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【 CASE REPORT 】

Ultimate Third Heart Sound

Ayu Shono, Shumpei Mori, Atsusuke Yatomi, Tsubasa Kamio, Jun Sakai, Fumitaka Soga, Hidekazu Tanaka and Ken-ichi Hirata

Abstract:
A 79-year-old man with dilated cardiomyopathy and severe functional mitral regurgitation presented with general fatigue and dyspnea. Auscultation revealed a systolic regurgitant murmur with a minimized second heart sound due to a low output. On the other hand, the third heart sound was ultimately enhanced, being visible and palpable as a pulsatile knock of the precordium. Phonocardiography and echocardiography successfully confirmed early-diastolic rapid distension of the left ventricle along with rapid ventricular filling and abrupt deceleration of the atrioventricular blood flow to be the precise etiology of the ultimate third heart sound, indicating critically deteriorated hemodynamics due to massive mitral regurgitation combined with a low output.

Key words: echocardiography, electrocardiography, mitral regurgitation, third heart sound, phonocardiography

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Introduction

A third heart sound reflects rapid left ventricular distention along with an increased atrioventricular flow. Although it requires experience to detect, precise auscultation of the third heart sound is crucial because this condition is associated with cardiovascular mortality.

We herein report a rare image and recording of an ultimately enhanced third heart sound auscultated in a case of massive functional mitral regurgitation and low output syndrome, with findings confirmed by phonocardiography and echocardiography. Of note, the augmented third heart sound was accurately recognized despite the absence of an audible second heart sound.

Case Report

A 79-year-old man with dilated cardiomyopathy (left ventricular end-diastolic dimension, 83 mm; left ventricular ejection fraction, 30%) and severe functional mitral regurgitation (regurgitant volume, 70 mL; regurgitant fraction, 60%) presented with general fatigue and exertional dyspnea. He was diagnosed with New York Heart Association functional class IV and had an elevated brain natriuretic peptide level at 876 pg/mL.

The electrocardiogram showed atrial fibrillation with a regular heart rate of 90 beats per minute, maintained with biventricular pacing on VVI mode. Auscultation revealed a systolic regurgitant Levine grade III/VI murmur, followed by a loud single heart sound (Supplementary material) that was most prominent in the fourth intercostal space on the left sternal border (recorded by a 3M™ Littmann® Electronic Stethoscope Model 3200; 3M Company, St. Paul, USA). The sound was visible as a periodic pulsation of the torso and palpable as a knock when the palm was placed on the precordium. As the sound was too great and brisk to simply be considered a second heart sound, phonocardiography was recorded on the left sternal boarder with a microphone, which was available during measurement of pulse wave velocity using a commercially available volume-plethysmographic apparatus (VaSera VS-3000; Fukuda Denshi, Tokyo, Japan). The phonocardiogram revealed that the sound was too late to be a second heart sound, prompting us to consider an ultimately enhanced third heart sound. The second heart sound was minimized due to a low output. All of these suspicions were confirmed with M-mode echocardiography (Fig. 1, Supplementary material).

A severely dilated left ventricle and resultant tethering of the mitral leaflets generated severe functional mitral regurgi-

Division of Cardiovascular Medicine, Department of Internal Medicine, Kobe University Graduate School of Medicine, Japan
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Correspondence to Dr. Shumpei Mori, shumpei_8@hotmail.com

