A Novel and Simple Method Using Pocket-Sized Echocardiography to Screen for Aortic Stenosis

Yukio Abe, MD, Makoto Ito, MD, Chiharu Tanaka, MD, Kazato Ito, MD, Takahiko Naruko, MD, PhD, Akira Itoh, MD, Kazuo Haze, MD, PhD, Takashi Muro, MD, Minoru Yoshiyama, MD, PhD, and Junichi Yoshikawa, MD, PhD, *Osaka, Kobe, and Nishinomiya, Japan*

Background: Pocket-sized echocardiography may serve as an initial tool to screen for aortic stenosis (AS). The purpose of this study was to evaluate the usefulness of a novel and simple method using pocket-sized echocardiography to screen for AS.

Methods: Subjects (n = 130) with systolic ejection murmur or known AS were studied. After physical examination, each aortic cusp's opening was visually scored using pocket-sized echocardiography as follows: 0 = not restricted, 1 = restricted, or 2 = severely restricted. The sum of the scores was defined as the visual AS score. On the basis of high-end echocardiography, an aortic valve area index <0.60 cm^2/m^2 and an aortic valve area index of 0.60 to 0.85 cm^2/m^2 were considered to indicate severe and moderate AS, respectively.

Results: For diagnosing severe AS (n = 27), a visual AS score ≥4 had sensitivity of 85% and specificity of 89%. For diagnosing moderate to severe AS (n = 57), a visual AS score ≥3 had sensitivity of 84% and specificity of 90%. The areas under the receiver operating characteristic curves for diagnosing severe and moderate to severe AS with a visual AS score (0.946 and 0.936, respectively) were slightly larger than those for a skilled physical examination (0.917 and 0.898, respectively) (P = NS for both) but were significantly larger than for an aortic valve calcification score also obtained using pocket-sized echocardiography (areas under the curve, 0.816 [P = .0015] and 0.827 [P = .0001], respectively).

Conclusions: A novel and simple method using pocket-sized echocardiography is useful for rapid grading of AS in subjects with systolic ejection murmur. (J Am Soc Echocardiogr 2013;■:■-■.)

Keywords: Aortic stenosis, Echocardiography, Pocket-sized imaging device, Physical examination, Cardiac screening

Aortic stenosis (AS) is the most common valvular heart disease, and the etiology of a large proportion of modern AS is senile degenerative calcification.[1,2] Thus, the prevalence of AS robustly increases with the age of the population. It is well known that mortality in patients with AS rises sharply soon after the onset of symptoms.[3] Moreover, even asymptomatic patients with significant AS have a risk for sudden death not preceded by symptoms in addition to a high probability of developing symptoms within a few years.[4-7] On the other hand, surgical aortic valve replacement provides symptom relief and increases life expectancy in most patients with significant AS. Therefore, the early detection of significant AS is very important.

From the Department of Cardiology, Osaka City General Hospital, Osaka, Japan (Y.A., M.I., C.T., K.I., T.N., A.I., K.H.); Department of Cardiology, Midori Hospital, Kobe, Japan (T.M.); Department of Internal Medicine and Cardiology, Osaka City University Medical School, Osaka, Japan (M.Y.); and the Department of Cardiology, Nishinomiya-Watanabe Cardiovascular Center, Nishinomiya, Japan (J.Y.).

Reprint requests: Yukio Abe, MD, Department of Cardiology, Osaka City General Hospital, 2-13-22 Miyakojima-hondori, Miyakojima-ku, Osaka, Japan 534-0021 (E-mail: *abeyukio@aol.com*).

0894-7317/$36.00

http://dx.doi.org/10.1016/j.echo.2013.03.008

AS is usually detected initially by the presence of a systolic ejection murmur (SEM), which is identified in almost all patients with AS.[8] Thus, patients with SEM are frequently referred to echocardiographic laboratories for high-end echocardiography. Complete examination with high-end echocardiography is thought to be the gold standard for the diagnosis of AS.[9] However, it is time-consuming and expensive for all subjects with SEM to undergo high-end echocardiography, because SEM is audible in approximately 50% of people aged >50 years and is not specific for significant AS.[10,11] In addition, it is common that there is a late diagnosis of significant AS and late referral for surgical aortic valve replacement, and delaying surgery negatively influences outcomes in patients with AS.[12] Therefore, some simple and fast measures to initially detect significant AS are needed.

There are other physical examination findings that diagnose significant AS more accurately than SEM, such as transmission of SEM to the neck, late peaking of SEM, a diminished second heart sound, delayed carotid artery upstroke, or carotid artery shudder.[11,13-19] These findings have been traditionally used to screen patients for AS before a complete examination with high-end echocardiography. In contrast, pocket-sized echocardiography can now easily be brought to patients and may serve as a tool for fast and accurate initial screening and as a complement to the physical examination. Furthermore, pocket-sized echocardiography may be used to rapidly triage patients who need more

Abbreviations

AS = Aortic stenosis

AUC = Area under the curve

AVA = Aortic valve area

AVAI = Aortic valve area index

CI = Confidence interval

LV = Left ventricular

SEM = Systolic ejection murmur

advanced methods to confirm the diagnosis of significant AS and has the potential to improve patient work flow.[20-24] However, the appropriate method to screen for AS using pocket-sized echocardiography has not yet been established.

The purpose of this study was to evaluate the usefulness of our novel and simple method using pocket-sized echocardiography to screen for AS.

