Echo Hawaii
Jan 18, 2018

3D Printing & Echocardiography

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HOUSTON Methodist DEBAKEY HEART & VASCULAR CENTER

Rapid Prototyping 101

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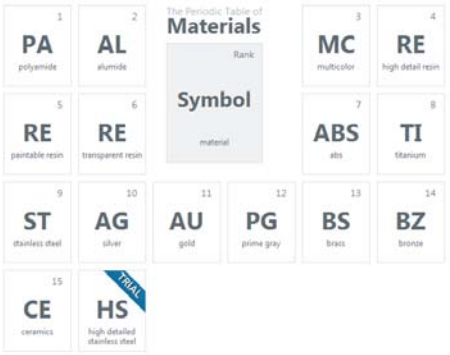
Complex Geometry + Multi-Material Fusion = Functional Anatomy (?)



ARS Question # 1

Audience poll

Finish this sentence….At my institution we use 3D printing to:

1. Plan all complex structural heart procedures.
2. Plan for selected complex structural heart procedures.
3. As a research tool with very little clinical usage.
4. What the heck is 3D printing? We never use it.

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Finish this sentence….At my institution we use 3D printing to:

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CV 3D Print Applications

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- Anatomic Teaching Tools
- Functional Flow Modeling
- Procedural Planning
- Device Innovation

The 3D printing steps

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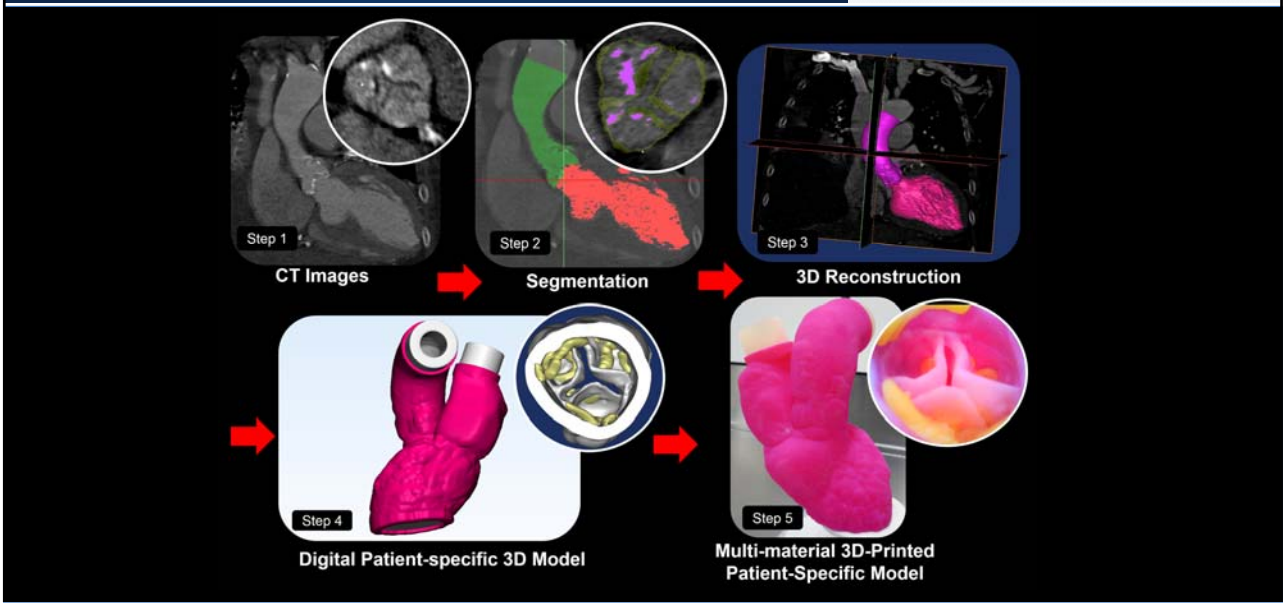
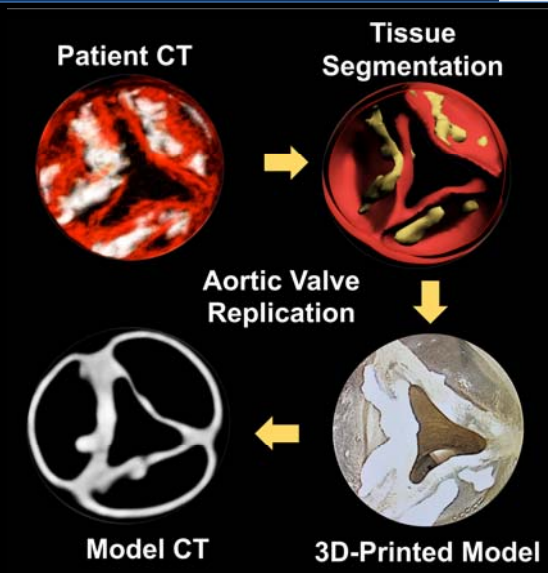
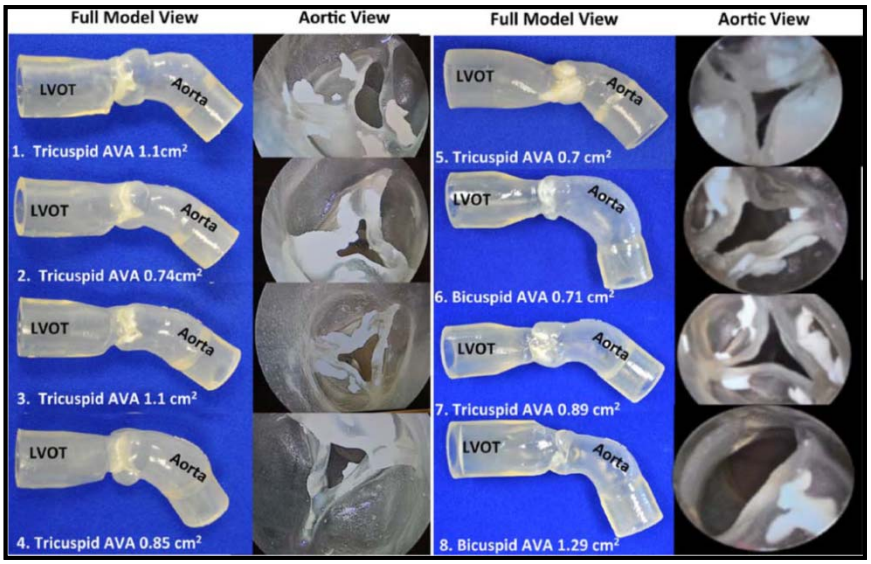


