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Characterization of astrocytes on topographical surfaces to reduce shunt failure

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Introduction: Through thorough analysis of over 300 patient's explanted catheters, our previous work has determined that the most prevalent cells attached to the silicone surface of failed shunts are astrocytes. Given this discovery and recent finding in the field of mechanobiology, we hypothesize that the degree of astrocyte attachment and proliferation will be affected by topographical features on the surface of silicone. Although microglia comprise a smaller proportion of cells attached to explanted catheters, their ability to induce polarization of astrocytes via pro-inflammatory mediators led us to also explore the effects of topographical features in a coculture of human astrocytes and microglia in addition to astrocyte monocultures.
Methods: Photolithography and soft lithography were used to manufacture silicone surfaces with varying topographical features that varied at the micron level in height and width totaling 95 distinct groups each with a minimum N = 4. Human astrocytes were seeded onto these surfaces and attachment and proliferation was determined as a function of feature height, size, and pitch over several time points. The effect of these surfaces in a coculture of human astrocytes and human microglia was also studied. Cellular characterization was determined via immunofluorescent and ELISAs to measure release of TNF-α and IL-1β.
Results: Human astrocytes were found to be significantly affected ($P < 0.05$) by feature size in both degree of attachment and proliferation. Lastly, the Introduction of microglia cocultured with astrocytes also had an effect on astrocyte behavior compared to the monoculture study.
Conclusions: Building on previous works, we were able to successfully characterize how human astrocytes behave with topographical features as a function feature size, depth, and pitch in vitro. Future direction will aim to assess how these patterns will translate in a dynamic environment where it is known that astrocyte behavior is affected by fluid flow.

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Long-term clinical results of the Flow ventricular catheter for hydrocephalus: brief report

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Abstract
Background: Previously, we studied the flow in ventricular catheters under steady and pulsatile boundary conditions by means of computational fluid dynamics (CFD) in several catheter designs with homogeneous flow patterns. We developed one prototype out of them after a validation study. Then, we tested the effectiveness of the Flow ventricular catheter in a prospective, multi centre, comparative study four years ago.
Methods: The Flow catheters were inserted in pediatric (n = 30) and adult (n = 10) patients with all types of hydrocephalus. Simultaneously, regular ventricular catheters were inserted in another 43 control patients in the participating centres. Programmable valves were utilized in 70% and antisiphon devices in 20% of the cases.
Results: Initial findings disclosed no case of Flow catheter obstruction and four catheter obstructions in the control cohort, all pediatric cases, during the first year. Subsequently, cases lost included three in the Flow catheter and five in the control group. No case of Flow catheter obstruction was identified during a mean follow-up period of six years at the time of this writing, while other four cases presented with multiple shunt revisions in the control group.
Conclusions: The Flow catheter, representing the next generation of ventricular catheters with a homogeneous flow pattern, can be inserted safely in hydrocephalic patients of all types, and this comparative study still showed a possible obstruction-free functionality.
Keywords: Hydrocephalus; Ventricular Catheter; Shunt malfunction; Flow catheter; Ventricular Catheter Prototypes; New Designs; Parametric; Computational Fluid Dynamics.

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Computational investigation on cerebrospinal fluid flow mixing states in aqueduct of patients with Hakim's disease

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Introduction: CSF flow in ventricles is a bidirectional flow synchronized with cardiac pulsation, and net CSF flow in a cardiac cycle is close to zero. Although the CSF flow has slow and steady cyclic properties in healthy conditions, Hakim's disease increases CSF flow velocity and stroke volume, known as hyperdynamic flow. We hypothesized that this hyperdynamic CSF flow may enhance CSF flow mixing through the ventricles and affect the CSF composites adjusted in each ventricle. Therefore, this study analyzed the CSF flow dynamics in aqueduct between the third and fourth ventricles using MRI-based computational simulation.
Methods: This study included 10 iNPH patients (6 males and 4 females, age: 61–83) and 44 healthy subjects (18 males and 26 females, age: 24–74). Subject-specific ventricular geometries were reconstructed from the T2-weighted MRI images, and the computational fluid dynamics simulation of the CSF flow dynamics was performed in each subject. As a computational condition, the CSF flow rate in the aqueduct was determined from the 4D flow MRI. CSF flow rate mixing in aqueduct was analyzed by massless particle tracking during 20 cardiac cycles and quantified using mix-norm ranging from 0 (not mixed) to 1 (completely mixed) as a multiscale mixing index.
Results: Steady cyclic CSF motion was observed in the healthy control group and the CSF mixing state was mild (mix-norm: 0.36 ± 0.11), with negligible CSF mixing between third and fourth ventricles. On the other hand, hyperdynamic CSF flow in patients caused excessive CSF mixing state through third and fourth ventricles (mix-norm: 0.52 ± 0.18), and mix-norm between patients and control groups were significantly different ($p < 0.001$).
Conclusions: Hyperdynamic CSF flow in patients with Hakim's disease leads to exaggerated CSF mixing through ventricles. This CSF flow mixing may alter the CSF chemical composition in each ventricle and disrupt the physiological homeostasis.