Clinical Evaluation of 360° and 180° Data Sampling Techniques for Transaxial SPECT Thallium-201 Myocardial Perfusion Imaging

Raymundo T. Go, William J. MacIntyre, Thomas S. Houser, Mauricio Pantoja, James K. O'Donnell, David H. Feiglin, Bruno J. Sufka, Donald A. Underwood, and Thomas F. Meaney

The Department of Nuclear Medicine, Division of Radiology and Department of Cardiology, Division of Medicine, Cleveland Clinic Foundation, Cleveland, Ohio

The most serious controversy regarding the application of transaxial SPECT technology to ^{201}Tl myocardial perfusion imaging is the choice between 360° compared with 180° data sampling techniques. The present study utilized the original 360° sampled raw data of 25 patients who had both SPECT ^{201}Tl myocardial perfusion imaging and coronary angio/ventriculography for back projection reprocessing to accomplish the 360°/180° comparison. The results show a high incidence, 36% (9/25), of false-positive segmental perfusion abnormality and a high incidence, 24% (6/25), of moderate to severe degree of image distortion with the 180° data sampled reconstructed images. These were not observed in the 360° data sampled reconstructed images. The above findings confirmed our previous preliminary conclusion that even though the 180° data sampling technique has the advantage of providing improved image contrast and reduction in acquisition time it is not a reliable technique and should be abandoned. The 360° data sampling is the technique of choice for transaxial SPECT ^{201}Tl myocardial perfusion imaging.

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Clinical studies comparing transaxial single photon emission computed tomography (SPECT) to planar thallium-201 (^{201}Tl) myocardial perfusion imaging for the detection of coronary artery disease (CAD) have shown better detection ability with the transaxial SPECT system (*1–6*). However, transaxial SPECT is still a developing and controversial technique. At present, the most serious controversy is the choice of data sampling. The question is whether data sampling around a complete 360° transaxial rotation is necessary or data sampling along a limited 180° arc would be sufficient for backprojection image reconstruction. The proponents of the latter data sampling technique had been attracted by the significant improvement in image contrast as shown in comparative 360°/180° phantom and limited clinical case studies (*7–9*), and the obvious reduction in data acquisition time. In the comparative studies mentioned, MacIntyre et al. reported false-positive perfusion abnormality in one case and severe image distortion in another with the 180° data sampling technique and indicated that the reliability of this sampling technique for back projection image reconstruction is suspect (*7*).

The purpose of this study is to assess the reliability of transaxial SPECT ^{201}Tl myocardial perfusion imaging using 360° compared with 180° data sampling techniques for back projection image reconstruction. In this study, the two data sampling techniques are compared in a larger number of clinical cases, and the incidence of false-positive segmental perfusion abnormalities and image distortion are determined.

MATERIALS AND METHODS

Patient selection

Twenty-five patients who had both transaxial

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For reprints contact: Raymundo T. Go, MD, Dept. of Nuclear Medicine, Cleveland Clinic Foundation, 9500 Euclid Ave., Cleveland, OH 44106.

SPECT ^{201}Tl myocardial perfusion imaging and coronary angiography with ventriculography performed within 6 mo of each other were included in this study. Case selection consisted of 15 patients who had normal coronary arteries on angiography and normal wall motion on contrast ventriculography. These normal patients had no other cardiac disease that would produce a false-positive thallium myocardial perfusion scan. The rest of the ten patients had contrast angiographic and ventriculographic evidence of CAD.

Patients were catheterized with either the Sones or Judkins technique. Ventriculography involved reading for wall motion abnormalities only and no ventricular volumes were calculated. Significant coronary disease was defined by a major vessel stenosis of 50% or greater.

Patients with single vessel disease were selected so as to eliminate any uncertainty that an additional perfusion defect could be a true-positive result rather than an induced artifact.

Original data acquisition and processing

The transaxial SPECT ^{201}Tl myocardial perfusion imaging data were originally acquired by a 360° rotation using a SPECT single-head imaging system* immediately after the injection of 2 mCi of thallous-201 chloride at peak exercise using a Bruce protocol. Rotation began posteriorly, scanning the left side first. A total of 64 views were obtained at 5.6 degree intervals requiring 30-sec acquisition time per view to complete the 360° circle (Fig. 1C). The total acquisition time for the stress study was 32 min. The total counts per study ranged from 7 to 10 million counts. Redistribution data were obtained 3–4 hr later with the same parameters but with the time extended to 48 min to approximate the original counts collected.

The collimator used was a low-energy, all-purpose (LEAP) collimator† which had a planar resolution at 20 cm of 1.6 cm and a SPECT resolution of ~1.9 cm. Routine uniformity and radius of rotation checks were performed. Data were acquired using a 64 × 64 matrix. Pixel size was 0.6 cm with a similar thickness.

Image reconstruction was performed using a minicomputer with a 64k memory and hardware floating point.‡ The acquired data were then smoothed using a nine point weighted data averaging technique then reconstructed with a Ramp equivalent convolution backprojection algorithm. The opposing 32 frames were averaged arithmetically. No attenuation correction was utilized. The 360° redistribution data were reconstructed and used for interpretation and patient diagnosis.

Reprocessing of the original data

Raw data along a 180° arc (32 frames) were selected from the original 360° acquired raw data obtained