AVA Replication

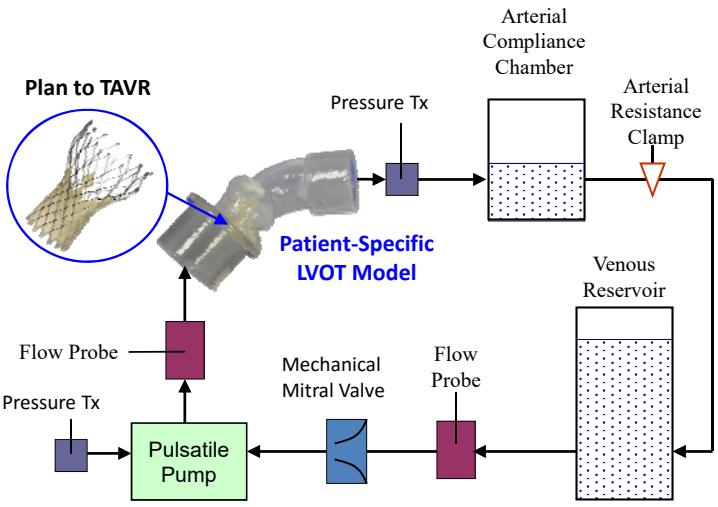


Aortic Root Replication

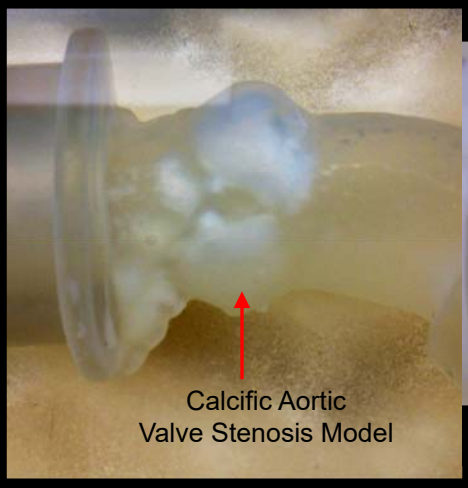


Maragiannis et al. Circ Cardiovasc Imaging. 2015

HeartBeat Simulator™ Setup

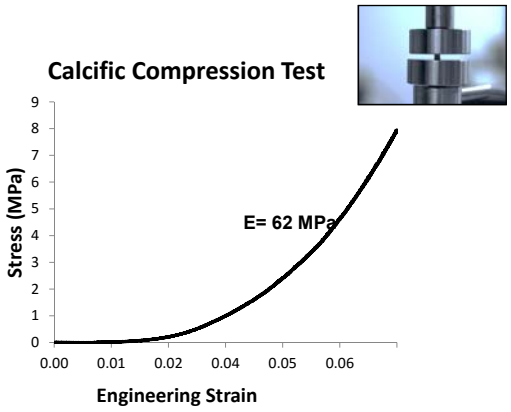


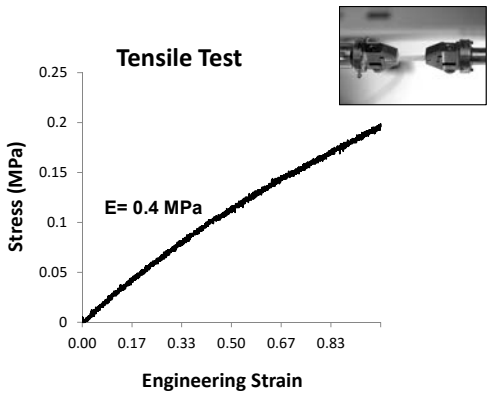
Patient-Specific LVOT Model



Pulsatile flow across a 3D printed model

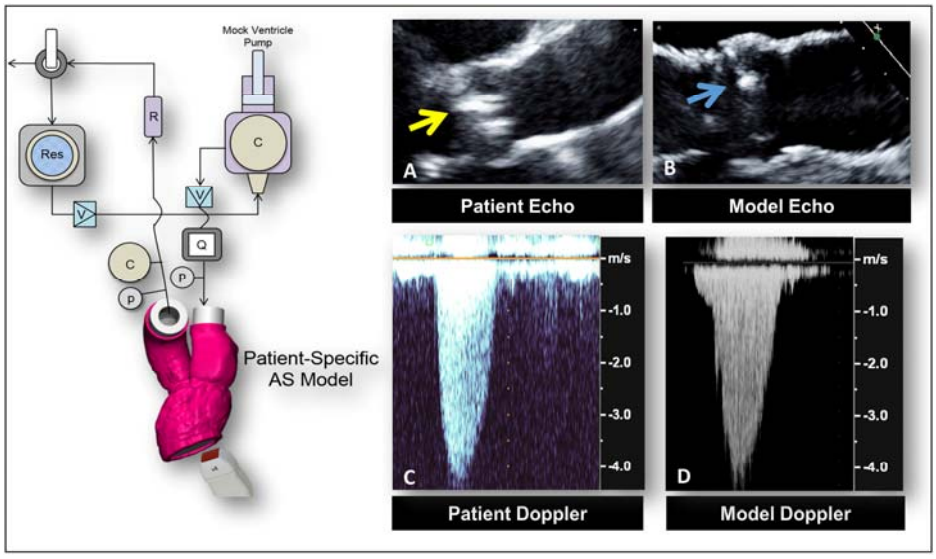
Mechanical Testing of Print Materials



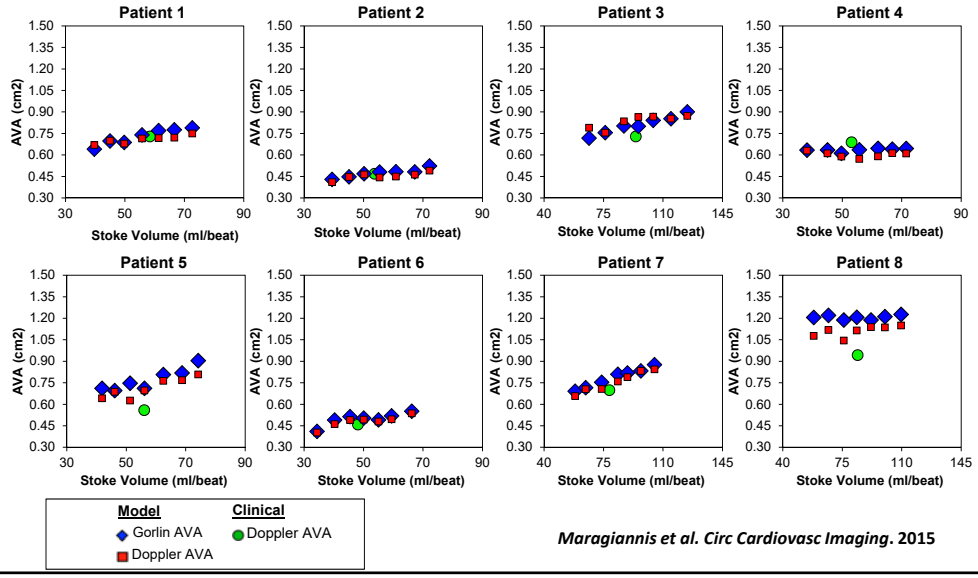


