

Superiority of Iodine-123 Compared with Iodine-131 Scanning for Thyroid Remnants in Patients with Differentiated Thyroid Cancer

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Purpose: Iodine-123 is a pure gamma emitter and has excellent characteristics for imaging with modern scintillation cameras. The goal of this study was to compare the performance of I-123 and I-131 as imaging agents for whole-body scanning in patients with differentiated thyroid cancer undergoing ablation for thyroid remnants after initial surgery.

Methods: Fourteen patients with differentiated thyroid cancer who had undergone near-total thyroidectomy and had serum thyroid-stimulating hormone levels greater than 40 mU/l underwent diagnostic scanning 5 hours after administration of 48 to 56 MBq (1.3 to 1.5 mCi) I-123 and 48 hours after administration of 111 MBq (3 mCi) I-131. After receiving ablative I-131 therapy, they also underwent whole-body planar imaging 7 days later. The diagnostic I-123 and I-131 scans were compared with each other and with the post-therapy images by two nuclear medicine physicians and one endocrinologist.

Results: The diagnostic scans revealed 35 foci in the thyroid bed and neck. The I-123 images showed all 35 foci, but only 32 of the 35 foci (91%) were seen on the I-131 scans. The findings of pre- and post-therapy scans were concordant in 11 of 13 patients, and the same general sites of uptake (left and right thyroid bed, midline) were revealed on both sets of images. In one patient, a focus seen on the diagnostic I-123 and I-131 images was not visualized on the post-therapy scan and was thought to represent possible stunning. An additional area of uptake in the lower right neck and upper mediastinum was present on the post-therapy scan of another patient, but it was not seen on diagnostic images.

Conclusion: These results show improved quality of imaging with 50 MBq (1.5 mCi) I-123 compared with 111 MBq (3 mCi) I-131 for whole-body scanning in patients with differentiated thyroid cancer undergoing thyroid remnant ablation. I-123 imaging may prove to be the preferred procedure in such settings in patients with differentiated thyroid cancer.

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RADIOIODINE ABLATION of a thyroid remnant after near-total thyroidectomy is a well-accepted therapy for many patients with differentiated thyroid cancer. Diagnostic I-131 scanning is generally performed before I-131 therapy to identify either residual thyroid tissue or metastases. The commonly accepted dose of I-131 (117 to 156 MBq or 3 to 4 mCi) administered for this purpose has been chosen by considering the desired sensitivity for detecting active tissues with iodine uptake and the possible deleterious effects on the targeted tissue for subsequent treatment. High doses result in optimal visualization, but several studies have reported that diagnostic I-131 scanning doses have adversely affected the subsequent uptake of the therapeutic I-131 dose by the thyroid remnant, which has been called the "stunning effect" (1-4). In addition, I-131 has a principal gamma photon energy of 364 keV, which is suboptimal for imaging with a scintillation camera. When a medium-energy (rather than a high) collimator is used, poor image resolution may be achieved because of septal penetration, causing a star-shaped artifact. Conversely, images acquired using a high-energy collimator have low counts because of excessive septal lead content. In addition, the routine use of high-energy collimators has been contained by the cost and its limited use for the I-131 isotope; therefore, these collimators are not available in many nuclear medicine departments.

Iodine-123, a pure gamma emitter, has excellent im-

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aging characteristics as a result of its optimal photon energy of 159 keV, which is well within the ideal gamma energy range for conventional scintillation cameras. Imaging with I-123 results in substantially less radiation burden to the thyroid cells than does I-131 because of its pure gamma emission and short half-life of 13 hours. Traditionally, logistical issues of cost and availability have precluded the routine use of I-123 imaging for diagnostic scanning in persons with thyroid cancer. However, with the routine availability and reasonable cost of cyclotron-produced radionuclides, including I-123, obstacles for appropriate use of such products have been overcome. In addition, some investigators have speculated that the short half-life of I-123, which requires completion of scanning within 24 to 36 hours, hypothetically may reduce its sensitivity for visualization of lesions that require further delayed imaging for optimal uptake.

In this study, we compared the performance of I-123 and I-131 as imaging agents for whole-body scanning in patients with differentiated thyroid cancer who were being evaluated for ablation of a thyroid remnant. This protocol was specifically designed to assess the utility of high doses of I-123 for whole-body scintigraphy in those patients with presumed thyroid remnants, with the expectation of its future application in patients with thyroid cancer undergoing surveillance scanning.

