Effects of low-dose dobutamine on left ventricular function in normal subjects as assessed by gated single-photon emission tomography myocardial perfusion studies

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Abstract. Electrocardiography gated single-photon emission tomography (gated SPET) allows the assessment of regional perfusion and function simultaneously and in full spatial congruency. In this study changes in global and regional left ventricular function in response to dobutamine infusion were assessed in ten healthy volunteers using sequential gated SPET myocardial perfusion acquisitions. Four consecutive gated SPET images were recorded 60 min after injection of 925 MBq technetium-99m tetrofosmin on a three-head camera equipped with focussing collimators. Two acquisitions were made at rest (baseline 1 and 2), and the third and fourth acquisitions were started 5 min after the beginning of the infusion of 5 and 10 µg kg⁻¹ min⁻¹ dobutamine, respectively. Systolic wall thickening (WT) was quantified using a method based on circumferential profile analysis. Left ventricular ejection fraction (LVEF) and volumes were calculated automatically using the Cedars-Sinai program. Nine of the ten subjects presented a definite increase in WT during dobutamine infusion. WT increased on average from 46%±14% at baseline to 71%±23% (range: 37%–106%; P<0.05) during 5 µg kg⁻¹ min⁻¹ dobutamine infusion and to 85%±25% (range: 62%–123%; P<0.05 with respect to WT at 5 µg kg⁻¹ min⁻¹) during 10 µg kg⁻¹ min⁻¹ dobutamine infusion. Apical segments showed the largest WT at baseline. The average WT response to dobutamine was similar for all parts of the myocardium. It is concluded that changes in WT induced by infusion of low-dose dobutamine can be assessed by sequential gated SPET myocardial perfusion studies. The “stress gated SPET” protocol proposed in this study might be helpful to distinguish viable from scar tissue in patients with coronary artery disease, by demonstrating a preserved inotropic response in hypoperfused myocardium.

Key words: Gated single-photon emission tomography – Myocardial perfusion – Low-dose dobutamine

Introduction

The integration of data concerning regional myocardial perfusion, obtained by scintigraphy, and regional function, obtained by echocardiography, is difficult since they are not acquired simultaneously. This is probably one of the main reasons why, in the recent literature, there is appreciable discordance between stress echocardiography and radionuclide imaging techniques for the identification of reversible myocardial dysfunction in patients with coronary artery disease [1, 2].

Electrocardiography-gated myocardial single-photon emission tomography (gated SPET) with technetium-99m labelled perfusion agents provides a unique opportunity to assess both regional perfusion and function simultaneously in full spatial congruency during a single study. Several investigators have demonstrated that gated SPET myocardial perfusion scintigraphy provides important information with regard to myocardial systolic function at rest that is highyl reproducible and agrees very well with results of two-dimensional echocardiography [3, 4]. Similar data were reported when comparing gated SPET with magnetic resonance imaging [5–7], which is considered a reference technique for the assessment of regional myocardial function in patients with normal and impaired left ventricular function [8, 9].

The aim of this study was to quantify changes in global and regional left ventricular function that occur during dobutamine infusion in normal volunteers using consecutive ECG-gated myocardial perfusion SPET acquisitions.

Original article

Materials and methods

Study population. Ten healthy male volunteers were studied (mean age 30.7±5.8 years). None of the subjects were taking any medication at the time of investigation. All individuals gave informed consent, and the study was performed according to the standard ethical guidelines of the Free University of Brussels.

Study design. Four consecutive gated SPET images (of 7 min each) were recorded. Two acquisitions were made at rest (baseline 1 and baseline 2); the third and fourth acquisitions were started 5 min after the beginning of the infusion of 5 and 10 µg kg⁻¹ min⁻¹ dobutamine (Dobutrex, Eli Lilly), respectively. Dobutamine was administered through a peripheral arm vein using a perfusion pump under continuous ECG monitoring. Blood pressure and heart rate were recorded at the end of each acquisition stage (Fig. 1).