Compression testing for rigid calcific nodules and tensile testing for soft tissue structures.

Replicating AS pressure gradients

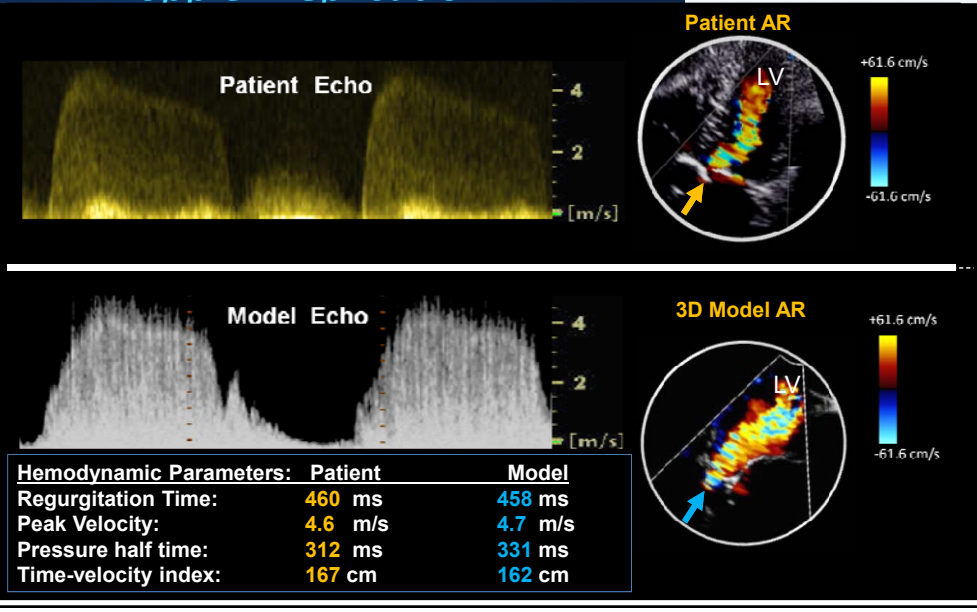


Replicated AVA flow dependency



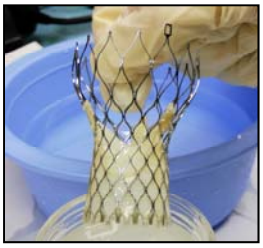
Maragiannis et al. Circ Cardiovasc Imaging. 2015

Aortic Regurgitation:
Doppler Replication



Hemodynamic Parameters:	Patient	Model
Regurgitation Time:	460 ms	458 ms
Peak Velocity:	4.6 m/s	4.7 m/s
Pressure half time:	312 ms	331 ms
Time-velocity index:	167 cm	162 cm

