Automatic quantification of right ventricular volumes and right ventricular ejection fraction with gated blood pool SPECT: Comparison of 8- and 16-frame gated blood pool SPECT with first-pass radionuclide angiography

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Background. **The aim of this study was to compare 8- and 16-frame gated blood pool single photon emission computed tomography (SPECT) (GBPS) for the determination of right ventricular ejection fraction (RVEF) and right ventricular (RV) volumes in subjects who underwent two consecutive GBPS studies.**

Methods and Results. **In this study 65 consecutive patients (29 men and 36 women) referred for first-pass radionuclide angiography (FP-RNA) underwent FP-RNA and both 8- and 16-frame GBPS. The mean FP-RNA RVEF was statistically lower than RVEF determined by 8-frame GBPS ($P < .001$) and 16-frame GBPS ($P < .001$). Comparison of RVEF by FP-RNA and GBPS yielded coefficients of 0.8666 ($P < .0001$) for 16-frame GBPS and 0.7290 ($P < .0001$) for 8-frame GBPS. The correlation of RVEF between 8- and 16-frame GBPS showed a coefficient of 0.6657 ($P < .0001$). The mean RV end-diastolic volume (EDV) calculated with 8- and 16-frame GBPS showed no statistical differences ($P = .3580$). The mean RV end-systolic volume (ESV) calculated with 8- and 16-frame GBPS also showed no statistical differences ($P = .2265$). Comparison of EDV by 8- and 16-frame GBPS yielded a coefficient of 0.7327 ($P < .0001$). The correlation between ESV by 8-frame GBPS and 16-frame GBPS showed a coefficient of 0.6067 ($P < .0001$).**

Conclusion. **GBPS is a simple and reproducible acquisition method for the assessment of RVEF and RV volumes. RVEF values calculated by 8- and 16-frame GBPS correlated well with FP-RNA, although mean RVEF values from FP-RNA were lower than GBPS RVEF values. In addition, RV ESV and EDV were both well correlated with 8- and 16-frame GBPS. GBPS should prove to be useful in diagnosis, as well as in following disease progression and evaluating the efficacy of therapeutic interventions, in patients with biventricular dysfunction. (J Nucl Cardiol 2005;12:553-9.)**

Key Words: Gated blood pool single photon emission computed tomography • right ventricular ejection fraction • end-diastolic volume • end-systolic volume

Clinically, right ventricular (RV) function provides important information and is relevant for the risk stratification and follow-up in patients with various diseases, such as primary pulmonary hypertension, acute pulmonary embolism, RV infarction, chronic coronary artery disease, congestive heart failure, congenital heart disease, and valvular heart disease.[1-6] In particular, RV ejection fraction (RVEF) has been shown to be a predictor of patient survival.[7,8]

First-pass radionuclide angiography (FP-RNA) is widely used for noninvasive evaluation of RV function. FP-RNA was developed to avoid overlap of counts from the left ventricle. However, FP-RNA also has some disadvantages. The problem of atrial overlap remains, and in many cases delineation of the right ventricle can be difficult. In addition, FP-RNA depends on good bolus injection and accurate camera positioning.

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Gated blood pool single photon emission computed tomography (SPECT) (GBPS) is a simple, highly reproducible, and accurate method for the determination of biventricular ejection fraction and volumes.[9-11] In addition, separating the ventricles and atria provides supplementary information regarding biventricular volumes, wall motion, and regional ejection fraction. There is also no need to search for the best septal projection at image acquisition, which is time-consuming. Recently, RVEF has been measured by use of GBPS.[11] However, relatively few GBPS studies have dealt explicitly with validating RV measurements.

Despite these advantages, GBPS has not replaced FP-RNA for the determination of RV function and RV volumes because of lack of automatic, fast, and reliable quantitative algorithms for assessing RVEF and RV volumes from GBPS.

