Real-time Observation of Ruptured Right Sinus of Valsalva Aneurysm by High Speed Ultrasono-cardiotomography

Report of a Case

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SUMMARY A two-dimensional echocardiographic manifestation of a ruptured right sinus of Valsalva aneurysm is described in this case report. The ultrasono-cardiotomograms demonstrated the aneurysm cut longitudinally and protruding into the outflow tract of the right ventricle. The configuration of the aneurysm was consistent with the contrast medium-filled sinus demonstrated by angio-cardiography. In systole, the aneurysmal sinus moved antero-inferiorly together with the aortic wall. The echocardiogram revealed an abnormal two-layered horizontal echo in the right ventricle which showed the aneurysm when the ultrasonic beam passed through the interventricular septum near the aortic root and mitral leaflets. During the operation, the protruding sinus and a small interventricular septal defect in the membranous septum under it were observed through the opened right ventricle. After the closure of the aneurysm, the two-dimensional echocardiogram no longer showed an abnormal configuration.

SINCE ULTRASOUND has been applied to the diagnosis of cardiac diseases, it has proved useful especially in anatomical and functional assessment of the structures of the left-sided heart, such as the mitral valve, aortic valve and left ventricle. Abnormal aortic wall echoes have been reported in such conditions as dissecting aneurysm and Marfan's syndrome. Some cases of right sinus of Valsalva aneurysm have been described, but they have not distinctly revealed the nature of the ruptured sinus itself. In the present report we describe a case in which the structure was demonstrated by high-speed ultrasono-cardiotomography and confirmed by operation.

Methods

Ultrasono-cardiotomograms and echocardiograms were obtained using a Sonolayergraph (Toshiba, Model SSL-51H) with a mechanical sector scanning system. A transducer, focused at 75 mm, which was made of lead zirconate-titanate, measuring 10 mm in diameter with a resonant frequency of 3 MHz, was used at the repetition rate of 3.6 KHz. It was mechanically oscillated at the rate of 15 or 18 cycles a second (30 or 36 cross-sections per second) by a scanner which was controlled to rotate alternately clockwise and counterclockwise. The oscillating angle of the transducer was detected by a potentiometer. The detected signals of rebounding echoes were displayed on oscilloscopes as B-mode so that the angle of an individual scanning line was equal to the angle of the transducer at the same instant. The oscillating angle of transducer was arbitrarily opened to the maximum of 90°, but the display angle on the oscilloscope was fixed at about 65°. When the oscillating angle of the transducer was smaller than the display angle on the oscilloscope, one image was composed of 120 or 100 scanning lines. When the former was greater than the latter, the scanning lines beyond the border were eliminated. To enable identification of the echo source, a particular scanning line was selected manually and B-mode was switched to M-mode to obtain the echocardiogram.

The patient was examined in the supine position. For coupling between the transducer and his chest, the so-called "proximity-immersed method" was employed and instead of degasified water, castor oil was utilized. The transducer was immersed in the oil bath placed on the chest surface and was brought close to the chest until multiple echoes from the bottom of the bath were eliminated.

Two methods were utilized to record the image on the oscilloscope screen: (1) a Polaroid camera or an ordinary 35 mm camera; and (2) 8 mm movie camera. Two ultrasono-cardiotomograms in this case report were taken at a shutter speed of 1/15 second by the ordinary camera.

Case Report

The patient was a 44-year-old man. His infancy was uncomplicated and he had a normal development. At the age of three years, he was first noted to have a heart murmur on routine examination, but he showed no symptoms during childhood and adolescence, enjoying sports without any restrictions. However, beginning in May of 1974, he experienced palpitation on exertion. On the night of August 17, 1974, he suddenly complained of dyspnea and his case was diagnosed as acute heart failure. Admitted to the...
Gamagori Municipal Hospital, he was given intensive care with oxygen, cardiotonics and diuretics, and showed improvement within a few days. He remained in the hospital until the 29th of October. After discharge, he was referred to the Nagoya University Hospital, where he was admitted for closer examination on November 5, 1974.

There was no history of rheumatic fever or syphilis. His father died from congestive heart failure.