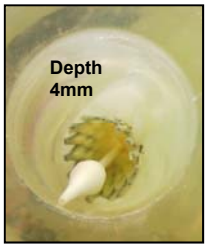
Bench-top TAVR



CoreValve Prosthesis

Sheathed Transcatheter CoreValve Prosthesis

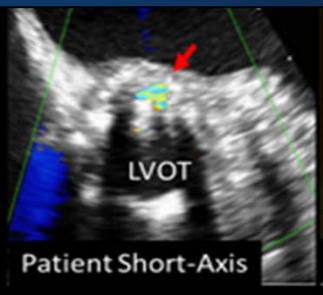
Crossing Stenotic Aortic Valve

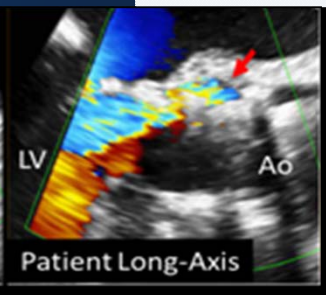


CoreValve Deployment

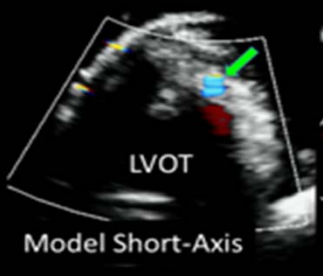
CoreValve Expanded Within LVOT Model

