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CHAPTER 47

Visualization of the Right Ventricular Free Wall in the Thallium-201 Scintigram in Patients with Right Ventricular Volume Overload

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SUMMARY

It is well known that the right ventricular (RV) free wall in the ^{201}Tl resting scintigram of healthy subjects can be only rarely and, at best, weakly visualized. It has been assumed that the visualization of the RV free wall can be taken as evidence of elevated pressure in the right ventricle. This study was thus undertaken to assess the visualization of the RV free wall in the presence of RV volume overload with normal RV pressures and to determine if a correlation with the extent of the overload exists. Fifty-three patients were studied, 23 of whom were found to be free of organic heart disease and served as healthy controls. Thirty patients had RV volume overload (atrial septal defect, partial anomalous pulmonary venous return, or isolated tricuspid insufficiency). In the resting scintigrams, the RV free wall was weakly visualized in three of the 18 healthy controls. In the exercise scintigrams of five other control subjects, the right ventricular free wall was clearly visualized and displayed an average "wall thickness" of 2.05 ± 0.26 cm. The RV free wall was clearly visualized in the resting scintigrams of all patients with RV volume overload and demonstrated a mean "thickness" of 2.56 ± 0.10 cm. No correlation was found between the scintigraphically measured "wall thickness" (consisting of the actual wall thickness and the amplitude of motion as shown in our earlier studies) and the extent of the RV volume overload. In five patients with RV volume overload, the ECG showed no evidence of RV strain. The echocardiogram showed paradoxical septal motion in 25 of the patients. Thus the ^{201}Tl scintigram represents a sensitive method for the detection of RV volume overload. The clear visualization of the right ventricular free wall cannot necessarily be construed as evidence for elevated right ventricular pressure.

It is well known that the right ventricular free wall in the thallium-201 resting scintigram of healthy subjects can be only rarely and, at best, weakly visualized (1,2). According to several investigators (3,4), a clear visualization of the right

ventricular free wall can be taken as evidence of elevated pressure in the right ventricle. There is, however, no information available with respect to whether or not the right ventricular free wall can be visualized in the ^{201}Tl scintigram in the presence of right ventricular volume overload associated with normal right ventricular pressure. The purpose of this study was to determine if a right ventricular volume overload associated with normal right ventricular pressure can be detected in the ^{201}Tl resting image. Furthermore, we attempted to determine if correlations exist between the scintigraphically measured "wall thickness" (which corresponds with the sum of the true wall thickness and the amplitude of motion (5)) and the extent of the right ventricular volume overload.

MATERIAL AND METHODS

Fifty-three patients whose ages ranged from 17 to 56 years were studied. Twenty-three of the patients in whom organic heart disease could be ruled out,

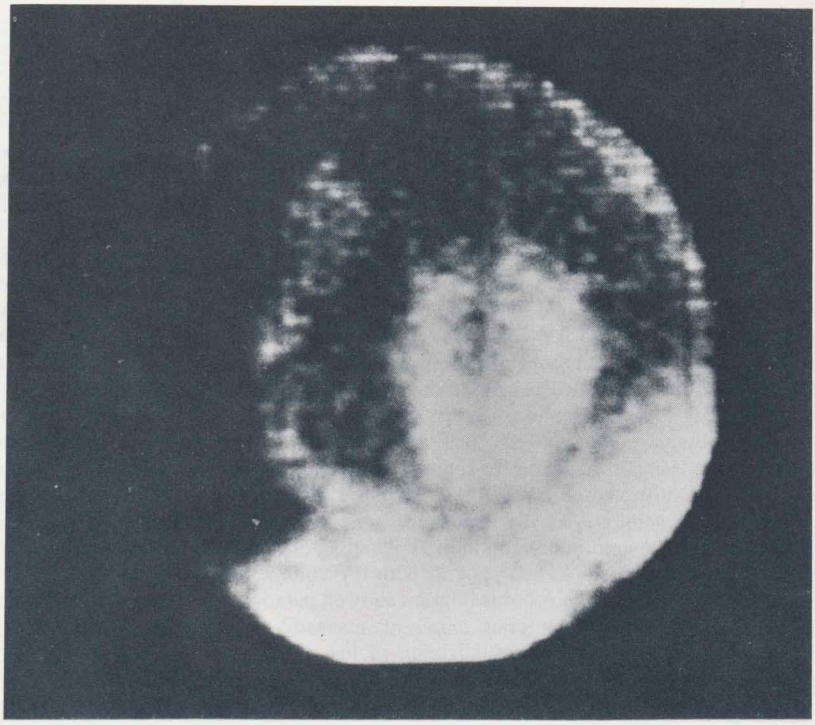

Figure 1. ^{201}Tl scintigram (45° left anterior oblique projection) of a 19-year-old patient with partial anomalous pulmonary venous return, 42% left-right shunt, and normal pulmonary arterial pressure. Unprocessed image. The right ventricular free wall can be readily visualized. The right ventricular cavity is greater than that of the left.

