



Postnatal Imaging of Mitral Valve Disease

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Evelina London Children's Hospital

Conflict of interest

- Consultancy
 - Philips Medical
 - Canon Medical
- Founder / Director of XRnostics, focusing on immersive imaging for planning cardiac surgery and interventions

Areas to be covered

- Modalities used to assess the mitral valve
 - 2D echo / 3D echo
 - MRI and CT
- Key anatomic features of abnormalities
- Advances
 - 3D Printing
 - Immersive visualisation

Echocardiography:

All probes can have standard modalities and 3D



High frequency
Small footprint
Infants / small children



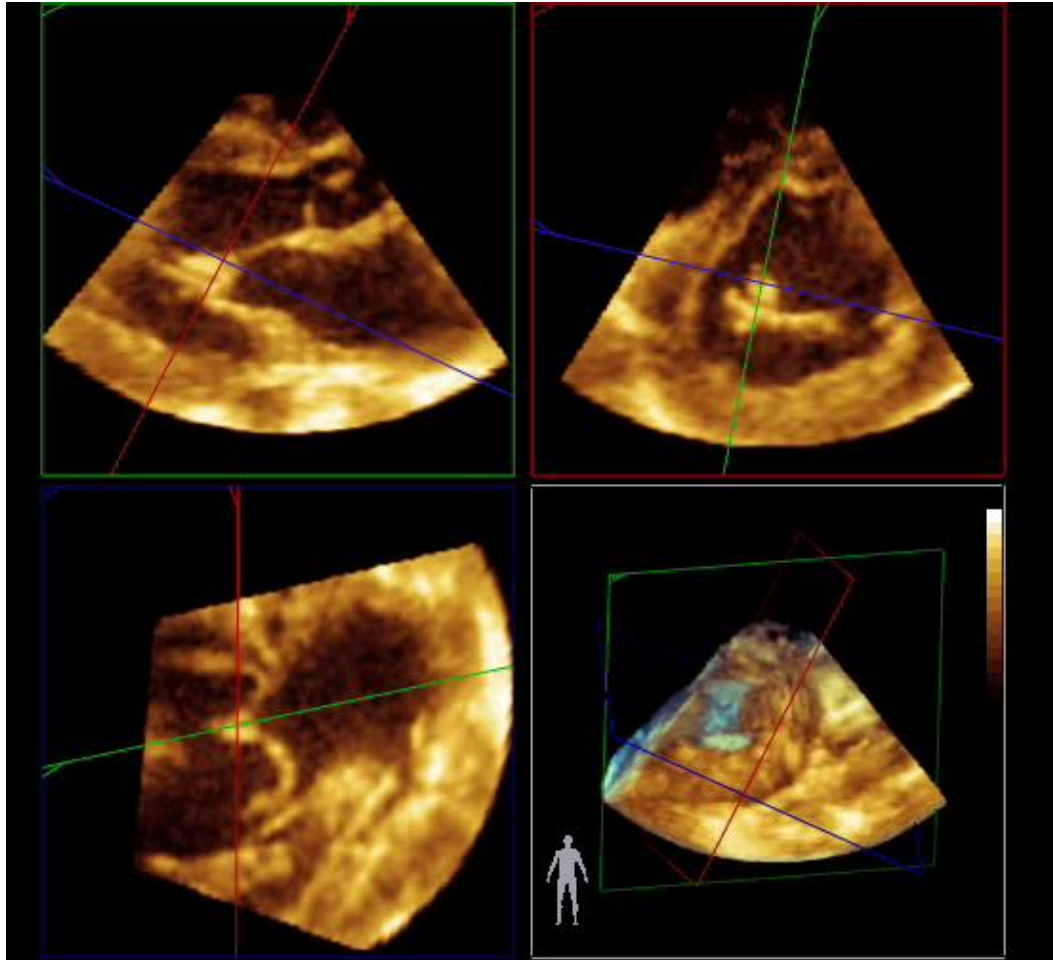
Lower frequency
Larger footprint
Older children / adults



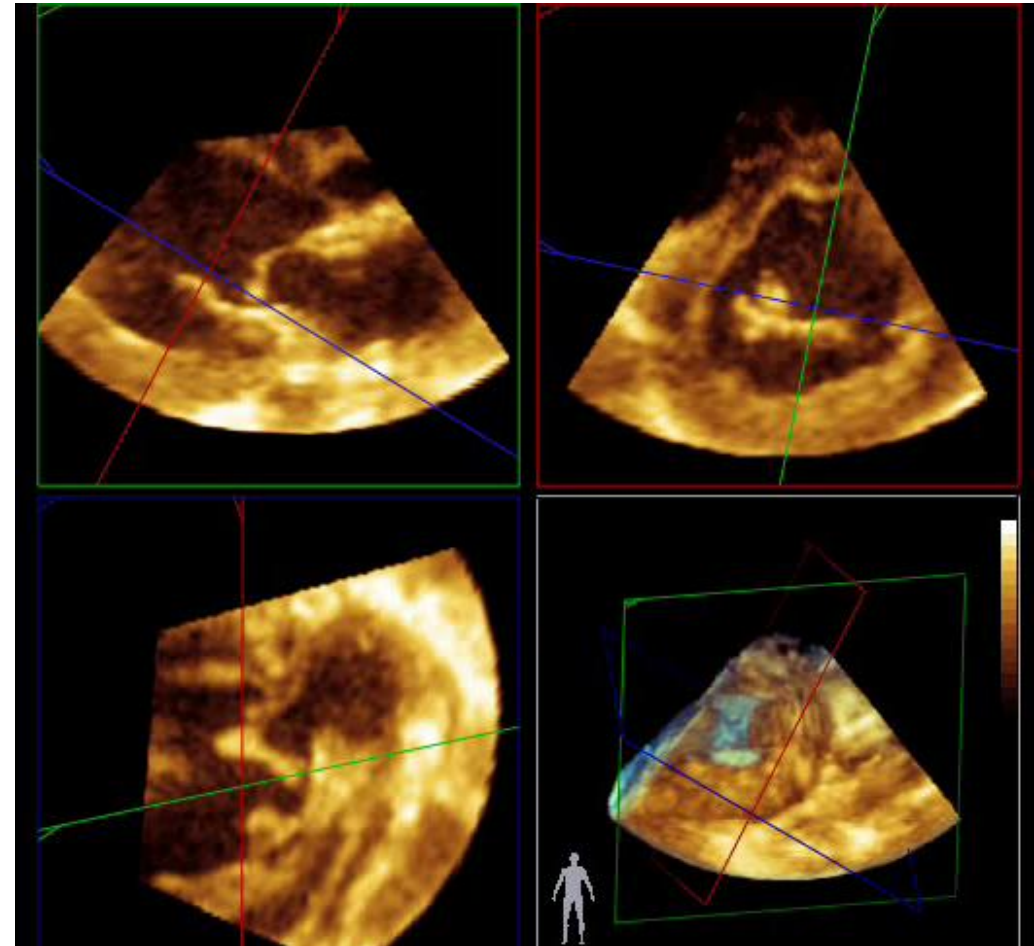
Patients >4kg

MPR “walk through” of MV

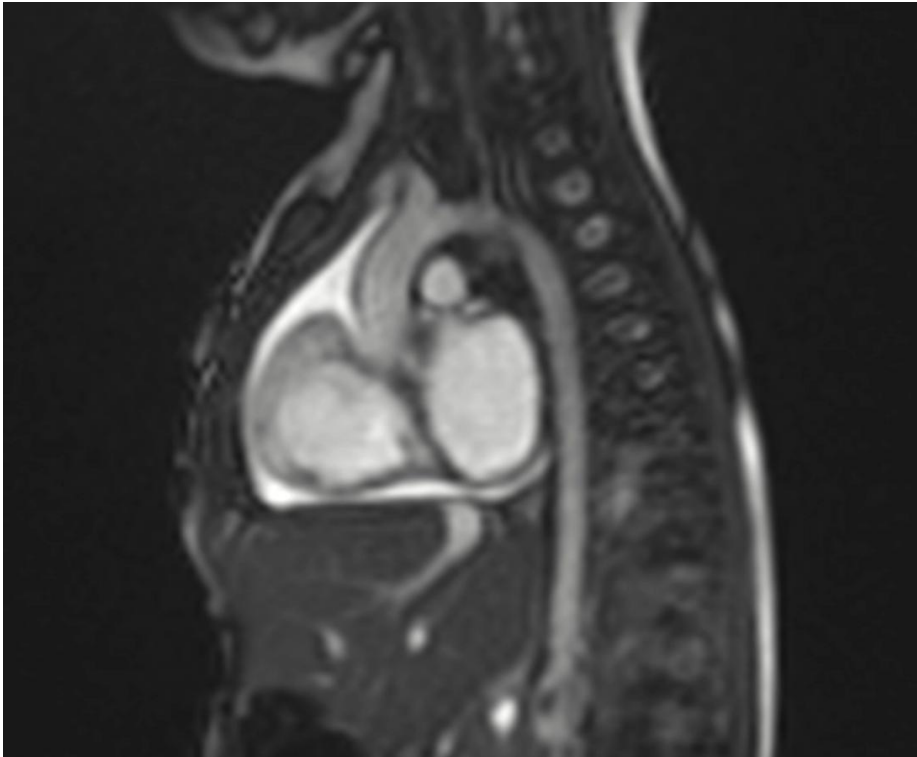
A3 , P3



A2, P2

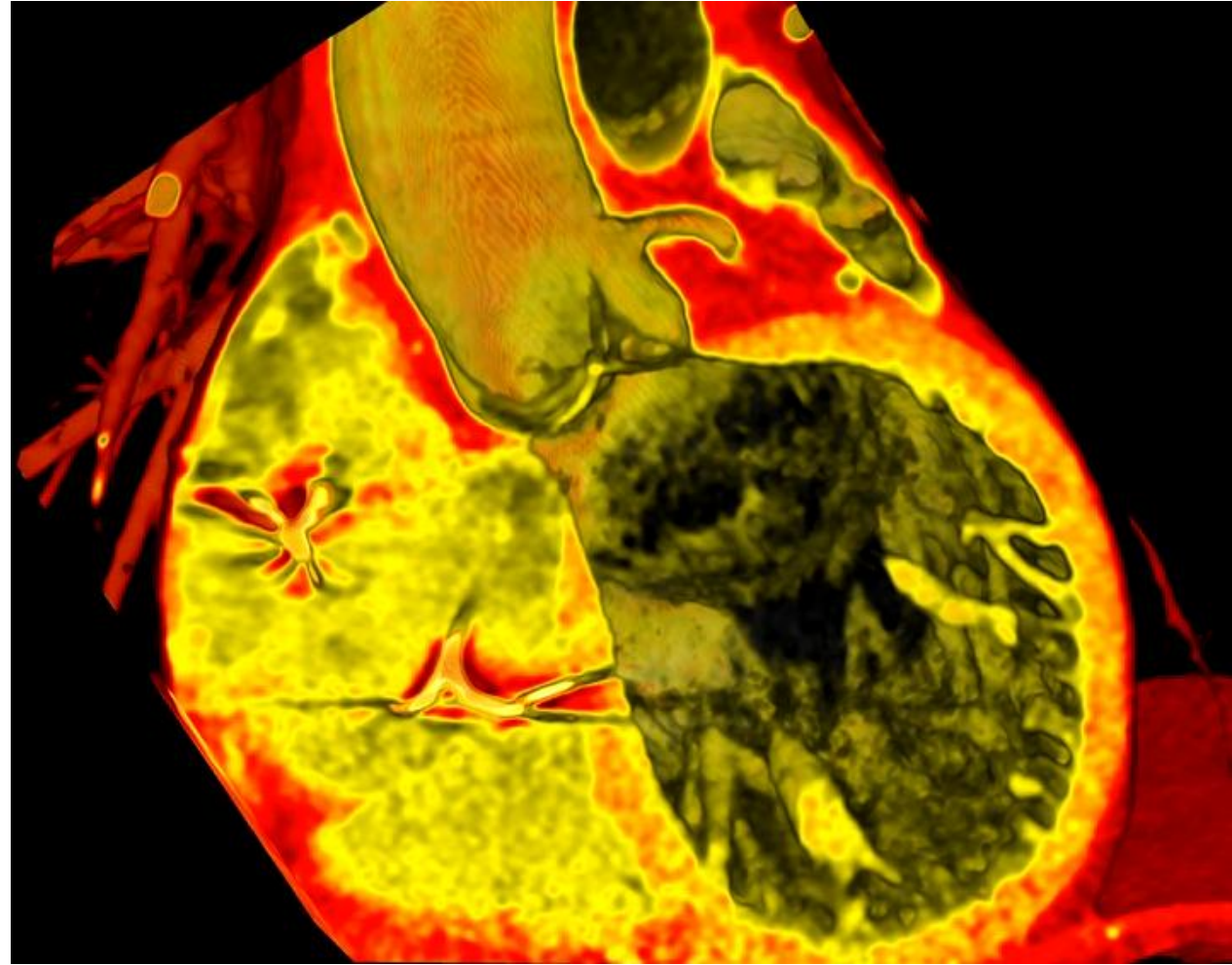
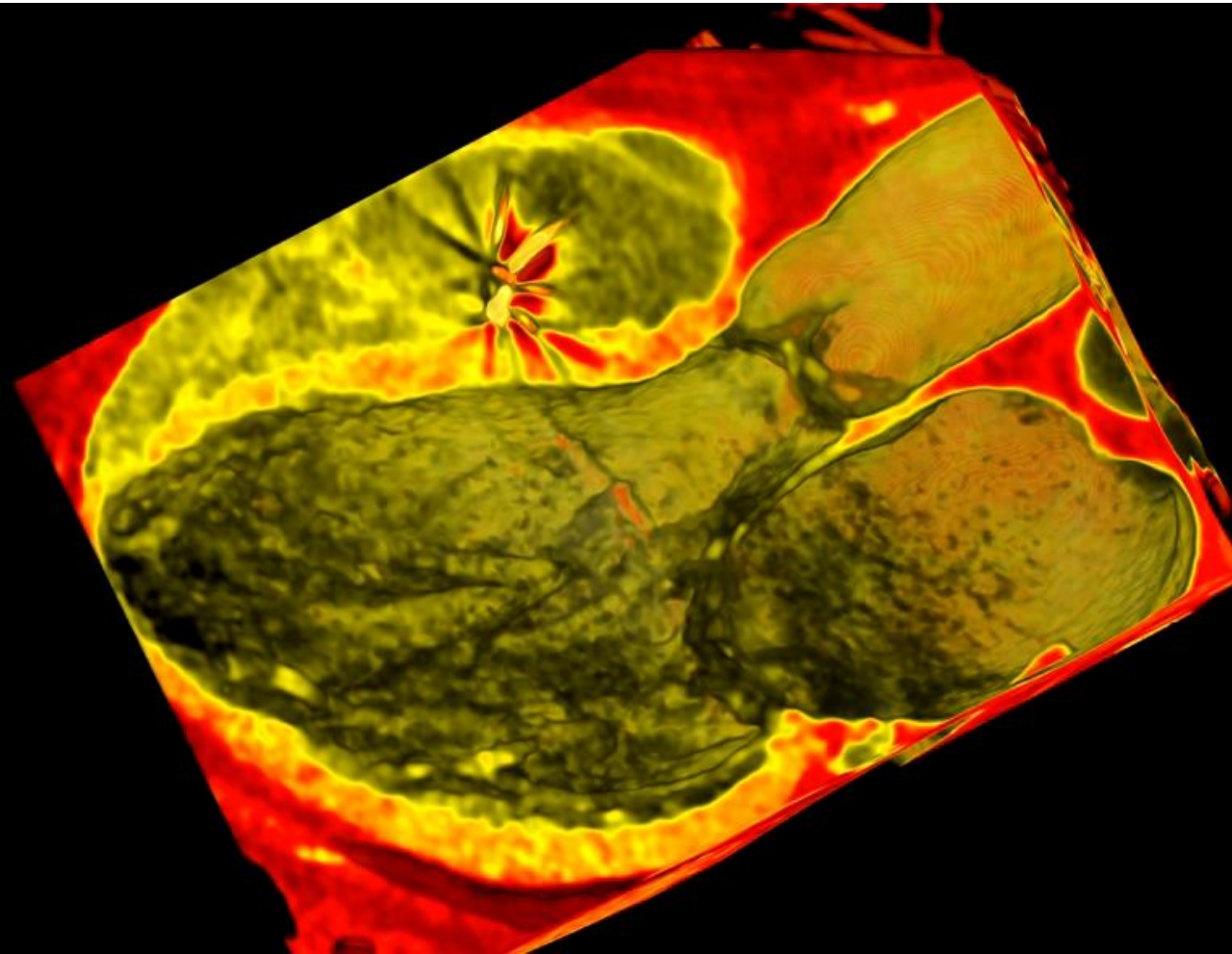


