the patient had prior diagnosis of hypertension and was on antihypertensive medications, or who had blood pressure more than 140/90 mmHg for two or more times. The study protocol was approved by the institutional review board of our hospital.

Statistical analysis

Data were expressed as mean and standard deviation (SD) for continuous variables and as number of cases and percentages for categorical variables. Unpaired t-test or Mann Whitney-U test was used to compare means of continuous variable between hypertensive and normotensive groups. Chi-Square test was used to assess the differences of proportion of categorical variables between hypertensive and normotensive groups. The cut-off diagnostic value of aortic root dimension in non-hypertensive population was presented by using 95% upper limit of ROC curve and 90% confidence interval. Pearson correlation was performed to assess the correlation of aortic root size and continuous data. Analysis of covariance was performed to adjust for the effect of covariance. All statistical analyses were performed with the commercially available statistical software package SPSS version 17.0 (SPSS, Inc, Chicago, IL). A p-value of ≤ 0.05 was considered statistically significant.

Results

Baseline characteristics

Baseline characteristics are shown in Table 1. Sixty patients (74.1%) were diagnosed hypertension. Mean age was 66.9 $\pm$ 11.2 years in hypertensive patients and 49.1 $\pm$ 16.4 years in normotensive patients. There were 40 women (66.7%) in hypertensive and 15 women (71.4%) in normotensive group. The blood pressure before transthoracic echocardiographic examination were 135 $\pm$ 23/72 $\pm$ 12 mmHg and 115 $\pm$ 18/65 $\pm$ 11 mmHg in hypertensive group and normotensive group, respectively.

Echocardiographic parameters

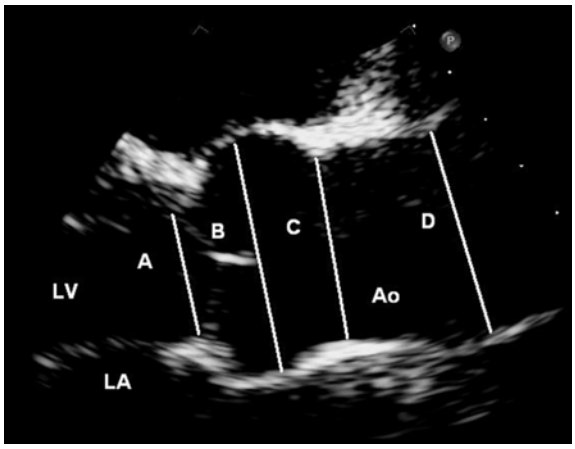

Fig. 1 Diagram of aortic root measurement (A = Aortic valve annulus, B = Sinus of Valsava, C = Sinotubular, D = Tubular)

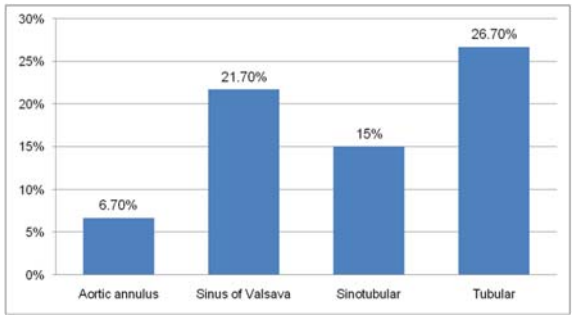

Fig. 2 Proportion of hypertensive patients that increase size of aortic root

The echocardiographic parameters are shown in Table 2. The LV wall thickness was increased among the hypertensive patients in both diastole and systole. The indexed LA volume was significantly greater in patients with hypertension compared to normotensive group (39.9 $\pm$ 13.4 mL/m^2 vs. 30.8 $\pm$ 8.7 mL/m^2, p = 0.001).

