$^{123}$I-MIBG myocardial imaging in hypertensive patients: Abnormality progresses with left ventricular hypertrophy

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Twenty-seven patients with essential hypertension were prospectively studied with $^{123}$I-labeled metaiodobenzylguanidine ($^{123}$I-MIBG) to assess the presence and location of impaired sympathetic innervation in hypertrophied myocardium. Thirteen patients had left ventricular hypertrophy on echocardiography, and 14 had normal echocardiograms. The wash-out ratio of $^{123}$I-MIBG in these two groups did not differ significantly (35.3 ± 6.1 and 35.4 ± 5.1) but was higher than in control subjects (29.4 ± 6.7). The delayed heart-to-mediastinum count ratio was lower in the patients with hypertrophy than in the patients without hypertrophy (1.93 ± 0.28 and 2.22 ± 0.21; p < 0.05) and the control subjects (1.93 ± 0.28 and 2.33 ± 0.25; p < 0.05). On SPECT imaging, abnormalities in segmental uptake were frequent at the posterior and postero-lateral wall in both groups, although the hypertrophic group had more significant impairment. Our results lead to the hypothesis that hypertension in more advanced stages may be associated not only with hypertrophic changes but also with more advanced regional impairment of cardiac sympathetic innervation.

Key words: metaiodobenzylguanidine (MIBG), single-photon emission computed tomography (SPECT), hypertension, left ventricular hypertrophy, adrenergic nerve

INTRODUCTION

Metaiodobenzylguanidine labeled with $^{123}$I ($^{123}$I-MIBG) is a unique pharmacologic agent that can be used to assess the functional condition of sympathetic innervation in the human myocardium. Many studies have demonstrated its clinical usefulness in patients with dilated cardiomyopathy, valvular heart diseases, coronary artery disease, hypertrophic cardiomyopathy, and dysrhythmias. This agent has not, however, been studied in patients with hypertensive heart disease, which is one of the most prevalent types of heart diseases, though the abnormality in the myocardial uptake of $^{123}$I-MIBG in patients with left ventricular hypertrophy secondary to valvular aortic stenosis has already been reported. We studied $^{123}$I-MIBG images obtained by planar and single-photon emission computed tomography (SPECT) to evaluate whether sympathetic innervation of the myocardium is impaired in hypertrophic left ventricles of hypertensive patients.

MATERIALS AND METHODS

Patients

We prospectively studied 27 hypertensive patients (12 men and 15 women; age range, 42 to 83 yr; mean age, 61 ± 10 yr), all of whom had a documented history of essential hypertension and were being treated at our outpatient clinic. Thirteen patients had echocardiographic evidence of left ventricular hypertrophy, which was defined as diffuse hypertrophy of the left ventricle with an interventricular septum thickness or posterior wall thickness exceeding 13 mm. The other 14 patients had otherwise normal echocardiograms. Left ventricular mass (LVM) was calculated with the following formula: LVM (in grams) = 1.04[(LVIDd + VSTd + PWTd)² − (LVIDd)²] − 13.6, where LVIDd denotes the left ventricular internal diameter at end-diastole, VSTd the ventricular septal thickness at end-diastole, and PWTd the posterior wall thickness at end-diastole. No patient had a history of angina pectoris, myocardial infarction, diabetes mellitus,
Fig. 1  Schematic diagram of single-photon emission tomographic images. (A) Twenty-seven segments of two short-axis images at the mid-basal (B-SX) and mid-apical (A-SX) levels and one vertical long-axis image at the mid-left-ventricle (V-LX). (B) Schematic representation of the 27 segments, appearing as a polar map image from base to apex. Here, segments, #3 is basal lateral, #6 is basal posterior, #9 is basal septum, #12 is basal anterior, #15 is mid-lateral, #18 is mid-posterior, #21 is mid-septum, #24 is mid-anterior, and #25–#27 are apex. (C) $^{123}$I-MIBG SPECT images of a 58-year-old man with left ventricular hypertrophy.

or any evidence of secondary hypertension. All patients underwent treadmill exercise stress electrocardiogram. Exercise stress thallium-201 scintigraphy were added if necessary, and concomitant coronary artery disease was ruled out in all patients. All antihypertensive medication, consisting mainly of calcium channel blockers or angiotensin converting enzyme inhibitors, was continued during this study. No patient received reserpine, tricyclic antidepressants or other drugs that could interfere with the myocardial uptake of $^{123}$I-MIBG. We also studied six healthy volunteers (three men and three women; mean age, $56 \pm 5$ [range 52 to 62] yr) with a normal echocardiogram and with no evidence of organic heart disease or hypertension as the control group.

SPECT study
The early planar and SPECT images were obtained with patients in the supine position 15 minutes after $^{123}$I-MIBG (111 MBq) was injected intravenously at rest. Four hours later, both the late planar and SPECT images were obtained with the SPECT system (Shimadzu SNC 510 R-20 and Scintipack 7000), equipped with a low-energy, parallel-hole, general-purpose collimator. Planar images were obtained 15 minutes and 4 hours after tracer administration in the anterior view over a 5-minute interval. SPECT imaging was then performed. Thirty-two projections with 30 seconds per view were obtained over 180 degrees, starting at a 45-degree right anterior oblique projection and ending in a 45-degree left posterior oblique projection. The energy level and window width used for collection of data were 159 keV $\pm$ 20% for $^{123}$I. The data were recorded in $64 \times 64$ matrices. After a preprocedure with a Butterworth filter, reconstruction was performed with a Shepp-Logan’s filter. Neither scatter correction nor absorption correction was applied. Short-axis, horizontal and vertical long-axis slices were then reorganized. Regions of interest (ROI) in the whole heart and the mediastinum were set manually on the early and delayed planar images and were used to calculate the mean heart-to-mediastinum count ratio (H/M ratio). $^{225}$ The ratio of tracer wash-out from the myocardium was determined over 4 hr without correction for the physical decay of $^{123}$I. The wash-out ratio was calculated with the following formula: wash-out ratio = [(Ci – Cd)/Ci] $\times$ 100, where Ci and Cd are the mean count of the whole heart on the initial and delayed planar images, respectively.

Image analysis
Segmental analysis of the four-hour delayed images of $^{123}$I-MIBG SPECT was performed visually by three independent observers, and disparity was resolved by consensus. Twenty-seven segments were determined on two