METHODS

Subjects and Protocol

We recruited 147 consecutive patients aged >20 years who had SEM with grade ≥2 or known AS and were referred to the echocardiography laboratory at the Osaka City General Hospital. Patients with atrial fibrillation or any other significant murmurs louder than SEM were excluded. Patients were also excluded if there was technical difficulty in observing the aortic valve cusps on pocket-sized echocardiography or in evaluating the aortic valve area (AVA) using the continuity equation with high-end echocardiography. Furthermore, patients with bicuspid aortic valves or those with any other significant disease leading to SEM, such as left ventricular (LV) outflow tract obstruction, were also excluded. The study protocol was approved by the institutional review board of the Osaka City General Hospital, and written informed consent was obtained from all patients. Subjects underwent cardiac physical examination, pocket-sized echocardiography, and high-end echocardiography in sequence.

Physical Examination

Subjects underwent cardiac physical examinations in the supine position. Physical examinations were performed by an experienced cardiologist, who was blinded to all other patient information. The presence or absence of the following physical examination findings was assessed: transmission of SEM to the neck, late peaking of SEM, a diminished second heart sound, delayed carotid artery upstroke, and carotid artery shudder.[13-19] Transmission of SEM to the neck was judged at the right carotid artery. Late peaking of SEM was judged as present if SEM had its peak intensity in mid-systole or later at the location with the maximal murmur intensity. A diminished second heart sound was considered present if the aortic component of the second heart sound was significantly smaller than the first heart sound at the second or third left intercostal space. During normal breathing, the aortic component of the second heart sound was identified by its temporal relation to the pulmonary component that occurs later in the inspiratory period. To assess the carotid artery pulse, the examiner applied both light and firm pressure over the carotid artery on the side where the carotid pulse was most palpable and determined whether there was a delayed carotid artery upstroke and carotid artery shudder.

Pocket-Sized Echocardiography

Pocket-sized echocardiography was performed using a Vscan (GE Healthcare, Little Chalfont, United Kingdom) by an expert sonographer corresponding to level 3,[25] who was blinded to all other patient information. The device weighs 390 g, including the phased-arrayed probe, which measures 135 × 73 × 28 mm. The device does not offer continuous-wave or pulsed-wave Doppler analysis but only two-dimensional grayscale imaging and color Doppler imaging. The image sector for echocardiographic imaging is 758. The bandwidth ranges from 1.7 to 3.8 MHz and is automatically adjusted. Subjects underwent a semicomprehensive cardiac screening protocol with the pocket-sized device in the left lateral decubitus position, focusing on visual assessment of LV systolic function and valves.

First, we imaged the aortic valve in the parasternal short-axis view and adjusted the transducer orientation and image display so that the valve was centered in the display. We visualized lines between each of the three commissures, as illustrated in Figure 1A. We then scored each aortic cusp's opening visually as follows: 0 = not restricted, 1 = restricted, or 2 = severely restricted. When a cusp did not open over the line between the commissures, the cusp's opening was classified as restricted. When a cusp's systolic motion was severely reduced or absent, the cusp's opening was classified as severely restricted. Examples of normal, restricted, and severely restricted cusp motion are demonstrated in Figures 1A–1D and Videos 1A to 1D (available at www.onlinejase.com). We defined the sum of the scores for the three cusps as the visual AS score (range, 0–6). Then, the degree of calcification of the aortic valve was also scored as follows: 1 = no calcification, 2 = mildly calcified (small isolated spots), 3 = moderately calcified (multiple larger spots), or 4 = heavily calcified (extensive thickening and calcification of all cusps).[5]

After the assessment of the aortic valve cusps, we visually evaluated the presence or absence of regional LV systolic dysfunction and global LV systolic dysfunction from images in the parasternal long-axis, parasternal short-axis, apical four-chamber, apical two-chamber, and apical long-axis views. Aortic, mitral, and tricuspid valvular regurgitations were qualified as none, mild, moderate, or severe by visual assessment of color Doppler imaging.[20] We also screened for any other significant abnormalities leading to SEM, such as LV outflow tract obstruction. Other unexpected abnormalities were also sought. The time required for examination using the pocket-sized device was measured in each subject.

High-End Echocardiography

Subjects underwent complete examination with high-end echocardiography performed by another level 3 sonographer, who was blinded to all other patient information. The iE33 (Philips Medical Systems, Bothell, WA), Acuson Sequoia 512 (Siemens Medical Systems, Mountain View, CA), or Aplio SSA-700A (Toshiba Medical Systems, Tokyo, Japan) was used for high-end echocardiography with second-harmonic mode. LV diastolic dimension, LV systolic dimension, LV mass index, and LV ejection fraction were evaluated according to the guidelines of the American Society of Echocardiography.[26] LV ejection fraction was evaluated using the biplane method of disks. Doppler flow data were obtained from the LV outflow tract region in pulsed-wave mode and from the aortic valve in continuous-wave mode using multiple transducer positions to obtain the maximal velocity. LV outflow tract diameter was measured in the parasternal long-axis view at the position used to obtain the pulsed-wave Doppler data. AVA was calculated using the continuity equation ($AVA = area_{outflow} \times$ velocity-time $integral_{outflow}$/velocity-time $integral_{valve}$). The AVA index (AVAI) was obtained by dividing AVA by body surface area, and an AVAI <0.60 cm^2/m^2 and an AVAI of 0.60 to 0.85 cm^2/m^2 were considered to indicate severe AS and moderate AS, respectively.[7,9,27]