

Who Needs MRI When We Have Computational Fluid Dynamics From 3DRA?

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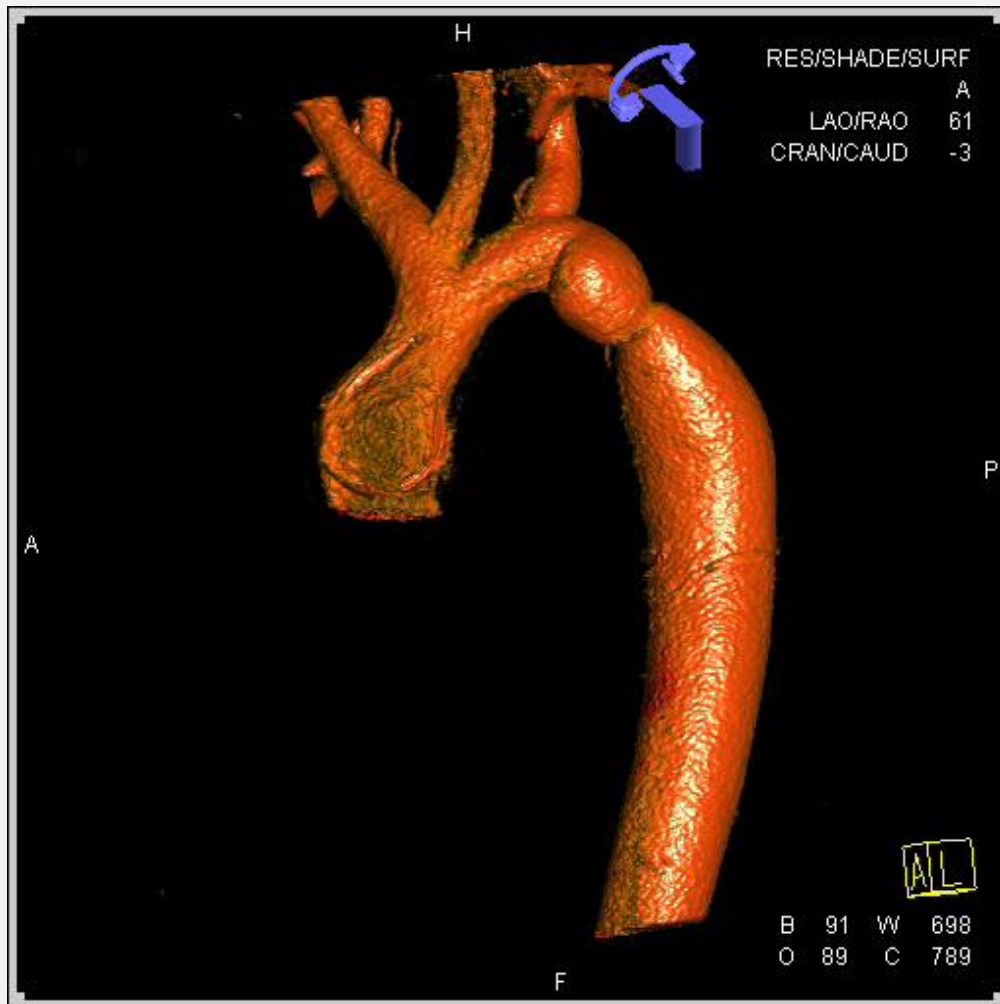
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In collaboration with

