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Effect of Patient Positioning on Left Lateral Thallium-201 Myocardial Images

David E. Johnstone, Frans J. Th. Wackers, Harvey J. Berger, Paul B. Hoffer, Michael J. Kelley, Alexander Gottschalk, and Barry L. Zaret

Yale University School of Medicine, New Haven, Connecticut

The effect of patient positioning on thallium-201 images in the left lateral projection was evaluated in 28 patients. The left lateral image was performed with the patient on his right side (LLrs) and also supine (LLsup). False-positive inferoposterior defects were reported in five patients (18%) in the LLsup view, but not in the LLrs view. Image quality was better in the LLrs view. The false-positive results in the LLsup view may result from two factors: a) overlap of the left hemidiaphragm and myocardium; or b) changes in orientation of the heart in the two lateral positions. Therefore, thallium-201 images in the LL position should be performed with the patient lying on his right side.

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Thallium-201 myocardial imaging has been applied widely for noninvasive detection, location, and quantification of myocardial infarction (*1–5*) and of transient myocardial ischemia induced by exercise or pharmacologic intervention (*6–11*). To best visualize perfusion defects that may be obscured by radioactivity in overlying normal tissue, studies should be performed in multiple projections. Most laboratories use at least three standard projections: anterior, 45° left anterior oblique (LAO), and left lateral (LL). Phantom studies have shown that defects are imaged best either en face or in tangent (*12*). Therefore, the left lateral projection should be best for visualization of the inferoposterior wall. In early experience with Tl-201 imaging in the left lateral projection, patient positioning was found to influence results (*13*); LL images obtained with patient supine often demonstrated apparent defects not seen when images were obtained with the same projection but with the patient lying on the right side. The purpose of the present study was to evaluate systematically the effects of patient positioning on Tl-201 images obtained in the left lateral projection.

MATERIALS AND METHODS

Twenty-eight consecutive patients referred for clinical Tl-201 imaging were included in this study.

Six of 28 patients were subjects with atypical chest pain but no demonstrable heart disease (four had normal coronary angiograms, two had reflux esophagitis and degenerative cervical-spine disease, respectively); seven patients had prior myocardial infarction; ten had chronic coronary-artery disease without sustained infarction; and five had miscellaneous noncoronary heart disease.

Myocardial imaging. Myocardial imaging was performed with a 37-photomultiplier camera equipped with a high-resolution parallel-hole collimator, using a symmetrical 20% window around the 80-keV x-ray. All studies were obtained following i.v. injection of 1.5–2.0 mCi of $^{201}TlCl$. Twenty-

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For reprints contact: Frans J. Th. Wackers, Yale University School of Medicine, Section of Cardiology, 87 LMP, 333 Cedar St., New Haven, CT 06510.

eight Tl-201 studies in 28 patients form the basis for the present communication. Scintigraphy was performed either at rest (14 patients), or 4½ hr following exercise (eight patients; the complete immediate postexercise and 4-hr redistribution study being performed on another camera), or immediately after exercise (six other patients). In this last group, redistribution was also studied after 4 hr but no additional LL images were obtained, and such studies are therefore not included. Imaging was performed as follows. The anterior and 45° LAO projections were made in the standard manner with the patient supine. The LL projection was obtained in two ways: a) with the patient supine (LLsup) and the detector parallel to the patient's sagittal plane (viewing the heart cross-table), and b) with the patient on his right side (LLrs) and the detector above and parallel to the table top. In both LL positions the left arm was abducted 180°. To avoid unnecessary resolution loss, care was taken to place the detector head in direct contact with the patient's left side. The order of obtaining each of the two LL images was determined randomly following the anterior and the 45° LAO images. The average imaging time for the 300,000 counts accumulated was 6 min.

To evaluate the effect of patient positioning on the long axis of the heart, we studied seven additional patients with normal Tl-201 images and with no clinical or electrocardiographic evidence of myocardial infarction. In these patients, anterior images were obtained with the patient supine (standard image) and on his right side. For spatial reference, a lead bar was taped to the chest in the third left intercostal space, and a cobalt-57 line source was taped in the left anterior mid-axillary line. In addition, 45° LAO and both LL images were obtained.