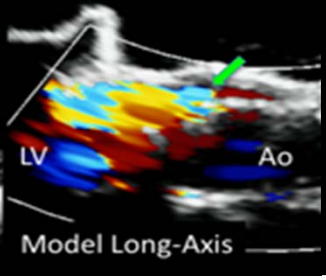
Replicating PVL





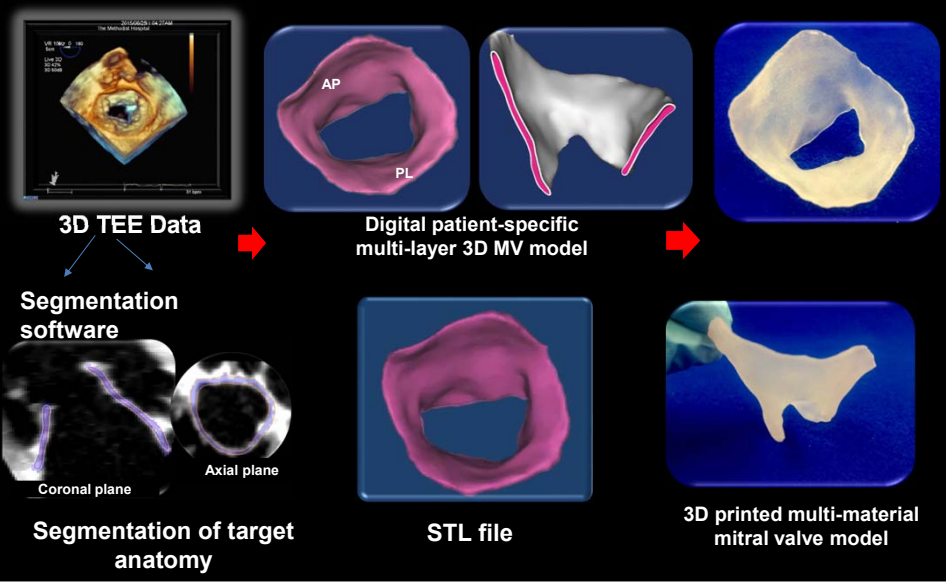
Patient Echo



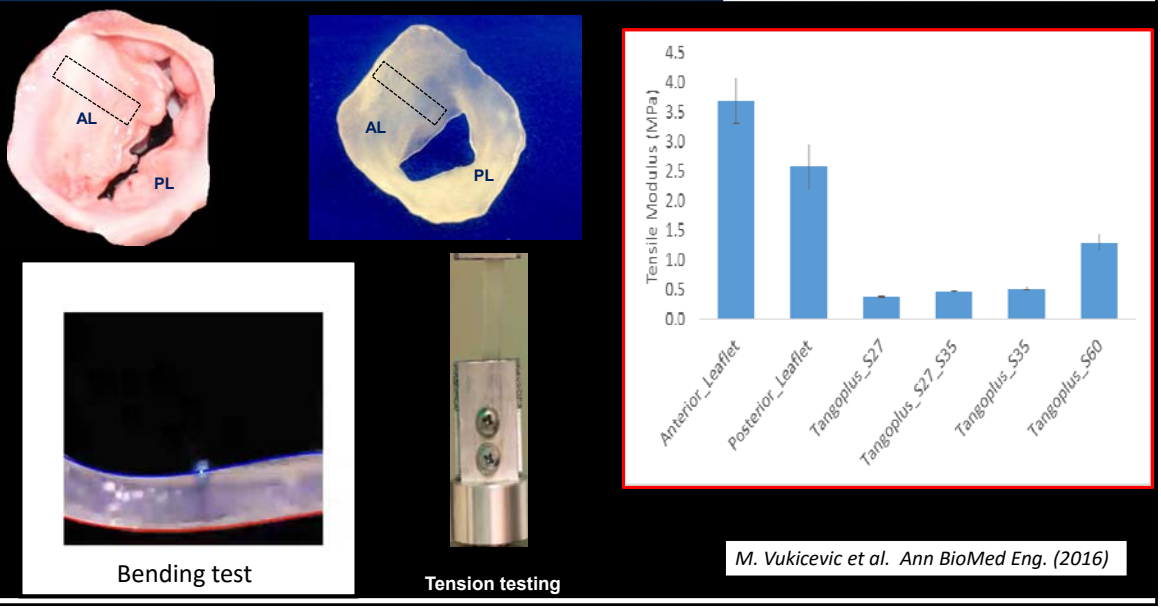


Model Echo

Mitral Valve reconstruction from 3D TEE

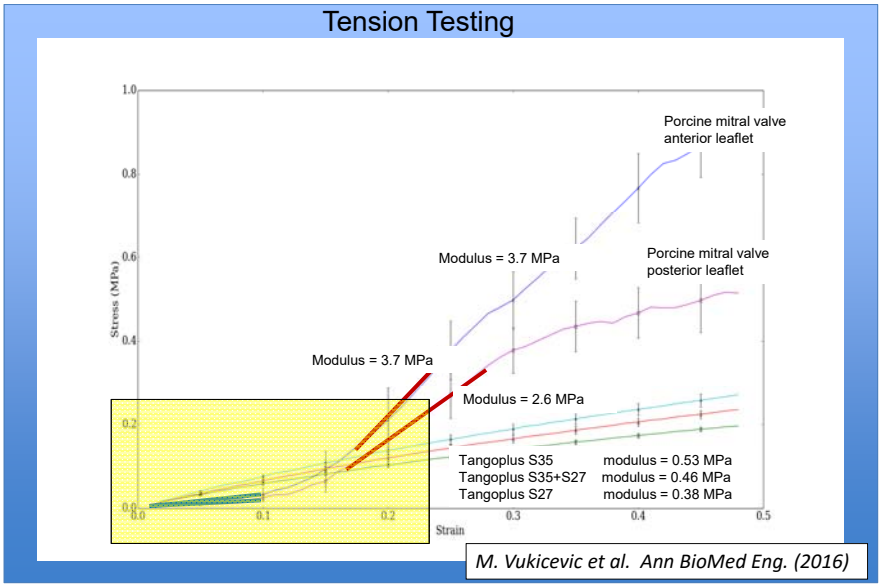


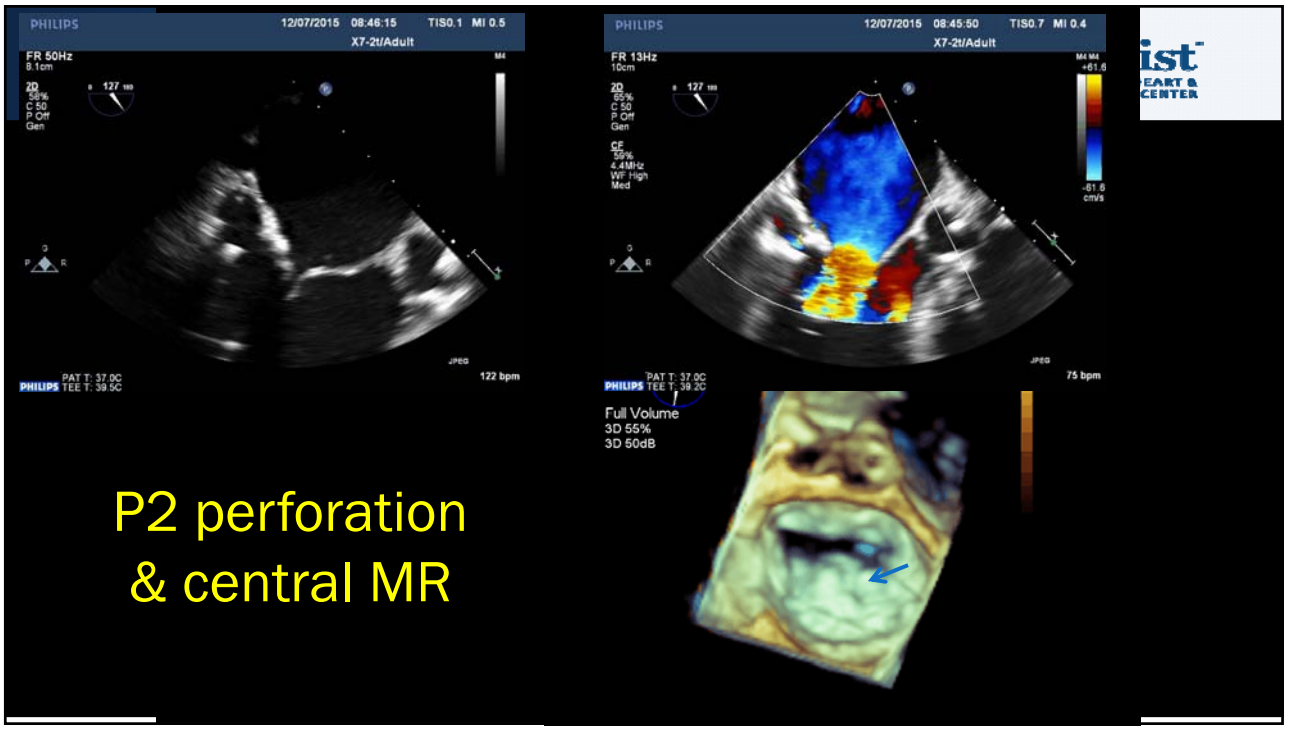
Mechanical Testing of Mitral Valve Materials



