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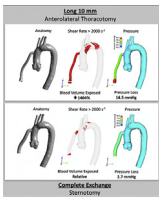

FLOW DYNAMICS DURING THE HEARTWARE HVAD TO HEARTMATE 3 EXCHANGE: A COMPUTATIONAL STUDY ASSESSING DIFFERENTIAL GRAFT LENGTHS AND SURGICAL TECHNIQUES

To the Editor:

We read with great interest the expert review by Salerno and colleagues[1] describing the technical challenges and best practices for managing the HeartWare HVAD (Medtronic) to HeartMate 3 (HM3, Abbott) exchange. The authors do a remarkable job defining the technical challenges and considerations for this operation, and the conclusion from the expert panel is that under optimal clinical scenarios, all components of the HVAD device including the entirety of the 10-mm HVAD outflow graft should be removed through a sternotomy procedure and replaced with the 14-mm HM3 graft. The authors also acknowledge that under certain scenarios, when complete excision of all HVAD components poses an unacceptable surgical risk, an alternative surgical approach involving an anterolateral thoracotomy can be considered, although this technique would necessitate leaving behind a long component of the original HVAD 10-mm graft. The authors rationalize this recommendation by stating that the anterolateral thoracotomy approach leads to remnant HVAD grafted material, which adds resistance to the outflow grafts that would impact pump performance.[2]

The authors are correct in their assertion that retaining the HVAD graft will alter flow through the LVAD by changing the head pressure flow curves for the HM3, although this potentially has theoretical advantages under certain clinical scenarios. Using a combination of lumped-parameter and 3-dimensional computational fluid dynamic models, our group studied the flow dynamics of 4 different HVAD to HM3 surgical techniques: (1) beveled anastomosis near the pump (anterolateral thoracotomy, long 10 mm); (2) beveled anastomosis near the aorta (long 14 mm); (3) beveled anastomosis 5 cm from the aorta (mid transition); and (4) the entire cannula 14 mm (complete exchange, expert panel consensus recommendation).[3] A complete exchange of the outflow cannula had the lowest blood volume exposed to shear rates of greater than 2000 s^{-1}, an upper border of normal physiologic shear rate.[4] A long 10-mm graft achieved through an anterolateral thoracotomy had a 281% larger blood volume exposed to very high shear rates compared with the long 14-mm graft (0.61 mL vs 0.16 mL) and 1464% increase compared with the complete exchange (0.61 mL vs 0.039 mL) (Figure 1).

Interestingly, the degradation in pressure down the outflow graft was greater with a lateral thoracotomy approach that leads to retained HVAD graft. At a simulated flow of 6 L/min for all scenarios, there was a modest 2.7 mm Hg decrease in pressure along the cannula with the complete exchange compared with a 14.5 mm Hg decrease in pressure with the anterolateral thoracotomy (Figure 1). The more sizable pressure decrease in the scenarios that retain longer portions of the 10-mm HVAD cannula may actually facilitate more frequent aortic valve opening because this would decrease the aortic transvalvular gradient. Such a pressure decrease may be advantageous in certain patient populations for whom fixed aortic valve closure would be problematic, such as those at risk for progressive aortic insufficiency. Patients with right ventricular dysfunction are also at risk for aortic valve closure secondary to underfilling of the left ventricle. The more sizable pressure decrease with a lateral thoracotomy approach together with the favorable effects that a lateral thoracotomy has on the right ventricle, independent of flow dynamics, may make this the preferred approach for a subset of patients.[5]

Jonathan Grinstein, MD[a]
Ryo Torii, PhD[b]
Christopher Salerno, MD[c]
Pablo J. Blanco, PhD[d]
Hector Garcia-Garcia, MD, PhD[e]
Christos V. Bourantas, MD, PhD[f]
[a]*Department of Medicine*
Section of Cardiology and
[c]*Department of Surgery*
Section of Cardiothoracic Surgery
University of Chicago
Chicago, Ill
[b]*Department of Engineering*
University College of London
London, United Kingdom
[d]*Department of Mathematical and Computational Methods*
National Laboratory for Scientific Computing
Petrópolis, Brazil
[e]*Department of Medicine*
Section of Cardiology

