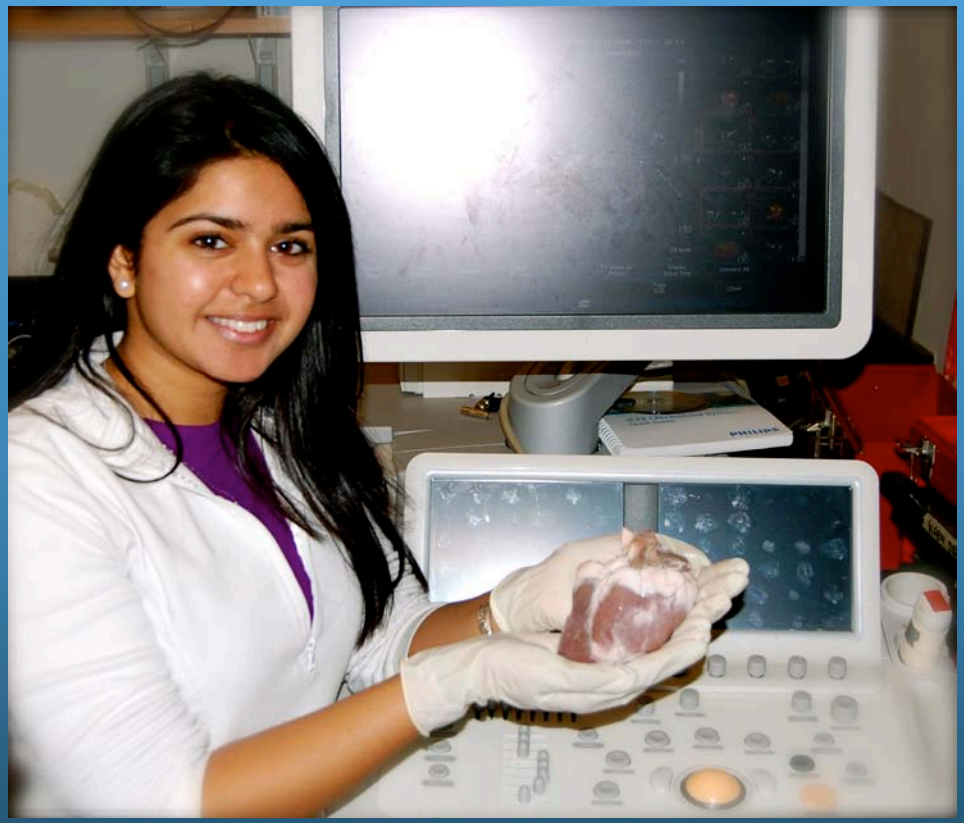
Hemodynamic Assessment of Bicuspid Aortic Valves as a Clinical Diagnostic Tool



