The Impact of Operator Decision on Quantitative Circumferential Profile Analysis of Myocardial Thallium-201 Scintigraphy: A Systematic Evaluation

Herrick J. Siegel, David C.P. Chen, Lynn Jacobs, and Geante Melchiore

University of California, San Diego, California; LAC-USC Medical Center, Los Angeles, California; University of Southern California, Los Angeles, California; and University of Di Ferrarra, Ferrara, Italy

Quantitative circumferential analysis of thallium-201 (^{201}Tl) myocardial stress/redistribution studies requires the operator to select the apex of the heart on the stress and delayed images. The impact of possible selection inconsistency on the contents of automatically generated reports from such a quantitative circumferential analysis program were systematically evaluated. The selection of the apex by 5, 10, and 15 degrees in both a clockwise and counterclockwise direction on anterior, LAO, and steep LAO projections of 23 patient studies were intentionally altered. Original automatically generated reports and reports using the distorted data were compared, and the incidence of change in the written reports were noted. Up to 30% of the reports were altered with as little as 10° of inconsistency in apical placement, and altered reports were seen with as little as 5° of intentional misplacement. In addition to accuracy in placement of the apical reference point, consistency in selection is essential, and review of stress/delayed distribution profile curve misalignment is necessary prior to the generation of automated reports.

Exercise thallium-201 (^{201}Tl) myocardial scintigraphy has proven to be a valuable noninvasive diagnostic tool for the detection of coronary artery disease (*1,2*). Although visual interpretation of the scintigraphic images alone has been shown to be effective, it is inherently subjective and, thus, less than ideal in terms of interobserver reproducibility (*3*). Because of this, numerous approaches have been developed to quantitate both the distribution of thallium within the myocardium as well as its redistribution kinetics or "washout" (*4–7*). Many of these programs involve a quantitative circumferential profile, which results in an analysis of the graphic distribution of the thallium within the myocardium after stress and redistribution. All such computer analysis programs require operator intervention to select both the center and the apex of the left ventricle. The stress and redistribution curves of these graphs are then compared to a normal patient data base, as well as to each other, to objectively identify areas of abnormal myocardial perfusion and/or abnormal redistribution (washout). A widely used program performs these analyses and generates both the graphic display and a verbal description of the abnormalities detected. We have noticed that inconsistency in the repeated selection of the position of the apex, because of various reasons including minor variations in patient or heart orientation between the stress and delayed images, will at times generate apparently erroneous automated reports regarding stress perfusion defects or abnormal washout. The purpose of this investigation is to quantitatively evaluate the impact of inconsistency in selecting the apical region on rest and redistribution images on the reports generated automatically by this type of computer analysis program.

MATERIALS AND METHODS

Twenty-three patients, 10 males and 13 females, who were undergoing stress and delayed exercise planar myocardial scintigraphy were studied. They ranged in age from 34 to 78 with a mean age of 55. Immediately and 4 hr postinjection of 2.5 mCi of ^{201}Tl, best separation left anterior oblique (LAO), steep LAO, and anterior projections were obtained for a fixed time according to the program's acquisition parameters. The center of the left ventricle and the apical point were selected by visual inspection of an experienced nuclear medicine physician, and their locations in terms of *x,y* coordinates were recorded. The program then defined the distribution of activity withinthe scintigraphic image and automatically generated a report of localized perfusion and washout abnormalities (Fig. 1).

The selection of the apex was then intentionally changed by increments of 5, 10 and 15° clockwise and counterclockwise, and new reports were generated and compared to the originals. Thus, seven apical positions were reviewed on each of the six views of 23 patients, resulting in the recording of 966 data points. An analysis was made of changes in the automated reports generated from the intentionally altered to the original unaltered data in terms of the impact of the magnitude, as well as the direction, of the alteration. A change was defined as a revision in the automated verbal description and the graphic representation of the location and presence of perfusion or washout abnormalities (Fig. 2).