M. Vukicevic et al. Ann BioMed Eng. (2016)

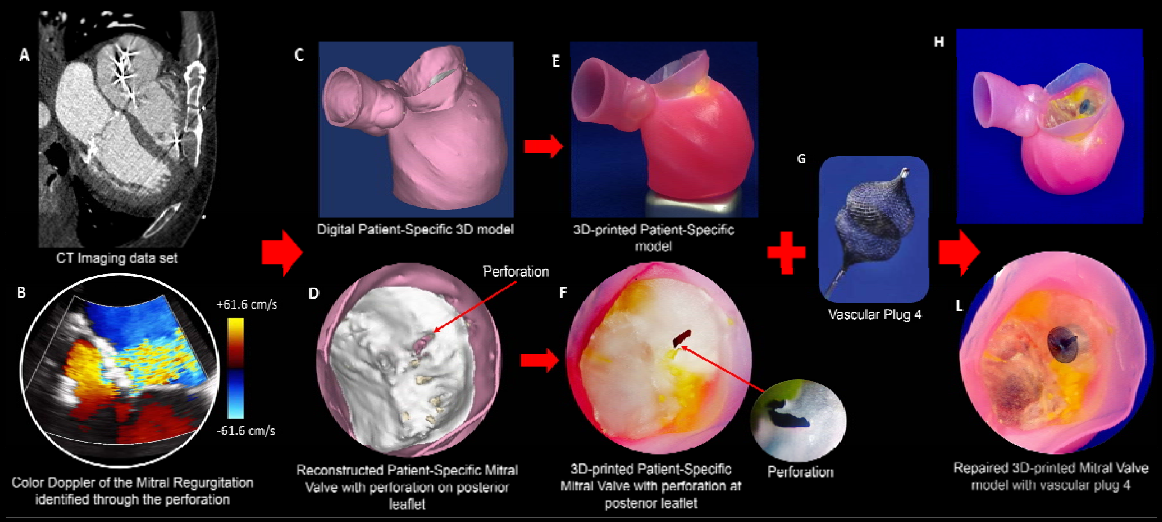
Mitral Leaflet Response to Stress



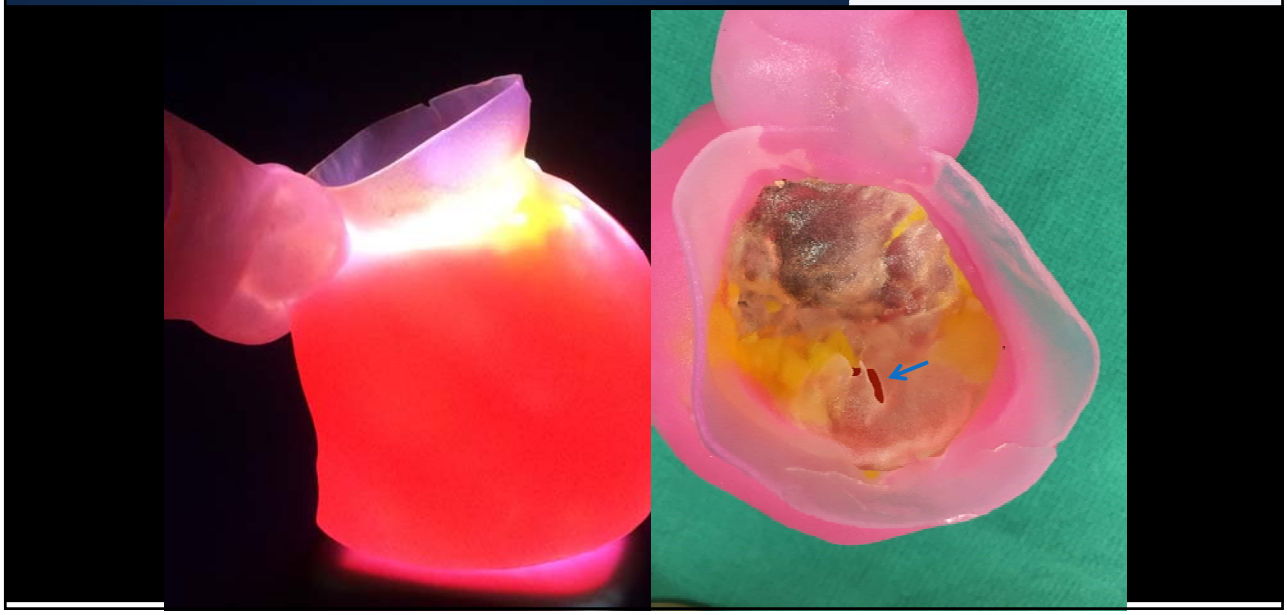


P2 perforation & central MR

Pre-procedural Planning of perforated mitral valve repair



Patient-Specific 3D Print P2 perforation



What device will fit?

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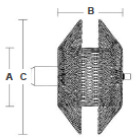
Ductus Diameter	Ductus Length <5mm	5.0 – 8.0mm	8.1 – 10.0mm	10.1 – 11.0mm	11.1 – 12.0mm
<2.5mm	ADO II 03-04	ADO II 03-06	ADO II 04-06	ADO II 05-06	ADO II 06-06
2.5 – 3.5mm	ADO II 04-04	ADO II 04-06	ADO II 05-06	ADO II 06-06	ADO II 06-06
3.6 – 4.5mm	ADO II 05-04	ADO II 05-06	ADO II 05-06	ADO II 06-06	ADO II 06-06
4.6 – 5.5mm	ADO II 06-04	ADO II 06-06	ADO II 06-06	ADO II 06-06	ADO II 06-06



Model / Reorder Number	[A] Waist Diameter (mm)	[B] Device Length (mm)	[C] Disc Diameter (mm)	Recommended Catheter Size (with AMPLATZER® TorqVue LP Delivery System)
9-PDA2-03-04	3	4	9	4 F
9-PDA2-03-06	3	6	9	4 F
9-PDA2-04-04	4	4	10	4 F
9-PDA2-04-06	4	6	10	4 F
9-PDA2-05-04	5	4	11	5 F
9-PDA2-05-06	5	6	11	5 F
9-PDA2-06-04	6	4	12	5 F
9-PDA2-06-06	6	6	12	5 F

Amplatzer Duct Occluder II

ST. JUDE MEDICAL
MORE CONTROL. LESS RISK.