2010 Undergraduate Research Kaleidoscope

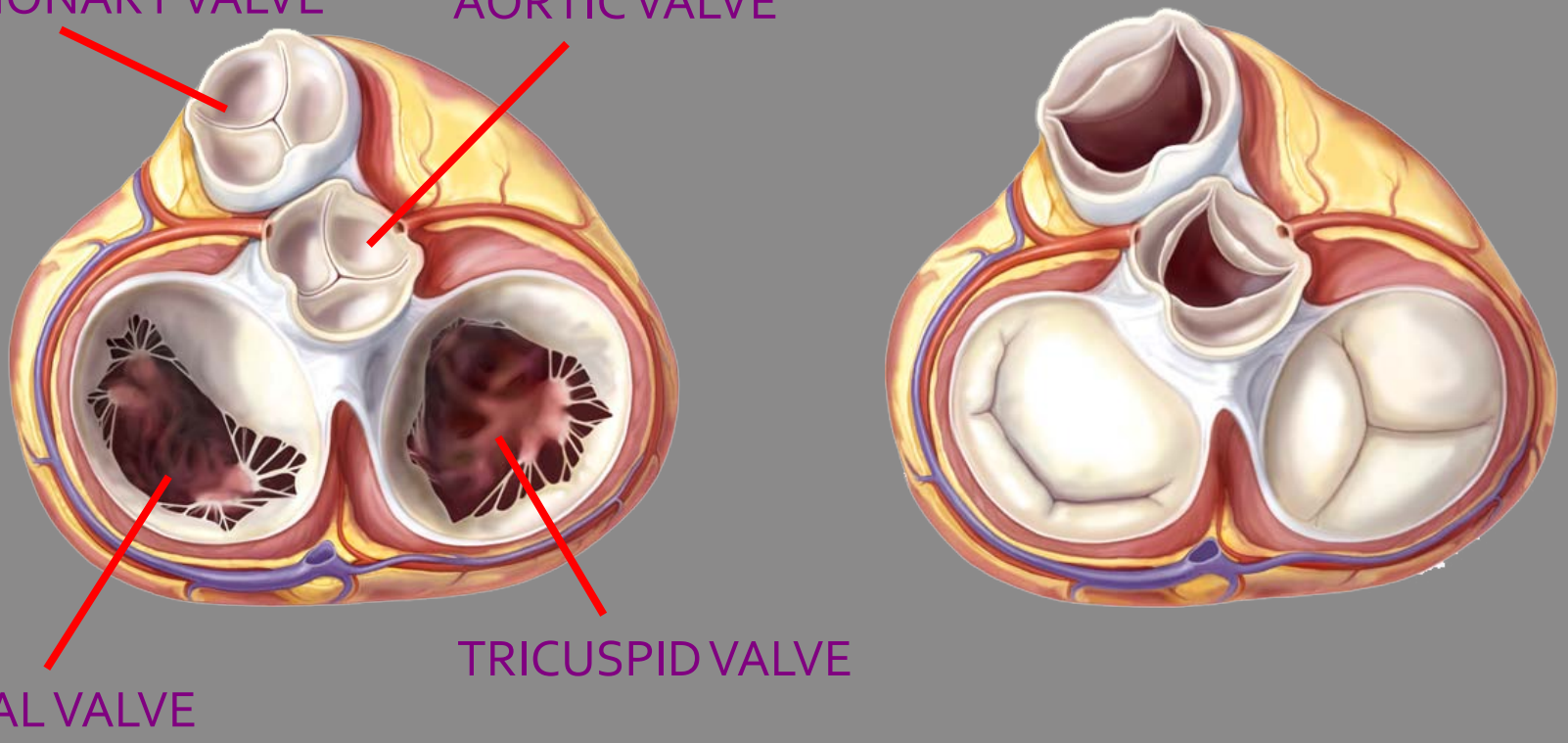
November 18, 2010

Shabnam Gupta
School of Engineering
Department of Biomedical Engineering
Mentor: Neela Saikrishnan

