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Are we implanting catheters that facilitate shunt failure?

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Background

While silicone catheters have vastly improved an array of medical treatments, reactions at the tissue-substrate interface often impede their functionality. In the treatment of hydrocephalus, delivering a silicone catheter into the cerebral ventricles allows drainage of cerebrospinal fluid from the cranial cavity; however, these catheters often get obstructed since chronic implantation facilitates adhesion of physiological components to the catheter surface. Theoretically, adhesion is initiated by the entropic drive of protein moieties to the shunt catheter surface. Protein-cell binding can then propagate exponentially leading to catheter obstruction. The strength of these interactions is dependent upon the wettability of the surface.

Materials and methods

In this study, the wettability of silicone catheters was investigated in a physiological model of cerebrospinal fluid flow through a catheter. Using a pulsatile flow apparatus at 0.3 mL/min, 3×10^6 astrocytes and macrophages were separately exposed to the lumen of native, hydrophobic silicone (decreased wettability, water contact angle 105.58° +/- 7.88) and oxidated, hydrophilic silicone (increased wettability, water contact angle 27.03 +/- 3.74°) in the presence or absence of serum protein. Because of its clinical importance, the effect of barium impregnation was also tested. Cell adhesion was assessed using pixel luminance analysis (Neurolucida, Williston, VT).

Results

The observed trend in these fluidic culture studies was a decrease in cellular adhesion on oxidated, hydrophilic silicone when samples were held horizontally and an increase in cellular adhesion on oxidated, hydrophilic silicone when samples were held vertically. Likewise, a significant decrease ($p < 0.01$) in cell adhesion on horizontally placed hydrophilic, oxidated silicone (decreased wettability) was detected after 20 hours of incubation. After ten hours of incubation, no significant differences were found, although similar cell adhesion trends were indicated. When the samples were soaked in serum, however, surface wettability did not have a significant effect on adhesion properties. Furthermore, shunt catheters with the inclusion of barium showed a significant increase in surface cell adhesion ($p < 0.01$) compared to the barium-free control.

Conclusion

The results of this study provide a better understanding of surface wettability on cellular growth and thus lead to the identification of novel surface modification strategies to improve long-term implantation. The clinical use of a hydrophilic catheter surface as opposed to the current hydrophobic catheter may decrease the rate of shunt

obstruction. Future studies are directed toward modification methods to sustain a more wettable shunt catheter surface as well as chronic *in vivo* tests of cell adhesion.