MRI



Accurate quantification of flow, volume, regurgitation

Cine CT



Relative merits

Back of a cigarette packet

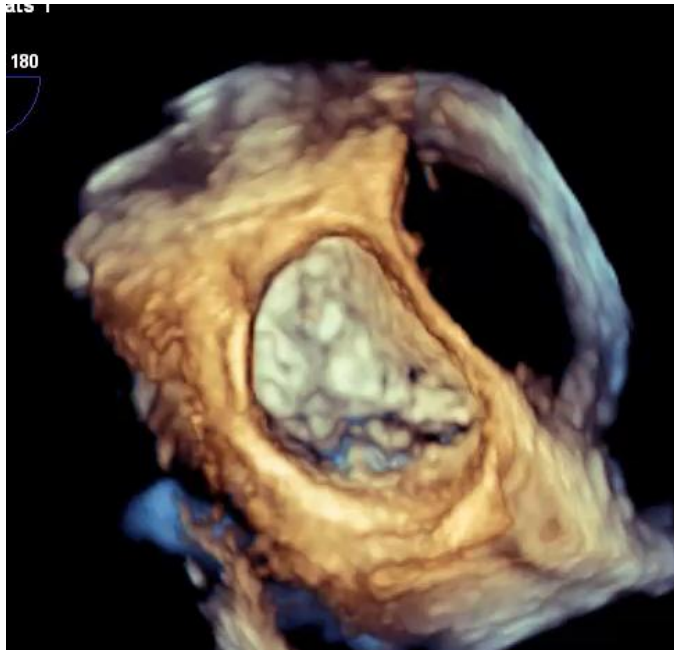
	TTE	TOE	CMR	CT
Portable	Green	Yellow	Red	Red
Radiation	Green	Green	Green	Red
Sedation / GA	Green	Red	Yellow	Yellow
High resolution	Green	Green	Green	Green
"Windows"	Yellow	Yellow	Green	Green
MR quantification	Yellow	Yellow	Green	Red
Flow / Vol measure	Yellow	Yellow	Green	Red
Pressure gradient	Green	Green	Yellow	Red

Echo features of key mitral valve abnormalities

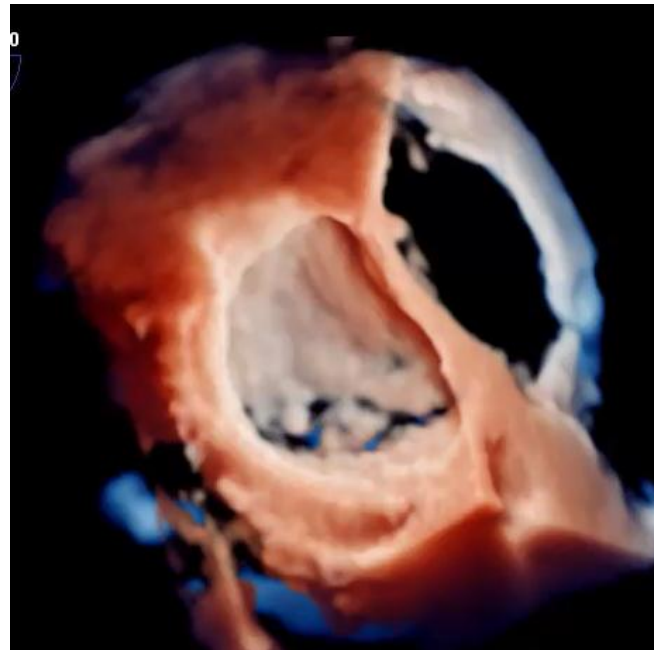
- Cleft mitral valve
 - Anterior
 - Posterior
- AVSD (Brief)
- Parachute mitral valve
- Supramitral membrane
- Double orifice mitral valve
- Mitral valve straddling

Newer image displays

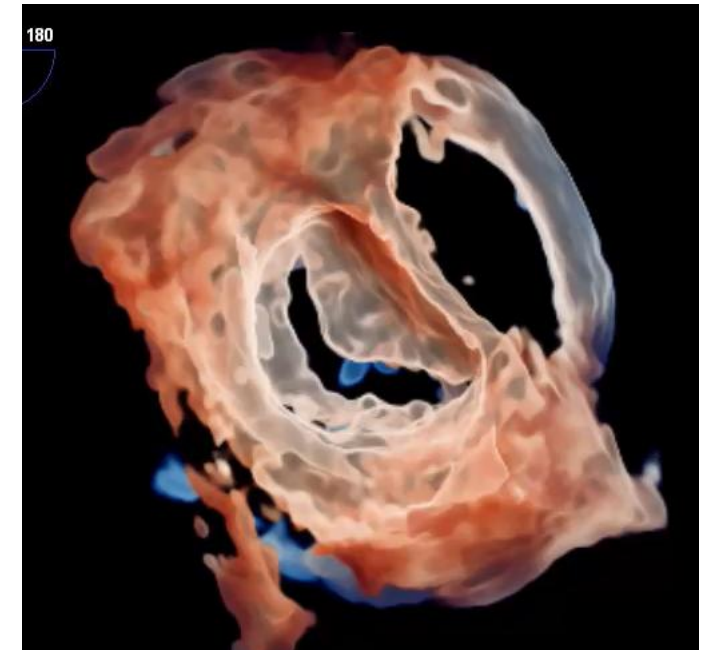
Standard



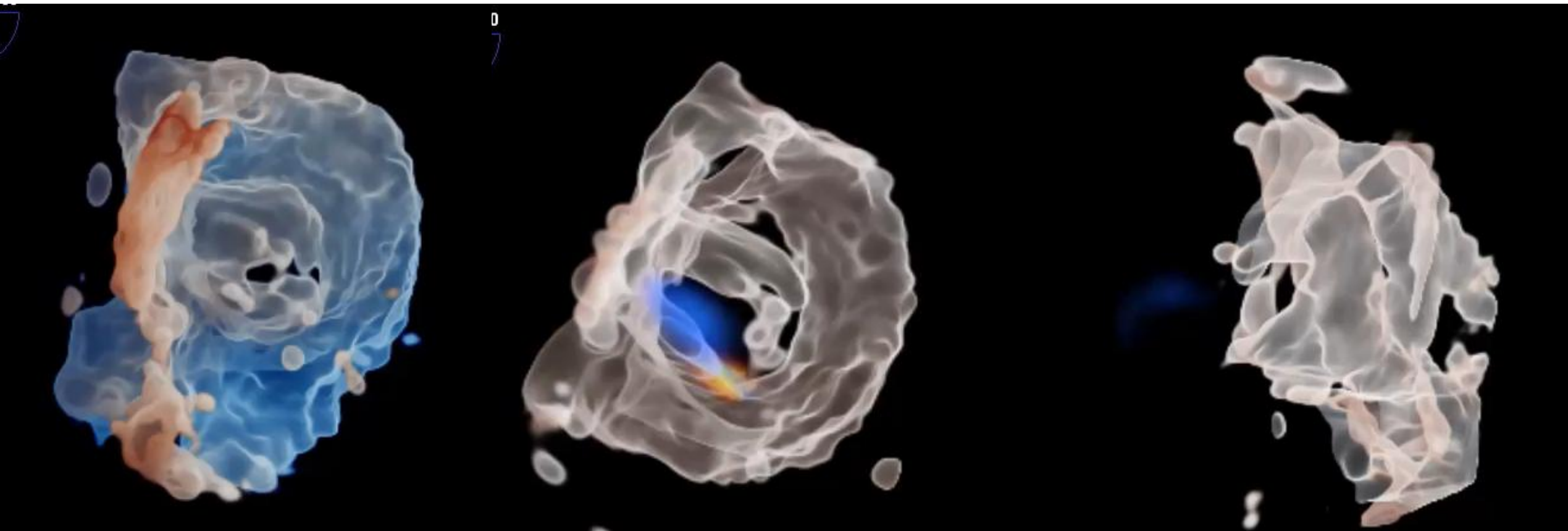
“Tissue”



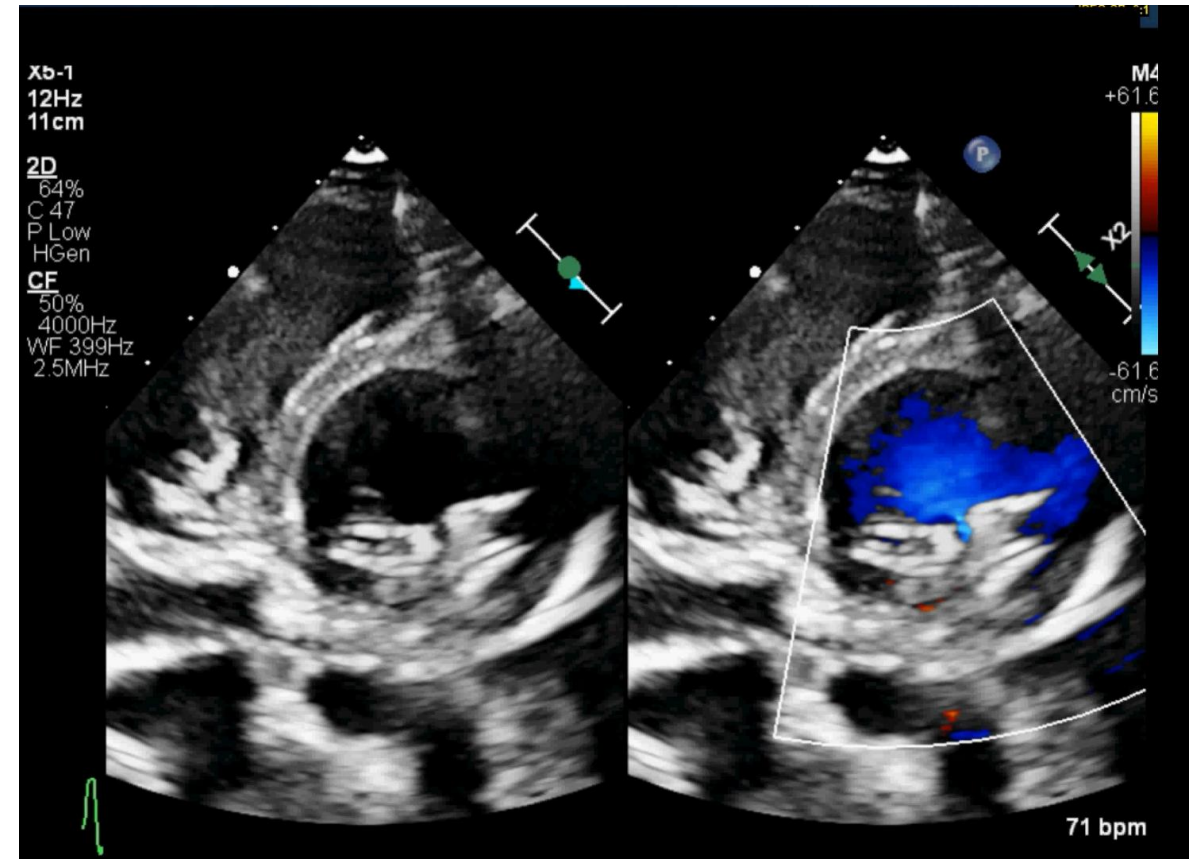
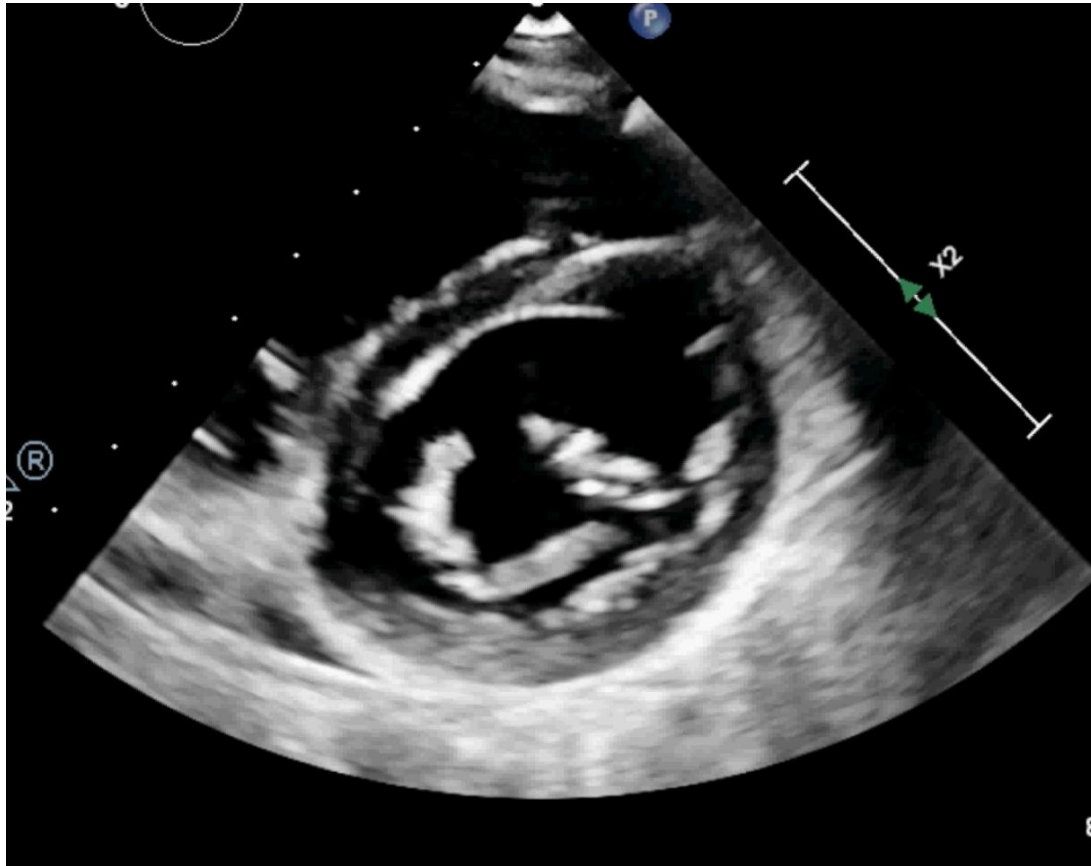
“Glass”



