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Progression of preserved systolic function heart failure to systolic dysfunction — A natural history study

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Abstract

Objectives: To assess the natural history of left ventricular (LV) structure and function in sequential heart failure admissions with preserved systolic function.
Background: Heart failure (HF) with preserved LV systolic function accounts for between 20% and 30% of typical HF populations. Few data are available concerning the natural history of structural and functional changes in the LV in this patient population.
Methods: We consented sequential admissions from the community with confirmed heart failure to participate in this study. Doppler-echocardiography was used to assess ejection fraction (EF), LV structure, regional wall motion and parameters of diastolic function including E : A ratio, E-wave deceleration time (DtE) and isovolumic relaxation time (IVRT). Follow-up echocardiography was carried out at three months (mean 103 ± 13 days) from discharge.
Results: Of 210 sequential admissions with primary heart failure 56 had preserved systolic function (LVEF ≥ 45%). Follow-up data at three months were available in 38 patients (mean age 72 years) with preserved LV systolic function. Of the group, 9 had been admitted within three months of discharge, 5 for recurrent HF. Eight patients (21%) exhibited significant decline in LV systolic function at follow-up, all with LVEF < 45%. Three exhibited regional wall-motion abnormalities with the remainder showing dilatation and global reduction in function. None of these eight had presented to hospital for any cause other than routine outpatient department (OPD) visits during the 3 months.
Conclusion: Patients with preserved systolic function HF, a significant number may progress to systolic dysfunction with or without clinical events.

Keywords: Diastolic heart failure; Ventricular remodeling

1. Background

Preserved systolic function heart failure is estimated to account for between 20% and 40% of any heart failure population [1–4]. However, little is published describing the natural history of LV structure and function in this group [5,6].

Progression from left ventricular hypertrophy to systolic dysfunction has been previously described in the hypertensive heart [7]. Similarly, in a canine model of left ventricular necrosis, it was observed that hypertrophy and preserved ejection fraction were present prior to dilatation and subsequent reduction in systolic function [8].

Abbreviations: HF; heart failure; LV; left ventricle; EF; ejection fraction; LVEDD; left ventricular end-diastolic diameter; LVESD; left ventricular end-systolic diameter; IVRT; isovolumic relaxation time; DtE; E-wave deceleration time; ECG; electrocardiogram; OPD; outpatient department; NYHA; New York Heart Association; AF; atrial fibrillation; LA; left atrial diameter; DCM; dilated cardiomyopathy; ACE; angiotensin converting enzyme.

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As part of a prospective study of consecutive admissions to our centre with acute left ventricular failure (LVF), we sequentially analysed LV structure and function in an unselected heart failure population presenting with echocardiographically preserved LV systolic function.

2. Methods

2.1. Patient population

This investigation conformed to the principles outlined in the Declaration of Helsinki and was approved by the St. Vincent's University Hospital Ethics Committee.

We assessed consecutive admissions from the community of all patients over 18 years presenting to St. Vincent's University Hospital emergency department with an initial diagnosis of heart failure (NYHA Class IV). Patients with intercurrent illness where heart failure was not felt to be the primary problem were excluded. Patients presenting with HF in the setting of myocardial infarction, unstable angina, or displaying ECG or cardiac enzymatic change consistent with ischaemia were excluded. We also excluded those in whom a subsequent rise in cardiac enzymes depicted a silent ischaemic event. Patients presenting with a history of palpitation suggestive of tachyarrhythmia prior to admission, with new onset atrial fibrillation (AF), or with persistent fast AF (which we defined as an average ventricular response rate of greater than 120) were also excluded.

Diagnosis of HF was confirmed or refuted by a senior member of the cardiology team (Consultant Cardiologist or Specialist Registrar) based on the presence of the following criteria: history and examination compatible with HF, chest X-ray appearance of congestion and response to initial therapy.

Doppler-echocardiographic studies were performed in all cases within three days of admission (baseline), and subsequently repeated at a follow-up outpatient clinic at 12 weeks from hospital discharge.

2.2. Echocardiographic examinations and measurements

Two-dimensional and Doppler-echocardiographic examinations were performed using Hewlett-Packard Sonos 5500 2.5 and 3.5 MHz transducers. LV septal thickness (IVS), posterior wall thickness (PWT), end-diastolic and end-systolic dimensions (LVEDD and LVESD) were measured by M-mode in the long-axis parasternal view at the level of the papillary muscles, as recommended by the American Society of Echocardiography. The left ventricular ejection fraction was calculated in the four-chamber view using a modified Simpson's formula. Preserved systolic function was defined as a LV ejection fraction greater than or equal to 45%, in the absence of significant valvular disease.

Aortic stenosis with a gradient of greater than 20 mm Hg was taken as being significant as an exclusion criterion. In patients with evidence of mitral stenosis, the valve area was calculated using a combination of 2D echocardiography and the pressure half-time method. Patients with significant mitral stenosis were excluded. Where the Mitral valve was heavily calcified, and valve area difficult to assess in this manner, these patients were excluded. The degrees of severity of mitral or aortic regurgitation were assessed with colour Doppler flow mapping techniques using all available windows. In cases where colour Doppler was considered unreliable because of eccentric regurgitant jets, confirmation was attained using pulsed Doppler with the sample positioned on the atrial side for mitral regurgitation, and the ventricular outflow tract for aortic incompetence. Any evidence of significant valvular incompetence was regarded as a criterion for exclusion [9].

To record mitral flow velocity, a pulsed-wave Doppler sample volume was placed between the tips of the mitral valve leaflets and aligned parallel with the inflow. The Doppler cursor was then positioned between the mitral valve and the LV outflow, and a continuous wave Doppler recording was obtained to allow measurement of the IVRT. Doppler recordings were taken using a sweep speed of 100 mm/s. Parameters of left ventricular diastolic function measured included peak velocities of both early (E_{max}) and atrial (A_{max}) diastolic filling, the E : A ratio, and isovolumic relaxation time (IVRT). E-wave deceleration time (DtE) was measured as the interval (ms) from the peak early mitral filling to an extrapolation of the deceleration to 0 m/s. In atrial fibrillation, Doppler indices were calculated using an average of 7 beats (range 6–12) selected on the basis of the quality of the recording and a cycle length equivalent to a heart rate of 60–100 bpm [10,11]. Cardiac cycles with fusion of two consecutive diastolic waves, as a consequence of a short RR interval, were excluded from analysis.

The 16-segment model of the American Society of Echocardiography was used to evaluate regional wall motion. Inward wall motion was visually assessed, wall motion for each segment being classed as normal, hypokinetic, akinetic, or dyskinetic. Wall-motion abnormalities were considered significant if they were present in two or more contiguous segments.

Indices for diastolic dysfunction were defined according to the European Working Group in Diastolic Heart Failure criteria for diastolic heart failure [12].

2.3. Endpoints and data analysis

Parameters reported in this study are LV ejection fraction (EF), end-systolic (LVESD) and end-diastolic (LVEDD) diameters, E : A ratio, IVRT, and E-wave deceleration time (DtE).

Reproducibility between observers was assessed by duplicate reading of all examinations of Doppler measurements and LV ejection fraction by two experienced echocardiographers. Initial assessment was performed on-line, with all echocardiographic examinations recorded on