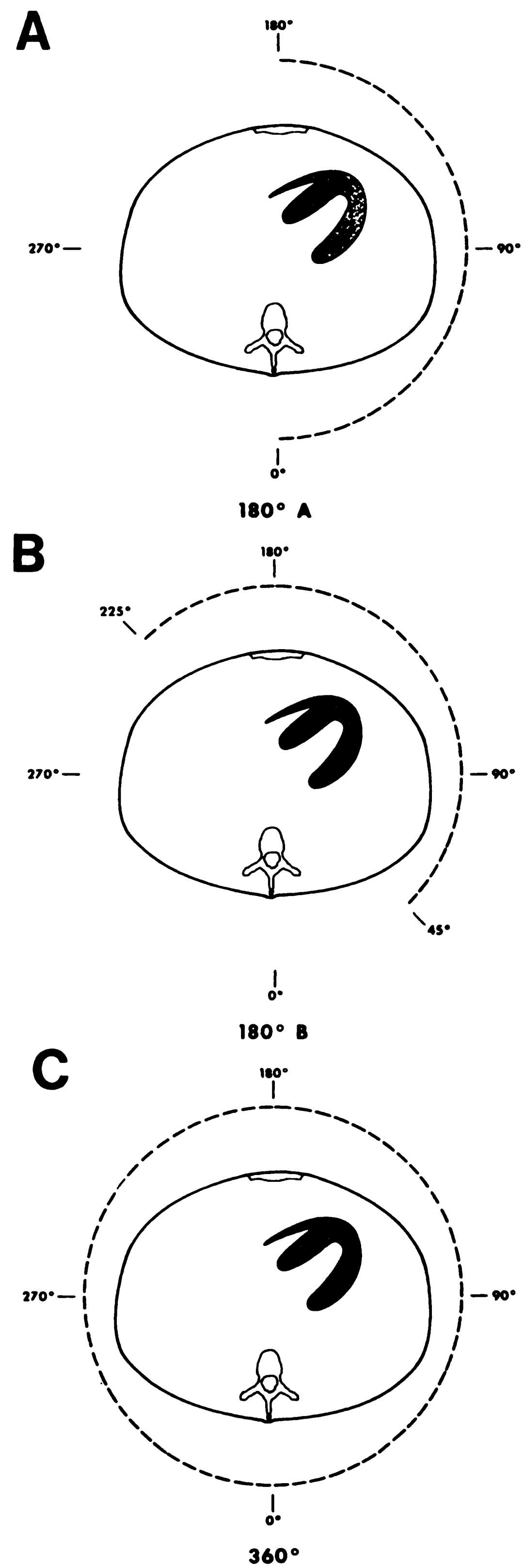

FIGURE 1
A, B, C: Diagrams show three types of data sampling techniques: A: (180°A) Rotates from 0° posterior to 180° anterior. B: (180°B) Rotates from 45° posterior to 225° anterior. C: (360°) Rotates from 0° posterior to 360° posterior

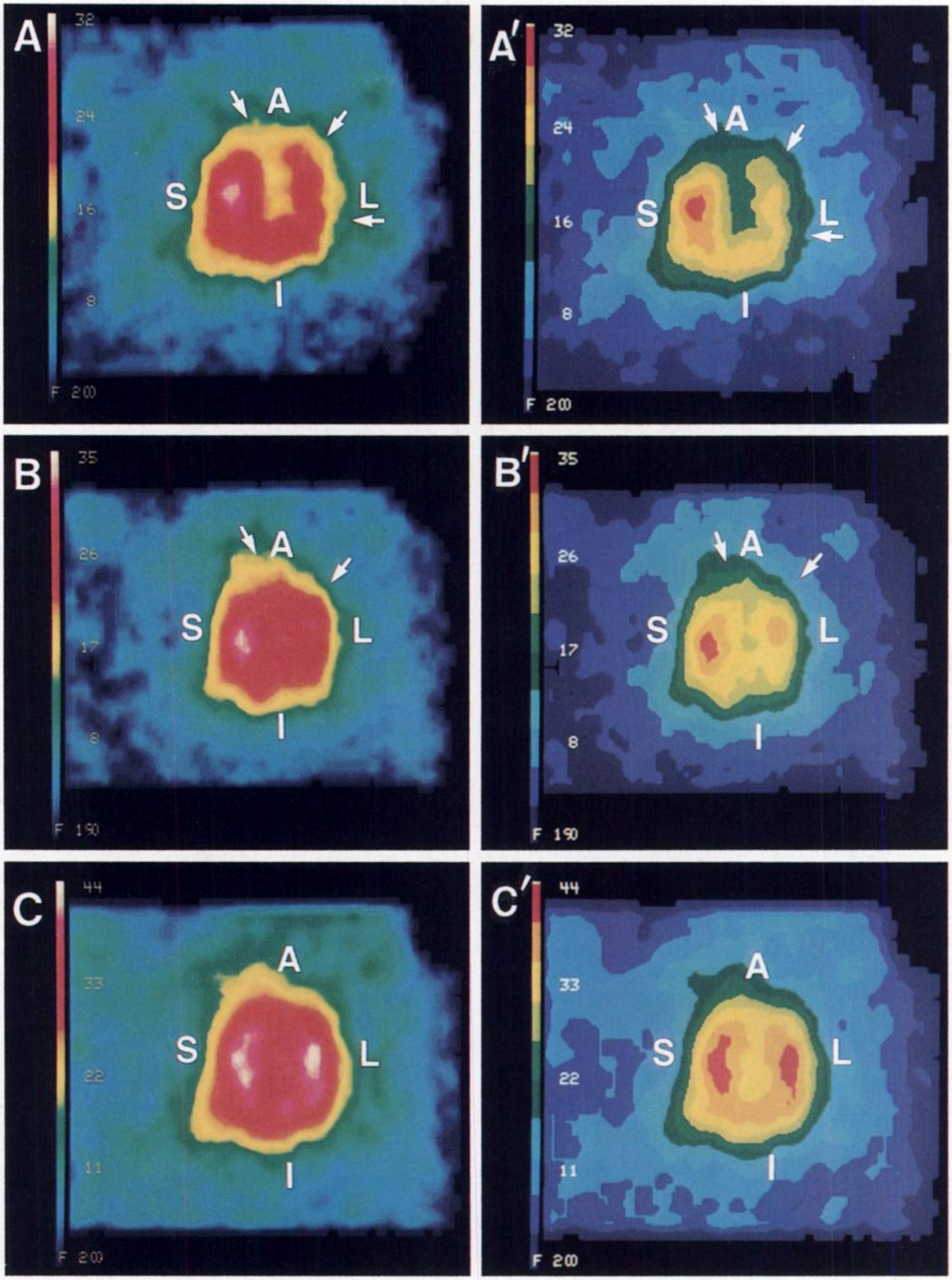

FIGURE 2
A, B, C: Patient without CAD. A: (180°A coronal) shows false-positive distal anterior defect and distal anterolateral and lateral decreased perfusion (arrows). B: (180°B coronal) shows less pronounced false-positive perfusion abnormality (arrows). C: (360° coronal) image is normal. A′, B′, and C′ are corresponding images of A, B, and C in 10% segmented color scale

from each patient and comprised two-thirds of the original total counts. The reduction in count rate has been found not to affect the image quality statistically. Two selections of 32 frames for 180° arc data sampling were made for backprojection image reconstruction: 180°A starts at 0° posteriorly at the spine and rotates around the left side of the body to end 180° anteriorly at the sternum (Fig. 1A); 180°B starts at 45° at the left posterior and also rotates around the left side of the body to 225° at the right anterior (Figure 1B). The identical back projection algorithm was used for reprocessing the 180° arc data for image reconstruction as the 360° sampled data. The opposite 32 segments were placed at zero and averaged arithmetically. No attenuation correction was utilized.

The 180° redistribution data were not reconstructed since the objective of the study was to determine the existence of a false-positive perfusion abnormality immediately post-stress and not to determine if it was a false-positive scan for either ischemia or infarction.