Myocardial image analysis. Unprocessed analog triple-lens Polaroid images were analyzed. The 56 LL images from the 28 patients were coded numerically in random manner. Each of these images was read independently by three observers without clinical information or knowledge of the manner in which the LL image had been obtained. It was generally not possible to recognize the position from the images. Each observer evaluated image quality as adequate or inadequate, and noted the presence and location of defects. A technically inadequate image was one in which the left ventricular myocardium was not clearly visualized because of low myocardium-to-background ratio or superposition of subdiaphragmatic activity. Normal images showed homogeneous distribution of Tl-201 throughout the left ventricle. A defect was defined as a discrete region of relatively decreased radioactivity compared with normal adjacent myocardium. The location of the defect was determined as previously reported (*13*).

Final data analysis was based on a consensus of all three observers. There was total agreement for 47 of 56 images, and agreement by only two of three observers in the remaining nine images. Following interpretation of individual images, the LL images were decoded and viewed together with their companion anterior and 45° LAO images. Scintigraphic data then were correlated with the clinical findings. A study was considered to be truly positive when there was other collaborating clinical evidence of myocardial infarction or of significant coronary-artery disease.

To further compare the diagnostic information of the respective LL images and to illustrate the data graphically, receiver operating characteristic (ROC) curves were constructed (*14–16*). The coded 56 LL images were evaluated independently by two other observers. The images were interpreted as either positive (the presence of a defect) or negative, and the probability for the presence of a scintigraphic abnormality was graded on a scale of 1 to 5 (1 = almost definitely not present, 2 = probably not present, 3 = unsure, 4 = probably present, and 5 = almost definitely present). By changing the threshold for defining the presence of a defect (5, 5+4, 5+4+3, 5+4+3+2 and 5+4+3+2+1) and then tabulating these results according to the clinical information, the true-positive ratio (an expression of sensitivity) can be determined and plotted against the false-positive ratio (an expression of specificity).

RESULTS

Image quality. The anterior and LAO images were of adequate technical quality in all 28 patients. Of the 56 LL images, 47 (84%) were of good quality and nine (16%) inadequate. Both LL images were inadequate in three patients, whereas in three additional patients only the LLsup images were inadequate. All inadequate LL images were obtained at rest.

Concordant LL image pairs. Of the 22 patients with good-quality images in both LL positions, 13 LL pairs (59%) provided concordant data. Four studies were performed at rest, five after 4½ hr of redistribution, and four after exercise. Both LL images were normal in nine patients. In four patients, inferior defects caused by previous infarctions were present on both LL projections, but there were qualitative differences in the apparent defect size. The defect appeared larger in the LLsup image in three patients, whereas in one the reverse was true.

Discordant LL image pairs. The two LL images provided discordant data in nine of 22 (41%) pa-

TABLE 1. CLINICAL AND IMAGING DATA IN NINE PATIENTS WITH DISCORDANT LEFT LATERAL Tl-201 IMAGES

Case No.	Thallium-201 segmental defects				ECG	Clinical data	Type of study
	LLrs	LLsup	Ant	LAO 45°			
1	N	Inf./post	N	N	N	Atypical chest pain, N coronary arteries	Rest
2	N	Inf./post	N	Ant./lat.	N	Angina pectoris 2-vessel disease (CX,LAD)	Redistr
3	N	Inf./post	N	N	N	Angina pectoris 3-vessel disease	Redistr
4	N	Inf./post	N	Septal	QV_{1-3}	CHF	Rest
5	N	Inf./post	N	N	N	Unstable angina	Rest
6	N	Inf./post	N	N	$Q_{2,3}$, AVF	Angina pectoris	Ex
7	Apical	N	N	N	N	Atypical chest pain N coronary arteries	Ex
8	Inf./apical	N	Ant./inf.	Inf.	$Q_{2,3}$, AVF	Angina pectoris 3-vessel disease	Redistr
9	Inf./post	N	N	N	T inverted V_{1-6}	NTMI	Rest

Ant = anterior
CHF = congestive heart failure
CX = circumflex coronary artery
ECG = electrocardiogram
inf = inferior
LAD = left anterior descending coronary artery
LAO 45° = left anterior oblique
LL = lateral
LLrs = left lateral view, patient on his right side
LLsup = left lateral view, patient supine
N = normal
NTMI = nontransmural myocardial infarction
Post = posterior

tients (Table 1). Four studies were performed at rest, three at redistribution and two after exercise. In six patients, defects were reported in the LLsup image, whereas the LLrs images were normal. Five of these patients showed inferoposterior defects in the LLsup position that could not be explained by the available clinical data (Fig. 1). In addition, none had inferior defects on the anterior or 45° LAO images. The remaining patient had a large inferoposterior defect present on the LLsup image, which corresponded to the electrocardiographic diagnosis of a previous transmural myocardial infarction. However, the significance of this image abnormality is unclear because the other three Tl-201 images were normal.

