Silent ST Depression and Cardiovascular End-Organ Damage in Newly Found, Older Hypertensives

Willem F. Terpstra, Johan F. May, Andries J. Smit, Pieter A. de Graeff, Frits H. Schuurman, Betty Meyboom-de Jong, Harry J.G.M. Crijns

Abstract—In hypertension, both reduced vascular supply and increased cardiac demand contribute to the development of (silent) myocardial ischemia. Our aim was to determine the prevalence of ST-segment depression and to analyze contributing factors in asymptomatic, previously untreated, older hypertensives. From a population survey, in 184 patients with mild hypertension (4 times systolic blood pressure ≥160 mm Hg and/or diastolic blood pressure ≥95 mm Hg), 60 to 75 years of age, cardiovascular end-organ damage was measured. Episodes of ST-segment depression were measured by 48-hour ambulatory Holter monitoring and were observed in 21 hypertensives (12%). They showed a significantly higher combined far-wall intima-media thickness of carotid and femoral arteries and more arterial plaques as measured by B-mode ultrasound compared with hypertensives without ST depression (0.00098±0.00021 versus 0.00088±0.00016 mm and 5.2±3.7 versus 3.7±2.8 plaques, P<0.05, respectively), whereas left ventricular mass index was not different (111±18 versus 104±24 g/m²; P=0.18, respectively). In hypertensives with transient ST-segment depression, a significant relation was found between left ventricular mass and ischemic burden (r=0.51, P=0.02). Approximately 1 of 8 unselected and previously untreated older hypertensives show asymptomatic ST-segment depression, suggestive of silent myocardial ischemia. These data suggest that vascular factors mainly determine the occurrence of ischemic ST-segment depression and cardiac factors determine the ischemic burden in older hypertensives. (Hypertension. 2001;37:1083-1088.)

Key Words: ischemia ■ hypertrophy, left ventricular ■ ventricular function, left ■ elderly ■ hypertension, secondary

Silent myocardial ischemia is defined as transient myocardial ischemia in the absence of angina pectoris or other cardiac symptoms. It is frequent among hypertensive patients with or without atherosclerotic coronary disease, even in the absence of epicardial coronary artery disease or left ventricular hypertrophy.1,2 Zehender et al.3 observed transient ST-segment depression on Holter monitoring in 33% of 150 middle-aged, ineffective treated, hypertensive patients without manifest coronary artery disease. The majority of these episodes of transient myocardial ischemia was not associated with symptoms. Hedblad and Janzon4 reported a high incidence of ischemic ST depression of 41% in treated hypertensive men with inadequate blood pressure control. Whether antihypertensive treatment influences the ST-segment depression in hypertension is debatable; without these drug treatment effects, the pathophysiology of ST-segment depression can be studied. To our knowledge, no study reported prevalence of asymptomatic ST-segment depression in a large group of never-treated, hypertensive patients.

Important vascular factors contributing to the occurrence of myocardial ischemia in hypertensive patients include atherosclerotic obstruction of the large coronary arteries and a reduced vasodilatory capacity of the coronary microcirculation caused by arteriolar hypertrophy and endothelial dysfunction. Another factor contributing to the occurrence of myocardial ischemia is the increased myocardial oxygen demand to supply the hypertrophic myocardium as it is seen in hypertension. Both vascular supply and cardiac demand factors reduce the capacity of the coronary circulation to increase myocardial blood flow during stress and therefore reduce the coronary blood flow reserve.

The objective of this study was to determine the prevalence and characteristics of transient ST-segment depression and its relation with cardiovascular end-organ damage as measured by left ventricular mass and large-vessel intima-media thickness (IMT) in previously untreated, older hypertensive patients.

Methods

Patients

Patients with previously untreated mild to moderate hypertension were recruited from a population survey performed in the north of
the Netherlands in 2 rural municipalities. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured 4 times at 3 occasions. Patients were included in the study if SBP or DBP was 4 times $\geq 160$ mm Hg or $\geq 95$ mm Hg, respectively, and if they were between 60 and 75 years of age and had not been treated with antihypertensive drugs. Exclusion criteria were angina pectoris, manifest coronary artery disease (history of myocardial infarction, ECG at rest with pathological Q waves, or ST-segment changes, interpreted by an experienced cardiologist), secondary hypertension of any cause, current or recent history of congestive heart failure, hemodynamically significant valvular heart disease, cardiac arrhythmias, renal insufficiency, and electrolyte disturbances (serum potassium $< 3.0$ mmol/L or $> 6.0$ mmol/L). Patients with pacemakers, bundle-branch block, and office blood pressure $> 220/115$ mm Hg were excluded. The research protocol was approved by the Medical Ethical Committee of the University Hospital of Groningen, and written informed consent was obtained from all subjects.

