Assessment of Left Ventricular Systolic Function by the Chest X-Ray: Comparison With Radionuclide Ventriculography

POUL F. HØILUND-CARLSEN, MD, DMSci,[1] NIELS GADSBØLL, MD, DMSci,[2] EBBE HEIN, MD,[3] POUL STAGE, MD,[4] JENS HENRIK BADSBERG, MSCi,[5] AND BIRTE HJORT JENSEN, MLT[6]

Odense, Denmark; Glostrup, Denmark; Hvidovre, Denmark; Copenhagen, Denmark

ABSTRACT

Background: The value of the plain chest roentgenogram in predicting cardiac status remains controversial.
Methods and Results: A total of 111 randomly selected survivors of acute myocardial infarction (age 38 to 83 years) were studied prospectively. X-ray and radionuclide examinations were performed on a morning in the second week after myocardial infarction. From the chest x-ray, left ventricular chamber size and pulmonary vascular congestion were graded visually, and relative cardiac volume was measured to allow for comparison with radionuclide left ventricular end-diastolic volume index (LVEDVI) and left ventricular ejection fraction (LVEF) determined by gated blood pool imaging. Despite significant tendencies for larger radionuclide LVEDVI and lower LVEF with greater radiographic left ventricular size, larger relative cardiac volume, and increasing degrees of pulmonary congestion, wide scatter, and large overlaps between groups precluded reliable radiographic prediction of radionuclide findings. The positive and negative predictive values for radiographic detection of an enlarged LVEDVI ranged from 59% to 80% and 56% to 71%, respectively, and for prediction of a decreased LVEF from 75% to 90% and 40% to 58%, respectively. Accuracy never exceeded 70%.
Conclusion: Our findings question the value of the chest roentgenogram in the detection and grading of left ventricular systolic dysfunction in patients with recent myocardial infarction.
Key Words: Chest roentgenogram, radionuclide imaging, ventricular volume, ejection fraction, pulmonary congestion.

Careful assessment of cardiac function has become increasingly important for the choice of optimal management of patients with congestive heart failure and myocardial infarction.[1–7] In this context, the plain chest roentgenogram has for decades been an adjunct to the initial clinical evaluation of each patient by providing visual estimation of cardiac size and judgment of the degree of pulmonary vascular congestion. Despite the advent of radionuclide ventriculography, echocardiography, and other modalities, which offer conceptually more direct and more precise estimates of left ventricular (LV) volumes and function, it appears that the chest x-ray is for many physicians still a firm element of the workup in patients with known or suspected cardiac failure. One reason for this could be that most recent guidelines do not take a clear stand as to the position of the chest x-ray in patient management (ie, with few exceptions they do not explicitly recommend or dissuade its use).[7–18] It was the aim of this study to elucidate the reliability of a standard radiologic examination in the assessment of LV systolic function. For practical reasons, we did this in a series of survivors of acute myocardial infarction.

Methods

Patients

During a period of 15 months, 111 patients surviving the acute phase of myocardial infarction had undergone both an x-ray examination of the chest and radionuclide ventriculography on the same morning in the second week after the infarction (median 9 days after, range 8–12). A detailed description of the study population from which these patients were derived has been given previously.[19] All gave informed consent to participate in the present investigation, which was approved by the local scientific ethical committee. The study conformed to the principles outlined in the Declaration of Helsinki. Thirty-four were women, median age 67 years (range 40–83), and 77 were men, median age 60 years (range 38–78).

From the [1]Department of Nuclear Medicine, Odense University Hospital, Odense, Denmark; Departments of [2]Cardiology, [3]Radiology, and [6]Clinical Physiology and Nuclear Medicine, Glostrup University Hospital, Glostrup, Denmark; [4]Department of Radiology, Hvidovre University Hospital, Hvidovre, Denmark; and [5]Department of Biostatistics, Panum Institute, University of Copenhagen, Denmark.

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Reprint requests: Poul F. Høilund-Carlsen, Department of Nuclear Medicine, Odense University Hospital, DK-5000 Odense C, Denmark.