Aortic root size

Patients with hypertension had significant larger sinus of Valsava and tubular part of aortic root than patients with normotension (3.26 $\pm$ 0.37 cm vs. 3.01 $\pm$ 0.33 cm, p = 0.009 and 3.16 $\pm$ 0.38 cm vs. 2.77 $\pm$ 0.36 cm, p < 0.001, respectively) (Table 2). There was no significant difference in aortic annulus and sinotubular diameter between both groups (p = 0.404 and 0.109, respectively) (Table 2). The cut-off for diagnosis of abnormal enlargement, value, which was shown as a 95% upper limit of aortic root diameter in normotensive

Table 1. Comparison of variables between of hypertensive and normotensive patients

	Hypertensive group (n = 60)	Normotensive group (n = 21)	p-value
Age, yr	66.9 ± 11.2	49.1 ± 16.4	< 0.001
Sex; M/F (%)	20/40 (33.3/66.7)	6/15 (28.6/71.4)	0.687
Height, m	1.59 ± 0.08	1.60 ± 0.07	0.608
Weight, kg	62.8 ± 12.7	61.4 ± 9.7	0.618
BSA, m2	1.63 ± 0.18	1.63 ± 0.14	0.958
Dyslipidemia	37 (61.7%)	2 (9.5%)	< 0.001
Diabetes mellitus	19 (31.7%)	0	0.004
Smoking	2 (3.3%)	1 (4.8%)	0.765
History of heart failure	7 (11.7%)	1 (4.8%)	0.361
SBP, mmHg	135 ± 23	115 ± 18	0.001
DBP, mmHg	72 ± 12	65 ± 11	0.020
Medication			
B-blocker	34 (57.6%)	6 (30%)	0.033
CCB	26 (44.1%)	1 (4.8%)	0.001
Nitrates	30 (50.8%)	17 (81%)	0.016
ACEIs	12 (20.3%)	1 (4.8%)	0.097
ARBs	39 (66.1%)	3 (14.3%)	< 0.001
Aspirin	22 (37.3%)	4 (19%)	0.125
Statin	32 (54.2%)	3 (14.3%)	0.002
Diuretic	16 (27.1%)	2 (9.5%)	0.097
Cholesterol	200.6 ± 46.7	199 ± 52.3	0.963
Triglyceride	134.6 ± 72.2	227 ± 210.8	0.125
LDL-C	110.5 ± 41.4	122.2 ± 64.8	0.706
HDL-C	57.8 ± 15.2	57 ± 18.4	0.944

Data were presented in mean, SD or number (percentage).
M, male; F, female; SBP, Systolic blood pressure; DBP, Diastolic blood pressure; CCB, Calcium channel blocker; ACEI, Angiotensin converting enzyme inhibitor, LDL-C = Low density lipoprotein cholesterol, HDL-C = High density lipoprotein cholesterol

patients, was shown in Table 3.

We analyzed whether age and gender have influence on the aortic root size. We found that male had a larger aortic root size compared to female as shown in Table 4. Aortic root size also increased with an increasing age. Correlation coefficient and p-value for the correlation between age and aortic root size were -0.006 and 0.995 for aortic valve annulus, 0.261 and 0.019 for sinus of Valsava, 0.190 and 0.090 for sinotubular junction and 0.391 and < 0.001 for tubular parts respectively. ANCOVA analysis showed that, when adjusted for age and gender, hypertensive status had effect only on tubular part of aortic root size (F = 3.88, p = 0.05).

Discussion

The results from this study show that normal reference values based on 95% upper normal limit are aortic valve annulus 2.30 (2.21-2.38) cm, sinus of Valsava 3.56 (3.35-3.77) cm, sinotubular junction and tubular parts 3.36 (3.13-3.59) cm, 2.79 (2.61-2.97) cm. Patients with hypertension had significant larger sinus of Valsava (mean diameter of 3.26 cm) and tubular part of aseending aorta (mean diameter of 3.16 cm) than patients with normotension.

