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Effect of Positional Changes across Joints on In Vivo Graft Blood Flow Using Implanted Sensors

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OBJECTIVES: Doppler diffraction-grating transducers (DGT) have been manufactured which are small enough [3mm x 1mm] to be embedded within the wall of synthetic vascular grafts and provide accurate angle-independent blood flow measurements. We utilized such implanted sensors to examine whether joint flexion decreases blood flow through prosthetic grafts and thus may account for the decreased patency of polytetrafluoroethylene (PTFE) grafts placed below the knee.

METHODS: Ten dogs (ages 1-2 years, weight 18-25 kilograms) underwent common iliac to common femoral artery bypass using 6 mm PTFE grafts in an end-to-side fashion. Implanted in the mid-portion of the graft was a 20 MHz DGT transducer connected via microcables to an externalized Universal Serial Bus (USB) connector at the level of the cervical spine. Conventional duplex ultrasound was performed on each graft immediately after placement and weekly thereafter. Beginning on post-operative day one, blood flow and mean velocity was measured via the USB connector and laptop computer with the animal in both the standing and sitting positions (maximal hip flexion).

RESULTS: Duplex ultrasound confirmed the patency status of the grafts in all cases. Blood flow and velocity measurements within the grafts demonstrated reproducible measurements in all animals. There was an expected increase in blood flow seen beginning on the first post-operative day, reflective of reperfusion hyperemia, from a baseline of 159 ± 20 ml/min to 444 ± 36 ml/min [$p < 0.0001$], which persisted during the first week. Hip joint flexion significantly affected blood flow through the graft, decreasing to 270 ± 38 ml/min [$p < 0.005$]. A similar decrease was seen in the mean velocity, dropping from 26 ± 2 cm/sec to 16 ± 2 cm/sec [$p < 0.005$] with hip flexion. Such decreased flow and velocity with sitting persisted throughout the follow-up period.

CONCLUSIONS: Implantable in-graft DGT sensors can successfully measure both blood flow and velocity *in vivo*. The sitting position, with flexion of the hip joint, significantly decreased both blood flow and velocity within the PTFE grafts. This suggests that prosthetic grafts which cross joints have decreased positional blood flow and this may explain their poor long-term patency in the infra-popliteal position.