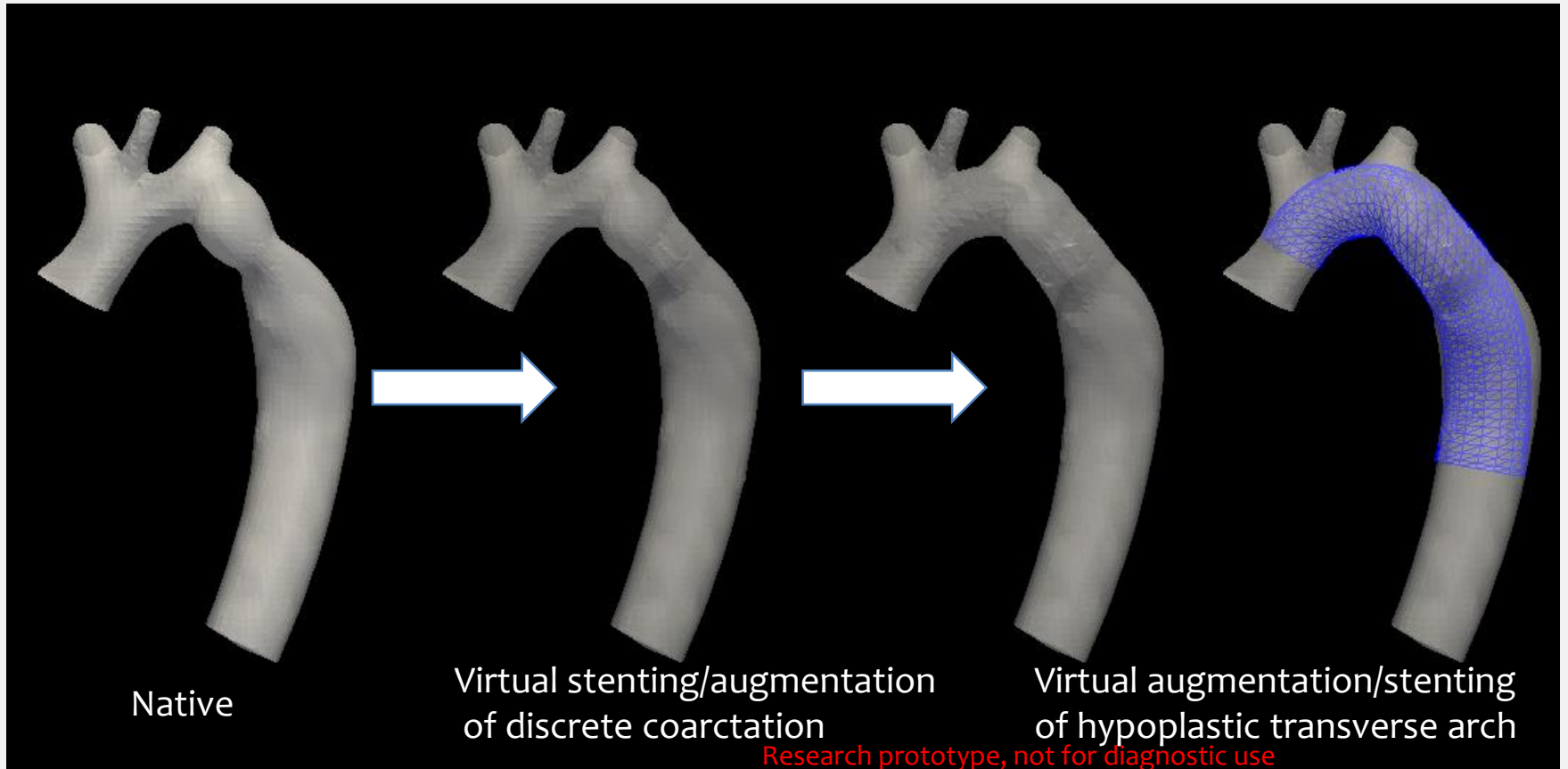
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Disclosures

- Medtronic Inc.: Research Grants
- Edwards Lifesciences: Consultant, Proctor, Research Grant
- Siemens Healthcare AX: Consultant
- St. Jude Medical: Consultant, Proctor, Research Grants
- B. Braun Interventional Systems Inc.: Proctor
- pfm medical, Inc.: Research Grant



