Magnetic resonance velocity mapping of transtricuspid velocity profiles in dilated cardiomyopathy

Yoshihito Nakagawa¹, Shinichi Fujimoto², Hiroshi Nakano², Reiko Mizuno¹, Asako Kimura¹, Toshio Hashimoto¹, and Kazuhiro Dohi¹

¹First Department of Internal Medicine and ²Department of Clinico-Laboratory Diagnostics, Nara Medical University, 840 Shijo-cho, Kashihara, Nara 634-8522, Japan

Summary. To investigate the velocity profiles and jet sizes of transtricuspid inflow by magnetic resonance imaging (MRI), we examined seven dilated cardiomyopathy (DCM) patients (mean age 37 ± 15 years) and 20 normal subjects (mean age 32 ± 7 years). We used a Siemens Magnetom Impact Expert (1.0T) together with a surface receiver coil. Electrocardiographic gating, triggered by the R wave, was performed. Cine gradient echo images were obtained in the short axis of the right ventricle. Velocity mapping of right ventricular inflow was obtained at peak early diastolic filling. Velocity profile curves across the tricuspid inflow were obtained at 1-cm intervals from the tricuspid ring up to 3 cm into the cavity. Maximum/mean velocities in both groups were 1.1 ± 0.1 at the ring level, unchanged at 1 cm from the tricuspid ring, and thereafter increased to 1.4 ± 0.3 at 2 cm and 1.5 ± 0.3 at 3 cm as peak velocity fell. Jet cross-sectional area was 10.4 ± 2.1 cm² at the ring level, and was unchanged at the 3-cm level in the normal subjects. However, in patients with DCM it was smaller than that in normals, and decreased in proportion to the distance from the tricuspid ring. Thus, tricuspid inflow velocity showed a relatively flat profile at the tricuspid ring and tip levels, becoming more dispersed at 2 and 3 cm from the ring. The cross-sectional area of the right ventricular inflow jet in the DCM patients was small and decreased in proportion to the distance from the tricuspid ring, although it appeared to be relatively constant in normal subjects.

Key words: Dilated cardiomyopathy – Magnetic resonance imaging – Right ventricular filling – Velocity profile

Introduction

Dilatation and depressed contractile function of the left ventricle are features of dilated cardiomyopathy (DCM), and alterations in left ventricular diastolic function have been demonstrated. Right ventricular diastolic function is also an important determining factor for chest symptoms and exercise tolerance in patients with left ventricular disease. However, little information is available concerning right ventricular diastolic function in DCM patients [1-4]. Analysis of the velocity profile of right ventricular filling has been limited because of anatomical complexities. A noninvasive technique such as Doppler echocardiography can provide useful information. Determining the Doppler transtricuspid inflow pattern can provide insights into the right ventricular diastolic filling dynamics. A disadvantage of the Doppler method, however, is that it determines only one point in the heart at a time, and cannot assess many points in the heart simultaneously. Recent advances in magnetic resonance imaging (MRI) have enabled us to obtain hemodynamic information or ventricular volume with good reproducibility [5]. Assessment of the velocity profile of the heart is crucial for calculating the flow volume using Doppler echocardiography. We observed relatively flat velocity profiles in our previous assessment of the velocity profiles of transtricuspid flow [6]. In the present study, we used MRI with velocity mapping to compare the velocity profiles of right ventricular diastolic filling in normal subjects with those in patients with DCM.

Patients and methods

Subjects

A total of 20 healthy Japanese volunteers (17 males and 3 females; mean age 32 ± 7 years) and seven DCM
patients (5 males and 2 females; mean age 37 ± 15 years) gave their informed consent to participate in this study.

**Magnetic resonance imaging**

For magnetic resonance velocity mapping, we used the Siemens Magnetom Impact Expert operating at 1.0 Tesla. A surface receiver coil was used. Electrocardiographic gating was performed in all anatomical and flow studies, and sequences were triggered by the R wave. Cine gradient echo images of the coronal section at a slightly anterior to mid-axillary line, including the heart, was obtained at first, and then a plane including both the apex of the right ventricle and the base of the heart were recorded. This plane was corrected to include both the mid-portion of the tricuspid valve and the apex of the right ventricle. The right ventricular long axis section was obtained. Thereafter, cine images with velocity mapping in the right ventricular short axis plane were obtained at 1-cm intervals from the tricuspid ring towards the apex. The imaging parameters were as follows; echo time, 6ms; repetition time, 30ms; flip angle, 25°; slice thickness, 6mm; field of view, 350 × 350mm; and flow encoding gradient, 75cm/s. Images were displayed on a 256 × 256 matrix from data acquired using 128 phase-encoding steps. We also obtained the right ventricular time–volume curve. The right ventricular cavity was traced in each image during the entire cardiac cycle. The right ventricular volume at each phase of the cardiac cycle was then calculated with Simpson's rule by summing the cavity areas using a slice thickness of 1cm. Time–volume curves for the right ventricle were plotted against time after the R wave. From these, we determined the phase of peak early diastole. Velocity mapping of right ventricular inflow was obtained at peak early diastolic filling. Velocity profile curves across the tricuspid inflow were obtained at 1-cm intervals from the tricuspid ring to 3 cm into the cavity (Fig. 1).

Maximum transtricuspid flow velocities were measured by drawing a velocity profile across the tricuspid inflow at each 1-cm interval up to 3 cm from the tricuspid ring level. Mean velocity across the velocity profiles was obtained by drawing an area of interest around the velocity profiles. The flow profile at any level was thus characterized as the ratio of peak-to-mean velocity. The cross-sectional areas were measured on the computer screen from velocity mapping acquired in the short axis planes.

**Statistical analysis**

Values are expressed as mean ± standard deviation. Values at different levels were compared by analysis of

---

Fig. 1a,b. Measurements of right ventricular inflow jet velocity profiles. a Horizontal view of the right ventricular inflow. b Velocity profile at the tricuspid ring level.