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A CASE OF FUZZY ECHO (FLOWING ECHO) AND AN EXPERIMENTAL STUDY ON ITS MECHANISM

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ABSTRACT

We encountered a case of valvular heart disease which showed the "fuzzy echo" with thrombus in the giant left atrium, and conducted an experiment in vitro to find out the echo source.

In the experiment, each blood component ((1) plasm, (2) whole blood, (3) washed red blood cells and (4) whole blood + γ-globulin) was prepeared; each blood component was put into a beaker with stirrer. A transducer from an ultrasonography was then immersed in each of these blood components and M-mode echograms (UCG) and ultrasonic tomograms were recorded in order to observe the difference in pattern according to blood component under both still and turning round on ultrasonogram.

On UCG, a belt-like echo from the bottom of the beaker toward the surface was seen in the order of (1) (2) (3) and (4) at atandstill. When the stirrer runs an increase in granular echo was observed in the same order.

From the above result, it was surmised that the "fuzzy echo" would present itself in the presence of a turbulent flow with red blood cells or aggregate of red blood cells (including rouleaux formation).

With the spread of ultrasonography, particularly ultrasonic tomography, cases showing the so-called "fuzzy echo" in the cardiovascular system have been reported one after another.[1)-5)]

In many of these cases, the "fuzzy echo" is found in the left atrial cavity in cases of mitral valvular heart disease with thrombus, and also in the left ventricular aneurysm in cases of myocardial infarction and in other aortic aneurysms.

Changes in the blood itself such as micro-thrombus and effects of the hemodynamics such as a turbulent flow have been mentioned as the possible causes.

We also encountered a similar echo in the left atrium with thrombus in cases of mitral stenoinsufficiency (MRS). In order to find out its cause, we conducted an experiment in which the blood components were altered and an artificial turbulent flow was induced in an attempt to reproduce the fuzzy echo in the ultrasonic tomography.