Virtual Stenting/Surgery

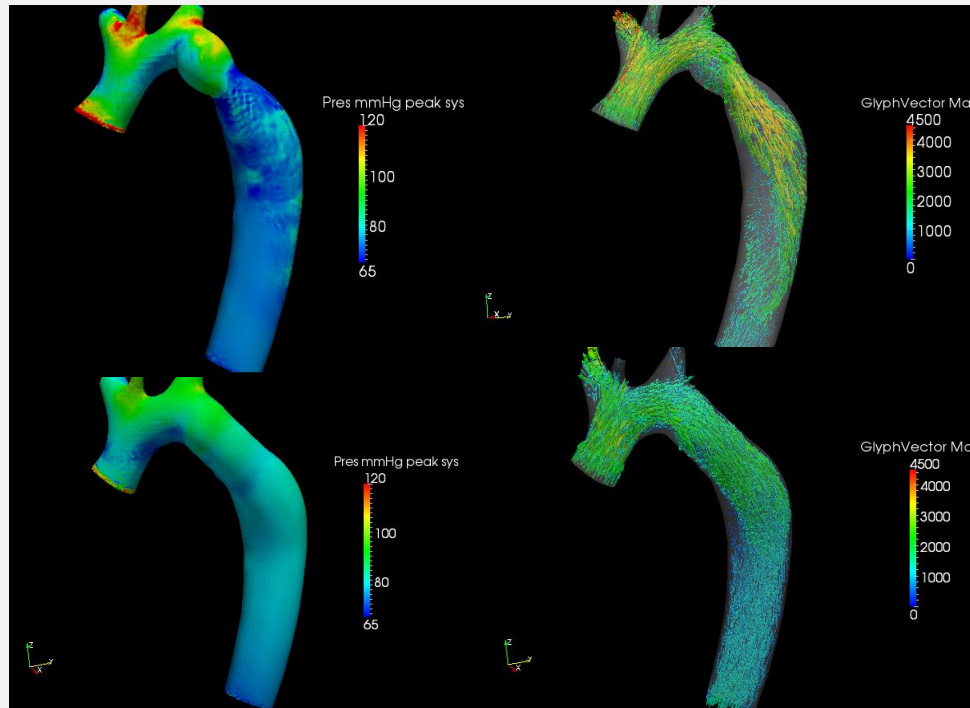


Virtual Stenting/Surgery

Pressure

Velocity

PRE

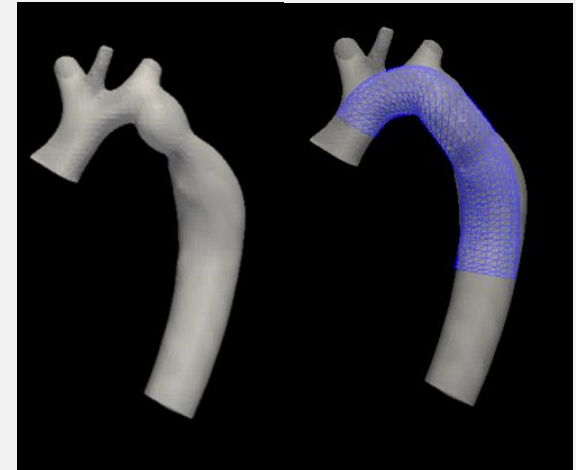
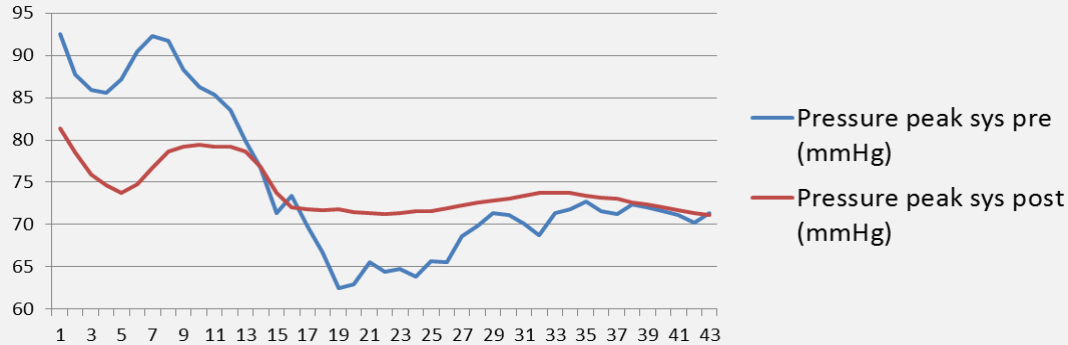


POST

Research prototype, not for diagnostic use

Virtual Stenting/Surgery

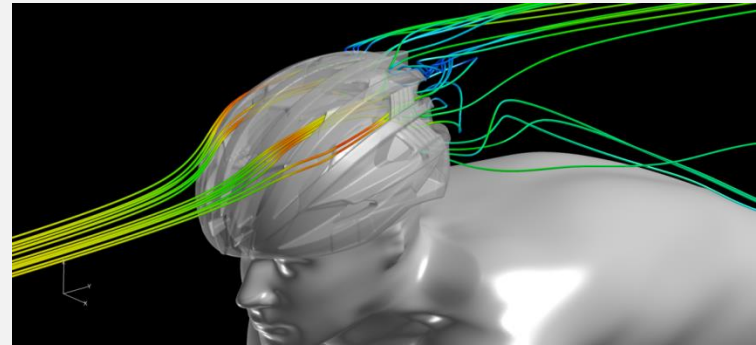
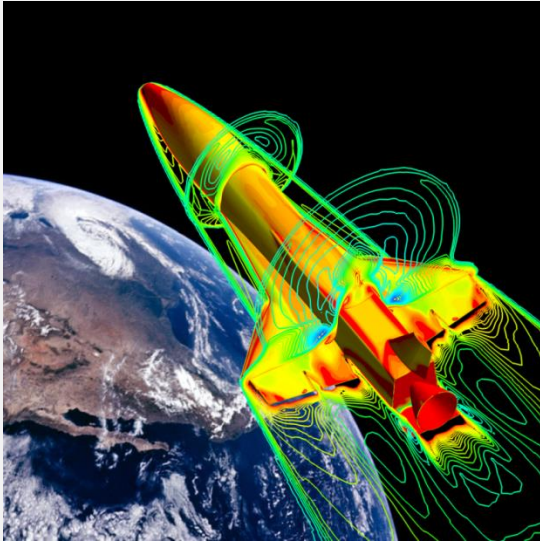
PSEG (mmHg)	Measured	Computed
PRE	20	19
POST	NA	5



Research prototype, not for diagnostic use

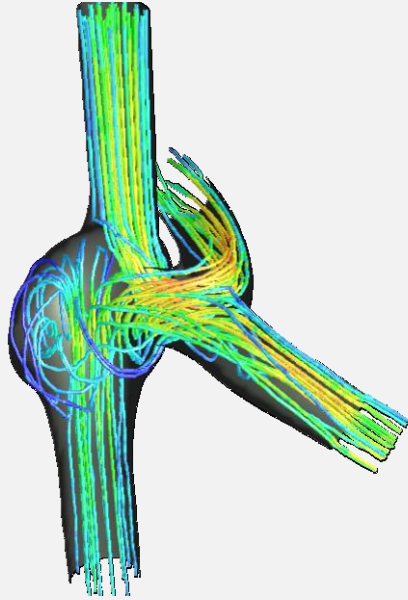
Computational Fluid Dynamics

- Mechanical engineering field for analyzing fluid flow, using computer-based simulation
- Used in aerodynamics and hydrodynamics