Image display and data analysis

Body axis, which includes transverse, coronal, and sagittal views as well as cardiac short axis tomographic image displays, were available and both were used for interpretation of the cases studied. Images were displayed using both a continuous and segmental color scale that corresponds to the percentage counts in each segment. In the continuous color scale, dark blue represents the lowest counts and pink-white represents the highest counts (Fig. 2A, B, and C). In the segmental color scale, each separate color indicates a 10% change in counts (Fig. 2A′, B′, C′). The normal thallium radioactivity distribution in the myocardial segments is irregular. A decrease in count rate up to 30% at the inferoseptal, inferior, inferolateral segments and a decrease in count rate up to 20% in the rest of the myocardial segments were considered within the normal range. This range was determined by comparison of the segmental color band (semiquantitative reading) to a quantitative profile readout (*10*). This variance is thought to be primarily due to variation in myocardial thickness but also includes variation in attenuation and partial volume effects. A decrease in count rate beyond the above limits in a myocardial segment was considered a perfusion abnormality. The normal patients and patients with CAD were mixed.

The three sets (180° A, 180° B, and 360°) of SPECT ^{201}Tl myocardial perfusion images reconstructed by backprojection from the same raw data obtained from each patient were analyzed and interpreted by three experienced nuclear physicians without the knowledge of the following information: (a) type of data sampling technique of each set of images; (b) previous scan diag-

TABLE 1

Location and Incidence of False-Positive Myocardial Segmental Perfusion Abnormalities in Patients with No Angiographic Evidence of Coronary Artery Disease (n = 15)

	Population characteristics				Data acquisition techniques		
Patient	Age (yr)	Sex	Wt. (kg)	Ht. (cm)	180°A	180°B	360°
1	50	M	85	171	None	None	None
2	48	M	98	189	Distal A*, AL†, L‡	Distal AS and S**	None
3	48	M	76	141	a§ and distal AL	None	None
4	29	M	73	168	None	None	None
5	55	F	79	157	Distal A, AL, and L	Distal A, AL	None
6	59	F	73	167	None	None	None
7	39	M	82	184	None	None	None
8	65	F	84	157	None	None	None
9	52	M	93	168	a, distal A, AL	a, distal A	None
10	54	M	72	167	None	None	None
11	38	M	85	181	Distal AS¶	Distal AS	None
12	40	M	67	170	None	None	None
13	42	M	89	187	Apico-inferior	Apico-inferior	None
14	30	M	62	191	None	None	None
15	32	M	76	182	Distal AS	Distal AS	None

Note: Segments indicated are those that showed false-positive segmental perfusion abnormalities. Word *none* means no false-positive perfusion abnormality was identified.

* A = Anterior.

† AL = Antero-laberal.

‡ L = Lateral.

§ a = Apex.

¶ AS = Antero-septal.

** S = Septum.

nosis; and (c) the coronary angiographic and ventriculographic diagnosis. A consensus diagnosis was obtained when opinion of the interpretation varied. Interpretation of the images was not only confined to the detection of myocardial segmental perfusion abnormalities but was extended to note the presence or absence of image distortion and the quality of image contrast in each set of the images performed on the patient. Image distortion was graded subjectively as mild, moderate, or severe. Image contrast was subjectively evaluated as to whether the myocardial segments or left ventricular chamber are sharply delineated or not.

RESULTS

False-positive perfusion abnormalities

In the group of 15 patients who have normal coronary arteries with normal left ventricular wall motion as shown by angiography and ventriculography, 12 were males and three were females. Their age ranged from 29 to 65 yr old; weight ranged from 62 to 98 kg and their height ranged from 141 to 191 cm (Table 1). Table 1 is the summary of the results of the analysis of these 15 patients which shows a high incidence of false-positive segmental perfusion abnormalities with the 180° data sampling technique with an incidence of 46% (7/15). Note that in these seven cases with false-positive perfusion abnormalities, six were males and only one was a female patient. False-positive cases seen with the 180°A technique were also seen with the 180°B technique except in one case in whom the study was normal as was the 360° technique.

In the group of ten patients who have single vessel CAD, seven were males and three were females. Their age ranged from 44 to 66 yr; weight ranged from 55 to 100 kg and their height ranged from 157 to 174 cm. (Table 2). Table 2 is the summary of the results of the analysis of ten patients who have single vessel CAD, four of whom had ventriculographic evidence of previous myocardial infarction as shown by the presence of segmental severe hypokinesis, akinesis, or dyskinesis. The analysis of this abnormal group shows that two (one male and one female) of ten patients had false-positive segmental perfusion abnormalities in segments supplied by normal coronary arteries with the 180° but not with the 360° data sampling technique.

The overall incidence of false-positive perfusion abnormality with the 180° data sampling technique in the two groups of patients was 36% (9/25); seven of these patients were males and two were females. In none of these patients was false-positive perfusion abnormality seen with the 360° data sampling technique.

In general, the false-positive perfusion abnormality is slightly more pronounced with the 180° A data sampling technique. Case 5, which has no CAD shows a more pronounced false-positive perfusion abnormality with the 180°A than 180°B (Fig. 2A and B). The 360° data sampling reconstructed image in this case is normal (Fig. 2C).

The false-positive perfusion abnormality did not always affect the same segment between the two 180° data sampling techniques. A segment that shows a false-positive perfusion abnormality with the 180°A

TABLE 2
Location and Incidence of False-Positive Perfusion Abnormalities in Myocardial Segments Supplied by Normal Coronary Arteries in Patients with Coronary Artery Disease (n = 10)

Population characteristics					Percent	Data acquisition techniques		
Patient	Age (yr)	Sex	Wt. (kg)	Ht. (cm)	coronary artery stenosis	180°A	180°B	360°
16	46	M	94	173	LAD-100%	None	None	None
17	60	F	55	157	LAD-90%	None	None	None
18	59	M	73	166	LAD-86%	None	None	None
19	55	M	99	172	LAD-80%	None	None	None
20	44	M	100	180	LAD-60%	None	None	None
21	57	M	66	165	RCA-100%	a*, distal A† and AL‡	Distal AL	None
22	66	M	83	168	RCA-100%	None	None	None
23	49	M	85	174	RCA-90%	None	None	None
24	54	F	65	162	LCX-80%	Distal, A and AL	Distal and AL	None
25	62	F	69	160	LCX-80%	None	None	None

Note: Segments indicated are those that showed false-positive perfusion abnormalities. Word "none" means no false-positive perfusion abnormality was identified in segments supplied by normal coronary arteries.
Cases 16, 21, 22, and 24 had ventriculographic evidence of previous myocardial infarction. Case 24 had previous infarction along left circumflex distribution which showed evidence of recanalization.

