
Peritoneal Fluid Causing Inferior Attenuation on SPECT Thallium-201 Myocardial Imaging in Women

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On SPECT thallium images, myocardial left ventricular (LV) anterior wall attenuation due to breast tissue is common in women. In contrast, in men, inferior wall counts are normally decreased compared to anterior counts. The purpose of this report is to describe cases of inferior wall attenuation of counts in women caused by peritoneal fluid, not myocardial disease. Twelve consecutive SPECT thallium myocardial studies performed in women on peritoneal dialysis, being evaluated for kidney transplant, were included in this study. For all studies, 3.5 mCi ^{201}Tl were injected intravenously. Thirty-two images were acquired over 180° (45° RAO progressing to 45° LPO) at 40 sec per stop. SPECT images were reviewed in short axis, horizontal long and vertical long axes. Data were also displayed in "bullseye" format with quantitative comparison to gender-matched normal files. Ten of 12 female patients studied had inferior wall defects on images, confirmed by bullseye display. All patients had ~2 liters of peritoneal fluid. Review of planar rotational views showed diaphragm elevation and fluid margin attenuations affecting left ventricular inferior wall. Thus, peritoneal fluid is a cause of inferior attenuation on ^{201}Tl cardiac imaging.

J Nucl Med 29:1860-1864, 1988

Left ventricular myocardial anterior wall attenuation due to overlying breast soft tissue is common in women on thallium-201 (^{201}Tl) single photon emission computed tomography (SPECT) myocardial imaging. In contrast to the findings in men, in women inferior wall counts are higher than anterior wall counts. In this article we report a series of cases of inferior wall attenuation of counts in women caused by peritoneal fluid.

METHOD

Twelve consecutive SPECT thallium myocardial imaging studies performed in women on chronic ambulatory peritoneal dialysis, being evaluated for kidney transplant were included in this study. These patients were all hospital inpatients; peritoneal dialysis fluid exchanges were performed at 4-6 hr intervals. Thus, ~2 l of peritoneal fluid was present for the duration of thallium imaging. The patients ranged in age from 24-64 yr (mean age 48 hr). At this institution, ^{201}Tl SPECT myocardial images at stress and redistribution are part of the

routine evaluation of patients being considered for renal transplantation.

Treadmill exercise ECG testing was performed using the Bruce protocol in eight patients. At 30-60 sec prior to termination of exercise, ~3.5 mCi of [^{201}Tl]chloride were injected intravenously. Immediately following termination of exercise the patient was positioned on the imaging table and 32 images over 180° starting at the 45° RAO projection and progressing to the 45° LPO projection were obtained. Image acquisition time was 40 sec per stop; the scintillation camera pulse height analyzer was set with a 15% window centered on the 80 keV photo peak of the mercury x-rays emitted in the ^{201}Tl decay scheme. Images were obtained utilizing a general all purpose parallel hole collimator. Routine quality control measures were performed daily on the SPECT scintillation cameras, including center of rotation and flood-field uniformity.

In four patients exercise could not be performed and the study was done using intravenous dipyridamole; 0.71 mg/kg were infused over a period of 5 min to achieve increased coronary artery blood flow, 3.5 mCi of [^{201}Tl]chloride were injected intravenously upon termination of the infusion, and the patient's SPECT imaging was started.

SPECT ^{201}Tl images were processed as follows: the raw data of each of the 32 images acquired over 180° were corrected for center of rotation and flood-field nonuniformity (Fig. 1). Using a Hanning filter with a cutoff frequency of 0.822, each

Received Feb. 18, 1988; revision accepted May 31, 1988.

