Minimizing Liver, Bowel, and Gastric Activity in Myocardial Perfusion SPECT

Alice J. van Dongen and Peter P. van Rijk

Department of Nuclear Medicine, University Medical Center Utrecht, Utrecht, The Netherlands

When using ^{99m}Tc-tetrofosmin for myocardial perfusion SPECT, increased liver, intestinal, or gastric activity may create a major problem in the visual and quantitative interpretation of the inferoposteroseptal walls, particularly at rest. The aim of this study was to determine what measures were required to minimize this extracardial activity. **Methods:** Ninety-seven patients had a SPECT scan at rest without attenuation correction. They were divided into 3 groups. Preparation consisted of no action taken (group 1), 150 mL whole milk 10 min after administration of tetrofosmin (group 2), or 450 mL water 10 min before acquisition (group 3). A further 55 patients had a SPECT scan at rest with attenuation correction. They were also divided into 3 groups, and preparation consisted of 150 mL whole milk 10 min after administration of tetrofosmin (group 4), 450 mL water 10 min before acquisition (group 5), or both whole milk and water (group 6). The presence of activity in liver, bowel, and stomach was determined visually on reconstructed images. Activity was defined as interfering when it might result in either an underestimation or an overestimation of the uptake in the myocardial wall. **Results:** Interfering activity was seen in 83% of the patients in group 1, in 74% in group 2, in 33% in group 3, in 61% in group 4, in 67% in group 5, and in 20% of group 6. **Conclusion:** The interpretation of inferoposteroseptal wall activity on myocardial rest SPECT images is facilitated by having the patient drink both whole milk and water at specified times before data acquisition.

Key Words: myocardial perfusion SPECT; tetrofosmin; liver, bowel, and gastric activity

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Compared with thallium, technetium-labeled tetrofosmin (Myoview; Amersham Cygne, Eindhoven, The Netherlands) for myocardium perfusion SPECT has many advantages. These include a higher photo peak energy that enhances image resolution and a shorter physical half-life resulting in a lower absorbed dose from the investigation (*1,2*). ^{99m}Tc-tetrofosmin also has 1 major drawback. Like other technetium-labeled myocardial perfusion agents, it is cleared by the liver and excreted by the biliary system. Abdominal activity after rest injection may be elevated because there is no exercise effect to reduce splanchnic activity. An adequate clearance is prerequisite for high-quality SPECT. However, by stimulating the clearance, the radioactivity may be transferred to another area. Increased bowel and gastric activity are as great a problem as high liver uptake in the visual and quantitative interpretation of the inferoposteroseptal myocardial walls, particularly in rest imaging (Fig. 1) (*3,4*).

When one uses filtered backprojection (FBP), image artifacts can be caused by so-called halo and spillover effects (*5*). The halo effect is a reconstruction artifact that is associated with the implementation of FBP on attenuated projection images, with focally increased activity in otherwise low-count surroundings. This may result in an underestimation of the inferoposteroseptal walls. Spillover of activity into the myocardium, resulting from photon scatter in the patient associated with activity in the liver, bowel, and stomach, may result in an overestimation of this area. Both artifacts are patient dependent, and their severity is hard to predict.

Although both halo and spillover are often mentioned in articles on myocardial SPECT, very little information is available on avoidance of these phenomena. Several protocols include the use of a fatty meal or intravenous cholecystokinin to stimulate hepatobiliary clearance (*5*). Others include giving patients a drink of milk (*6,7*), a milk shake (*8*), or water (*9*).

The aim of our studies was to determine what measures need be taken before commencing myocardial SPECT acquisition at rest, both with and without attenuation correction, to minimize interference of liver, bowel, and gastric activity.