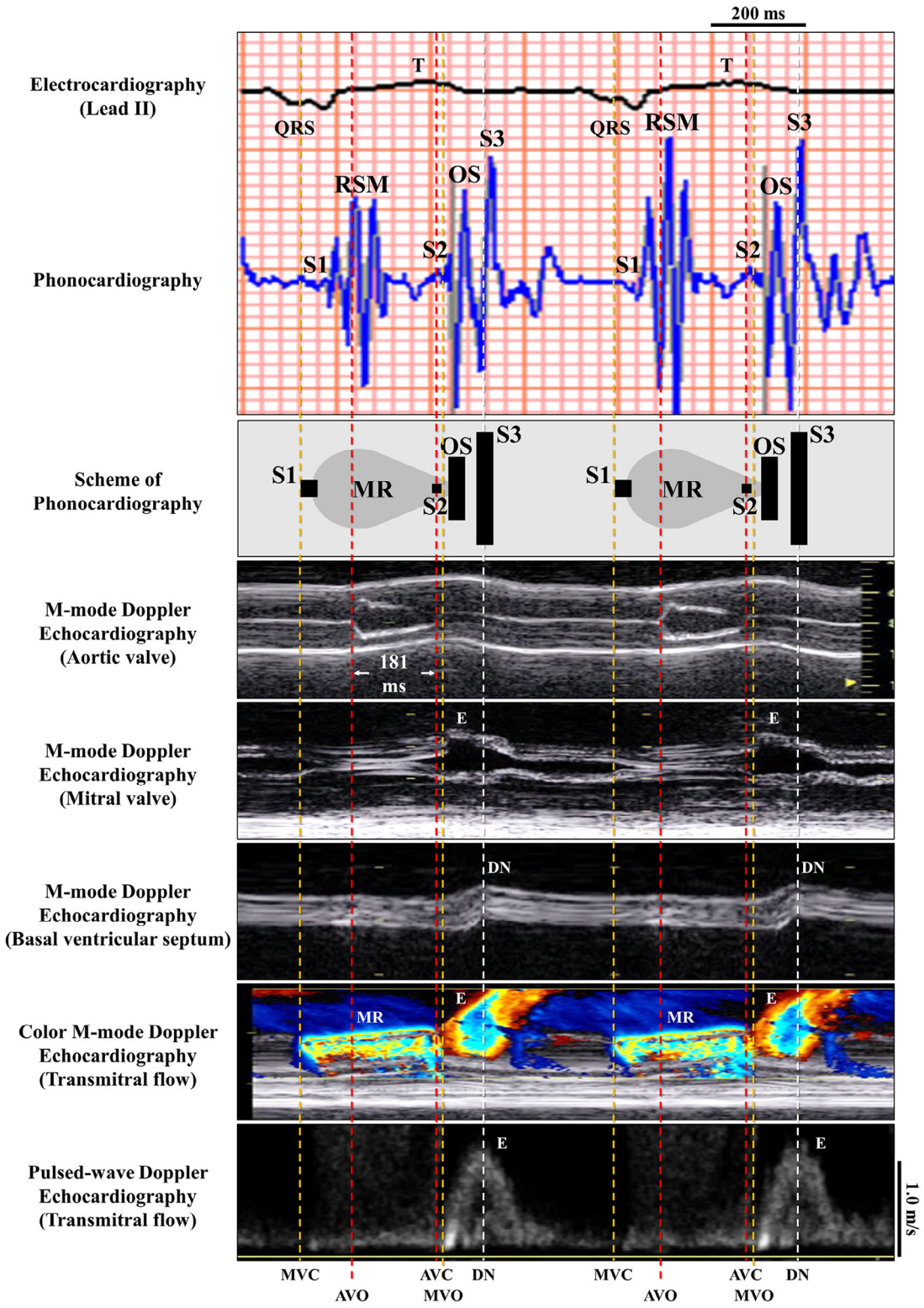

Figure 1. **Electrocardiography, phonocardiography, and echocardiography findings demonstrating an ultimate third sound (S3). The first heart sound (S1) was decreased because of systolic dysfunction accompanied by semi-closure of the mitral valve. Note the inaudible or minimized second heart sound (S2), accompanied by semi-closure of the aortic valve and a short ejection time, reflecting a low output. The basal ventricular septum demonstrated brisk anterior motion (early-diastolic notch, DN) at the timing of the S3, which was created by the rapid distension of the left ventricle immediately after the initiation of early-diastolic inflow. The early-diastolic wave (E) velocity was increased at 118 cm/s with a decreased deceleration time of 112 ms. AVC: aortic valve closure, AVO: aortic valve opening, MR: mitral regurgitation, MVC: mitral valve closure, MVO: mitral valve opening, OS: opening snap, RSM: regurgitant systolic murmur**

