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EVALUATION OF REGIONAL PULMONARY VENTILATION USING POSITRON EMISSION TOMOGRAPHY AND N-13 NITROGEN GAS: (1) PRINCIPLES AND METHOD.

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We have developed a new method to evaluate regional pulmonary ventilation quantitatively using N-13 labeled nitrogen gas which is 13 times less soluble in blood than xenon. The nitrogen gas is produced from CO_2 through (p,α) reaction in a baby cyclotron, Cypris.

The subject is allowed to rebreathe 20mCi of radioactive nitrogen gas diluted with 15 liter of oxygen gas in a closed circuit. After the global activity of the lungs reaches equilibrium a 3-minute scan (EQ) is performed. Then the patient inspires the room air to wash out the radioactive nitrogen gas and another scan (WO) is performed during the washout phase.

The EQ image has delineated defects caused by pulmonary arteries. The regional activity in WO phase images divided by that in EQ should yield time constant of regonal ventilation on condition that regional activity follows single exponential compartment model and the dead space is disregarded. Thus our mothod provide regional pulmonary ventilation parameters quantitatively and in high resolution.

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FUNCTIONAL MAP DISPLAY OF POSITRON GASES FOR ASSESSMENT OF DIFFUSION IN DISEASED LUNG.

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$C^{15}O_2$, $^{11}CO_2$ and ^{11}CO were produced by an in house cyclotron to assess regional diffusing capacity of the lung.
Using a γ-camera, breath holding images were taken serially after inhalation of the positron gases. Regional clearance rate was obtained by computer analysis of first exponential component of the time-activity curves. Regional clearance indices were calculated as (initial-10 sec. images)/initial images, which was displayed as functional map.
5 healthy volunteers and 15 patients with COPD and 15 with Pulmonary fibrosis were studied.
The whole lung clearance rate correlated well with DLCO/VA. The functional map showed higher clearance in lower lung field in normal controls and dicreased clearance in the area corresponding to perfusion defects in COPD and Pulmonary fibrosis. Whereas, in certain fibrotic lung dicreased clearance was also observed in regions with no evidence of perfusion defects.
The functional map display of positron gases is an useful indicator of the regional diffusing capacity of the normal and deseased lung.

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EVALUATION OF REGIONAL PULMONARY VENTILATION USING POSITRON EMISSION TOMOGRAPHY AND N-13-NITROGEN GAS - (2) COMPARATIVE STUDY WITH XE-133 VENTILATION STUDY.

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Xe-133 have been widely used for evaluation of regional pulmonary ventilation. However, its significant solubility in blood and low energy gamma-ray emitted by Xe-133 limit the accuracy of ventilation study. Our new ventilation study using positron emission tomography(PET) and N-13 probably overcomes most of these problems because of low solubility of N-13 in blood and precise attenuation correction of PET. Fifteen patients including 13 with chronic obstructive pulmonary disease underwent PET with N-13 and Xe-133 studies. Compared to Xe-133 images, PET images proved to be more sensitive for detection of mild obstructive changes than Xe-133 images. PET images also demonstrated peripheral air trapping in patients with chronic bronchiolitis or bronchial asthma, and irregular areas of ventilation abnormality in the central zone of the lung in patients with pulmonary emphysema. PET with N-13 seems to be useful for more accurate localization and quantitation of ventilation abnormality.

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EVALUATION OF REGIONAL PULMONARY VENTILATION USING POSITRON EMISSION TOMOGRAPHY AND N-13-NITROGEN GAS - (3) COMPARATIVE STUDY WITH CT.

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Recently, transmission computed tomography(CT) has been introduced for evaluation of morphological changes occurring in pulmonary parenchyma. Our new ventilation study, PET with N-13, also provides tomographic images of ventilation abnormality with high spacial resolution. Thus, it has been possible to compare ventilation abnormalities with morphological changes on tomographic images. Ten patients underwent PET with N-13 and CT. In a patient with interstitial pneumonitis related to collagen disease, CT revealed fibrotic changes in subpleural areas. These abnormal areas showed decreased radioactivity on equilibrium image of PET while washout image was normal. In patients with chronic bronchiolitis, Peripheral air trapping was frequently demonstrated on PET images. The predilection of ventilation abnormality for peripheral zone of the lung was more obvious on PET images than CT images. In patients with pulmonary emphysema, the predilection of ventilation abnormality for central zone of the lung was demonstrated on both CT and PET images.