Real Time Observation of the Echo Source of Systolic Hump in Hypertrophic Obstructive Cardiomyopathy with High Speed Ultrasono-Cardiotomography

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SUMMARY

The present study was undertaken to discuss the echo source of systolic hump in hypertrophic obstructive cardiomyopathy (HOCM) from a viewpoint of B-mode echocardiography. Cross-sectional images were obtained from 4 patients with HOCM using a Sonolayergraph of Toshiba, SSL-51H. This equipment is characterized by its high speed mechanical sector scanning and wider angle.

Recordings were made with ordinary 35 mm camera or Polaroid in conjunction with 8 mm cinecamera.

Our data showed that systolic hump in this lesion was not caused by anterior systolic movement of anterior mitral leaflet, but was emanated from the chordae tendineae attached to the anterior or posterior mitral leaflet. In systole, the anterior mitral leaflet moved backward for closure, while the chordae tendineae approached the bulged interventricular septum resulting in the formation of systolic hump.

Additional Indexing Words:

Systolic anterior motion Idiopathic hypertrophic subaortic stenosis
B-mode echocardiography M-mode echocardiography Left heart
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STANDARD M-mode echocardiography is an indispensable technique for the evaluation of hypertrophic obstructive cardiomyopathy. However, it is not suitable for the spacial presentation of intracardiac structure in detail, since it is essentially one-dimensional.

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Since the advent of cross-sectional echocardiography, there have been a variety of documents¹⁾⁻⁷⁾ regarding hypertrophic obstructive cardiomyopathy. However, attention has been paid mostly to the mechanism of left ventricular obstruction and the echo source of systolic hump still remains to be solved.

A recent report presented by Martin and associates⁸⁾ has given rise to further study on the systolic hump in this lesion.

The purpose of the present paper is to discuss the echo source of systolic hump or SAM (systolic anterior motion) in hypertrophic obstructive cardiomyopathy by real time observation with high speed ultrasono-cardiotomography.

MATERIALS AND METHODS

Four patients, 2 males and 2 females, ranging in age from 16 to 44 years were studied. The diagnosis was established in each case by catheterization and angiography in conjunction with standard M-mode echocardiography. Findings are listed in Table I. All of the subjects had a prominent systolic hump in M-mode echocardiograms.

Table I. Case Materials

No.	Name	Age	Sex	SAM in M-mode UCG	Systolic LV Pressure (mmHg)	
					apex	outflow
1	K. G.	22	M	yes	140	115
2	Y. S.	24	F	yes	145	130
3	K. O.	16	M	yes	170	125
4	Y. S.	44	F	yes	290	160

SAM=systolic anterior motion or systolic hump, LV=left ventricle

Ultrasound recordings of the systolic hump were made using a Sonolayergraph of Toshiba, Model SSL-51H and a 3MHz transducer. As previously reported from our laboratory,⁹⁾ this equipment is characterized by its high speed mechanical sector scanning and real time observation of intracardiac structures.

All the subjects were examined in the supine position. For better acoustic coupling between chest surface and transducer, the so-called "proximity immersed method"⁹⁾ was used, in which the probe was soaked in a vinyl bag filled with castor oil. The distance from the chest surface was approximately 5 mm. A cross-section along the left ventricular long axis was usually employed.

Two methods⁹⁾ were utilized to record cross-sectional images on the oscilloscopic screen. First, the photographs were taken by an ordinary 35 mm camera or Polaroid in synchrony with ECG, and occasionally taken at a shutter speed of 1/10 or 1/15 sec without a triggering circuit. The second approach was a cinematographic method with a commercially available 8 mm cinecamera.

RESULTS

A representative M-mode echocardiogram is shown in Fig. 1. This picture was taken from a 16-year-old male with hypertrophic obstructive cardiomyopathy (K.O.). As indicated by a white arrow, a prominent systolic hump or SAM is visualized in systole. The interventricular septum (IVS) is extremely thickened and encroaches upon the left ventricular outflow tract. The systolic pressure gradient between left ventricular outflow and apex was 45 mmHg according to the hemodynamic finding (Table I).

In order to detect the echo source of the systolic hump in this patient, two-dimensional echocardiograms were obtained along the left ventricular long axis as shown in Fig. 2. In diastole (left picture), the anterior mitral leaflet (AML) approaches the extremely thickened interventricular septum (IVS), while in systole (right picture), the chordae tendineae (CT) are anter-

Fig. 1. A representative M-mode echocardiogram taken from a 16-year-old male with HOCM. As indicated by a white arrow, a prominent systolic hump is visualized in systole. IVS=interventricular septum, SAM=systolic hump or systolic anterior motion, AML=anterior mitral leaflet, PML=posterior mitral leaflet, LVPW=left ventricular posterior wall.

