SCIENTIFIC LETTER

Differential value of left atrial systolic and diastolic volumes as independent predictors of congestive heart failure or early death in acute myocardial infarction

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Maximum left atrial (LA) volume is associated with diastolic properties of the left ventricle and has recently been shown to predict cardiovascular events in a wide spectrum of people.^{1–3} In contrast to Doppler variables of left ventricular (LV) diastolic function, which are affected by acute haemodynamic changes, maximum LA volume is more stable, integrating the effects of increased LV filling pressures from pre-existing cardiovascular conditions. Minimum LA volume, however, is influenced by both pre-existing conditions leading to increased LV filling pressures and acute haemodynamic changes that affect LA contraction. We sought to assess the independent predictive power of maximum and minimum LA volumes for the development of congestive heart failure (CHF) or death within 30 days after myocardial infarction (MI).

METHODS

Of 456 consecutive patients with acute MI admitted to our centres during 1996, 12 died shortly after admission. Echocardiographic evaluation was not possible within 48 hours because of logistic limitations in 22 patients and because of inadequate imaging in 23. On admission CHF was diagnosed in 70 patients (Killip class $\geq$ II or atrial fibrillation). The remaining 324 patients (65 women, mean age of 60 (12) years) constituted the study population. Relevant clinical data were prospectively collected from all patients.

All patients underwent a complete echocardiographic examination. LV volumes were measured with the biplane modified Simpson's algorithm. Doppler assessment was in accordance with the guidelines of the American Society of Echocardiography.⁴ Maximum and minimum LA volumes were measured by the method of discs from the apical four chamber view at end systole and end diastole.⁵ A maximum LA volume index (LAVI) cut off value of 32 ml/m² (normal + 2 SD) was used as reported previously^{1–3} and confirmed subsequently in a group of 25 normal volunteers (15 men and 10 women) with a mean age of 62.5 (6) years and a mean body surface area of 1.85 (0.18) m². Their mean maximum LAVI was 23.2 (4.6) ml/m² and mean minimum LAVI was 7.9 (2.6) ml/m². The minimum LAVI cut off value used was 13 ml/m² (normal + 2 SD). Intraobserver and interobserver variabilities for the minimum and maximum measurement of LA volume ranged between 4–9%. LV filling patterns were determined according to the European Study Group on Diastolic Heart Failure criteria.

RESULTS

End systolic (maximum) LAVI > 32 ml/m² was found in 44 patients (14%) and end diastolic (minimum) LAVI > 13 ml/m² was found in 67 (21%).

Compared with patients with maximum LAVI $\leq$ 32 ml/m², patients with maximum LAVI > 32 ml/m² were older, had a lower body surface area, a prevalence of history of smoking, and

a higher prevalence of cerebrovascular attack or transient ischaemic attack. The prevalence of female sex, hypertension, diabetes mellitus, hyperlipidaemia, history of MI, and history of revascularisation did not differ. Compared with patients with minimum LAVI $\leq$ 13 ml/m², patients with minimum LAVI > 13 ml/m² were older and had a lower prevalence of history of smoking.

No significant difference in the treatment with intra-aortic balloon pump or thrombolysis was noted; however, patients with maximum LAVI > 32 ml/m² and minimum LAVI > 13 ml/m² had a lower incidence of percutaneous coronary intervention. At hospital discharge, the use of nitrates, antiarrhythmic agents, or lipid lowering drugs did not differ. However, patients with maximum LAVI > 32 ml/m² and minimum LAVI > 13 ml/m² received aspirin less often. Patients with minimum LAVI > 13 ml/m² received β adrenergic blocking agents less and angiotensin converting enzyme inhibitors more often.

Maximum LAVI > 32 ml/m² and minimum LAVI > 13 ml/m² were associated with lower LV ejection fraction, moderate or severe mitral regurgitation, higher LV end systolic and diastolic volumes, and peak mitral valve E wave velocity. Neither the LV filling pattern nor the E:A ratio was significantly different.

At 30 days of follow up 46 patients (14.2%) had CHF and 3.1% had died. Patients with maximum LAVI > 32 and minimum LAVI > 13 had significantly higher rates of CHF or all cause mortality (27.3% v 13.2%, $p = 0.016$ and 28.4% v 11.7%, $p < 0.001$, respectively). Univariate variables significantly associated with CHF or 30 day all cause mortality were age, paroxysmal atrial fibrillation during hospitalisation, anterior MI, LV ejection fraction, LV end systolic index, restrictive LV filling pattern, moderate and severe mitral regurgitation, maximum LAVI > 32 ml/m², and minimum LAVI > 13 ml/m². Significant univariate variables were included in the logistic regression model. The model was analysed once with minimum LAVI > 13 ml/m² and once with maximum LAVI > 32 ml/m² to avoid their close association. Independent predictors of CHF and 30 day all cause mortality were age, LV ejection fraction, moderate or severe mitral regurgitation, and minimum LAVI > 13 ml/m² (table 1).

DISCUSSION

LA volume is influenced by LV filling pressure before the acute MI and may be regarded as the heart's "diastolic memory". By tracking the decreasing cardiac reserve in patients with acute MI, LA volume becomes a powerful predictor of long term outcome.^{2,3} We showed that LA volume is associated with the development of CHF or 30 day

Abbreviations: CHF, congestive heart failure; LA, left atrial; LAVI, left atrial volume index; LV, left ventricular; MI, myocardial infarction

Table 1 Multivariate analysis of predictors of 30 day CHF or death

Characteristic	OR	95% CI	p Value
LV ejection fraction	0.39*	0.22 to 0.67	<0.001
Age	1.40†	1.03 to 1.95	0.04
Mitral regurgitation (moderate/severe)	3.62	1.09 to 11.95	0.03
Minimum LA volume index >13 ml/m ²	2.30	1.00 to 5.20	<0.05
LV restrictive pattern	2.10	0.92 to 4.75	0.08
LV end systolic volume index	0.89‡	0.76 to 1.02	0.10
Anterior myocardial infarction	1.86	0.87 to 3.98	0.11
Diabetes	1.66	0.72 to 3.72	0.23
Hypertension	1.52	0.76 to 3.06	0.24
Female sex	0.82	0.32 to 1.95	0.66
Previous myocardial infarction	1.19	0.48 to 2.81	0.70

*Odds ratio (OR) calculated for a 10% increase; †OR calculated for a 10 year increase; ‡OR calculated for a 5 ml/m² increase.

CI; confidence interval, LA; left atrial, LV; left ventricular.

mortality in low risk patients admitted with acute MI in Killip class I. However, only increased diastolic LA volume was found to be an independent predictor of 30 day development of CHF or death in this group, presumably because minimum LA volume is also influenced by the extent of atrial contraction, a compensatory mechanism influenced by acute haemodynamic changes in the setting of acute MI. It may be argued that, whereas maximum LA volume represents the long term diastolic memory of the heart, minimum LA volume represents also the short term diastolic memory of the heart.

All echocardiographic examinations were performed within the first 48 hours of admission. At this early stage, LV dysfunction may still be reversible in patients after reperfusion, thereby overestimating their future risk. On the other hand, the remodelling process and its increased risk after an MI is not reflected by an early LV assessment. Differences in patients' medical treatment and coronary interventions dichotomised by LA volume reflect early manifestations of heart failure and cardiac function determined by echocardiography. These differences might have had some effect on 30 day outcome that could not be accurately assessed without prior randomisation.

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