Physiological Significance of Ventilation-Perfusion Inequalities

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Ventilation-perfusion inequalities of the lung can be visualized by processing ventilation and perfusion scintigraphic images by administration of radioxenon. Physiological consequence of the ventilation-perfusion inequalities is thought to cause loss of gas exchange function of the lung. However, any attempt to qualify these scintigraphic data related with the physiological consequence has not yet been done.

Both ventilation ($\dot{V}$) and perfusion ($\dot{Q}$) image were converted into 40×40 digitized frames and were processed by the digital computer to construct ventilation/perfusion image ($\dot{V}/\dot{Q}$) and to derive quantitative relation between $\dot{V}$ and $\dot{V}/\dot{Q}$ as well as $\dot{Q}$ and $\dot{V}/\dot{Q}$. These quantitative relations were input into the gas exchange model of the computer program as proposed by West et al., and alveolar-arterial gas pressure difference (A-aD) were calculated as a measure of gas exchange efficiency of the lung from these quantitative relations.

Five young healthy non-smokers, four aged healthy non-smokers and four aged healthy smokers were investigated primarily. The relation between $\dot{V}$ and $\dot{V}/\dot{Q}$ as well as $\dot{Q}$ and $\dot{V}/\dot{Q}$ were constituted the lognormal distribution function which were calculated to be of normal range of A-aD. However, in the case of smoker, the first moment of both distribution functions dissociated each other with higher values of the second and the third moment which was calculated to be a significant magnification of A-aD. In seventeen subjects with various lung disease, the estimated values of A-aDo_2 were compared with the measured values of A-aDo_2, and a good correlation was found ($r=0.77$). This type of quantification to interprete scintigraphic data into physiological values should be legitimate, if it is possible.

Particle Size Measurement and Mode of Deporision of ^{99m}Tc-Albumin Aerosol

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There are many unknowns in clinically used aerosol inhalation lung imaging. One is a particle size of aerosol and the other is its mode of deposition. The purpose of the present study is to clarify these two questions by the following experimental methods.

Particle size was measured in an empty column of glass by a sedimentation method. Aerosol

diameter was calculated after Davies' formula by measuring time required for sedimentation and number of aerosol was estimated by counting radioactivity.

Regarding number distribution of ^{99m}Tc-albumin aerosol, mode diameter (d_{mod}) was 0.85μ with a half-width value (λ) of 0.22μ and median diameter (d_{mod}) was 0198 μ with geometric standard deviation (σg) of 1.63. Regarding count distribution, d_{mod} was 1.9 μ with λ' of 2.2 μ and d_{mod} 4.2 μ with δg of 3.81. ^{99m}Tc-albumin microsphere of predetermined size was used to validate the size measurement of ^{99m}Tc-albumin aerosol with a favorable agreement.

In order to simulate the human trachea, the main and lobar bronchi, glass or vinyl tubes of 15, 10 and 6 mm in diameter, straight or curved in shape, and/or with partial obstruction, were used to determine the mode of aeroslo deposition. Imaging was made with a scintillation camera. Aerosol deposition was uniform in straight tubes, increased at the site of curvature, or marked forming a tail distal to narrowing of the lumen. When a mass was placed in the lumen to make it partially obstructed, a round spot was seen proximally and a tail-like deposition pattern distally. A slight increase in radioactivity was seen at the site of bifurcation which was simulated after the carina.

Further basic studies are currently under way in the direction of quantitative analsyis of aerososl deposition and deposition patterns in different flow rates or in different experimental models.

Auscultation and Radioaerosol Scintigraphy. Their Complementary Nature

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A rhonchus, adventitious lung sound which arises in the bronchopulmonary tree, is an important auscultatory finding which suggests partial obstruction of the airways. However, the accurate site of stenosis can not be determined by ausculatation alone. On the other hand, radioaerosol scintigraphy has proven to be a valuable adjunct to demonstrate partial as well as complete obstruction of the airways. The purpose of the investigation was to substatiate a rhonchus with radioaerosol scintigraphy, demonstrating the site of stenosis.

With bronchial carcinoma or tuberculous stricture whose major bronchus was partially obstruced, a clear hot spot of aerosol was observed in the aerosol scintigram at the obstruced site. The origin of rhonchi which were prominent in the diseased lung could be localized accurately by the spot.

With bronchial asthma, multiple hot spots were recognized in the hilar area of both lungs. Rhonchi were diffusely audible in both lungs. These rhonchi and hot spots disappeared during a period of attack free.

In summary, auscultation and radioaerosol scintigraphy have a complementary feature, a combined use of which should facilitate a diagnosis of bronchial obstruction.