

Outlining the body contours with scattered photons in lymphoscintigraphy for sentinel nodes

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Although lymphoscintigraphy is a useful method of detecting the sentinel nodes of malignancy, conventional lymphoscintigraphy images only the sentinel nodes without revealing their anatomical location. We, therefore, used scattered photons to attempt to outline the body contours of patients with either breast or esophageal cancer. Lymphoscintigraphy was performed 3 to 4 hours after the injection of 111 MBq of ^{99m}Tc tin colloid into the peritumoral region. Images were obtained with dual-energy windows of 130 to 150 keV for the primary photons and 70 to 110 keV for the scattered photons. The images constructed from the scattered photons clearly showed the contours of the body, and the fusion images constructed from the primary and scattered photons allowed for easy identification of the location of the sentinel nodes. The results of this study confirm that images obtained from scattered photons on lymphoscintigraphy are helpful in identifying the anatomical location of sentinel nodes.

Key words: sentinel node, lymphoscintigraphy, ^{99m}Tc tin colloid, scattered photon, Compton scattering

INTRODUCTION

RECENTLY, sentinel node navigation surgery has been investigated for various kinds of malignancies in the light of minimally invasive surgery.¹ Although conventional lymphoscintigraphy is useful for detecting sentinel nodes, it images only the nodes and provides no indication of their anatomical location. In this study, we have attempted to overcome this problem by using scattered photons to outline the body contours.

MATERIALS AND METHODS

Seven women with breast cancer (35–75 years old, T stage: T1 or T2) and five men with esophageal cancer (39–65 years old, T stage: T1 or less) whose lymphoscintigrams clearly revealed sentinel nodes were included

in this study.

One hundred and eleven MBq of ^{99m}Tc tin colloid (1.5 to 2 ml), which was labeled by adding tin (II) chloride [Sn(II)Cl_2] solution (Nihon Medi-Physics, Nishinomiya) to ^{99m}Tc pertechnetate solution, was injected into the peritumoral regions, either manually or endoscopically. Lymphoscintigraphy for sentinel nodes was performed 3 to 4 hours after the injection. After the high-activity areas around the primary foci were covered with 3-mm thick lead plates, images were acquired with a gamma camera (GCA7200A/DI, Toshiba, Tokyo) with a low-energy, high-resolution, parallel-hole collimator. Lead plates were put over the strong-activity areas around the injection sites monitoring the display, but the high-activity areas were not always completely covered.

Scintigrams were obtained for about 15 minutes with dual-energy windows, 140 ± 10 (130 to 150) keV for the primary photons and 90 ± 20 (70 to 110) keV for the scattered photons referring to the energy spectrum (Fig. 1).

We determined whether we could visualize the body contour in the image with the scattered photons, and whether the anatomical location of the sentinel nodes in

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the fusion images obtained from the two energy windows could be identified.

In four cases (two breast cancer and two esophageal cancer cases), additional images were obtained after radioactive markers were put on the body surface to verify whether the contours drawn on the images constructed by the scattered photons corresponded to the actual body surfaces. The radioactive markers were made by putting

0.1 ml of tin colloid solution, which was made by diluting the original solution 100 times, into a 1 ml injection syringe.

The protocols for the detection of sentinel nodes have been approved by the Ethical Committee of Keio University School of Medicine, and informed consent was obtained from all patients included in this study.

RESULTS

In all of the seven breast cancer cases, the lymphoscintigrams with primary photons clearly imaged the sentinel nodes (Fig. 2a). The counts did not overflow after 15 minutes of acquisition in any case. The images constructed from the scattered photons clearly showed the contour of the body (Fig. 2b). The fusion images constructed from the primary and scattered photons allowed for easy identification of the anatomical location of the sentinel nodes (Fig. 2c). In the two cases that were imaged with radioactive markers on the body surfaces, no clinically significant mismatch was recognized between the images of the radioactive markers on the body surface and