Materials and Methods

Fourteen consecutive patients with differentiated thyroid cancer were examined. The mean age of the 11 women and 3 men was 43 years. The thyroid cancers were classified as papillary in 12 patients, follicular in one, and Hurthle cell in one. All had undergone near-total thyroidectomy and had diagnostic radioiodine scanning within 7 weeks of surgery. Scans were obtained after withdrawal from triiodothyronine for at least 2 weeks and subsequent serum thyroid-stimulating hormone levels greater than 40 mU/l in every patient enrolled in the study. Patients followed a low-iodine diet for 1 week before the diagnostic radioiodine doses were administered.

The protocol required the oral administration of 48 to 56 MBq (1.3 to 1.5 mCi) I-123 in the morning on day 1. Five hours later, images were obtained with a 20% window centered at the 159-keV photopeak of this radionuclide. A dual-head scintillation camera system (Picker International, Cleveland, OH) equipped with a low-energy, all-purpose parallel-hole collimator was used for all patients. The acquisition time for a whole-body scan was 20 minutes, which was followed by 10-minute static imaging of the head and neck regions. The patients then received an oral 111-MBq (3 mCi) dose of I-131, and diagnostic scans were obtained 42 to 44 hours later using a 20% window centered at the 364-keV photopeak. A medium-energy, all-purpose parallel-hole collimator was used for all patients. The acquisition time for a whole-body scan was 20 minutes, which was followed by 10-minute static imaging of the head and neck regions.

Thirteen patients who showed at least one focus of functioning thyroid remnant or metastasis received ablative I-131 ther-

apy (3,700 to 5,500 MBq; 100 to 150 mCi) within 5 days of the diagnostic imaging. Seven days after I-131 therapy, all patients underwent whole-body planar scanning (post-therapy scans) and the results were compared with the pretherapy diagnostic images.

Two nuclear medicine physicians (L.K.S., A.A.) and one endocrinologist (S.J.M.) evaluated the diagnostic I-131 and I-123 scans and compared the number and location of the foci of functioning thyroid remnants or metastases between the two studies. The findings of the diagnostic scans were compared with those of the post-therapy scans. When either diagnostic scan showed radioiodine uptake in a lesion that was not seen on the post-therapy scan, the ability of the tissue to concentrate the therapeutic I-131 dose was considered affected (impaired or stunned) as a result of the diagnostic I-131 radioiodine dose.

All participants gave their informed consent, and the institutional review board of the University of Pennsylvania approved the study.

Results

The diagnostic scans revealed 35 foci in the thyroid bed and neck. The I-123 images showed all 35 foci, but only 32 of the 35 foci (91%) were seen on the I-131 second scans. Of the three foci not visualized on the diagnostic I-131 scans, one was in each of three different patients (Fig. 1). In one patient (Fig. 1A), an additional area of uptake in the lower right thyroid bed was visible on the I-123 image that was not seen with I-131 scanning. In another patient (Fig. 1B), I-123 images showed an additional focus in the midline. This was not thought to be esophageal uptake because it was present after the patient swallowed water and on the post-therapy images. In the third patient (Fig. 1C), a distinct focus was visible on I-123 scans, just to the right of the midline. The two sites just adjacent to this focus on the I-123 scan were apparent on the I-131 scan; perhaps poor resolution resulting from septal penetration from these sites may have obscured it on the I-131 images.

Pre- and post-therapy scans were concordant in 11 of 13 patients. The same general sites of uptake (left and right thyroid bed, midline) were revealed, although adjacent foci in the same area could not always be distinguished on I-131 scans after therapy, because of septal penetration. In one patient (Fig. 2A), the left thyroid bed uptake visualized on both I-123 and I-131 diagnostic scans was only questionably visualized on the post-therapy scan, and we believe this may represent stunning. The post-therapy scan showed an additional area of uptake in the right lower lateral neck in another patient (Fig. 2B) that was not detected on either I-123 or I-131 diagnostic scans. The uptake in this area was later confirmed by anatomic imaging studies, and metastatic lymph nodes were removed surgically. In addition, comparison among all three pairs of scans (I-123 and diagnostic and therapeutic I-131 images) revealed superior image quality on I-123 images.