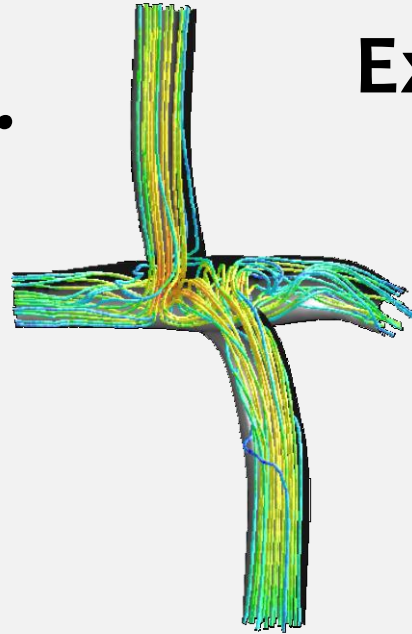


Computational Fluid Dynamics in CHD

**Lateral
Tunnel
Fontan**



vs.

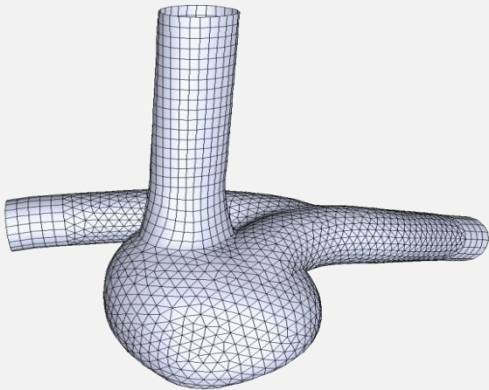


**Extracardiac
Conduit
Fontan**

CFD Workflow

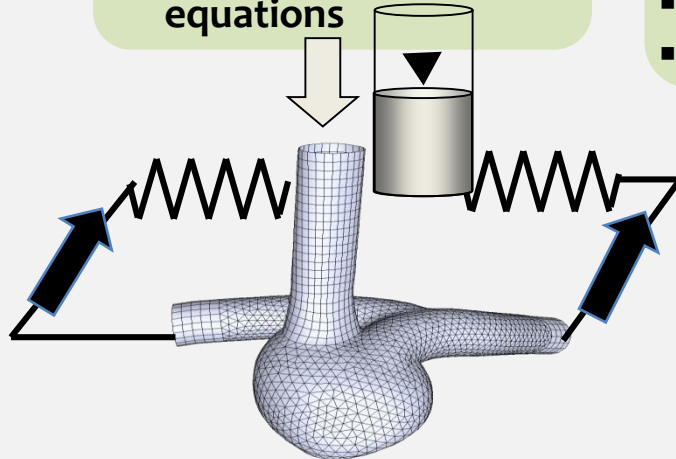
PRE-PROCESSING

- Clinical question
- DICOM Loading
- Segmentation
- Mesh Generation



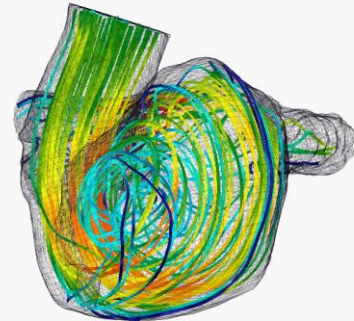
SOLUTION

- Set up boundary conditions
- Solve Navier-Stokes equations



ANALYSIS

- Vectors
- Particle tracking
- Blood flow profiles
- Pressure distribution
- Wall shear stress