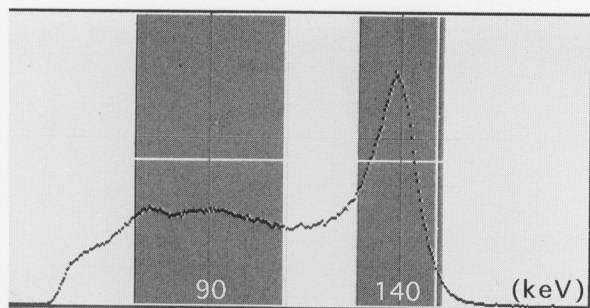
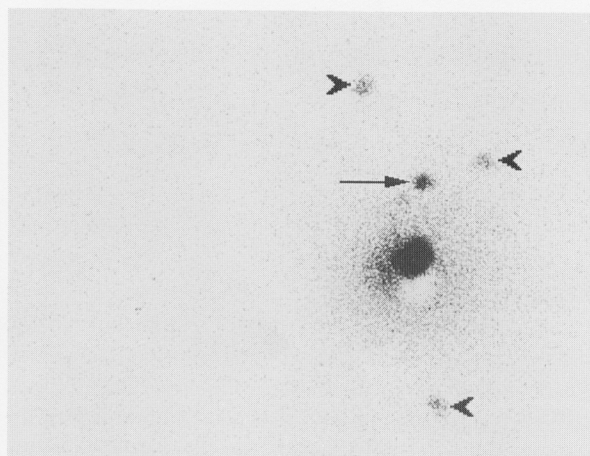
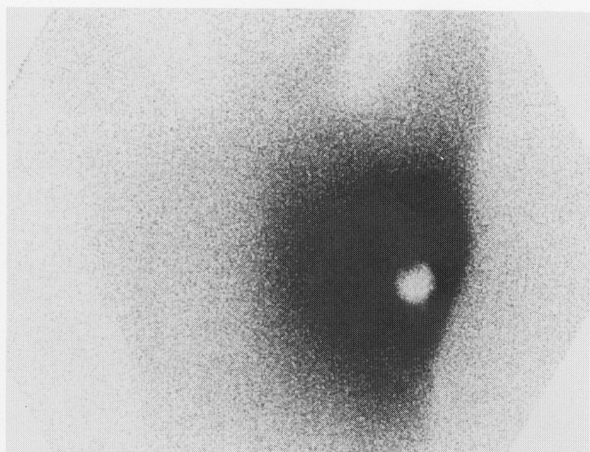


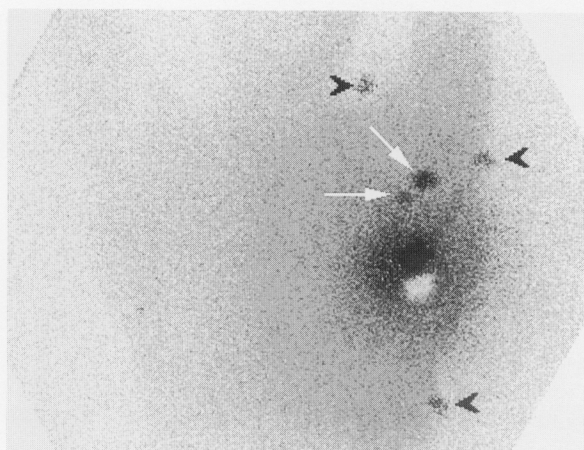
Fig. 1 The energy spectrum obtained from a patient with breast cancer who was injected ^{99m}Tc into the peritumoral region. Gray zones indicate the windows where photons are acquired.