Gated SPET myocardial perfusion imaging. The subjects received 925 MBq technetium-99m tetrofosmin intravenously at rest. SPET images gated in eight time bins were acquired starting 60 min after tracer administration on a three-head camera (MultiSPECT3, Siemens, Inc., Hoffman Estates, III.). The average RR interval was calculated just before each acquisition. The tail drop phenomenon was corrected using a forward/backward framing mode by 75%.

Consecutive acquisitions were performed according to a “fast” gated SPET protocol of 7 min with the subjects remaining in the same position. In this “fast” acquisition protocol, focussing collimators (Cardiofocal) were used to enhance the sensitivity without impairing the resolution [10, 11]. Each detector described a circular orbit (radius: 283 mm) over 120° with 20 stops of 18 s. Data were acquired in a 64×64 format, zoom 1.23. Transverse slices of gated data were reconstructed by filtered backprojection using a Butterworth filter, order 5 and a cut-off frequency of 0.4 Nyquist. Images were reoriented according to the long axis of the left ventricle.

Measurement of myocardial wall thickening. Circumferential wall thickening (WT) profiles were generated from the end-diastolic (ED) and end-systolic (ES) peak count distribution profiles computed on three short (apical, mid-ventricular, basal) and two long (horizontal, vertical) left ventricular axis slices. The myocardium was sampled over 360° (96 radii) in the short-axis slices and over 90° (24 radii) in the long-axis slices. Percent WT was calculated as:

\[ \% \text{WT} = \frac{\text{ES peak act} - \text{ED peak act}}{\text{ED myocardial max}} \times 100, \]

where ES peak act is the systolic peak activity, ED peak act is the diastolic peak activity and ED myocardial max corresponds to the maximum activity measured in the entire left myocardium at end diastole.

The left ventricle was then divided into 13 segments: four segments per short-axis slice (each including 24 radii), and an apical segment (including 2×24 radii of the horizontal and the vertical long-axis slices). WT values were then averaged per segment and per study.

The homogeneity of the WT in the left ventricle was estimated by calculating the coefficient of variability of all radial WT values in the studies at baseline and during dobutamine administration.

Left ventricular ejection fraction and volumes. Global left ventricular ejection fraction (LVEF) and volumes were calculated from the gates SPET images using the full automatic algorithm developed at Cedars-Sinai (QS-Quant, Siemens, Inc.) [12]. The stroke volume was calculated as the difference between end-diastolic and end-systolic volume.

Statistical analysis. Data are expressed as the mean±SD. Comparisons among groups were performed with the Wilcoxon’s signed rank test. Probability values less than 0.05 were considered significant.

Results

Haemodynamic responses to dobutamine

The response of the haemodynamic variables to dobutamine administration is shown in Table 1 and Fig. 2B and C.

Systolic blood pressure increased from 104±5 mmHg at baseline to 140±20 mmHg (P<0.05) and 161±14 mmHg (P<0.05) during dobutamine administration at 5 and 10 µg kg⁻¹ min⁻¹, respectively. No significant change in diastolic blood pressure was observed. Heart rate did not change at 5 µg kg⁻¹ min⁻¹ (67 bpm vs 65 bpm, P=NS) but increased to 82±14 bpm at 10 µg kg⁻¹ min⁻¹ (P<0.05).

Stroke volume increased from 59±9 ml at baseline to 76±10 ml (P<0.05) during infusion of 5 µg kg⁻¹ min⁻¹ dobutamine. At 10 µg kg⁻¹ min⁻¹ dobutamine no significant further increase in stroke volume was observed.

LVEF increased from 54%±7% to 67%±7% (P<0.05) at 5 and to 71%±10% (P<0.05) at 10 µg kg⁻¹ min⁻¹ dobutamine. Changes in LVEF resulted primarily from a progressive decrease in end-systolic volume (P<0.05 at 5 and 10 µg kg⁻¹ min⁻¹) and to a lesser degree from changes in end-diastolic volume.

Effects of dobutamine administration on wall thickening

Global measurements. WT at rest averaged 47%±13% at baseline 1 and 46%±14% at baseline 2 (r=0.78, systematic error=3.16%, random error=3.80%, P=NS).

During administration of dobutamine, WT increased to 71%±23% (range: 37%–106%; P<0.05) at 5 µg kg⁻¹