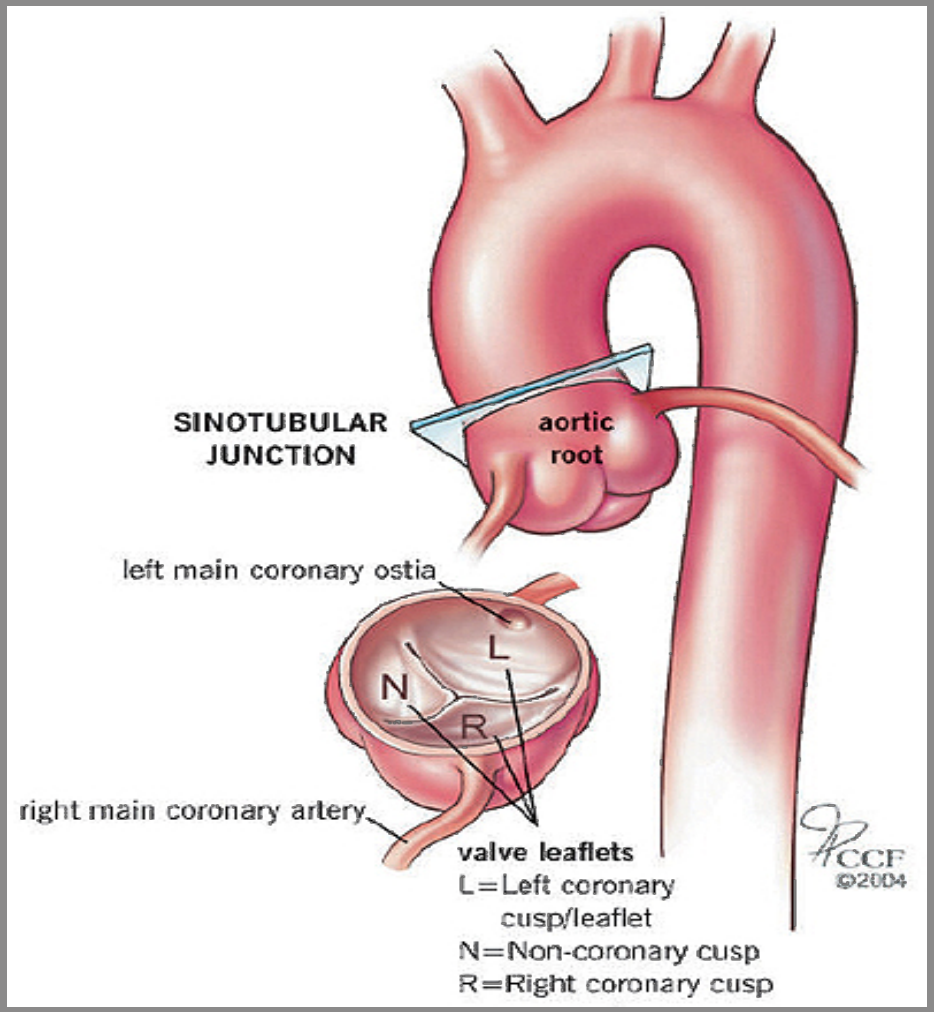
Background- The Heart

DIASTOLE

SYSTOLE



Background- The Aortic Valve



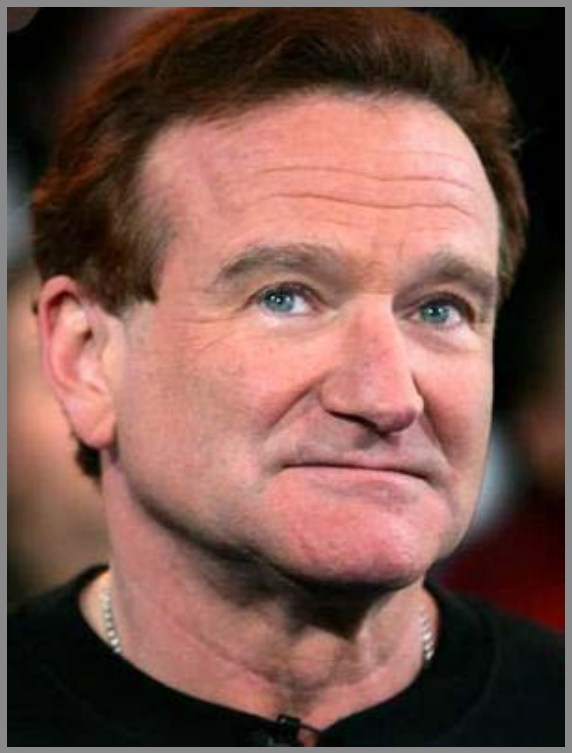
Source: Cleveland Clinic

Valve Geometries

Normal

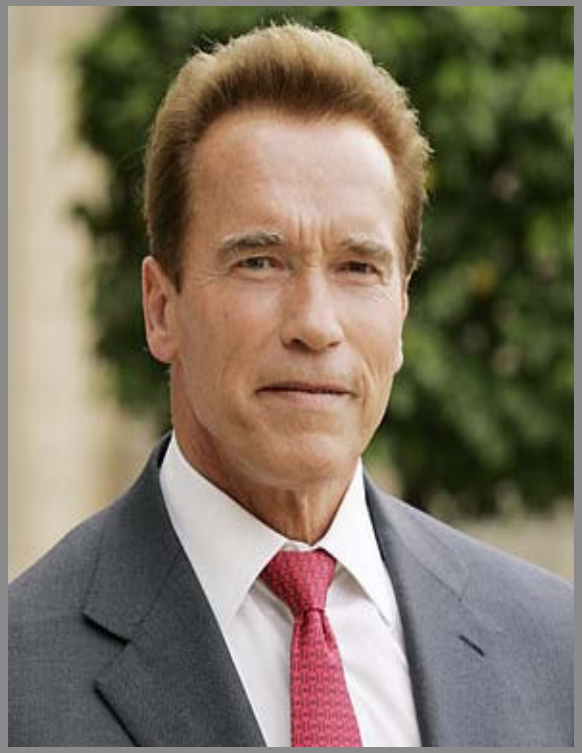
Bicuspid

Familiar Faces



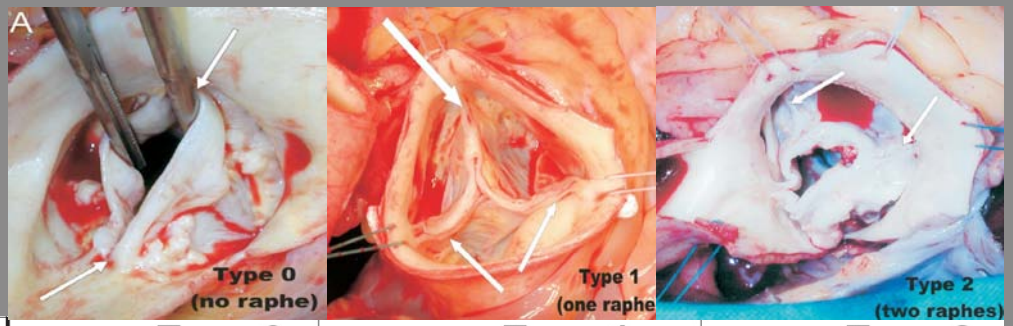
Robin Williams

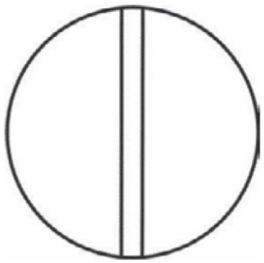
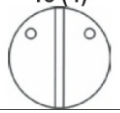
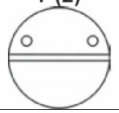
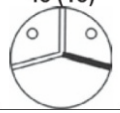
Barbara Bush



Arnold Schwarzenegger

Background on BAV



main category: number of raphes	0 raphe - **Type 0**  21 (7)		1 raphe - **Type 1**  269 (88)			2 raphes - **Type 2**  14 (5)
1. subcategory: spatial position of cusps in Type 0 and raphes in Types 1 and 2	lat 13 (4) 	ap 7 (2) 	L – R 216 (71) 	R – N 45 (15) 	N – L 8 (3) 	L – R / R – N 14 (5) 
2. subcategory:						
VALVULAR FUNCTION — I	6 (2)	1 (0.3)	79 (26)	22 (7)	3 (1)	6 (2)
VALVULAR FUNCTION — S	7 (2)	5 (2)	119 (39)	15 (5)	3 (1)	6 (2)
VALVULAR FUNCTION — B (I + S)		1 (0.3)	15 (5)	7 (2)	2 (1)	2 (1)
VALVULAR FUNCTION — No			3 (1)	1 (0.3)		