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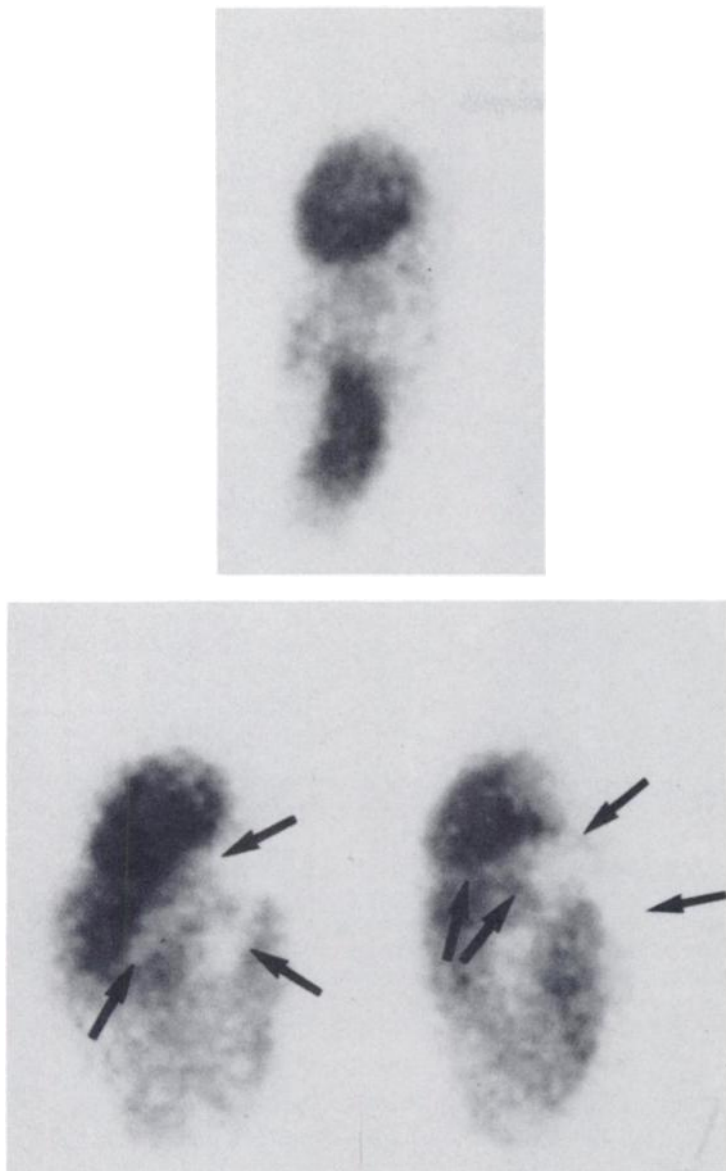


FIGURE 1
 Corrected raw data planar images from the set of 32 images acquired over 180° rotation by the scintillation camera are shown. Above, a single planar image in a patient being evaluated for renal transplant while on hemodialysis. There is no evidence for inferior wall attenuation. Below, 2 planar images in a patient on peritoneal dialysis. Arrows indicate fluid margins. Elevation of the diaphragm interfering with inferior myocardial wall counts can be appreciated.

image was filtered prior to backprojection to reconstruct tomographic slices of the left ventricle displayed in short axis (Fig. 2), horizontal long axis, and vertical long axis projections. From these image data, a bullseye polar map was generated. The bullseye, comprised of a series of concentric circles with the apex at the center and the base at the periphery, displays myocardial counts in each pixel at an intensity or color on a scale in proportion to the maximum count pixel in the bullseye. The patient's bullseye map is compared to a gender matched normal file. In addition to the bullseye map, a standard deviation map is also generated, to indicate when the counts in any given pixel relative to the maximum pixel count in the bullseye display, exceeds 2.5 s.d. for the gender matched control group below the maximum pixel level (Fig. 3).

Thallium scans were reviewed according to a protocol which included examination of tomographic images in all projections, short axis, horizontal long axis, and vertical long axis, as well as the 180° planar rotational images of the chest to assess levels of soft tissue and other attenuating factors and

to identify patient motion during the acquisition which might invalidate the results. All studies were analyzed using a motion detection program described previously (1). Following the review of the rotational planar images, the bullseye displays were evaluated. Based on all data a final interpretation of the thallium image study was made.

RESULTS

Ten of the 12 female patients studied had inferior myocardial wall defects seen on the images and confirmed on the bullseye display with > 2.5 s.d. below maximum pixel count values compared to the normal file. To illustrate the findings, Figures 1-3 show a normal pattern of thallium count distributions in a female being evaluated for renal transplant who was on hemodialysis, and one of the ten patients with peritoneal fluid causing inferior wall attenuation, called significant by the bullseye polar map display.