RESULTS

With a clockwise rotation of 15° on the anterior view, eight of 23 (34%) of the automated reports were altered. Five of 23

For reprints contact: David C.P. Chen, MD, LAC-USC Medical Center, 1200 N. State St., Rm. 5250, Los Angeles, CA 90033.

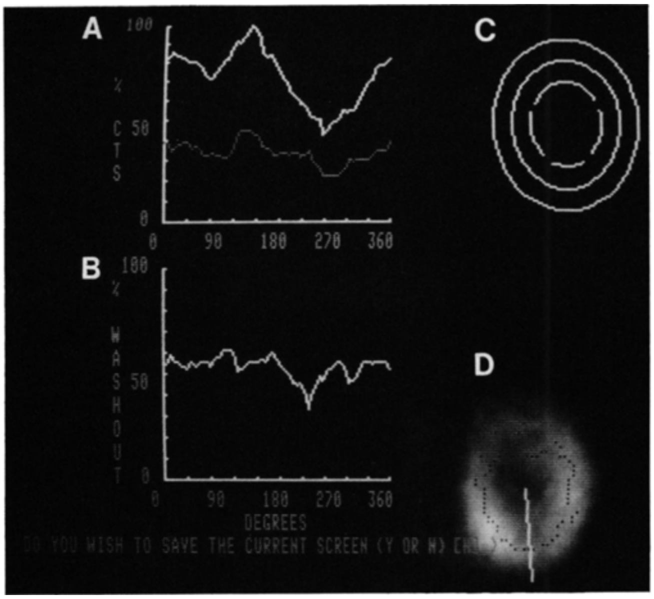

Fig. 1. (A) The upper curve represents the perfusion distribution of the left ventricle during exercise. The lower curve represents the perfusion distribution at rest. (B) Curve represents the difference between the previous two curves and the amount and distribution of washout. (C) Graphic representation of stress distribution (center circle) and washout distribution (outer circle) of the left ventricle compared to a normal population. The unbroken circles in this case signify that no abnormalities are present. (D) Perfusion image from which data was derived with white vertical line passing through the apex.

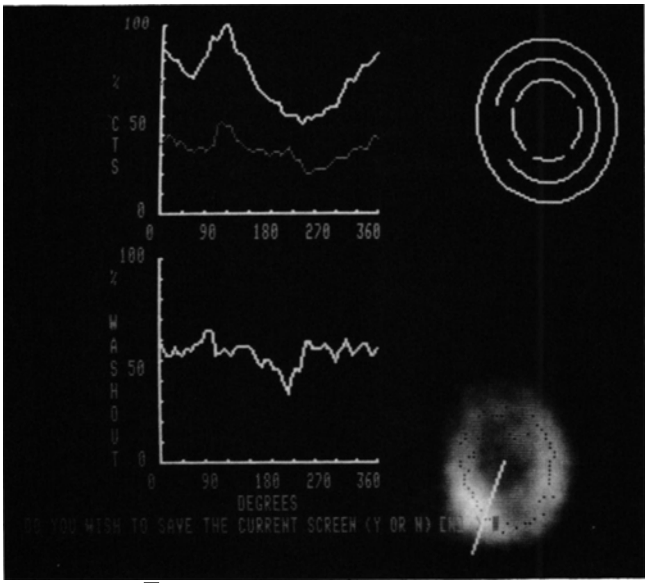

Fig. 2. Same patient data as in Figure 1, with apex intentionally displaced 15° clockwise. New apparent perfusion abnormality in septum is noted by break in middle ring (arrow).

(22%) automated reports were altered with a 10-degree clockwise rotation of the apex on the anterior view; four of 23 (15%) reports were altered with as little as a 5-degree clockwise rotation. In addition, on the anterior view, 2 of 23 (9%) reports were altered with a 5- or 15-degree counterclockwise rotation of the selection the apex, and 3 of 23 (13%) reports were altered with a 10-degree counterclockwise rotation (Fig. 3).