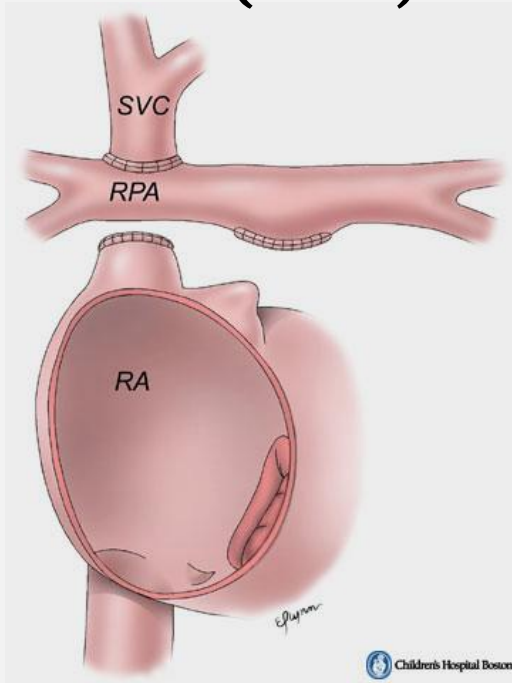


CFD Using Angiographic CT

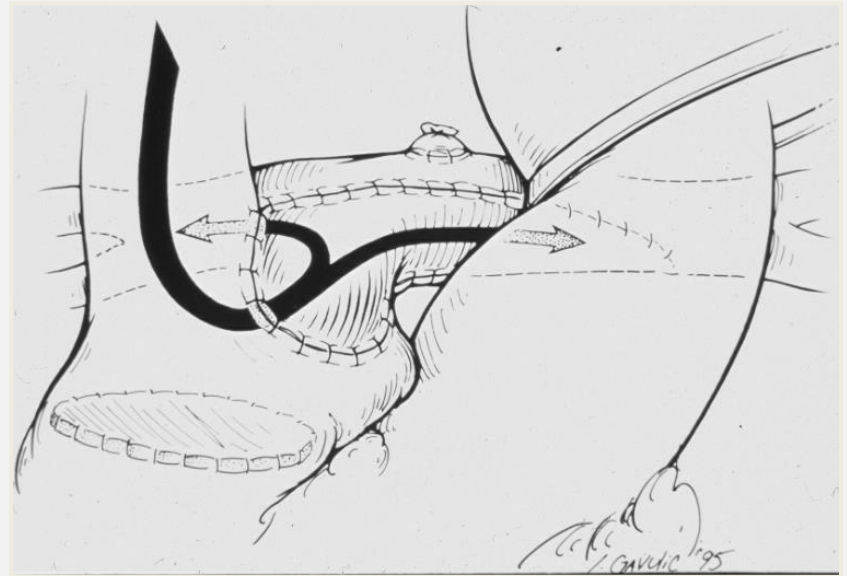


Second Stage Palliation

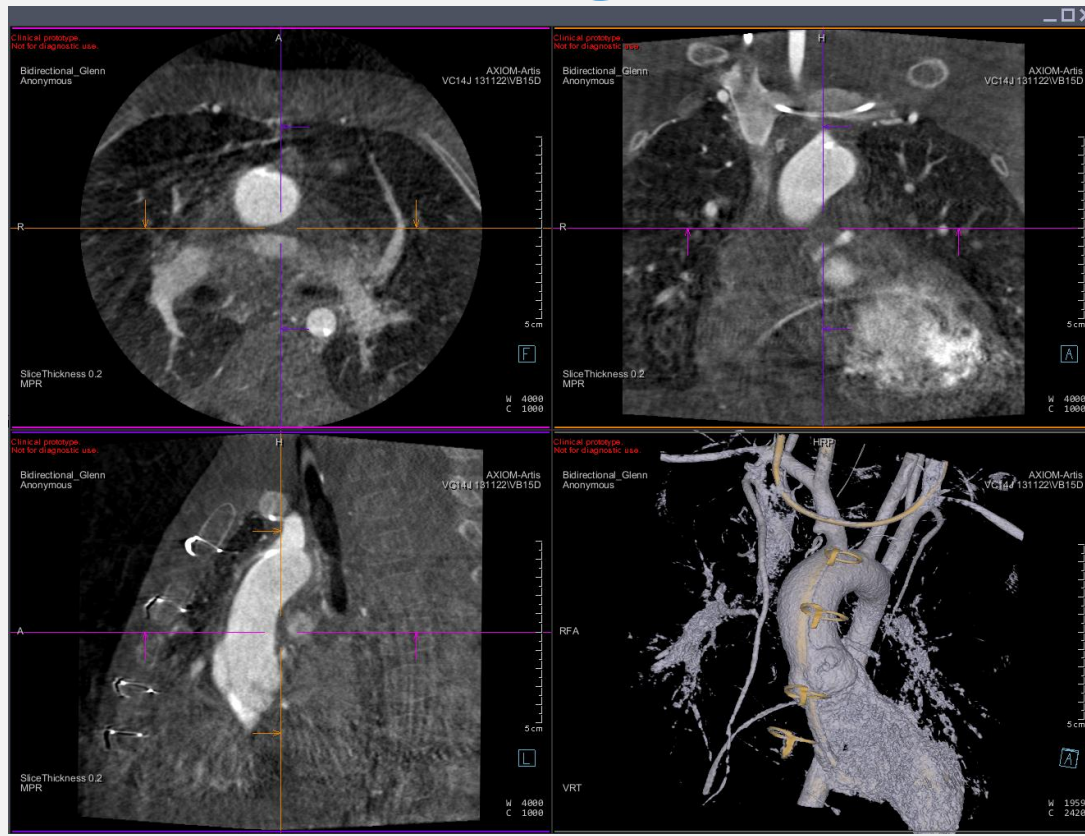
Bidirectional
Glenn (BDG)



Hemi-Fontan
Procedure (HFP)