* a = Apex.

† A = Anterior.

‡ AL = Antero-lateral.

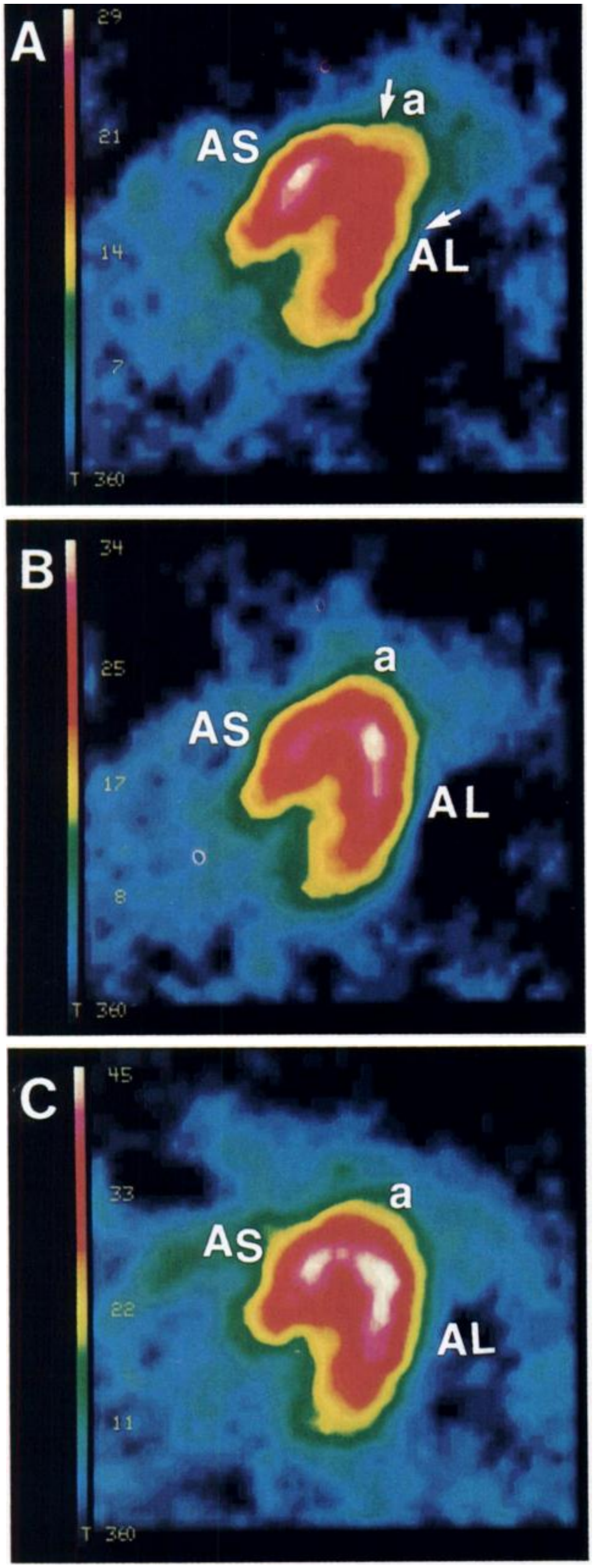

FIGURE 3
A, B, C: Patient without CAD. A: (180°A transverse) shows false-positive apical and distal anterolateral decreased perfusion (arrows). B: (180°B transverse), and C: (360° transverse) show normal reconstructed images

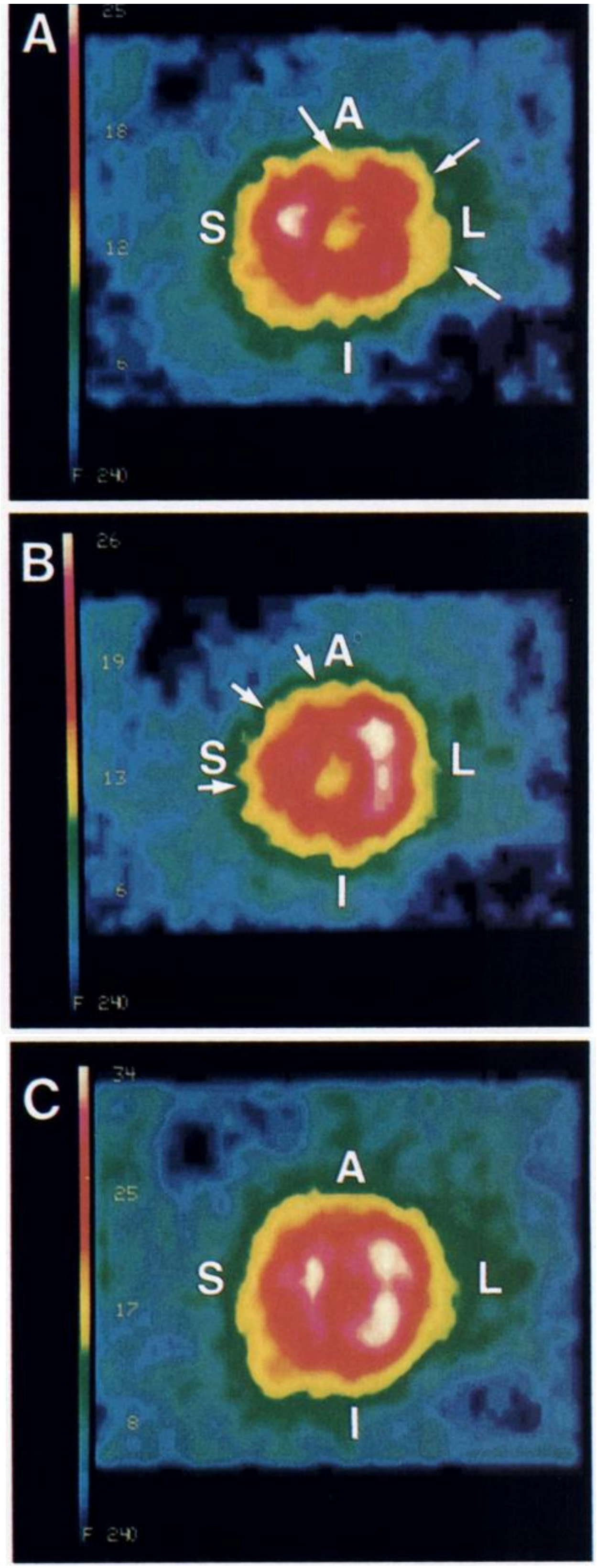

FIGURE 4
A, B, and C: Patient without CAD. A: (180°A coronal) shows false-positive distal anterior and anterolateral decreased perfusion (long arrows) with normal distal anteroseptal and septum; B: (180°B coronal) shows "flipped" image with false-positive decreased perfusion now at distal anteroseptal and septum (short arrows) and distal anterolateral and lateral now appear normal. C: (360° coronal) shows normal reconstructed image