served as healthy controls. Scintigrams were prepared at rest in 18 of these subjects and during exercise in five. Right ventricular volume overload associated with normal pulmonary arterial pressure was documented at cardiac catheterization in each of the 30 other patients. Twenty-three had atrial septal defect (six with ostium primum defect and 17 with ostium secundum), five had partial anomalous pulmonary venous return, and two had isolated, congenital, tricuspid insufficiency. Scintigrams were obtained with an Anger-camera (Radicamera, Nuclear-Data) in six projections (ventral, 30°, 45°, and 60° left anterior oblique, left lateral, and 30° right anterior oblique) with a low-energy, high-resolution collimator at 69–80 keV and a 20% window; 300,000 counts per image were collected 10 minutes after the injection of 1.0–2.0 mCi of ^{201}Tl (Duphar Co., Petten, The Netherlands). The data were stored in a small delicate computer system (Medstor, Nuclear Data). Scintigraphic "wall thickness," consisting of the actual wall thickness and the amplitude of motion, was assessed from the unprocessed images obtained in the 45° left anterior oblique projection. A 10 × 1 cm lead marker was used for calibration. The size of the right ventricular cavity was compared with the left ventricular cavity by means of visual estimation.

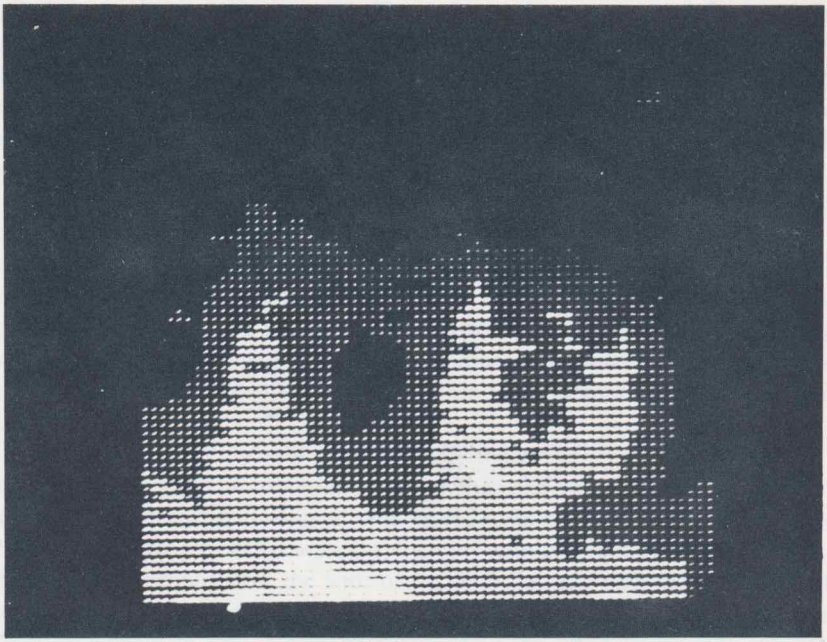

Figure 2. ^{201}Tl scintigram (45° left anterior oblique projection) of a 36-year-old patient with atrial septal defect, 55% left-to-right shunt, and normal pulmonary arterial pressure. Image processed by digitizing into five gray levels. The right ventricular free wall can readily be visualized. The right ventricular cavity is greater than that of the left.

RESULTS

Controls

The right ventricular free wall was only weakly visualized in the resting ^{201}Tl scintigram in three of the 18 healthy controls. In these patients, the scintigraphically measured "wall thickness" was less than 1 cm.

In the five healthy controls in whom exercise scintigrams were prepared, the right ventricular free wall was clearly visualized and measured 2.05 ± 0.26 cm in "thickness." In each case the right ventricular cavity was smaller than that of the left.

Right Ventricular Volume Overload

In the patients with right ventricular volume overload, left-to-right shunting averaged 50.3 ± 2.5% with a range of 24–75%. The systolic pulmonary artery pressure was 27.1 ± 0.98 mm Hg (range 14–31 mm Hg), the mean diastolic pulmonary artery pressure was 10.6 ± 0.56 mm Hg (range 5–13 mm Hg), and the mean pulmonary artery pressure averaged 15.9 ± 0.67 mm Hg (range 8–21 mm Hg). The right ventricular free wall was clearly visualized (Figures 1 and 2) in

