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Parametric designs based on CFD for a new generation of ventricular catheters for hydrocephalus

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Background: To drain the excess of cerebrospinal fluid in a hydrocephalus patient, a catheter is inserted in one of the brain ventricles, and then connected to a valve. This so-called ventricular catheter is a standard-size, flexible tubing with a number of holes placed symmetrically around several transversal sections or “drainage segments”. Three-dimensional computational dynamics shows that most of the fluid volume flows through the drainage segment closest to the valve. This fact raises the likelihood that those holes and then the lumen get clogged by the cells and macromolecules present in the cerebrospinal fluid, provoking malfunction of the whole system.

Objective: To better understand the flow pattern, we have carried out a parametric study via numerical models of ventricular catheters.

Methods: The parameters chosen are the number of drainage segments, the distances between them, the number and diameter of the holes on each segment, as well as their relative angular position.

Results: These parameters were found to have a direct consequence on the flow distribution and shear stress of the catheter. As a consequence, we formulate general principles for ventricular catheter design. To exclude the drainage area of the segments from the set of parameters, the drainage areas of the distal segment, and the proximal segment, were conveniently chosen in each group, while the drainage areas of the remaining segments.

Conclusions: These principles can help develop new catheters with homogeneous flow patterns thus possibly extending their lifetime.

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Characterization of biomaterials using AFM based fast nanoscale imaging and quantitative nanomechanical techniques

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Besides structural and physico-chemical composition, topography, roughness, adhesiveness as well as mechanical properties of biomaterials are the relevant factors making them suitable for biomedical applications. All these factors affect cell differentiation and tissue formation, and are crucial for their integration as well as healing capacity in the human body. Atomic Force Microscopy is suitable for measuring all of these characteristics with nanometer scale resolution under physiological conditions. We have developed a multipurpose AFM device allowing comprehensive characterization of biological samples such as live cells, tissues and biomaterials in the nanoscale. True optical integration allows the simultaneous use of advanced inverted optical microscope techniques such as DIC or confocal laser scanning microscopy, but also upright optics, such as macroscopes for the investigation of opaque samples. With our “Quantitative Imaging” (QI™) mode several sample properties, such as the topography, stiffness and adhesiveness, can be obtained with one measurement in high resolution. Even more complex data like Young’s modulus images, topography at different indentation forces in terms of tomography, or recognition events can be obtained. A variety of biological samples have been investigated to demonstrate the capability and flexibility of QI™. The NanoWizard® ULTRA Speed technique allows fast AFM imaging of dynamic processes with approximately 1 frame per second. The kinetics of collagen type I fibrillogenesis was imaged *in situ* with high spatiotemporal resolution, revealing the formation of the 67 nm D-banding hallmark. With the CellHesion® technique, the adhesion of a single living cell to any substrate can be measured and validated using comprehensive analysis tools. The side-view cantilever holder enables a side view of the cell-sample interface while performing adhesion experiments, providing complementary information without expensive z-stacking. The inherent drawbacks of traditional AFM imaging modes for fast imaging or for challenging samples like living cells can be overcome by the NanoWizard® ULTRA Speed and QI™ mode. We present an enhancement of the AFM technique providing a versatile tool for an extensive characterization of biomaterials.

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