“Glass” or transparency mode

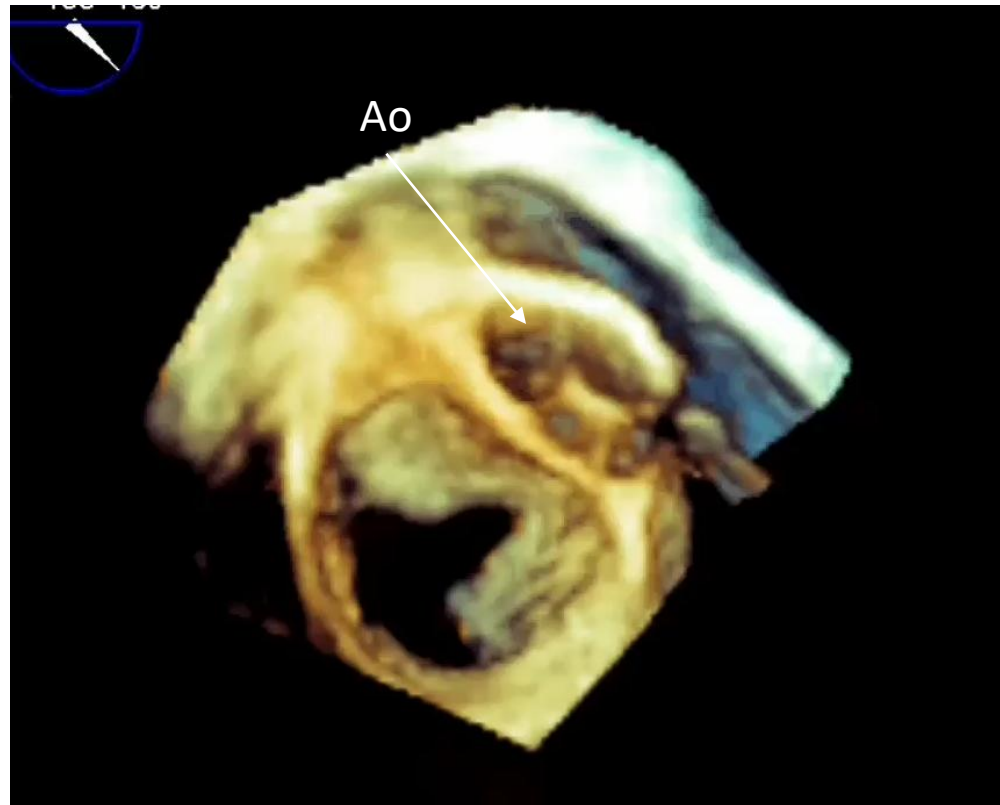


Cleft of anterior MV leaflet

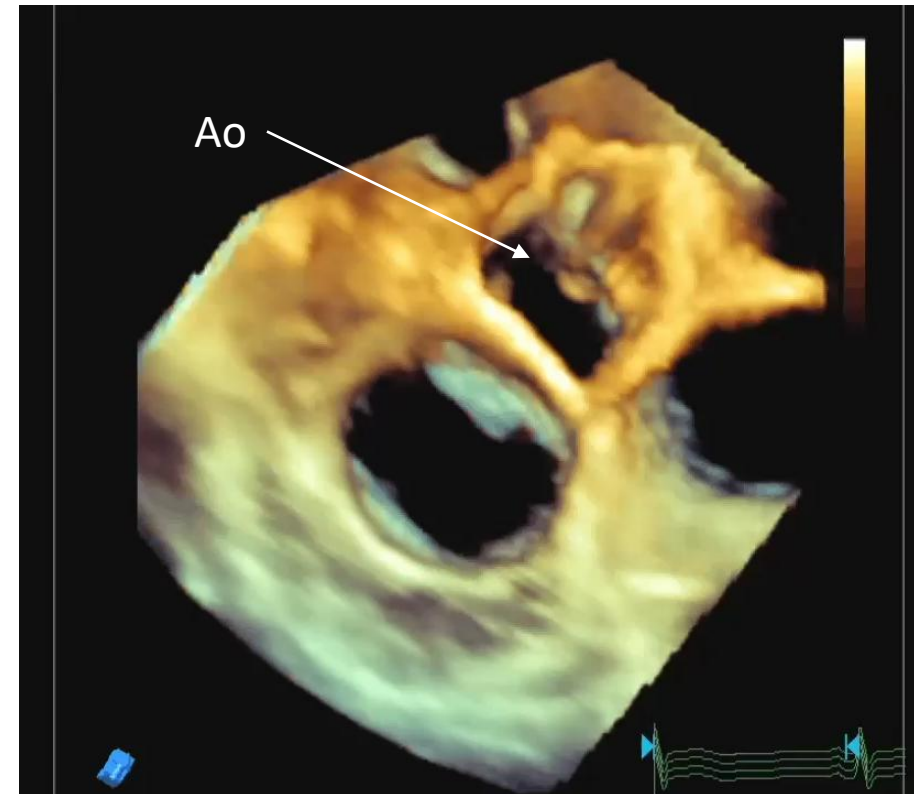


View from LA: True cleft of the mitral valve

Cleft anterior mitral valve leaflet



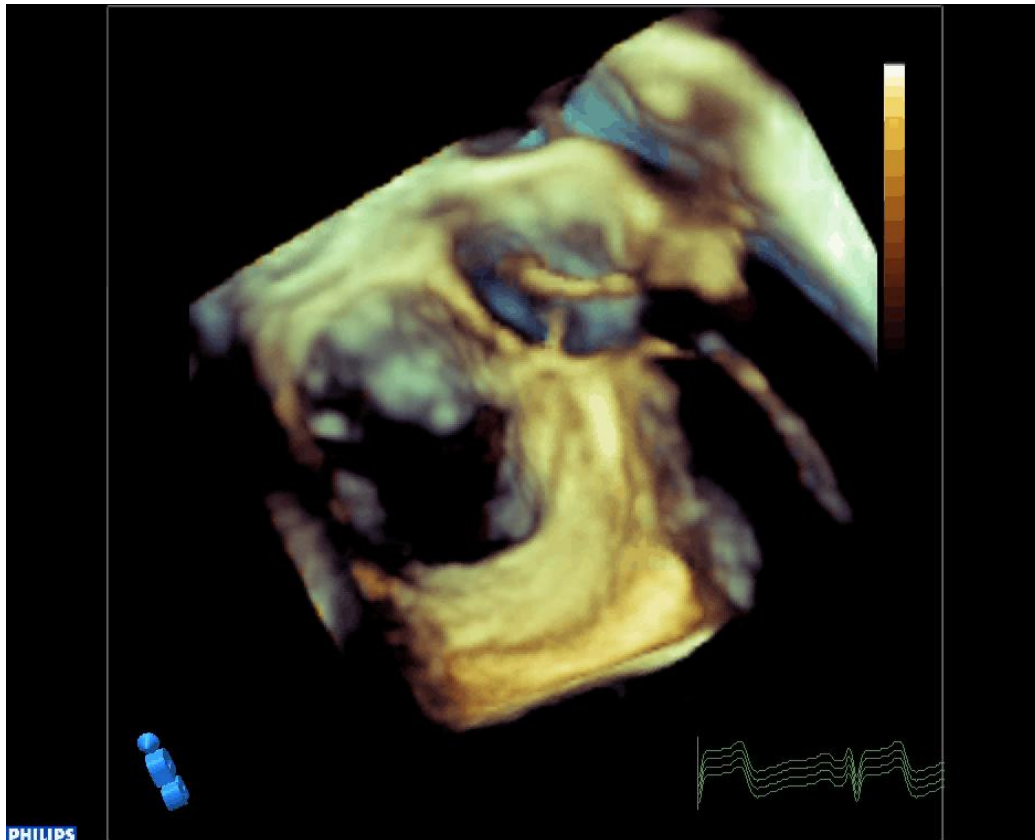
Normal mitral valve



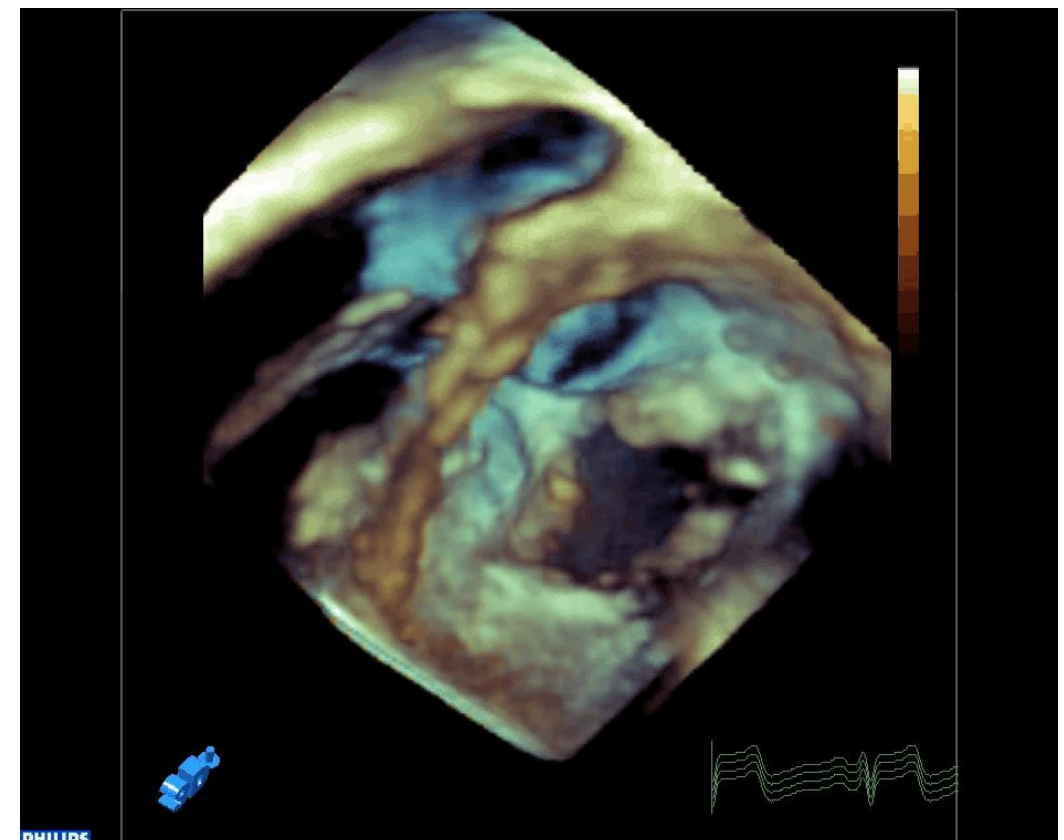
Cleft angled towards aorta

Cleft mitral valve

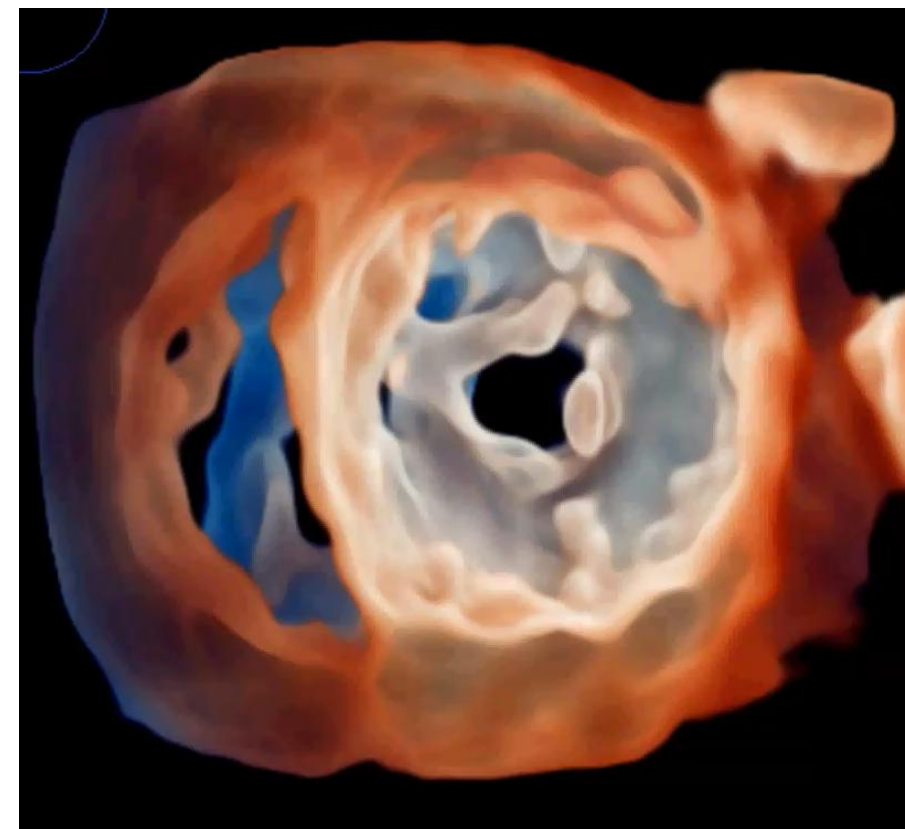
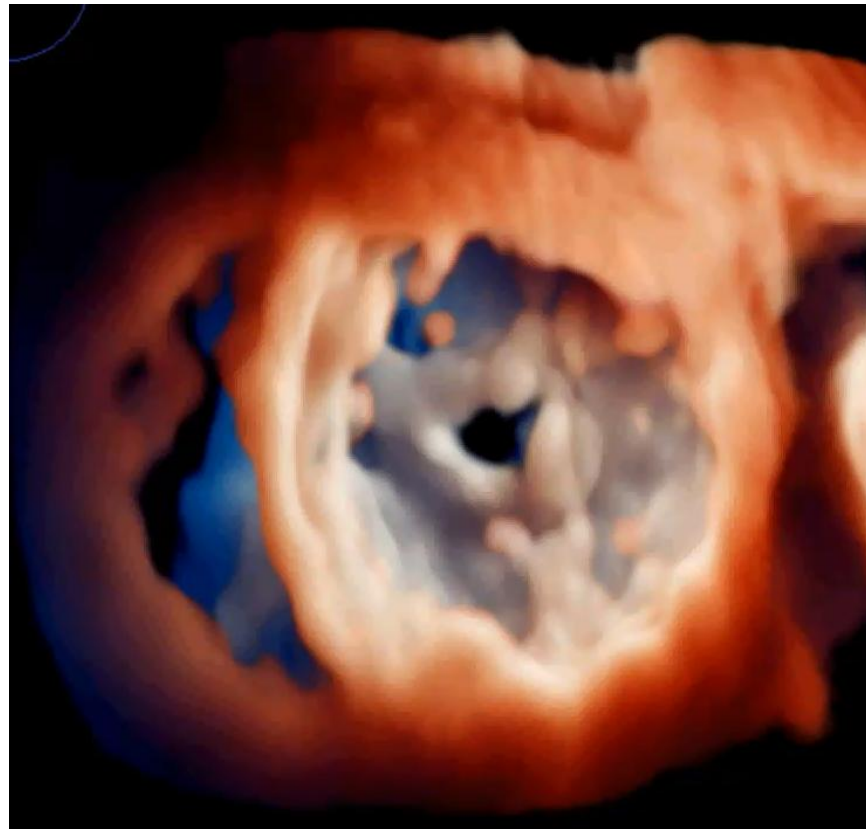
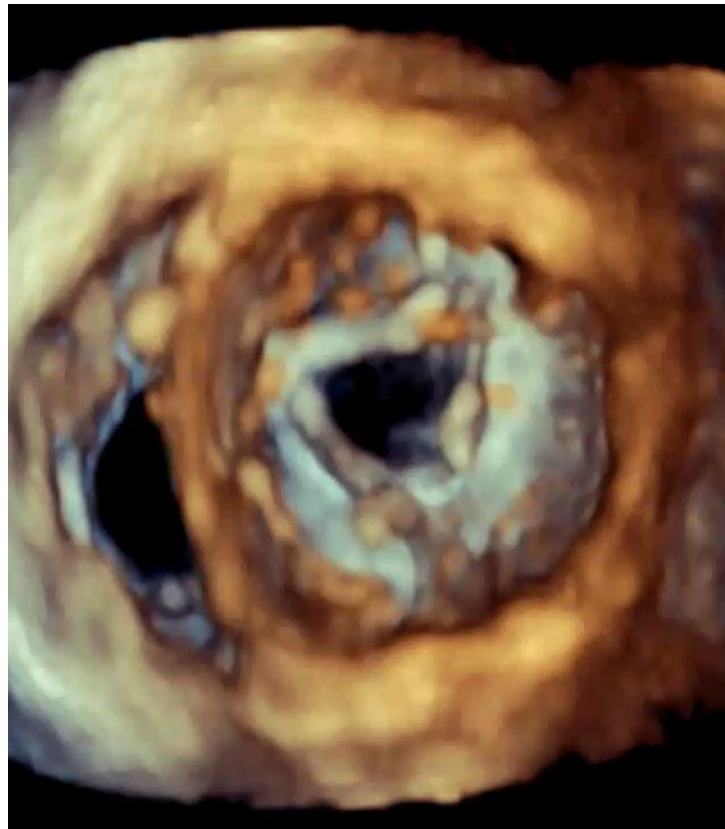
Atrial aspect