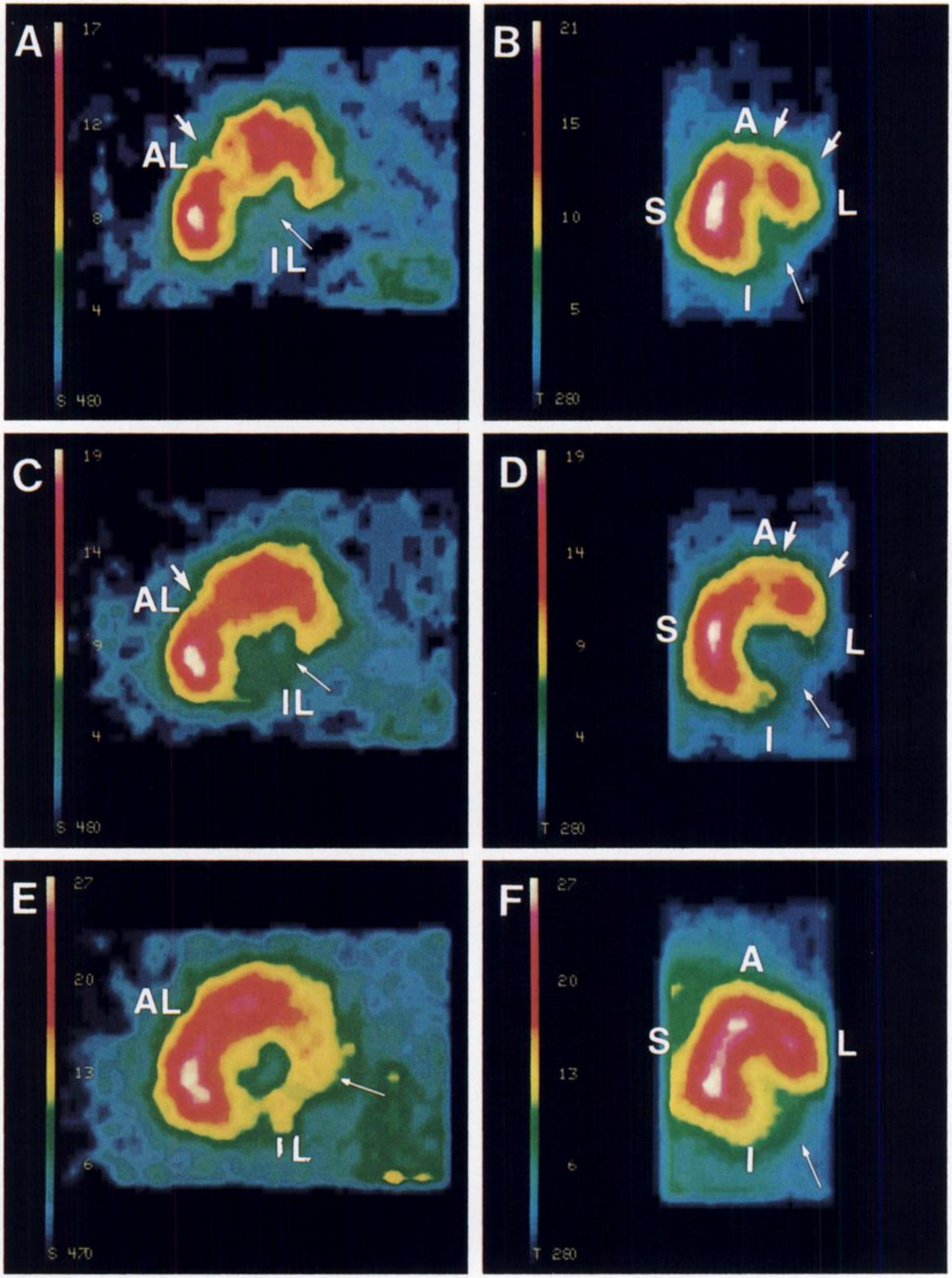

FIGURE 5

A–F: Patient with previous myocardial infarction involving lateral and inferolateral segments and coronary angiographic evidence of recanalization of LCX artery to about 80% stenosis. A, B (180°A sagittal and coronal), and C, D (180°B sagittal and coronal) show false-positive perfusion abnormalities at the distal anterior and distal anterolateral segments (thick arrows) while E, F (360° sagittal and coronal) show only true perfusion defect involving the lateral and inferolateral segments (thin arrows) sampling technique may be normal with the 180°B sampling technique. This is illustrated in Case 3 which shows a false-positive decrease perfusion at the apex and distal anterolateral wall with the 180°A (Fig. 3A), however, these areas appear normal with the 180°B data sampling techniques (Fig. 3B). The 360° data sampling technique in this case is normal (Fig. 3C).

The false-positive perfusion abnormality may be "flipped" between the 180°A and 180°B data sampling techniques. This is illustrated in Case 2. The 180°A reconstructed images show a false-positive decreased perfusion at the distal anterior, anterolateral, and lateral walls with a normal distal anteroseptal and septum (Fig. 4A), however, with the 180°B reconstructed image, the false-positive decreased perfusion has "flipped" to the distal anteroseptal and septum while the distal anterolateral and lateral walls are normal (Fig. 4B). The 360° reconstructed image in this case is normal (Fig. 4C).

Case 24 shows a true myocardial scar at the distal lateral and inferolateral segments. A false-positive perfusion defect and decreased perfusion are present at the distal anterior wall and distal anterolateral segments, respectively, seen in both the 180°A (Fig. 5A and B) and 180°B (Fig. 5C and D) data sampling techniques but not in the 360° (Fig. 5E and F) data sampling technique. This case illustrates that a patient with a true single-vessel CAD can be falsely shown to have two-vessel CAD with 180° data sampling.

Image contrast

Image contrast was again noted to be definitely improved with 180° data sampling in all cases compared to the 360° data technique. However, despite the slight degradation of the image contrast quality in the 360° data sampled reconstructed images, all the true perfusion defects in these ten patients with myocardial ischemia or infarction were displayed and detected without difficulty even if the perfusion defect is small. The superior image contrast with the 180° data sampled reconstructed image is illustrated in Fig. 6. Note the sharper delineation of the left ventricular segments and the left ventricular cavity (Fig. 6A). However, the small true distal inferior perfusion defect is displayed at about the same image contrast quality in the 360° (Figure 6B) as in the 180° data sampled reconstructed image (Fig. 6A).

