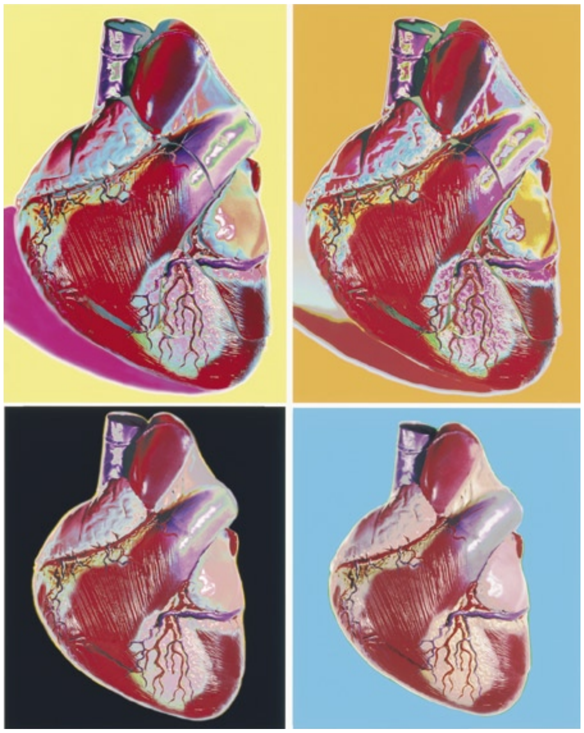
Vascular regeneration

It's all in the geometry

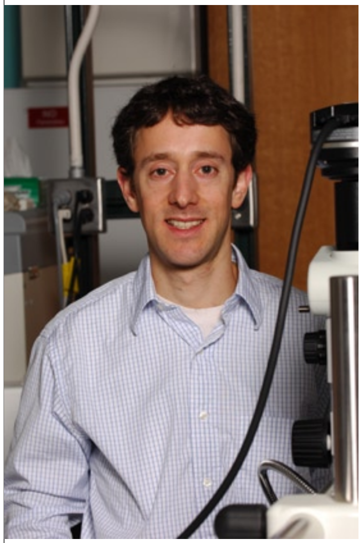


FOLLOWING A TYPICAL coronary artery bypass surgery, vein grafts tend to fail due to blockage after only a decade. Jeremy Goldman would like to create a graft that will last a lifetime.

"The key is to understand the biomechanics involved—specifically, the role of shear stress on the endothelial cells that line our arteries and veins," explains Goldman, an assistant professor of biomedical engineering at Michigan Tech.

Shear stress is high—and blockage is rare—in sections of vessels and arteries that are relatively straight. However, regions that curve and branch experience low shear stress, and tend to see the most disease. These areas may also experience swirling, oscillating, "vortex" blood flow.

According to Goldman, the outcome of bypass surgery can vastly improve by employing just the right math. "In bypass surgery today, the geometry of a conventional vein graft doesn't match the geometry of the host artery, resulting in vortex flow and low shear stress. This, in turn, results in narrowing and thickening of the inner layer of the graft."



Through in vivo work with rats, Goldman and co-researchers Lin Zhong and Shu Liu at Northwestern University have designed a vein graft with a geometry that minimizes the development of vortex blood flow.

"With this technique, we found that we can reduce progression of disease after bypass surgery by approximately 80 percent," he notes.

Shear stress plays an important role in vascular disease overall. "In regions of vasculature where we can't change the blood vessel geometry, as we can when using vein grafts, we could possibly inhibit the shear stress signal." Goldman explains.

"Endothelial cells seems to convert the biomechanical stimulus of shear stress into a language that other cells, located deeper in the vascular wall, understand. Once we know that language, we can disrupt the process with drugs and prevent those cells from becoming activated to promote vascular disease."

Goldman is now collaborating with joint materials science and biomedical engineering Associate Professor Daniel Clupper to construct an external stent device that will restrict the vein graft to the proper geometry. Next steps include working with a heart surgeon to create a new surgical procedure to use this device for coronary bypass.

"When it comes to the vascular system, shear stress is a good thing," adds Goldman. "It makes sense that exercise—which increases shear stress—reduces our risk of heart disease."

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