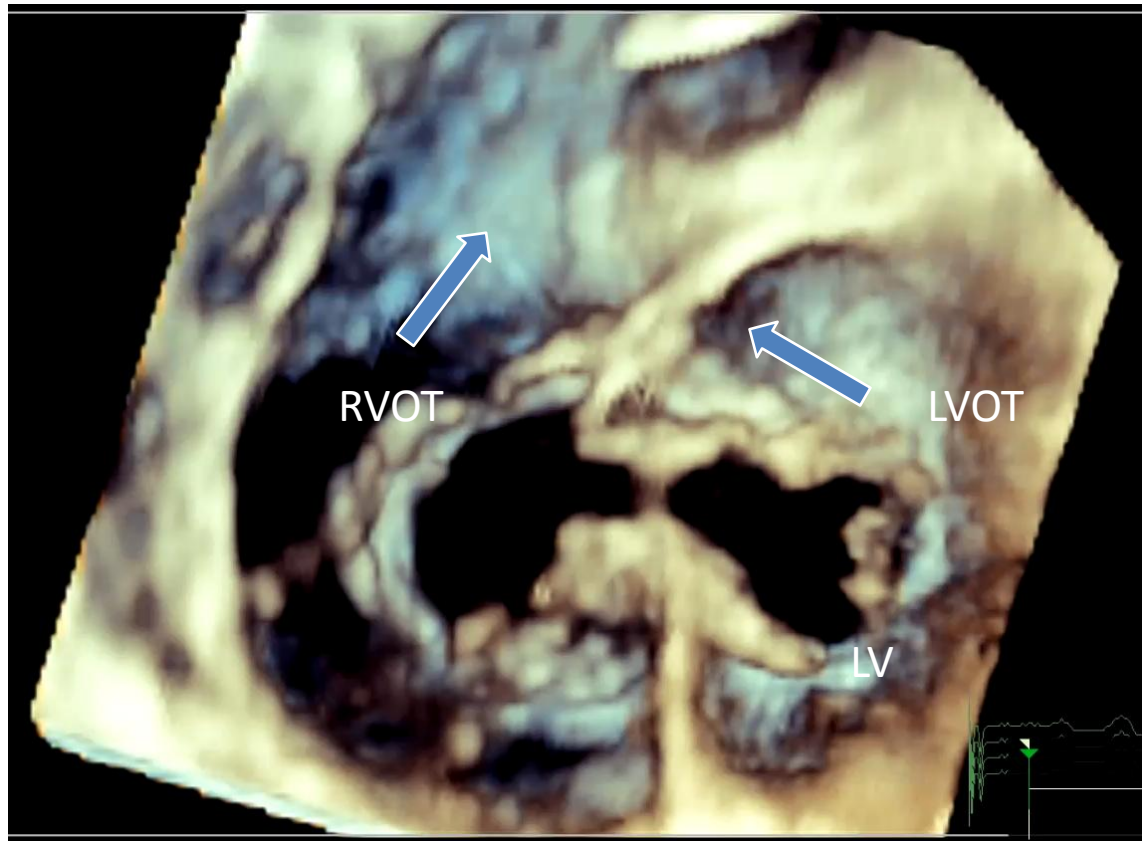
Ventricular aspect



Different means of representing



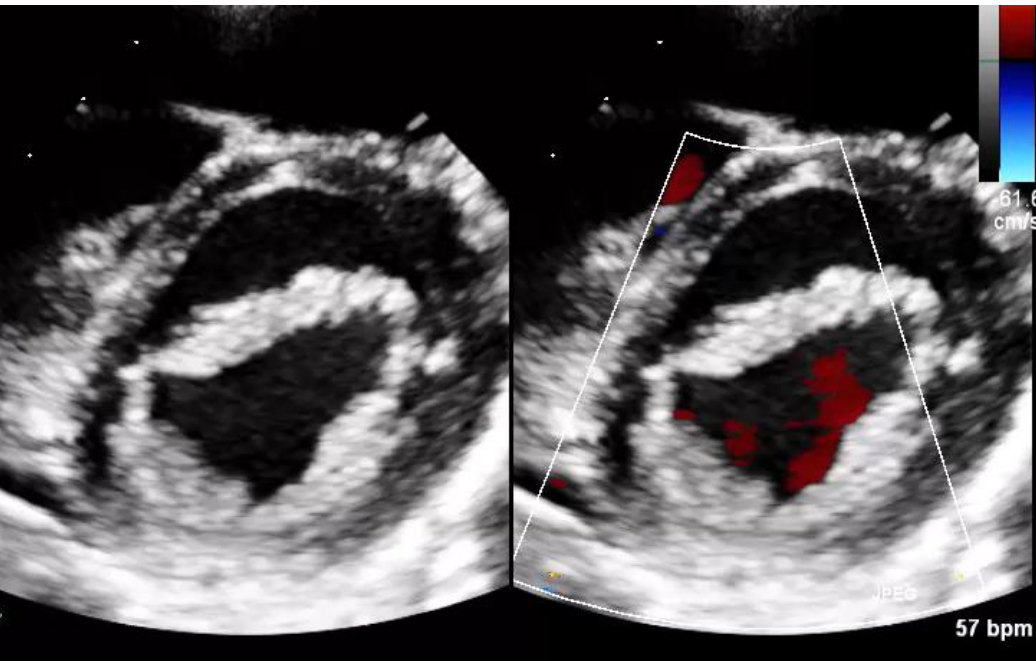
Atrioventricular septal defect – en face from ventricles



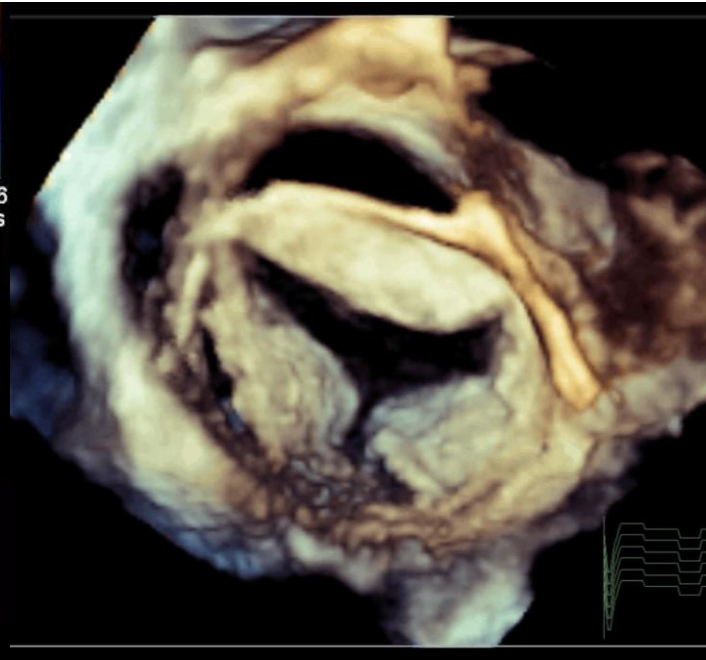
- Intraoperative 3D imaging
- Full visualisation of critical valvar anatomy
- Unrivalled anatomic detail