Physical examination on admission revealed a small stature (159.2 cm, 52 kg) and pale skin color. Body temperature was 36.5°C. Blood pressure was 116/50 mm Hg and the pulse was 68 and regular. The neck veins were distended and the liver extended 2 cm below the right costal margin. There was no ankle edema and the lung fields were clear. A broad cardiac impulse was located on the precordium, and systolic and diastolic thrills were palpable. On auscultation, a grade VI/VI continuous, harsh murmur, maximal in the 4th intercostal space along the left sternal border, was audible over a wide area. The first and second sounds were of normal intensity, whereas the third and fourth sounds were not audible.

Laboratory examination revealed no anemia. Electrolytes, serum transaminase, LDH, alkaline phosphatase, bilirubin and creatinine were within normal ranges. Tests for C reactive protein and rheumatoid arthritis factor were negative and the antistreptolysin-O titer was 100 Todd units.

Electrocardiogram showed left ventricular hypertrophy (RV = 4.1 mV, SV = 2.2 mV, ST depression in II, aV, V, V) and negative T in leads V, V., Ventricular premature beats resembling left bundle branch block were occasionally recorded.

Chest X-ray demonstrated cardiomegaly; the left and right ventricular segments protruded markedly and the cardiothoracic ratio was 66.7%. Pulmonary vessels were engorged.

Ultrasono-cardiotomograms in figures 1 and 2, obtained by scanning the intermediate plane between the cross-sections of the long axis of the left ventricle and the sagittal plane along the left parasternal line, revealed the ruptured right sinus of Valsalva aneurysm. In normal subjects, the anterior aortic wall is in continuity with the interventricular septum, whereas in this case, the lower portion of the anterior aortic wall adjacent to the septum, that is, the right sinus of Valsalva, protruded into the right ventricular outflow tract and the echo-interruption of its tip showed it to be ruptured. In systole, the ruptured aneurysm moved slightly downward and forward. The sinus in systole was less oblique than diastole. The right coronary cusp seemed to cover the sinus in systole. A ventricular septal defect was not recognized. The echocardiogram showed an abnormal double-layered echo in the right ventricle which was recorded only during the period from mid-systole to early diastole (fig. 3). This echo was obtained when the ultrasonic beam penetrated the protruding sinus (beam direction A shown in fig. 2). When the transducer was angled higher (beam direction B shown in fig. 2), the more complicated echoes indicating the aneurysm were recorded in front of the base of the anterior mitral leaflet (fig. 4). When the transducer was angled even higher, the echoes of the anterior and posterior aortic walls were clearly detected. The right coronary cusp showed a dip in early systole (fig. 5).

Right and left heart catheterization was performed and the hemodynamic and oxygen content data are summarized in table 1. Right atrial pressure (27/13, mean 21 mm Hg) and main pulmonary artery pressure (76/28, mean 48 mm Hg) were elevated. Dye dilution curve showed left-to-right shunt and a significant step-up of oxygen content was found at the right ventricle.

Angiocardiography showed the regurgitation of contrast medium from the aorta to the right ventricle through the ruptured right sinus of Valsalva aneurysm protruding anteriorly (fig. 6).

Figure 1. A diastolic ultrasono-cardiotomogram of a 44-year-old patient with a ruptured sinus of Valsalva aneurysm, obtained by scanning the intermediate plane between the cross-sections of the long axis of left ventricle and the sagittal plane along the left parasternal line. The right sinus protruding into the right ventricle is indicated by an arrow. The echo-interruption of its tip shows it to be ruptured. The interventricular septal defect is not recognized. AAO = anterior aortic wall; PAO = posterior aortic wall; IVS = interventricular septum; RVO = outflow tract of right ventricle; AML = anterior mitral leaflet; PML = posterior mitral leaflet; LA = left atrium; AV = aortic valve.

Figure 2. A systolic ultrasono-cardiotomogram of the patient with the ruptured sinus of Valsalva aneurysm protruding into the right ventricle. The configuration of the aneurysm is less oblique in comparison with that in diastole. It is moved somewhat antero-inferiorly by cardiac contraction. RCC = right coronary cusp; PM = papillary muscle; A = A = ultrasonic beam direction A and B, corresponding to the echocardiograms shown in figures 3 and 4, respectively.
Marfan’s syndrome, ankylosing spondylitis and bacterial endocarditis. The patient under study showed no findings to suggest an acquired cause, and his condition ruled out Marfan’s syndrome and ankylosing spondylitis. For these reasons, his sinus of Valsalva aneurysm was considered a congenital anomaly.

