Journal of Cardiology 61 (2013) 428–435

Contents lists available at SciVerse ScienceDirect

Journal of Cardiology

journal homepage: www.elsevier.com/locate/jjcc

Original article

Major determinants and possible mechanism of dobutamine-induced left ventricular outflow tract obstruction in patients with a sigmoid ventricular septum

Ayako Tano (MD), Yuji Kasamaki (MD, FJCC)*, Yasuo Okumura (MD), Masakatsu Ohta (MD), Tatsuya Kofune (MD), Nobuyuki Fujii (MD), Yosihiro Aizawa (MD), Toshiko Nakai (MD), Satoshi Kunimoto (MD, FJCC), Takafumi Hiro (MD, FJCC), Ichiro Watanabe (MD, FJCC), Atsushi Hirayama (MD, FJCC)

Division of Cardiology, Department of Medicine, Nihon University School of Medicine, Tokyo, Japan

ARTICLE INFO

Article history:
Received 28 September 2012
Received in revised form
18 December 2012
Accepted 22 January 2013
Available online 15 March 2013

Keywords:
Sigmoid septum
Latent left ventricular outflow tract obstruction
Dobutamine stress echocardiography

ABSTRACT

Background: A sigmoid ventricular septum (SVS) may be related to normal aging, but some people with an SVS develop a left ventricular outflow tract (LVOT) obstruction (defined as a gradient of >30 mmHg). Therefore, we investigated the association of LVOT obstructions with an SVS by dobutamine stress echocardiography (DSE) and assessed the possible mechanism of the latent LVOT obstruction.

Methods and results: DSE was performed in 64 subjects with SVS (mean age: 73.3 ± 7.7 years; 36 women) without an LVOT obstruction. In 40 of the 64 subjects, an LVOT obstruction occurred during the DSE (defined as latent obstruction). At rest, the subjects with a latent obstruction had a shorter end-systolic mitral leaflet tethering distance ("α" distance, i.e. the distance between the tip of the posterior papillary muscle and the contralateral anterior mitral annulus) than those without one (29.9 ± 4.2 mm versus 35.2 ± 4.6 mm), as well as a smaller end-systolic LVOT diameter (13.4 ± 2.7 mm versus 16.1 ± 3.4 mm) and larger ejection fraction (72.0 ± 5.0% versus 67.8 ± 5.9%) (all $p < 0.05$). They also had a higher LV outflow velocity at rest (1.23 ± 0.24 m/s versus 1.03 ± 0.24 m/s) and during the Valsalva maneuver (1.31 ± 0.27 m/s versus 1.03 ± 0.27 m/s) (both $p < 0.05$). After adjusting for these parameters, the resting end-systolic "α" distance and LV outflow velocity at rest remained independent predictors of a latent obstruction.

Conclusion: A short leaflet tethering distance ("α") was the major determinant of a latent obstruction, suggesting that a mitral leaflet displacement/redundancy caused by a short "α" distance contributes to the LVOT obstruction.

Introduction

A sigmoid ventricular septum (SVS) is considered to be related to the normal aging process and has not been reported to be associated with an adverse prognosis [1–3]. However, a left ventricular outflow tract (LVOT) obstruction can occur in persons with an SVS [4,5]. According to one report, about 50% of persons with an SVS have an excessive response to dobutamine and develop an LVOT obstruction even in the absence of regional left ventricular wall motion abnormalities, i.e. so-called "latent LVOT obstruction" [6]. In patients with hypertrophic obstructive cardiomyopathy (HOCM), which is well known to cause LVOT obstructions, the mechanism of the obstruction has been investigated extensively [7–15]. However, little is known regarding the mechanism of latent LVOT obstructions associated with SVS. Therefore, the objectives of the present study were: (1) to investigate the occurrence of LVOT obstructions in persons with SVS during dobutamine stress echocardiography (DSE); (2) to determine the predictors of latent LVOT obstructions; and (3) to identify the possible mechanisms of latent obstructions.

