Determination of Thyroid Gland Mass Using the Scintillation Camera and Computer

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A scintillation camera-computer method for determining thyroid gland mass prior to ^{131}I therapy for Graves' disease is described. The method was developed to replace an older rectilinear scanner technique previously used. The two methods were compared and the scintillation camera-computer method was found to have a small standard error of the estimate and a high degree of correlation with the rectilinear method.

The weight of the thyroid gland is an important factor entering into the determination of the activity of ^{131}I to be administered for the treatment of hyperthyroidism caused by Graves' disease (*1–2*). The estimation of the gland mass by palpation is subject to wide variations, and the magnitude of the error could have the effect of either under or over treatment with ^{131}I. The original method of measuring the thyroid gland mass using rectilinear scanners and ^{131}I in four patients gave $<6\%$ error when compared to actual thyroid mass weighed after surgery (*3*). Since scintillation cameras have almost completely replaced the use of rectilinear scanners, this study was undertaken to develop a substitute method for measuring thyroid gland mass using a scintillation camera.

MATERIAL AND METHODS

Seventeen patients with Graves' disease were referred to nuclear medicine for evaluation for ^{131}I therapy. Each patient received 5–10 mCi of [^{99m}Tc]pertechnetate intravenously. Twenty minutes later, an anterior rectilinear scan over the neck was obtained using the high resolution focusing collimator followed by an anterior scintillation camera image using a low energy high resolution parallel hole collimator. The standard field-of-view scintillation image was magnified by a factor of 1.93 using a software zoom and was acquired by a nuclear medicine computer into a 64×64 image matrix for 500k counts. A phantom of known dimensions (Fig. 1) was filled with 0.1–0.5 mCi [^{99m}Tc]pertechnetate and imaged in an identical manner.

Both the rectilinear scan and the scintillation camera-computer image were analyzed in order to determine the thyroid gland mass by the following formula:

$$\text{Thyroid gland weight (g)} = \text{area (cm}^2) \times \text{average length (cm)} \times \text{volume factor (g/cm}^3)$$

Rectilinear Method

The thyroid gland area was determined by planimetry of the outline of the scan. The average length was calculated following measurement of the maximum length of each lobe with a ruler. The mass was estimated by using the above formula

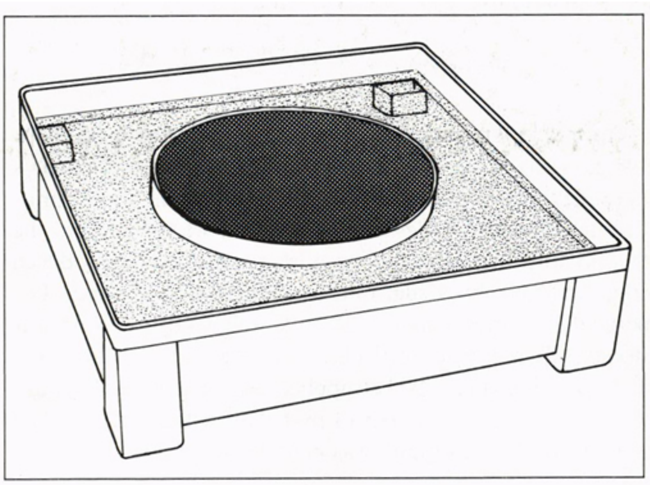

FIG 1. Diagram of the phantom of known dimensions with a diameter of 6.43 cm and an area of 32.5 cm^2.