Diseased valve

Motivation for Project

Bicuspid Aortic Valves

ASYMPTOMATIC FOR YEARS

Diagnosed late in life

1-2% of population

ECHO as standard of care

Cheaper than PC-MRI

Objective of Project

Clinical diagnostic tool for BAV Patients

Ultrasound for images

Reconstruct geometries & repeat

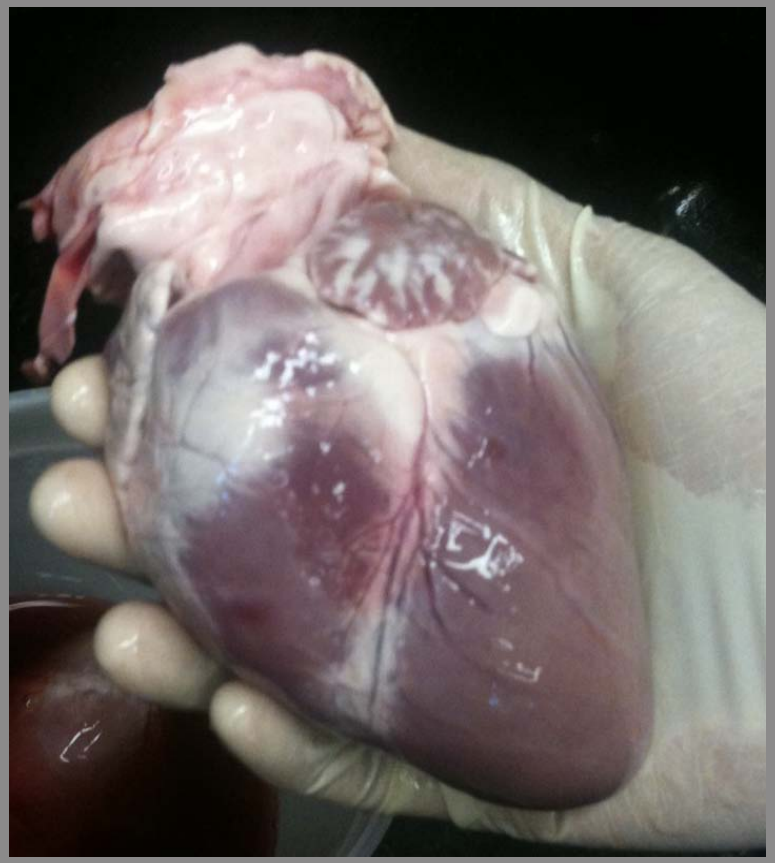
Assess Hemodynamics

Project Overview

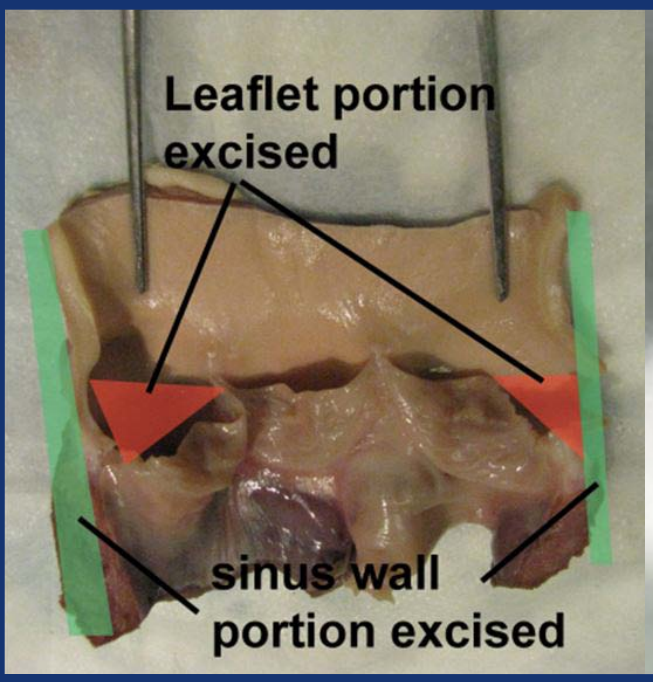
- Excise Valve & Mount on ring ✔
- Fix ring in chamber of flow loop ✔
- Use 3D-ECHO to obtain images ✔
- Characterize hemodynamics