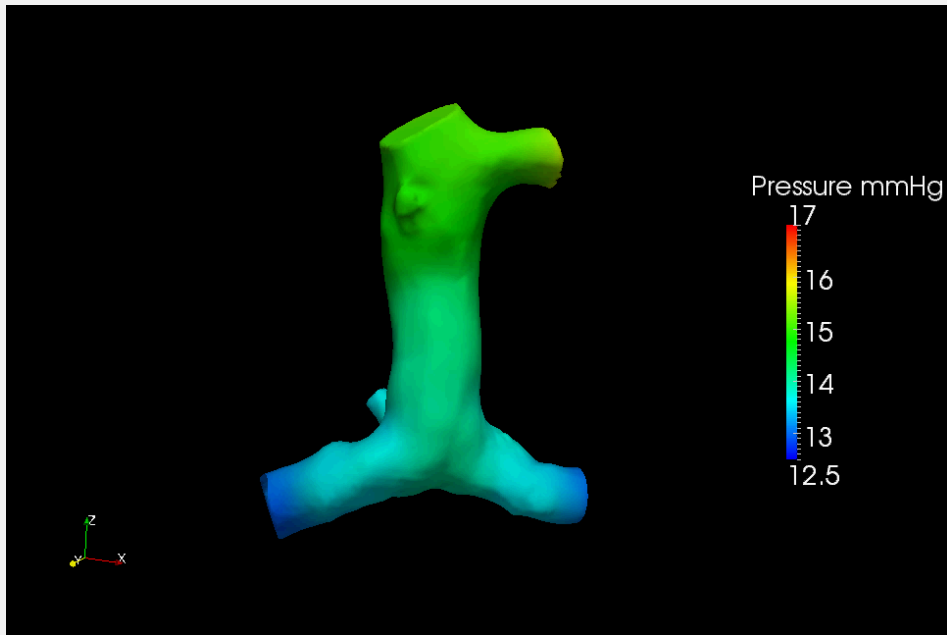
CFD Using Angiographic CT for BDG



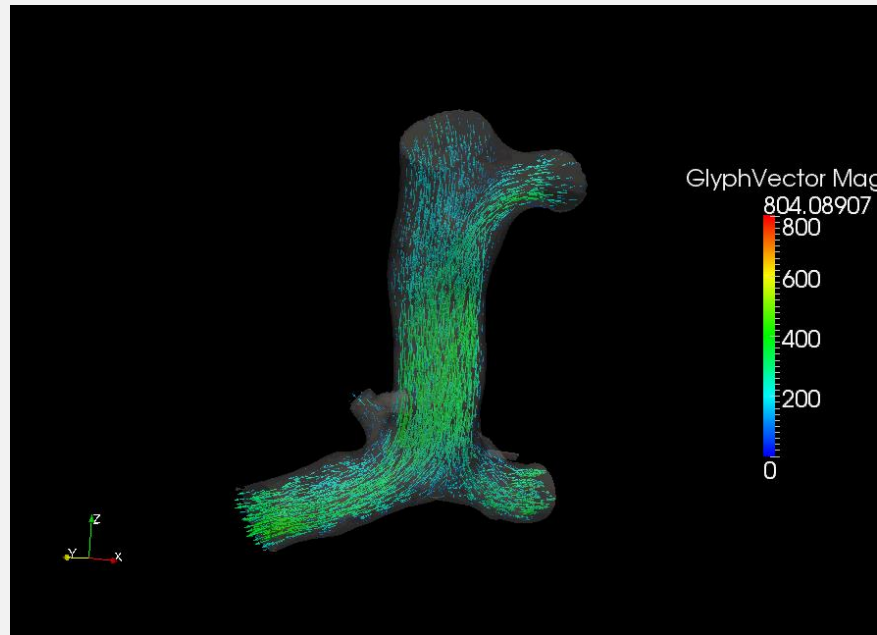
Research prototype,
not for diagnostic use