Holter Monitoring
All patients underwent 48 hours of Holter monitoring during unrestricted daily life and were asked to keep a detailed diary of their activities and symptoms. Ambulatory 48-hour ST-segment monitoring was performed with a 4-channel ambulatory cardiological monitor in Grampian (Marquette series 8500) with modified leads aVF, V1, and V5 for the ECG and the fourth channel to record a 32-Hz time signal. This signal was used in a phase-locked loop circuit as well as a timer for the AD converter to correct tape speed irregularities. The ECG was analyzed on a Marquette XP analyzer (software version 5.6) and reviewed by an experienced analyst and supervised by a cardiologist, who were both blinded to clinical data. The $1 \times 1 \times 1$ rule according to P.F. Cohn was applied. The criteria to be studied were horizontal or downsloping ST-segment depression of $\geq 0.1$ mV. The depression in one of the leads had to last $\geq 1$ minute to be scored as an ischemic period. Episodes during postural changes and/or intraventricular conduction changes as explanations for ST-segment depression were excluded. When an ST-segment depression started within 1 minute after the end of the previous one, it was only recorded as a new one when abrupt changes in the ST-T shift were excluded. Number and total duration of ischemic periods, maximal ST depression, and ischemic burden, defined as total ST depression multiplied by time, were determined. Ambulatory ECG monitors were hooked up at the end of the physical examinations, usually between 11 AM and 4 PM, and were removed after 48 hours.

B-Mode Ultrasound Imaging
The B-mode ultrasound imaging of the carotid and the femoral arterial walls was done with an Acuson 128 (Acuson Corp) ultrasound machine, equipped with a 7.0-MHz L7384 linear array transducer, by 2 experienced sonographers who were blinded to the clinical data. The methods used to record and analyze B-mode ultrasound images have been described in detail before. In short, 10 prespecified segments, 3 from the left and right carotid arteries and 2 of the left and right femoral arteries, were scanned. In the carotid artery, the arterial segment 1 cm proximal to the carotid dilation (the common carotid artery), the arterial segment between the carotid dilation and carotid flow divider (carotid bulb), and a 1-cm-long arterial segment distal to the flow divider (internal carotid artery) were measured. In the femoral artery, a 1-cm-long arterial segment proximal to the femoral dilation (common femoral artery) and a 1-cm arterial segment distal to the femoral flow divider (superficial femoral artery) were measured. Of each arterial segment, 5-second real-time image sequences were stored on an S-VHS. B-mode ultrasound video images were analyzed off-line (S-VHS Panasonic NV-FS 100 HQ; VCR; Sony GYM-1400 QM multisync monitor; IDEN IVT-7p time base correctors, IPC 80486 personal computer equipped with DT2861 and DT2862 frame grabbers). Image analysis software was developed in cooperation with Selzer et al. The mean value of the IMT of the mean far walls of 3 carotid artery segments and 2 femoral artery segments was used for analysis. The IMT of the far wall was evaluated as the distance between the luminal-intimal interface and the medial-advential interface. When macrovascular lesions were obvious and the IMT was not measurable, lesions were considered plaques. Plaques were scored as a dichotomous variable in the 10 predefined arterial segments in both the near and far walls, and the score of plaques was expressed as the total amount of plaques of all arterial segments. The average plaque score of all arterial segments per patient was used for analysis. The measurement error of variation in the population studied was 0.03 mm for the mean maximum far-wall IMT. The primary end point of the B-mode ultrasound study was the combined mean far-wall IMT of the 10 segments of the carotid and femoral arteries.