Patient-Specific 3D Print Modeling for Leaflet Repair

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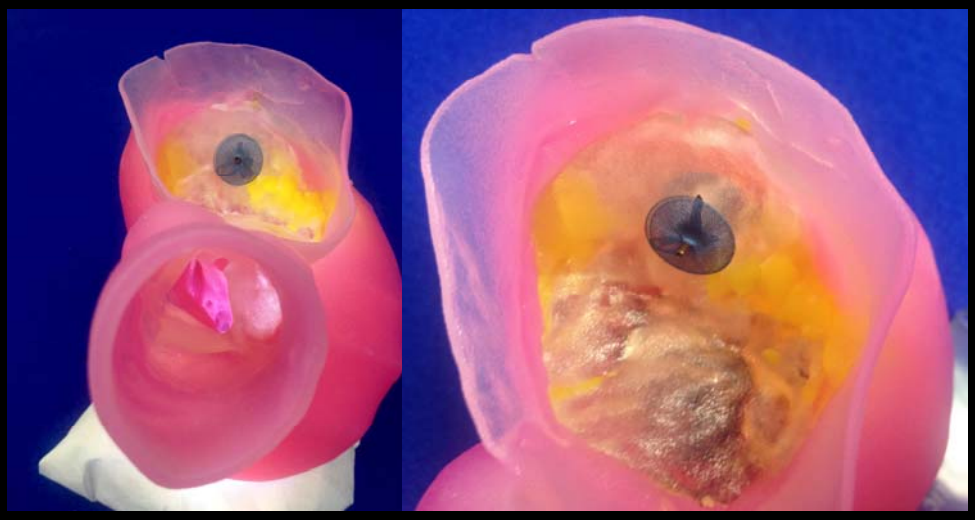
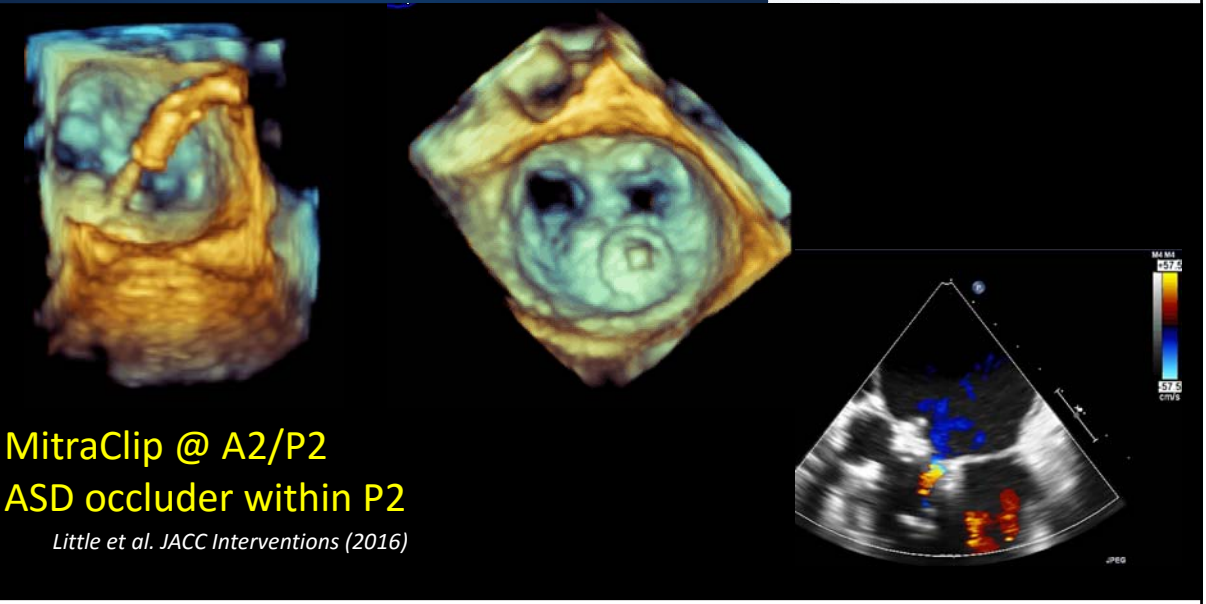


Atrial View

Replicating the calcium too

Ventricular View

Guiding the practiced procedure

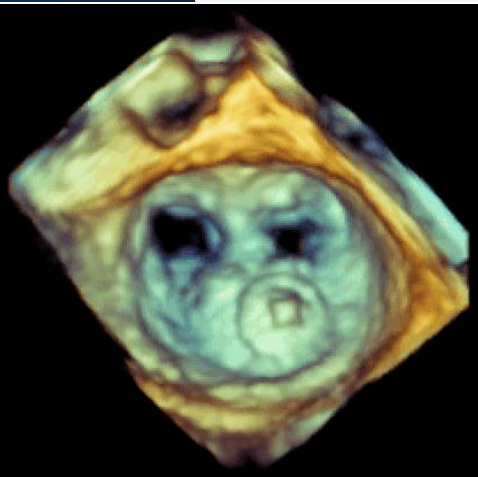


MitraClip @ A2/P2
ASD occluder within P2

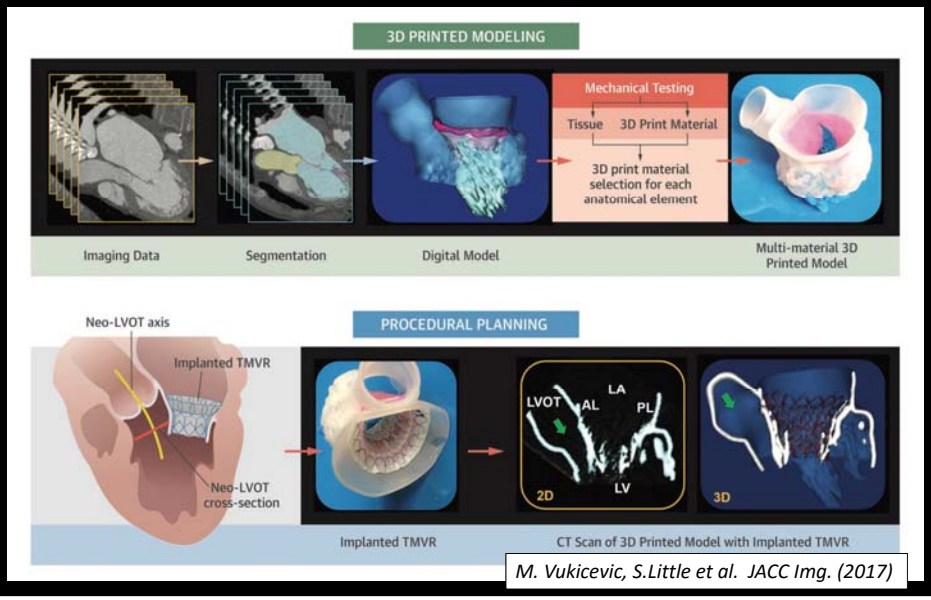
Little et al. JACC Interventions (2016)

A familiar result?