Recently, two automatic processing algorithms for the calculation of biventricular function and volumes from GBPS have been developed and are commercially available.[12,13] However, the optimal number of frames per cardiac cycle during the acquisition of GBPS has not been investigated. In addition, no other study has investigated the comparison of 8- and 16-frame GBPS for measurements of RVEF and RV volumes.

In this study we aimed to compare 8- and 16-frame GBPS for the determination of RVEF and RV volumes, taking FP-RNA as the gold standard, in subjects who underwent two consecutive GBPS studies.

MATERIALS AND METHODS

Patients

Table 1 shows the demographic data of patients. The study population included 65 consecutive patients (29 men and 36 women; mean age, 62.3 ± 10.4 years) referred for FP-RNA for evaluation of preoperative cardiac risk stratification (n = 39), prechemotherapy cardiac function (n = 18, breast cancer), and congestive heart failure (n = 8). All patients underwent FP-RNA and GBPS in the same session. Exclusion criteria included patients with frequent arrhythmias, acute cardiac event, or hemodynamic instability. All patients signed informed consent forms before the study, and the Institutional Review Board of Pusan National University Hospital, Busan, Republic of Korea, approved the study protocol.

Table 1. Characteristics of study patients (N = 65)

Age (y)	62.3 ± 10.4
Men/women	29/36
Body mass index (kg/m^2)	28.6 ± 6.9
Previous history	
Hypertension	9 (13.8%)
Diabetes mellitus	12 (18.5%)
Congestive heart failure	8 (12.3%)
Smoking	27 (41.5%)
Prior myocardial infarction	0
Heart rate (beats/min)	79 ± 14
Systolic blood pressure (mm Hg)	129 ± 42
Mean R-R interval (ms)	883 ± 136
Wall motion	
Normal	57
Hypokinesia	8
Akinesia	0

FP-RNA Acquisition and Processing

Twenty minutes before radionuclide injection, patients received the stannous agent intravenously. Thirty minutes later, 800 MBq technetium 99m pertechnetate, in a volume measuring less than 0.5 mL, was introduced into the venous line and flushed through the line by a rapid injection of 50 mL of normal saline solution. Data from the 30° right anterior oblique view of the gamma camera gated to the electrocardiogram were acquired with a magnification factor of 2.67 for a duration of 600 seconds. We used 16 frames per cardiac cycle, a 64 × 64 matrix, a ±10% R-R acceptance window, and an energy window of 20% centered at 140 keV for acquisition with a low-energy, high-resolution, parallel-hole collimator. All images were acquired with an ADAC Vertex dual-headed gamma camera (ADAC, Milpitas, Calif). The images were transferred to a Pegasys (ADAC) computer system for analysis. During processing, all frames of the gated view were temporarily smoothed and a region of interest (ROI) was drawn on the right ventricle to assess end-systolic and end-diastolic frames. On both frames, an ROI was drawn through the pulmonary and tricuspid valve levels and around the ventricle. The best time interval of the FP-RNA was chosen between the appearance of activity in the superior vena cava and just before arrival in the lungs. A time-activity curve of FP-RNA was generated within the ROI. The ventricular region was used to estimate ventricular counts at both end systole and end diastole. The average of the counts in the background for each frame of the cardiac cycle was used for background correction, and RVEF was calculated by use of the standard formula.

GBPS Acquisition and Processing

Immediately after FP-RNA was performed, both 8- and 16-frame GBPS studies by use of a gamma camera were performed consecutively. For GBPS studies, acquisition parameters consisted of 32 steps per 180°, 90 seconds per step, 8 and 16 frames per cardiac cycle, a 64 × 64 matrix, body contour, a 20% energy window centered at 140 keV, a ±10% R-R acceptance window, and image magnification of 1.3 with a low-energy, high-resolution, parallel-hole collimator. The projection images were processed on a Pegasys computer system. Data were reconstructed by ramp filtered backprojection after prefiltering of the projection data with a 2-dimensional Butterworth filter. A single operator reoriented the