Ultrasound in Med. & Biol., Vol. 34, No. 5, pp. 753–759, 2008

0301-5629/08/$–see front matter

ELSEVIER

doi:10.1016/j.ultrasmedbio.2007.11.008

● *Original Contribution*

DIFFERENTIATION OF LEFT VENTRICULAR DIASTOLIC FUNCTION BY MID-DIASTOLIC MITRAL ANNULAR MOTION PATTERNS

HO-MING SU,*† TSUNG-HSIEN LIN,* CHEE-SIONG LEE,* HSUEH-WEI YEN,* CHIH-HSIN HUANG,* KAI-HUNG CHENG,*† HSIANG-CHUN LEE,* WEN-TER LAI,* SHENG-HSIUNG SHEU,* and WEN-CHOL VOON*

*Division of Cardiology, Department of Internal Medicine, Kaohsiung Medical University Hospital, Kaohsiung Medical University and †Department of Internal Medicine, Kaohsiung Municipal Hsiao-Kang Hospital, Kaohsiung, Taiwan

(*Received* 5 *June* 2007, *revised* 14 *October* 2007, *in final form* 12 *November* 2007)

Abstract—Mid-diastolic mitral annular motion may be driven by strain energy, an energy for myocardial recoil, stored during the previous systole. Hence, various patterns of mid-diastolic mitral annular motion may imply different left ventricular (LV) diastolic function. The purpose of this study is to compare LV diastolic properties among different types of mid-diastolic mitral annular motion. Two-hundred and three consecutive subjects underwent an echocardiographic examination at our outpatient clinic. Study subjects were classified into three groups according to mid-diastolic mitral annular motion patterns. Upward and downward La waves were defined, respectively, as a clear apically and atrially directed mid-diastolic annular motion on at least three consecutive beats with the average peak velocity ≥2 cm/s. Subjects with upward La wave, with downward but without upward La wave and without La wave were categorized as groups 1, 2 and 3, respectively. Early diastolic mitral annular velocity (Ea) was higher and the ratio of transmitral E wave velocity to Ea was lower in group 1 than in groups 2 and 3 (all $p < 0.001$). The diagnostic accuracy of upward La wave in prediction of normal diastolic function fell between 75% and 88%. In conclusion, patients with upward La wave had better LV diastolic function and lower LV filling pressure than patients without it. Upward La wave is useful in prediction of normal diastolic function. Therefore, analysis of mid-diastolic mitral annular motion may be complementary to other measures of LV diastolic function. (E-mail: wcvoon@giga.net.tw) © 2008 World Federation for Ultrasound in Medicine & Biology.

Key Words: **Mid-diastolic mitral annular motion, Tissue Doppler echocardiography, Diastolic function, Filling pressure.**

INTRODUCTION

Heart failure is a common cause of cardiovascular death and may occur in the presence of either a normal or abnormal left ventricular ejection fraction (EF) (Levy et al. 2002; Lloyd-Jones et al. 2002; Jessup et al. 2003). Diastolic heart failure, or heart failure with a preserved left ventricular systolic function, is a growing epidemic (Cowie et al. 1999; Senni et al. 1998; Vasan et al. 1999). Diastolic dysfunction itself has substantial adverse prognostic significance, demonstrating the importance of proper diagnosis of diastolic dysfunction. Doppler echocardiography is the noninvasive method of choice for the assessment of diastolic dysfunction. Pulsed wave Doppler transmitral inflow variables remain the cornerstone of the evaluation of diastolic function (Nishimura et al. 1997). Although mitral inflow usually consists of two forward flows, *i.e.*, mitral E and A waves, it may occasionally have additional forward flow during mid-diastole. (Hatle et al. 1993; Keren et al. 1986). The mitral L wave, defined as a forward mitral inflow during mid-diastole, with a peak velocity ≥20 cm/s, was reported to be a marker of advanced diastolic dysfunction and predictor of future heart failure events (Ha et al. 2004; Lam et al. 2005).

Tissue Doppler echocardiography provides a regional approach to cardiac wall kinetics through myocardial velocity measurements. The early diastolic mitral annular velocity (Ea) has been shown to be a useful parameter of myocardial relaxation (Nagueh et al. 1997).

