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USE OF THE MAGNIFYING OR CONVERGING COLLIMATOR IN BRAIN SCANNING

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Higher resolution in brain scanning is achieved by the use of magnifying or converging collimators compared with the resolution obtainable using standard parallel-hole collimators. A low-energy 9,500-hole magnifying collimator system with magnifications of 20–40% exhibited the same or better resolution with 2.5x–3x the efficiency of a parallel 15,000-hole, high-resolution collimator system. Comparative studies indicate that the use of a low-energy magnifying collimator may be the technique of choice for routine brain scanning.

The theoretical basis for the use of magnifying or converging collimators with gamma cameras has been given along with line and volume phantom studdies (*1*). It was demonstrated that magnified scans display better resolution than scans from equivalent straight-bore gamma camera collimators. Magnification has also been proposed for use in gamma camera tomography (*2*).

The present work was done with a view toward evaluating the use of magnifying collimators for broad, clinical applications with the focus on the brain scan. The goal was to optimize the use of the available camera crystal area, much of which is unused in standard scanning applications such as brain scanning, and thus to achieve higher resolution without effective loss of field of view or sensitivity.

MATERIALS AND METHODS

The original studies were done in several patients with abnormal brain scans. They consisted of a comparison between the standard 4,000-hole straight-bore collimator with a 1,200-hole inverted diverging collimator machined to be usable in the magnifying mode. The FWHM of these two collimators for 140-keV gamma rays was found to be about 1.2 cm using a line phantom in air (*1*).

Most recently we have been using an 11,500-hole low-energy diverging collimator (*3*) inverted to act as a 9,500-hole magnifying or converging collimator. This collimator was compared for both normal and abnormal patients with a Nuclear-Chicago 15,000-hole, straight-bore, "high-resolution" collimator. The FWHM of the low-energy magnifying collimator with standard Nuclear-Chicago Pho/Gamma camera was estimated to be 1.1 cm below 2 in. collimator-to-source distance in air. The FWHM of the low-energy high-resolution collimator with standard Pho/Gamma camera as estimated from data supplied by Nuclear-Chicago Corp. (*4*) was 1.2 cm for collimator-to-source distance in air of less than 2 in. More significantly, however, the improvement in the intrinsic part of the camera MTF for magnifications of better than 20% was calculated using the theoretical discussion of Ref. *2*. Using an intrinsic camera FWHM of 1.1 cm (*4*) and magnification of 20%, the ratio of the MTFs with and without magnification was calculated to be: exp $(2.0\ f^2)$, where f is the spatial frequency in cm^{-1}. Typically then for a spatial frequency of ½ cycle/cm, the improvement in MTF would be over 50%. The relative

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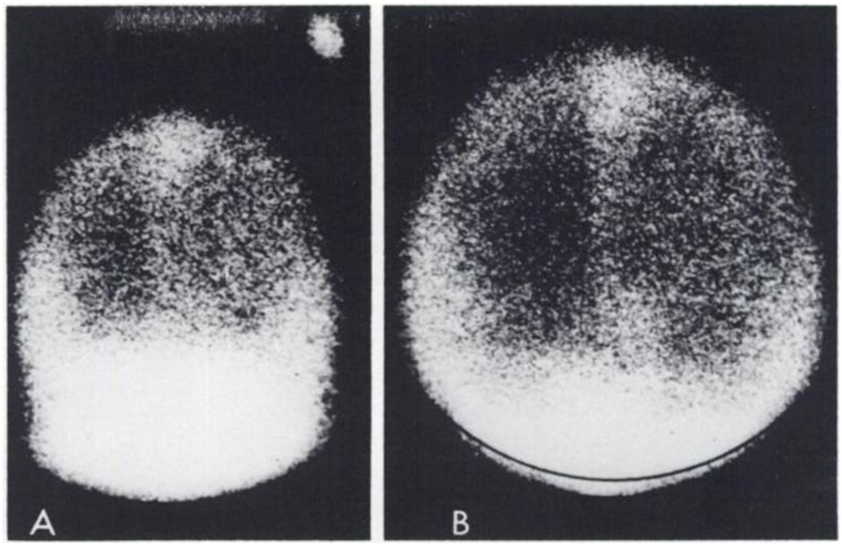

FIG. 1. Anterior view of 59-year-old woman with pathologic diagnosis of metastatic carcinoma to corpus callosum. A is view with 4,000-hole straight-bore, medium-energy collimator. B is view with 1,200-hole medium-energy inverted diverging collimator.

sensitivities were measured by determining the ratio of the number of dots counted on a 1-sec exposure of a 70-mm film using the same physiological area for each collimator. The sensitivity of the low-energy collimator was found to be 2.5× to 3× that of the high-resolution collimator.