Methods

Study population

We screened 78 consecutive patients who had SVS together with various cardiac symptoms [41 patients (53%)], any electrocardiographic (ECG) abnormalities [44 patients (56%)] and/or cardiothoracic ratio ≥50% on the chest X-ray [18 patients (23%)], and who were referred to our echocardiography laboratory from

* Corresponding author at: Division of General Internal Medicine, Department of Internal Medicine, Nihon University School of Medicine, Ohyaguchi-kami machi, Itabashi-ku, Tokyo 173-8610, Japan. Tel.: +81 3 3972 8111; fax: +81 3 3972 1098.
E-mail address: kasamaki.yuuji@nihon-u.ac.jp (Y. Kasamaki).

0914-5087/$ – see front matter © 2013 Japanese College of Cardiology. Published by Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jjcc.2013.01.008

September 2009 to August 2010. Fourteen patients met the exclusion criteria described below, so the remaining 64 patients (36 women and 28 men; mean age: 73.3 ± 7.7 years) underwent DSE to investigate the occurrence of an LVOT obstruction. Detection of an SVS was based upon a quantitative assessment by sonographers and cardiologists with more than 5 years of experience. We defined the SVS according to the following criteria [3,7]: (1) an upper interventricular septal thickness ≥14 mm; (2) an upper septal thickness/mid-septal thickness ratio ≥1.3; (3) an angle between the anterior wall of the aorta and right ventricular side of the interventricular septum (septal θ) <120° in the parasternal long-axis view; and (4) no wall motion abnormalities or mid-septal scarring that could result in isolated septal thickening. The exclusion criteria were: (1) an asymmetric septal hypertrophy (mid-septal thickness/posterior wall thickness ratio ≥1.3); (2) valvular heart disease (moderate to severe mitral or tricuspid regurgitation with a regurgitant fraction >20%, severe aortic regurgitation with a steep jet deceleration rate <200 ms, or aortic stenosis with an aortic valve area <3.0 cm^2); (3) an implanted pacemaker; (4) ischemic heart disease (detected by an exercise stress test, computed tomography angiography, or pharmacological/exercise stress thallium scintigraphy; (5) a history of a cerebral or aortic aneurysm; (6) an age >90 years; (7) global or local abnormalities of the left ventricular contraction; and 8) poor quality echocardiographic images. This study was approved by our institutional human research committee (Nihon University Itabashi Hospital Review Board).

Dobutamine stress echocardiography

DSE was performed as reported previously [16]. In brief, as the 12-lead ECG and blood pressure were monitored, dobutamine was infused at an initial rate of 10 μg/kg/min, which was subsequently increased to 20, 30, and 40 μg/kg/min every 3 min. At baseline, both the general echocardiographic parameters and the following specific parameters were measured: (a) upper and mid interventricular septal thickness at the end-diastolic phase; (b) LVOT diameter; (c) septal θ (Fig. 1A); and (d) the mitral leaflet tethering distance ("α", defined as the distance from the tip of the posterior papillary muscle to the contralateral anterior part of the mitral annulus in the apical three-chamber view) (Fig. 1B and C). These specific parameters were measured at both end-systole and end-diastole. The LV ejection fraction (EF) was measured by biplane Simpson's method. In addition, we measured the LV posterior wall thickness (PWT), relative wall thickness (RWT), and LV mass (LVM = 0.8 × (1.04 ([LV end-diastolic dimension (LVEDD) + PWT + mid interventricular septal thickness]^3 − [LVEDD]^3)) + 0.6 (g)). The LV mass index (LVMI) was calculated by the LVM/body surface area. The RWT was measured as 2 × PWT divided by the LVEDD.

