Another step toward intelligent surgical planning

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The applications of computational fluid dynamics (CFD) to cardiovascular medicine and surgery just keep getting better. Trusty and colleagues1 examine a way that CFD could be used to plan “complex” Fontan operations. These patients are those whose anatomy does not “guarantee” a relatively even distribution of hepatic blood flow (HBF) to both lungs with a conventional extracardiac conduit or lateral tunnel. The typical example would be an interrupted inferior vena cava with azygous continuation to a left superior vena cava and a right-sided hepatic veins-to-right pulmonary artery conduit. Inadequate HBF to a lung may result in pulmonary arteriovenous malformations, which cause cyanosis and are difficult to treat.

Trusty and colleagues1 had each of 7 patients undergo preoperative magnetic resonance imaging (MRI) and catheterization, from which anatomic, flow, and pressure waveform data were used to construct an anatomic and physiologic computational model. The model was modified by the addition of a computer aided design–generated surgical reconstruction (with surgeon input) corresponding to the “best guess” of the optimal surgical approach to achieve adequate HBF to both lungs. The operation was then performed, the surgeon presumably trying to reproduce the optimal preoperative model. Postoperatively, MRI and catheterization were repeated, and another computational model was generated. The difference between the preoperatively and postoperatively calculated HBF to each lung was recorded. Trusty and colleagues1 found a mean difference of ~17% with a range from 0% to 45%. By running other simulations, they found that much of the difference was due to anatomic and not flow-related differences between the preoperative and postoperative models. The authors convincingly argued that CFD-based surgical planning can predict an acceptable postoperative result (adequate HBF) with reasonable fidelity.

The greatest challenge, as emphasized by Trusty and colleagues,1 is for the surgeon to reproduce the recommended operation with good fidelity. The surgeon must be intimately involved in the preoperative modeling, because he/she knows best what configuration is surgically feasible. On the other hand, the imaging team must provide accurate representation of the directly relevant anatomic structures, including the surrounding anatomy, that is, any structure that may impede the optimal placement of the graft(s). The surgeon must then be committed to making measurements to place grafts in positions and angles that match those of the preoperative model.
Could this approach become standard of care? The approach requires protocolized measurements of the relevant quantities from MRI and catheterization, a standardized, well-validated CFD software program, personnel to supervise model generation, and surgeon commitment to both generate a priori models and execute the optimal configuration in the operating room. This “package” will take time to gain traction, but it holds a key to better clinical care and should be pursued.

**Reference**