MATERIALS AND METHODS

Study 1

SPECT myocardial imaging at rest was performed on 97 patients (68 men, 29 women; age range, 30–70 y; mean age, 53 y) as part of a 1-d rest–stress protocol. ^{99m}Tc-tetrofosmin (300 MBq) was administered at rest. Data were acquired in a 64 × 64 image matrix as 3 × 20 (6°) × 60-s projections using a Prism 3000 camera (Picker International, Inc., Cleveland, OH) with a high-resolution, parallel-hole collimator. Tomographic transaxial slices (1 pixel thick) were reconstructed using a reconstruction diameter of 30 cm and a Wiener/Ramp filter. From the transaxial data, 3 sets of orthogonal slices (short axis, horizontal, and vertical long axis) were obtained for each study.

The patients were divided into 3 groups. The first group (n = 37) was treated according to the manufacturer's instructions—i.e.,

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For correspondence or reprints contact: Alice J. van Dongen, MA, Department of Nuclear Medicine, E 02.222, University Medical Center Utrecht, P.O. Box 85500, 3508 GA Utrecht, The Netherlands.

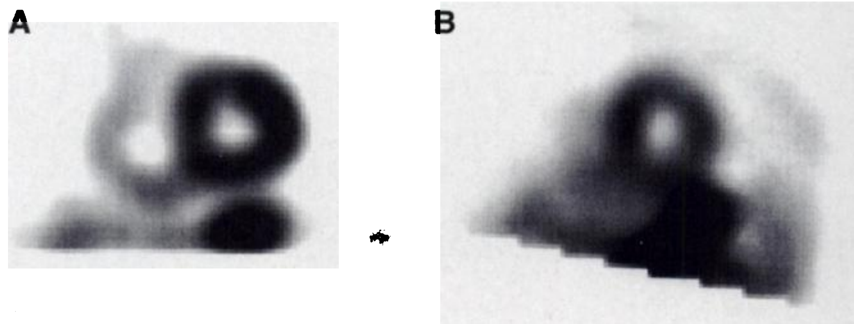

FIGURE 1. Short-axis FBP images with halo effect (A) and spillover of activity (B), which compromise estimation of myocardial perfusion.

nothing was undertaken to influence liver clearance. The patients in group 2 (n = 33) were given 150 mL whole milk 10 min after injection. The patients in group 3 (n = 27) were given 450 mL water 10 min before starting acquisition. In all groups, SPECT imaging commenced 30–40 min after administration of the radiopharmaceutical.

The presence of activity in the liver, bowel, or stomach in groups 1–3 was determined visually by 3 experienced nuclear medicine physicians (separately, on screen) on FBP images. The data were offered for reading in random order, and the physicians were unaware of the patient grouping. Activity was classified as interfering when it could result in either an overestimation or an underestimation of uptake in the myocardium and when the readers required the additional information from the stress SPECT to confidently assess the perfusion in the inferior, posterior, or septal walls. In the few instances in which there was no initial agreement, the data were reviewed simultaneously by the 3 physicians at a later date, and a consensus was reached. Therefore, there was complete agreement on the results presented in this article.

Study 2

After completion of study 1, the Prism 3000 camera was equipped with a transmission line source and new software for iterative reconstruction with attenuation correction. To evaluate the influence of this technique on the presence of artifacts associated with activity in the liver, bowel, and stomach, a second study was begun. For comparison, all original protocols should have been repeated with attenuation correction; however, because of the poor quality of the studies in which no measures were taken to influence clearance, we believed it was unethical to continue study of that specific group.

SPECT myocardial imaging at rest was performed on an additional 55 patients (44 men, 11 women; age range, 28–70 y; mean age, 55 y) as part of a 1-d rest–stress protocol. ^{99m}Tc-tetrofosmin (300 MBq) was administered at rest. Data were acquired in a 64 × 64 image matrix using a Prism 3000 camera with cardiac fanbeam collimators and a gadolinium line source. Emission images were acquired as 2 × 60 (6°) × 20-s projections, and transmission images were acquired as 1 × 60 (6°) × 20-s projections. Tomographic transaxial slices (1 pixel thick) were reconstructed using a reconstruction diameter of 31.4 cm, 20 iterations, an EM-ML algorithm, and Metz postfiltering. From the attenuation-corrected transaxial data, 3 sets of orthogonal slices (short axis, horizontal, and vertical long axis) were obtained for each study.