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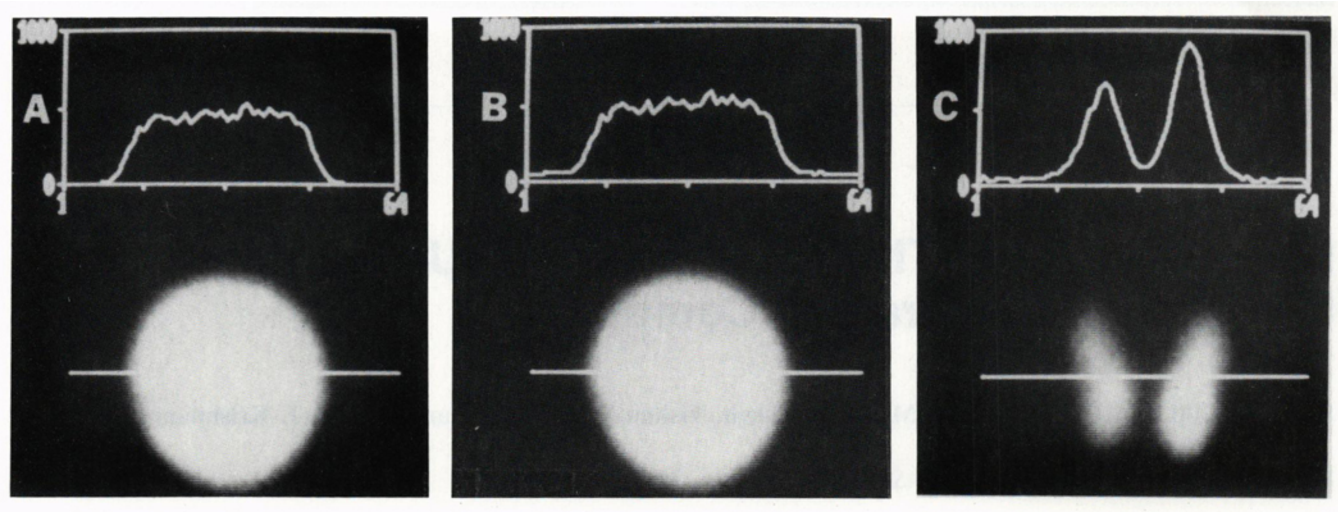

FIG. 2. A) Slice profile through the raw phantom data demonstrating few background counts. This data resulted in a region of interest of 1,573 pixels using a threshold of 10%. B) Slice profile through the phantom data with background counts added to simulate patient data. The region of interest was 1,705 pixels in size with a 10% threshold. C) Slice profile through the patient thyroid gland data. Notice that the background statistics of B and C are alike.

where weight in g = (area in cm²) × (average length in cm) × (0.321 g/cm³) (*1,3*).

Scintillation Camera-Computer Method

This method was based on threshold edge detection of the thyroid gland in comparison to a circular phantom with a diameter of 6.43 cm and area of 32.5 cm². The first step in the analysis was to adjust the background of the phantom so that it had the same statistics as the background in the patient image. This step was necessary to insure that the same region of interest edge threshold was selected for the patient data and the phantom (Fig. 2). A ratio of the background counts to thyroid gland counts was calculated:

$$\text{Ratio} = \frac{\text{cts/pixel background}}{\text{cts/pixel thyroid gland}}$$

Secondly, the number of background counts per pixel to add to the phantom image was calculated:

$$\text{Counts to add} = \frac{\text{cts/pixel phantom} \times \text{ratio}}{1 - \text{ratio}}$$

The number of counts per pixel were then added to the phantom image to create similar background statistics. Both images were then smoothed using a 9-point smoothing algorithm.

A threshold edge detection algorithm was applied to the thyroid image. The threshold was decreased until the produced edge matched the visual outline of the thyroid gland. The percentage varied between 10–20%. This edge outline was stored and the number of pixels over the thyroid were recorded. The same threshold was then applied to the phantom. The edge was stored and the number of pixels recorded (Fig. 3). The area of the thyroid gland was calculated:

$$\text{Area} = \frac{\text{number of thyroid gland pixels} \times \text{known phantom area}}{\text{number of phantom pixels}}$$

The edge outline of the thyroid gland was displayed at the maximum static display size. The length of each lobe was directly measured with a ruler on the CRT screen and recorded. This process was repeated for the diameter of the phantom. The lobe lengths were calculated:

$$\text{Lobe length (cm)} = \frac{\text{lobe length measurement (cm)} \times \text{known phantom diameter (cm)}}{\text{phantom diameter measurement (cm)}}$$

The mean of the two lobe lengths was used in the formula for gland weight. The same volume factor, 0.321 g/cm³, was used.

RESULTS AND DISCUSSION

Figure 4 summarizes our results. It was necessary to correct the scintillation camera-computer measured thyroid gland mass using regression analysis because this method underestimated the gland mass when compared to the rectilinear method. From our results the equation was determined as follows:

$$\text{Thyroid gland mass} = (\text{camera mass} - \text{Y intercept})/\text{slope}$$

$$\text{Thyroid gland mass} = (\text{camera mass} - 10.371)/0.525$$

The most common technical pitfalls of this procedure were: 1) the same threshold percentage must be applied to both the patient data and the phantom data to insure the same edge detection algorithm; and 2) the presence of hyperfunctioning nodules prevented automated thyroid gland edge detection.