Echocardiography
Echocardiographic examinations were recorded by a single trained observer. An Acuson XP-10 echocardiograph (Acuson Corp) with a 2.5- to 4.0-MHz transducer was used. Left ventricular diameters were measured in 2D mode according to the Penn Convention in the left lateral decubitus position. Three recordings were made of the end-diastolic left ventricular wall (LVPW), interventricular septum (IVS), and left ventricular end-diastolic diameter (EDD). To estimate left ventricular mass, the cube formula of Devereux and Reichek was used. To calculate left ventricular mass index, the left ventricular mass was divided by body surface area. For classification of the 4 groups of left ventricular geometry (normal geometry, concentric remodeling, eccentric left ventricular hypertrophy [LVH], and concentric LVH), the following cutoff values were used. LVH was defined as left ventricular mass index $\geq 125$ g/m$^2$; increased relative wall thickness (RWT) was defined as RWT $\geq 0.45$, as proposed by Koren et al. Systolic wall stress was determined according to the formula

\[
\text{Systolic wall stress} = 10 \cdot \text{dyne/m}^2 = (1.33 \cdot \text{SBP} \cdot \text{LVEDD/2})/(\text{IVS+LVPW}).
\]

Statistical Analysis
Descriptive statistics and comparisons between groups were performed with the SPSS statistical package (SPSS for Windows, version 8.0, SPSS Inc). All descriptive data are expressed as mean $\pm$SD. Equality of variances between groups with or without transient ST-segment depression were tested with Levene’s test. The independent $t$ test for equality of means was used to detect significant differences between the two groups as appropriate. In the case of categorical variables, the $\chi^2$ test was used. Changes in heart rate within patients were tested by a paired $t$ test. Univariate analysis of the associations between end-organ damage and parameters of ST-segment depression were performed with Pearson correlation coefficients after natural log transformation of the ST-segment parameters. To identify the determinants of episodes of ST-segment depression, logistic regression analysis was used. Clinical baseline variables included age, gender, body mass index, smoking, total cholesterol, HDL, LDL, non–insulin-dependent diabetes, SBP and DBP, pulse pressure, rate-pressure product, systolic wall stress, combined mean far-wall IMT, average plaque score, and left ventricular mass index.

Results
Patients
From the population survey, 1969 subjects had their blood pressure taken. A total of 1162 subjects had normal blood pressure, 421 subjects were treated with antihypertensive drugs, 214 subjects were identified as having untreated systolic hypertension, and 172 subjects were identified as having untreated diastolic hypertension. From these 386 untreated subjects, 184 fulfilled the inclusion and exclusion criteria and entered the study. Table 1 shows a comparison between hypertensive subjects with and those without ST-segment depression. The two groups differed with respect to body mass index and pulse pressure but not with respect to age, SBP and DBP, and lipid profile.
Prevalence of ST-Segment Depression

Recordings of Holter monitoring of adequate quality could be obtained from 178 patients (53% men), with a monitoring period of at least 46 hours. Of 6 patients, the quality of the Holter monitoring was inadequate for analysis. A total of 21 patients (12%) had a total of 97 episodes of significant ST-segment depression (median, 3.0 episodes per patient; range, 1 to 19). The prevalence was 9% in women and 13% in men. The duration of the single episodes was between 1.2 and 17.2 minutes (mean SD: 6.3.3). The range of total ischemic burden was between 2.5 and 453 mm/min. All patients had sinus rhythm, and no patient was taking digitalis medication. No patient recorded symptoms such as angina pectoris, so all ischemic periods were asymptomatic or at least not likely to be associated with definite symptoms of angina pectoris.

Circadian Variation in Ischemic Episodes and Relation to Heart Rate

Circadian variation in the frequency of ischemic episodes is shown in Figure 1. Ischemic episodes were nearly absent during the 6 night hours from 11 PM to 5 AM and had a peak during the morning hours after awakening between 7 AM and 11 AM and another less prominent peak during the evening between 7 PM and 10 PM. This circadian variation in ischemic episodes was not statistically significant (P=0.3).

The heart rate (± SD) during ST depression was significantly higher than the mean heart rate during 48 hours (92±22 versus 70±8 bpm, P<0.001, respectively). Mean heart rate at the onset of an ischemic episode was 92±22 bpm; mean heart rate at the peak of an ischemic episode was 106±18 bpm. A total of 17% of all episodes was accompanied by a reduction of heart rate, 25% of all episodes were accompanied by a small (1% to 15%) increase in heart rate, and 42% of all episodes were accompanied by a significant increase in heart rate (>15%). Three patients, with a total of 6 events (16%), had a heart rate at the onset of an ischemic event ≈130 bpm. No patient showed paroxysmal atrial fibrillation.

