Effect of Hypertension on Aortic Root Size and Prevalence of Aortic Regurgitation

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ABSTRACT:

BACKGROUND:
Although early reports suggested that hypertension predisposed to aortic root enlargement and consequent aortic regurgitation, more recent pathological and M-mode echocardiographic studies have not found an association between hypertension and aortic root enlargement when age is considered.

OBJECTIVE:
The aim of this study is to asses the effect of hypertension on aortic root size and to estimate the prevalence of aortic regurgitation.

METHODS:
measurement of two-dimensional echocardiographic diameters of the aortic root at four locations and compared findings with resting blood pressures and measures of body BMI in ١١٠ normotensive and ١١٠ hypertensive men and women matched for age and sex.Colour and continuous wave Doppler study are used to diagnose and assess severity of aortic regurgitation.

RESULTS:
Aortic diameters at the anulus (٢,٤٠±٠,٢٩ versus ٢,٣٣±٠,٢٤ cm, *P*=.٠٦) and sinuses (٣,٤٥±٠,٤٣ versus ٣,٣٥±٠,٣٥cm, *P*=.٠٨) were marginally higher, whereas diameters at the supra-aortic ridge (٢,٩٣±٠,٣٩versus ٢,٧٣±٠,٣٣cm, *P*<.٠١) and ascending aorta (٣,٢٧±٠,٤٤versus ٣,١٢±٠,٣١ cm, *P*<.٠١) were significantly increased in hypertensive subjects. Aortic diameters increased with increasing quartiles of diastolic and systolic pressures, particularly at the supra-aortic ridge and ascending aorta. In multivariate analyses, blood pressure remained an independent determinant of distal aortic diameters after body size and age were considered. Aortic regurgitation was seen in ٦ normotensive and ٨ hypertensive subjects and did not differ in severity.

CONCLUSION:
Hypertension is associated with a slight increase in aortic root size, most notably of the supra-aortic ridge and proximal ascending aorta. Although dilatation at the commissural attachment might be expected to predispose to an increase in aortic regurgitation, we did not detect such a difference in this population of, asymptomatic hypertensive individuals.

INTRODUCTION:
Although early case reports and pathological series suggest that hypertension might directly predispose to aortic regurgitation because of enlargement of the aortic root,[٤،٥] more recent pathological[٣,١٠] and M-mode echocardiographic[١١،١٢] studies have not found an association between blood pressure and aortic root size when the confounding influence of aging is considered. Thus, aortic root diameter is strongly related to age,[١٣،١٤] and senescence may result in cystic medial necrosis.[٣،١١] In contrast, other M-mode echocardiographic studies have noted significant relations of aortic root diameter to systolic[١٤] and diastolic[١٥،٢٠] pressures. Furthermore, severe aortic regurgitation due to idiopathic aortic root dilatation is associated with antecedent hypertension. [٢،٨]Discrepancies in the existing literature regarding the effect of hypertension on aortic root enlargement may partially reflect methodological shortcomings in the accuracy and reproducibility of aortic and blood pressure measurements. Although M-mode echocardiography is reliable in assessing aortic root diameter [٦،٧] it results in systematic underestimation of aortic diameter at the sinuses of Valsalva due to cyclic cardiac translational changes[٣]and does not permit extensive assessment of the entire aortic root, including the supra-aortic ridge, which serves as the site of

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commissural insertion. Commissural support is of critical importance in the maintenance of normal geometry and hence leaflet coaptation.[٩،١٩]In addition, clinical estimates of blood pressure may be less accurate in reflecting vascular load and thereby target-organ damage than are ambulatory blood pressure determinations.[٢٠،٢١], we designed the present study to assess the effect of blood pressure on aortic size by examining comprehensive two-dimensional echocardiographic measurements of aortic root diameters in age- and sex-matched normotensive and hypertensive subjects in comparison with age, body size, and blood pressure measurements.