On the steep LAO view, an intentional clockwise rotation of 5, 10 or 15° clockwise rotation resulted in an alteration of ~10% of the reports (2 of 23, 3 of 23, and 3 of 23, respectively). A counterclockwise rotation of 15° altered ~35% of the reports (8 of 23), while a 10- or 5-degree counterclockwise rotation changed ~30% of the reports (7 of 23) (Fig. 4).

On the best separation (45° LAO), ~10% of the reports were erroneously altered (2 of 23) when either a 5-degree clockwise or counterclockwise rotation was applied. Approximately 20% (4 of 23) of the reports were altered when either a 10- or 15-degree clockwise or counterclockwise rotation of the apex was utilized (Fig. 5). Overall, 414 reports were generated using, 5-, 10-, 15-degree clockwise or counterclockwise rotations of the region's selected apical point. Seventy-three of the 414 reports were altered when compared to the original reports.

DISCUSSION

The application of a quantitative circumferential profile analysis program to stress and rest thallium myocardial scintigraphic data has been demonstrated to be a valuable method to minimize diagnostic subjectivity and enhance accuracy. However, present software programs require subjective operator involvement, which is a potential source of error. In the program utilized for this study, the stress distribution curve is compared to that of a normal population. Thus, it is obvious that accuracy in selecting the apex as the reference point in a manner identical to that used for a normal population is essential to avoid misalignment of the curves and the production of erroneous perfusion results. In addition, the analysis programs determine the redistribution or amount of washout within any region of the myocardium by subtracting the relative distribution of thallium as defined by the delayed circumferential profile curve from the stress curve. Therefore,

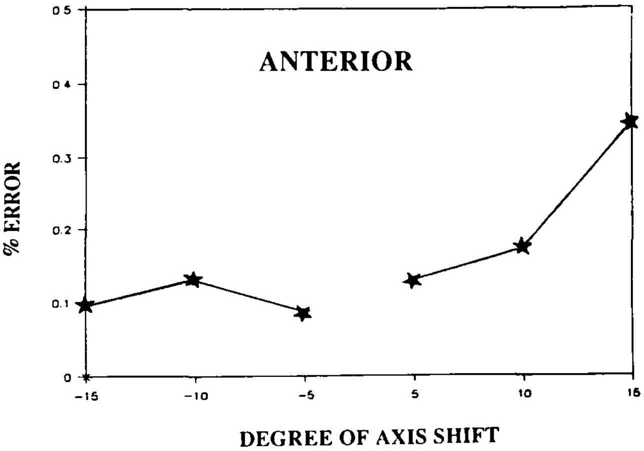

Fig. 3. Percentage of erroneously altered reports versus the degree of apical shift in the clockwise and counterclockwise (negative numbers) directions for the anterior view.

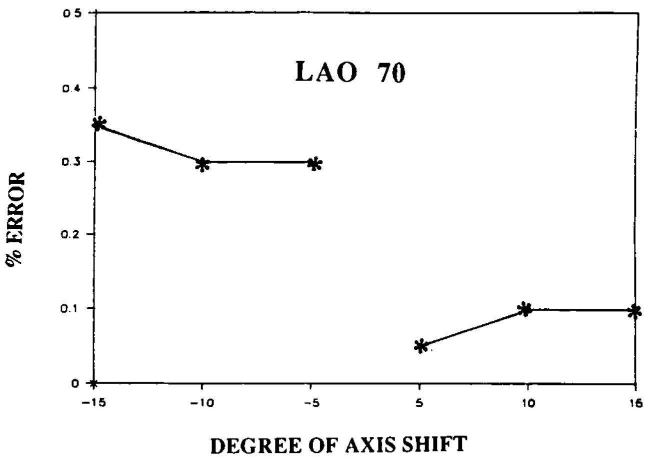

Fig. 4. Percentage of erroneously altered reports versus the degree of apical shift in the clockwise and counterclockwise (negative numbers) directions for the steep LAO view.