Cleft of posterior mitral valve leaflet

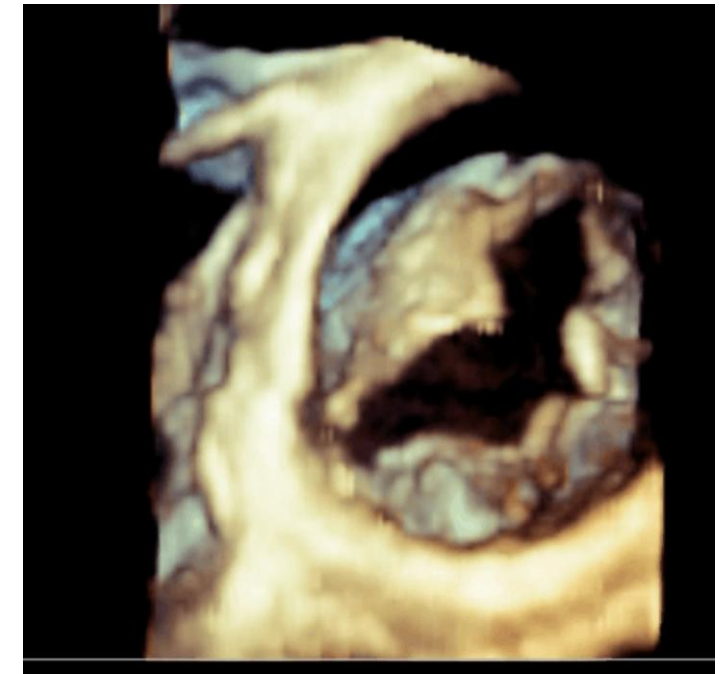
SAX with mapping of MR



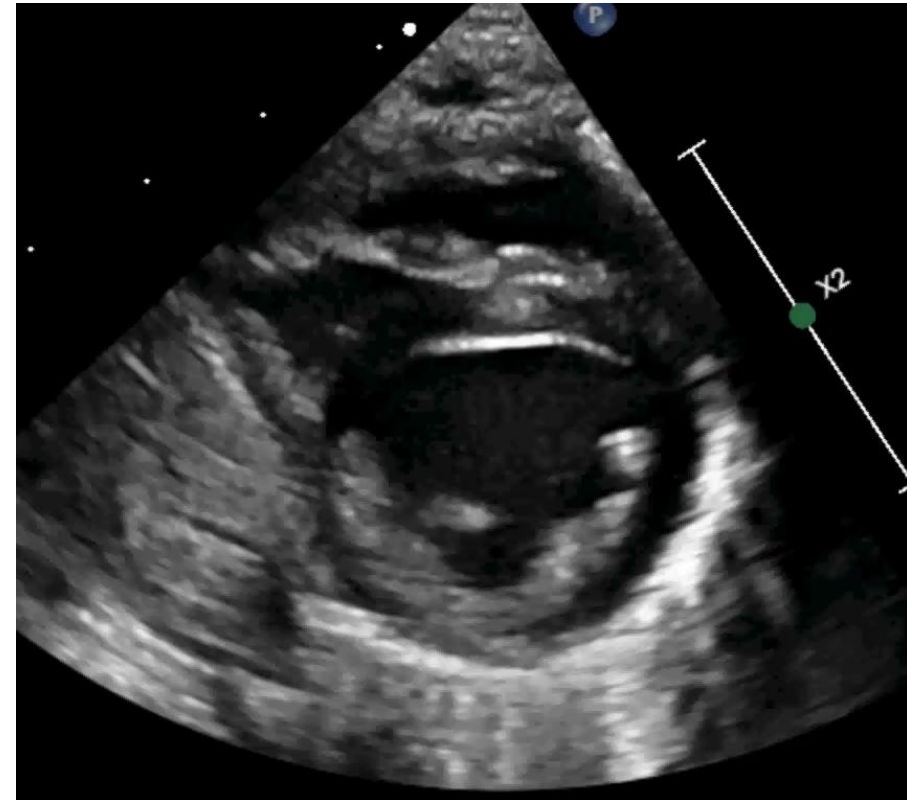
Atrial aspect



Ventricular aspect

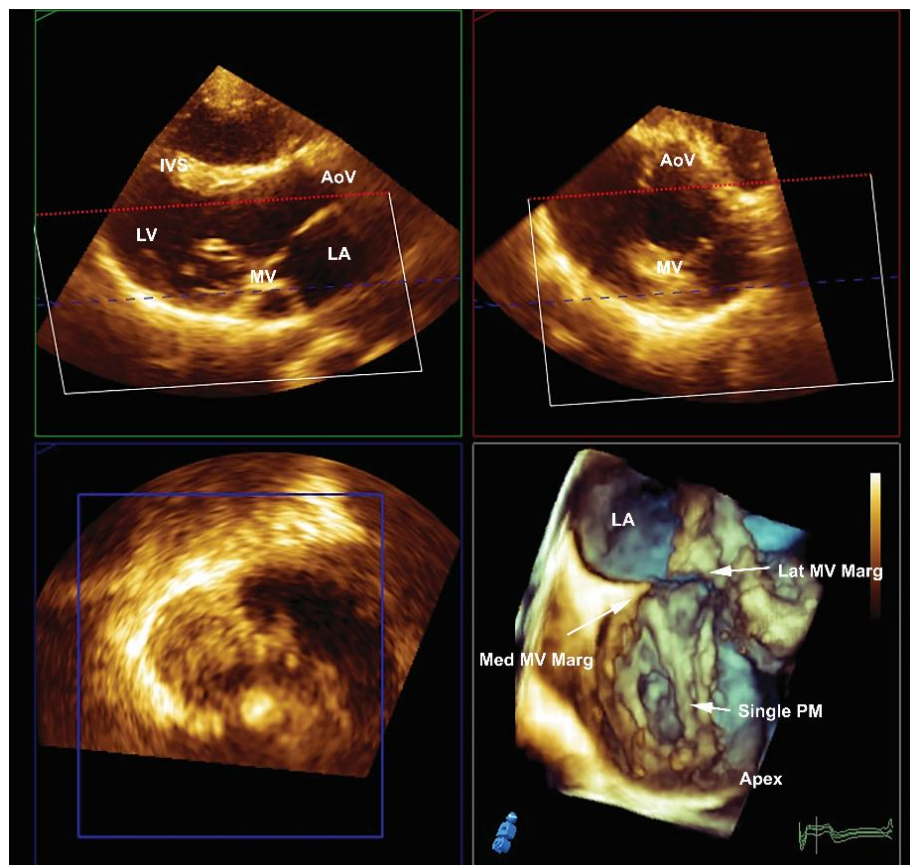


Parachute mitral valve

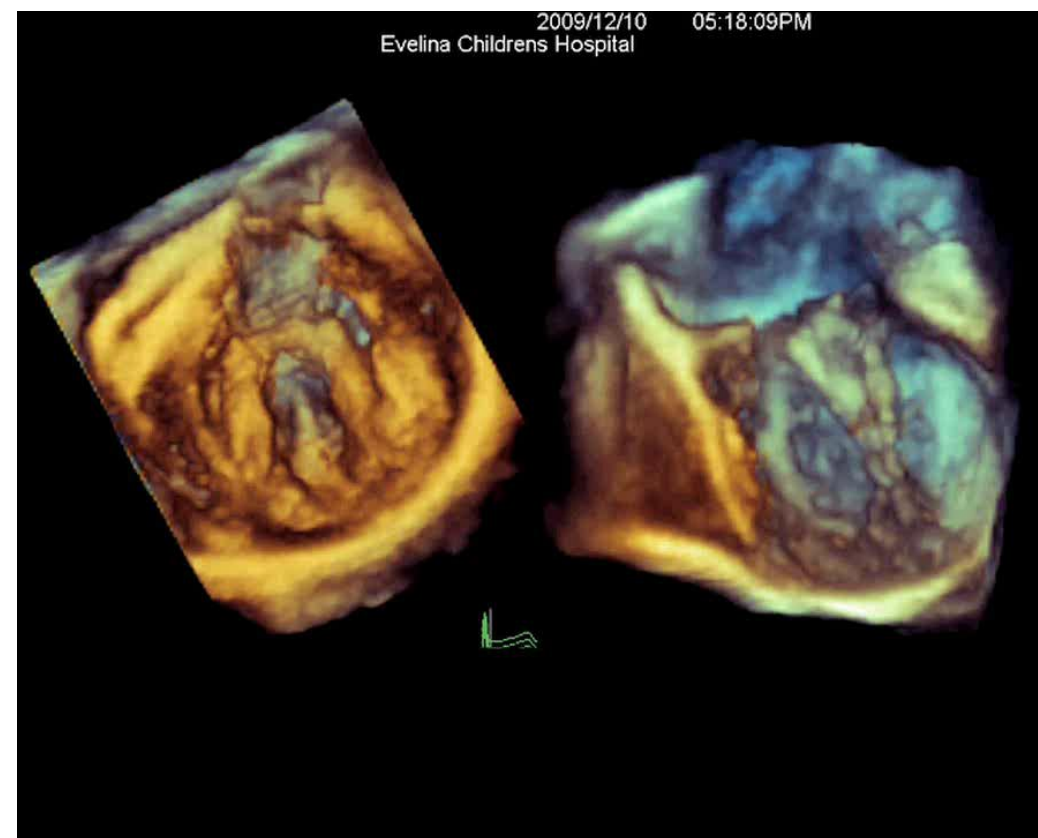


Assessment of chordal support – parachute mitral valve

Parachute Mitral Valve



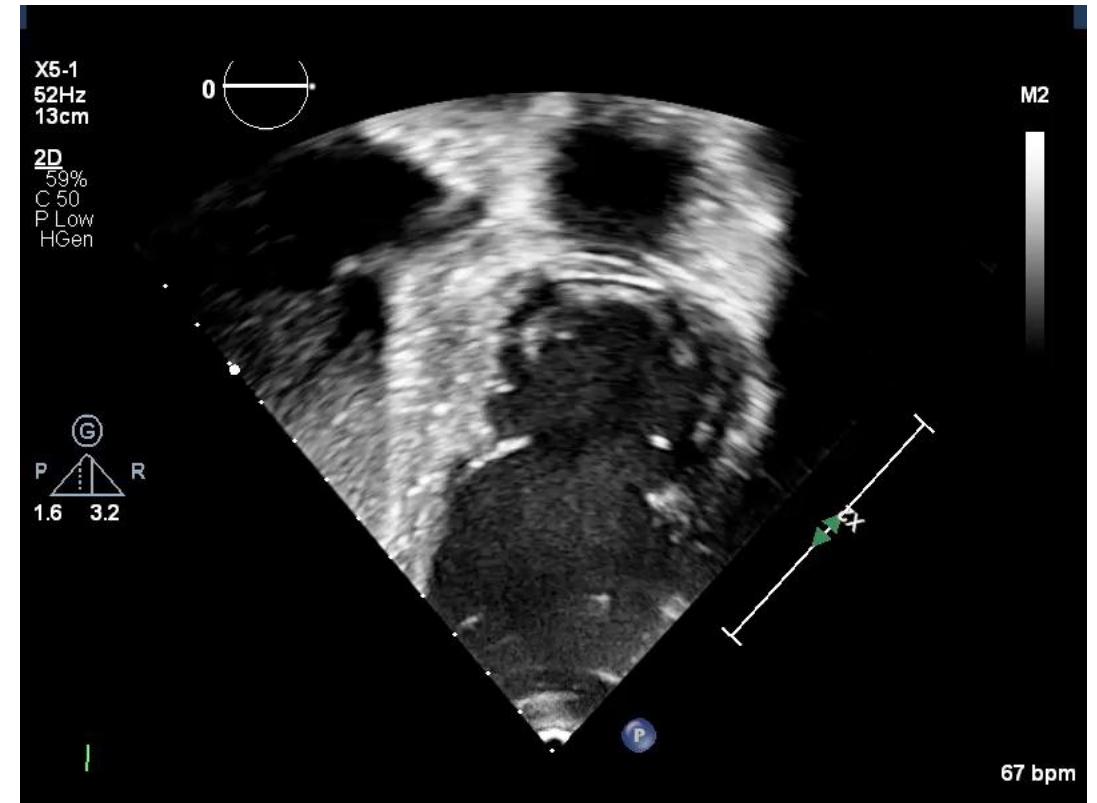
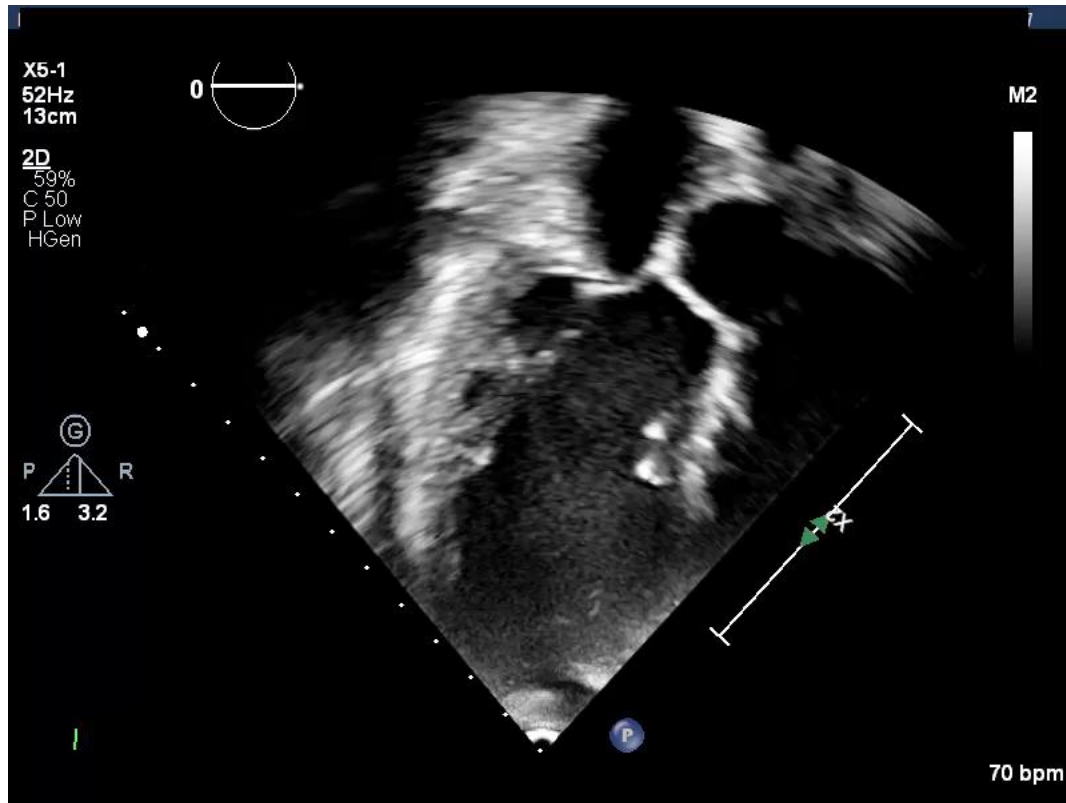
Normal v Parachute Mitral Valve



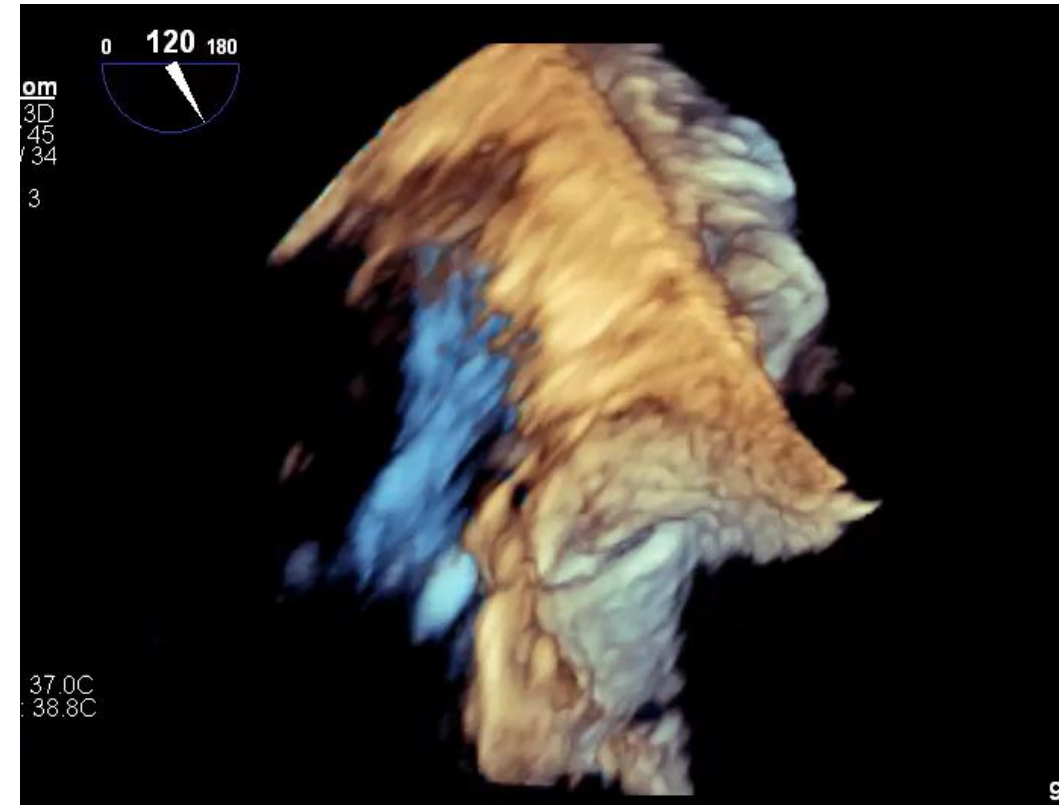
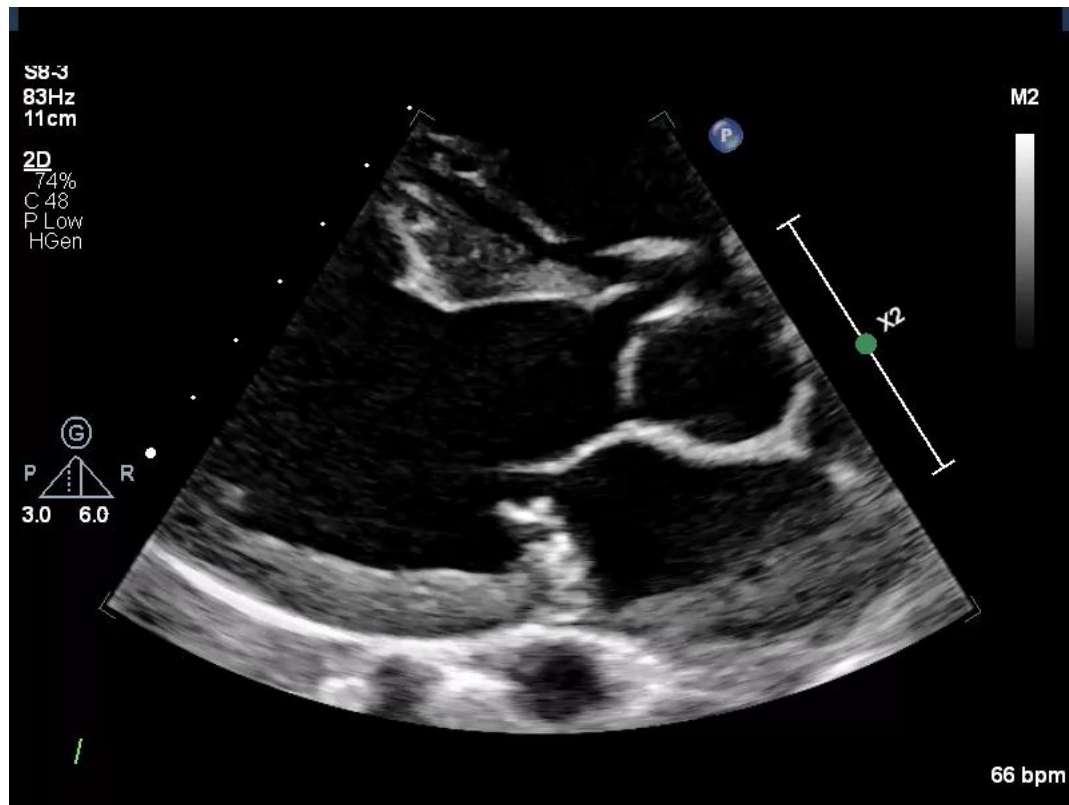
Valverde et al, 2011

Supramitral membrane

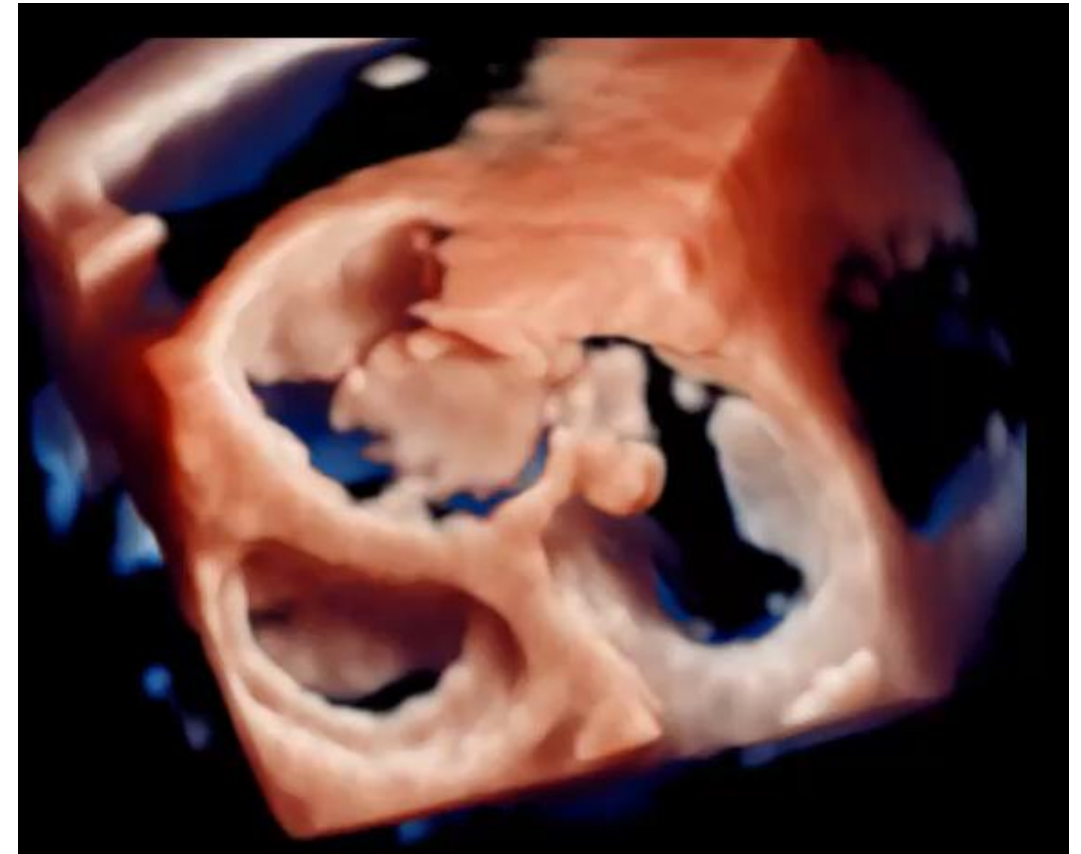
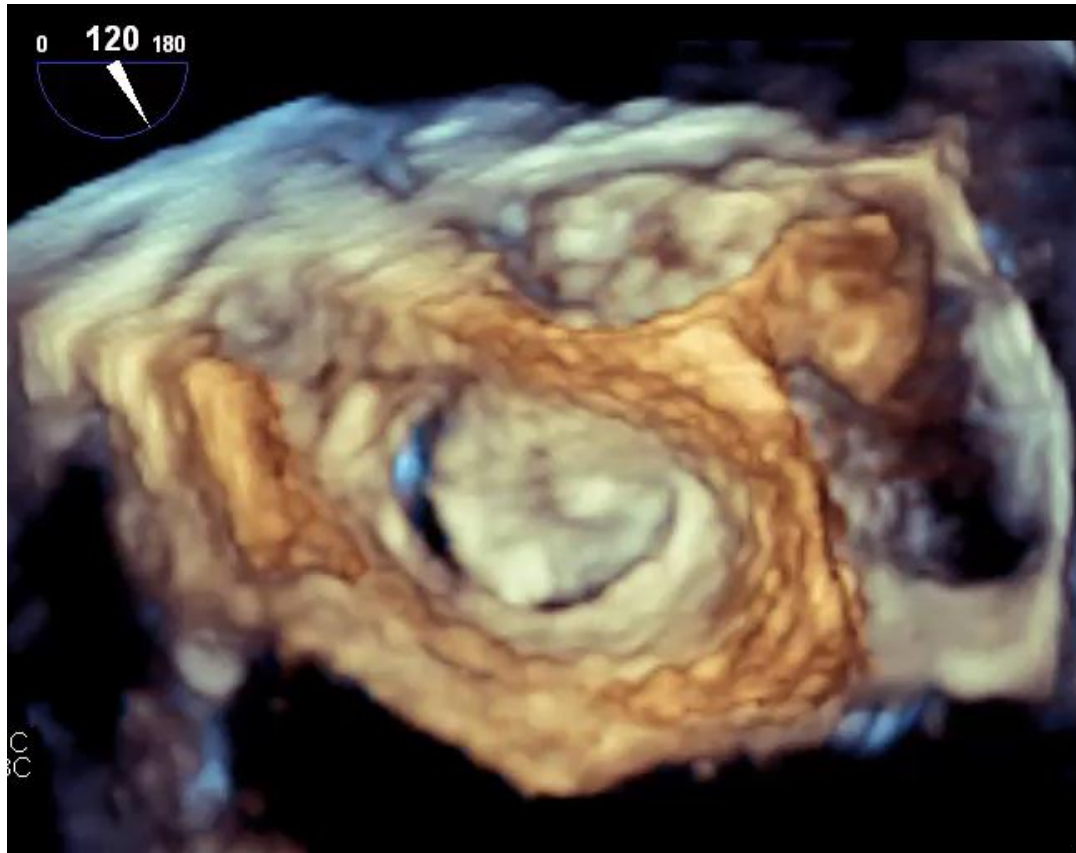
TTE – 2D