Image distortion

Analysis of the 25 cases shows varying degrees of image distortion with 180° but not in the 360° data sampling technique. The 180°A showed a more pronounced distortion than 180°B sampling technique. Nineteen of the 25 cases showed varying degrees of mild to moderate image distortion consisting of elongation of the left ventricle with a few showing elongation of the apex with decreased perfusion (Fig. 7A). Six of the 25 cases (24%) showed moderate to severe image distortion. Severe image distortion consisted of moderate to severe elongation of the left ventricle with bizarre rod-like extension of the apex (Fig. 8A and B). Notice the absence of image distortion in the 360° data sampled reconstructed images (Figs. 7B, 8C and D).

DISCUSSION

Previous studies by different investigators have all shown improved image contrast as an advantage of 180° data sampling (*7–9*) beside the obvious advantage of significant reduction in acquisition time. The improved image contrast is related to the exclusion of the frames from the right side of the body that contains much less myocardial radioactivity, therefore, reducing scatter and improving the signal to noise ratio. The reduction in acquisition time is provided by the asymmetric location of the heart within the left side of the thorax. Based on these two advantages, Tamaki et al. recommended 180° data sampling as the choice for transaxial SPECT ^{201}Tl myocardial perfusion imaging (*8*). Preliminary studies in our laboratory, however, indicated that the reliability of the 180° data sampling technique is suspect because these studies showed artifactual perfusion abnormality in one patient and severe image distortion in another (*7*).

False-positive perfusion abnormalities

Results of the present analysis of these larger numbers of clinical cases confirmed the serious problems of 180° data sampling technique. The most serious problem of the 180° data sampling technique is the random creation of a high incidence (36%) of false-positive segmental perfusion abnormalities in segments supplied by normal coronary arteries. These false-positive perfusion abnormalities were most frequently located along the distribution of the left anterior descending coronary artery; the artery that shows the highest incidence of CAD. In contrast, false-positive segmental perfusion abnormality was never seen in the 360° data sampled reconstructed images. Normally there is a 20 to 30% decreased count rate at the inferoseptal, inferior, and inferolateral segment in the 360° reconstructed images which is due to internal photon attenuation and scatter. This is a constant finding and can now be easily recognized as a normal variant. This photon attenuation is accentuated in the 180° sampled reconstructed images and is more difficult to differentiate from scar.

The frequent random occurrence of false-positive perfusion abnormalities with 180° data sampled reconstructed images makes proper interpretation of myocardial perfusion images impossible. The presence of false-positive perfusion abnormalities will affect the true specificity of the test. The appropriate management of patients with CAD will also be affected because this test is performed not only to detect CAD and to identify the number of vessel involvement but also to resolve cases with borderline coronary artery stenosis. In the latter cases, knowing the true myocardial perfusion status of the segment supplied by the coronary artery in question is essential for therapeutic intervention.

The artifactual creation of false-positive segmental perfusion abnormalities and image distortion in the 180° data sampled reconstructed images are primarily related to the limited angle data sampling around the 180° arc because the heart is asymmetrically positioned and variably angled within the left side of the thorax.

The production of artifactual defects in normal myocardium has been well documented with experimental and clinical studies by Williams et al. (*11*) and Tamaki et al. (*1*), respectively, using limited angle data sampling with seven pinhole tomography. Tamaki's case illustration showed that data sampling with limited

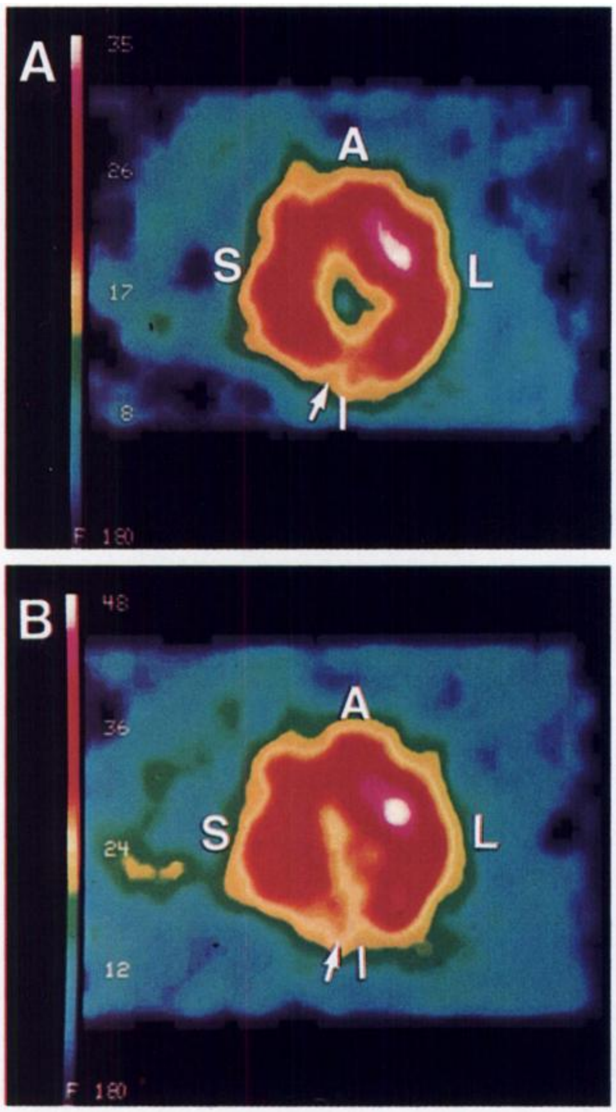

FIGURE 6
A, B: Patient with single vessel CAD. A (180° coronal) image shows better contrast and provides sharper delineation of left ventricular segments and left ventricular cavity. However, small distal inferior wall true perfusion defect (arrow) is displayed at about same image contrast quality in 360° (Fig. 6B) as in 180° data sampled reconstruction image (Fig. 6A)