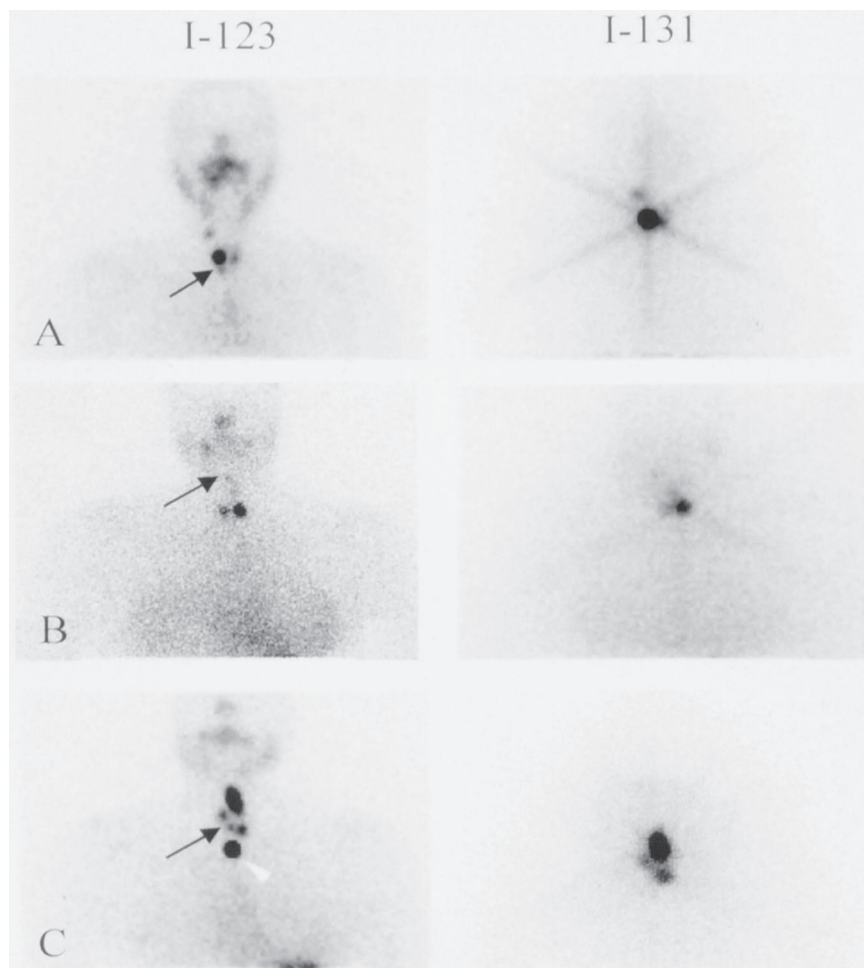


Fig. 1. (A–B) The results of diagnostic scanning were compared 5 hours after 50 MBq (1.5 mCi) I-123 and 48 hours after 111 MBq (3 mCi) I-131 were administered to three patients. Each patient had one additional focus detected on the I-123 image (indicated by the black arrows) that was not seen on the I-131 image. (C) The white arrow indicates a marker placed over the sternal notch.

Discussion

Our results show superior quality of imaging with 50 MBq (1.5 mCi) I-123 compared with 111 MBq I-131 for whole-body scanning in patients with differentiated thyroid cancer undergoing ablation for thyroid remnants. Only 91% of the foci visualized on I-123 images were seen on I-131 scanning. To our knowledge, no other published studies have directly compared I-123 and I-131 diagnostic whole-body scans in the same patients. Park and colleagues (5) reported using low-dose 11-MBq (300 μ Ci) I-123 before therapeutic I-131 ablation, but whole-body scanning was not routinely performed and most of the patients did not undergo subsequent diagnostic I-131 scans. The diagnostic accuracy of these 11-MBq I-123 scans for detecting thyroid remnants was 89.5%. Our greater diagnostic accuracy for imaging thyroid remnants was 100% and may reflect the higher I-123 dose used. Another report compared low-dose 10- to 20-MBq (270 to 540 μ Ci) I-123 head and neck images at 2 hours with 185-MBq (5 mCi) I-131 whole-body

images at 48 to 72 hours in patients undergoing ablation for thyroid remnants. Of the 19 patients described, 18 had positive results of I-123 and I-131 diagnostic scans, but the remaining patient was examined only with I-131. The authors concluded that I-123 scans were not as sensitive as I-131 scans, but the lower dose of I-123 used in that study may account for the difference in findings (4). In our study, the improved image quality with I-123 may be attributed to the relatively high dose of I-123 and scanning 5 hours rather than 2 hours after administration. One other published study used a high-dose (3,700 MBq, 10 mCi) of I-123 for whole-body scanning, but the images were compared with post-therapy scans rather than with diagnostic I-131 images and showed 94% concordance (6). We have achieved a similar concordance with post-therapy scans using the smaller dose of 50 MBq (1.5 mCi) I-123.

