《招待講演》

Pinhole Scintigraphy of Bone and Joint: A Breakthrough of Nonspecificity of Conventional Scintigram

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For those who are familiar with the piecemeal analysis of roentgenogram it is rather queer to notice that scintigraphic images were not subjected to such an analytical approach leaving the problem of nonspecificity of scintigraphic examination unsolved. The reason is obvious. It is due to well known poor resolution of the ordinary scintigram and even the application of SPECT has contributed little in overcoming this drawback. By principle, piecemeal analysis of morphological changes is based on the observation of shape, appearance or contour, position, size, and internal architecture of anatomical structures such as bone and joint. The conventional or standard scintigram obtained with parallel-hole collimator does not disclose anatomical details sufficiently enough to make use of such an analytical approach in the morphological diagnosis of bone and joint diseases.

After eight years of the clinical use of pinhole scintigraphy (PS) in diagnosing various bone and joint diseases, we have become convinced that PS made with a pinhole collimator with appropriate aperture size is an important, practical breakthrough of nonspecificity of conventional scintigram by revealing the topographic characteristics individual bone and joint both in the normal and pathologic conditions. We have found that the quality of PS image in terms of resolution is almost comparable to that of roentgenogram as far as gross anatomy is concerned.

The present communication describes technical, methodological, and clinical aspects of PS as it has been applied in the diagnosis of some 465 cases of various bone and joint diseases. The paper report the results of (1) a systematic sequentitative assessment of the diagnostic value of the findings revealed by PS to evaluate its usefulness objectively and (2) a series of clinical study on various bone and joint diseases to sort out specific findings of each disease group and to compare such PS findings with those of x-ray examinations.

The first-stage study involved analysis of informations obtained from 72 cases of various bone and joint diseases in addition to a group of normal controls by comparing the image quality, in terms of anatomy, shown by single-pass-area scanning (SPAS), single-spot-scintigraphy (SSS), and PS. The gamma cameras used were either an Ohio Nuclear Sigma 407, a Siemens Scintiview II, or Digitrac 7500 with 2-, 3-, or 4-mm pinhole collimator.

PS images were made 2 hours after intravenous injection of 15–30 mCi of technetium-99m methylene diphosphonate (MDP). The collimator-face-to-target distance was 3–8 cm and detector-to-collimator-face distance was 21 cm or 37 cm according to the type of machine. 400 K–500 K counts were accumulated in 25–60 minutes according to the bone or joint examined. The time required for the accumulation of 10 K counts was 76.35 sec, 57.41 sec, and 31.67 sec with 2-mm, 3-mm, and 4-mm pinhole collimator, respectively.

The biological effects of the injected MDP (15/30 mCi, child/adult) was 0.5/1 rad to bone and 0.1/0.3 rad to gonads. Such radiation doses were much less than those of calcium-47 (2.5/0.3 rad, bone/gonads) strontium-85 (4.0/0.3 rad), and fluorine-18 (1.8/0.3 rad).

The quality and anatomical detials of each image of SPAS, SSS, and PS were assessed by 3 radiologists using an arbitrary scoring scale of 1, 2, and 3 according to the resolution. Grade 1 represented positive findings without detail, grade 2 a

hot or cold area with somewhat disernible anatomy, and grade 3 an excellent demonstration of the anatomy. The relative diagnostic specificity of SPAS, SSS, and PS was 1.35 ± 0.76, 1.63 ± 0.55, and 2.93 ± 0.61, respectively. The difference between each display method was highly significant with an especially high value for PS.

The second-stage study involved the sorting out of diagnostically significant findings of various bone and joint diseases, with an emphasis on the differential diagnosis of metastatic cancer, compression fracture, infections, spondylosis, end-plate based vertebral sclerosis, facet syndrome of the spine. The PS findings were analyzed also in arthritides, osteitis, transient synovitis, avascular necrosis of the hip, fractures, meniscus tear of the knee joint and such relatively rare diseases as chondromalacia patellae, slipped femoral epiphysis, Stieda-Pellegrini's disease, and others. At the same time those PS findings were correlated with x-ray findings in each disease. The importance of different projections to localize more specifically the pathologic change to a definitive anatomical site of the skeletal system was emphasized.

The use of PS resulted in significant improvement of the specificity of scintigraphic findings. The anatomical structures such as the pedicle, facet joint, neural arch, and spinous process of the vertebra and the epiphysis, physeal line, metaphysis, subchondral bony layer, and the joint cavity of the hip, knee, ankle, and other joints were distinctly discerned. In summary (1) The PS image was roughly comparable to that of x-ray and (2) PS was an easily practicable solution to the problem of the nonspecificity of multihole-collimator planar image. Therefore PS should be a part of scintigraphic examination when differential diagnosis is critical and a scintigraphic machine dedicated solely to PS imaging is to be developed to save time and reduce radiation hazards.

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Clinical Applications of SPECT with Special Reference to Oncology

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Single photon emission tomography SPECT has been used in nuclear medicine since the early 1960's when Kuhl and Edwards developed a rectilinear scanning system for use in neuronuclear medicine. Tomography is now used extensively for diagnosis by ultrasound, x-ray CT scanning and magnetic resonance imaging. The improvement in quality of the images is due to the enhanced contrast produced by the tomographic technique. Radioisotope emission tomography has special problems which are produced by the low information density in the images. However recently several developments have occurred which have greatly enhanced the value of SPECT in clinical practice. New radiopharmaceuticals have been become available which concentrate to relatively high levels in the pathology than in the normal surrounding tissues. Examples include MIBG, Tc-99m HM-PAO, labelled antibodies and of course bone imaging agents. Radioisotope imaging equipment has improved dramatically with the development of high resolution stable detectors with good uniformity, fast computing and good operator interactive displays. The result has been a great improvement in the clinical images from tomographic examinations which are available in seconds after the acquisition has been completed. However these results can only be obtained with the application of good quality control and the correct use of filters to match the clinical situation (1).

Emission tomography is used for diagnosis and research in most organs of the body.