Current development and future aspect of Emission Computed Tomography

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PROGRESS AND PROBLEMS IN INSTRUMENTATION OF EMISSION COMPUTED TOMOGRAPHY.

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Utilization of single photon emitters and positron emitters in nuclear medicine plays an important role for delineation of biomedical mechanism. Efforts to obtain good quality images for diagnosis lead to an idea of section imaging techniques, as well known by the first trial reported by Kuhl and Edward in 1963, resulting later in progress as emission computed tomography. In those days scintillation scanners were in the palmy days as instrumentation for diagnostic imaging in nuclear medicine. Recalling those days we feel as if we were separated by an age. After a quarter century passing, the instrumentation of emission computed tomography has splendidly developed, being closely connected with the development of electronics. As we can see in history gamma cameras were realized by coming of the transistor age. Success in positron emission tomography is owing to coming of the integrated circuit age. Computer age has been indispensable to development of emission computed tomography instrumentation. The first device of the positron emission tomography was explored with NaI(Tl) scintillation detectors. These detectors were soon replaced by bismuth germanate crystal because of its high detection efficiency to annihilation photons and non-hygroscopicity. These features have pushed the development of high resolution positron emission tomographs. Usefulness of positron emission tomography has been shown by a number of brain and body studies with multi-slice ring detectors. Newly developed detectors for high resolution positron emission tomographs are reviewed together with tomographic systems utilizing time-of-flight information with a promissible scintillator of BaF_2 crystals. Single photon emission computed tomography devices are also reviewed. The application of gamma cameras to the emission computed tomography has required more precise performance of the gamma cameras such as uniformity, linearity and mechanical performance of centering of rotating detector head to eliminate artefacts from resultant images. Consequently we can see improved image quality with such gamma camera systems. System resolution has been improved by putting the detector as close to a patient as possible, to avoid camera-shoulder contact by selective reduction of camera shielding or 30° angulation of camera head with slant hole collimation. Several types of multi-detector ring systems are reviewed. These systems offer the advantages of high sensitivity and rapid data acquisition, but they provide a few slices. To improve quantitation of single photon emission computed tomography, more sophisticated software for absorption correction is required to explore with a way such a weighted back-projection method.

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MAJOR FACTORS AFFECTING QUANTITATION IN SPECT IMAGING AND THEIR CORRECTIONS.

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With the current development of rotating gamma camera systems, single photon emission computed tomography(SPECT) is now widely used as an important tool in diagnostic nuclear medicine. Nevertheless, at present the quality of SPECT is not necessarily satisfactory for a quantitative physiological study due to the poor sensitivity and resolution of the SPECT system, the incompleteness of the attenuation compensation and the Compton-scatter correction, etc.. For further development of SPECT, these problems are needed to be overcome.

The major factors affecting quantitation in SPECT imaging are summarized as follows; 1.reconstruction algorithm, 2.gamma camera and collimator performance, 3.physical aspects, and 4.physiological aspects. We have investigated these factors and searched for the practical correction methods for them by a computer simulation and phantom studies. In this symposium, the problems were payed attention in applying to the clinical field or in developing the software for correcting the above factors, taking the attenuation correction, the Compton-scatter correction and the respiratory-motion correction as examples.

As to the gamma-ray attenuation correction, various algorithms have been proposed, which are classified into three types; pre-correction, post-correction and iterative-correction methods. The usefulness of these algorithms were compared one another using the mathematical phantoms with various activities, uniform or non-uniform distributions of the tissue attenuation coefficients and errors in determining a body contour. The more practical algorithm is desired, which is also applicable to the case with a non-uniform distribution of the attenuation coefficients.

For consideration of the Compton-scatter effect and its correction, we need to estimate the content and the distribution of scattered photons accurately. We tried it using the Monte Carlo technique. Furthermore, we tried to correct the Compton-scatter effect by a digital filter which was convolved with the projection data, and compared it with the methods proposed previously such as a dual energy-window method. Although our method caused a good result in the scatter correction, the more accurate and practical method is desired for estimation and correction of the scattered photons.

The physiological motions such as a respiratory movement affected not only the quantitation but also the lesion detectability in SPECT. For correction of these factors, the gating method was used, and it is considered to be available.