Detection of Tricuspid Regurgitation by Contrast Echocardiography

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Contrast echocardiography with simultaneous M-mode echocardiography was performed in 77 cases of tricuspid regurgitation (TR) and 168 cases having no TR (non-TR).

The echocardiographical characteristics of TR were as follows: 1) By the subxiphoid approach, a contrast appeared in the inferior vena cava during systole. In some cases of non-TR, a similar appearance was noted but limited to the atriosystolic or late systolic-to-early diastolic phases. Such confusing cases should be excluded by the simultaneous observation of the M-mode contrast echogram. 2) By apical four-chamber view, a negative contrast echo above the tricuspid valve and subsequent back and forth movements of the contrast across the valve were useful. This movement, however, may be misleading on two-dimensional echo and the M-mode echocardiogram was also necessary to obtain the exact timing and the direction of regurgitant flow. 3) Presence of the dilated inferior vena cava.

The sensitivity of this method was extremely high, and the specificity was also excellent for TR.

Echocardiography, both M-mode and two-dimensional, has a great capability in the diagnosis of cardiovascular diseases. However, the blood flow profile cannot be analyzed by a routine echocardiography. In recent years, contrast echocardiography has been developed to identify cardiac structures and regurgitant blood flow and intracardiac shunts. Applications of such a technique to the real time two-dimensional echocardiography, abbreviated as “2-D echo”, seems promising because of the fact that it provides the similar flow pattern to angiography. We have designated this method the “contrast echoangiography”. The present report deals with the results of echocardiographic analyses in cases of tricuspid regurgitation (TR).

MATERIALS AND METHODS

Subjects in this study consisted of 77 cases of TR and 168 controls (non-TR). The diagnosis of TR was based on the clinical findings, course of the diseased state, laboratory data including intracardiac phonocardiogram, right ventricular angiography and pulsed Doppler technique.

Real time two-dimensional echocardiogram was recorded using Hitachi EUB-10 or Aloka SSD-800 with a 2.25 MHz transducer. M-mode echocardiogram was also obtained simultaneously during contrast echoangiography in each case.

The main echocardiographic section was obtained either by the subxiphoid approach in order to observe the right atrium (RA) and the inferior vena cava (IVC), or by the apical four-
Fig. 1. Cross-sectional echocardiograms demonstrating echo beam direction utilized for the simultaneous record of M-mode echocardiogram during echoangiography. A: Subxiphoid approach (M-mode echo beam direction was changed according to the height of regurgitant flow). B: Apical four-chamber view. Abbreviations: RA = right atrium; IVC = inferior vena cava; Hep. V = hepatic vein; RV = right ventricle, LV = left ventricle.

chamber view, the approach to see the back and forth motions of contrast echo across the tricuspid valve (Fig. 1).

Indocyanine green was mainly used as a contrast material. Five mg of it in one ml of distilled water was injected into the antecubital vein and immediately followed by a bolus injection of 5 to 10 ml of cooled saline.

All tracings were recorded on the video tape or 16 mm cinefilm, and simultaneous M-mode echocardiograms were recorded on the Honeywell strip chart recorder to confirm the precise timing and direction of regurgitation. Recordings were all done during quiet respiration.

RESULTS

Inferior Vena Cava Section

Flow Pattern in Non-TR Cases: The contrast injected into the antecubital vein reached the RA but it hardly appeared in the IVC. Although in some cases significant appearance was observed, the timing was confined to atrial systole (Fig. 2), late systole to early diastole (Fig. 3) or early diastole (Fig. 4). Sometimes contrast appeared at the beginning of expiratory phase or through the expiratory phase and had no relation to the cardiac cycle (Fig. 5).

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Fig. 3. M-mode contrast echocardiogram in a patient with atrial septal defect (38-year-old female). Contrast echoes appeared in the IVC during late systole to early diastole, at the time of a v wave of the jugular venous pulse. Abbreviations are the same as in Fig. 1.

Flow Pattern in TR Cases: As opposed to the normal cases and non-TR cardiac patients, the contrast injected into the peripheral vein reached the RA slightly earlier than in the control cases, and the echo appeared in the dilated IVC during systole, the timing of which was accurately assessed by the simultaneously taken M-mode echocardiogram (Fig. 6). The hepatic echo was gradually enhanced by the contrast. During diastole, the contrast in the IVC drained into the RA and the IVC became echo free near the end-diastolic phase whenever the TR was not so severe. These characteristic features of the contrast echocardiography were observed in 69 out of the 77 TR cases.