PATIENTS AND METHODS:

SUBJECTS

This cross –sectional study included hypertensive subjects and normotensive subjects who were free of clinically apparent cardiac disease when echocardiography was performed they were free from abnormal valve pathology .They were matched for sex and age. Those patients were recruited from medical outpatients units in Baghdad teaching hospital ,and from Iraqi center for heart diseases in medical city ,Baghdad .Many cases had been also examined in Ibn Al-Nafees hospital,Bghdad.the study was conducted from March to August ٢٠١١.All subjects underwent standard and Doppler echocardiography. Hypertension was defined according to the recommendations of the Seventh Report of the Joint National Committee on Prevention ,Detection ,Evaluation, and Treatment of High Blood Pressure, or on the bases of treatment with antihypertensive medication for a known diagnosis of hypertension.

Measuring blood pressure

Supine brachial blood pressure was determined after the echocardio-graphic study using a standard mercury sphygmomanometer.Blood pressure was measured in fractions of millimeters of mercury (mmHg). It has an inflatable rubber cuff attached to a pressure-monitoring device. The two numbers that indicate blood pressure are expressed as a fraction, for example, ١٢٠/٨٠ mmHg.

Body mass index (BMI)was calculated as weight in kilograms divided by square of height in meters. Obese where those who have BMI>٣٠ kg/m²

Body surface area was calculated as:

BSA= √height(m)xweight(kg)/٣٦

Each subject received an explanation of study and gave informed consent.

Echocardiography

All subjects underwent two-dimensional and Doppler echocardiogram according to the recommendations of the American Society of Echocardiography . All subjects were examined in the left lateral decubitus position by using (Philips Enviser and sonoAce version٢ ultrasound systems equipped with ٢-٤ MHz transducer).

Aortic size

Measurements at end systole were made by the leading edge technique in the parasternal long axis view at for locations: (١) aortic annulus,(٢) maximal diameter of the sinus of Valsalva ,(٣) supra_aortic ridge (sinotubular junction)and (٤) maximal diameter of the proximal aorta. Measurments were taken on up to four separate cycles and averaged. Pulsed and color Doppler examination were performed for determination of the presence and severity of aortic regurgitation.

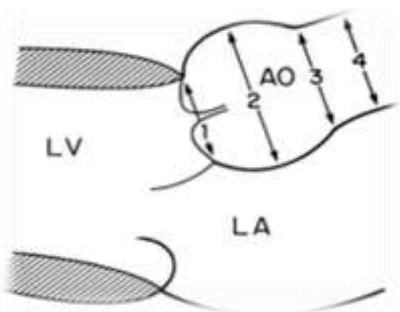

Figure ١:
Diagram of the aortic root in the two-dimensional parasternal long-axis view. Measurements were obtained at the level of the aortic annulus (١), sinuses of Valsalva (٢), supra-aortic ridge (٣), and proximal ascending aorta (٤). LV indicates left ventricle; LA, left atrium; and AO, aorta. (٣١)

Assessing severity of aortic regurgitation :

Assess aortic regurgitation as mild, moderate, severe depending on jet width, vena contracta , pressure half time

Vena contracta:

In parasternal long axis veiw look at the color jet through the valve . The vena contracta is the narrowest part of the jet below the valve. Jet width as proportion of outflow tract . Measure the vena contracta (jet width). Measure the width. Report the jet width as a percentage of the LV outflow tract of the left ventricular outflow tract at the same point

Parameters to determine severity of aortic regurgitation

	Mild	Sever
Vena contracta	< ٠,٣ cm	>٠,٦cm
Jet width of LVOT	Central <٢٥٪ of LVOT	Central ,>٦٥٪ of LVOT
Pressure half time	>٥٠٠msec	<٢٠٠msec

Data Analysis And Statistical Methods

Mean values are presented with SD as the index of dispersion .Differences between mean values of the two groups were tested with Student t test .the strength of the relationship of each aortic root measurement with the body size and blood pressure variable was evaluated by the Pearson correlation coefficient .Independence of association was tested in multivariate analyses. Significance of differences between blood pressure quartiles was evaluated by ANOVA. Significance of differences in populations was evaluated with the value of P<.٠٥ was considered statistically significant.