In the three remaining patients with discordant image pairs, the LLsup images were normal, whereas defects were evident in the LLrs images. In one patient a small apical defect was seen on the LLrs image, but not on any of the other three companion images. In the second patient, an inferoapical defect was noted, corresponding to the electrocardiographic impression of a previous infarction. In the remaining patient, an inferoposterior defect in the LLrs position could not be explained by the other scintigraphic data, but this patient had evi-

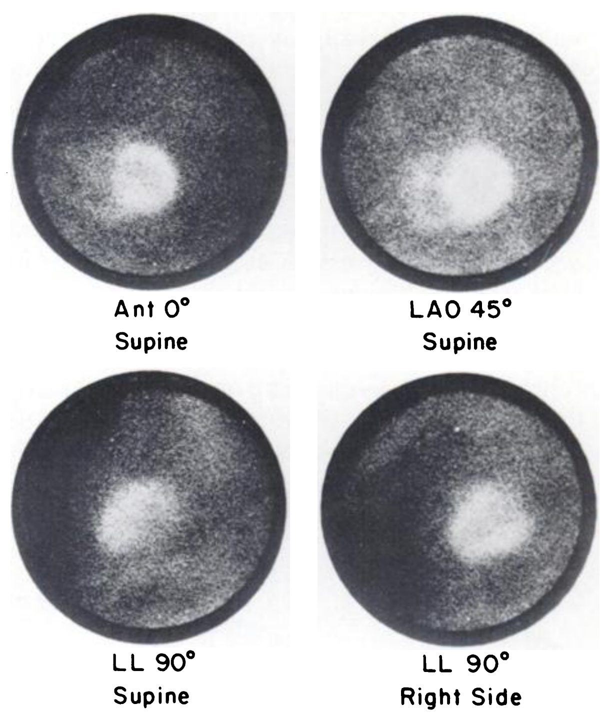

FIG. 1. Thallium-201 scintigraphy in four projections in Case 1, with normal coronary arteries. Images were obtained 10 min following injection. Inferoposterior defect is seen on LL image in supine position, but is not apparent on LL image with patient on his right side. Anterior and 45° left anterior oblique images (top) are normal.

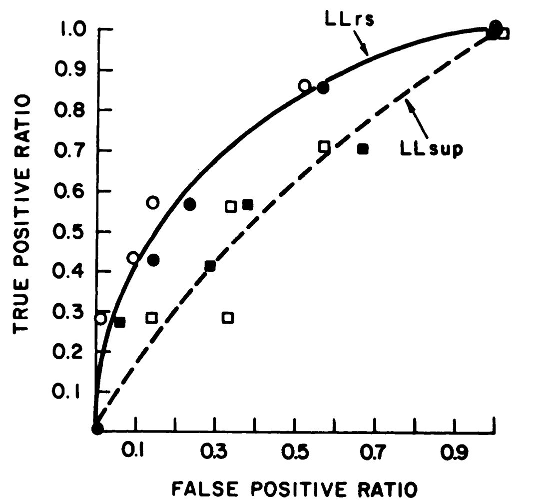

FIG. 2. Receiver operating characteristic (ROC) curves constructed from ROC score of respective LL images. The true-positive ratio is plotted against the false-positive ratio. Concave curve (solid line), representing data from LLrs position, approximates ideal ROC curve. Independent scores from LLsup position (broken line) show considerably more interobserver variation. ○ = observer 1 LLrs ROC score. ● = observer 2 LLrs ROC score. □ = observer 1 LLsup ROC score. ■ = observer 2 LLsup ROC score. LLrs = left lateral image, patient on right side. LLsup = left lateral image, supine.

dence of sustained prior nontransmural myocardial infarction.

Thus, on the LLsup image five false-positive and two false-negative results were obtained, compared with one false-positive and one-false negative result on the LLrs image.

Receiver operating characteristic curves. Receiver operating characteristic curves plotted from the data of the two series of LL images are shown in Fig. 2. Compared with the LLsup curve, the concave curve that represents data from the LLrs position is shifted upwards and to the left, clearly indicating that the LLrs provides a more accurate diagnostic test. Thus, a true-positive result is more probable at any given point on the curve than a false-positive result. Additionally, there was better agreement between the two observers in their interpretations of the LLrs images than of the LLsup images. The independent scores for the LLsup position show considerably more scatter between the two observers, and the resultant ROC curve is obviously less reliable than that derived from the LLrs position.