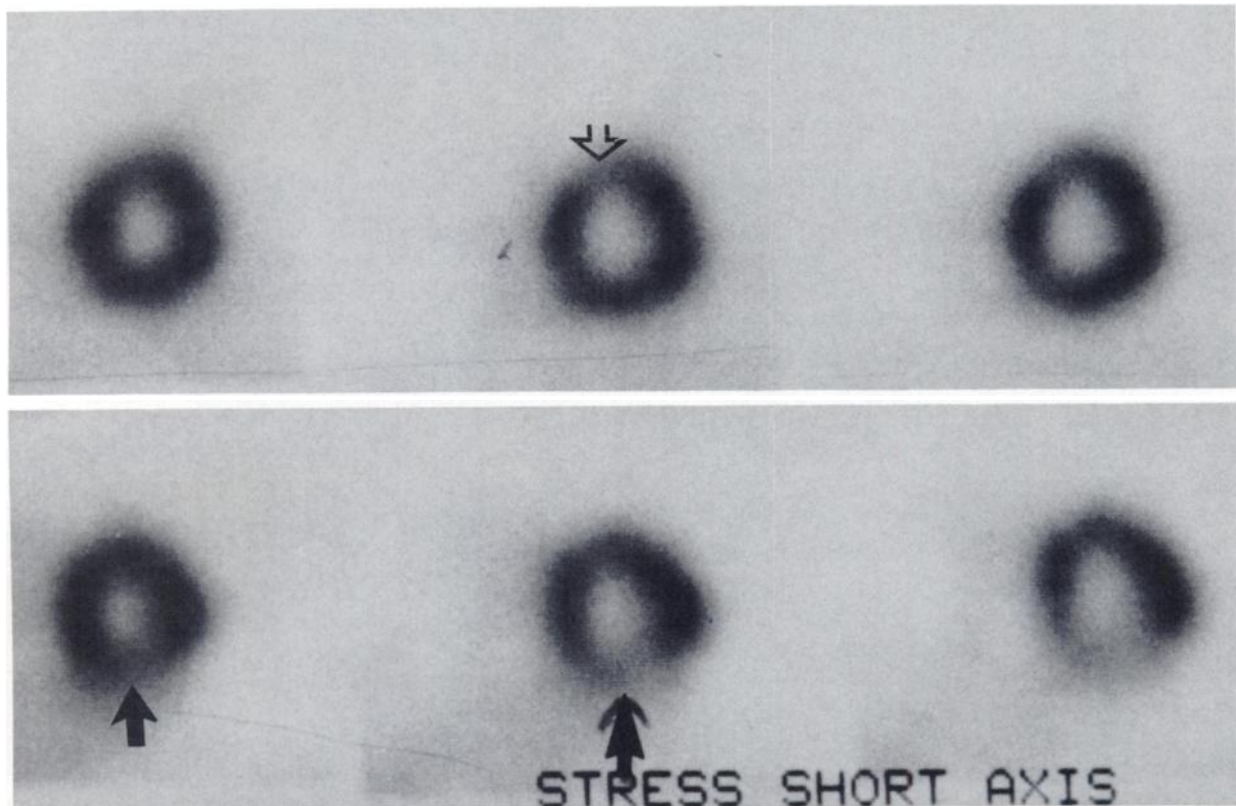


FIGURE 2

Above, short axis reconstructed tomography slices of the left ventricle at a mid ventricle level, in the female patient on hemodialysis. The anterior wall shows fewer counts than the inferior wall in this normal female pattern of short axis reconstructed thallium images. Open arrow indicates decreased anterior wall counts caused by breast attenuation. Below, similar left ventricular short axis tomographic images of a patient on peritoneal dialysis show decreased counts inferiorly (closed arrows). The inferior wall attenuation exceeds the normal breast attenuation seen anteriorly.

All 12 studies were technically satisfactory. There was no evidence of unacceptable motion demonstrated by the motion detection program. Eleven of the 12 patient studies had < 0.5 pixel motion in the vertical (axial) direction and one patient had 0.6 pixel motion in the vertical (axial) direction.

DISCUSSION

The normal distribution of ^{201}Tl counts on SPECT and planar myocardial scintillation camera images in males and females has been a much discussed and troublesome topic (1-6). It is clear that there is a different normal distribution of counts for males and females. Attenuation by breast tissue, diaphragmatic tissue, and chest wall varies greatly from males to females and from one subject to the next.

A mild decrease in count density in the thin membranous septum is expected in both males and females. In both males and females, a mild to moderate decrease in LV inferior wall count density is expected, presumably due to photon attenuation by the diaphragm. In females, however, there is also mild to severe anterior

or anterolateral, photon attenuation by breast tissue, which is not the case for normal males. Thus, in females, inferior wall counts usually exceed anterior wall counts. Furthermore, in very large breasted women, the attenuation can extend from anterolateral to inferior wall (7, 9).

Fixed anterior defects due to breast attenuation vary in appearance depending on size and position of breasts. Conversely, small or absent breasts result in greater anterior wall count density and thus relatively decreased inferior counts as compared to normal females (2). The chest diameter in all patients in this study was generous (85 cm to 135 cm); this would preclude the possible explanation for relatively decreased inferior counts due to small or absent breast tissue. In the women studied, large, pendulous breasts might have contributed to inferolateral attenuation in two of our patients. Motion artifact (1) was excluded by review of the planar 180° acquisition images in cine format and the analysis of each study using a motion detection program (1). "Upward creep" (5), another reported cause of inferior wall attenuation, was not noted in our patient group. Abdominal viscera overlying the inferior wall may contribute to inferior LV wall count attenuation, but exami-