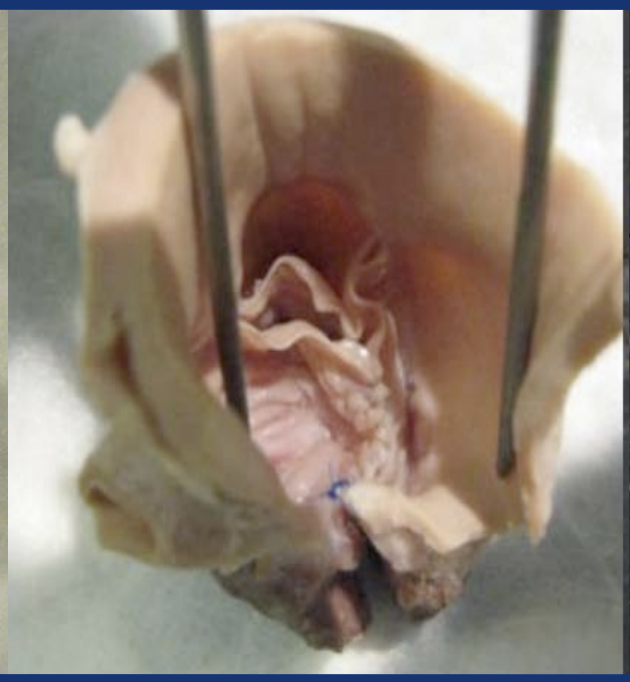
How to obtain valves

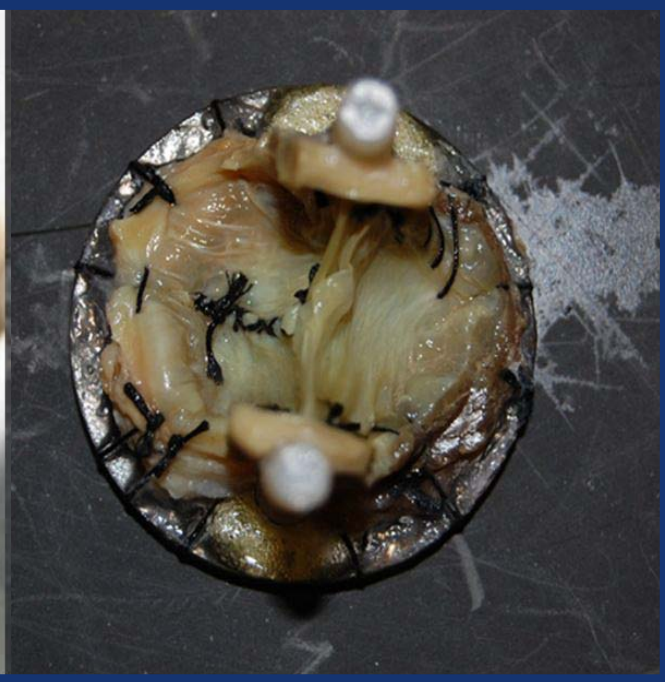
Excising the aortic root



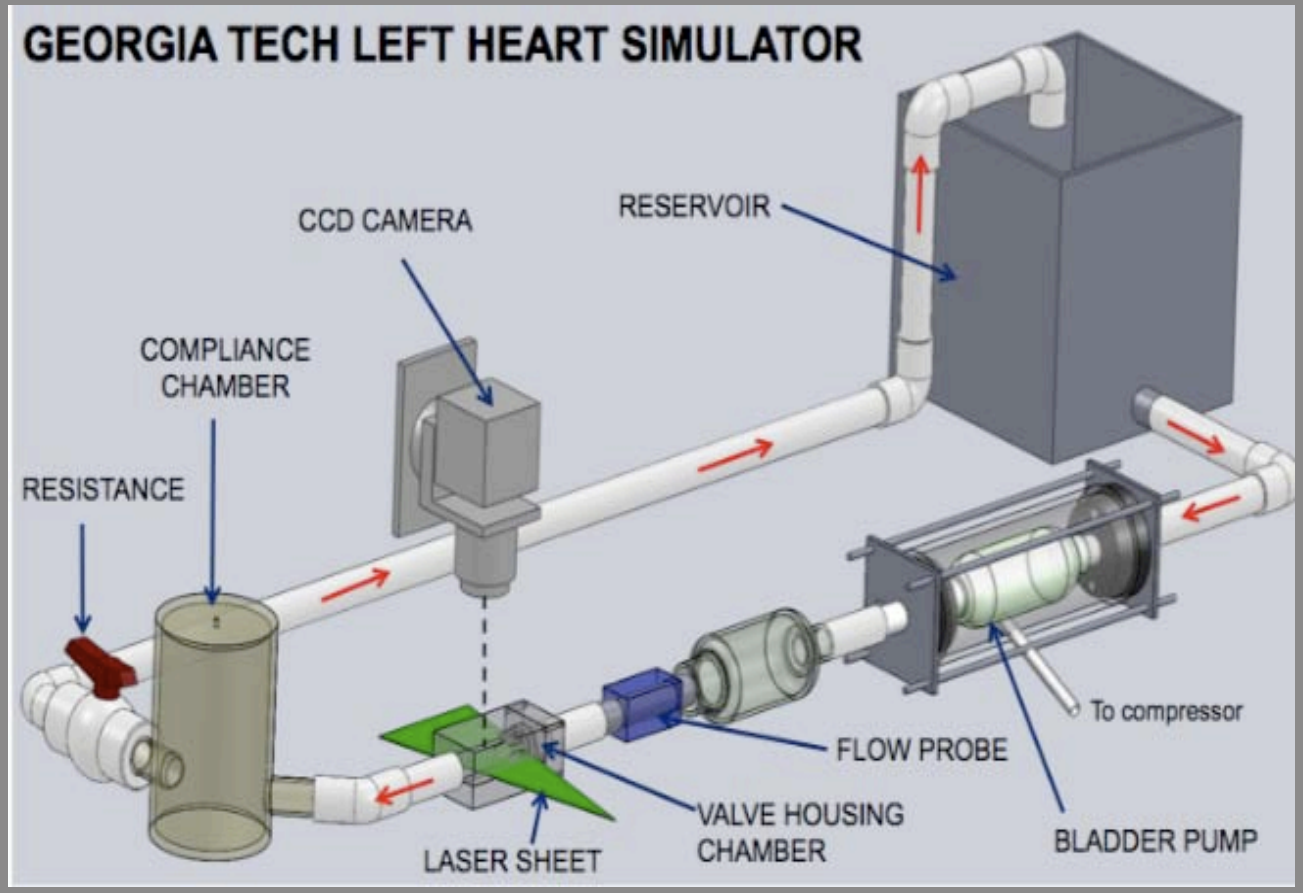