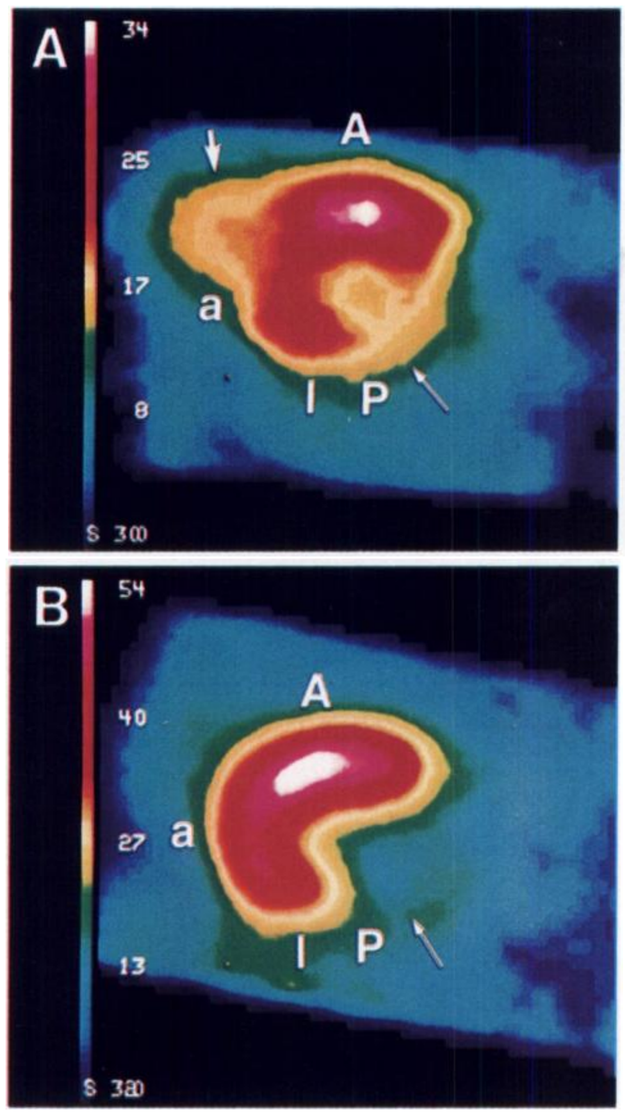

FIGURE 7
A, B: Patient with previous myocardial infarction involving inferoposterior wall (I, P). A: (180° sagittal) shows moderate distortion with elongation of apex with decreased perfusion of the apex (thick arrow). B: (360° sagittal) does not show any image distortion at apex

angles produced the well-known artifactual defect along the antero-septal and septal region in a patient without CAD. This defect was not present when the study was repeated with transaxial SPECT imaging using the 360° data sampling technique (*1*). The limited angular sampling of seven pinhole tomography is much more severe than the 180° arc technique. The similarity in location of the false-positive defect between the two techniques seen in some patients suggests similarity in mechanism. This effect has been eliminated by the 360° data sampling technique.

As discussed in the preliminary study of MacIntyre et al., the selection of 32 frames from the original 64 frames to represent 180° data sampling is not entirely similar because the total count density in the myocardium is approximately two-thirds of the original 360° raw data. This reduction in count, however, cannot explain the creation of the false-positive perfusion abnormalities seen randomly in normal patients (*7*).

Image distortion

Study of normal cardiac anatomy comparing transaxial SPECT ^{201}Tl myocardial perfusion images derived from 360° data sampling technique, gated cardiac NMR images, and cadaver heart sections have shown excellent anatomic correlation without evidence of distortion of the shape of the left ventricle or distortion of specific myocardial segments on the part of ^{201}Tl SPECT imaging (*12*).

The relatively high incidence (24%) of moderate to

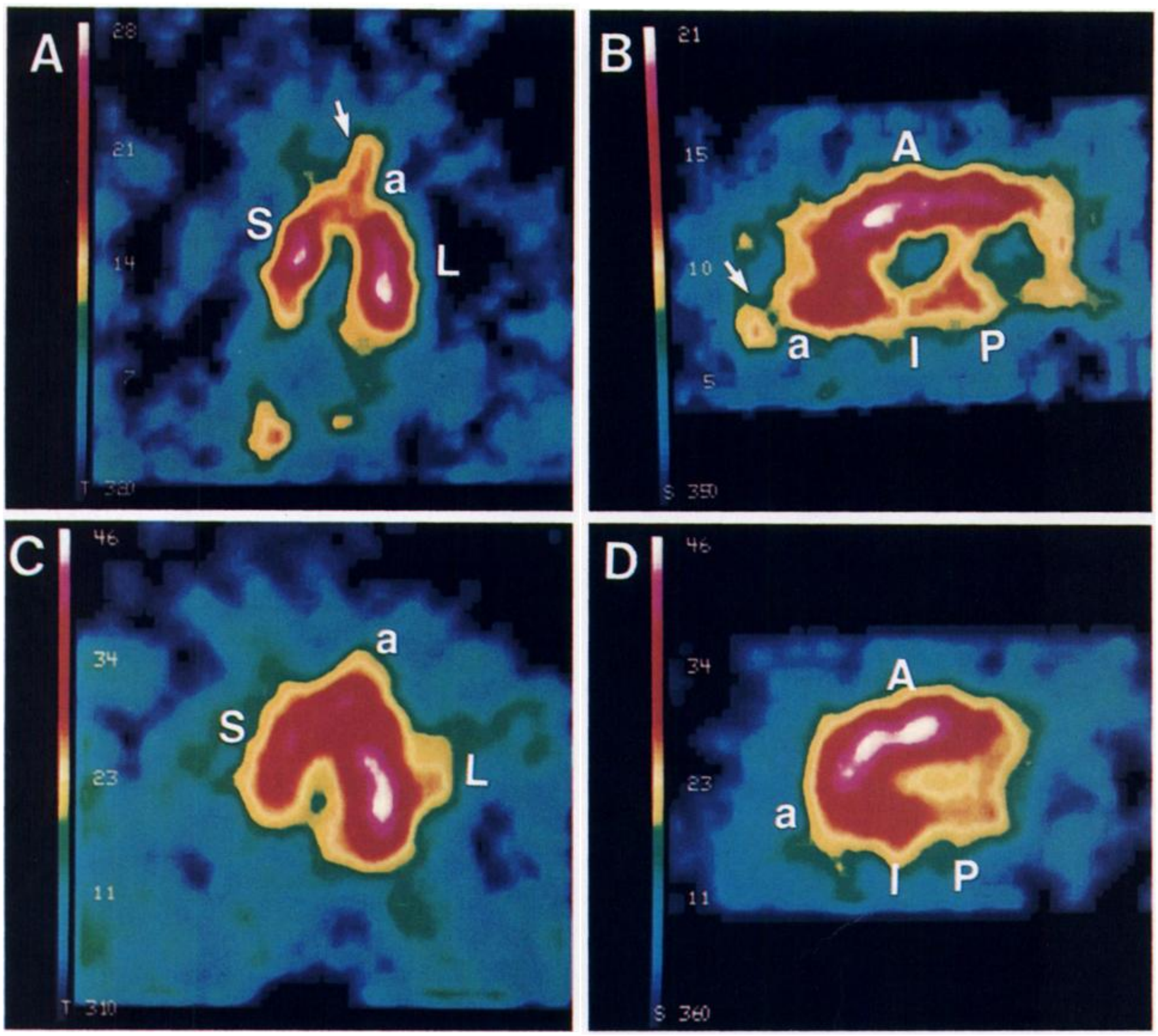

FIGURE 8
A–D: Patient with previous myocardial infarction involving inferoposterior wall (thin arrows). A, B: (180° transverse and sagittal) images show severe image distortion with elongation of left ventricle and bizarre rod-like protrusion of apex (thick arrows). C, D: (360° transverse and sagittal) images of same patient with no image distortion