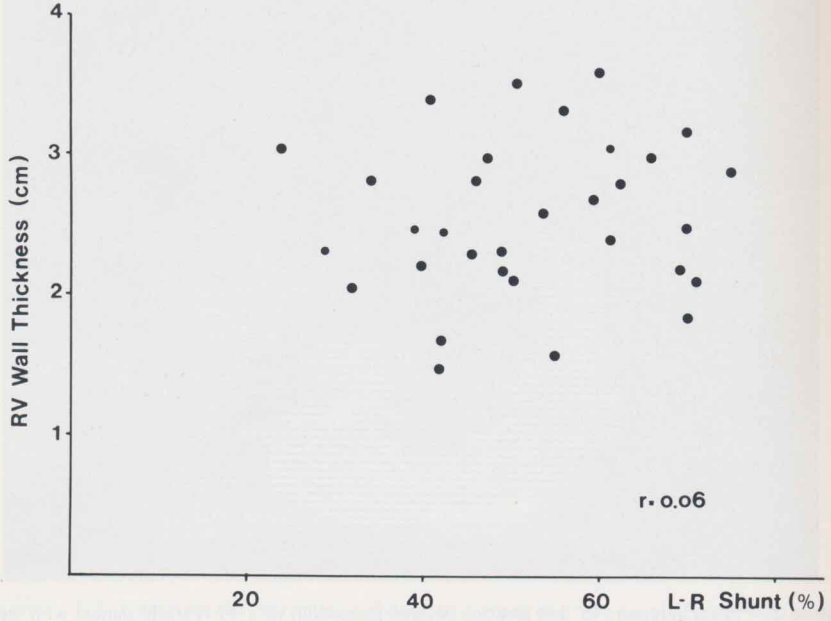

Figure 3. No correlation was found between the scintigraphically measured "thickness" of the right ventricular free wall and the extent of the left-to-right shunting in 28 patients with atrial septal defect or partial anomalous pulmonary venous return and normal pulmonary arterial pressure.

each of these patients and averaged 2.56 ± 0.1 cm (range 1.6–3.6 cm). The ratio of RV/LV size averaged 0.99 ± 0.03 (range 0.69–1.42). With the exception of one patient with a left-to-right shunt of 24% in whom the right ventricular cavity in all projections was smaller than that of the left, all patients with right ventricular volume overload displayed right ventricular cavities of equal or greater size than that of the left ventricle. No correlation was found between the scintigraphically measured "wall thickness" and any of the following three parameters: the extent of left-right shunting ($r = 0.06$) (Figure 3), the pulmonary flow ($r = 0.01$), or the pulmonary flow index ($r = 0.12$). Right ventricular strain was indicated in the ECGs of 20 of the patients, whereas the ECG findings in four other patients of incomplete right bundle branch block were equivocal because of their relatively young age. The ECGs of five patients with left-to-right shunts between 24% and 59% showed no evidence of right ventricular strain. Echocardiography revealed paradoxical septal motion in 25 of the patients and normal septal motion in five patients with left-to-right shunts between 24% and 47%.

DISCUSSION

The right ventricular free wall could be visualized slightly in the ^{201}Tl resting scintigram in 16.5% of the controls. This is in good agreement with the incidence found by Strauss et al. (6). The fact that the right ventricular free wall either cannot be detected or can only be slightly visualized in healthy subjects represents lesser activity concentration (7) proportional to the moderately decreased myocardial blood flow (8–10) and to the relatively small muscle mass, as compared with the left ventricle.

An increase in blood flow induced by a rapid resting heart rate or stress testing (11) renders scintigraphic visualization of the right ventricular free wall in healthy subjects. The fact that the right ventricular free wall could be visualized in all patients with right ventricular volume overload in spite of normal right ventricular pressures and normal right ventricular muscular thickness (12) can most probably be attributed to an increased muscle mass with subsequent elevation of the registered impulse rate, in addition to an increased myocardial blood flow.

In consideration of the scintigraphically measured "wall thicknesses" it is obvious that they are substantially greater than the actual thicknesses demonstrated in anatomical-pathological studies (13). As shown in our earlier studies (2.5), as compared to echocardiography, the scintigraphically measured "wall thickness" is composed of the sum of the end-diastolic wall thickness and the amplitude of motion of the ventricular wall. In view of this fact, there is no reason to expect to find a correlation between the scintigraphically measured "wall thickness" and the extent of overload. Whether or not gating, with its 10-fold increase in registration time, will yield a more exact scintigraphic determination of wall thickness, is questionable.

Nevertheless, the ^{201}Tl scintigram represents a sensitive method for detection of right ventricular overload. This is particularly supported by the finding of clear visualization of the right ventricular free wall in all patients with hemodynamically demonstrated right ventricular volume overload. In contrast, the ECG was notably less sensitive, indicating right ventricular strain in only 70% of these patients. The echocardiogram revealed right ventricular volume overload in 25 of 30 patients. As shown in our previous studies (2), the ^{201}Tl scintigram is also more sensitive than the ECG in the detection of right ventricular pressure overload.

In summary, the ^{201}Tl scintigram represents a sensitive method for the detection of right ventricular pressure or volume overload. The clear visualization of the right ventricular free wall, however, cannot be construed as evidence of elevated pressure in the right ventricle.

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