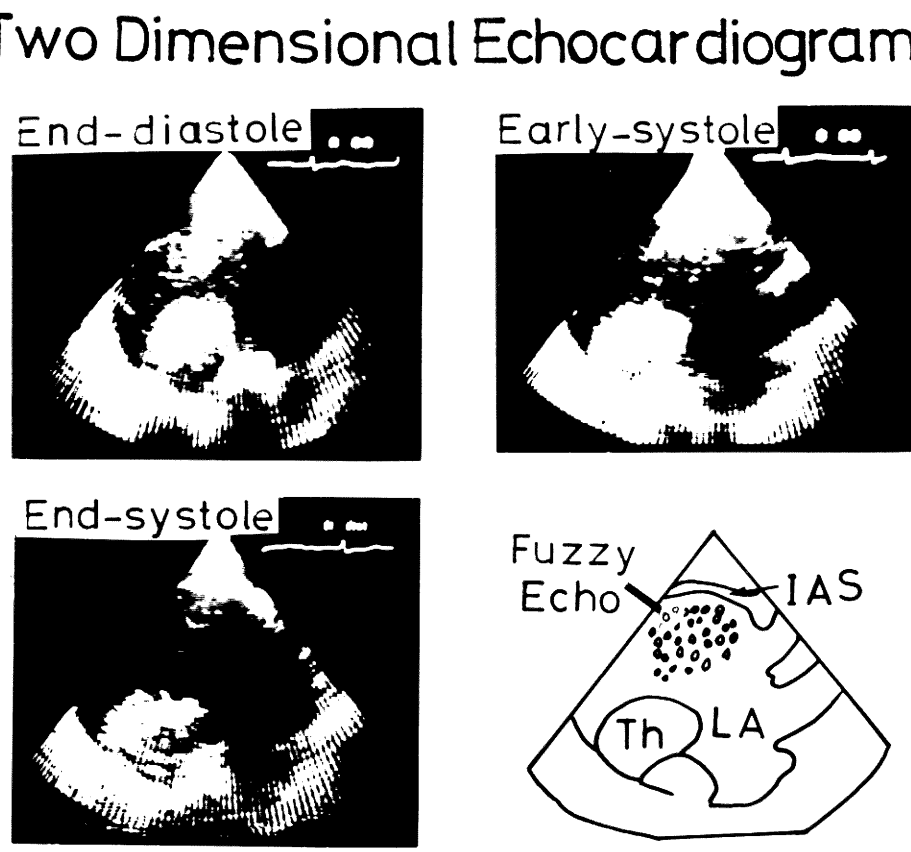

Fig. 1. Ultrasonic tomograms
IAS=Intra-atrial septum
Th=Thrombus
LA=Left atrium

Case Report

On May 10, 1980, a 72-year-old woman was hospitalized for a fainting fit due chiefly to cerebral thrombosis.

On auscultation, a rumbling murmur (levine 4°) and a holosystolic murmur (Levine 2°) were heard and a mitral stenoinsufficiency (MRS) diagnosis was done. Atrial fibrillation was confirmed by ECG.

Utrasonic tomograms revealed fuzzy echo (flowing echo) with a giant thrombus in the left atrium as shown in Fig. 1. These fuzzy echoes were observed most clearly from the enddiastole to the early systole, flowing from around the thrombus to the mitral valve in the diastole.

The echoes were not observed in the left ventricle. M-mode echocardiography (UCG) revealed findings of mitral stenosis; that is, a decrease in DDR (23 mm/sec.) of the anterior cusp of the mitral valve and a parallel movement of the posterior cusp.

Neurological symptoms observed on admission, probably due to cerebral thrombosis, disappeared in a short time.

Surgical operation was scheduled to be performed as soon as possible, but the patient died of a recurrence of cerebral thrombosis on June 27, 1980.

Experimental Study

1) Method

Fig. 2 shows an experimental scheme. As shown in the scheme, 300 ml each of 1) plasma, 2) whole blood, 3) washed red blood cell and 4) whole blood + γ-globvlin as blood components kept at 37°C were transferred to a beaker containing a stirrer. A transducer was immersed in each of these components and then ultrasonic tomograms and M-mode echograms were recorded with the stirrer at a standstill or in motion. The composition of blood is shown on the left side of Fig. 3.

As the control, 300 ml of physiological saline solution deaerated by boiling was introduced into the beaker and a similar experiment was repeated.

A stirrer was used to induce a turbulent flow artificially and made to run at a slow speed to prevent air bubbles from being mixed, Using Toshiba SSH-11A, ultrasonography was performed under fixed conditions including gain (60 db). Ultrasonic tomograms were recorded on video tape. M-mode echograms were recorded on a strip chart with the paper speed set 5 cm/sec.

The experiment was repeated to examine its reproducibility. After the experiment, a comparison was made of the whole blood and whole blood + γ-globulin (25°C at room temperature) under a light microscope. (× 400)

2) Experimental results

i) M-mode echograms

a) Physiological saline solution:

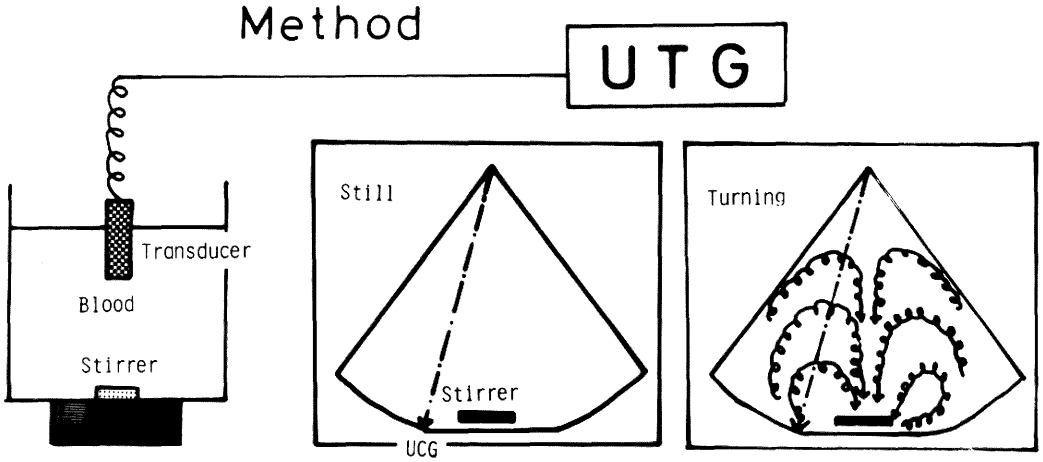

Fig. 2. Experimental schema
UCG=M-mode echograms
UTG=Ultrasonic tomography

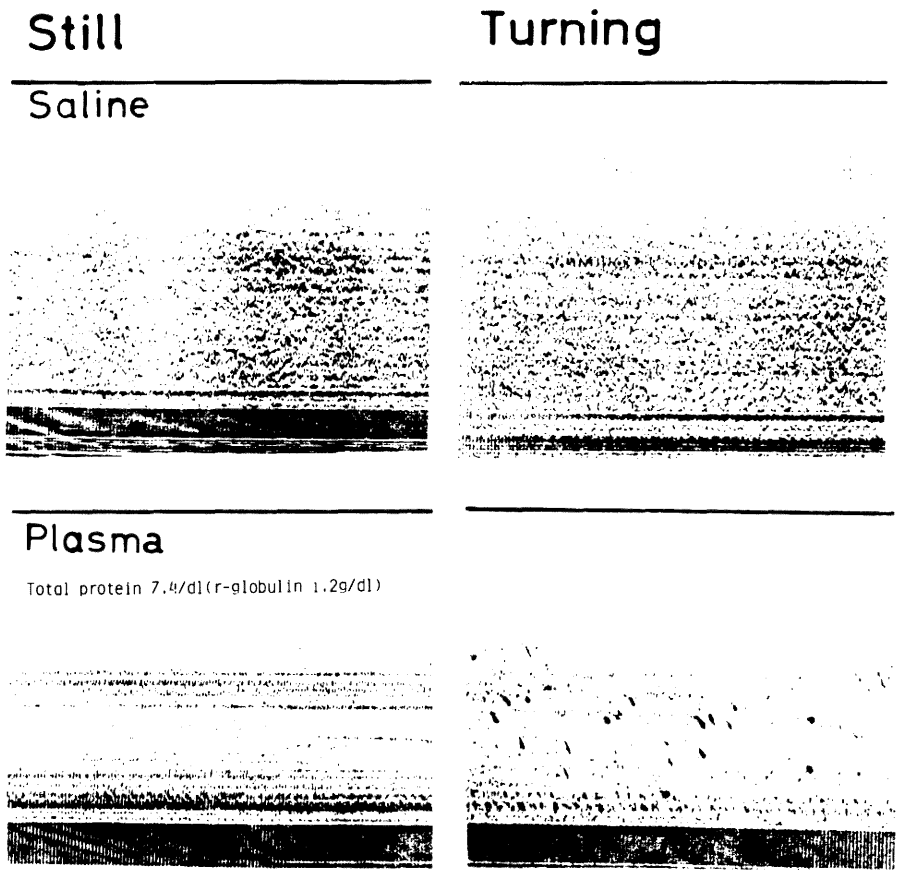

Fig. 3. M-mode echograms

Fine echoes were seen with the stirrer both at a standstill and turning round, but they were clearly different from the fuzzy echoes. (Fig. 3)

b) Plasma:

Almost the same echograms as in a) were given. but 2-3 brokenline echoes were seen with the stirrer at standstill. Dotted-like echoes, small as the number was, were seen with the stirrer runnig. (Fig. 3)

c) whole blood:

Several belt-like echoes were seen mainly at the bottom of the beaker with the stirrer at a standstill. These echoes disappeared with stirrer running and a large number of granular echoes appeared all over the beaker. (Fig. 4)

d) washed red blood cells:

