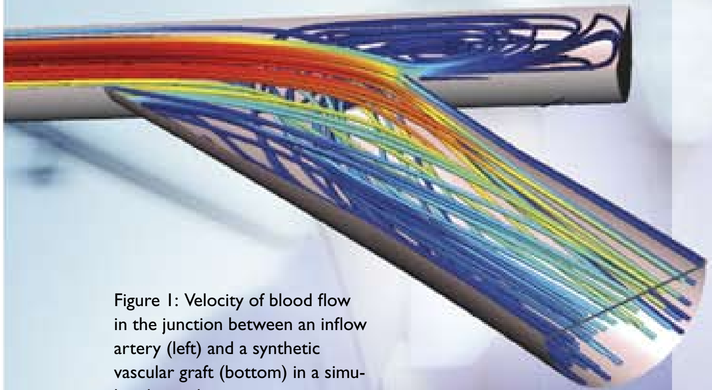

Figure 1: Velocity of blood flow in the junction between an inflow artery (left) and a synthetic vascular graft (bottom) in a simulated vascular-access circuit.

THE IMAGE OF A PHYSICIAN performing a bedside diagnosis might not come to mind when thinking of the typical person doing simulation and modeling. However, this technology has become so accessible to the practicing scientist and engineer that there's hardly a "typical" modeler any more. In his job as a physician, Dr. Steven Conrad has used modeling to refine artificial organs.

Dr. Conrad graduated from Medical School in 1978 and then completed an MS in Biostatistics and a PhD in Biomedical Engineering from Case Western Reserve University. He joined the faculty of the LSU School of Medicine in Shreveport in 1986 and established a critical-care program.

Physician moves modeling into patient care

BY PAUL G. SCHREIER

Dr. Conrad's experience with modeling began when he got interested in simulating physiological systems. In particular, he explains, "until recently, artificial organs were frequently designed empirically without simulation, which I felt could bring them to higher efficiencies. I wanted to model fluid and molecular transport in the fiber membrane of an artificial kidney, but I had no time to write code. With COMSOL, though, I immediately fell in love with the finite element concept. Fortunately, the application modes removed the nitty-gritty details of solving the PDEs so I didn't have to delve into computational methods." Dr. Conrad had to configure the hollow fibers and determine the amount of blood and dialysate flow. He adds, "I want to find which operating parameters can get the best efficiency out of existing designs as well as look at new designs to get even higher efficiency."

Furthermore, the simulations he performed with COMSOL Multiphysics have provided insight into the complexities of fluid and toxin removal with continuous dialysis performed in the ICU, and the results have given him insight into the best ways to apply this therapy to different types of critical illnesses. For instance, Figure 1 depicts the velocity of blood flow in the junction between an inflow artery (left) and a synthetic vascular graft (bottom) in a simulated vascular-access circuit used in patients who require long-term hemodialysis. The 3D Navier-Stokes equation was used to model the fluid flow. The development of complex secondary flows in the ligated arterial segment (right) and swirl flows in the graft segment (bottom) are easily identified. This COMSOL model allows the prediction of pressure losses in the circuit and provides insight into the diminuation of the graft function that can occur over time.

Meanwhile, he has started two other FEA projects. In one he is helping design a blood catheter for extracorporeal life support (ECLS), and in the other he helps analyze complications of the vascular access circuits used for hemodialysis, a process that removes waste products and free water from the blood when the kidneys can't do so. "Vascular access complications," says Dr. Conrad, "represent the greatest cause for hemodialysis patient hospitalizations."

"COMSOL's flexibility makes it a perfect all-round tool for a doctor."

Results from the FEA models lie close to experiments run on a mock hemodialysis vascular access loop and are superior to previously used analytical models. "COMSOL Multiphysics' flexibility in the systems and physics it can model makes it a perfect all-round tool for the many applications that a doctor can encounter," concludes Dr. Conrad. ■

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