severe image distortion with the 180° data sampling reconstructed image is another serious disadvantage. Image distortion will have a deleterious effect on image interpretation because localization and assessment of the extent of perfusion abnormalities will become more difficult. Alignment of the slices of the stress and redistribution images will also become less precise especially if there is a significant change in left ventricular size with elongation between the images of the stress and redistribution phases. This would render differentiation between myocardial infarction and ischemia difficult.

Budinger's theoretical studies have shown that the more limited the angular range of data sampling, the more image distortion occurs in SPECT imaging (*13*). In case of exact organ symmetry, the distortion due to limited angular sampling are minimized, however, as departure from symmetry increases, the fidelity of the reconstructed images decrease with more limited angular sampling.

Other considerations

The superior image contrast of the 180° data sampled reconstructed images was again confirmed by our study; however, the image contrast degradation of the 360° data sampling reconstructed images was not significant to mask even a small perfusion defect. The mild degradation of image contrast did not preclude proper interpretation of images nor did it decrease the accuracy of detecting CAD in this group of patients even if the perfusion defect is small.

The most attractive advantage of the 180° data sampling technique is a significant reduction of acquisition time, however, the same advantage can now be accomplished with the introduction of the dual head tomographic camera system which is now commercially available. The dual-head technique would allow a reduction of acquisition time by a factor of two but also introduces the problems of alignment and equalization.

Other less apparent but equally serious disadvantages of the 180° data sampling technique are the difficulty of applying the attenuation correction program (*9*) and the nonvalidity of quantitative analysis (*14*).

CONCLUSION

The significant improvement in image contrast and the reduction of acquisition time are advantages that make 180° data sampling very attractive to advocates of this acquisition technique; however, the present clinical evaluation comparing 360° with 180° data sampling techniques for transaxial SPECT ^{201}Tl myocardial perfusion imaging confirmed our initial reservation that the 180° data sampling technique is not reliable. The present study, in a larger series of clinical cases, showed a high incidence of false-positive segmental perfusion abnormalities in the normal left ventricular myocardium and a high incidence of moderate to severe image distortion with the 180° data sampling technique that will affect proper identification of the number of vessel involvement and the true specificity of the test. These artifacts were not seen in the 360° data sampled reconstructed images.

Our study showed unequivocal evidence that using the 180° data sampling technique for back projection image reconstruction of transaxial SPECT ^{201}Tl myocardial imaging is not reliable and "such ill considered shortcuts" (*14*) should be discouraged and abandoned in clinical practice. The 360° data sampling is the acquisition technique of choice for back projection image reconstruction of transaxial SPECT ^{201}Tl myocardial perfusion imaging.

FOOTNOTES

* Siemens Rota Camera, Siemens Medical Systems Inc., Iselin, NJ.

† Siemens Medical Systems Inc., Iselin, NJ.

‡ Sopha Development, Inc., Atlanta, GA (formerly Informatek States, Norcross, GA), Simis IV.

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REFERENCES

1. Tamaki N, Mukai T, Ishii Y, et al: Clinical evaluation of thallium-201 emission myocardial tomography using a rotating gamma camera: Comparison with seven pinhole tomography. *J Nucl Med* 22:849–855, 1981
2. Maublant J, Cassagnes J, Le Jeune J: A comparison between conventional scintigraphy and emission tomography with thallium-201 in the detection of myocardial infarctions. *J Nucl Med* 23:204–208, 1982
3. Ritchie JL, Williams KL, Harp G, et al: Transaxial tomography with thallium-201 for detecting remote myocardial infarction. Comparison with planar imaging. *Am J Cardiol* 50:1236, 1982
4. Kirsch CM, Doliwa R, Buell U, et al: Detection of severe coronary heart disease with thallium-201: Comparison of resting single photon emission tomography with invasive arteriography. *J Nucl Med* 24:761–767, 1982
5. MacIntyre WJ, Go RT, Cook SA, et al: Comparison of stress and redistribution 201-thallium planar imaging with a single photon transaxial tomographic technique. *Nuclear Medicine and Biology,* Vol II. Paris, France, Pergamon Press, 1982, pp 1281–1284
6. Tamaki N, Yonekura Y, Mukai T, et al: Values and limitations of segmental analysis of stress and redistribution Tl-201 ECT for location of coronary artery

disease. *Eur J Nucl Med* 9:99, 1984
7. MacIntyre WJ, Go RT, Houser TS, et al: Evaluation of 180° and 360° reconstruction of the heart by transaxial tomography with thallium-201. In *Digital Imaging: Clinical Advances in Nuclear Medicine,* New York, Society of Nuclear Medicine, 1982, pp 197–203
8. Tamaki N, Mukai T, Ishii Y, et al: Comparative study of thallium emission myocardial tomography with 180° and 360° data collection. *J Nucl Med* 23:661–666, 1982
9. Coleman RE, Jaszczak RJ, Cobb FR: Comparison of 180° and 360° data collection in thallium-201 imaging using single-photon emission computerized tomography (SPECT). *J Nucl Med* 23:655–660, 1982
10. Pantoja M, Go RT, O'Donnell JK, et al: Thallium-201 emission tomography using the short axis display in coronary artery disease detection: A quantitative assessment. *Radiology* 153:58, 1984 (abstr)
11. Williams CD, Ritchie JL, Harp GD, et al: In vivo simulation of thallium myocardial scintigraphy by seven pinhole emission tomography. *J Nucl Med* 21:821–828, 1980
12. Go RT, MacIntyre WJ, Yeung HN, et al: Volume and planar gated cardiac magnetic resonance imaging: A correlative study of normal anatomy with thallium-201 SPECT and cadaver sections. *Radiology* 150:125–129, 1984
13. Budinger TF: Physical attributes of single photon tomography. *J Nucl Med* 21:579–592, 1980
14. Hoffman EJ: 180° compared with 360° sampling in SPECT. *J Nucl Med* 23:745–746, 1982