Prevention of Motion Artifacts on Dual Isotope Subtraction Parathyroid Scintigraphy

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A simple, effective technique is described to identify and eliminate motion artifacts which might potentially invalidate dual isotope subtraction parathyroid scintigraphy. Cobalt-57 markers, appropriately placed on the patient, allow detection of movement and permit realignment if movement occurs between imaging sequences. This technique should assure the accuracy of dual isotope parathyroid subtraction scintigraphy.

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The introduction of dual isotope subtraction scintigraphy has resulted in a resurgence of parathyroid imaging (*1,2*). Many investigators have demonstrated the usefulness of this technique in the evaluation of patients with parathyroid adenomas (*3–5*). Characteristically, a parathyroid adenoma demonstrates discordance between the thallium-201 (^{201}Tl) image and the technetium-99m (^{99m}Tc) pertechnetate image. Often, visual inspection of the planar static images reveals the location of the adenoma; occasionally, subtraction techniques by a computer are necessary to confirm the presence of a small, unsuspected adenoma. However, meticulous attention to detail is required for proper subtraction scintigraphy. With long imaging times characteristic of this procedure, especially when a pinhole collimator is utilized, unintentional movement of the patient during imaging may result in a false-positive focus of thallium activity mimicking an adenoma after subtraction (*7*). Re-registration computer programs to correct patient movement can solve this problem, but are not widely available. Those reported in the literature are either poorly documented or correct only in the X-Y axis and do not correct for rotational motion (*3*). As a noncomputational alternative, a technique using cobalt-57 (^{57}Co) markers has been developed which allows one to detect and correct patient movement during the imaging sequence.

METHODS

This imaging technique is a modification of that described by Winzelberg et al. (*6*). All images were obtained using a large field-of-view (LFOV) Anger scintillation camera with a converging collimator. Simultaneous computer acquisition was performed using a 64 × 64 matrix and a zoom factor of 1.48 (no zoom used on screening image of mediastinum).

Acquisition

Thallium-201 imaging. The patient is placed supine on the imaging table and intravenously injected with 3 mCi (111 MBq) of [^{201}Tl]chloride. A 500,000 count screening image of the lower neck and mediastinum is obtained, usually in less than 5 min, and inspected for ectopic activity. The patient's head with the neck extended is then placed in a sponge cradle. Adhesive tape is placed across the patient's forehead and chin and secured to the sides of the imaging table. Cobalt-57 markers (10 μCi) are placed on the chin and medial aspect of each clavicle (Fig. 1), and secured with adhesive tape. A piece of transparent x-ray film is then cut to size and taped over the persistent scope (P-scope) screen. Using a 122-keV 20% ^{57}Co energy window, the position of the ^{57}Co markers is marked with a felt tipped pen on the transparent film covering the P-scope. Two sequential 500,000 count ^{201}Tl images of the neck are then obtained using 20% windows centered around the three major ^{201}Tl photopeaks (80, 135, and 167 keV). These require, on the average, 5 to 7 min each. Detection of patient motion during the thallium image acquisition is accomplished by inspecting for concordance of the ^{57}Co markers with the ink marks on the P-scope film during acquisition. The ^{57}Co markers are easily seen on the P-scope when three ^{201}Tl photopeaks are employed.

Without altering either camera or patient positioning, 2 mCi (74 MBq) of [^{99m}Tc]pertechnetate are injected intravenously. The photopeak is changed to 140 keV with a 20% window. Five minutes after injection, serial 500,000 count images of the neck are obtained every 5 min for a total of five images. Concordance of the ^{57}Co markers with the ink marks on the P-scope is verified and any possible patient motion corrected by moving the patient (between images), and realigning the ink marks with the visualized ^{57}Co marker activity on the P-scope.

