Lack of Correlation Between Left Ventricular Mass and Diameter of Left Coronary Artery Main Trunk in Hypertensive Patients

Cesare Cuspidi, Laura Lonati, Lorena Sampieri, Laura Valagussa, Iassen Michev, Gastone Leonetti, and Alberto Zanchetti

The study was designed to evaluate whether the increase in left ventricular (LV) mass in essential hypertensives (H) is associated with a proportional increase in diameter of the left coronary artery (LCA) trunk. Twenty-six hypertensives, 14 with left ventricular hypertrophy (LVH) (left ventricular mass index [LVMI] > 134 g/m² in men and > 110 g/m² in women) and 12 without LVH, and 10 normotensive controls (C) underwent clinical laboratory and echocardiographic transthoracic examination. LV dimensions were measured according to the Penn convention and LV mass calculated by the formula of Devereux. The LCA main trunk was visualized by two-dimension short axis view at the level of the great vessels section, and the diameter measured as intima–intima distance at end-diastole. Hypertensives with and without LVH and C had similar age, sex, and body surface area distribution. LVMI was, by definition, significantly higher in H with LVH than in H without LVH and in C (144 ± 21, 113 ± 13, and 98 ± 10 g/m², P < .01), whereas the diameter of the LCA trunk was similar in all groups (0.48 ± 0.1, 0.48, and 0.46 cm, respectively). There was no significant correlation between LVMI and LCA diameter in H (r = 0.21, P = not significant). The diameter of LCA trunk was significantly correlated only with BSA (r = 0.5, P < .01), LV end-systolic and end-diastolic diameters (r = 0.5 and r = 0.4, P < .05). Our data suggest that in H the increase in LVM is not associated with a concomitant increase of epicardial coronary artery diameter, and this finding may account in part for the impairment of coronary blood flow reserve in LVH. Am J Hypertens 1999;12:1163–1168 © 1999 American Journal of Hypertension, Ltd.

KEY WORDS: Arterial hypertension, left ventricular hypertrophy, transthoracic echocardiography, left coronary main trunk.
nary oxygen supply is a discrepancy between the diameter of epicardial coronary arteries and cardiac mass in patients who had suffered coronary events. On the other hand, the physiologic cardiac hypertrophy observed in athletes has been reported to be associated with an increased diameter of extramural coronary arteries. Few studies have examined the relationship between coronary artery size and LV mass in arterial hypertension using angiography or transesophageal echocardiography and none of them have measured coronary lumen diameter with standard echocardiography.

In the present study we have measured the diameter of the common left coronary artery (LCA) trunk by transthoracic echocardiography in essential hypertensive patients with and without LVH to investigate whether a relationship exists between left ventricular mass and the diameter of extramural coronary arteries.

**METHODS**

**Study Population** The overall study population consisted of 36 subjects, 10 healthy volunteers and 26 hypertensive patients with optimal quality echocardiographic examinations. In 9 patients hypertension had recently been diagnosed (at least five measurements of clinic systemic blood pressure during the previous 6 months ≥160/90 mm Hg) and had never been treated. In the other 17 patients antihypertensive therapy was discontinued for at least 1 week before the study began.

Individuals with valvular or primary myocardial heart disease, previous myocardial infarction, and heart failure were excluded, as were those with diabetes and marked dyslipidemia, renal and hepatic insufficiency. In 8 of the 26 patients a coronary angiogram was performed to rule out the suspicion of coronary artery disease suggested by chest pain or a positive exercise electrocardiogram; they were included because the angiogram showed normal coronary arteries.

All 36 subjects underwent complete two-dimensional, M-mode, and Doppler transthoracic echocardiographic examinations for measurement of LV mass, function, and main left coronary trunk diameter. All participants were informed about the procedure and gave their informed consent.

**Echocardiography** In all subjects standard M-mode, two-dimensional, and Doppler echocardiography was performed by two highly skilled physicians (CC and LL) using a commercially available instrument (ATL 3000 HDI Bothell, Washington DC) equipped with a 2.25-MHz imaging transducer to exclude any structural cardiac alteration, except LVH.

