A Contiguous-Slice Design for Single-Photon Emission Tomography (SPECT)

Ernest M. Stokely

The University of Texas Health Science Center at Dallas, Dallas, Texas

Recent multislice, single-photon emission tomographic systems produce nonoverlapping transverse-section images, requiring repositioning of the patient and repeated studies to obtain a complete set of cross-sectional data. A complete, overlapping set of transverse-section images can be obtained by designing a collimator with alternating, staggered centerlines that are offset in the slice dimension.

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Multiple-crystal, multidetector, single-photon emission tomographic (SPECT) systems have recently been introduced for cross-sectional imaging of the head (*1–4*). The high sensitivity shown by these systems, when compared with SPECT systems using a rotating camera, is due to the more effective design of focusing collimators and the ability to move the detectors close to the organ being imaged. The shortcoming of the collimators incorporated in these non-Anger devices is the inability to produce contiguous transverse sections without axially translating the device or patient. The ability to sample contiguous sections is particularly important for rapid studies such as regional measurements of cerebral blood flow (rCBF) with Xe-133. Patient repositioning is practical for static imaging studies when the localization of the radiopharmaceutical is stable with time. Figure 1 is a schematic of the line-spread function for a system that provides transverse sections simultaneously.* Note that two complete sections of information are missed by the present collimator (arrows). The clinical significance of missing data from 2-cm gaps is obvious. This problem is exemplified in Fig. 2.

NEW METHOD

The three slices from the tomograph* are 4 cm apart, each slice having a 2-cm FWHM axial resolution. A new collimator design is recommended to produce contiguous-slice information. The design is similar that of a TCT collimator proposed by Kwoh et al. (*5*). The layout of the collimator centers is shown in Fig. 3. Alternating detectors are displaced by 50% of the crystal height in the slice dimension. Interlaced cross-sectional images are produced by detector groups 4, 5, and 6. The slice-dimension line-spread functions of this collimator arrangement are shown in Fig. 3.

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For reprints contact: Ernest M. Stokely, PhD, Dept. of Radiology, The University of Texas Health Science Center at Dallas, 5323 Harry Hines Blvd., Dallas, TX 75235.

DISCUSSION

Two considerations must be given to this detector-collimator geometry. First, is the linear sampling along the projection, which is halved by this arrangement, still adequate to support the desired transverse-section resolution? Second, will the system's sensitivity support the reduction in the number of counts per slice?

In this instrument* the physical crystal width is 1.3 cm. In both it and the Kuhl-Edwards Mark IV (*1,6*), a decrease in the linear sampling distance in the transverse plane can be achieved, being proportional to the number of detector arrays (i.e., the number of offsets). Since the instrument has four detector arrays, the linear sampling distance between interlaced detector centerlines can be reduced to 0.325 cm in the transverse plane, a distance that will support resolutions greater than 0.65 cm (Nyquist sampling interval). In the proposed contiguous axial sampling scheme, the detector's array offset will be used to double the axial sampling; thus the sampling in the transverse plane will be reduced by a factor of 2, lowering the intrinsic transverse resolution. The expected intrinsic resolution with the contiguous-slice collimator is 1.3 cm. This resolution is adequate to support the resolution of the present collimators (1.3–1.8 cm).

The second consideration, a loss of sensitivity, occurs because the overall count rate of the present system would be divided among six slices rather than three. Our early clinical results with

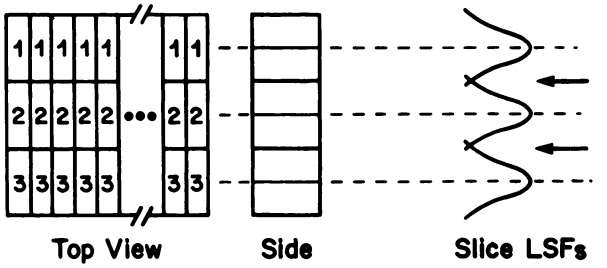

FIG. 1. Line-spread functions in axial dimension for present collimator-detector system used by Tomomatic 64.

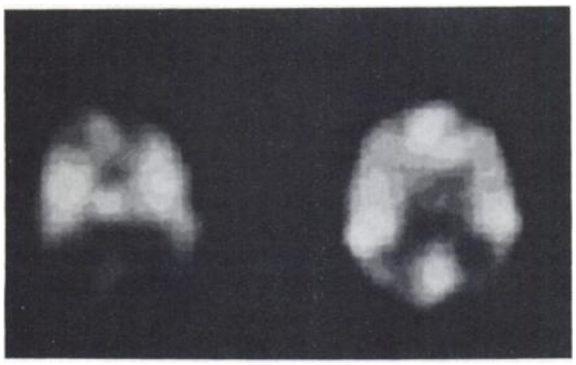

FIG. 2. Studies from a patient with inferior occipital-lobe stroke. Right-hand section, at 7 cm above canthomeatal line, is from an initial study of cerebral blood perfusion; it indicates little ischemia in posterior portion of brain. Left-hand section is from repeat study 30 min later with patient repositioned 2 cm; it shows large area of occipital-lobe ischemia at 5 cm above CM line, not seen in previous study.

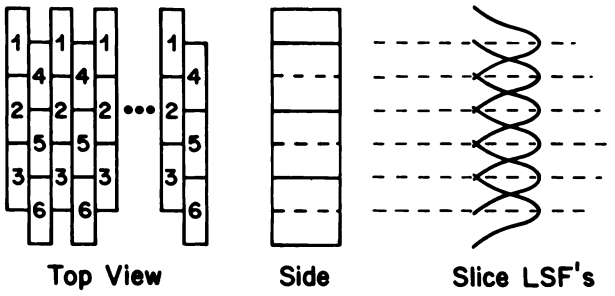

FIG. 3. Line-spread functions in axial dimension for proposed contiguous-slice collimator-detector system.

the noncontiguous collimator show that the advantages for contiguous slices will offset a reduction in the effective resolution, which in this system will be improved by incorporating improved techniques for attenuation correction and scatter rejection. The sensitivity and resolution can also be improved by the use of Xe-127.

FOOTNOTE

* Tomomatic-Medimatic A/S, Gersonsvej, Hellerup, Denmark.

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