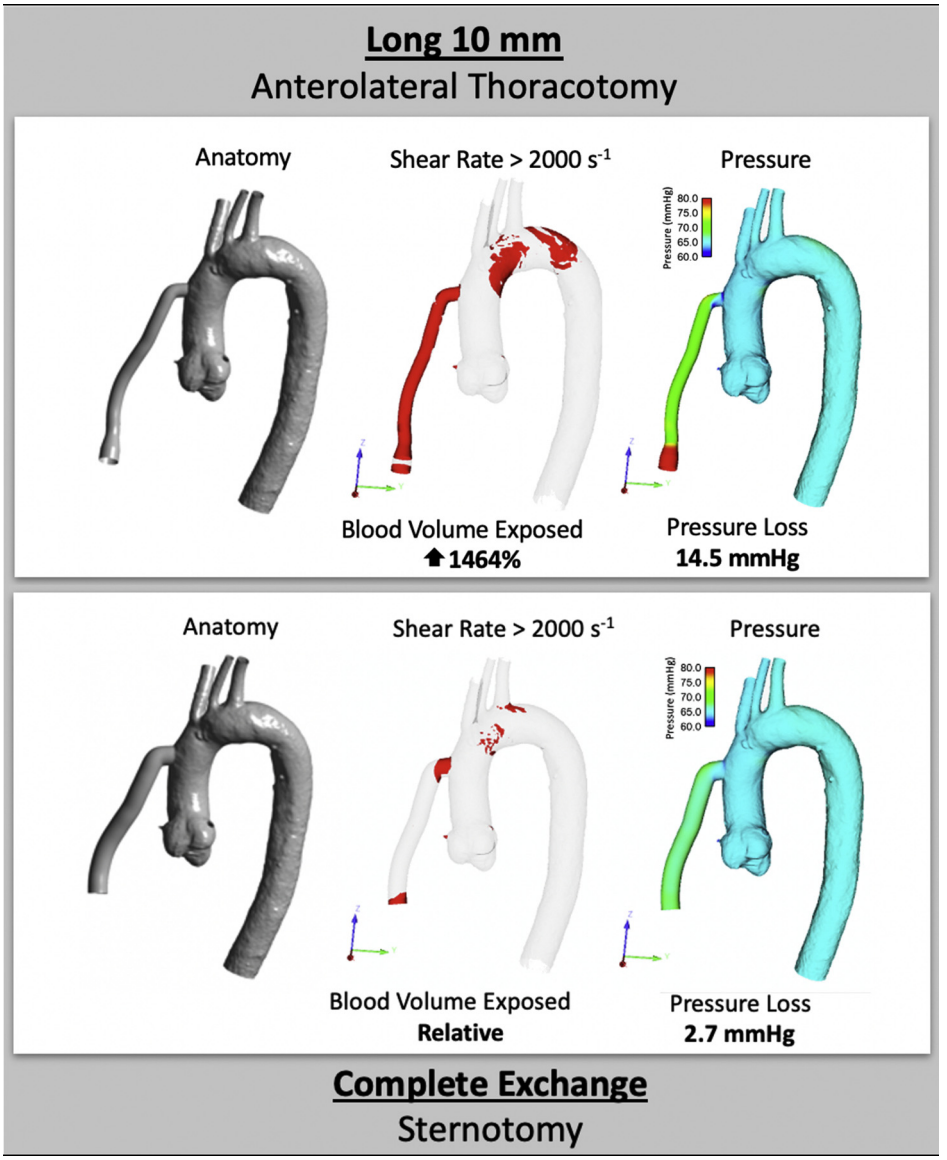

FIGURE 1. Anatomy, shear rate, and pressure differential comparing the partial exchange with residual long 10-mm graft to the complete exchange during the HVAD to HM3 exchange.

MedStar Cardiovascular Research Network
Washington, DC
[f]Department of Medicine
Section of Cardiology
Barts Heart Centre
London, United Kingdom

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