

## VI

## Magnetic Resonance Assessment of the Accuracy of Radionuclide Methods for the Quantification of Valvular Regurgitation and Atrial Shunting

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Magnetic resonance imaging provides an accurate method for the assessment of left and right ventricular volumes, and this study validates such measurements by a comparison of left and right ventricular stroke volumes which should be identical in normal subjects over the period of imaging. The stroke volume ratio is used to measure atrial shunting and valvular regurgitation, and the results compared with radionuclide ventriculography and cardiac catheterisation.

**METHODS** Magnetic resonance images were acquired using a Picker International Vista MR2055 superconducting machine operating at 0.5 tesla. A spin echo sequence with an echo time of 24 ms was used to acquire multiple contiguous 1 cm transverse sections at end diastole and end systole. Acquisition time was approximately 3 minutes per pair of images depending upon heart rate. Left and right ventricular volumes were determined by summing the areas of the chambers in each section, and left and right ventricular stroke volumes and ejection fractions were calculated.

Pulmonary to systemic flow ratio was measured in the patients with atrial septal defect from the pulmonary time-activity curve of a first-pass radionuclide ventriculogram,<sup>1)</sup> and in all patients equilibrium radionuclide ventriculography was performed, using functional background subtraction and single left and right ventricular regions of interest assigned with the help of the Fourier phase and amplitude images. Left ventricular ejection fraction, right ventricular ejection fraction and the left to right ventricular stroke volume ratio were calculated.

Cardiac catheterisation was performed with measurement of pulmonary to systemic flow ratio by oximetry, and semiquantitative assessment (grades 1 to 4) of mitral and aortic regurgitation from the left ventriculogram and aortogram respectively.

38 patients were studied: 18 with aortic regurgitation, 10 with mitral regurgitation and 10 with atrial septal defect. In addition, 20 normal subjects were studied by magnetic resonance alone.

**RESULTS** The mean value of the stroke volume ratio measured by magnetic resonance in the 20 normal subjects was 1.01 with standard deviation 0.067. From this it can be calculated that the accuracy of individual magnetic resonance volume measurements is approximately 2%. Figure 1 shows the correlation between individual values of left and right ventricular stroke volumes with the line of identity shown as a dotted line. The linear regression line is not significantly different from the line of identity.

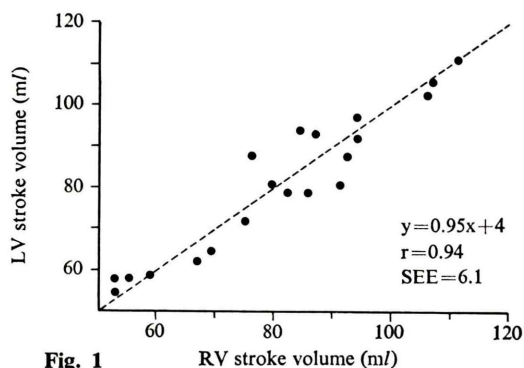


Fig. 1

**Fig. 1** Left and right ventricular stroke volumes measured by magnetic resonance in 20 normal subjects.

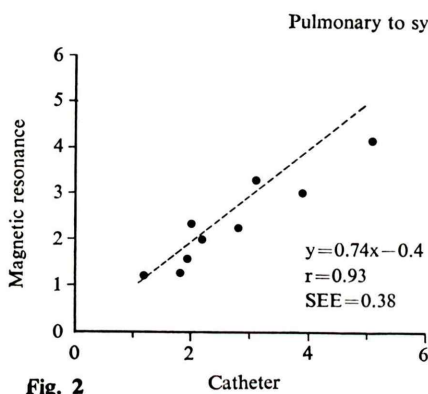


Fig. 2

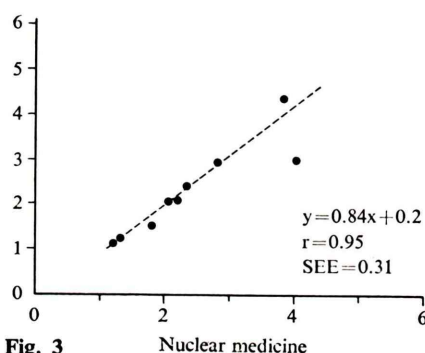
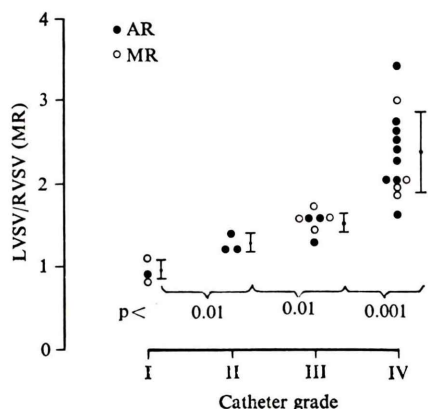
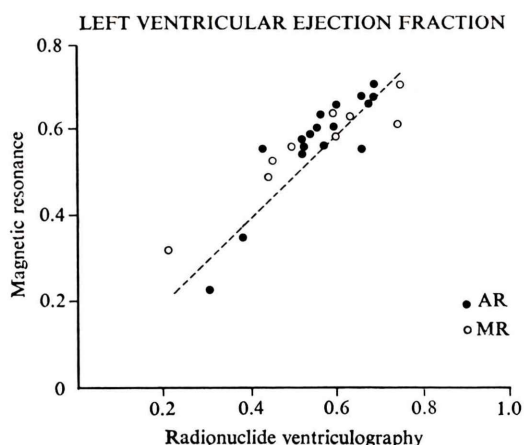


Fig. 3

**Figs. 2 and 3** Correlation of Qp/Qs measured by magnetic resonance, cardiac catheterisation and radionuclide ventriculography in atrial septal defect.