RESULTS

Comparison of Age, Body Size, and Blood Pressure

Table (١) shows distribution of studied group according to age ,body size and blood pressure. Mean age (٥٥,٩٨±٩,٢٤ versus ٥٥,٦±٨,٩٥ years ,p=NS) was identical in both two groups. The height (١,٧٠±٠,٠٨m versus ١,٦٩±٠,٠٧m in the two groups p=NS) and the body surface area (١,٩٠±٠,٢٠ versus ١,٨٧±٠,٢١m²,P=NS) were similar in the two groups, the average weight of hypertensive subjects was ٦Kg more than that of normotensive subjects(٧٩,١±١٥,٤ versus٧٣,١±١٥,٧ kg,P<٠,٠٤),and body mass index ,was slightly higher in the hypertensive group (٢٧,٢± ٣,٨ versus٢٥,٨±٤,١Kg/m²,P<.٠٥).Heart rate was slightly increased in the hypertensive group (٧١±١٢ versus ٦٧±٩ bpm,P<.٠٥).

Comparison of aortic diameters

Table (٢) shows Aortic root diameters at the annulus and sinuses of Valsalva are higher in the hypertensive group ,but the differences did not achieve statistical significance. Diameter at the supra –aortic ridge and proximal ascending aorta were significantly increased in the hypertensive group (P<.٠١ for both comparisons). Table (٣) shows that Indexing the diameters by height were significantly increased in the hypertensive group, When the entire population was divided by sex (١٢٠ men and ١٠٠ women), diameters remained significantly larger for hypertensive than normotensive men at the supra-aortic ridge and proximal ascending aorta (P<.٠٠٥ for both comparisons).

Comparison between height and body surface area index regarding aortic root measurements in patient group as shown in table(٤)indexing by body surface area eliminated statistical significance,whereas indexing by height were higher in all aortic root reading as shown in table (٥).

Relation of Aortic Root Dimension to Age ,Body Size and Blood pressure.

As demonstrated in Table (٦), age did not bear a significant univariate relation to aortic diameter in the two age-matched populations. Aortic root diameters at all levels were significantly related to height, and body surface area. Aortic diameters at all levels were also significantly related to systolic and diastolic pressures when the entire population was considered.As indicated in table(٦) among normotensive subjects, aortic diameters were more strongly related to systolic pressure .In multiple regression analysis that involve the whole study population with height ,age ,and systolic blood pressure entered as variables ,height was the strongest predictor of aortic diameter at all levels (P<.٠٠٠٠٥ for all).Age was also an independent determinant of all aortic diameters.systolic pressure also entered the model for each diameter except at the sinus of Valsalva as demonstrated in table(٧).

Comparison of Aortic Measurements by Severity of Pressure Load

Fig ٢ shows aortic root diameters compared by quartiles of hemodynamic load. When the combined normotensive and hypertensive study population was divided into quartiles of casual systolic pressure (first quartile, <١٢٢ mm Hg; second quartile, ≥١٢٢ and <١٤٠; third quartile, ≥١٤٠ and <١٥٧; fourth quartile, ≥١٥٧), progressive enlargement was found only at the supra-aortic ridge (P<.٠٠٥) and ascending aorta (P<.٠٥). When the entire study population was divided into quartiles of casual diastolic pressure (first quartile, <٧٨ mm Hg; second quartile, ≥٧٨ and <٨٤; third quartile, ≥٨٤ and <٩٢; and fourth quartile, ≥٩٢), all aortic diameters were found to significantly increase with increasing blood pressure, with the most significant increases occurring in the more distal segments.

Aortic Regurgitation

It was found in ٥,٥٪of the normotensive subjects and ٧,٣٪ of the hypertensive subjects p=NS.Aortic regurgitation was mild in two and moderate in four normotensive subjects ,and mild in three and moderate in five hypertensive subjects.

Table ١: Distribution of the studied groups according to age ,body size and blood pressure.

