THE IMPORTANCE OF COMPUTATIONAL METHODS APPLIED TO ANEURYSMS AND THEIR TREATMENT

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ABSTRACT

Ischemic and hemorrhagic brain vascular diseases are currently a major cause of mortality in the so-called developed world. Conditional hemorrhage by rupture of cerebral aneurysms should also been considered within this group. Kassel and Drake reported that annually 28 000 Americans suffer from subarachnoid hemorrhage caused by aneurysm rupture. In Portugal it is expected that the clinical incidence is approximately 1000 to 1200 cases/year with 53% of patients under the age of 50 years. There is a slight increase in frequency in women from 53% to 60%. The incidence of a cerebral aneurysm in autopsy studies is approximately 5%. Despite improvement in treatment results in recent years, Locksley at the Cooperative Study in 1966 established a mortality due to rupture of an aneurysm around 68% and Winn refers to a risk of late re-hemorrhage of 3% per year.

This problem has given the scientific community in recent decades a great deal of research into the pathophysiological process of aneurysmal lesion that involves several factors. Some of these are in relation to congenital defects of the muscular layer of the arterial wall (Forbes) and the presence of abnormal fibers collagen (Pope) and others are acquired, including the degeneration of intemal elastic lamina (Glynn) and inflammatory processes (Handler). Regardless of these factors, the growth of aneurysms seems to result from hemodynamic disturbance triggered by the pulse wave in the arterial wall. According to Ferguson, the turbulent flow induces intraluminal aneurysm dilatation and produces vibration of the arterial wall which also accelerates the degenerative process leading to the disintegration of the internal elastic membrane.

The mechanism of rupture of an aneurysm appears to be the sudden increase in blood pressure. Rupture usually occurs at the top of the aneurysm with occurrence related to factors such as size of the aneurysm (critical diameter between 6 - 10 mm), its location and geometry in relation to blood flow.

The research effort in studying aneurysms involves an intensive multidisciplinary work of medical doctors, biologists, physicists, mathematicians and engineers, especially in the area of mathematical modeling and simulation, and experiments with biomaterials. This approach is based on the need to understand the clinical complexity of vascular pathology from the biophysical mechanisms of the arterial wall resulting from the basic physical changes in elasticity and hemodynamics. All these data through mathematical models and computer simulations have a strong impact on clinical practice and predictive medicine. This research intends to acquire knowledge that will enable a more accurate understanding of the etiology of the multiple factors involved in these pathological vascular changes and also try to predict the natural history and prognosis in particular cases of major bleeding risk.

In this talk we will refer to the rapid development of new endovascular surgical protocols using multiple turns of materials such as platinum coils, micro balloons and stents in minimally invasive treatment of brain aneurysms. The data can also contribute to the improvement and development of new biomaterials for use in endovascular therapy. Studies of physiology and anatomical results as well as complications after surgery will also be referred.