## Aims of Surgery:

1. Create unobstructed systemic flow
2. Balance the systemic-pulmonary circulation

## Birmingham (augmentation-reimplantation) technique:

- Perform the augmentation of the ascending aorta and aortic arch (with the patch suture down to the ascending aortic root)
- Join the pulmonary artery to the incision of the patch

## Treatment:

This will be a step-by-step 3D surgical animation that visualizes the Norwood Procedure (Birmingham technique) including placement/orientation of patches, direction of suture insertions, and close-up views of the surgical field of interest. Currently, the HOST videos include 3D segmentations to depict the procedure, however there are limitations such as the inability to show orientation of patches or dynamic movement/procedures including incisions and suture placements. This animation can be integrated with video footage of the surgeons performing the procedure to enhance the current videos that are currently available.

In addition to this, an online web 3D viewer will be prototyped that can use this animation data to progress a user step-by-step through the entire procedure (Documents still in progress)

## Script:

**[] - Represents actions/transitions during animation**

**Description of Scene:** Animation will solely focus on the heart model. The background will be a solid color to increase saliency of the heart and reduce distractions. All elements (E.g. sutures, probes, needles) will be modeled and animated in 3D. There will be 2D graphical/text overlays to point to size comparisons, direction of needles, and anatomical labels.

**Script will be divided into 4 sections:**

1. Ligation and transection of PDA
2. Aortic Incisions and Anastomoses
3. Patch Anastomosis
4. Reimplantation of the Pulmonary Artery

[Heart model appears in center of frame and important anatomical features are highlighted to orient the viewer (PDA, Pulmonary artery, Hypoplastic ascending aorta)]

[Heart model rotates, and regions continue to be highlighted for the viewer's reference (PDA, Hypoplastic arch)]

### Ligation and transection of PDA

[Text 'Part 1 - Ligation and transection of PDA' appear Ligation of the proximal patent ductus arteriosus (PDA) will be performed close to the pulmonic end. A tie is made around 2-3mm above the origin of the left pulmonary artery (LPA) to avoid the left pulmonary artery stenosis. [Show ligation of PDA]

Transect the main pulmonary artery at the midpoint between the sinotubular junction (STJ) and the base of the right pulmonary artery (RPA) [show transection]

Create a small oval-shaped patch which will be sutured at the confluent branch pulmonary arteries [show oval patch and close-up of sutures being placed into the pulmonary arteries] This patch will help prevent stenosis of the pulmonary artery origin.

Transect the PDA and residual ductal tissue at the descending aorta end [rotate camera and show transection] Create two transections at the aortic isthmus - the first at the midpoint of the previous PDA and another at the aortic end of the previous PDA. [show transections]

## Aortic Incisions and Anastomoses

[Text - 'Part 2 - Aortic Incisions']

Cut a straight incision on the anterior wall of the descending aorta (3-5mm) [Show incision] Cut an inferolateral incision along the lesser curvature of the aortic arch which extends towards the ascending aorta (2-3mm above the STJB)

Begin to anastomose between the posterior wall of the descending aorta and the posterior wall of the aortic arch. [Show suture placements and directions on posterior aortic arch] - the starting point of the suture is at the center of the posterior wall and should be completed in two steps [show suture placements on to complete aortic arch]

The back wall anastomosis should result in a widened posterior wall.

## Patch Anastomosis

Cut a long 'oval-shaped' patch - the width of the patch should be roughly 1.5x the diameter of the descending aorta and at least the length of the lesser curvature - the patch is usually cut longer than this and trimmed later [Patch comes into frame - Show comparison of diameter of descending aorta to width of patch] Anastomose the distal tip of the patch to the descending aorta incision - begin the suture 1 stitch away from the apex of the incision and continue to suture the patch along the inferior wall of the descending aorta [show suturing and direction of needle] Trim any excessive edge at the descending aorta [animate removal of excess]

Continue to suture the patch along the anterior wall of the descending aorta toward the aortic back wall anastomosis [animate suturing] Then tie the suture [Animate tying of suture]

Continue the suture along the inferior wall of the aortic arch (lesser curvature) to the distal aortic arch between the 2nd-3rd head and neck branch [animate suturing]

Switch to suturing the patch on the anterior wall of the descending aorta toward the other end of the aortic back wall anastomosis [animate suturing] Then tie the suture [Animate tying of suture]

Continue the suture along the anterior wall of the aortic arch (greater curvature) to the distal ascending aorta [animate suturing] Suture along the greater curvature to the point where the lesser curvature was previously anastomosed.

Continue the suture from the inferior wall of the aortic arch (lesser curvature) to the proximal ascending aorta [animate suturing] Trim any excess on the patch [animate removal of excess patch] Continue the suture toward the apex at the proximal ascending aorta and back to the anterior wall of the aortic arch (greater curvature) [animate suturing] The suture should continue until the site of expected pulmonary implantation.

Before closing the suture, probe to ensure the patency of the augmented ascending aorta [animate probe inserting into ascending aorta and deforming aorta]

## Reimplantation of the pulmonary artery

If necessary, trim the distal pulmonary artery to the appropriate length before being reimplanted to the patch (length adjusted according to the site of incision and location of PA). Using

forceps, hold the pulmonary root up against the patch with forceps to identify the location of the incision that needs to be made on the patch. [animate forceps moving pulmonary root against patch]

Make an incision on the patch that will be used to attach the pulmonary artery [animate incision into patch] Extend the incision to make a long oval shaped hole with the same circumference as the pulmonary artery end [animate creation of oval shaped hole]

Start anastomosing between the posterior wall of the pulmonary artery and the posterior wall of the patch incision [animate suturing]

Switch to the other side and continue the suture between the anterior wall of the pulmonary artery and the anterior wall of the patch incision [animate suturing] Then tie the suture [animate tying]

Finally, complete the patch anastomosis of the ascending aorta [animate suturing]


The relationship between the aorta and pulmonary artery is maintained.


[Text 'Final result of Birmingham technique - Norwood procedure']

[Bring model to center of frame and rotate to show final result - highlight relevant structures as with beginning]