ST-Segment Depression and Vascular End-Organ Damage

Table 2 shows a comparison of cardiovascular end-organ damage in patients with or without ST-segment depression. Hypertensive patients with ST-segment depression showed an increased IMT, expressed as total mean far-wall IMT, and an increased frequency of plaques in the arterial segments studied. Within the group of hypertensives with ST-segment depression, the ischemic burden was not correlated with total

| TABLE 1. Characteristics of Hypertensive Patients With and Those Without ST-Segment Depression |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
| Characteristics                 | Patients With ST Depression (n=21) | Patients Without ST Depression (n=162) | P      |
| Male gender, %                  | 62              | 52              | 0.385           |
| Age, y                          | 67±5            | 67±4            | 0.777           |
| Body mass index, kg/m²          | 26.6±2.7        | 28.4±3.9        | 0.044*          |
| Office SBP, mm Hg               | 162±16          | 177±13          | 0.098           |
| Office DBP, mm Hg               | 91±8            | 95±8            | 0.051           |
| Pulse pressure, mm Hg           | 91±14           | 82±14           | 0.006*          |
| Isolated systolic hypertension, % | 71              | 46              | 0.032*          |
| Mean heart rate, 24-h, bpm       | 71±9            | 73±8            | 0.172           |
| Total cholesterol, mmol/L       | 6.1±1.0         | 5.9±0.9         | 0.585           |
| LDL cholesterol, mmol/L         | 3.99±0.98       | 3.96±0.82       | 0.883           |
| HDL cholesterol, mmol/L         | 1.26±0.33       | 1.25±0.30       | 0.850           |
| Triglyceride, mmol/L            | 1.73±0.92       | 1.62±1.30       | 0.725           |
| Current smoker, %               | 19              | 27              | 0.426           |
| Diabetes mellitus type II, n    | 1               | 5               | 0.681           |

Values are expressed as mean±SD.

*Difference significant at P<0.05.

Figure 1. Circadian distribution of episodes of ST-segment depression during 48-hour Holter monitoring. Multiple episodes in any patient were counted separately for occurrence hour; no episode overlapped >1 hour. Each bar shows count for hour.
**TABLE 2. Cardiovascular End-Organ Damage in Hypertensive Patients With and Those Without ST-Segment Depression**

<table>
<thead>
<tr>
<th>End-Organ Damage</th>
<th>Patients With ST Depression</th>
<th>Patients Without ST Depression</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVMi, g/m²</td>
<td>111±18</td>
<td>104±24</td>
<td>0.177</td>
</tr>
<tr>
<td>RWT</td>
<td>0.49±0.07</td>
<td>0.48±0.05</td>
<td>0.304</td>
</tr>
<tr>
<td>IVS, m</td>
<td>0.0113±0.001</td>
<td>0.0111±0.0011</td>
<td>0.495</td>
</tr>
<tr>
<td>LVpedd, m</td>
<td>0.0108±0.0008</td>
<td>0.0106±0.0009</td>
<td>0.209</td>
</tr>
<tr>
<td>LVEFD, m</td>
<td>0.0448±0.0050</td>
<td>0.00446±0.0047</td>
<td>0.872</td>
</tr>
<tr>
<td>Wall stress, 10²</td>
<td>245±31</td>
<td>243±31</td>
<td>0.749</td>
</tr>
<tr>
<td>IMTTot, m</td>
<td>0.00096±0.00021</td>
<td>0.00088±0.00016</td>
<td>0.014*</td>
</tr>
<tr>
<td>IMTAC, m</td>
<td>0.00099±0.00021</td>
<td>0.00092±0.00016</td>
<td>0.067</td>
</tr>
<tr>
<td>IMTAF, m</td>
<td>0.00096±0.00032</td>
<td>0.00084±0.00021</td>
<td>0.112</td>
</tr>
<tr>
<td>Average plaque score</td>
<td>5.2±3.7</td>
<td>3.7±2.8</td>
<td>0.025*</td>
</tr>
</tbody>
</table>

LVMi indicates left ventricular mass index; IMTAC, IMT of arteria carotis; IMTAF, IMT of arteria femoralis; and IMTTot, IMTAC+IMTAF.