The Never Ending story dog

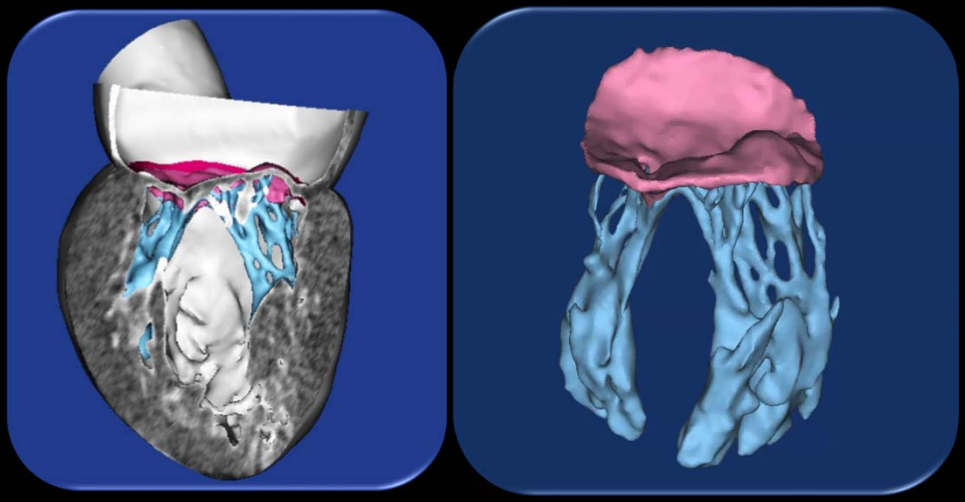


Modeling LVOT obstruction

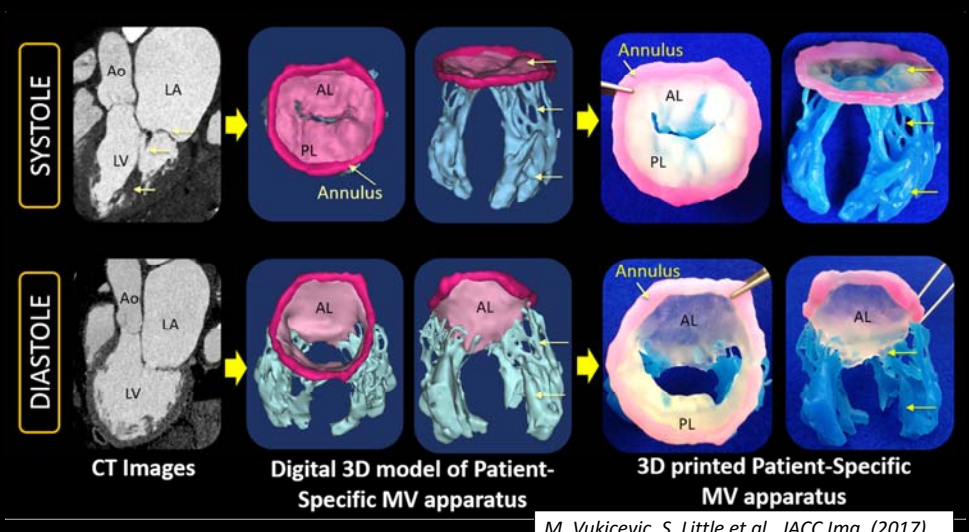


M. Vukicevic, S.Little et al. JACC Img. (2017)

CT-based patient-specific MV

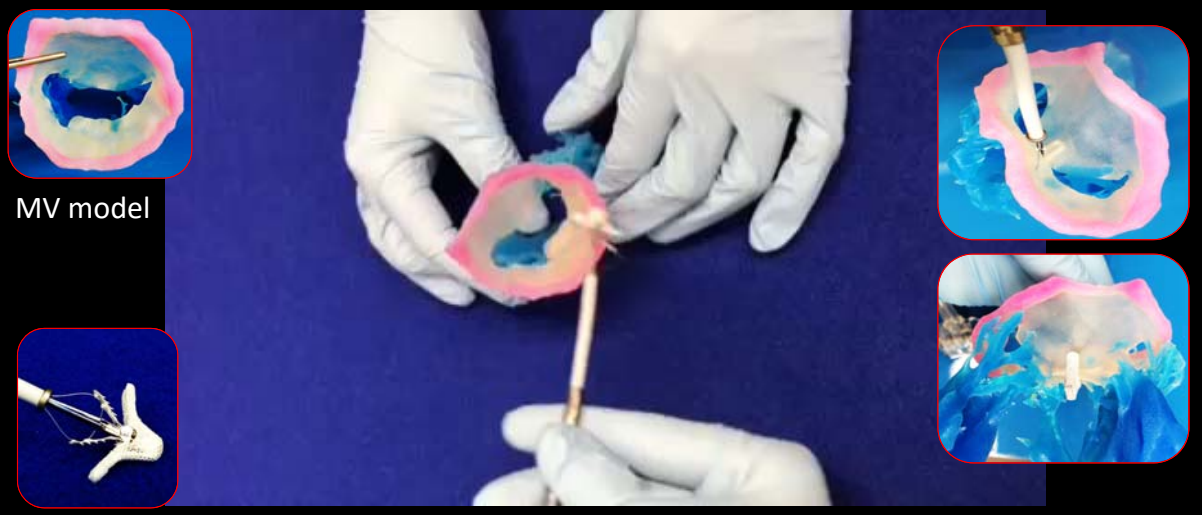


Mitral valve 3D printing



M. Vukicevic, S. Little et al. JACC Img. (2017)

MitraClip implantation in a patient-specific 3D printed MV apparatus



Why do we need models?

3D-Printed Valve models:

- Can replicate patient-specific geometry
- Can be coupled to physiologic flow
- Provide a reproducible testing environment
- Are a cheap arena for mistakes and innovation
- Have already changed how we practice and perfect structural heart interventions

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