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In each patient, routine chest x-ray was taken and radionuclide ventriculography performed few hours apart. Twenty-two patients had a history of arterial hypertension and 11 a diagnosis of obstructive pulmonary disease. Fifty-five received diuretics, 32 digoxin, 6 β-blocking agents, and 11 calcium-entry blockers. The diagnosis of myocardial infarction was based on characteristic symptoms and typical electrocardiogram changes when confirmed by a significant serial rise (>30 U/L) in the serum creatine kinase enzyme MB concentration.[20]

Chest X-Ray

Posteroanterior and lateral chest films were taken with the patients in the erect position. All chest films were described by an experienced senior radiologist, who was unaware of radionuclide and clinical findings. If necessary, he consulted films of both projections and drew help lines to assist definition of measuring points. LV chamber size was visually graded as being either normal (Grade 1), possibly enlarged (Grade 2), or enlarged (Grade 3). Relative cardiac volume was determined according to Jonsell,[21] with an upper limit of normal = 450 mL/m^2 for women and = 500 mL/m^2 for men.[22] Pulmonary vascular congestion was graded according to slightly modified criteria of Kostuk and coworkers: no pulmonary congestion (Grade I), isolated flow shift to upper lobes (Grade II), interstitial oedema (Grade III), and alveolar edema (Grade IV).[23]

Radionuclide Ventriculography

The patients were examined in the resting supine position by a gamma camera with a dedicated computer using autologous red blood cells labeled with 1100 MBq ^{99m}Tc and multigated equilibrium imaging applying an individual left anterior oblique view. For each study, 5 million counts were collected with 40 frames per electrocardiographic RR interval. LV ejection fraction (LVEF) was calculated from the background corrected counts within the end-diastolic and end-systolic perimeters.[24] LV end-diastolic volume index (LVEDVI) was determined as the absolute LV end-diastolic volume using the count-based principle with correction for the individual loss of radiation, dependent on measured LV depth, and expressed per square meter body surface area calculated from height and weight measured immediately before acquisition. The accuracy of volume determinations by this method has previously been validated by comparison with simultaneous thermodilution measurements.[25] For comparison with the radiologic findings, the radionuclide variables were arbitrarily divided into 4 categories: normal, mildly, moderately, and severely abnormal, with abnormal indicating either a decrease or an increase depending on the variable measured. Normal values, previously determined in a series of healthy subjects[25,26] and arbitrarily chosen limits for the 4 categories[19] are given in Table 1.

Statistical Analysis

Because many datasets were not normally distributed results are given as medians and ranges. Between group differences were tested for using 1-way analysis of variance (chi-square approximation). Radiologic relative cardiac volumes and radionuclide end-diastolic ventricular volume indexes were compared by linear regression analysis. For calculation of predictive values, all variables were considered binary (ie, as being normal or abnormal). For radiologic estimation of ventricular size, normal included Grades 1 and 2 (normal and possibly enlarged), whereas abnormal meant Grade 3 (enlarged) only. For evaluation of the degree of pulmonary vascular congestion, Grades I and II meant normal, whereas Grades III and IV meant abnormal. Radionuclide data were divided into normal and abnormal, the latter including mild, moderate, and severe abnormality. The predictive value of a positive and a negative test and the diagnostic accuracy of the test were calculated as given by Galen and Gambino.[27]

Results

LV Size

Semiquantitative radiographic gradings of LV size compared with radionuclide variables are depicted in Fig. 1 (upper panel). There was a highly significant tendency for larger LVEDVI ($P < .0001$) and lower LVEF ($P < .0002$) with greater LV size on the roentgenogram. The chest x-ray identified correctly 63% (38 of 56) of patients with an increased LVEDVI and 64% (35 of 55) of patients with a normal LV volume (Fig. 1). Correspondingly, radiologic LV size identified 63% (46 of 73) and 68% (26 of 38), respectively, of patients with either a decreased or a normal radionuclide LVEF (Table 2).

Relative Cardiac Volume

Radiographic relative cardiac volume compared with radionuclide LVEDVI and LVEF is depicted in Fig. 2. The heart was enlarged on the x-ray of 80 patients (72%) and was of normal size in 31 patients (28%). There was a clear tendency for increased LVEDVI and lower LVEF with larger relative cardiac volume ($P < .001$ for both) (Fig. 2).

Pulmonary Vascular Congestion

The relationship between the radiologic interpretation of peripheral pulmonary findings and radionuclide LVEDVI and LVEF appears in Fig. 1 (middle panel). Sixty-four patients (58%) had no radiographic signs of pulmonary congestion, 27 (24%) had an isolated flow shift to the upper lobes, 14 (13%) had interstitial edema, and 6 (5%) had alveolar edema. There was a highly significant tendency for larger LVEDVI ($P < .0003$) and lower LVEF ($P < .0002$) with increasing degrees of pulmonary vascular congestion (Fig. 1).

Table 1. Normal Values and Arbitrary Limits for Radionuclide Abnormalities

Radionuclide Variable	Normal	Slightly Abnormal	Moderately Abnormal	Severely Abnormal
LVEDVI (mL/m^2)	≤90	91–110	111–130	>130
LVEF	≥0.53	0.40–0.52	0.30–0.39	<0.30

LVEDVI, left ventricular end-diastolic volume index; LVEF, left ventricular ejection fraction.