Values are expressed as mean±SD.

*Difference significant at P<0.05.

IMT (r=0.20, P=0.38), nor with the mean far-wall IMT of carotid (r=0.16, P=0.50) or femoral (r=0.16, P=0.08) artery segments, respectively. Moreover, the ischemic burden was also not associated with the total amount of plaques (r=0.22, P=0.33).

**ST-Segment Depression and Cardiac End-Organ Damage**

No significant difference was found in left ventricular dimensions and left ventricular mass index between the two groups. Rate-pressure product and the systolic wall stress were not different between the two groups. However, within the group of hypertensives with ST-segment depression, left ventricular mass was significantly correlated with the ischemic burden (r=0.51, P=0.02), as seen in Table 3.

**FIGURE 2. Scatterplot shows correlation between ischemic burden and left ventricular mass in older hypertensive patients with episodes of ST-segment depression.**

**TABLE 3. Logistic Regression Analysis for Predicting ST-Segment Depression**

<table>
<thead>
<tr>
<th>Variable</th>
<th>β</th>
<th>SE</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass index</td>
<td>−0.1697</td>
<td>0.0823</td>
<td>0.0392</td>
</tr>
<tr>
<td>Pulse pressure</td>
<td>0.0411</td>
<td>0.0184</td>
<td>0.0258</td>
</tr>
<tr>
<td>IMTTot</td>
<td>2.8947</td>
<td>1.4233</td>
<td>0.0420</td>
</tr>
<tr>
<td>Smoking</td>
<td>−1.1785</td>
<td>0.6885</td>
<td>0.0860</td>
</tr>
<tr>
<td>Constant</td>
<td>−3.3567</td>
<td>2.8342</td>
<td>0.2363</td>
</tr>
</tbody>
</table>

IMTTOT indicates total mean far-wall IMT. Shown are predictors of ST-segment depression, determined by backward elimination from the model including age, gender, risk factors for coronary artery disease, and vascular and cardiac end-organ damage. Model R² =0.182; P=0.001.

Factors Contributing to Ischemic Episodes

From a variety of baseline characteristics, logistic regression analysis identified pulse pressure (P<0.05), body mass index (P<0.05), and combined mean far-wall IMT (P<0.05) as significant independent factors relating to the occurrence of ST-segment depression in these older hypertensive patients, as seen in Table 3.

**Discussion**

This study documents a lower-than-expected prevalence of ST-segment depression in older hypertensive patients: 9% in women and 13% in men. Among the studies concerning hypertensive patients free from clinical signs of coronary artery disease but after antihypertensive drug treatment, the prevalence was reported to vary in the range of 23% to 37%.3,11–13 In the study of Zehender et al,3 hypertensive patients were selected on the basis of ineffective or untolerated antihypertensive treatment, whereas 2 other studies at variance with ours included obese patients (type I diabetes).11,12 Trenkwalder et al13 found 37% prevalence of ST-segment depression in an even older but smaller (n=41) hypertensive group with a mean age of 79 years (range, 70 to 94 years). Our findings comply with the Cardioscreening Study, which documented a prevalence of 15% of ST-segment depression during 48 hours of Holter monitoring or exercise stress testing in 414 mild to moderate hypertensives, but this was found in a younger age group (50 to 70 years of age). The majority of ST-segment depression was observed during Holter monitoring (10.9%) and a minority during exercise stress testing (6.1%), but in contrast with our results, ST-segment depression was more common for women than for men (17.5% versus 5.2%, respectively), and only 31% of their patients were previously untreated.14 It should be remarked that all our patients were in a primary care setting and were previously untreated for hypertension. In the unselected, population-based Cardiovascular Health Study, the prevalence of ST-segment depression in ambulatory ECGs in a sample of 1511 men and women >65 years of age was also similar to ours, with 9% in women and 13% in men.15 However, this study also included patients with conditions known to interfere with the ST segment, such as previous myocardial infarction, angina pectoris, atrial fibrillation, and...
digitalis medication. The majority of their participants was not hypertensive, and ambulatory monitoring was done for 24 hours instead of 48 hours, which has been shown to increase episodes of patients with asymptomatic ST-segment depression by \( \approx 30\% \).\(^{16} \)