With the stirrer at standstill, belt-like echoes were seen from the middle to the bottom of the beaker similar to c). With the stirrer running, granular echoes, thicker in

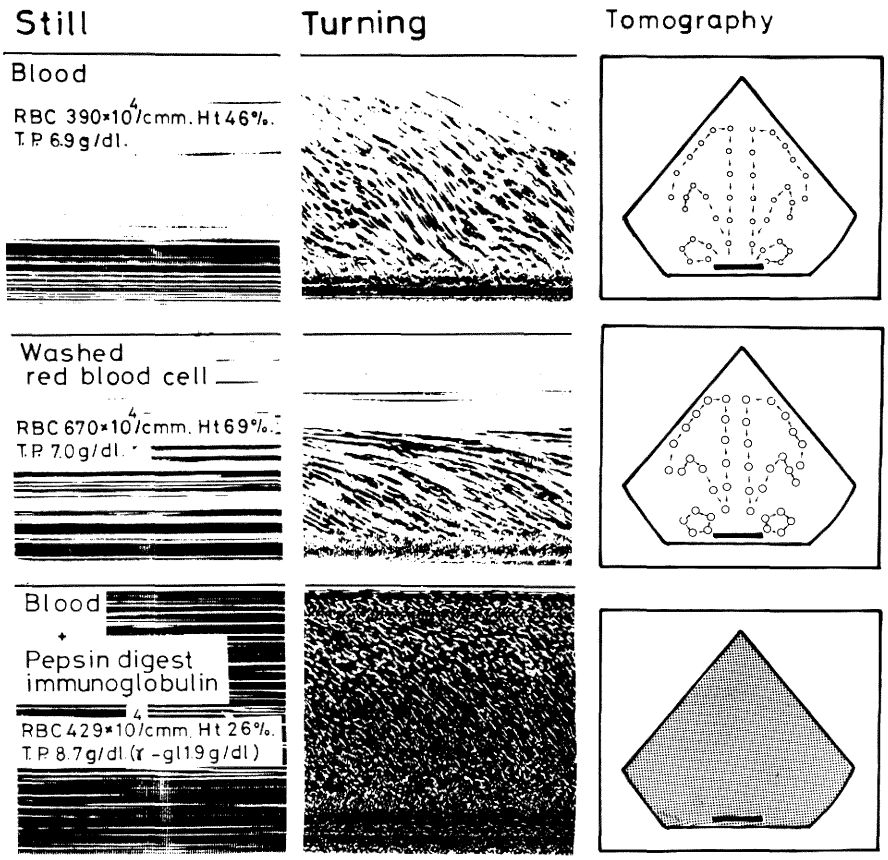

Fig. 4. M-mode echograms (left middle)
Ultrasonic tomogram (right)

density and longer in length than those in c), were seen.

e) whole blood + γ-globulin:

With the stirrer at a standstill, belt-like echoes increased in number to exceed those in d) and then spread all over the beaker. With the stirrer running, granular echoes, smaller than those in c), were observed all over the beaker. (Fig. 4)

ii) Ultrasonic tomograms

On the right of Fig. 4 are shown the scheme of ultrasonic tomograms for whole blood, washed red blood cells and whole blood + γ-globulin with the stirrer running.

On the ultrasonic tomograms for physiological saline solution and plasma, fine echoes were seen but echoes showing a movement in a fixed direction were not observed.

On the ultrasonic tomograms for whole blood, washed red blood cells and whole blood + γ-globulin, granular echoes showed a movement like a fountain as illustrated in scheme. Granular echoes increased in size in the following order: whole blood + γ -globulin, whole blood and washed red blood cells and whole blood + γ-globulin.

On these ultrasonic tomograms, echoes from whole blood + γ-globulin looked akin to the fuzzy echo in the case study, and the movement in the turbulent flow around the stirrer most resembled the fuzzy echo.

iii) Rouleaux formation in whole blood + γ-globulin

Light microscopic examination revealed rouleaux formation consisting of 5-10 red blood cells per visual field both in whole blood + γ-globulin and whole blood. As to the numerical ratio, whole blood + γ-globulin was 1.5-fold higher.