For many years the thyroid gland mass, as determined by the rectilinear method, was used to calculate the amount of ^{131}I to be administered for the treatment of Graves' disease (*1*). We were able to replace the rectilinear method with a scintillation camera-computer method to meet this need when

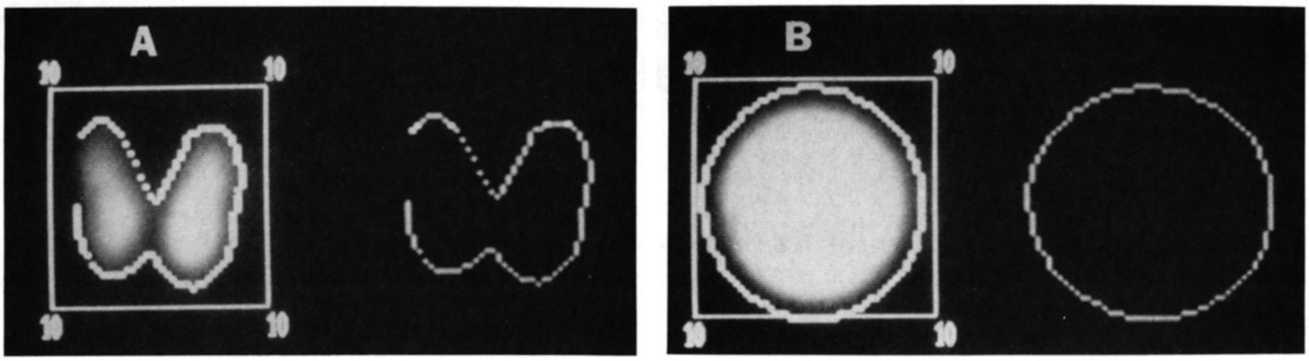

FIG. 3. A) Thyroid gland edge generated by this method. The threshold was reduced to 10% in order to produce an edge outline that displayed a maximum size. B) Phantom edge generated with the identical threshold of 10%. The diameter was measured from this edge outline displayed at maximum size.

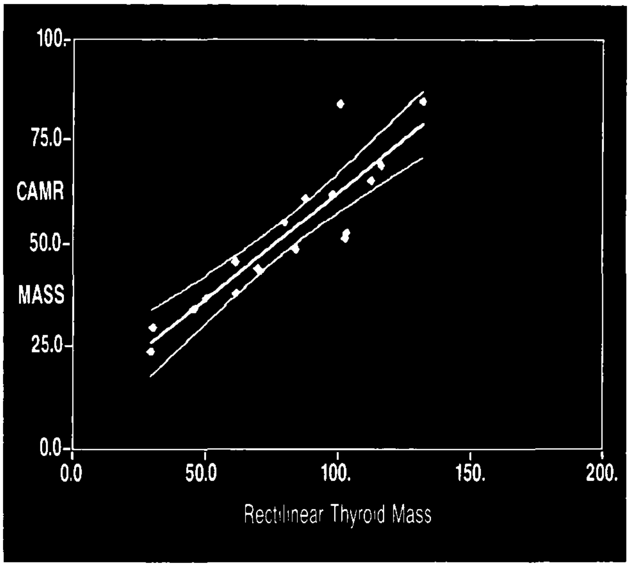

FIG. 4. Correlation of thyroid gland mass as measured by scintillation camera-computer and rectilinear scanner methods. In 17 patients, a correlation coefficient of $r=0.90$ ($p<0.001$) was found, and the standard error of the estimate was 8 g. The line of best fit is displayed as the center line with the 95% confidence limits for mean values on either side.

the rectilinear scanners were no longer in use. The two methods correlated well so that our therapy protocol was not dramatically altered when the rectilinear scanner was replaced.

It was concluded that the thyroid gland mass could be measured using the scintillation camera-computer method. This measurement was accurate and provided for objective quantification of radiotherapeutic ^{131}I.

FOOTNOTE

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