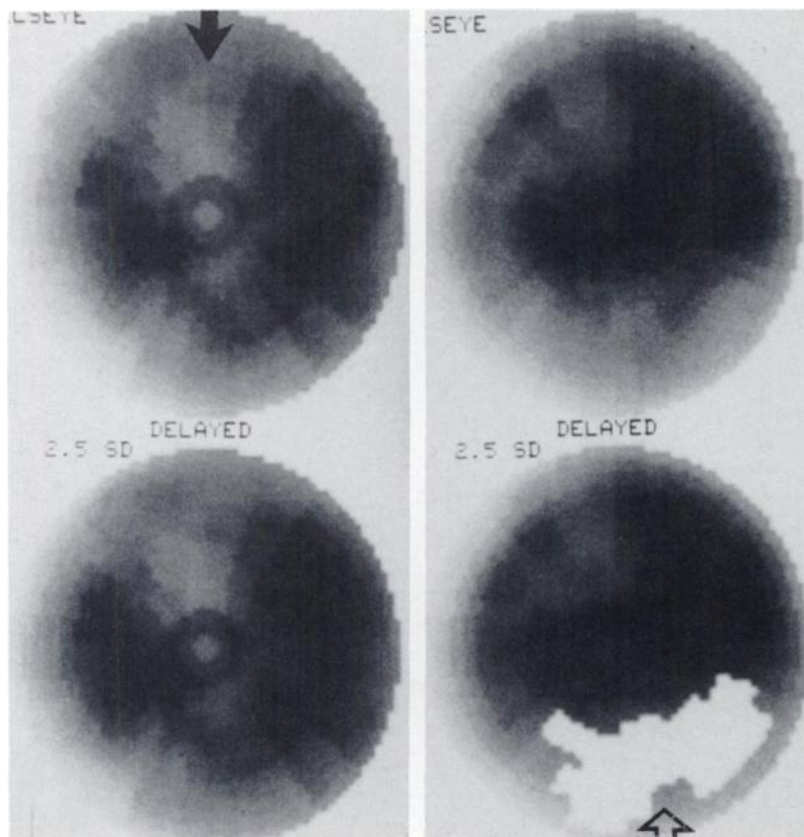


FIGURE 3

Above, the bullseye display of counts per pixel in concentric circles of myocardial slices with the apex at the center and the left ventricular base at the periphery. These raw data bullseye polar maps show the pattern in the normal hemodialysis female patient (left), with decreased counts anteriorly (arrow) compared to inferiorly. In contrast, in the normal female patient on peritoneal dialysis (right) there are markedly decreased counts inferiorly, exceeding the anterior count decrease. The counts laterally exceed the counts septally in normal myocardium. The bullseye displayed in the upper right panel is the raw bullseye from the peritoneal dialysis patient whose images were shown in Figure 2. Below, the "black-out" (in this case "white-out") standard deviation, gender matched normal file bullseye is shown for the hemodialysis patient (left) and the peritoneal dialysis patient (right). Pixels which exceed 2.5 s.d. below the gender matched normal file in comparison with the maximum count pixel in the bullseye are displayed in white. The standard deviation plot on the left shows no whited-out areas. In contrast, the bullseye display in the lower right panel shows a large inferior wall region of pixels which exceeds 2.5 s.d. from normal gender matched bullseye files of pixel counts (open arrow).

nation of the rotational planar images in cine format in our patients indicated that this was not a factor in the patients studied.

The vast majority of patients referred for ^{201}Tl myocardial imaging as part of the renal transplant evaluation are in chronic hemodialysis. Inferior wall attenuation is not seen in this group. In contrast, 10/12 patients on peritoneal dialysis had fixed inferior attenuation greater than 3–5 s.d. units beyond normal mean pixel count values for women, compared to the maximum pixel count value in the bullseye display (Fig. 3). A photopenic zone under the diaphragm could be seen on planar rotational images (Fig. 1), consistent with peritoneal fluid as the probable cause of inferior LV wall myocardial attenuation. Patients on peritoneal dialysis have as much as 1,000–2,000 cc of peritoneal fluid, which can elevate the patient's diaphragm when the patient is supine as required for ^{201}Tl image acquisition.

None of these patients were referred for cardiac catheterization, as careful review of the 180° planar images indicated that there was an inferior wall attenuation

problem (Fig. 1), rather than myocardial disease in that region; also, there was no reversible ischemia to warrant catheterization. Thus, although scar could not be entirely excluded as a cause of the inferior defect, the explanation of fluid attenuation was considered most likely.

In summary, this study reports the observation that large volumes of peritoneal fluid may cause inferior attenuation on SPECT and planar ^{201}Tl myocardial imaging.

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