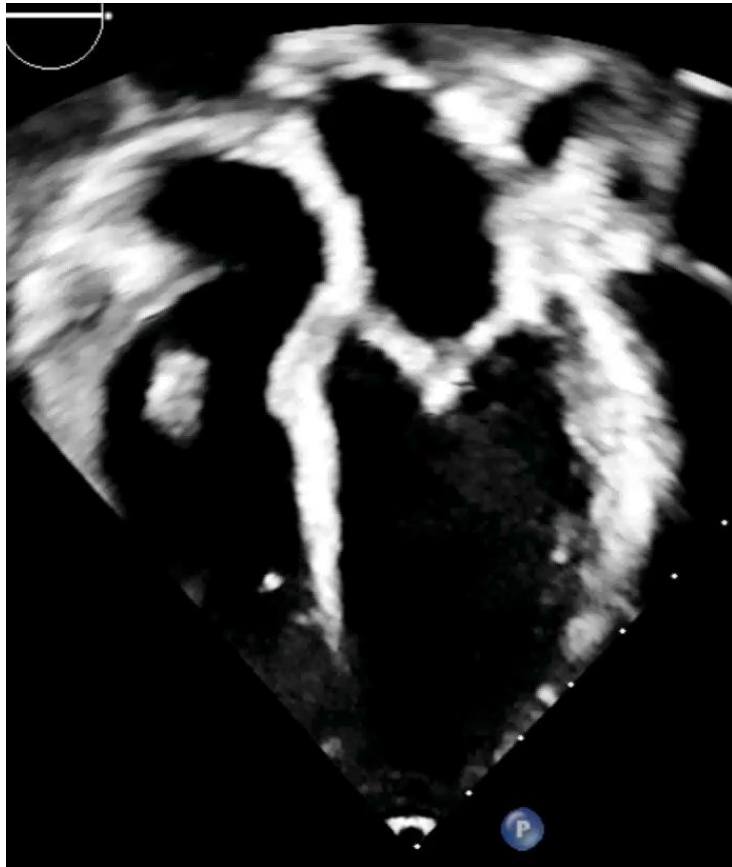
Long axis views – 2D and 3D



TOE of same patient - views from left atrium

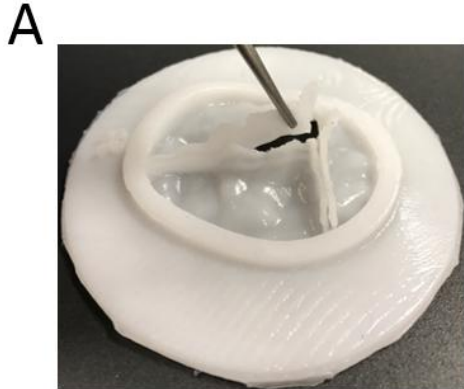


Double orifice mitral valve



Printing of patient-specific valves

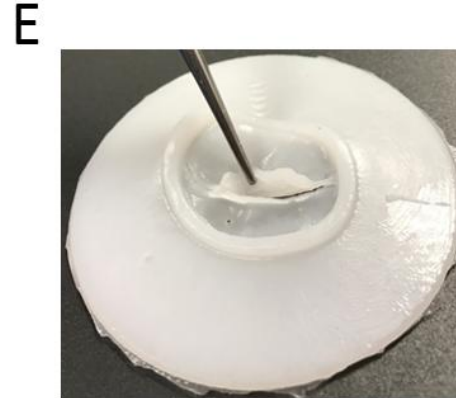
Tricuspid Valve



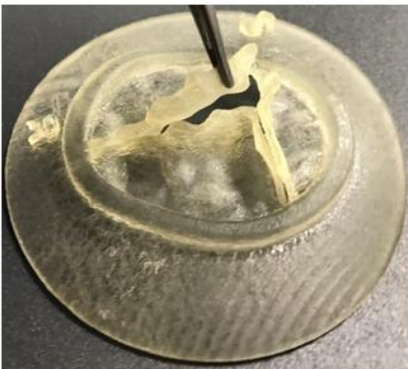
AVSD



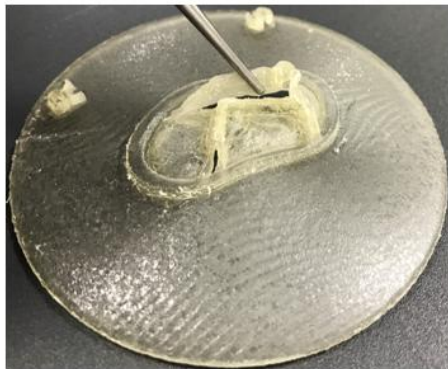
Mitral Valve



B



D



F

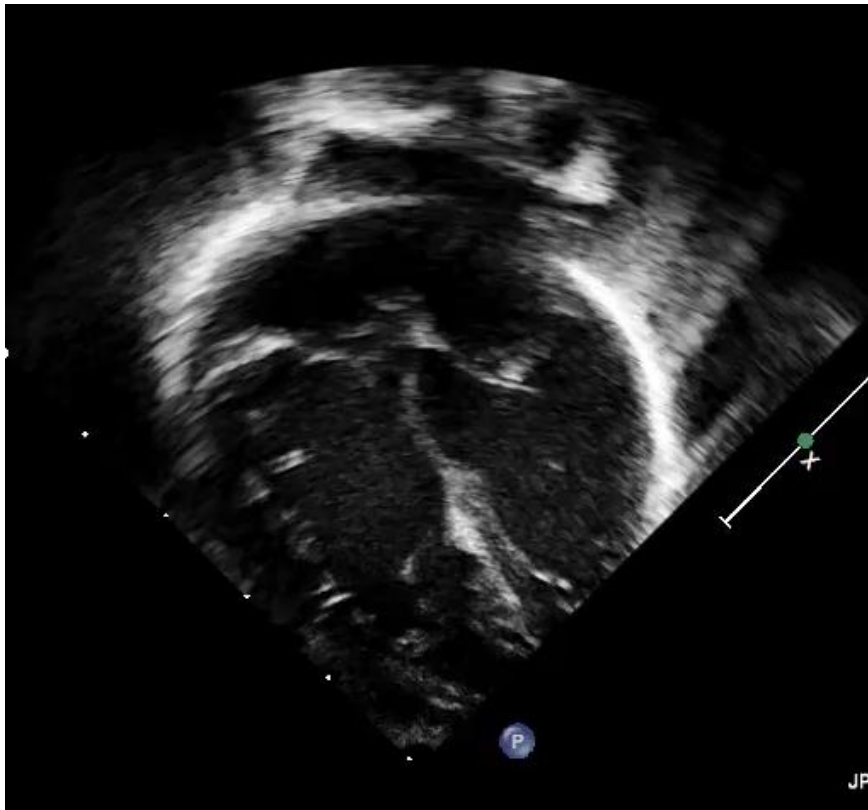


- Not dynamic
- Single phase of cardiac cycle
- Need segmented

Images: Matthew Jolley CHOP

Initial 4Ch view and sweeps

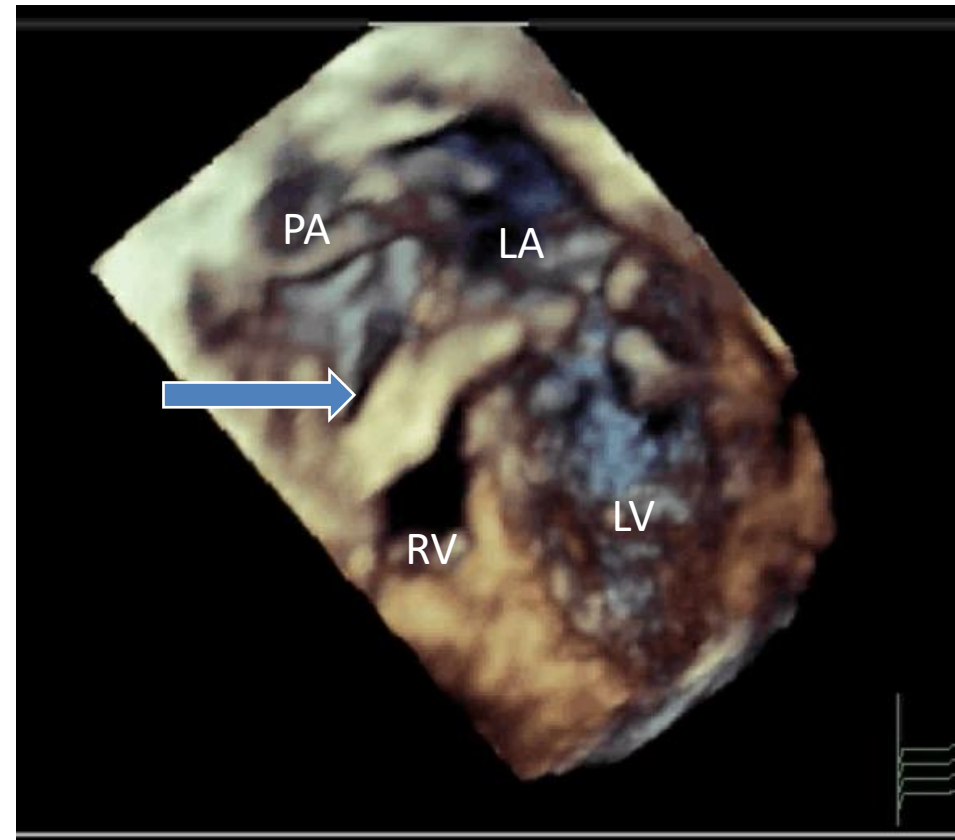
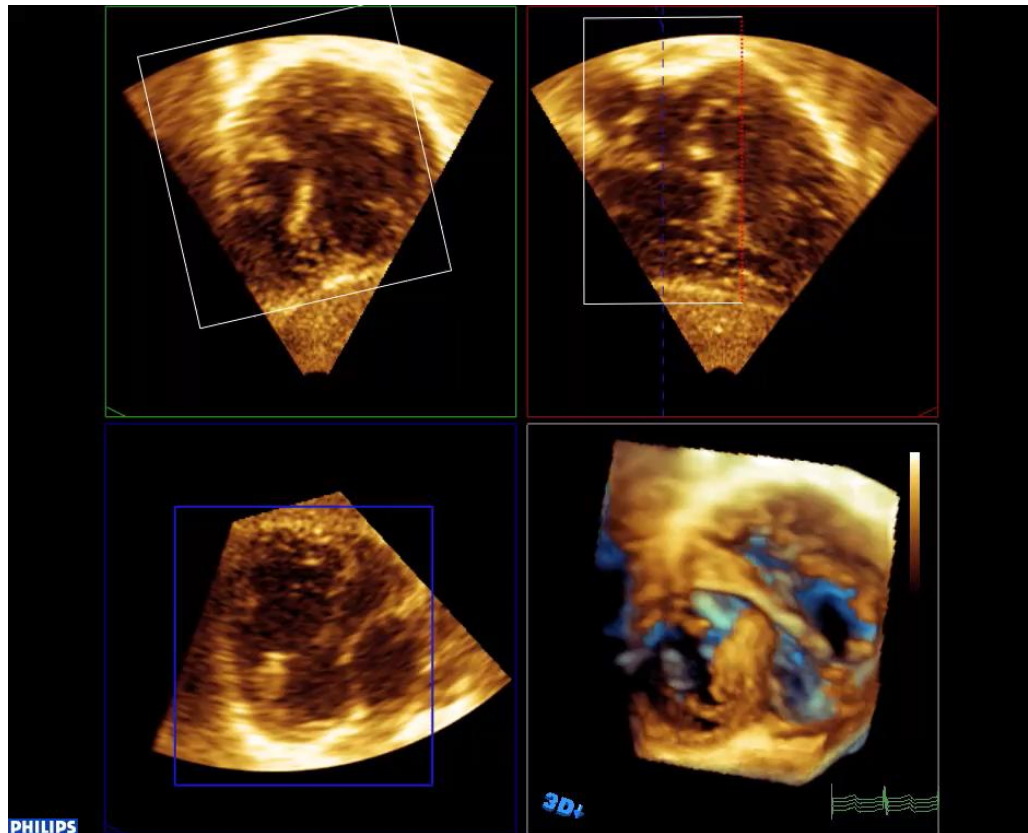
Four chamber view



Sonographic sweep



DORV with subpulmonary VSD + straddling MV

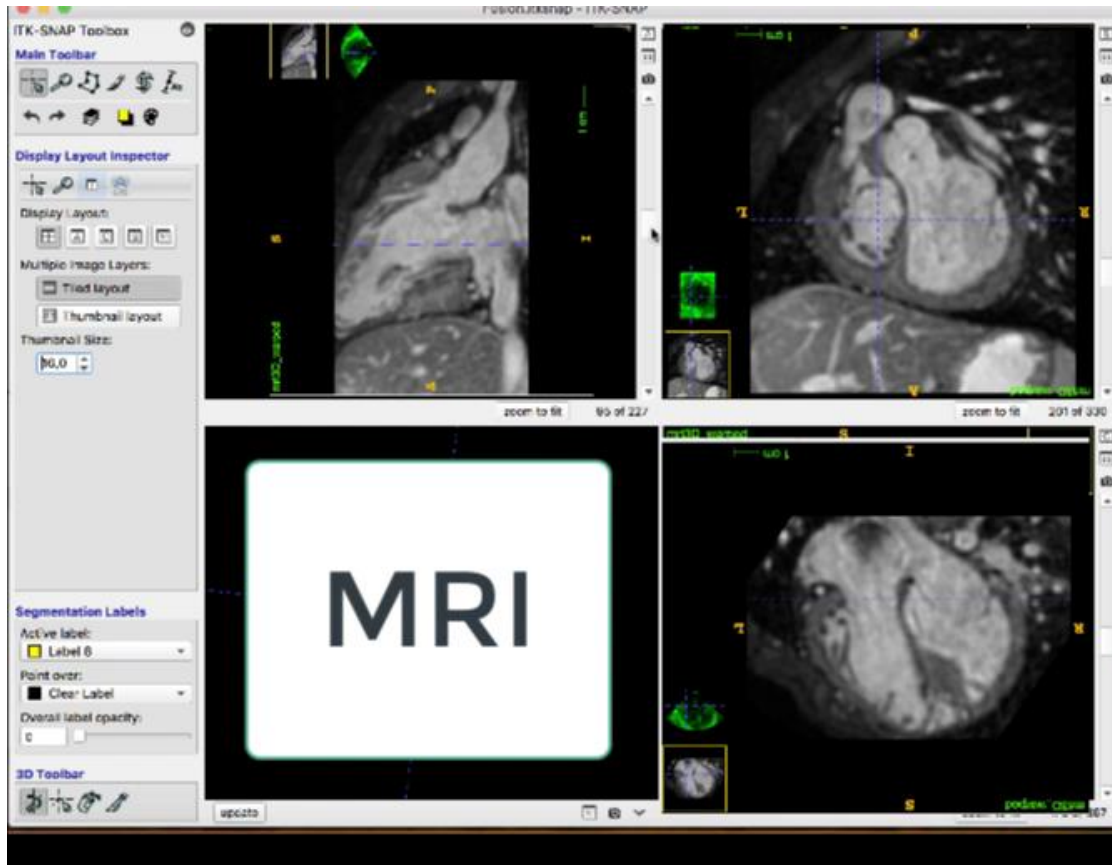


CARDIOVASCULAR FLASHLIGHT

doi:10.1093/eurheartj/ehaa654
Online publish-ahead-of-print 13 August 2020

3D hybrid printed models in complex congenital heart disease: 3D echocardiography and cardiovascular magnetic resonance imaging fusion

