Radionuclide First Transit and R-Wave Synchronized Imaging: Correlation of Three Methods of Determining Left Ventricular Ejection Fraction with Contrast Angiography

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Left ventricular ejection fractions in 25 patients, as determined by first transit and R-wave synchronized imaging, were compared with contrast angiography. The ejection fraction obtained by first transit and R-wave synchronized images using a varying region of interest correlated well with the contrast angiography (r = 0.96; r = 0.99 respectively). Use of a fixed end-diastolic region of interest consistently underestimated the ejection fraction (r = 0.92).

Left ventricular performance is commonly determined by contrast angiography. Radionuclide angiocardiography is rapidly becoming a diagnostic tool in the evaluation of heart disease. The left ventricular ejection fraction (LVEF) determined by first transit and equilibrium techniques has been shown to be accurate (1-15). Current R-wave synchronized imaging has also proved an accurate and reproducible method for determining left ventricular performance (16-23). This study compares the accuracy of LVEF determinations from: (a) first transit data, (b) R-wave synchronized images using an operator-defined, fixed end-diastolic region of interest, and (c) computer-defined regions of interest that track the left ventricular border through systole.

Methods

Twenty-five patients undergoing cardiac catheterization also had radionuclide first transit and R-wave synchronized blood pool imaging. Contrast angiography was performed in the 30° right anterior oblique projection after 40-60 ml of Renografin was injected into the left ventricle. Cineradiography images were recorded and the LVEF was calculated by conventional single plane area length method (24).

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FIG. 1. Comparison of ejection fraction determined by first transit and contrast angiography.
subtracted, time-activity data curve was generated and the ejection fraction was calculated by identifying with the lightpen end-diastolic and end-systolic count data.

As shown, ejection fraction equals:

\[
\frac{\text{ED Counts} - \text{ES Counts}}{\text{ED Counts}}
\]

After a 10-min equilibration period, R-wave synchronized images were acquired in the anterior and left anterior oblique projections. The cardiac cycle was divided into 16 image segments and stored directly in core memory (ADAC) as consecutive images in a \(64 \times 64\) byte mode matrix. Upon completion of the equilibrium study, the images were transferred to magnetic disk. An algorithm developed by Bell et al. was used to discriminate arrhythmic cycles (25). The LVEF was calculated using two different methods.

**Method 2: Operator-Defined End-Diastolic Fixed Region of Interest**

A single left ventricular region of interest was defined by the operator using a left anterior oblique end-diastolic image. A background region of interest was also created. A time-activity curve of the cardiac cycle using only one ventricular area of interest was generated and corrected for background. The ejection fraction was calculated from end-diastolic and end-systolic count data.

**Method 3: Computer-Defined Varying Regions of Interest**

Nine point spatial smoothing with background subtraction was performed on each image in the cardiac cycle. An automated computer program then:

1. determines the left ventricle region of interest for each image of the cardiac cycle (the program permits operator intervention to modify the region of interest);
2. determines a background region of interest;
3. generates a time-activity curve representative of counts obtained from each region of interest; and
4. calculates the ejection fraction from end-diastolic and end-systolic count data.

**Results**

All three methods were successfully performed with each of the 25 patients. The processing time for the first transit method was 10–15 min. Processing time for the end-diastolic fixed region of interest was 10 min. The automatic computer-defined regions-of-interest method rarely worked in a totally automatic fashion. It was necessary for the operator to edit the regions of interest in 80\% of the patients to assure that each region corresponded to visually acceptable ventricular borders. This intervention was greater when there was considerable change in the left ventricle size.

Regression plots for each method are shown in Figs. 1, 2, and 3. The fixed region-of-interest method underestimated the ejection fraction as compared to the varying region-of-interest method (Fig. 4).

**Conclusion**

The first transit and R-wave synchronized imagings differ markedly in their methodology but both techniques
provide a reliable means of assessing global left ventricular performance. A region of interest that remains fixed throughout the cardiac cycle (method 2) will record data that may not be representative of the left ventricle during systole. This causes the systole count to be overestimated, which in turn reduces the apparent ejection fraction. This underestimation of the ejection fraction can be eliminated if the region of interest becomes smaller with systole.

The ejection fraction determined by first transit and R-wave synchronized images using a varying region of interest throughout the cardiac cycle correlated well with contrast angiography (r = 0.96; r = 0.99, respectively). The fixed end-diastolic, region-of-interest method consistently underestimated the ejection fraction (r = 0.92).

References