Changes in position of the heart. All seven patients studied with fixed external markers demonstrated positional changes in the long axis of the heart. In the supine position, the long axis of the heart points towards the left lateral chest wall. When the patient is turned on his right side, the heart shifts toward a more craniocaudal orientation (Fig. 3). Of these seven patients, three demonstrated inferoposterior defects only in the LLsup position and not in LLrs; inferior-wall defects were not seen on the other standard images in these three patients.

DISCUSSION

This study demonstrates the effect of patient positioning on left lateral Tl-201 images. Apparent false-positive inferoposterior defects were detected in five patients (18%) when the left lateral image was obtained with the patient supine and the detector parallel to the sagittal plane. These defects were not present when the patient was turned on his right side and the detector was oriented parallel to the table top. There was no relation between the type of study (rest, redistribution, or after exercise) and the presence of false-positive results. Three false-negative images were obtained, two with the LLsup and one with the LLrs position. In addition, one false-positive apical defect was obtained in LLrs position. It is conceivable that this represents a normal variant seen in only one position (*12,13*). The LLrs image was of adequate technical quality in 25 patients (89%). When the LLrs views were technically inadequate, the companion LLsup images were equally inadequate.

Myocardial imaging with Tl-201 should be performed in multiple projections to evaluate systematically the entire myocardial distribution. Furthermore, diagnostic reliability is enhanced when a defect corresponding to a given anatomic location is present in more than one projection. The left lateral image is essential for routine Tl-201 imaging,

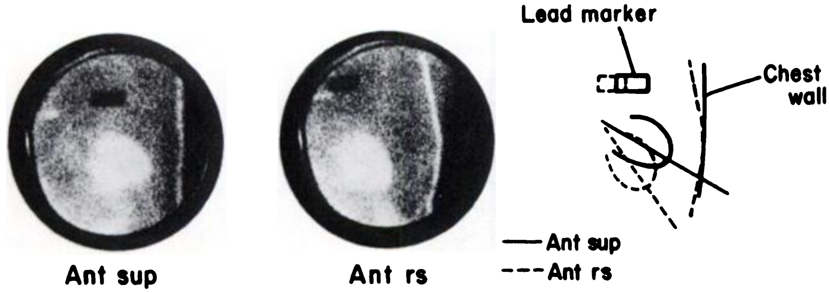

FIG. 3. Anterior thallium-201 images in supine position (Ant sup), and with patient on his right side (Ant rs). When turned from supine to right side, long axis of heart becomes more "vertical" as schematically illustrated. Lead marker and left mid-axillary line served as fixed external reference.

since only in this projection is the inferoposterior left ventricular wall well visualized.

Since many of the observations in this study were based on subjective interpretation of the Tl-201 images, possible biases were eliminated by coding the LL images so that individual images were interpreted independently of the other clinical and radionuclide data including the position in which they were performed. Further support for the value of LL images performed with the right side down, rather than back down, is provided by the ROC curve analysis. This analysis encompasses a wide range of sensitivities (true-positive ratio) and specificities (false-positive ratio) for detection of Tl-201 defects. The ROC curve calculated from the LLsup data approaches a straight line, as would an ROC curve resulting from pure guess work (*14*). The concave LLrs curve allows a higher sensitivity for any given specificity than the LLsup curve. Moreover, there was better agreement between the two independent observers in their interpretations of the LLrs images than the LLsup images.

Possible explanations for the apparent false-positive and false-negative defects in the LL position include a) geometric considerations and b) radiation attenuation by adjacent structures. As demonstrated by the spatial reference images taken in anterior position, the long axis of the heart shifts from horizontal toward "vertical" as the patient moves from the supine position to the right-side-down position. In the LLrs image, the inferoposterior segments are parallel to the detector, providing an en face image of this region. However, in the LLsup image, the inferoposterior wall is more nearly perpendicular to the detector, which may lead to foreshortening of the inferoposterior segments. False-positive defects in the LLsup position could result from distortion of these segments, whereas false-negative defects could result from greater superposition of normal and abnormal regions. The relative importance of this mechanism in providing false-positive LLsup defects is unclear because among the seven patients in whom the axis shift was demonstrated, only three showed inferoposterior defects on the LLsup image not seen on the LLrs image.