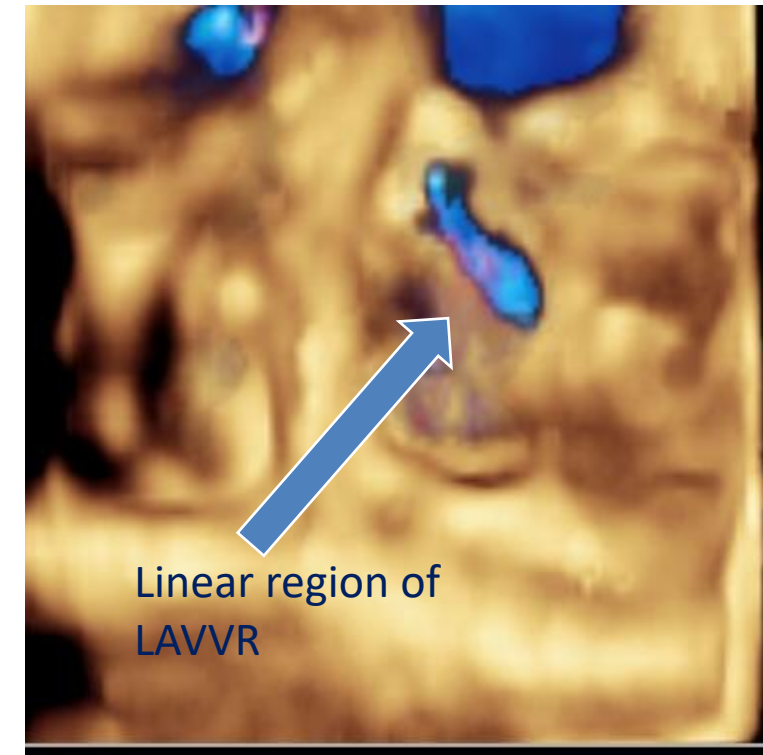
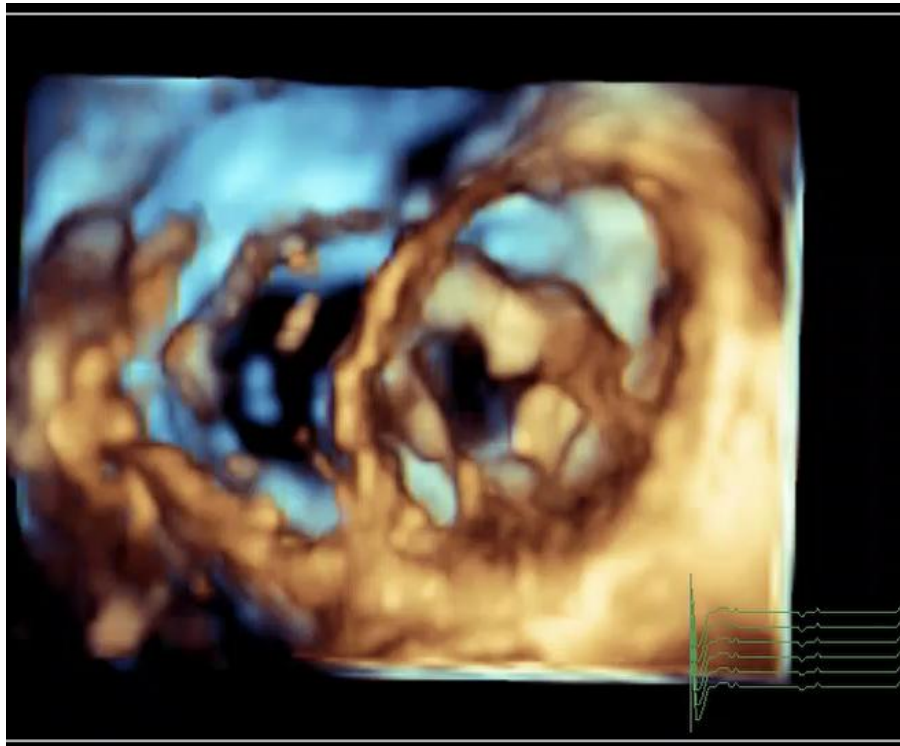
Alberto Gomez ¹, Gorka Gomez ², John Simpson ^{1,3}, and Israel Valverde ^{1,3,4,5*}



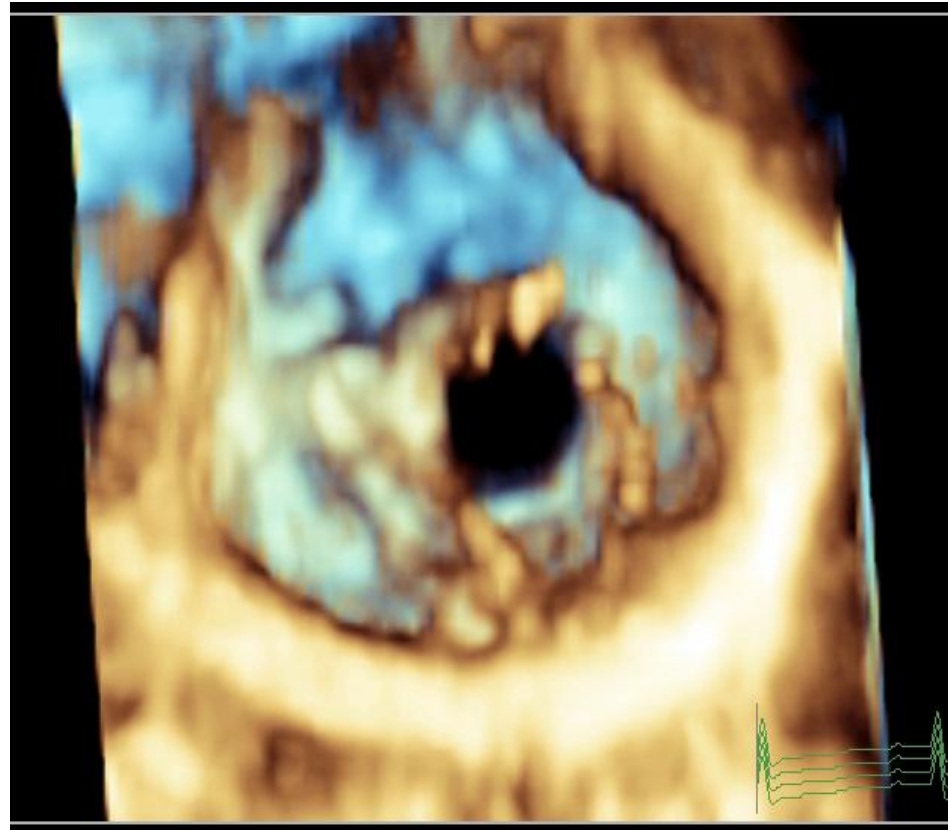
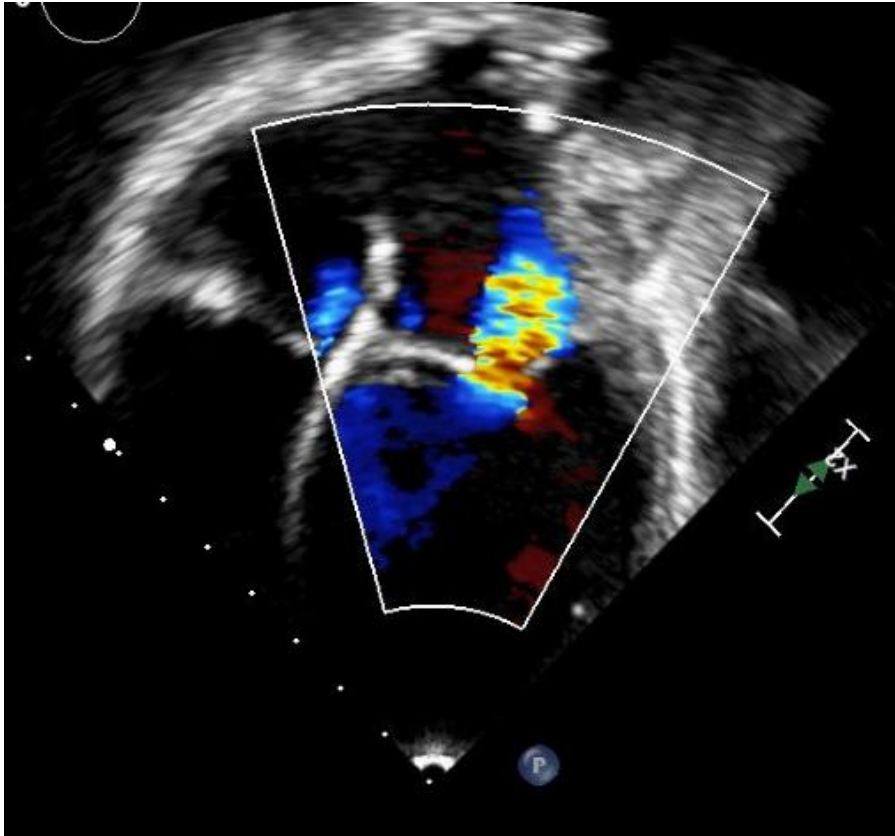
New imaging solutions

- Quantification of mitral valve regurgitation
- Enhanced visualisation
 - Immersive imaging (VR / AR)

AV valve regurgitation

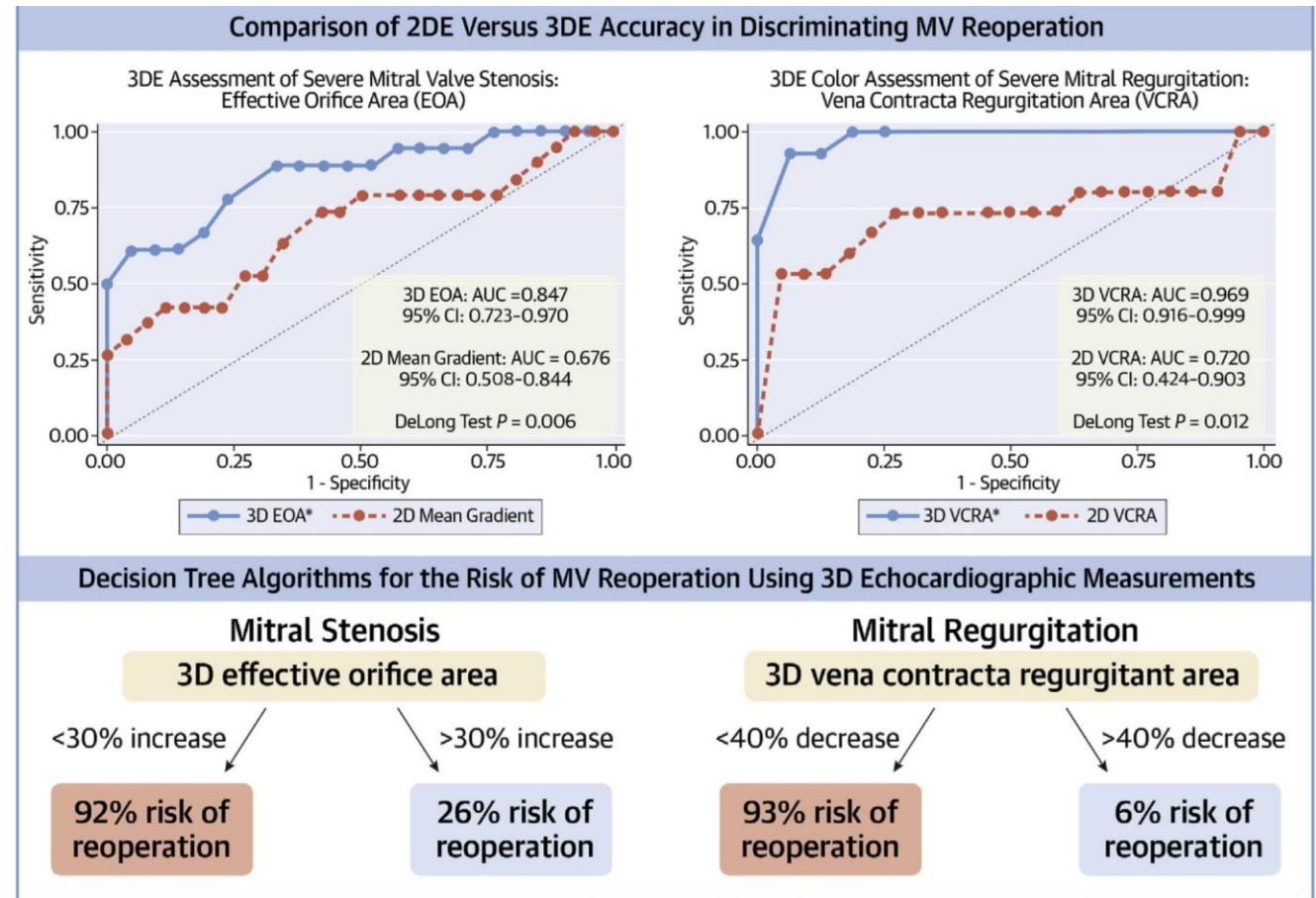


Postoperative left AVVR



3D assessment of MR predicts reoperation

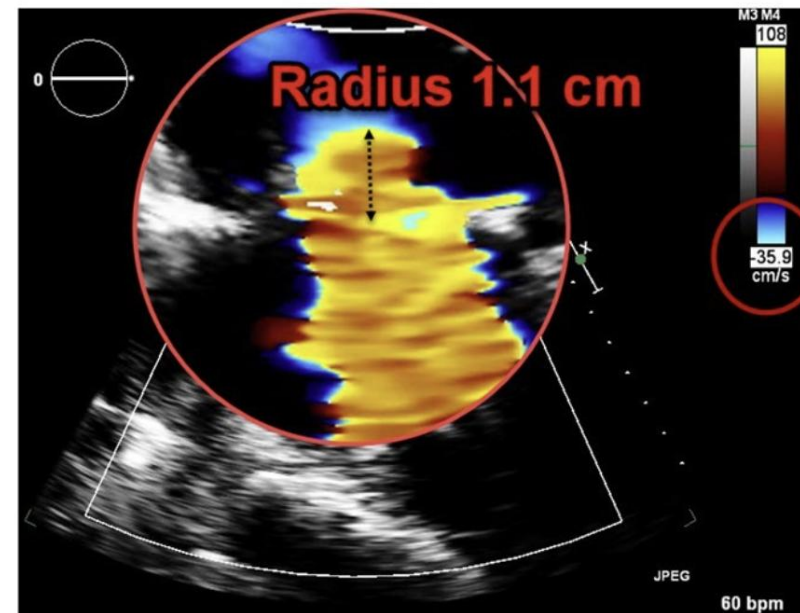
- Recent study from Boston
- 206 children
 - 105 mitral stenosis
 - 75 mitral regurgitation
 - 64 mixed MV disease
 - 31% required reoperation



Lang N, et al. JACC Adv. 2024;3(8):101081.