There are limited data on the normal values of aortic diameter especially in Asian population. A report from Chinese population showed a mean and standard deviation of aortic valve annulus and sinotubular junction[7]. However, it did not report the upper normal limit. In our opinion, upper normal limit should be of more advantage for clinical use[8]. They showed that aortic root size increased with increasing age which is similar to results from our study. In contrast to what we found, they showed that the female had a larger aortic root size when compared to the male. They reported a

Table 2. Comparison of echocardiographic parameter between of hypertensive and normotensive patients

	Hypertensive group (n = 60)	Normotensive group (n = 21)	p-value
Aortic root by M-mode, mm	31.8 ± 3.7	30.4 ± 3.5	0.123
LA diameter, mm	44.5 ± 7.7	39.1 ± 5.3	0.004
LVEF, %(by Teichholz method)	72.2 ± 13.2	70.5 ± 6.9	0.592
IVSd, mm	12.5 ± 2.5	10.4 ± 1.7	0.001
LVDd, mm	44.3 ± 4.9	45.6 ± 4.1	0.275
PWd, mm	10.5 ± 1.8	8.8 ± 1.4	< 0.001
IVSs, mm	16.7 ± 2.8	13.9 ± 1.7	< 0.001
LVDs, mm	25.2 ± 4.3	27.3 ± 4.0	0.052
PWs, mm	15.0 ± 2.5	13.6 ± 2.4	0.023
LVEF, % (by biplane Simpson's method)	74.9 ± 7.2	72.9 ± 6.5	0.263
EDV, mL	53.7 ± 18.5	61.5 ± 14.4	0.084
ESV, mL	14.0 ± 7.6	16.7 ± 5.7	0.150
LA volume index, mL/m2	39.9 ± 13.4	30.8 ± 8.7	0.001
Mitral E, cm/s	88.4 ± 28.8	99.5 ± 23.1	0.123
Mitral A, cm/s	104.0 ± 22.4	81.0 ± 23.3	< 0.001
Septal e', cm/s	5.55 ± 1.69	8.86 ± 3.0	< 0.001
E/septal e'	17.2 ± 6.7	12.1 ± 3.4	0.001
Aortic root diameter			
Aortic annulus, cm	2.11 ± 0.33	2.08 ± 0.13	0.404
Sinus of Valsava, cm	3.26 ± 0.37	3.01 ± 0.33	0.009
Sinotubular, cm	2.45 ± 0.31	2.32 ± 0.29	0.109
Tubular, cm	3.16 ± 0.38	2.77 ± 0.36	< 0.001

Data were presented in mean ± SD or number (percentage).
LA, left atrium; LVEF, LV ejection fraction; IVSd, interventricular septal thickness in diastole, LVDd, LV dimension in diastole; PWd, posterior wall thickness in diastole; IVSs, interventricular septal thickness in systole; LVDs, LV dimension in systole; PWs, posterior wall thickness in systole; EDV, end-diastolic volume; ESV, end-systolic volume; Mitral E, early diastolic mitral inflow velocity; Mitral A, late diastolic mitral inflow velocity; Septal e', early diastolic septal annular velocity.

Table 3. 95% upper limit of aortic root size in normotensive patients

	95% upper limit (90% coefficient interval)
Aortic valve annulus (cm)	2.30 (2.21-2.38)
Sinus of Valsava (cm)	3.56 (3.35-3.77)
Sinotubular (cm)	2.79 (2.61-2.97)
Tubular (cm)	3.36 (3.13-3.59)

Table 4. Comparison of aortic root size between male and female

	Male (n = 26)	Female (n = 55)	p-value
Aortic root diameter			
Aortic annulus, mm	2.19 ± 0.13	2.06 ± 0.12	< 0.001
Sinus of Valsava, mm	3.45 ± 0.37	3.07 ± 0.32	< 0.001
Sinotubular, mm	2.55 ± 0.35	2.35 ± 0.27	0.007
Tubular, mm	3.19 ± 0.44	2.99 ± 0.38	0.039

mean diameter at aortic valve annulus and sinotubular junction of 1.19 and 1.39 cm/m^2 in population with 50-60 years of age which are slightly smaller to what we demonstrated in our study (1.30 and 1.49 cm/m^2).

