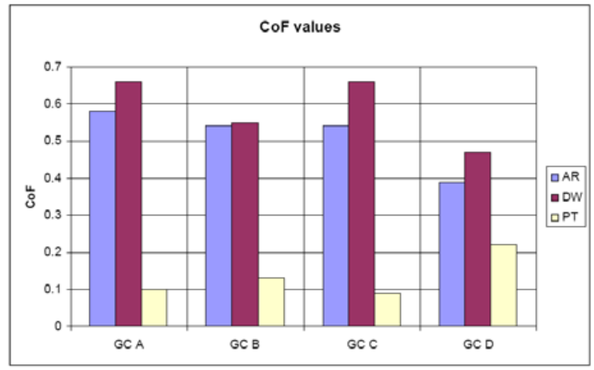
Guide Catheter Surface Treatment to Minimize Endovascular Trauma

H. Rangwala, A. Meyer, S. Rudin, R. Baier
State University of New York at Buffalo, Buffalo, NY 14214, USA

Statement of Purpose: Guide Catheters (GC) routinely utilized to access endovascular sites and deliver balloons, stents, coils, and guidewires, and contrast agents, can cause frictional damage to intra-vascular walls as well as initiate thrombus generation. According to previously published studies of gas-plasma-treated catheter materials, catheter-on-catheter friction-lowering qualities associated with increased surface polarities are quite persistent (1,2). The purpose of this investigation was to determine if lowering of GC/vascular wall frictional forces could be achieved while also retaining Critical Surface Tension (CST) values associated with minimal thrombosis (3,4), thus maintaining overall biocompatibility during endovascular treatment.

Methods: A pin-on-disc reciprocating friction/wear device (5) was used to articulate As-Received (AR), Detergent-Washed and distilled water-rinsed (DW), and Gas-Plasma-Treated (PT) Guide Catheter segments against saline-lubricated interior surfaces of longitudinally slit and flattened segments of preserved human umbilical cord vein grafts of known surface properties supporting a 30-year record of blood-compatible performance in peripheral arterial reconstruction (6,7). New Guide Catheters, of 4 different brands (GC A to D), were selected from endovascular supplies of the Toshiba Stroke Research Center (SUNY/Buffalo), and their exterior surfaces characterized by comprehensive contact angle measurements to determine CSTs and surface energies, and MAIR-IR spectroscopy to determine surface chemical compositions (8) in their AR, DW, and PT states prior to Coefficient of Friction (CoF) determinations at normal loads of 30 - 70 g. Gas plasma treatment of detergent-washed catheter samples was done for 2 min in room air, using a Harrick Plasma (Ithaca, NY) device.

Results: MAIR-IR of AR catheter segments revealed three of the four devices were nylon-type polyamide polymers, and the fourth a polyurethane polymer, each catheter with a different type of manufacturer-applied coating that variably transferred to the analytical prism during IR analysis. Three of the AR devices displayed CST values between 20 and 30 mN/m, previously associated with minimal thrombogenecity of angiographic catheters (3,4). CoF varied from approximately 0.4 to nearly 0.6 for AR catheters moving against the saline-lubricated surfaces of vein graft segments. Much lower values for catheters have been sought by others studying lubricious substances (9). DW catheters had slightly increased CSTs and water contact angles, evidence for partial to full removal of the manufacturer-applied coatings. MAIR-IR spectra, however, indicated retained hydration of the materials' surface zone. CoFs of DW catheters against vein grafts were approximately 0.5 to nearly 0.7, each catheter's friction increasing over the AR value. All PT catheter segments displayed significantly reduced water contact angles, consistent with PT-induced surface oxidation documented by increased polar surface components of their composite surface free energies (10). PT catheters, however, still had CSTs and dispersive components of their surface free energies in the zone between 20 and 30 mN/m. PT catheter CoF values (approximately 0.1 to 0.2) were markedly less than COFs for AR and DW catheters against saline-lubricated vein grafts [see Figure].



Simple increases in hydrophilicity are not sufficient to account for these results, noting that the highest CoF (0.22) for a PT catheter was for GCD. Although GCD had relatively low water contact angles in both its AR and PT conditions, it had the highest CST in both its AR and PT conditions.

Conclusions: These results support the conclusion that, when both members of an articulating couple are sufficiently polar and hydrophilic to maintain at least a vicinal layer of frank bulk water between them, hydrodynamic lubrication can be sustained for materials that otherwise resist bioadhesion and, thus, minimize tissue damage. Under the conditions reported here, the manufacturer-applied coatings on the 4 representative GC did not produce coefficients of friction as low as the gas-plasma-treated catheters. Treating as-manufactured GC with gas-plasma processes could produce surface zones of intrinsically high polarity, while maintaining thrombo-resistant qualities associated with retained low CSTs.

References: (1) Triolo P, Andrade J (1983) J Biomed Mater Res 17:129-147; (2) Triolo P, Andrade J (1983) J Biomed Mater Res 17:149-165; (3) Wilner G, Caseralla G, Baier R, Fenoglio C (1978) Circ Res 43:424-428; (4) Baier R (2006) Mater Sci: Med 17: 1057-162; (5) Meyer A, Baier R, Chen H, Chowhan, M (2006) J Adhesion 82:602-627; (6) Baier R, Akers C, Natiella C, Meenaghan M, Wirth J (1980) Vasc Surg 14:145-157; (7)Dardik H, Wengerter K, Qin F, Pangilinan A, Silvestri F, Wolodiger F, Kahn M, Sussman B, Ibrahim I (2002) J Vasc Surg 35:64-71; (8) Baier R (1987) Ann NY Acad Sci 516:68-77; (9) Ho S, Nakabayashi N, Iwasaki Y, Boland T, LaBerge M (2003) Biomaterials 24:5121-5129; (10) Kaelble D (1970) J Adhesion 2:66-81;

Acknowledgments: NIH Grants R01 EB002873 and NS43924