**Fig. 4** Correlation of left to right ventricular stroke volume ratio with grade of regurgitation determined by cardiac catheter.



**Fig. 5** Correlation of left ventricular ejection fraction measured by magnetic resonance and radionuclide ventriculography.

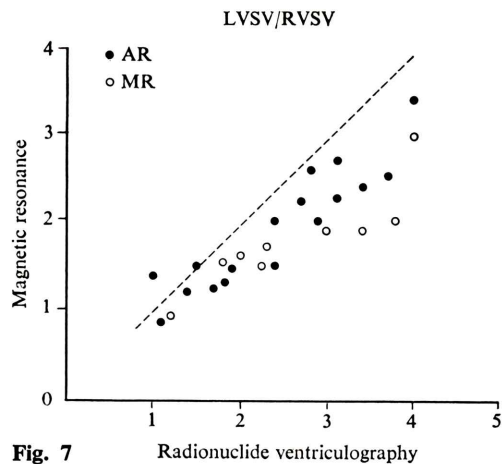
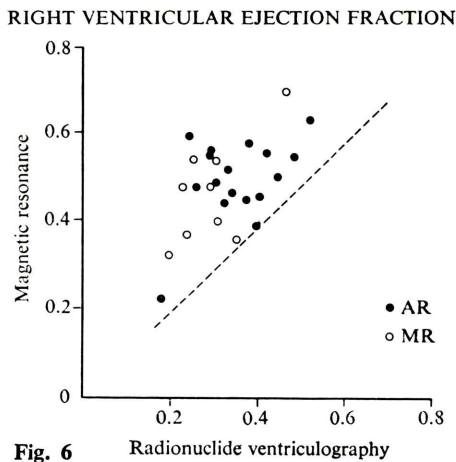


Fig. 6 Radionuclide ventriculography

Fig. 7 Radionuclide ventriculography

**Figs. 6 and 7** Correlation of right ventricular ejection fraction and left to right ventricular stroke volume ratio respectively measured by magnetic resonance and radionuclide ventriculography.

Figure 2 shows the correlation magnetic resonance and oximetric measurement of pulmonary to systemic flow ratio in the patients with atrial septal defect. Correlation is good, but not as good as between magnetic resonance and radionuclide ventriculography (Fig. 3). This implies that the noninvasive techniques are more accurate than oximetry.

Figure 4 shows the magnetic resonance of stroke volume ratio compared with angiographic assessment of the severity of regurgitation in the patients with mitral and aortic regurgitation. There is good agreement although it can be seen that the angiographic category of severe regurgitation covers a wide range of regurgitant fractions from approximately 50% to 70% (regurgitant fraction =  $1 - 1/\text{stroke volume ratio}$ ).

Figures 5 to 7 show the correlation between magnetic resonance and radionuclide ventriculography for left ventricular ejection fraction, right ventricular ejection fraction and stroke volume ratio respectively. There is good correlation for left ventricular ejection fraction ( $y = 0.78x + 5$ ,  $r = 0.89$ ) and stroke volume ratio ( $y = 0.61x + 0.3$ ,  $r = 0.86$ ), but less good correlation for right ventricular ejection fraction ( $y = 2.1x - 9$ ,  $r = 0.61$ ). Right ventricular ejection fraction is underestimated by the radionuclide technique.

**DISCUSSION** Magnetic resonance measurements of the stroke volume ratio in normal subjects shows that the method is very accurate and that it is a suitable reference by which to judge other techniques.<sup>2)</sup> Previous comparisons of radionuclide volume measurements have been with invasive ventriculography,<sup>3)</sup> but such comparisons are difficult because of the different condition under which the techniques are performed.

Right ventricular ejection fraction measurements by radionuclide ventriculography are subject to several sources of error. First pass techniques tend to overestimate the result because of poor mixing of the bolus within the right ventricle, whereas equilibrium techniques underestimate

it because of overlap between the right atrium and ventricle in the left anterior oblique projection, which leads to underestimation of both right ventricular stroke counts and background.<sup>4)</sup> The method used in this study accepts the limitations of the technique, but has the virtue of reproducibility.<sup>5)</sup> The better correlation of the stroke volume ratio with magnetic resonance compared with that for right ventricular ejection fraction implies that background estimation is the major factor causing inaccuracy of radionuclide right ventricular ejection fraction, since background does not need to be estimated to compute the stroke volume ratio. Although the stroke volume ratio is overestimated, it remains a good measure of the severity of valvular regurgitation. In the patients with atrial septal defect, the right heart was dilated with considerable overlap between the atrium and the ventricle, and so right ventricular ejection fraction was seriously underestimated.

**CONCLUSION** Magnetic resonance provides an accurate noninvasive method to quantify valvular regurgitation and atrial shunting, and is a suitable standard by which to judge other methods. Equilibrium radionuclide ventriculography underestimates right ventricular ejection fraction and overestimates the left to right ventricular stroke volume ratio, but it remains accurate in the quantification of valvular regurgitation.

#### References

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