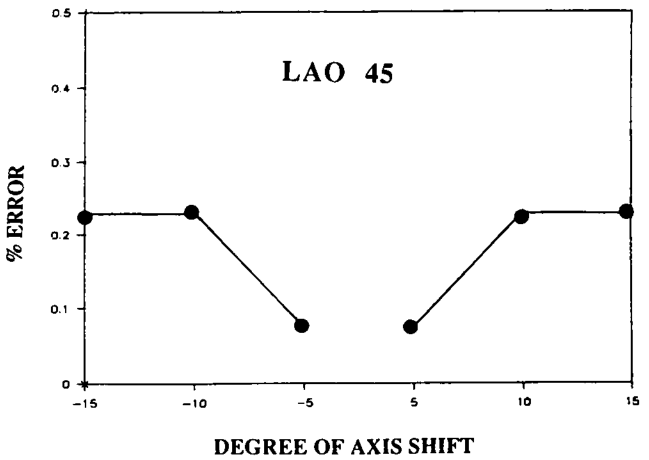

Fig. 5. Percentage of erroneously altered reports versus the degree of apical shift in the clockwise and counterclockwise (negative numbers) directions for the 45° LAO view.

consistency, in addition to accuracy, in the assignment of the apical point used as the curve's reference point is, as we have demonstrated, extremely important. We have noted that a 10-degree misalignment can result in an error rate as high as 30%, and even inconsistency in choosing the apex by as little as 5° can result in a change in the final automated circumferential analysis report. The highest incidence of altered reports occurred with clockwise misplacement on the anterior view and counterclockwise misplacement on the steep LAO view.

The generation of altered reports associated with inconsistency in apical selection may be related in part to a left or right shift of the individual perfusion profile curves. In that instance, the first point of the perfusion curves always bares a defined relationship to the apex. An apical misalignment between stress and delayed images produces not only a curve shift but also an erroneous difference curve (washout curve) and perhaps an incorrect report. In addition, these analysis programs frequently search along defined radii at fixed sampling intervals (i.e., 6°) to determine the data from which the profile curves are generated. A misalignment not only causes the above described curve shift, but if the angle of apical misplacement is not a multiple of the fixed sampling interval the radii are, in fact, not passing through identical portions of the image. Finally, since the individual stress perfusion curve is compared to a normal population curve, significant apical misplacement can result in an inappropriate comparison with possible creation or masking of perfusion abnormalities.

CONCLUSION

In view of these findings, it is recommended that in applying a circumferential profile analysis program to stress and delayed thallium myocardial scintigraphic data, not only should accuracy of the selection of the apical point be assessed, but a review of the consistency of selection and possible stress/delayed curve misalignment be performed prior to the generation of automated reports.

REFERENCES

1. Bailey IK, Griffith LSC, Rouleau J, et al. Thallium-201 myocardial perfusion imaging at rest and during exercise. Comparative sensitivity to electrocardiography in coronary artery disease. *Circulation* 1977;55:79–87.

2. Ritchie JL, Trobaugh GB, Hamilton GW, et al. Myocardial imaging with thallium-201 at rest and during exercise: Comparison with coronary arteriography and resting and stress electrocardiography. *Circulation* 1977;56:66–71.

3. Rigo P, Bailey IK, Griffith LSC, et al. Value and limitations of segmental analysis of stress thallium myocardial imaging for localization of coronary artery disease. *Circulation* 1980;61:973–981.

4. Burrow RD, Pond M, Schafer AW, et al. "Circumferential profiles:" A new method for computer analysis of Thallium-201 myocardial perfusion images. *J Nucl Med* 1979;20:771–777.

5. Garcia E, Maddahi J, Berman D, Waxman A, et al. Space/time quantitation of thallium-201 myocardial scintigraphy. *J Nucl Med* 1981;22:309–317.

6. Watson DD, Campbell NP, Read EK, et al. Spatial and temporal quantitation of planar thallium myocardial images. *J Nucl Med* 1981;25:577–584.

7. Lim YL, Chesler DA, Boucher CA, et al. A new computer analysis to quantitate and display regional thallium-201 uptake following coronary angioplasty (Abstract). *Clin Res* 1982;30:201A.