Suturing & Mounting Valve







Experimental Setup



Equipment

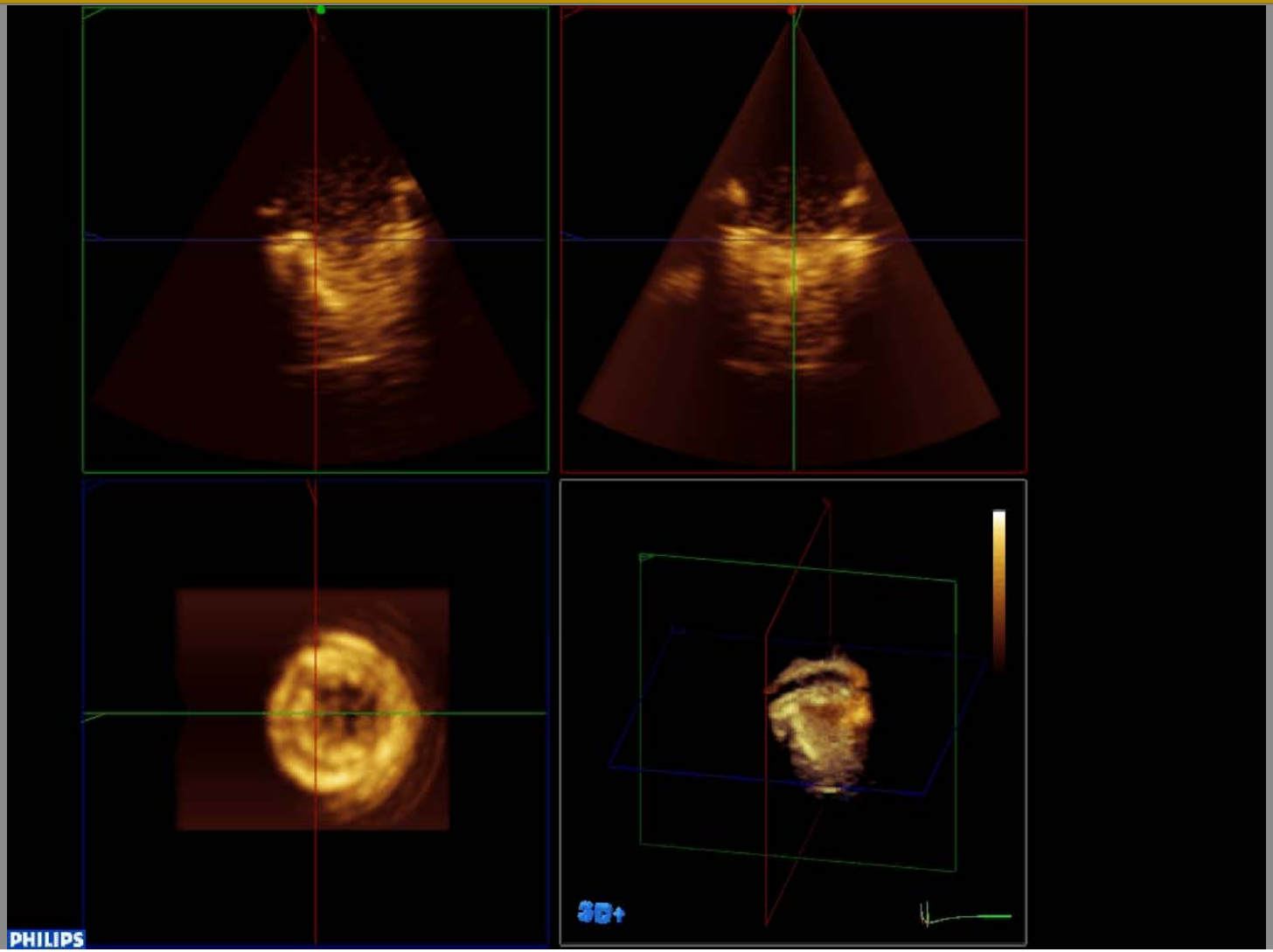
Ultrasound Machine:
iE33, Philips Inc, Andover, MA