RESULTS

In general, it was found that the small number of holes in the 1,200-hole inverted diverging collimator made its sensitivity insufficient to allow its use in general screening. However, repeat magnified scans to elucidate areas of suspicion found using the 4,000-hole straight-bore collimators sometimes showed significant clarification. In Fig. 1, the 4,000-hole straight-bore collimator did not clearly resolve the inferior frontal lesion as well as did the magnifying collimator on the anterior view.

In the most recent studies to compare statistically similar scans of the brain with respect to overall visual resolution using the two collimators, the counting times for the high-resolution collimator scans were increased by a factor of 2.5–3.0 above those for the corresponding low-energy magnifying collimator scans. In most cases, the magnified views showed resolution equal to that obtained with the high-resolution collimator (Fig. 2). On a few occasions (Figs. 3, 4) the nature of the lesions was more clearly defined on the projection done with the magnifying collimator.

No artifact related to the use of the magnifying collimator has been found to be significant in over 600 brain scans. One observer (*5*) has reported that if the converging collimator is used on the posterior view, obliquity considerations may cause the normally hot oropharynx to project onto an occipital location or into the posterior fossa. In our experience, this artifact was related solely to insufficient flexion of the head (Fig. 5) and was occasionally seen even with straight-bore collimators.

In addition, it was observed that although more care must be taken in positioning the patient, there is usually no loss in effective field of view using the new collimator.

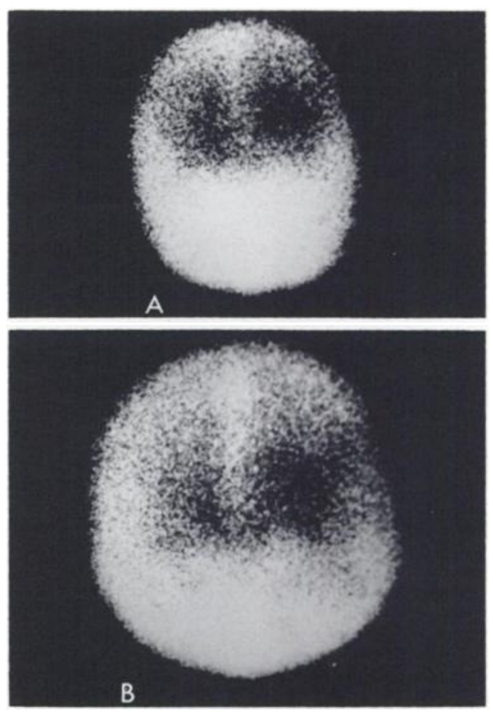

FIG. 2. 50-year-old woman with history of two grand mal seizures in last year prior to admission. On physical examination there was mild right facial paralysis and slightly increased deep tendon reflexes on left. Carotid angiogram revealed aneurysm of left internal carotid at bifurcation. A is anterior view using 15,000-hole high-resolution collimator showing area of increased uptake in left inferior frontal region in paramedial location. B is anterior view using 11,500-hole diverging collimator in magnifying or converging mode showing focal area of increased uptake in same location and to same extent.

DISCUSSION

Recently, scans of the human thyroid and of myocardial blood flow in dogs as well as scans of phantoms have been presented, comparing the performance of magnifying collimators having under 1,000 holes and 2× magnification with a pinhole collimator (*6*). It was concluded that magnifying collimators do not have broad general application and are limited to small thin objects of interest.