Left ventricular internal diameters and parietal thicknesses were calculated from two-dimensionally guided M-mode tracings and measured at end-diastole in five consecutive cycles according to the recommendations of the Penn convention. Only frames with optimal visualization of the interfaces and showing simultaneously the interventricular septum, LV internal diameters, and posterior wall were considered adequate to determine LV mass. LV mass was calculated by the formula introduced by Devereux et al and normalized by body surface area. In our laboratory the intraobserver and interobserver coefficients of variation for LV mass index are 7.4% and 8.6%, respectively. The fractional shortening, an index of LV performance, was determined by the formula: \( \frac{(\text{end-diastolic dimension} - \text{end-systolic dimension}) \times 100}{\text{end-diastolic dimension}} \). The relative wall thickness, a measure of LV geometry, was calculated as the sum of the interventricular septum and the posterior wall thickness divided by the end-diastolic dimension. A ratio ≥0.45 was considered expression of LV remodeling or of concentric LVH.

Echo-Doppler investigation of LV inflow was performed with the subject in the left lateral decubitus, at the end of expiration. Doppler mitral flow was recorded on photographic paper at 100 mm/s, and the following variables were measured: early diastolic peak flow velocity (E), late diastolic peak flow velocity (A), and their ratio (E/A).

**Left Coronary Artery Main Trunk Measurement**

The transthoracic echocardiographic approach allows quantitative examination of the coronary ostium and the proximal portion of left and right coronary arteries only. On the standard right parasternal short axis aortic root view, the ostium of the LCA and the left main trunk were successfully visualized in all the 36 individuals. The LCA main trunk on the longitudinal section appears as two parallel echogenic lines (that represent the lumen intima–media interface) separated by an “echo-free” interface, that corresponds to the arterial lumen (Figure 1). The end-diastolic lumen diameter was measured as intima–media distance. The standard echocardiographic image was magnified (three to four times). The intraobserver variability of LCA trunk diameter measurement was 3.8% ± 2.1% and interobserver variability was 4.7% ± 2.9%. The precision of the echocardiographic measurements of LCA main trunk was expressed by comparing echocardiographic with angiographic measurements in the group of 8 patients who also underwent diagnostic coronary angiography. There was a highly significant correlation between the transthoracic echocardiographic and the coronary angiography measurements of the LCA main trunk diameter in the group of 8 hypertensive patients who underwent angiographic study for suspected coronary artery disease (Figure 2).
Statistical Analysis Values are expressed as means ± SD. Statistical evaluations between the groups were performed by Student's t test. Correlations were obtained by using Pearson's equation. P < .05 was considered statistically significant.

RESULTS

Characteristics of Patients The hypertensive patients were divided in two groups based on the absence (group IIa, n = 12) or the presence (group IIb, n = 14) of LVH. LVH was defined as a left ventricular mass index ≥134 g/m² for men and ≥110 g/m² for women. Age, sex distribution, body surface area, cholesterol levels, and cigarette smoking habit were similar in the two groups of hypertensives and in the normotensive controls. Systolic and diastolic blood pressure values were comparable in hypertensives with and without LVH and significantly higher, by definition, than in normotensives (Table 1).

Left Ventricular Structure and Function The interventricular septum and LV posterior wall thickness were significantly higher in patients with LVH than they were in those with normal LV mass and in normotensive controls. No statistical difference was found between LV end-diastolic and end-systolic internal diameters among the three groups.

The LV mass index (LVMI) was significantly higher, by definition, in hypertensives with LVH than in hypertensives without LVH and in normotensive controls (144 ± 21 v 113 ± 13 and 98 ± 14 g/m², respectively, P < .01). The fractional shortening, which is a rough index of LV systolic performance, did not differ between the three groups. LV filling, evaluated by the ratio of peak velocity of mitral flow in early (E) and in late diastole (A), was altered in patients with LVH, who had a significantly lower ratio than the patients without LV hypertrophy and the normotensive controls (Table 2).

LV Main Coronary Trunk Diameter The diameter of main coronary trunk was the same in both hypertensive groups (0.48 ± 0.1 v 0.48 ± 0.1 cm, P = not significant [NS]) and comparison of hypertensives with normotensive individuals (0.46 ± 0.1 cm, P = NS) showed a trend to larger diameter in the former group but without statistical significance.

Correlations Between LCA Trunk Diameter and LV Mass Index There was no significant correlation between LCA trunk lumen diameter and LVMI considering all hypertensives together (r = 0.29, P = NS) (Figure 3). LCA trunk diameter was significantly correlated with body surface area (r = 0.5, P < .01) and LV end-diastolic and end-systolic diameters (r = 0.5 and r = 0.4, respectively, P < .01) only.