**Significance of ST-Segment Depression**

The observed ST-segment depression in our study was likely to reflect myocardial ischemia. Patients with specific ECG abnormalities at rest that could have influenced the ST segment had been excluded. Because left ventricular mass was not significantly different in the groups with or without ST-segment depression, repolarization abnormalities secondary to increased left ventricular mass are not likely to be responsible for the transient asymptomatic ST-segment depressions observed in our population. Moreover, only two of these mild-to-moderate hypertensive patients with ST-segment depression had concentric LVH, and the rest of the patients with ST-segment depression were not significantly different divided over the remaining left ventricular geometry groups. The finding of a high percentage of hypertensives with concentric remodeling and a relatively low percentage of hypertensives with LVH is similar to a previous study in primary care.\(^{17} \) Although caution should be used in the interpretation of episodes of transient ST-segment depression for patients free from clinical signs of coronary artery disease, the absence of ST-segment depression on resting ECG, the circadian pattern, and the relation with heart rate of the majority of the events observed are compatible with being episodes of silent myocardial ischemia.

**Mechanisms of Myocardial Ischemia**

This study shows that vascular remodeling induced by hypertension is an important determinant for silent ischemia. Therefore, the threshold for ischemia to develop depends mainly on vascular supply factors in older hypertensives, whereas cardiac demand factors mainly determine the extent of the ischemia. Both structural factors such as intima-media hypertrophy and arterial plaques and functional factors such as increased vasomotor tone caused by abnormal endothelium-derived relaxation play a crucial role in the induction of transient myocardial ischemia.\(^{18,19} \) Although increased IMT as assessed by B-mode ultrasound imaging is only moderately correlated to the percentage of coronary stenosis as assessed by quantitative coronary arteriography,\(^{20} \) there is some evidence that increased IMT in older subjects is associated with asymptomatic ischemia, as evidenced by exercise ECG or exercise thallium scintigraphy.\(^{21} \) The observed difference in pulse pressure, positively related with increased IMT,\(^{22} \) partly supports the view of the vascular supply being the major determinant for the occurrence of ischemic ST-segment depression because pulse pressure can also be expressed as a determinant of myocardial oxygen demand.

Myocardial demand appears to be less important for the occurrence of ischemic ST-segment depression because left ventricular mass and LVH do not explain the occurrence of transient ST-segment depression in these older hypertensives. These findings are in agreement with those of previous studies that did not reveal any difference between left ventricular mass of hypertensives with and those without ischemia.\(^{1,12–14,23} \) Moreover, the lower body mass index in the group with ST-segment depression further suggests that the occurrence of ischemic ST-segment depression is not primarily determined by cardiac demand because overweight has been reported to be associated with increased left ventricular mass.\(^{24} \) A possible explanation might be the reduced level of physical activity among overweight subjects. Our findings are supported by findings from the Cardiovascular Health Study, in which overweight was associated with a 33% reduction of likelihood of ischemic episodes after adjustment for other risk factors.\(^{15} \)

The severity of myocardial ischemia, expressed as ischemic burden, is mainly determined by cardiac demand factors because increased myocardial mass rather than vascular abnormalities was associated with the extent of transient ST-segment depression. This might be associated with endothelial dysfunction because recently a significant relation was found between increased left ventricular mass and endothelial dysfunction in hypertensive patients.\(^{25} \) In contrary, the ischemic burden was not associated with structural vascular supply factors such as IMT and arterial plaques.

**Conclusions**

Our study provides strong evidence that in older hypertensives, the occurrence of ischemic ST-segment depression is determined mainly by vascular factors rather than left ventricular mass. Thus, supply markers such as IMT and arterial plaques as markers of generalized atherosclerosis are mainly responsible for the occurrence of ischemic ST-segment depression, and demand markers such as left ventricular mass are mainly responsible for the ischemic burden. The occurrence of silent ischemia during daily life has been found to be an independent predictor of cardiovascular events in hypertensive patients.\(^{4,26} \) Until now, the risks of myocardial infarction and cardiovascular death associated with the occurrence of silent ischemia in hypertensive patients are unknown. However, the early detection of silent myocardial ischemia by Holter monitoring might be useful for the identification of hypertensive patients who should be investigated further and considered for a more specific treatment.

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