CFD Using Angiographic CT for BDG

Pressure



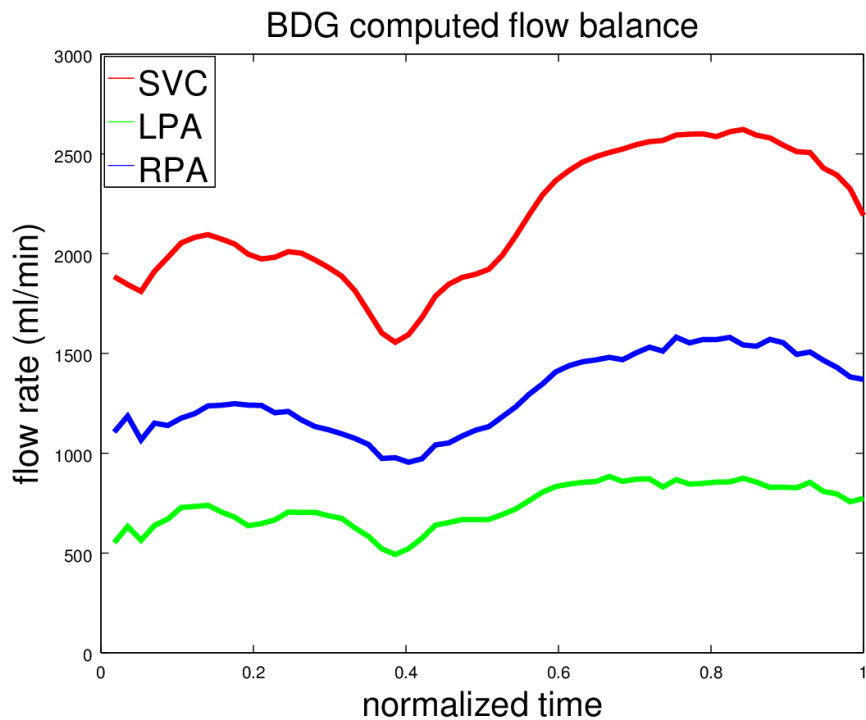
Velocity



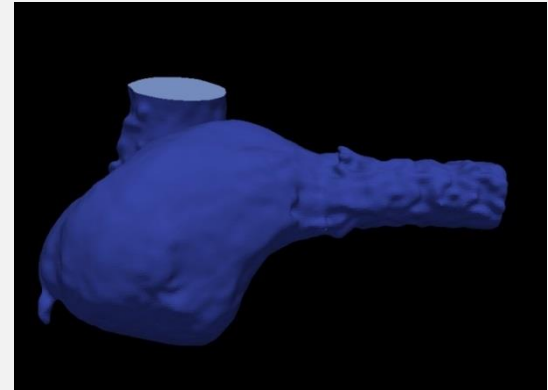
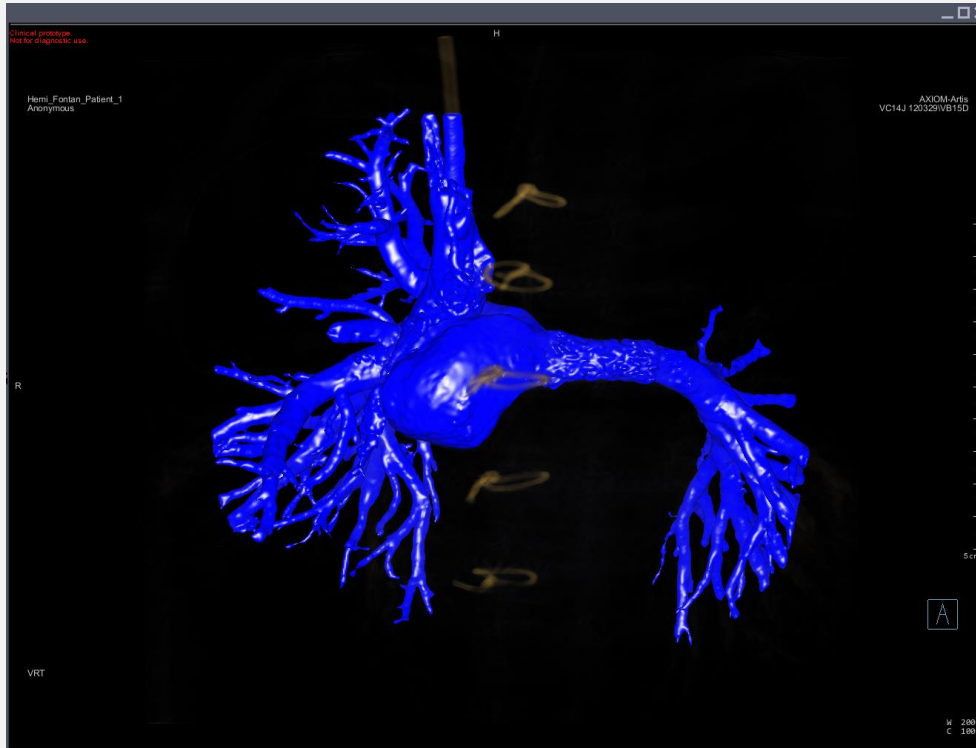
Research prototype, not for diagnostic use