Apical Four-chamber View

Flow Pattern in Non-TR Cases: The contrast in the RA proceeded to the tricuspid valve and entered into the RV during subsequent ventricular diastole. Yet it was difficult to analyse the details of the flow pattern on a two-dimensional echocardiogram because the contrast echoes ran into the RV via the RA. The M-mode echocardiogram which was recorded simultaneously
showed clearly the details of the flow pattern through the long axis of the tricuspid valve (Fig. 7). Forward flow which approaches the transducer placed on the apex is shown as upward-slanting lines and the backward flow which leaves the transducer is shown as downward-slanting lines. In atrial systole and rapid inflow phase of diastole, forward flow from the RA to the RV was observed crossing the tricuspid valve. During ventricular systole, pansystolic forward flow was observed in the RV and early to mid systolic forward flow followed by late systolic backward flow was observed in the RA. A slight retrograde motion of contrast near the tricuspid valve was recorded in the RA at the time of the closing of the tricuspid valve, since the contrast was pushed back by the closure of the tricuspid valve.

Flow Pattern in TR Cases: The four-chamber view usually showed the negative contrast echo above the tricuspid valve due to the regurgitant flow or back and forth movements of the contrast across the tricuspid valve. But in many cases these signs were not clear enough to be diagnostic. The M-mode echocardiogram which was simultaneously recorded showed pansystolic or late systolic downward-slanting lines from the RV to the RA instead of normal upward-slanting lines (Fig. 8). These features were observed in all the 40 TR cases in which the M-mode echocardiogram of apical four-chamber view was simultaneously taken. The regurgitation of contrast from the RV was also clearly recorded in 12 cases having an equivocal sign of TR, 3 of which showed even a negative finding by an IVC M-mode contrast echocardiogram.

Diameter of the Inferior Vena Cava

In 168 control cases the diameters of IVC measured during expiratory phase ranged from 7 to 26 mm, averaging 16 ± 4 mm (mean ± SD) and they were changing markedly during respiration. In 20 of these cases a more than 20 mm dilatation of IVC was observed and in 18 cases a significant appearance of contrast in the IVC was found. The timing of appearance in these cases was different from that of TR. In the 77 TR cases the diameter of IVC was dilated significantly, ranging from 20 to 40 mm (average: 25 ± 5 mm) and their diameter was relatively
Fig. 6. M-mode contrast echocardiogram in a patient with mitral stenosis, atrial fibrillation and tricuspid insufficiency (59-year-old female). Marked regurgitant flow into the IVC and hepatic vein during systolic phase was recorded as the flow approached a transducer. During diastole the contrast echo was cleared up. Abbreviations are the same as in Fig. 1.

Fig. 7. M-mode contrast echocardiogram (apical four-chamber view) in a normal person (23-year-old male). Forward flows to the transducer were observed during whole systole, atrial systole and rapid inflow phase of diastole in the RV (black arrowheads). In the RA back flows were observed during early and late diastoles (white arrowheads). Abbreviations: RV = right ventricle; RA = right atrium; TV = tricuspid valve. A: control, B: after injection of contrast.
constant during respiration compared with that of the controls.

DISCUSSION

The diagnosis of regurgitation by ultrasonic technique can be made by two approaches, one being the pulsed Doppler technique and the other the contrast echocardiography.

The advantages of the contrast method are numerous. It is a noninvasive bedside technique and completely safe. Its feasibility and reproducibility are excellent. Moreover, the sensitivity and specificity are sufficient to detect TR. Thus, this method can be used as a gold standard in TR diagnosis.

The excellent sensitivity of contrast echocardiography with simultaneous M-mode echocardiography for TR was supported by the fact that the systolic appearance of contrast echo in the IVC was detected in 69 of the 77 TR cases and that pansystolic or late systolic regurgitant flow from the RV to the RA was detected in all 40 TR cases studied, including the 12 equivocal cases. It is speculated that these 12 equivocal cases have the mildest TR which is not detectable by all clinical means including auscultation; exercise loading, intracardiac phonocardiography or other invasive methods must be used for diagnosis. The diagnosis of TR by 2-D echo was reported by Lieppe and his associates in 1978. They concluded that the evidence of TR on the contrast 2-D echo was the appearance of contrast in the IVC and the back and forth movements across the tricuspid valve. Our results are essentially the same. In addition, the present data also disclosed the presence of false positive cases in which the contrast echo appeared in the IVC in non-TR cases. This false positive appearance was observed during the atriosystolic, the late systolic-to-early diastolic or the expiratory phase. Our results also disclosed that the M-mode echocardiogram recorded with the beam directed through the long axis of the tricuspid valve was a more sensitive and more reliable method for detecting TR than that of the IVC.

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REFERENCES

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