Our experience with the use of the low-energy magnifying collimator in routine brain scanning suggests that the clinical utility of these collimators is wider than has been originally indicated. The sensitivity of the low-energy magnifying collimator is 2.5× to 3× that of the high-resolution collimator, yet the resolution is no worse. In spite of the fact that only a 20–40% magnification is obtained, a significant increase in visual resolution is achieved without unduly limiting the size of the object of interest. This seems to indicate that the new magnifying collimator combines the best features of the two Nuclear-Chicago 15,000-hole low-energy collimators: high resolution and high sensitivity. A more optimal compromise between sensitivity and resolution is achieved using the new collimator than is currently available using either a straight-bore 15,000-hole collimator or pinhole collimator. Consequently, it is suggested that the low-energy magnifying collimator can be used as the collimator of choice even when there is a heavy caseload of brain scans. Other clinical settings in which low-energy magnifying collimators may be of value in the future are routine scanning of small organs such as kidney, thyroid, heart, and, in general organ scanning of pediatric patients.

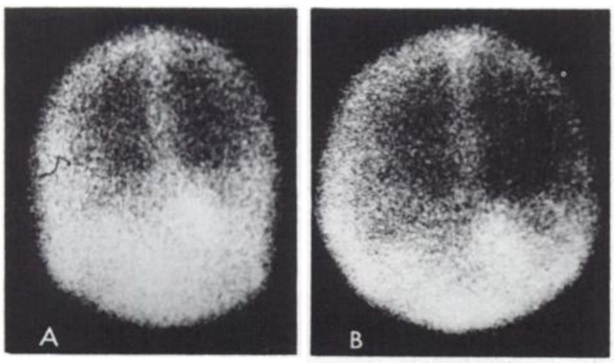

FIG. 3. 66-year-old man with 1-year history of headache and tendency to fall to left. Positive findings on examination included bilateral papilledema, slight ataxia with left hand, and slightly more active knee jerks on right. At operation, hemangioblastoma of right cerebellar hemisphere was found. A is posterior view with 15,000-hole high-resolution collimator showing increased uptake in right cerebellar hemisphere near cerebellopontine angle. B is posterior view with 11,500-hole diverging collimator in magnifying or converging mode showing better definition of lesion.

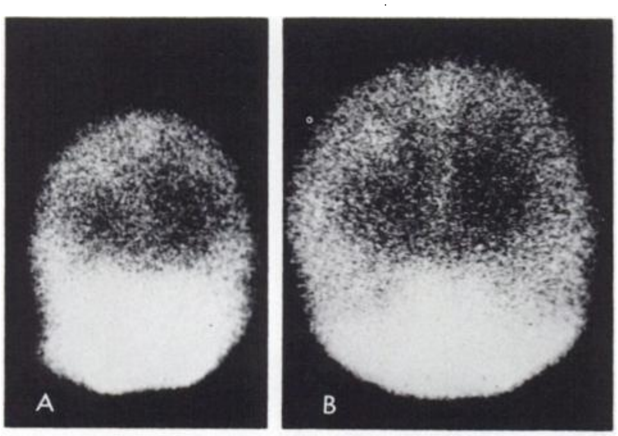

FIG. 4. 72-year-old woman with sudden onset of left side paresis. Dynamic study showed decreased perfusion in right hemisphere in arterial phase. Clinical impression was right hemispheric cerebrovascular accident. A is anterior view with 15,000-hole high-resolution collimator showing increased activity in superior portion of right hemisphere. B is anterior view with 11,500-hole diverging collimator in magnifying mode showing better delimitation of lesion.

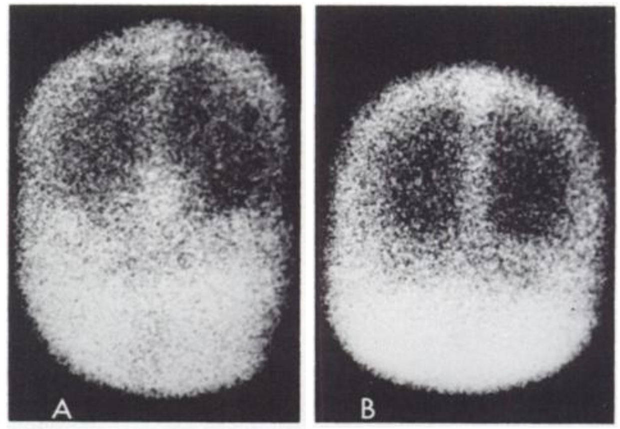

FIG. 5. Posterior views of normal patient with 11,500-hole diverging collimator in magnifying mode. A is poorly flexed posterior view showing "pseudo-lesion" due to projection of oropharyngeal activity onto right occipital area. B is properly flexed posterior view which fails to confirm any abnormality of uptake in right occipital region.

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