Post-therapy scanning in one patient showed possible stunning, which is presumed to be a result of the greater radiation delivered by the diagnostic dose of I-131 be-

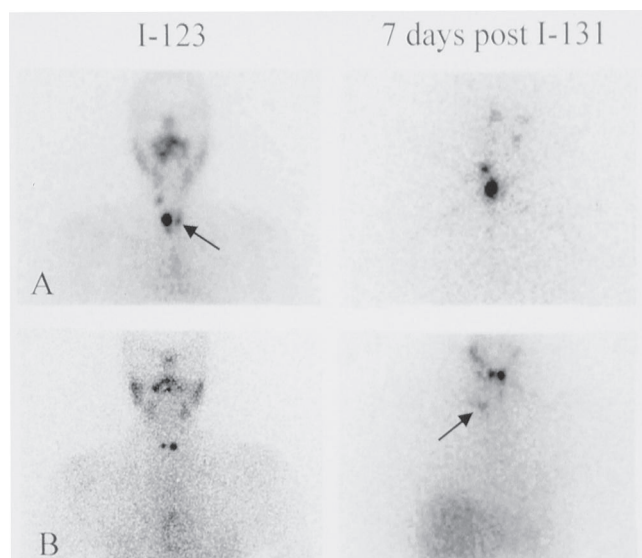


Fig. 2. The results of diagnostic scanning were compared 5 hours after 50 MBq (3 mCi) I-123 and 7 days after I-131 therapy was administered to ablate the thyroid remnant in two patients. (A) One patient had a focus in the left thyroid bed on the diagnostic I-123 scan (indicated by the black arrow) that was not seen on the post-therapy scan. (B) One patient had an additional focus in the right lower lateral neck on the post-therapy scan (indicated by the black arrow) that was not detected on either I-123 or I-131 diagnostic scans.

cause of its energetic beta decay. Although there is no evidence of decreased uptake of the therapeutic dose in the residual thyroid or metastases in those patients who have received diagnostic doses of I-123, this may occur in as many as 40% of patients who receive only 111 MBq (3 mCi) I-131 as a diagnostic agent (2). It would be unlikely that the relatively higher doses of I-123 used in this study (48 to 56 MBq; 1.3 to 1.5 mCi) would cause stunning. The dose of I-123 that we used in this study was calculated to deliver substantially less radiation to the thyroid tissue than would 111 MBq (3 mCi) I-131 (by a factor of 100 times). In one of our patients, post-therapy scanning revealed additional foci that were not seen on diagnostic scans with either I-131 or I-123. Compared with diagnostic I-131 imaging, post-therapy imaging may show additional areas of uptake in as many as 27% of patients (7). It is possible that delayed imaging with I-123 at 24 hours would have shown these lesions.

The design of our study had several constraints. To minimize the number of visits to the nuclear medicine laboratory, the I-123 scans were obtained only at 5 hours and then I-131 was administered. We expect that the optimal timing for imaging I-123 may prove to be 24 hours. This could allow visualization of lesions with low

uptake rates and, therefore, further improve resolution of I-123 images as a result of greater uptake in the tissue and significantly decreased background activity. An I-123 scan was not obtained at 24 hours because this would have required the patients return to the Nuclear Medicine Department on a third day.

In addition, none of our patients had metastatic disease outside the locoregional area. Therefore, these data cannot address the concentration of I-123 by pulmonary or bone lesions. However, in our ongoing studies of surveillance scanning of such patients, we have found such uptakes (unpublished data) and expect that I-123 imaging will provide optimal results in such settings. Furthermore, performing SPECT in addition to planar images may enhance the sensitivity of the proposed radiotracer. Based on experience with other studies, tomographic imaging is substantially superior to planar studies and should be adopted if an appropriate dose and the optimal radionuclide are selected for imaging.

Another limitation was the use of a medium-energy collimator for I-131, but this is routinely available in most nuclear medicine departments.

In conclusion, I-123 appears to be a superior imaging agent compared with I-131 for diagnostic scanning and is associated with a lower radiation dose to the thyroid remnant, remaining metastases, and the rest of the body. This may optimize the success of the subsequent I-131 therapy and appropriate selection of patients for this purpose.

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