Generally, in the congenital type, the basic defect is believed to be an absence of the media in the sinus wall, which appears to be due to a lack of continuity between the media of the aorta and the annulus of the aortic valve. When the defect of the aortic media occurs, the wall behind the right coronary cusp most commonly is involved. Moreover, an aneurysm of the right sinus usually protrudes into the right ventricle. The aneurysm is easily recognized clinically when it ruptures. It is associated with a new, continuous, loud murmur, progressive heart failure and pulmonary congestion. It resists any medical treatment except surgical closure. The most reliable diagnostic measure for this condition is angiocardiography. However, ultrasono-cardiography can delineate the ruptured aneurysm protruding into the right ventricle. Moreover, the echographic configuration of the sinus is very similar to that seen by angiocardiogram.

In our experience, there are two other entities which must be differentiated from the sinus of Valsalva aneurysm. The first is the weak echo at the junctional area between the

### Table 1. Hemodynamic and Oxygen Saturation Data

<table>
<thead>
<tr>
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<th>Preoperative</th>
<th>Postoperative</th>
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<tbody>
<tr>
<td></td>
<td>Pressure (mm Hg)</td>
<td>Oxygen (%)</td>
</tr>
<tr>
<td>Right atrium</td>
<td>27/13 (21)*</td>
<td>72.6</td>
</tr>
<tr>
<td>Right ventricular inflow</td>
<td>76/8 (40)</td>
<td>85.5</td>
</tr>
<tr>
<td>Right ventricular outflow</td>
<td>76/6 (40)</td>
<td>91.2</td>
</tr>
<tr>
<td>Main pulmonary artery</td>
<td>76/28 (48)</td>
<td>93.8</td>
</tr>
<tr>
<td>Left pulmonary artery</td>
<td>80/25 (50)</td>
<td>94.0</td>
</tr>
<tr>
<td>Femoral artery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left ventricle</td>
<td>112/4 (70)</td>
<td></td>
</tr>
<tr>
<td>Aorta</td>
<td>112/56 (80)</td>
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*Mean pressure in parentheses.
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anterior aortic wall and the interventricular septum which
occasionally is seen in the subjects with slightly dilated right
aortic sinus. An echo defect is observed at the junctional
area in some subjects. But these findings do not imply the
presence of ruptured right sinus of Valsalva aneurysm. The
major difference is that the right sinus in such subjects is not
as large as the aneurysm. In addition, an echo defect is
rarely seen due to the echo-interruption from the ruptured
aneurysm. The second entity is an interventricular septal
defect including tetralogy of Fallot. This is more easily
differentiated since the septal defect does not show a protrusion
into the right ventricle. However, an aneurysm of the
membranous ventricular septum \(^{13-15}\) with perforation and a
pouch of tricuspid valve associated with ventricular septal
defect \(^{13}\) may mimic the right sinus of Valsalva aneurysm
very closely. The greatest difference is that the septal defect
is due to the interruption of the septum below the aortic cusp
echo and the ruptured right sinus of Valsalva aneurysm is
due to interruption of the aortic wall over the aortic cusp
echo.

The echocardiogram revealed an abnormal echo in the
right ventricle, that is, a two-layered, canal-like pattern indi-
cating the aneurysm itself, something which has never
been described. It was recorded throughout mid-systole to
early diastole because the protruding sinus had been moved
into the path of the ultrasonic beam by cardiac contraction
and then been moved out of its path by cardiac relaxation.

Cooperberg and coworkers \(^{13}\) reported that the cardinal
echographic findings in their case were a defect in the
anterior aortic root through which the right coronary cusp
appeared to prolapse, and an abnormal echo in front of the
defect. Matsuo and coworkers \(^{13}\) also reported a similar case.
However, such findings differed from the present echocar-
diographic patterns. In both cases, the posterior wall of the
aneurysm was not detected, probably due to the positional
gap between the direction of the ultrasonic beam and the
posterior wall. In contrast, we could successfully record both
anterior and posterior walls of the aneurysm, since the ultra-
sonic beam penetrated them. Moreover, Johnson and
associates \(^{13}\) reported the abnormal systolic dip of the right
coronary cusp, which is consistent with the present finding.

It is concluded that two-dimensional echocardiography
and conventional echocardiography are useful means to
diagnose ruptured right sinus of Valsalva aneurysm.

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