K. Heart, Lung and Peripheral Circulation

Computer Processing on the Determination of Total and Regional Pulmonary Functions (Functional Imaging) Using ^{133}Xe

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The purpose of this paper is to investigate the computer processing for the determination of total and regional pulmonary functions using ^{133}Xe. A dose of about 4 mCi of ^{133}Xe was used for perfusion study and 8 mCi for inhalation study. Sequential 2 second frames in 64×64 matrix form were acquired with a joint camera-computer system (GCA-202, DAP-5000N). Pulmonary function indices of IC, FRC, TLC, IC/TLC, FRC/TLC and mean transit time (MTT) were estimated for each of the total, left and right lungs, and printed out automatically.

For the assessment of the regional pulmonary functions, functional imaging was performed using four indices of normalized ventilation ($\dot{V}$) index, normalized perfusion ($\dot{Q}$) index, ventilation-perfusion ratio ($\dot{V}/\dot{Q}$) and MTT as parameters. Also, relative standard deviations (RSD) for each of these parameters were computed to examine the statistical error for this processing. The computed values for overall matrix elements were displayed on a CRT with calibration dots and ercorded by a polaroid camera.

The effect of the map smoothing on the quality of the functional images were examined observing the functional images smoothed with various filter factors and the respective RSD maps.

In view of the resolution and the statistical error, the map smoothing with filter factor of 10.2 appeared most suitable. In normal case, each functional image of four parameters processed by this suitable condition presented diffuse distributions. The mean values of RSD for overall matrix elements over the lung field were about 7 percent in the $\dot{V}$ index, the $\dot{Q}$ index and the $\dot{V}/\dot{Q}$ functional images and about 5 percent in the MTT.

It is considered that our method of ^{133}Xe pulmonary function study with the on-line computer system is of special values for clincial use, since total and regional pulmonary functions were either automatically printed out or displayed in the form of images with a few minutes.

Clinical Evaluation of the On-line Computer-aided Pulmonary Function Study Using ^{133}Xe

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Clinical evaluation of on-line computer-aided ^{133}Xe pulmonary function study was discussed. In this method, estimated values for the total and differential lung function indices are automatically printed out and regional functions are displayed as functional images which have a frame mode with 64×64 matrix (0.5 cm $\times$ 0.5 cm of unit area) showing continuous distribution of estimated values for each of various pulmonary function indices as brightness. All studies were performed in upright sitting position.

In normal subject $\dot{Q}$-image showed increasing

brightness from apex to base of the lung representing the gravity dependent gradient. The brightness for the base was 3~4 times as much as the apex, $\dot{V}/\dot{Q}$-images showed inverse distribution. In cases with mitral stenosis, $\dot{Q}$-images showed just inversion of normal pattern, descresing from the apex to the base, while $\dot{V}$-images showed diffuse distribution. In pulmonary thrombosis, the affected areas were shown as cold areas in $\dot{Q}$-images and hot areas in $\dot{V}/\dot{Q}$-images, indicating the effect of dead space. In chronic obstructive lung disease, each of total and differential lung volume for TLC, FRC, FRC/TLC was increased. Both $\dot{V}$-images and $\dot{Q}$-images showed multifocal irregular distribution. MTT-images showed multifocal areas with delayed washout by which the extent and the degree of the obstruction were estimated.

This on-line computer-aided ^{133}Xe pulmonary function study facilitates the quantitative determination of total, differential and regional pulmonary functions and is considered very useful for diagnosis and follow up of various lung diseases.

Dynamic Analysis for Regional Pulmonary Function Using ^{133}Xe

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Using ^{133}-Xe, a Xenon lung function unit (Nuclear Associates, Inc.) and a large area scintillation camera (the effective field, 34 cm in diameter), combined with the computer system (TOSBAC 3400 Model 31), the regional pulmonary function was evaluated in 8 normal subjects, 13 patients with PSS (progressive systemic sclerosis), 7 patients with FLD (fibrosing lung disease) and 16 patients with COLD (chronic obstructive lung disease). As the regional pulmonary function together with the data of pulmonary function (%VC, $FEV_{1.0\%}$, PaO_2, and so on), ventillation index ($\dot{V}$) and perfusion index ($\dot{Q}$) were obtained by single breath method, and clearance half time ($T_{1/2}$) and ratio of disappearance constant (λ_i/λ_t) were calculated from wash out curves for equilibrated ^{133}-Xe gas in the steady state. Statistical Analysis was performed for these data. Preliminary results obtained are as follows.

(1) Results of the principal component analysis by using the data of total pulmonary function suggested that the normal subjects, the patients with PSS, FLD and COLD were effectively distinguished each other.

(2) As the results of the analysis with the parameter of regional pulmonary function in each division of lung field, in the case of the $\dot{V}$, $\dot{Q}$, $T_{1/2}$, the normal and the abnomal groups might be separated with high probability. But the effects of the discrimination between the groups of the abnormal were inferior to those with the data of total pulmonary function measured by the spirometer.

Data Processing for Regional Ventilation Study Using ^{133}Xe

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We made a computer program for the convenient processing of the data obtained in regional ventilation study, which has beenused for clinical diagnosis.