Fig. 2. Cross-sectional echocardiograms from the same patient as in Fig. 1. These images were obtained along the long axis of left ventricle. In diastole (left picture), the AML fully opens and approaches the extremely thickened IVS, while in systole (right picture), the chordae tendineae (white arrow) are anteriorly pulled toward the outflow tract of left ventricle. At this moment, the AML retreats backward in the opposite direction. RV=right ventricle, AO=aorta, LA=left atrium, LV=left ventricle, PM=papillary muscles, CT=chordae tendineae, CT(SAM)=the chordae tendineae are the echo source of systolic hump.

iorly pulled toward the outflow tract of the left ventricle. At this moment, the anterior mitral leaflet moves backward in the opposite direction. Furthermore, based upon a real time observation by 8 mm cinematography, it is impossible for the mitral leaflet to be an echo source of systolic hump, since it is located well away from the outflow tract of left ventricle when the chordae tendineae maximally approach the outflow.

Fig. 3 shows another example of SAM in M-mode echocardiogram taken of a 22-year-old male (K.G.). A white arrow indicates a prominent systolic hump. As shown in Table I, there was a systolic pressure gradient of 25 mmHg in the left ventricular cavity.

B-mode echocardiograms of the same patient as in Fig. 3 are demonstrated in Fig. 4. The cross-sectional images were obtained through the long axis of left ventricle. Similar to the K.O.'s case, the chordae tendineae comes into close contact with the interventricular septum in systole (left picture), in contrast with the anterior mitral leaflet going back for closure. In addition, the anterior mitral leaflet moves forward maximally in diastole for opening (right picture). This phenomenon implies that the SAM is generated by the chordae tendineae.

Fig. 3. M-mode echocardiogram from a 22-year-old male with HOCM. A white arrow shows a prominent SAM in systole. The AML fully opens in diastole and comes in touch with the thickened IVS.

The interventricular septum is extremely thickened and encroaches upon the left ventricular cavity in concert with the hypertrophied papillary muscles (PM).

The summary of results is listed in Table II; in all the subjects, the systolic hump is generated by the chordae tendineae attached to the anterior or posterior mitral leaflet.

DISCUSSION

Conventional M-mode echocardiography has been successfully used in the diagnosis of idiopathic hypertrophic subaortic stenosis. And the systolic hump is considered to be one of the most important diagnostic criteria of this lesion. There have been many reports¹⁾⁻⁷⁾ regarding the systolic hump as derived from abnormal forward movement of anterior mitral leaflet during systole.

Fig. 4. Cross-sectional echocardiograms from the same patient as shown in Fig. 3. These pictures were taken along the long axis of left ventricle. In systole (left panel), the chordae tendineae (black arrow) are anteriorly pulled and closely contact the thickened IVS, whereas the AML moves backward. In diastole (right panel), the AML approaches the IVS. The systolic hump is generated by the chordae tendineae with certainty.

Table II. Echo Source of SAM

No.	Name	Age	Sex	SAM in M-mode UCG	Echo Source of SAM
1	K. G.	22	M	yes	chordae tendineae
2	Y. S.	24	F	yes	chordae tendineae
3	K. O.	16	M	yes	chordae tendineae
4	Y. S.	44	F	yes	chordae tendineae

In this study we attempted to protest against this theory since there is a great discrepancy between our observation and those in the documents¹⁾⁻⁵⁾ previously reported by other authors. The analysis of the systolic hump or SAM in their studies were mostly based on M-mode echocardiography. It lacks the spacial orientation of mitral apparatus since it is essentially one-dimensional.

In this connection, B-mode echocardiography is thought more useful for two-dimensional display of fine intracardiac structures. Henry and associates⁶⁾ commented on the mechanism of left ventricular outflow tract obstruction in this lesion using cross-sectional echocardiography. However, chordal contribution to the SAM formation was not mentioned in their report. Furthermore, Cohen and associates⁷⁾ noted with B-mode echocardiography that sys-

tolic hump may present the motion of only a small part of the mitral leaflet, perhaps the free edge or redundant valve tissue.

In order to identify the echo source of systolic hump, it is necessary to carefully observe the subtle movements of mitral apparatus and to distinguish mitral leaflet from chordae tendineae using motion picture or video system. And it is also important to repeat the real time observation of chordal area.

According to our experience, anterior mitral leaflet maximally approaches the bulged interventricular septum in diastole, whereas it is positioned well away from the septum in systole. In contrast, the chordae tendineae show a rapid forward movement toward the thickened interventricular septum in systole, resulting in the formation of systolic hump.

It is most likely that systolic hump is not generated by abnormal systolic motion of anterior mitral leaflet, but derived from the chordae tendineae attached to anterior or posterior mitral leaflet. It is impossible that the anterior mitral leaflet maximally contacts the interventricular septum in mid-systole, because it is located well away from the septum for its closure.

The fallacy committed by other authors¹⁾⁻⁵⁾ is probably caused by the difficult spacial orientation of echo source with M-mode echocardiography. At present, however, it is not always easy in each case to determine which chordal system, anterior or posterior, plays a main role in the genesis of systolic hump.

It is not clear that chordae tendineae contribute to the left ventricular obstruction, but a combination of the septum and papillary muscles is thought to be a major factor causing the obstruction. The chordae tendineae may be sucked by a Venturi's effect in contrast with the anterior mitral leaflet retreating backward.

Recently, Nimura and associates¹⁰⁾ protested against the theory that systolic hump is caused by anterior systolic motion of mitral leaflet. We insist here on the importance of real time observation of heart with B-mode echocardiography, since it provides a spacial orientation of echo source of systolic hump.

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