	Patient Mean±SD n=١١٠	Control Mean±SD n=١١٠	P-value t-test
Age	٥٥,٩٨±٩,٢٤	٥٥,٦٠±٨,٩٥	NS
Weight	٧٩,١±١٥,٤	٧٣,١±١٥,٧	٠,٠٤
Height	١,٧٠±.٠٨	١,٦٩±.٠٧	NS
BMI	٢٧,٢±٣,٨	٢٥,٨٠±٤,١	.٠٥
BSA	١,٩٠±.٢٠	١,٨٧±.٢١	NS
Heart Rate	٧١±١٢	٦٧±٩	.٠٥
Systolic BP	١٤١,٣٥±١٨,٣٧	١٢١,٠٥±١٤,٣٢	.٠٠١
Diastolic BP	٩٠,٣٥±٨,٠٨	٦٨,٠٥±٨,٧٩	.٠٠١

Table٢: Comparison of Aortic dimensions between patient and control groups.

variable	Patient Mean±SD n=١١٠	Control Mean±SD n=١١٠	P
Aortic annulus (cm)	٢,٤±.٢٩	٢,٣٣±.٢٤	NS
Sinus of Valsalva (cm)	٣,٤٥±.٤٣	٣,٣٥±.٣٥	NS
Sinotubular (cm)	٢,٩٣±.٣٩	٢,٧٣±.٣٣	٠,٠١*
Ascending aorta (cm)	٣,٢٧±.٤٤	٣,١٢±.٣١	٠,٠١*

Table ٣: Comparison of Aortic Dimensions indexed for Height.

Variable	Patient Mean±SD n=١١٠	Control Mean±SD n=١١٠	P
Annulus / Height	١,٤٠±.١٤	١,٣٦±.١٣	NS
Valsalva / Height	٢,٠٣±.٢٠	١,٩٧±.٢٠	NS
Sinotubular /Height	١,٧٢±.١٩	١,٦١±.١٨	.٠٠٥*
Ascending /Height	١,٨٩±.٢٣	١,٨٠±.١٩	.٠٠٥*

Table ٤: Comparison of Aortic Dimensions indexed for Body Surface Area (BSA).

		N	Mean	SD	P
Pair ١	Anulus/height	١١٠	١,٣٧٩٢	.٠٧	.٠٠٠١
	Anulus/BSA	١١٠	١,٢٣٦	.٠٨	
pair ٢	Valsalva/height	١١٠	١,٩٥٦٢	.١٣	.٠٠٠١
	Valsalva/BSA	١١٠	١,٧٧٣٢	.١١	
Pair ٣	Sinotubular/Height	١١٠	١,٦٦٤٦	.٠٨	.٠٠٠١
	Sinotubular/BSA	١١٠	١,٤٩٢٩	.٠٩	
Pair ٤	Ascending/Height	١١٠	١,٧٦٥٣	.٠٩	.٠٠٠١
	Ascending/BSA	١١٠	١,٥٩٣٢	.١١	

Table ٥: Comparison between height and body surface area (BSA) index regarding aortic root measurement in patient group.

variable	Annulus	Sinus of Valsalva	Sinotubular	Ascending aorta
	P	P	P	P
Height	.٠٠٠٥*	.٠٠٠٥*	.٠٠٠٥*	.٠٠٠٥*
Age	.٠٠٥*	.٠٠٠٥*	.٠٠٥*	.٠٠٥*
Systolic pressure	.٠٥*	NS*	.٠١*	.٠٠٥*

Table ٦: Relation of Aortic dimension to Age ,Body Habitus and Blood Pressure Univariate Analyses.