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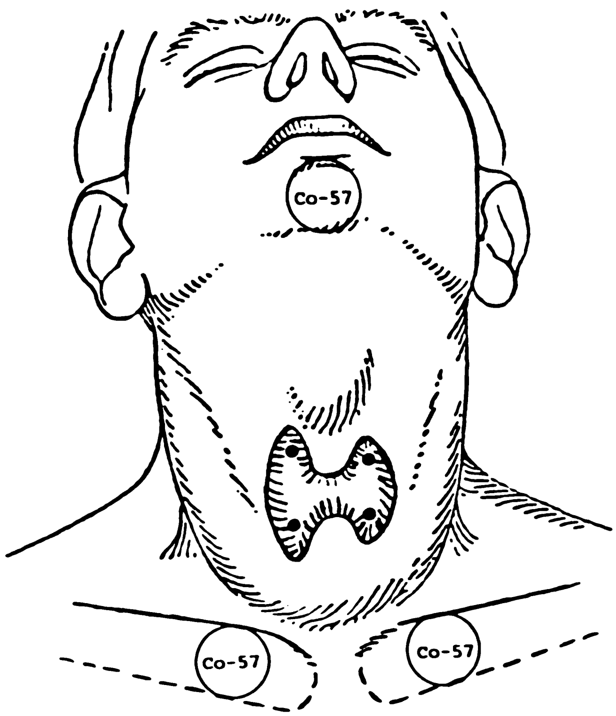


FIGURE 1
Line drawing of surface anatomy demonstrates proper positioning of ^{57}Co markers.

Computer Analysis

Check for motion. After selecting the optimum pertechnetate image, a small square region of interest (ROI), ~5 × 5 pixels, is drawn to encompass each of the ^{57}Co markers. A rectangular ROI is also drawn to encompass the entire thyroid gland. The total counts in the thyroid ROI is determined and recorded for later use in image normalization. The ROIs are then saved to a file for later recall and comparison. A thallium image is then selected that demonstrates optimum thyroid uptake and patient positioning. This is accomplished by sequentially displaying the thallium images, starting with the last one acquired, and recalling from computer memory the ^{57}Co ROIs created on the ^{99m}Tc image.

Normalization of thallium image. The rectangular thyroid region of interest generated on the pertechnetate image is then recalled and superimposed on the ^{201}Tl image. The total number of counts within the thyroid ROI on the ^{201}Tl image is determined and compared to the count data from the same ROI on the pertechnetate image. This count ratio is calculated and used to normalize the ^{201}Tl image to the pertechnetate image.

Subtraction. The pertechnetate image is then computer subtracted from the ^{201}Tl image, and the resulting subtraction image is visually inspected for residual ^{201}Tl activity which might suggest an adenoma.