DISCUSSION

The present study shows that in patients with essential hypertension the increase of LV mass is not associated with a proportional increment of the diameter of extramural coronary arteries. At variance from what was observed in normotensive subjects by another study, in the 26 hypertensive patients evaluated in the present study the diameter of the common coronary trunk was not significantly related to LVMI. This observation will be discussed considering the following points: 1) factors influencing the caliber of coronary arteries, and 2) dimensions of coronary arteries and pathologic LVH.

Determinants of Coronary Artery Diameter The major part of postmortem and angiographic studies was aimed at the search of atherosclerotic plaques. In vivo factors influencing the caliber of epicardial coro-
Coronary arteries has been poorly investigated, as only in a limited number of angiographic studies the diameter of coronary arteries has been measured in subjects free from major cardiovascular diseases.

The influence of age on the dimensions of coronary arteries has been analyzed in a few studies, but the results are controversial. A tendency to an increase in the diameter of coronary arteries with aging has been observed in some postmortem studies, but these results have been denied by subsequent autopic and angiographic studies.19–22 In a recent study by Leung et al,19 using a computerized system, the diameter of coronary arteries was found to decrease with aging. Indeed, the cross-sectional area of coronary arteries was significantly inversely related with age (r = 0.53).

The mechanism by which the dimensions of the coronary arteries decrease with aging is not clear. It could be related to the presence of concentric atherosclerosis, which is not detected by current angiographic methods; this process will tend to decrease the vascular lumen in middle-age subjects and in the elderly. Alternatively, to the age-dependent intima–media thickening of the vascular wall, not necessarily attributable to the atherosclerotic process, to the changes of the coronary dimensions due to the decreased demand of coronary flow as a consequence of the reduced physical activity in the advancing age, or finally to the age-dependent changes to the myocardial structure and consequently of the coronary flow.22,23

Gender does not seem to be an important factor per se in determining coronary dimensions. Some investigators observed that the coronary diameter is smaller in women than in men; however, this difference is only due to the different body surface area of the two sexes.24,25 Body surface area is an important demographic variable; in the present study we found, in agreement with other studies, a significant correlation between this variable and the diameter of the common trunk (r = 0.5).

### TABLE 1. CLINICAL CHARACTERISTICS OF STUDY SUBJECTS

<table>
<thead>
<tr>
<th>Control Subjects Group I</th>
<th>Hypertensives Without LVH Group IIA</th>
<th>Hypertensives With LVH Group IIB</th>
<th>P (IIA v IIB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>49.2 ± 8.7</td>
<td>50.0 ± 10.1</td>
<td>48.2 ± 11.0</td>
</tr>
<tr>
<td>Gender (M/F)</td>
<td>7/3</td>
<td>8/4</td>
<td>10/4</td>
</tr>
<tr>
<td>BSA (m²)</td>
<td>1.84 ± 0.3</td>
<td>1.85 ± 0.2</td>
<td>1.83 ± 0.2</td>
</tr>
<tr>
<td>Smokers</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total plasma cholesterol (mg/dL)</td>
<td>222 ± 35</td>
<td>236 ± 42</td>
<td>239 ± 45</td>
</tr>
<tr>
<td>SBP (mm Hg)</td>
<td>120.4 ± 10.1</td>
<td>151.4 ± 30.0*</td>
<td>154.7 ± 16.4*</td>
</tr>
<tr>
<td>DBP (mm Hg)</td>
<td>80.3 ± 7.1</td>
<td>89.3 ± 12.9*</td>
<td>92.9 ± 13.0*</td>
</tr>
<tr>
<td>HR (beats/min)</td>
<td>74.5 ± 11.0</td>
<td>71.5 ± 10.8</td>
<td>69.8 ± 12.7</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SD; *P < .05 v control subjects.

BSA, body surface area; SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate.