The patients in the second study were divided into 3 groups. The patients in group 4 (n = 23) were given 150 mL whole milk 10 min after injection. The patients in group 5 (n = 12) were given 450 mL water 10 min before starting acquisition. The patients in group 6 (n = 20) were given both 150 mL whole milk 10 min after injection and 450 mL water 10 min before starting acquisition. In all groups, SPECT imaging commenced 30–40 min after administration of the radiopharmaceutical.

The presence of liver, bowel, or gastric activity in groups 4–6 was determined visually by the same 3 nuclear medicine physicians (separately, on screen) on attenuation-corrected images under the same conditions as described in the first study.

RESULTS

Demographic Data

SPECT myocardial imaging at rest was performed in 152 patients (112 men, 40 women; age range, 28–70 y; mean age, 54 y). All subjects were referred to the nuclear medicine department by the cardiology outpatient clinic. There were no exclusion criteria other than previous gallbladder excision. The patients seen in 1 particular month were assigned to the same study group. Thus, the groups representing a typical outpatient population were formed in 6 consecutive months, accounting for the different group sizes.

Statistical Analyses

All patients had a functioning gallbladder. Liver, bowel, and gastric activity was seen in 31 patients in group 1 (83%), 11 patients in group 2 (33%), and 20 patients in group 3 (74%).

A phenomenon that can be attributed to attenuation correction was evident in group 4. Dispersing hepatobiliary activity over a large area is a technique that worked moderately well with FBP images, but attenuation correction amplifies both scattered and unscattered photons. Thus, the scattered radiation can be displayed more prominently on attenuation-corrected images than on noncorrected images. Liver, bowel, and gastric activity was seen in 14 patients (61%) compared with 33% in the earlier study.

In group 5 (water) the occurrence of liver, bowel, and gastric activity dropped from 74% (measured in the earlier study) to 67% (n = 8) after attenuation correction. Liver, bowel, and gastric activity was seen in only 20% of the patients in group 6 (n = 4) (Table 1).

To determine whether the groups were significantly different, a Pearson χ^2 test was performed, resulting in a P of 0.000 for the groups in study 1 and a P of 0.009 for the groups in study 2. When a Fisher's exact test is performed, correcting for the small number of patients and the various

TABLE 1
Percentage Occurrence of Interfering Activity

Group	No. of patients	Preventive action	Interfering activity (%)
1	37	None	83
2	33	Milk*	33
3	27	Water†	74
4	23	Milk*	61
5	12	Water†	67
6	20	Milk* and water†	20

*10 min after injection.
†10 min before acquisition.

group sizes, the results remain significantly different. In both studies, the results of the group with the lowest percentage of interfering activity were compared with the results of the other 2 groups in the same study (Table 2).

The occurrence of liver, bowel, and gastric activity did not depend on either sex or age. Because the rest study was followed by a stress SPECT study on all patients, diagnostic accuracy was compromised in only a few cases.

DISCUSSION

To date, the problems caused by halo and spillover effects can only be partially solved by new imaging techniques. It has been suggested that the effects of areas of high activity close to the myocardium, as in the liver, can be eliminated by the application of attenuation correction (*10*). Other authors state that scatter effects may be more serious on attenuation-corrected images because the procedure cannot distinguish between scattered and unscattered photons (*11*). Both components are amplified equally during attenuation correction.

In addition, iterative reconstruction will eliminate the halo effects but will not diminish scatter. To achieve that it is necessary to estimate and remove the scatter component from the measured signal and to incorporate the depth-dependent response of the imaging system in the reconstruction algorithms (*12*). These techniques are not yet commonly available outside of research settings; therefore, it is important that liver, bowel, and gastric activity be restricted to the minimum.

TABLE 2
Results of Fisher's Exact Test

Comparison	P*
Group 2 vs. group 1	0.000
Group 2 vs. group 3	0.002
Group 6 vs. group 4	0.012
Group 6 vs. group 5	0.021

*Exact significance (2 sided).