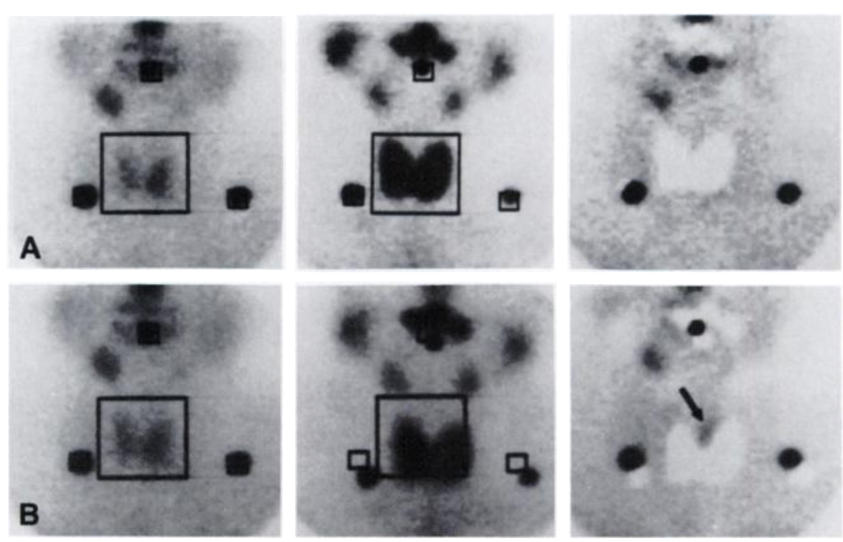
RESULTS

A normal dual isotope subtraction study is demonstrated in Figure 2A. With proper alignment, the subtraction study shows no residual thallium activity to suggest an adenoma, although a right submandibular focus was noted which turned out to be an enlarged lymph node at surgery. We intentionally moved the patient's chin ~2 cm just prior to the acquisition of one of the patient's pertechnetate images. This is clearly demonstrated in Figure 2B by misalignment of the ^{57}Co ROIs comparing the thallium and pertechnetate images, and the resultant subtraction study generated an artifactual focus along the upper medial border of the left thyroid lobe which simulated an adenoma.

DISCUSSION

Dual isotope parathyroid scintigraphy is becoming a widely accepted method for localization of parathyroid adenomas. It has proven to be useful in the evaluation of both the pre-operative patient suspected of harboring an endogenous or ectopic adenoma and the postoperative patient presenting with recurrent chemical evidence of parathyroid disease. Visual inspection of unmanipulated images often discloses the location of large

FIGURE 2
Dual isotope subtraction study in patient proven not to have parathyroid disease. A: In the absence of motion between the thallium image (left) and the technetium image (middle), no residual thallium activity is present on the subtraction image (right) to suggest adenoma. False-positive thallium activity was seen in a surgically proven right submandibular lymph node. B: Intentional movement of the patient between the thallium image (left) and the technetium image (middle) is documented by the ^{57}Co ROIs. Subsequent subtraction image (right) reveals a false-positive thallium focus (arrow) mimicking a parathyroid adenoma.



adenomas and subtraction techniques are frequently rewarding for smaller adenomas. Subtraction does require meticulous attention to detail, including identification and avoidance of patient movement.

The problem of patient motion is related to the amount of attention given to the details of any procedure and with the frequency of performance of an examination. Whether this motion is clinically significant to the interpretation of the dual isotope parathyroid study remains to be answered by a prospective study controlling for motion. Speculating on the significance of motion, detection would seem to depend on size, as it does in other scintigraphic modalities. Consequently, large lesions do not even require subtraction while small ones tend to be better detected by subtraction.

Using ^{57}Co markers should prove to be a simple and efficient method for not only detecting but also correcting movement during the imaging procedure. This method minimally prolongs the patient imaging time, although additional time is required for complete computer processing of the subtraction study. We feel this small increment in time is more than justified by the increased confidence of anatomic alignment of the different isotope images prior to their subtraction.

Recently, several nuclear medicine computer vendors have announced forthcoming software capable of re-registrating any set of computer-acquired images. The ability to re-register computer acquired images offers advantages over any method such as applying ^{57}Co markers in that no particular patient methodology need be observed; the images are subtracted regardless of patient positioning. A limit does occur when the re-registration program provides X-Y axis correction and omits rotational capability. This should prove to be of little significance in the average procedure where some attention is given to patient positioning.

As an alternative to digital subtraction, Okerlund et al. (*8*) have described a color analysis procedure which uses the individual computer-acquired images from the thallium and technetium isotopes. On a pixel by pixel basis, a separate composite color image is created by assigning a color to the intensity of the magnitude of the difference between the two isotopic images; a hue is then ascribed this color based on the ratio of the two pixel count rates. The resultant image is in this manner color-coded; red is assigned where thallium dominates, magenta for less relative thallium amount, and, finally, blue where technetium is dominant. The relative merit of the color composite image over computer subtraction remains undefined.

In conclusion, we have described a simple and inexpensive method for identifying patient movement which allows realignment of the patient during the imaging sequence. This technique should eliminate motion artifacts, thereby assuring the accuracy of dual isotope subtraction parathyroid imaging.

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