INHALED AEROSOLS: DEPOSITION AND CLEARANCE

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INTRODUCTION

Aerosols are widely used in the lung for therapeutic, diagnostic and experimental purposes. Filtration of inhaled particles out of the airstream occurs due to the aerodynamic defences of the airways above the larynx which ensure that a small proportion only reaches the bronchial tree. In the lower airways (those below the larynx) the air flow conditions which are determined to a large extent, by the branching architecture of the tracheobronchial tree ensure that many particles will deposit centrally (i.e. in the proximal airways). However, changes of the mode of inhalation and physical properties of the aerosol can result in differing deposition patterns of these particles within the lungs. The site of deposition of inhaled particles within the lungs will determine the mechanism(s) involved for their subsequent clearance. In this article clearance due to particle solubility will not be considered since it will be covered elsewhere in this symposium.

THE LUNGS

Physiologists tend to describe organs of the body in terms of models. Several such models have been proposed for the human lung. One model is due to Weibel (1) who, in his model A, measured the airway dimensions of an average adult lung with a volume of 4.8 litres at about three-quarters maximal inflation. Weibel's model uses symmetrical branching from the trachea (generation 0) to the alveoli (generation 23). Generation 0 to 16 (terminal bronchioles) comprise the conducting (ciliated) airways the main purpose of which is to transport gases to and from the periphery with very little exchange taking place with
blood. The terminal bronchioles (generation 17) to the alveoli make up the alveolar (respiratory/pulmonary) region of the lung. It is in this region that exchange of gases takes place.

The airway diameter in the tracheobronchial tree (conducting airways) decreases distally from some 16 mm at the trachea to 0.6 mm at the level of the terminal bronchioles. However, because of the ever increasing number of airways at any one airway generation the total cross section increases towards the periphery. These airways are also known as ciliated airways because of the presence of ciliated cells. Differing types of secretory cells are also found at all levels in addition to the mucous glands which are located primarily in the larger airways (2).

The terminal bronchioles divide into respiratory bronchioles which in turn divide further into alveolar ducts from which open numerous alveolar sacs. The ultrastructure of the lung periphery is very delicate. The alveolar-capillary membrane is composed of three layers, epitheliod (about 0.1 μm thick), basement membrane plus interstitial substance, and capillary endothelium giving a total thickness of 0.7-0.8 μm. The continuity of the alveolar walls is interrupted by the pores of Kohn. The role of these pores may be to permit collateral ventilation and the migration of phagocytes. The cells lining the alveoli are the type I and II pneumocytes - the latter being responsible for the production of surfactant (lipoprotein material) which lines the alveoli and prevents them from collapsing. The alveolar surface area ranges from 100 to 190 m² while the capillary surface is 120-150m² suggesting a fairly close match. The blood capillary volume is said to be 150-200 ml. Ciliated cells are absent from this region of the lungs (3).

**AEROSOL DEPOSITION MECHANISMS**

There are essentially 5 mechanisms that can give rise to a significant aerosol deposition within the lungs (4).

**Impaction.** Deposition due to impaction arises when particles which are carried in air are not capable (because of their momentum) to follow the airflow streamline when air changes