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Three Dimensional (3D) Printing and Functional Assessment of Aortic Stenosis Using a Flow Circuit: Feasibility and Reproducibility

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Abstract: (Your abstract must use Normal style and must fit into the box. Do not enter author details)

Background: Recent reports have created 3D printed models of cardiac structures and various defects, mainly congenital, from echocardiographic (echo) or computed tomography (CT) data. We sought to functionally assess the 3D printed model of severe aortic stenosis (AS) using a flow circuit. The case of an 83 year old man with severe calcific AS was studied. On echo, at a heart rate of 60 b.p.m. and a blood pressure of 122/70 mmHg, the calculated stroke volume (SV) was 67 mL (indexed 29mL/m2), the peak/mean gradients were 68/45 mmHg, the aortic valve area 0.82 cm2 and the ejection fraction 60%.
Methods: Based on a high resolution, contrast enhanced CT at the 70% phase, a 3D reconstruction (Mimics, Materialise) and modeling (Rhino 3D, McNeel and Associates) software were used to prepare the model for printing, which was done with a Stratasys Connex 350 printer (figure 1). Tango+ material was used for soft tissue and VeroWhite material for calcifications. The 3D printed model was connected into a flow circuit containing a pulsatile pump (Harvard Apparatus Model 1423), a pressurized and an unpressurized tank (figure 2). Flow was measured using a transonic flow probe (model ME 13 PXN, Transonic Systems, Inc.) and meter (model T410, Transonic Systems, Inc). Pressures proximal and distal to the aortic model were obtained via fluid filled sensors (model DTX Plus DT 4812D, Becton Dickinson) and signal amplifiers (model 11-4123-09, Gould). The data was acquired using LabVIEW.
Results: In order to simulate the patient's HR and SV, the pump was set at a rate of 60 strokes per minute, with a stroke output of 70 ml. Figure 3 depicts the measurements obtained. The gradients obtained were 67/51 mmHg, very close to those obtained by echo. Altering the flow settings generated different gradients.
Conclusion: Functional assessment of a 3D printed model of severe AS using a flow circuit is feasible and yielded gradients similar to those obtained by echo. 3D printing may become a helpful tool in the understanding of valvular pathophysiology.

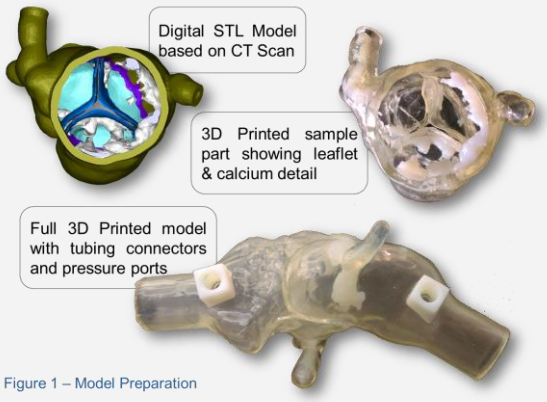

Figure 1 – Model Preparation

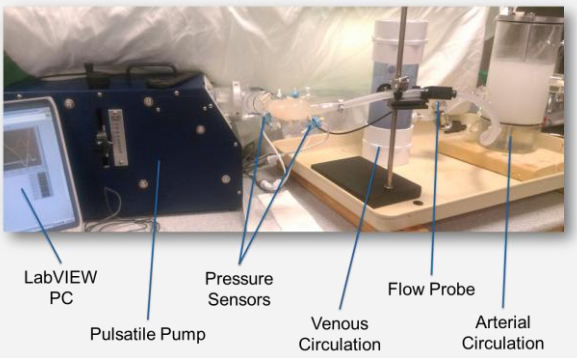

Figure 2 – Test Loop Setup

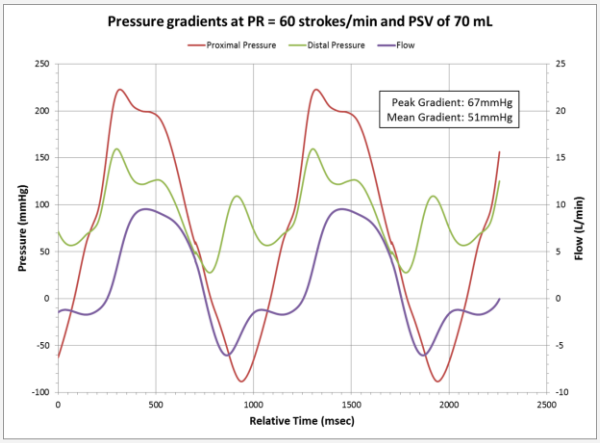

Figure 3 – Pressure measurements