Other interesting data were in a report from Japanese population[6]. They also reported mean and standard deviation of aortic root diameter. If we look at data in population of 50-60 years of age, we found that aortic root diameters of Japanese population are similar to our population. The diameter of aortic valve annulus, sinus of Valsava and sinotubular junction in Japanese

population were 2.3, 3.3, and 2.8 cm (2.2, 3.5 and 2.6 cm in our study) or 1.3, 1.9, and 1.6 cm/m^2 (1.2, 2.0, and 1.5 in our study) when adjusted for body surface area for men. For women, these numbers were 2.0, 2.9, and 2.5 cm (2.1, 3.1, and 2.4 cm in our study) or 1.4, 2.0, and 1.7 cm/m^2 (1.3, 2.0 and 1.5 cm/m^2 in our study) when adjusted for body surface area.

We found that hypertensive patients had a larger aortic root size when compared to normotensive population at the level of the sinus of Valsalva and tubular part of aseending aorta. However, this finding may be influenced by age since hypertensive populations were older. After the adjustment for age and gender, the hypertensive population had still a larger tubular part when compared to population with normotension.

In conclusion, we reported a normal reference value for aortic root size in Thai population. The aortic root sizes are influenced by hypertensive status, age and gender.

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Potential conflicts of interest

None.

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การเปรียบเทียบขนาดของ aortic root ในคนปกติและผู้ป่วยความดันโลหิตสูง

เดโช จักราพานิชกุล, ศรีสกุล จิรกาญจนากร

***ภูมิหลัง**: ค่าปกติของขนาดของ aortic root ยังไม่มีการรายงายในประชากรไทย*

***วัตถุประสงค์**: 1) เพื่อรายงานค่าปกติของขนาด aortic root ในประชากรไทย 2) เพื่อศึกษาความแตกต่างของขนาด aortic root ในคนปกติและผู้ป่วยความดันโลหิตสูง*

***วัสดุและวิธีการ**: เป็นการศึกษาย้อนหลังในประชากร 81 คน ที่ได้รับการตรวจคลื่นเสียงสะท้อนหัวใจ และได้รับการวัดขนาด aortic root ด้วยวิธีมาตรฐานโดยทำการวัด 4 จุด คือ ที่ annulus ของ aortic valve, sinus of Valsava, รอยต่อของ sinus และ tubular และส่วน tubular ถือว่าผู้ป่วยเป็นความดันโลหิตสูง ถ้าเคยมีประวัติความดันโลหิตสูงและได้รับยารักษาอยู่หรือวัดความดันโลหิตขณะพัก 2 ครั้ง เกิน 140/90 มม. ปรอท*

***ผลการศึกษา**: เป็นผู้ป่วยความดันโลหิตสูง 60 คน ความดันปกติ 21 คน อายุเฉลี่ย 66.9 ปี ในกลุ่มความดันโลหิตสูง และ 49.1 ปี ในกลุ่มความดันโลหิตปกติ ค่าปกติของขนาดของ annulus ของ aortic valve, sinus of Valsava, รอยต่อของ sinus และ tubular และส่วน tubular เป็น 2.30 (2.21-2.38), 3.56 (3.35-3.77), 2.79 (2.61-2.97), และ 3.36 (3.13-3.59) ตามลำดับ ผู้ป่วยความดันโลหิตสูงมีขนาดของ annulus ของ aortic valve, sinus of Valsava, รอยต่อของ sinus และ tubular และส่วน tubular ใหญ่กว่ากลุ่มความดันโลหิตปกติ*

***สรุป**: ผู้วิจัยได้รายงานค่าปกติของขนาด aortic root ในประชากรไทยบางส่วนของขนาด aortic root ขึ้นกับอายุ เพศ และภาวะความดันโลหิตสูง*