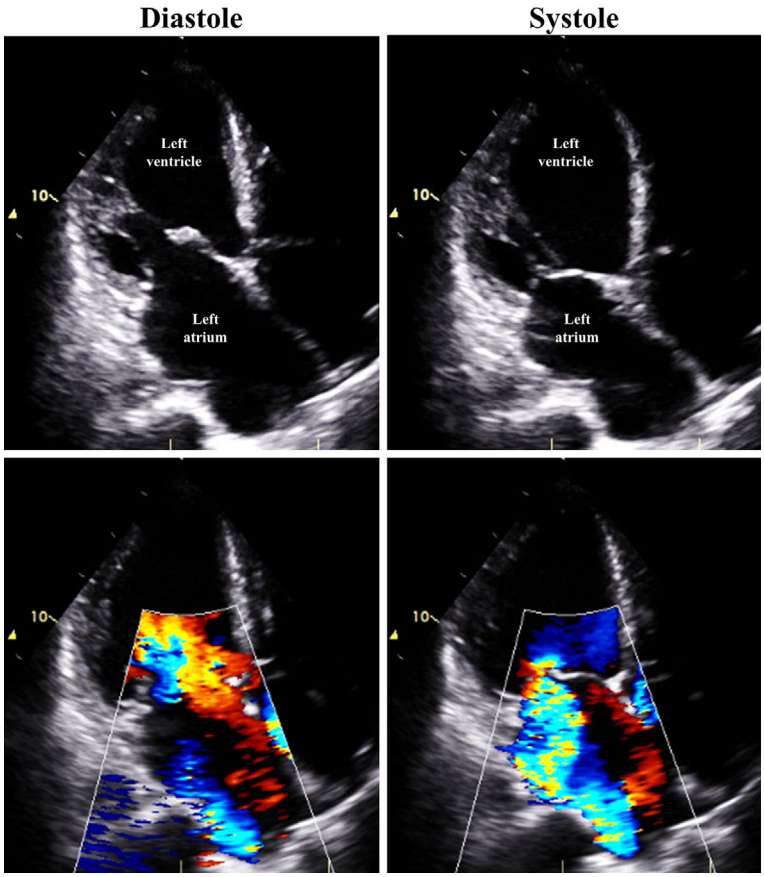

Figure 2. **Severe functional mitral regurgitation and relative narrowing of the mitral valvar orifice with accelerated ventricular filling was observed, combined with a severely dilated left ventricle and resultant tethering of the mitral leaflets (left panels). The anterior mitral leaflet showed myxomatous changes. The left ventricle was not visualized along its central axis in these sections.**

tation (Fig. 2) and relative narrowing of the mitral valvar orifice with accelerated ventricular filling. The anterior mitral leaflet showed myxomatous changes as well. Right heart catheterization findings were compatible with decompensated hemodynamics, classified as Forrester classification IV, with a pulmonary artery wedge pressure of a-/v34/m31 mmHg with a prominent v-wave, pulmonary artery pressure of s49/d16/m32 mmHg, right ventricular pressure of s50/b0/e8 mmHg, and right arterial pressure of a-/v12/m10 mmHg. The cardiac index obtained with the calculated Fick method was 1.20 L/min/m^2. Unfortunately, full medical support, including a substantial dose of catecholamine, human atrial natriuretic polypeptide, and diuretics, failed to improve the patient's hemodynamics, and he died two months after his admission due to end-stage heart failure.

Discussion

The third heart sound is mainly created by the early-diastolic rapid distension of the left ventricle that accompanies rapid ventricular filling and abrupt deceleration of the atrioventricular blood flow (1). The higher the transmitral inflow rate and the steeper the rapid filling wave, the greater the amount of deceleration of the left ventricular inflow and the more likely a third heart sound will be generated (1). Among valvular diseases, a third heart sound is most commonly auscultated with mitral regurgitation. The third heart sound is the initial clue suggesting left heart failure and is associated with severe mitral regurgitation, a low ejection fraction, restrictive diastolic filling, functionally severe heart failure, and cardiovascular mortality (2, 3). Recognition of the third heart sound is therefore crucial for prompt treatment. However, auscultation of the third heart sound requires training, experience, and dedication. In the present case, the enhanced third heart sound was able to be readily recognized by a junior resident (T. K.), highlighting the educational value of sharing such findings.

Usually, the mitral regurgitant murmur shows a constant intensity throughout the systole. In cases with massive mitral regurgitation, however, there is rapid increase in the left atrial pressure in late-systole, which is reflected in the prominent v-waves in the pulmonary artery wedge pressure recordings. In this situation, due to the rapid elevation in the left atrial pressure in late-systole, the intensity of mitral regurgitation tends to decrease in late-systole compared to early-systole. This is reflected in the prominent early systolic regurgitant murmur which decreases its intensity toward late-systole in a decrescendo manner, which thus mim-

ics a systolic ejection murmur (Fig. 1, Supplementary material).

An opening snap is most often associated with mitral stenosis. However, it can be audible with mitral regurgitation due to excessive blood flow across the mitral valve (4) at the time of the peak open position of the anterior mitral leaflet (Fig. 1). Although the opening snap was poorly distinguishable from the ultimate third heart sound in the present case (Supplementary material) mainly due to the high pacing rate, it consistently occurred before the peak of the rapid filling wave (4), when a third heart sound appeared (Fig. 1).

Precise auscultation is essential in physical examinations, and M-mode echocardiography is useful for confirming auscultation findings with excellent temporal resolution (5). All current findings, including an inaudible second heart sound and visible and palpable ultimate third heart sound, indicate critically deteriorated hemodynamics due to massive mitral regurgitation combined with a low output in the setting of an enormously enlarged left ventricle; these findings require prompt treatment, including catecholamine and/or mechanical support.

The authors state that they have no Conflict of Interest (COI).

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