402 - BME Design Excellence Award - 2 - BVP Model - Executive Summary

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Pulmonary valve stenosis (PS) represents 31-34% of all canine congenital heart disease diagnoses. In canines with PS, the leaflets of the pulmonary valve are thickened or fused, causing obstructed blood flow. The most widely accepted treatment for PS in canines is balloon valvuloplasty (BVP). In this procedure, a balloon catheter is inserted through the external jugular vein, guided to the pulmonary valve and inflated to tear apart the leaflets and improve blood flow. Transcatheter procedures, such as BVP, have steep learning curves and require ample practice to master. Multidimensional imaging-based models enhance training by providing resident veterinarians the opportunity to practice and maintain procedural skills outside of live patient cases. As there are currently no simulation models for BVP, the purpose of this project was to develop an anatomically accurate 3D model of a canine heart to simulate PS for veterinary cardiology residents to learn and practice this procedure.

The final model consists of a 3D printed heart, jugular vein, video stand, peristaltic pump, heart and jugular stand, and water basin. The heart was segmented from a computed tomography angiography scan of a french bulldog provided by the UW School of Veterinary Medicine. The heart was printed with Formlabs Elastic 50A resin as this material is transparent and has similar mechanical properties to cardiac tissue. The heart was printed in two halves to allow the user to open the heart and study the anatomy. The jugular vein and heart are secured into the model basin with 3D printed supports. The heart stand was designed using a negative scan of the heart model with a 1 mm tolerance between the heart and box to ensure the heart is secured sufficiently. The video stand holds a camera over the model and projects the image onto a monitor to replicate a fluoroscopic view during a real procedure.

After preliminary testing, the heart was re-segmented to increase the volume of the right ventricle and smooth the surface of the heart walls. Additionally, the internal heart walls were coated in petroleum jelly to help facilitate sliding the catheter through the heart. The original length of the jugular vein made catheter navigation challenging, so a shorter vein was created for a more beginner-friendly model. The longer jugular vein can be swapped in for more advanced users. Finally, a peristaltic pump was developed to simulate blood flow at a rate analogous to the flow of blood through a french bulldog. This allows users to practice “floating” the catheter through the right ventricle, a common practice in BVP.

The model anatomy and procedural accuracy was validated by the client Dr. Sonja Tjostheim, a Clinical Assistant Professor of Cardiology for the Department of Medical Sciences. After validation, the model was tested by 3 cardiology residents, 3 cardiology attendings, and 3 residents from specialties outside of cardiology at the UW School of Veterinary Medicine. Participants were asked to complete an initial survey focused on prior exposure to BVP, overall knowledge and confidence in completing the procedure. Following a brief lesson on PS and BVP, participants performed 3 separate procedures on the model. After completion, participants answered questions regarding different aspects of the model and if the model would be a successful training tool. The results showed that 9/9 participants believe the model would be a useful training tool for cardiology residents and would recommend the model for teaching procedural skills. Additionally, 7/9 of participants reported feeling more confident in their ability to perform BVP after using the model and 8/9 participants agreed that the experience of navigating the catheter through the model was realistic. Based on the study results, the BVP model provides veterinary cardiology residents with a realistic, anatomically accurate tool to build confidence and gain skill in navigating the procedure’s steep learning curve.