a

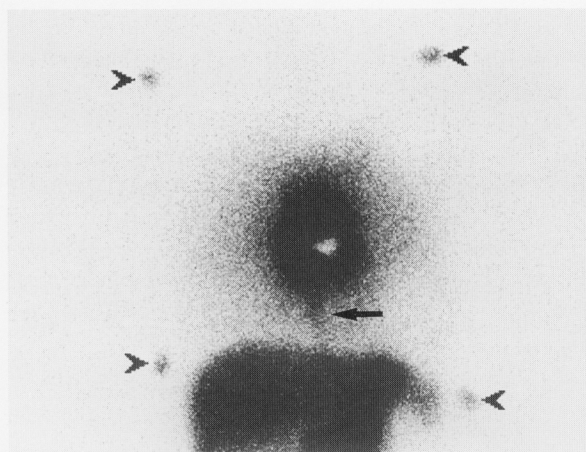


b

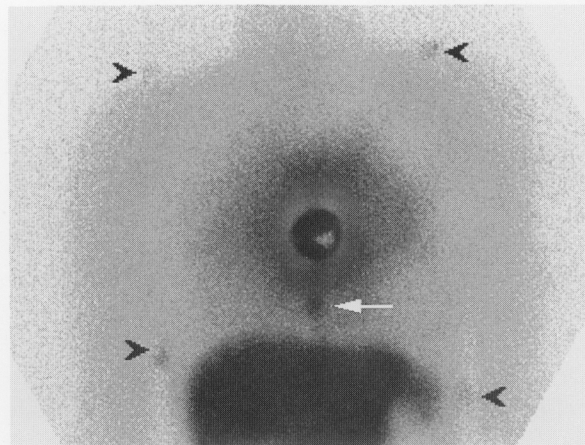


c

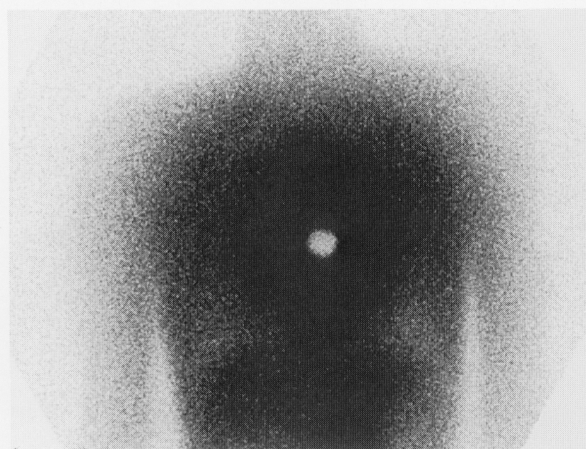
Fig. 2 Breast cancer (left breast) (35 year-old woman). The image with primary photons shown here is acquired by putting radioactive markers on the body surface, i.e. left supraclavicular region, left axillary margin and left flank. The image with primary photons (a) draws sentinel node in the upper lateral aspect of the primary focus (arrow). The radioactive markers on the body surface were also visualized (arrowheads). The image with scattered photons (b) outlines the contour of her body and, mainly left portion of her chest. (This image is printed darker than the original one because the contour of the body is clearly delineated.) The fusion images of both primary and scattered photons (c) clearly show the sentinel nodes (arrows, another hot node may exist in the lower aspect of the original sentinel node) located in her left axillary region. No remarkable mismatch is noted between the body contour on the images with scattered photons and the true body surface shown by radioactive markers (arrowheads).



a



c



b

Fig. 3 Esophageal cancer (47 year-old man). The image with primary photons shown here is acquired by putting radioactive markers on the body surface, i.e. both sides of the shoulders and flanks. The image with primary photons (a) depicts the sentinel node in the lower aspect of the primary tumor (arrow). The arrowheads indicate the radioactive markers on the body surface. The image with scattered photons (b) indicates the outline of his body. The summation of both images (c) facilitates the identification of the anatomical locations of sentinel nodes (arrows). The hot spots by radioactive markers put on the body surface (arrowheads) were concordant with the contour of the body silhouetted by scattered photons.

the body contours drawn on the images constructed by scattered photons.

When the covering of high-activity areas around the injected sites was incomplete as in the case shown in Figure 2, no significant artifact was noted in the high activity areas.

Similar results were obtained in the patients suffering from esophageal cancer. The images obtained with primary photons clearly depicted the sentinel nodes (Fig. 3a). The body contours were well imaged with the scattered photons (Fig. 3b), and the fusion images constructed of both the primary and scattered photons allowed the easy identification of the anatomical location of the sentinel nodes (Fig. 3c).

As in the two breast cancer cases, there was no significant mismatch between the radioactive markers put on the body surface and the body contours drawn on the images with scattered photons in the two esophageal cancer cases.

The processing of the images took less than 10 minutes in both breast and esophageal cancer cases.

DISCUSSION

To date, it has been reported that additional imaging after injection of ^{99m}Tc pertechnetate² and transmission imaging with a gamma emitter as an external source^{3,4} are used for drawing the contours of the body on lymphoscintigrams, but these methods can present such problems as extended examination time and exposure of patients and technicians to an increased dose.

In order to solve these problems, we have attempted to use images constructed by means of scattered photons. When gamma rays arose by the degradation of ^{99m}Tc pass the human body, scattered photons occur everywhere in the body caused mainly by Compton scattering.⁵ Therefore, the distribution of the scattered photons can reflect the contours of the body if the imaging is performed with a parallel-hole collimator. The energy of these scattered photons is lower than 140 keV and mainly distributed around 90 keV, according to the energy spectrum. We, therefore, acquired the scattered photons at an energy window between 110 and 70 keV. As a result, the images constructed by the scattered photons successfully silhouetted the contours of the body. The combination of the

images obtained with scattered photons and the image-detecting sentinel nodes with the primary photons enables us to easily identify the anatomical location of sentinel nodes.

The superimposition of the images with scattered photons and those with radioactive markers demonstrated that, in cases of either breast or esophageal cancer, there was no clinically significant mismatch between the body contours on the images with scattered photons and the true body.

One advantage of this imaging method is that there is no anatomical discrepancy between the location of the sentinel nodes and the contours of the body because the acquisition of both primary and scattered photons is performed simultaneously. Furthermore, the exposure dose does not increase since no additional radionuclide injection is required. As this image processing took no more than 10 minutes, we believe that this method could be easily accepted in clinical practice.

Since all of the patients enrolled in this study had clearly imaged sentinel nodes, the simple summation of the images of both primary and scattered photons could allow the easy identification of sentinel nodes. Nevertheless, the simple summation of both images constructed with primary and scattered photons would make the activity of sentinel nodes obscure when sentinel node filling with the radionuclide is scanty. In such circumstances, the images should be overlaid after the activity of the image of primary photons for sentinel nodes has been enhanced.

Because the activity of scattered photons weakens as the distance from the primary focus increases, the gradation of the distribution of the activity on the scattered-photon images might be modulated to better delineate the contours of the body.

Although some modifications may be necessary, this method of using scattered photons to outline the body contours is useful in the application of lymphoscintigraphy,

and the visualization of sentinel nodes located near the primary focus might be affected by covering the areas of strong activity around the injection sites. The optimal injection dose for the imaging of sentinel nodes is yet to be determined.

In conclusion, supplementation of lymphoscintigraphy for sentinel nodes with the information obtained from scattered photons is useful because it can outline the body contours and clearly identify the anatomical location of the sentinel nodes with no additional burden on the patient.

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