EDITORIALS

Radionuclide Right Ventricular Ejection Fraction

Applications in Valvular Heart Disease

During the past five years, radionuclide assessment of right ventricular performance has been applied to the pathophysiologic study of patients with coronary artery disease, chronic obstructive pulmonary disease, and congenital heart disease. There are two broad categories of radionuclide techniques suitable for assessment of right ventricular performance. This evaluation can be performed by analysis of the first transit through the central circulation (first-pass technique) or by analysis of the entire equilibrium blood pool after intravascular labeling (equilibrium gated technique).

Using first-pass radionuclide angiocardiography, quantitative analysis is based on the principles of indicator dilution theory. The major assumption of the method is that there is homogeneous mixing of the radioactive tracer with blood. In this way, changes in externally detected radioactive counts are proportional to changes in chamber volume. Both right and left ventricular performance can be evaluated from the same study, because there is temporal and anatomic segregation of radioactivity within each of the cardiac chambers. Analysis of the high-frequency components of the time-activity curve allows determination of indices of right and left ventricular performance. Because data analysis is based on several cardiac cycles, the major potential limiting factor of the first-pass approach is the relatively low count rates of the raw data. This is particularly important when studies are performed on conventional analog single-crystal scintillation cameras. In contrast, the computerized multicrystal camera or the recently developed digital single-crystal camera allows accumulation of higher count rates, thereby minimizing this problem.

The study by Winzelberg and associates in this issue (see page 520) describes an elegant modification of the first-pass technique, which appears to be well suited for the conventional single-crystal camera. This involves data acquisition in conjunction with the patient’s ECG. Calculation of right ventricular ejection fraction is based on summed end-diastolic and end-systolic counts, temporally related to the R wave of the ECG. In contrast to other first-pass studies, the bolus injection is made using the Oldendorf technique, allowing acquisition of an average of ten beats. This approach appears to be less dependent on injection of an intact tracer bolus. For assessment of right ventricular ejection fraction, the gated first-pass study is performed in the 30° right anterior oblique position to separate the right atrium and right ventricle without overlap of activity with the left ventricle.

In the alternative radionuclide technique, gated cardiac blood pool imaging, the entire equilibrium blood pool is imaged at various times during cardiac contraction by synchronizing the collection of scintillation data with a marker of cardiac contraction. Since ECG events generally bear a fixed relationship to the mechanical activity of the heart, repetitive sampling of specific phases of the cardiac cycle from each of many beats can be performed until the cardiac image has an adequate count density. Generation of time-activity curves requires analysis of the 45° left anterior oblique position study, because this is the view that usually separates activity within the two ventricles. In this position, the left atrium contributes relatively little to left ventricular counts because of its distance from the detector and its position superior and posterior to the left ventricle. This approach has been used extensively for evaluation of left ventricular function. However, in the same position, the right atrium contributes substantially to right ventricular counts. Even with a variable region of interest, there still appears to be overlap of the right atrium and right ventricle at various times throughout the cardiac cycle. Studies of right ventricular ejection fraction at rest and during exercise have demonstrated that this parameter provides important physiologic data on right ventricular pump performance. However, it is clear that the ejection fraction measurement, whether left or right ventricular, is dependent on...
preload and afterload in addition to intrinsic myocardial contractility. The complex interactions of these factors are not fully understood. The present study by Winzelberg et al clearly extends these results to patients with valvular heart disease. The authors show that right ventricular ejection fraction determined by gated first-pass radionuclide angiography does not correlate well with either right ventricular systolic pressure, an indicator of the severity of pressure overload and afterload \((r=0.23)\), or right atrial pressure, a marker of right ventricular filling pressure and preload \((r=-0.17)\). These findings suggest that right ventricular ejection fraction has many physiologic determinants and is not wholly a reflection of either preload or afterload. Multiple compensatory mechanisms are brought into play to maintain right ventricular ejection fraction, even in the face of severe pressure overload. It is important to note that they found the right ventricular ejection fraction to be significantly lower in patients with right ventricular systolic pressures greater than 50 mm Hg than in those with pressures less than 50 mm Hg. Their conclusions concerning the prognostic implications of reduced right ventricular ejection fraction in the early postoperative course are somewhat limited. First, follow-up only included the immediate postoperative period and did not extend to a longer, perhaps clinically more relevant, period. In addition, postoperative right ventricular ejection fraction and hemodynamic measurements were not obtained.

From a technical perspective, the comparisons presented by the authors between gated first-pass and gated equilibrium right ventricular ejection fraction are important to highlight. In the overall group of patients, which includes both normal subjects and patients with marked right ventricular dysfunction owing to pressure overload, there is a relatively poor correlation between these two techniques \((r=0.61)\). By the gated first-pass techniques, the normal range for right ventricular ejection fraction (expressed as the mean ± 2 SD) was 46 to 74 percent. This agrees very closely with previous radionuclide first-pass and contrast angiographic studies. However, by equilibrium blood pool imaging, the normal range for right ventricular ejection fraction extends from 31 to 62 percent. The substantially lower right ventricular ejection fraction obtained with the gated equilibrium technique probably is due to the overlap of the right atrium and right ventricle, especially in patients with right ventricular dysfunction. These results clearly differ from those previously reported by Maddahi et al and Slutsky et al. This anatomic overlap may be diminished by use of a 30° slant hole collimator. Further detailed validation studies appear to be warranted.

The direct comparison of hemodynamic measurements and radionuclide angiographic assessment of right ventricular function provided by Winzelberg et al demonstrates that clinically relevant data can be derived from assessment of right ventricular systolic performance. Further clinical applications of this approach should provide new insights into the natural history of valvular heart disease and should allow better assessment of the effects of various interventions on biventricular performance.

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REFERENCES

The Pulmonary Function Test
Cautious Overinterpretation

"The general tendency in pulmonary function testing at the clinical level is toward cautiously noncommittal overinterpretation expressed in language replete with modifiers.”


These words are as applicable today as they were a dozen years ago. Clinical pulmonary function testing remains an art rather than a science. Its problems pertain to at least four areas of uncertain-