	Patient Mean±SD n =١١٠	Control Mean±SD n=١١٠	P
Annulus / BSA	١,٢٨±.١٤	١,٢٧±.١٥	NS
Valsalva / BSA	١,٨٢±.٢٤	١,٨١±.٢٦	NS
Sinotubular/ BSA	١,٥٣±.١٩	١,٤٩±.٢١	NS
Ascending / BSA	١,٧١±.٠	١,٦٦±.٢٢	NS=.٠٩

Table ٧: Relation of Aortic Root Dimensions to Age ,Body Habitus and Blood Pressure; multivariate analyses.

variable	annulus	Sinus of Valsalva			Supraaortic ridge			Ascending aorta
	r	P	r	P	r	P	r	P
Age	.٠٨	NS	.١١	NS	.٠٧	NS	.٠٩	NS
Height	.٤٤	<.٠٠٠١	.٤٢	<.٠٠٠١	.٤٥	<.٠٠٠١	.٤٣	<.٠٠٠١
Weight	.٤١	<.٠٠٠١	.٣٤	<.٠٠٠١	.٣٥	<.٠٠٠١	.٣١	<.٠٠٠١
BSA	.٤٨	<.٠٠٠١	.٤٢	<.٠٠٠١	.٣٩	<.٠٠٠١	.٤١	<.٠٠٠١
Systolic BP	.١٨	<.٠٠٠١	.١٧	<.٠٠٠١	.٢٣	<.٠٠٠١	.٢٠	<.٠٠٠١
Diastolic BP	.١٧	<.٠٠٠١	.١٨	<.٠٠٠١	.٢٥	<.٠٠٠١	.٢٤	<.٠٠٠١

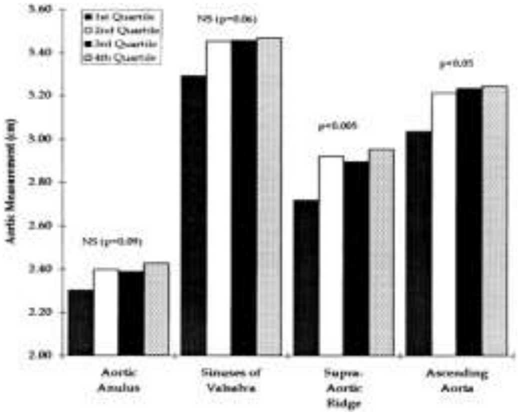

Figure ٢(A): Aortic root diameters in the entire population compared by quartiles of hemodynamic load., Aortic root dimensions in relation to quartiles of systolic pressure.

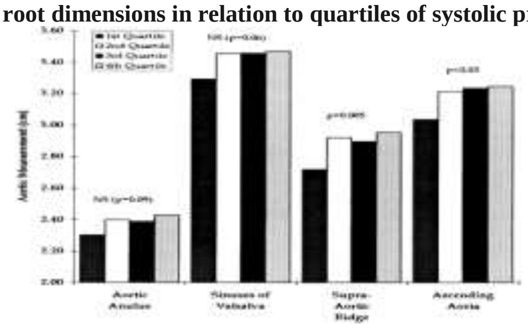

Figure ٢(B): Aortic root diameters in the entire population compared by quartiles of hemodynamic load., Aortic root dimensions in relation to quartiles of diastolic pressure.

DISCUSSION:

A small but significant enlargement of the aortic root was detected in that current study ,when comparing age and sex matched populations of hypertensive and normotensive subjects of a similar body size. Differences were found most consistently in the distal segments of the aortic root (the supra aortic ridge and ascending aorta) . The effect of blood pressure was most evident when the severity of blood pressure was taken into account by comparing groups divided by quartile of blood pressure (most notably, diastolic).Although the greatest differences in aortic root diameter were found in the distal segments, including the level of commissural support to the aortic valve, the prevalence of aortic regurgitation was law in our populations and did not significantly differ between the normotensive and hypertensive groups and that can be explain by that Aortic valve is the least valve to have Regurgitation in comparison to other valves and effect of hypertension more one sinuotubular junction ,not on annulas. Previous study evaluating the relation of aortic root size to blood pressure have yielded conflicting results. Recently,Vasan et al (١٥) using two –dimensionally guided M-mode measurement of the sinuses of Valsalva in the Framingham Heart Study ,found The additional influences of blood pressure measurements, although highly significant statistically, were small and revealed direct relations of aortic root dimensions with diastolic and mean arterial pressures and inverse relations with systolic and pulse pressures.that diastolic pressure was directly related to aortic diameter, where as both systolic and pulse pressure were inversely related to aortic diameter after adjustment for age ,height and weight(٣٢) .In the earlier study(٢) involving ١٠٢ patients with severe aortic regurgitation ,they found similar mean M-mode aortic diameter in normotensive and hypertensive groups. Age (P<.٠٠٠٥) and diastolic pressure(P<.٠٥) were multivariate correlates of aortic diameter in the normotensive group, whereas only age (P<.٠٠٥) predicted aortic diameter in the hypertensive group (٢).Tell et al (١٦) in the Cardiovascular Health Study found a relation between diastolic but not systolic pressure and M-mode echocardiographic dimensions when the entire elderly cohort was analyzed: however ,when the healthier sub group, (no coronary heart diseases or antihypertensive therapy)was examined, aortic diameter was not associated with blood pressure. Other researches have shown either no relation of blood pressure to M-mode aortic measurement or relation only to systolic pressure.(١٤) In the present study ,using a more thourgh and accurate measurement of the entire aortic root, we found significant differences between normotensive and hypertensive subjects in aortic root diameter, primarily at supra-aortic ridge and proximal ascending aorta. Failure to find a statistically significant difference at the sinuses of Valsalva and aortic annulus (the area usually measured by M-mode echocardiography) may explain the relatively weak relations of blood pressure to aortic root diameter in previous studies and may reconcile discrepant findings in earlier pathological studies of hypertensive patients succumbing to aortic regurgitation in which higher segments of the aorta may have been examined. (٦،٧) Despite similar mean pressures, systolic and diastolic pressures may vary considerably(٢٢) with the degree of wave amplification, being maximal in the young, normotensive individual with a compliant vasculature.(٢٣) When aortic root diameter increases, aortic valve cusps are unable to expand in area, and the degree of cusp overlap is reduced, eventually leading to aortic regurgitation.(٢٤،٢٥)Since the point of commissural attachment is at the supra-aortic ridge, increases in this diameter are more likely to be of greater pathophysiological significance(٩) Thus, dilatation in the more distal segment of the aortic root has been shown to be associated with more-severe left ventricular structural and functional abnormalities in patients with severe aortic regurgitation due to idiopathic root dilatation in comparison with patients with severe aortic regurgitation due to valvular disease(٢) Therefore, the greatest hemodynamic effects of root dilatation appear to be when it occurs at the distal portions of the aortic root. Although hypertension was associated with larger measurements in the distal aortic root in the present study, there was no significant difference in the prevalence of aortic regurgitation between the normotensive and hypertensive subjects, perhaps because of their relatively young age, mild degree of hypertension, and otherwise healthy status. In fact, in a previous analysis limited to individuals with severe aortic regurgitation, antecedent hypertension was strongly associated with the presence of idiopathic aortic root dilatation as the cause of aortic regurgitation(٢). Relationships of body size to aortic size have been uniformly noted in previous populations(٢٦,٢٩،٣٠) and were confirmed in the present study. Indexation of the aortic diameters for body surface area eliminated differences in aortic size between normotensive and hypertensive subjects, whereas indexation for height marginally amplified differences. Seder JD et al have suggested that the use of body surface area as a means of adjustment for differences in body size is mathematically incorrect and that indexation of aortic diameter for height is a more linear and mathematically sound way of comparing measurements(٢٧).

CONCLUSION:

١. Aortic root diameters at the supra-artic ridge and proximal ascending aorta are significantly greater in hypertensive patients compared with an age –and –sex matched normotensive population.
٢. Although hypertension was associated with larger measurements in the distal aortic root in the present study, there was no significant difference in the prevalence of aortic

regurgitation between the normotensive and hypertensive subjects because it have more effect on distal portion of root and less on annulas .

٣. There is strong statistical association between the height and aortic root measures in both normotensive and hypertensive subjects.

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