Quantification of MR by 3D echocardiography

- Subjective
- Poorly validated in children
- Quantitation (PISA)
 - Assumes circular jet
 - Single regurgitant jet
 - Holosystolic

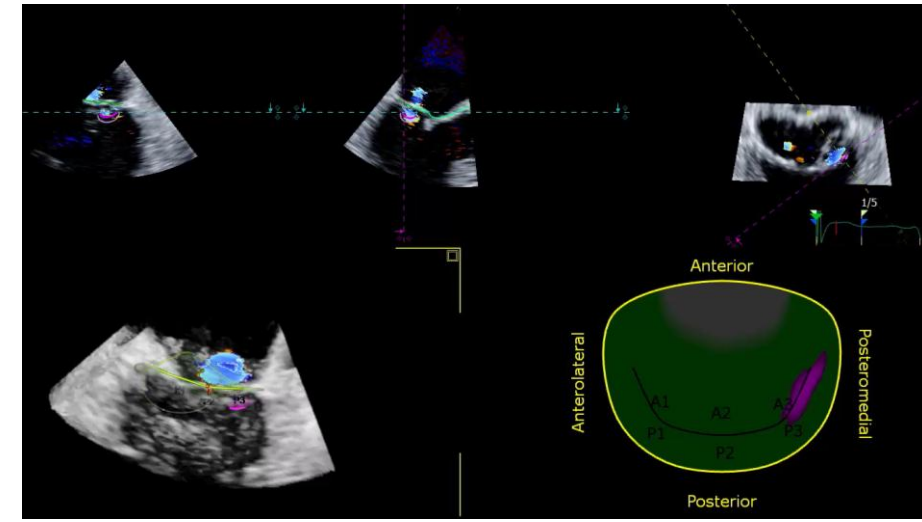
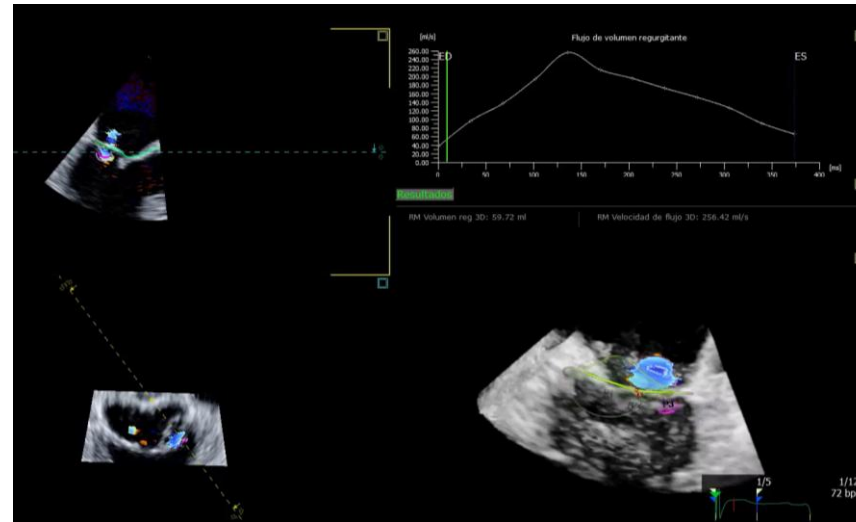


$$\text{RFlow (mL/sec)} = 2\pi r^2 \times V_a$$

$$\text{RFlow} = 2\pi(1.1)^2 \times 35.9$$

$$\text{RFlow} = 273 \text{ mL/s}$$

Quantification of mitral valve regurgitation

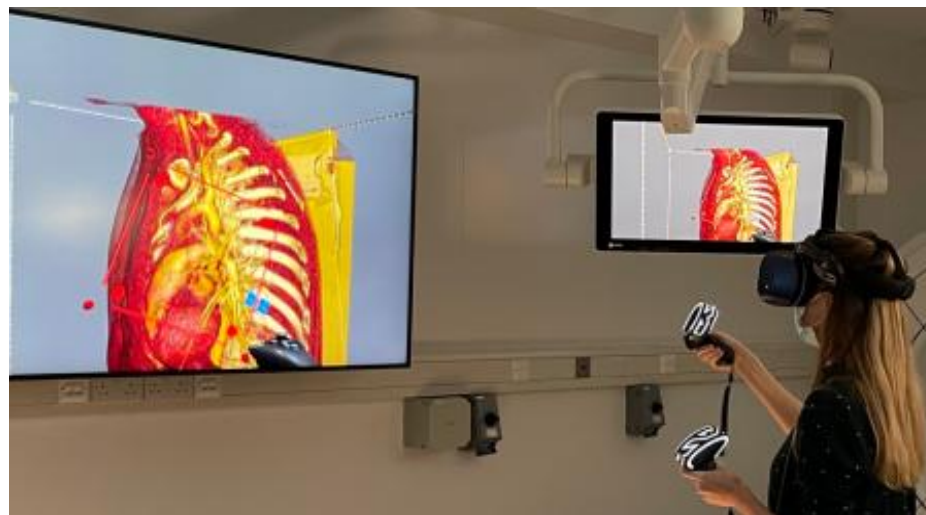
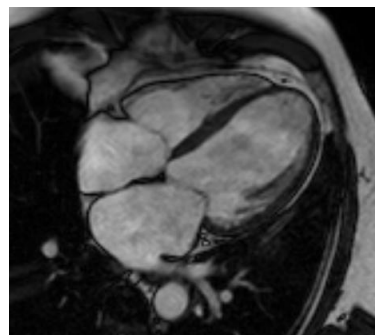
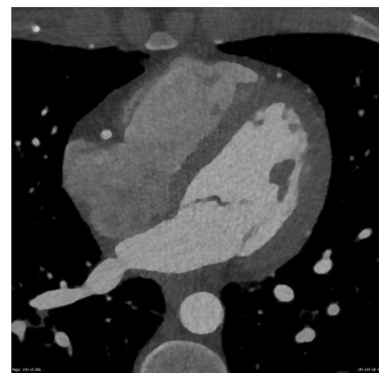


Manufacturers are developing AI powered means of quantifying mitral valve regurgitation

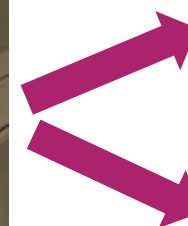
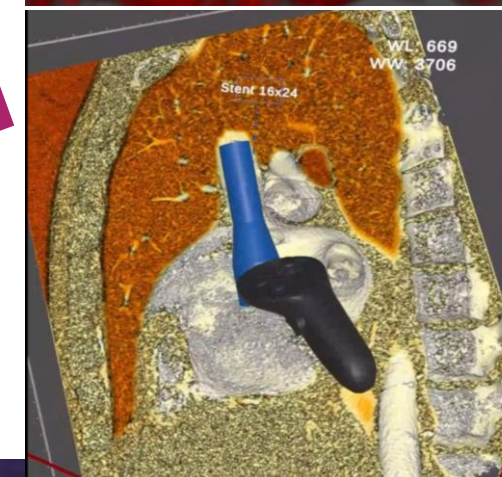
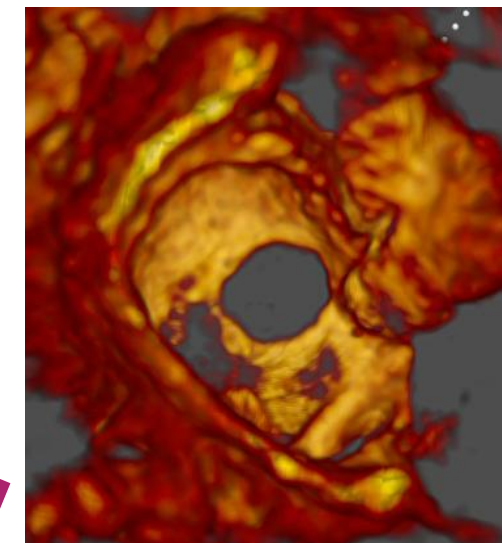
- ✓ Non-circular jets
- ✓ Multiple jets
- ✓ Not holosystolic

Immersive imaging from standard images

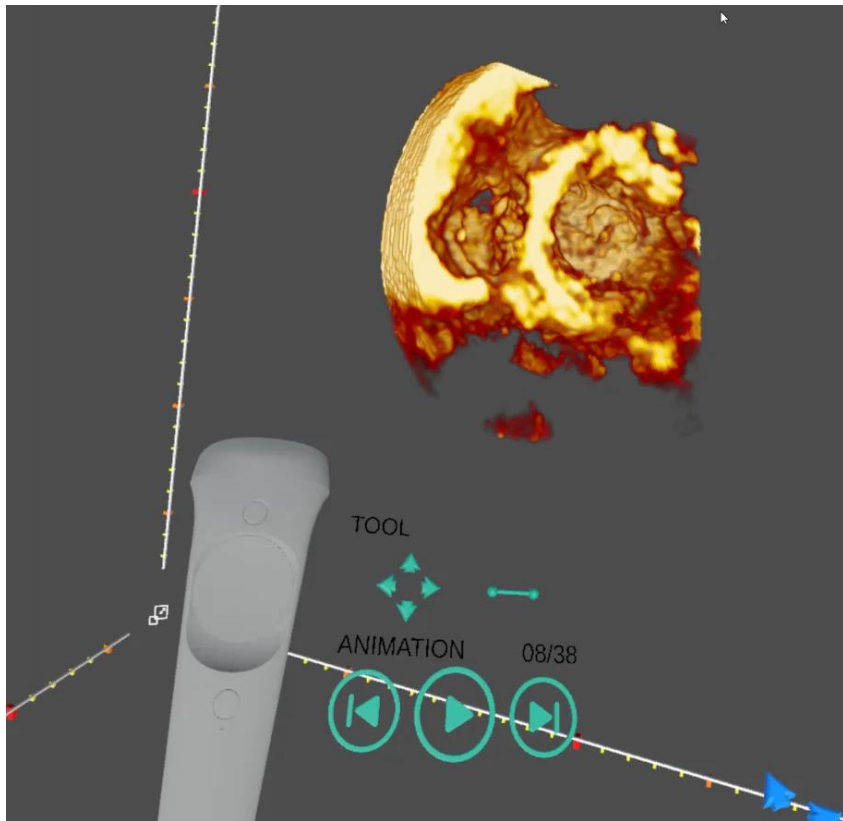
Fully immersive imaging in seconds



Heart VR™



Virtual reality – immersive display of AV valves

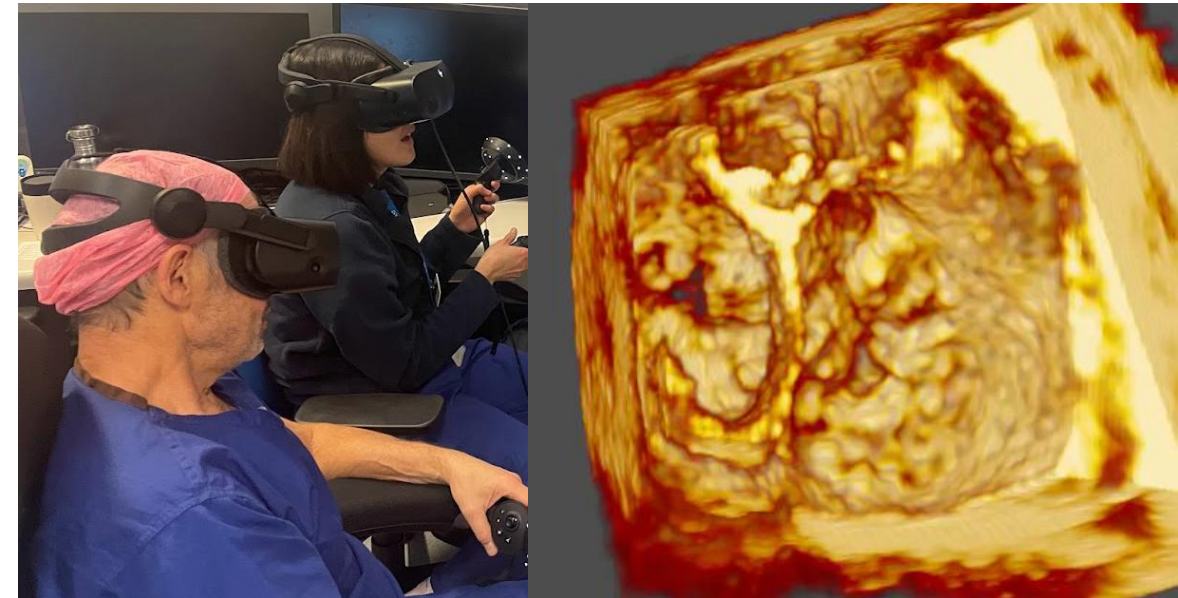
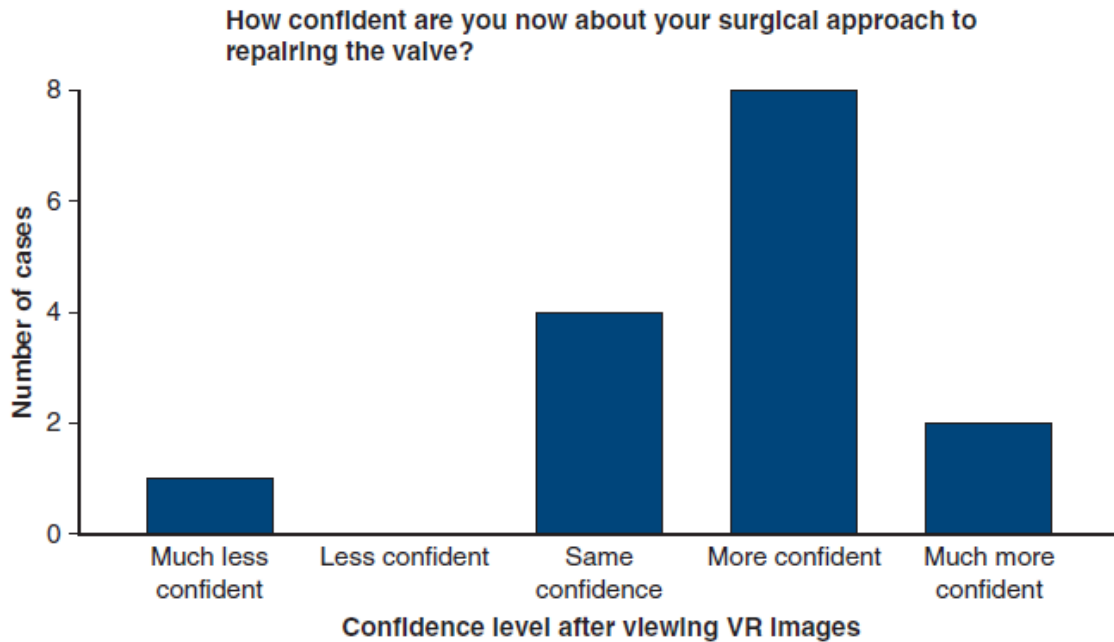


Images, Heart VR, www.xrnostics.com

- All usual functionality
 - Stop/start/scroll
 - Measure
 - Manipulate
 - Crop

Virtual Reality to Plan AV valve Repair

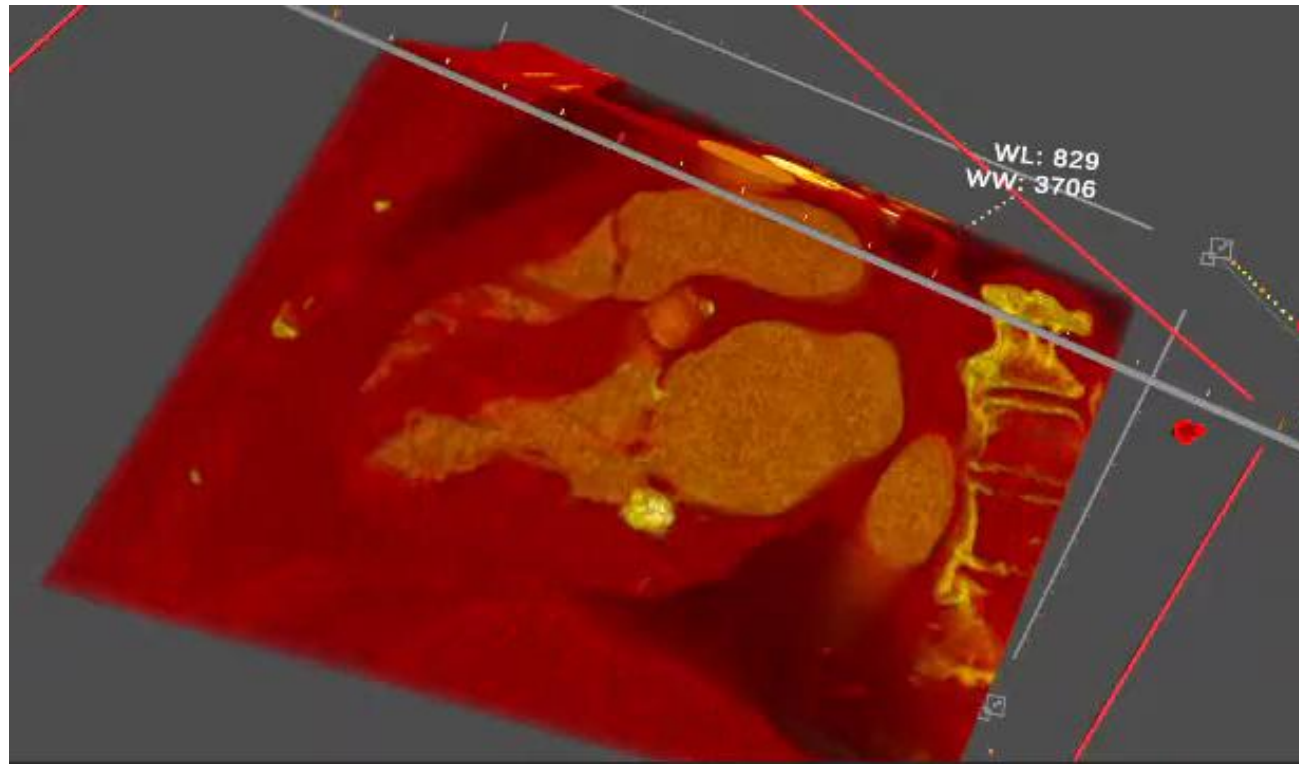
- Heart VR™ preferred by surgeons compared to standard imaging ⁽¹⁾
- Heart VR™ positively impacted surgical approach ⁽¹⁾



(Pushparajah et al, JTCVS Techniques 2021)

Dynamic imaging with other modalities – cine CT

Automated nulling of blood pool to show internals



Images: Heart VR

Thank you for your attention