An alternative explanation for false-positive defects in the LLsup image is attenuation of myocardial radiation by adjacent structures. The spleen and stomach are unlikely to be responsible for the "defect," since these organs are not immediately adjacent to the heart. Moreover, they accumulate varying amounts of Tl-201. The left hemidiaphragm is the only structure in close proximity to the left ventricle. Chest radiographs show that there is wider separation between heart and left hemidiaphragm in the right lateral decubitus than in the supine position (Fig. 4). In addition, fluoroscopic observations (*17*) indicate that there is greater excursion of the left hemidiaphragm "above" the inferior surface of the heart in the supine position than in the right lateral decubitus position. Application of these radiographic findings to radionuclide imaging with Tl-201 may help explain the apparent false-positive defects encountered in the LLsup images (Fig. 5). It seems conceivable that the motion of the diaphragm "above" the inferoposterior wall of the left ventricle in the LLsup position could cause attenuation of radiation from inferoposterior segments, resulting in false-positive defects.

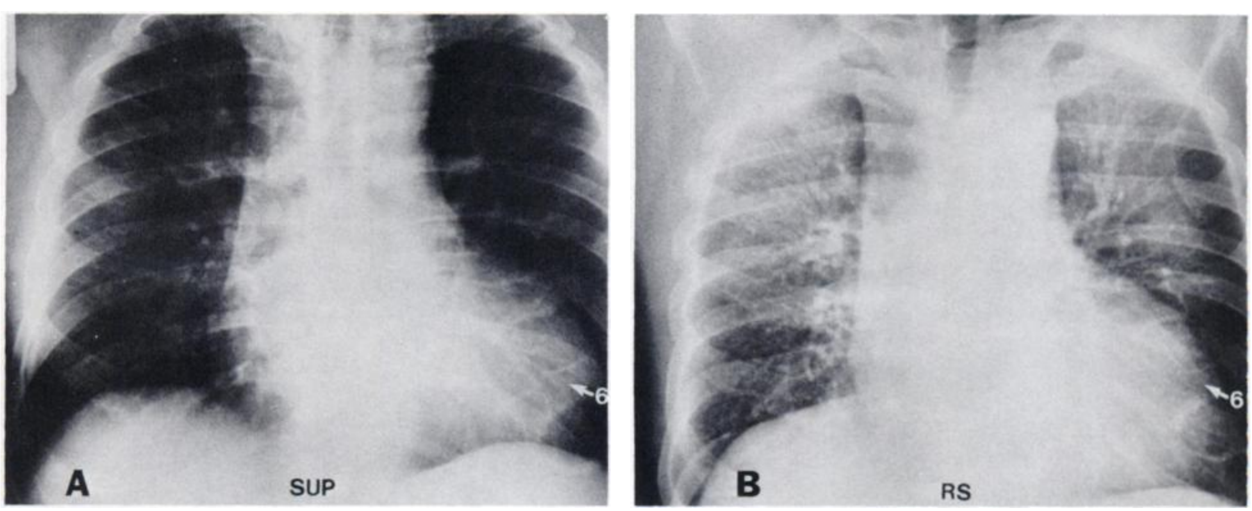

FIG. 4. Supine (A) and right lateral decubitus (B) anteroposterior chest radiographs of same patient. With patient on his right side, left hemidiaphragm is moved caudad, with more separation between diaphragm and heart. Left sixth rib (arrow) is identified for reference. RS = patient on his right side; SUP = patient supine.

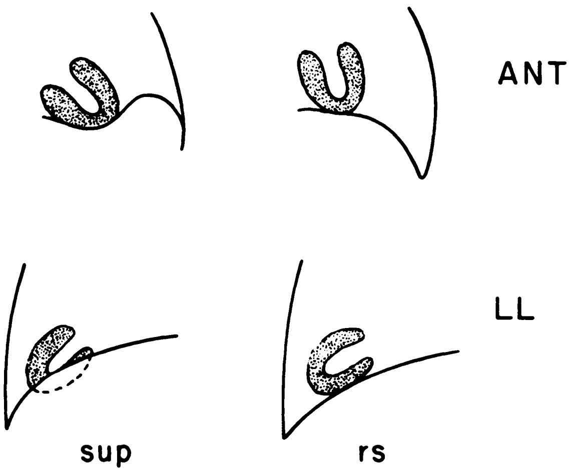

FIG. 5. Schematic illustrations of interrelationship between left hemidiaphragm and heart in supine (sup) position and with patient on his right side (rs). Top panel shows anterior (ANT) view and lower panel left lateral (LL) view. In supine position, excursion of left hemidiaphragm above inferior border of heart may result in attenuation of Tl-201 radiation from inferoposterior myocardial segments.

In summary, LL Tl-201 images should be performed with the patient on his right side and the detector parallel to the sagittal plane. This approach minimizes false-positive defects that cannot be explained by other radionuclide or clinical data, and decreases the number of technically inadequate LL images.

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