### TABLE 2. ECHOCARDIOGRAPHIC PARAMETERS IN STUDY SUBJECTS

<table>
<thead>
<tr>
<th>Control Subjects Group I</th>
<th>Hypertensives Without LVH Group IIA</th>
<th>Hypertensives With LVH Group IIB</th>
<th>P (IIA v IIB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVTDd (mm)</td>
<td>46.1 ± 2.5</td>
<td>47.5 ± 3.4</td>
<td>48.5 ± 4.1*</td>
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<tr>
<td>LVTSd (mm)</td>
<td>28.2 ± 3.4</td>
<td>29.2 ± 4.3</td>
<td>29.7 ± 5.4</td>
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<tr>
<td>IVS (mm)</td>
<td>9.3 ± 0.8</td>
<td>10.4 ± 1.5</td>
<td>12.5 ± 1.6*</td>
</tr>
<tr>
<td>PW (mm)</td>
<td>8.7 ± 0.9</td>
<td>10.0 ± 0.7*</td>
<td>11.0 ± 1.3*</td>
</tr>
<tr>
<td>FS %</td>
<td>38.8 ± 3.5</td>
<td>37.0 ± 2.3</td>
<td>37.3 ± 4.1</td>
</tr>
<tr>
<td>LVMI (g/m²)</td>
<td>91.3 ± 10.1</td>
<td>112.1 ± 13.4*</td>
<td>143.8 ± 20.9†</td>
</tr>
<tr>
<td>E/A</td>
<td>1.5 ± 0.2</td>
<td>1.4 ± 0.3</td>
<td>1.0 ± 0.3*</td>
</tr>
</tbody>
</table>

Data are expressed as mean ± SD; *P < .05; †P < .01 v control subjects.

LVTDd, left ventricular diastolic diameter; LVTSd, left ventricular systolic diameter; IVS, interventricular septum thickness; PW, posterior wall thickness; FS, fractional shortening; LVMI, left ventricular mass index; E/A, protodiastolic to telediastolic transmitral peak flow velocity ratio.
an adaptive response of this arterial district to the increased oxygen demand of the hypertrophic myocardium either at rest or during exercise. Physiologic hypertrophy of the athletic heart is associated with a proportional increase of the cross-sectional area of the coronary arteries.

**Dimensions of the Extramural Coronary Arteries and Pathologic Hypertrophy of the Left Ventricle** The relationship between LV pathologic hypertrophy and the diameter of coronary arteries is a second point to be considered and is a more controversial issue. The limited number of data available has stimulated our interest in undertaking the present study.

The result of the present study, the first to our knowledge, performed with a transthoracic echocardiographic method, shows that in hypertensive patients with LVH the coronary diameter is comparable to that of hypertensive patients showing an LV mass within the normal range (113 g/m²), a value that is only slightly increased compared to normotensive subjects (98 g/m²).

From a methodologic point of view, our results are supported by the following considerations: 1) the echocardiographic evaluation of the common trunk is validated by the concomitant angiographic measurement in 8 of 26 patients and the correlation between the two methods is statistically significant; 2) our results were not affected by differences in demographic characteristics such as age, body surface, and sex, which were superimposable between the two groups.

Thus, it can be concluded that LVH in hypertension, different from physiologic hypertrophy, is not associated with a detectable increase in coronary diameter; this different response may contribute, in part, to the decrease of coronary reserve. Thus, our observations, although limited to the common coronary trunk, agree with the results of a recent angiographic study by Nitemberg and Antony in two groups of hypertensive patients with and without LVH, whose mean values of mass index were superimposable to ours. The absence of an increase of coronary diameter in patients with LVH may be a marker of the presence of functional and structural alterations. About the first point, it is well known that in hypertensive patients the coronary vasomotor tone may be increased due to the stimulated activity of the sympathetic and the renin angiotensin aldosterone system. An increased adrenergic tone may decrease the diameter or prevent its increase induced by an enhanced oxygen demand. The altered sympathetic control of coronary circulation may become more pronounced with the progression of the hypertensive disease, in the presence of the organ damage such as LVH.

From an anatomic point of view it is possible that, as in other vascular districts, such as carotid and femoral district, the thickness of the complex intima–media of the coronary arteries increases at the expense of the lumen, causing a thickening not detectable by angiographic and echographic methods. From a clinical point of view, the lack of a concomitant increase of coronary caliber and LV mass, may suggest the presence of another mechanism that, in association with other factors, may compromise the balance between the oxygen demand and supply in the hypertrophic myocardium, thus increasing the risk of ischemia and infarction.

**REFERENCES**