The LVOT velocity was measured at rest and during the Valsalva maneuver by pulsed Doppler echocardiography (Fig. 2A and C). During a dobutamine infusion at each rate (10–40 mg/kg/min), the LVOT velocity was measured by continuous Doppler echocardiography. When the LVOT velocity reached more than 1 m/s, the LVOT pressure gradient was estimated using the simpli-

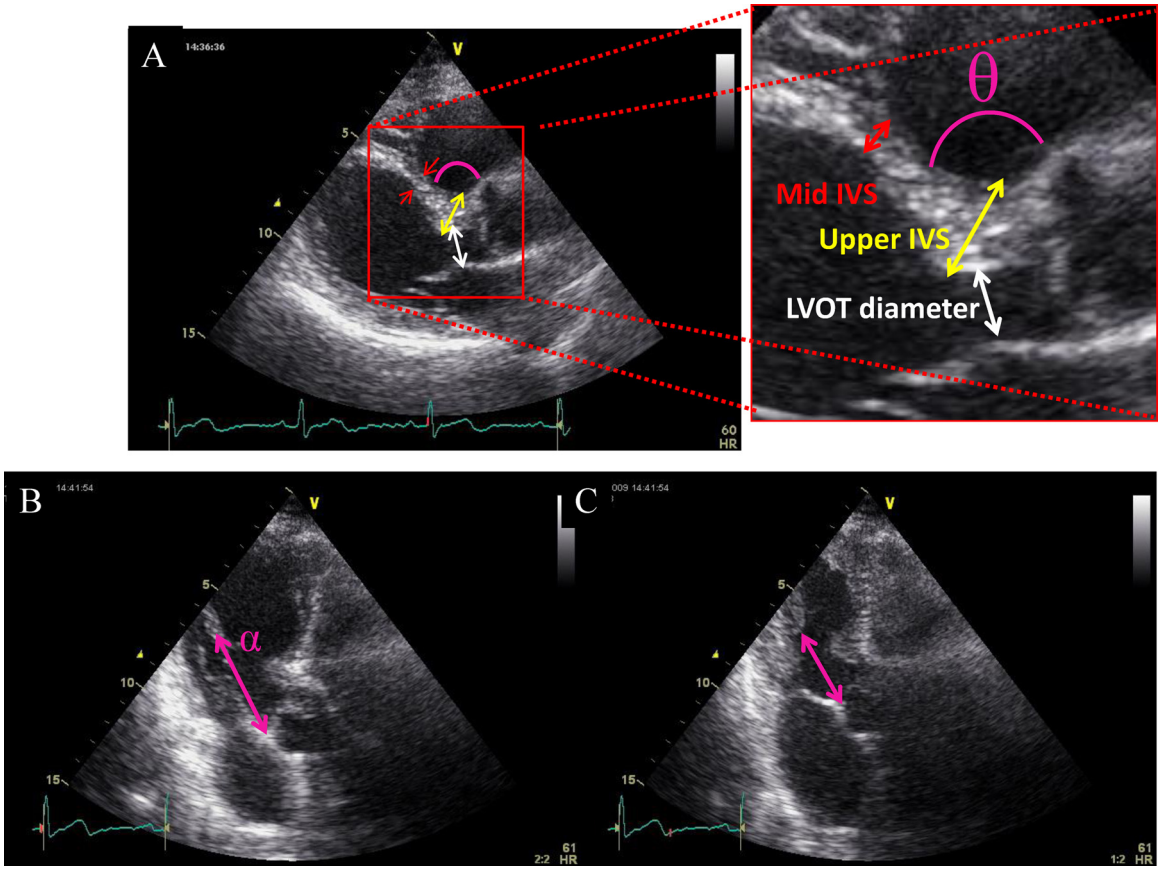

Fig. 1. Representative example of a sigmoid ventricular septum patient with a latent left ventricular outflow tract (LVOT) obstruction. Measurement of the baseline echocardiographic parameters in the parasternal long-axis view and enlarged view of the LVOT (A), as well as in the apical three-chamber view at end-diastole (B) and end-systole (C). (A) The septal angle "θ" is the angle between the anterior wall of the aorta and the right ventricular side of the interventricular septum (IVS) at end-diastolic phase. The bidirectional red, yellow, and white arrows indicate the mid-IVS, upper IVS, and LVOT diameter, respectively. (B and C) The leaflet tethering distance "α" is defined as the distance between the tip of the posterior papillary muscle and the contralateral anterior part of the mitral annulus (bidirectional purple arrow). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)