Mathematical and numerical modelling of the human lung

Foreword

Among all systems in medical modelling, the respiratory one certainly holds a pole position for complexity and interacting multiscales and multiphysics. Breathing involves gas transport through the respiratory tract with its visible ends, nose and mouth. Air then streams from the pharynx down to the trachea. The trachea extends from the neck into the thorax, where it divides into right and left main bronchi, which enter the corresponding lungs. The inhaled air is then convected in the "fractal" bronchus tree which ends in the (something like 500 millions of) alveoli embedded in a viscoelastic tissue, made in particular of blood capillaries, and where gaseous exchange occurs. Surfactant reduces the surface tension on the alveolus wall, allowing them to expand. Gaseous exchange relies on simple diffusion on a large surface area over a short path between the alveolus and the blood capillary under concentration gradients between alveolar air and blood. Inhaled air contains dust and debris or curative aerosols which, for the undesired particles, must be filtered, if possible, before they reach the alveoli, whereas the therapeutic one should be more or less deeply inhaled, depending on the part of the lung to be cured. Each lung is enclosed in a space bounded below by the diaphragm and laterally by the chest wall. The air movement is achieved by the displacement of the diaphragm and parenchyma tissue. But the lung may fail to maintain an adequate supply of air. Accidental inhalation of liquid or solid, asthma crisis, pathologies changing the elastic behaviour of the parenchyma (like emphysema or fibrosis), obstructed nose, cancer may occur.

The present volume aims at investigating the capabilities of mathematical and numerical models to provide a better understanding of those phenomena. It follows two workshops held at Paris (december 2006) and Orsay (June 2006) closing a cooperative program financed by the ministry of research entitled "le-poumon-vous-dis-je", which gave the opportunity to scientists from different areas (biologists, physicists, mathematicians, computer scientists) to exchange their views and contribute to this field which is highly demanding of interdisciplinarity.

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