Address correspondence to: Wen-Chol Voon, MD, Division of Cardiology, Department of Internal Medicine, Kaohsiung Medical University, 100 Tz-You 1st Road, Kaohsiung City 807, Taiwan. E-mail: wcvoon@giga.net.tw

The E/Ea has also been correlated with left ventricular filling pressure (Nagueh et al. 1997; Ommen et al. 2000). In contrast with the numerous studies regarding Ea (Nagueh et al. 1997; Ommen et al. 2000), the studies about mid-diastolic mitral annular motion are fewer. Ha et al. (2006) have even shown that the presence of a mid-diastolic mitral annular motion in patients with triphasic mitral inflow velocity pattern indicates advanced diastolic dysfunction and elevated left ventricular filling pressure. In addition, Riordan and Kovács (2007) demonstrated that patients without diastolic mitral annular oscillations after the Ea wave had relaxation-related diastolic dysfunction. Mid-diastolic mitral annular motion may be driven by strain energy, an energy for myocardial recoil, stored during the previous systole. Hence, various types of mid-diastolic mitral annular motion may imply different diastolic function. However, to date, few data are available regarding the relationship between mid-diastolic mitral annular motion patterns and left ventricular diastolic function. Hence, the purpose of this study is to compare the left ventricular diastolic properties and filling pressures among different types of mid-diastolic mitral annular motion.

METHODS

Study patients

Two-hundred and twenty-one consecutive subjects under an echocardiographic examination recruited from our cardiologic outpatient clinic were screened for this study. Ten patients with significant mitral valve disease and eight patients with inadequate echocardiographic visualization were excluded. The remaining 203 patients formed our study group. All patients were in sinus rhythm. The protocol was approved by our Institutional Review Board and all enrolled patients gave written, informed consent.

The study subjects were classified into three groups on the basis of the mid-diastolic mitral annular motion patterns (Fig 1). If a subject had upward La wave, defined as a clear apically-directed mid-diastolic annular motion on at least three consecutive beats with its average peak velocity ≥2 cm/s, he was entered into group 1 (Fig. 1a and b). If a subject had downward La wave, defined as a clear atrially-directed mid-diastolic annular motion on at least three consecutive beats, with its average peak velocity ≥2 cm/s, but had no upward La wave, he was entered into group 2 (Fig. 1c). The other study subjects without upward or downward La wave were classified into group 3 (Fig. 1d). The setting of lowest velocity limit of La wave (2 cm/s) was mainly to avoid the interference of background noise with the verification of the presence or absence of La wave.

Doppler echocardiographic evaluation

The echocardiographic examination was performed with a Vivid 7 (General Electric Medical Systems, Horten, Norway), with the participant respiring quietly in the left decubitus position. Two-dimensional and two-dimensionally guided M-mode images were recorded from the standardized views. The Doppler sample volume was placed at the tips of the mitral leaflets to get the left ventricular inflow waveforms from the apical four-chamber view. All sample volumes were positioned with ultrasonic beam alignment to flow. Tissue Doppler imaging was obtained, with the sample volume placed at the lateral corner of the mitral annulus from the apical four-chamber view. The wall filter settings were adjusted to exclude high-frequency signals and the gain was minimized. The Doppler waveforms were recorded on a magneto-optical disc for later analysis.

In addition, to evaluate the relationship between mid-diastolic mitral annular motion patterns and stages of left ventricular diastolic dysfunction, we also categorized our study subjects according to mitral inflow filling patterns. The mitral inflow filling patterns were classified into three types as normal, abnormal relaxation and pseudo-normal/restrictive types on the basis of E/A, Ea and E/Ea. The normal filling pattern was recognized if E/A ratio was >0.9, Ea >8 cm/s and E/Ea <10; abnormal relaxation filling pattern if E/A ratio was ≤0.9; and pseudo-normal/restrictive filling pattern if E/A ratio was >0.9 and Ea ≤8 cm/s or E/Ea ≥10 (Bruch et al. 2000; Farias et al. 1999; Firstenberg et al. 2000; Garica et al. 1998; Khouri et al. 2004; Nagueh et al. 1997).

Statistical analysis

All data were expressed as mean (± standard deviation). SPSS 11.0 (SPSS, Inc., Chicago, IL, USA) was used for statistical analysis. Multiple comparisons between the study groups were performed by one-way analysis of variance (ANOVA) followed by *post hoc* test adjusted with a Bonferroni correction. Categorical variables were compared by chi-square analyses. All tests were two-sided, and the level of significance was established as $p < 0.05$.

RESULTS

The clinical and echocardiographic characteristics among the study groups are shown in Table 1. The patients in group 1 were younger than those in groups 2 and 3 (both $p < 0.001$). The prevalence rate of diabetes mellitus and hypertension was lower in group 1 than in groups 2 and 3 ($p \leq 0.026$). The study was done with the patients taking their usual medications.

Heart rate was not different among groups. Left atrial dimension (LA) and left ventricular end-diastolic