Comparative Dosimetry of High-Detail Computed Tomography Using the Siemens Somatom-2 and Complex Motion Tomography for Examination of the Sella Turcica

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Recent studies have questioned the value of hypocycloidal polytomography of the sella turcica for the diagnosis of pituitary microadenomas because of the substantial number of false-positive and false-negative diagnoses [1, 2]. With the improving image quality available with state-of-the-art computed tomographic (CT) scanners, high-resolution CT appears at least as sensitive as polytomography in diagnosing sellar adenomas [3, 4]. Thus, it is probable that CT scanning will become the optimum test for establishing the diagnosis. In view of this, we believe it is of interest to compare the radiation dosimetry for these two examinations. Therefore, this study seeks to compare CT and polytomographic examination of the sella turcica in terms of radiation exposures received by the thyroid, skin, lens of the eye, and pituitary gland, and also in terms of the "integral exposure," which is a measure of the total ionizing energy absorbed by the head and often is a useful single-number index representing the radiation hazard associated with a radiographic procedure.

Materials and Methods

The dosimetric study was carried out using a wax head phantom and thermoluminescence dosimeters (TLDs). The wax head phantom, which was modeled on the Rando phantom head, neck, and shoulder sections, had a biparietal diameter of 15 cm and an anteroposterior diameter of 20 cm. The TLDs (Harshaw TLD-100 chips, 3 x 3 x 0.9 mm) were affixed on the surface and inside the wax head phantom (fig. 1). Their locations were intended to measure exposures to "skin," "lenses," and "pituitary," and to permit the calculations of "integral exposures." The wax head phantom loaded with TLDs was subjected first to a simulated polytomographic examination of the sella, and then (with fresh TLDs) to a simulated CT study of the sella. Two sets of calibration factors were derived for the TLDs to allow for the difference between the CT and polytomography beam qualities. Using a diagnostic x-ray unit adjusted to match each of the beam qualities in turn, the TLDs were exposed "in air" to a level of a few roentgens, with the exposure simultaneously monitored by a 6 cm³ ionization chamber and electrometer (MDH Industries model 1015C). After this, the TLDs were stored in darkness for 48 hr and then read out on a Victoreen 2800 TLD reader. After subtraction of background readings, individual calibration factors were calculated, and all subsequently measured exposures were converted to roentgens using the appropriate calibration factor for each beam quality. The independence of the calibration factor on exposure level was checked and verified.

The CT examination of the sella is diagrammed in figure 1A. Ten

Fig. 1.—TLD placement and geometry of CT scans (A) and polytomography fields (B).
contiguous 2-mm-thick coronal scans were obtained using a Siemens Somatom-2 scanner, starting at 10 mm posterior to and ending at 10 mm anterior to the sella. Technique factors used were: 10 sec scan, 460 mAs, and 125 kVp. The filtration of the x-ray beam was 0.4 mm of copper plus 2.5 mm of aluminum (effective). The correct alignment of the scan planes with the plane of the TLDs was verified by examination of the CT scan images.

The polytomographic study of the sella is diagrammed in figure 1B. Static exposures were made on a Philips Polytomone three-phase unit with field size of 6.3 × 4.1 cm and a focus-to-fulcrum distance of 122 cm. (In actual patient studies, 49° hypocycloidal motion is used; however, the type of motion will not significantly affect exposures measured.) A lateral scout film was first obtained, followed by 23 lateral 1-mm-thick tomograms starting at 11 mm to the left and ending 11 mm to the right of the midline. Technique factors used for the lateral exposures were 54 kVp, 120 mAs. These were then followed by an anteroposterior scout film and five anteroposterior tomograms of thickness 1 mm, starting at 2 mm posterior and ending 2 mm anterior to the sella. Technique factors used for the anteroposterior exposures were 60 kVp and 180 mAs. Kilovoltage accuracy was verified using a Victoreen Wisconsin Cassette.

For the CT study, the integral exposure was obtained by linear interpolation between measured "skin" exposures and double exponential fitting of the exposures measured inside the head phantom. Single exponential fitting was used to determine the polytomone integral exposure.

Results

Table 1 summarizes the results of the study. Pituitary exposure is about twice as high in the Polytomone examination as in the CT study. Without protective eye shields, the lens exposure in the Polytomone study is much greater than with CT, although, with the use of eye shields, the exposure would be greatly reduced. Entrance exposure is about three times as high in the Polytomone examination as with CT. Thyroid exposure is far higher in the CT study if the sequence of scans intersects the thyroid gland. Finally, integral exposure is about 1.5 times as high in the Polytomone examination as in the CT study.

Discussion

In general, the examination of the pituitary by CT appears to be less hazardous to the patient in terms of radiation exposure than by polytomography. In polytomography, the lens exposure can be significantly reduced by using protective eye shields. In CT, the examination should be performed so as not to allow the thyroid gland to fall within the primary radiation field. It should be noted that the technique factors used in the polytomone study reflect the fact that a fast rare-earth screen-film combination was used. If non-rare-earth intensifying screens were used, all the Polytomone exposures would be at least doubled. However, the Somatom-2 CT scanner is also a very dose-efficient machine, and, if a less dose-efficient CT scanner were used, the CT exposures would also be increased. In this context, we believe that the comparison we have made in this study is not particularly biased toward either imaging method. The fact that the head phantom used was fabricated out of wax rather than a more realistically tissue-equivalent material would tend to bias the pituitary and integral exposures in favor of the CT examination. However, we do not believe that this factor would affect our general conclusions that, at this institution, the CT examination of the sella turcica involves lower radiation exposure to the patient than does the polytomographic examination.

References