When ^{99m}Tc-tetrofosmin myocardial perfusion SPECT is performed without attenuation correction, the quality of the rest images is vastly improved by giving the patients 150 mL whole milk at a specified time. However, the results of the second study suggest that neither milk nor water alone is sufficient to minimize interfering extracardial activity when attenuation correction is applied to myocardial SPECT using ^{99m}Tc-tetrofosmin.

It is believed that whole milk not only stimulates liver clearance but also stimulates peristaltic movement (*13*) and that water reduces activity in the gastric fundus and speeds up the migration of biliary secreted activity through the bowel. Activity dispersed more diffusely throughout the entire abdomen is less likely to cause reconstruction artifacts.

CONCLUSION

Administration of both whole milk and water to the patient at the specified times will improve the quality of attenuation-corrected myocardial perfusion SPECT images, thus facilitating the interpretation of the inferoposteroseptal myocardial wall. When SPECT is performed without attenuation correction, a drink of whole milk may suffice.

REFERENCES

1. Sridhara BS, Braat S, Rigo P, Itti R, Cload P, Lahiri A. Comparison of myocardial perfusion imaging with technetium-99m tetrofosmin versus thallium-201 in coronary artery disease. *Am J Cardiol.* 1993;72:1015–1019.
2. Zaret BL, Rigo P, Wackers FJT, et al. Myocardial perfusion imaging with ^{99m}Tc-tetrofosmin: comparison to ^{210}Tl imaging and coronary angiography in a phase III multicenter trial. *Circulation.* 1995;91:313–319.
3. Braat SH, Leclerq B, Itti R, Lahiri A, Sridhara B, Rigo P. Myocardial imaging with technetium-99m-tetrofosmin: comparison of one-day and two-day protocols. *J Nucl Med.* 1994;35:1581–1585.
4. Germano G, Chua T, Kiat H, Areeda JS, Berman DS. A quantitative phantom analysis of artifacts due to hepatic activity in technetium-99m myocardial perfusion SPECT studies. *J Nucl Med.* 1994;35:356–359.
5. Middleton GW, Williams JH. Significant gastric reflux of technetium-99m-MIBI in SPECT myocardial imaging. *J Nucl Med.* 1994;35:619–620.
6. Garcia E, Cooke CD, Van Train KF, et al. Technical aspects of myocardial SPECT imaging with technetium-99m sestamibi. *Am J Cardiol.* 1990;66(suppl):80E–90E.
7. Adachi I, Sugioka Y, Tanaka Y, et al. Clinical efficacy of ^{99m}Tc-tetrofosmin myocardial scintigraphy: comparison to ^{210}Tl myocardial scintigraphy [in Japanese]. *Kaku Igaku.* 1993;30:351–362.
8. Hurwitz GA, Clark EM, Slomka PJ, Siddiq SK. Investigation of measures to reduce interfering abdominal activity on rest myocardial images with Tc-99m-sestamibi. *Clin Nucl Med.* 1993;18:735–741.
9. Boz A, Karayalçin B. Which is better for inferior wall evaluation: a full or empty stomach [letter]? *J Nuc Med.* 1996;37:1916–1917.
10. Nuyts J, Dupont P, Van den Maegdenbergh V, Vleugels S, Seutens P, Mortelmans L. A study of the liver-heart artifact in emission tomography. *J Nucl Med.* 1995;36:133–139.
11. Ficaro EP, Fessler JA, Shreve PD, Kritzman JN, Rose PA, Corbett JR. Simultaneous transmission/emission myocardial perfusion tomography: diagnostic accuracy of attenuation-corrected ^{99m}Tc-sestamibi single-photon emission computed tomography. *Circulation.* 1996;93:463–473.
12. Hutton BF, Hudson HM, Beekman FJ. A clinical perspective of accelerated statistical reconstruction. *Eur J Nucl Med.* 1997;24:797–808.
13. Russo A, Fraser R, Horowitz M. The effect of acute hyperglycaemia on small intestinal motility in normal subjects. *Diabetologia.* 1996;39:984–989.