Discussion

Eleven cases of the fuzzy echo have been reported in Japan since Rasmussen[6] found it in the left ventricle of a patient with septal scar in 1978. However, the mechanism by which it is produced has not been elucidated. As a possibility, mention is now made of 1) microthrombus and/or platelet aggregation, 2) rouleaux formation and 3) turbulent flow.[1)-6)]

Recently, the fuzzy echo has been classified into two types according to the difference in tomograms. One is a flowing echo which is often seen where blood becomes stagnant, as observed in the giant left atrium in our present case. the other is a spraying echo is seen near the valve where blood is gushing out like a jet, as found in the patients with artificial mitral valves.

Ozawa et al.[8] have recorded an echogram showing granular echoes turning round in aneurysm of abdominal aorta like the ones we obtained in the experiment.

In the present experiment, blood was divided into two groups, one containing corpuscles and the other not. In the former group, the number of red blood cells was changed or γ-globulin was added. A comparative study mainly using ultrasonic tomograms was made as to the difference in these blood groups.

As a result, granular echoes and their fountain-like movement, as seen in the blood

group containing corpuscles, were not observed in the ultrasonic tomograms for the blood group containing no corpuscles. This fact shows that blood corpuscles are related to the echo source of granular echoes.

When the number of red blood cells was changed, more granular echoes were observed in the group having many red blood cells. On the other hand, the echo source is liable to be located at the bottom of the beaker when the stirrer is at a standstill. This lead us to speculate that red blood cells form rouleaux or red blood cell aggragate. Furthermore, When γ-globulin was added to whole blood, more granular echoes were obtained; the granular echoes obtained were small, spread all over the beaker and were more similar to the fuzzy echo than were the whole blood and washed red blood cell group.

From the experimental facts above, it is surmised that red blood cell or an aggregate of red blood cells is the echo source of "fuzzy echo", particularly the flowing echo, and that this red blood cell or aggregate of red blood cells turns round slowly to give off the fuzzy echo.

Tanaka et. al.[9] calculated the size and number of air bubbles as the echo source of micro bubbles in ultrasonography. It is, therefore, necessary to exclude the possibility of micro bubbles of 10-50μ being mixed with the red blood cells.

In the experiments with whole blood or washed red blood cells, however, the echo sources did not spread all over the beaker but converged on the bottom and these echo sources looked as though blown up by the revolution of the stirrer. This strongly suggests that the aggregate of red blood cells formed at the bottom is the echo source. This is, if the echo source are micro-bubbles attached to red blood cells, they will not converge on the bottom.

As to the possibillity of red blood cells becoming the echo source Beppu et al.[10] induced stagnation of blood flow in the right atrium and right ventricle by stenosing the pulmonary artery in open-chest dogs and found the flowing echo there. They reported that when blood flows faster than a certain fixed rate, rouleaux disappear. This points to the possibility that the echo source disappears when the echo seen in the left atrium flows into the left ventricle rapidly via the mitral valve, substantiating the finding that no fuzzy echo is seen in the left ventricle.

In our experiment too, the possibility was considered that these granular echoes would disappear if the flow rate was increased by using a larger stirrer and accelerating the revolution speed. However, it was not confirmed experimentally for fear of bubbles being mixed with the red blood cells.

CONCLUSION

1) We encountered a case which showed the fuzzy echo with thrombus in the giant left atrium, and conducted an in vitro experiment in order to clarify the mechanism by which it is produced.

2) The echo was seen in the presence of red blood cells. With the blood composition changed, the echo presented different patterns. When γ-globulin was added, the echo increased in number.

3) On the ultrasonic tomograms, a part indicating the turbulent flow was akin to the fuzzy echo.

4) Accordingly, it is surmised that the "fuzzy echo" presents itself in the presence of a slow turbulent flow with red blood cell or an aggregate of red blood cells (inclusive of rouleaux formation) as the echo source.

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