Pediatric Probe

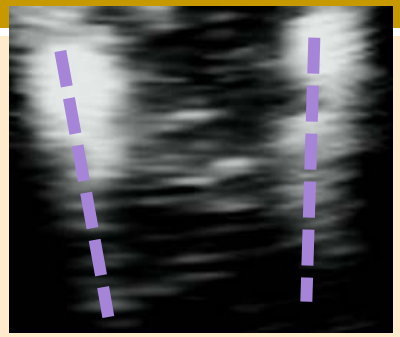
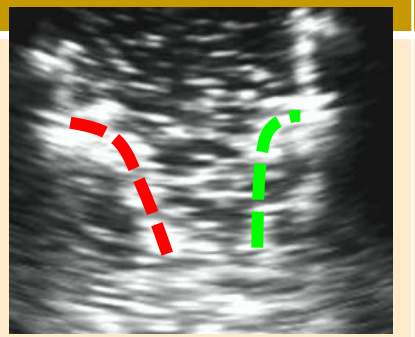
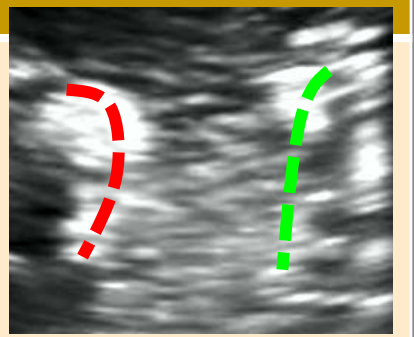
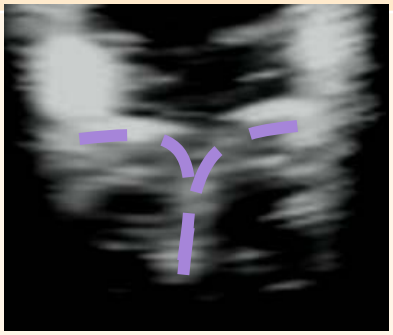
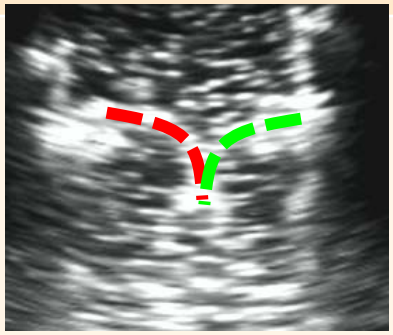
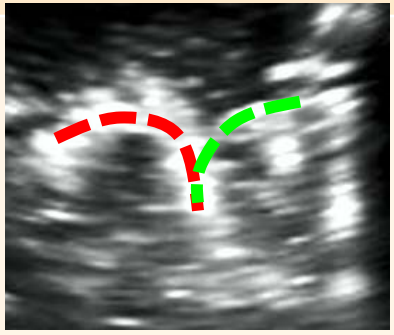
2D Image- Normal valve

Xplane Image- BAV

Full-Volume Images- BAV



2D ECHO ASSESSMENT OF VALVES

	Normal tricuspid AV	BAV1 (Eccentric)	BAV2 (Central)
Systole (Fully open)			
Diastole (Fully closed)			

NORMAL LEAFLET

NORMAL LEAFLET

BICUSPID LEAFLET

Future tasks

$$\frac{\partial}{\partial\theta}\left(\bar{h}_0^3\frac{\partial\bar{P}_0}{\partial\theta}\right)+\left(\frac{D}{L}\right)^2\frac{\partial}{\partial\bar{z}}\left(\bar{h}_0^3\frac{\partial\bar{P}_0}{\partial\bar{z}}\right)=\Lambda\frac{\partial\bar{h}_0}{} \quad (7)$$

$$U=\bar{U}+u'$$

$$\tau_{\text{mean}}=\frac{\overline{\sigma_{p1}}-\overline{\sigma_{p2}}}{2}$$

$$\frac{\partial}{\partial\theta}\left(\quad\frac{\partial}{\partial\theta}\right)\quad\frac{\partial}{\partial\theta}\left(\quad\right)\quad\cos\theta\frac{\partial\bar{P}_0}{\partial\theta}\Big)+\left(\frac{D}{L}\right)^2\quad\frac{\partial}{\partial\bar{z}}\left(\quad\frac{\partial}{\partial\bar{z}}\right)\Big\} \quad (8)$$

$$+\left(\frac{D}{L}\right)^2\frac{\partial}{\partial\bar{z}}\left(3\bar{h}_0^2\cos\theta\frac{\partial\bar{P}_0}{}\right)$$

$$\overline{\sigma_{p1}}=\rho\left[\frac{\overline{u'u'}+\overline{v'v'}}{2}+\sqrt{\left(\frac{\overline{u'u'}-\overline{v'v'}}{2}\right)^2+\left(\overline{u'v'}\right)^2}\right]$$

$$V=\bar{V}+v'$$

$$\cos\theta\frac{\partial\bar{P}_0}{\partial\theta}\Big)+\left(\frac{D}{L}\right)\frac{\partial}{\partial\bar{z}}\left(\bar{h}_0^3\frac{\partial\bar{P}_0}{\partial\bar{z}}\right)+\Big\} \quad (9)$$

$$+\left(\frac{D}{L}\right)^2\frac{\partial}{\partial\bar{z}}\left(3\bar{h}_0^2\cos\theta\frac{\partial\bar{P}_0}{\partial\bar{z}}\right)=$$

$$\overline{\sigma_{p2}}=\rho\left[\frac{\overline{u'u'}+\overline{v'v'}}{2}-\sqrt{\left(\frac{\overline{u'u'}-\overline{v'v'}}{2}\right)^2+\left(\overline{u'v'}\right)^2}\right]$$

Kaleidoscope of Mechanical Heart