CFD Using Angiographic CT for BDG

Flow split computed: 36% to LPA, 64% to RPA



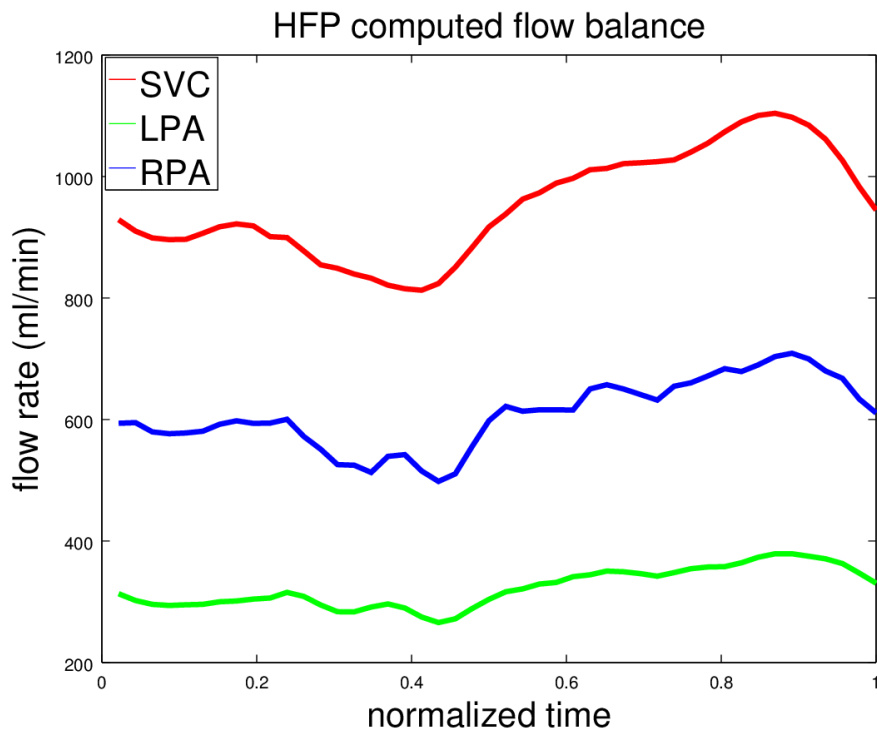
CFD Using Angiographic CT for HFP



Research prototype, not for diagnostic use

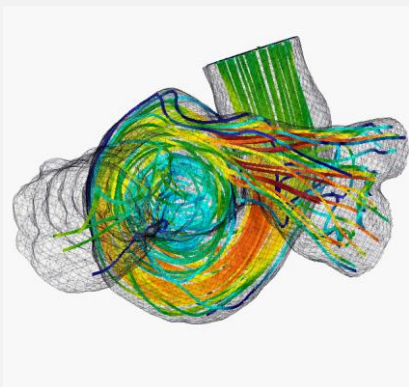
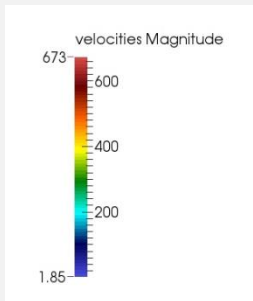
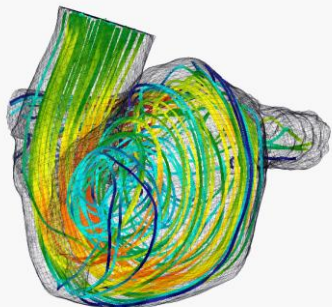
CFD Using Angiographic CT for HFP

Flow split computed: 35% to LPA, 65% to RPA

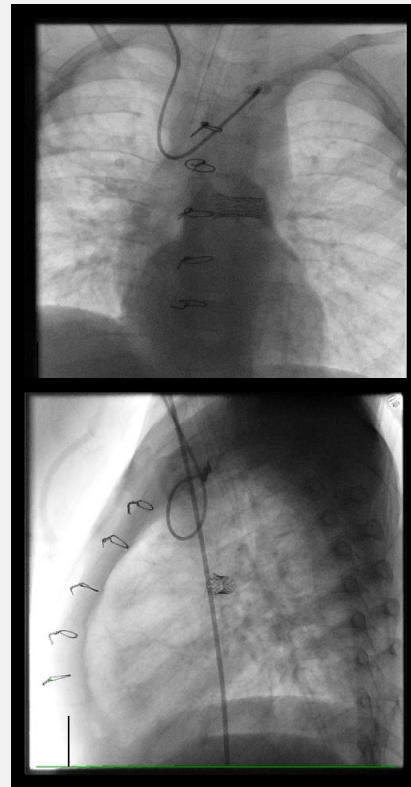


CFD Using Angiographic CT for HFP

Streamlines



Qualitative Validation

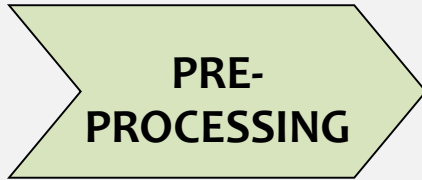


CFD Using Angiographic CT for BDG and HFP

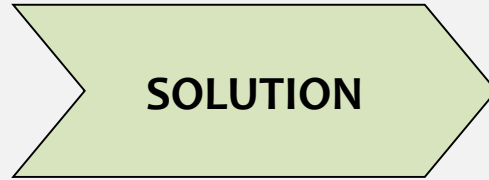
Summary of computed performance indices

	BDG	HFP
Pressure drop (from SVC to LPA)	0.8 mmHg	1.0 mmHg
Pressure drop (from SVC to RPA)	0.9 mmHg	1.0 mmHg
Power loss	1.4 mW	1.9 mW

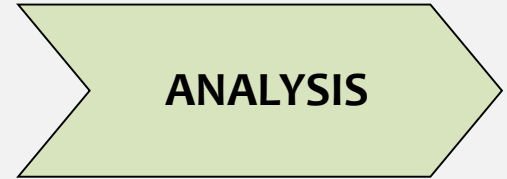
Processing Times



< 1hr per case



<10 min per case



<10 min per case

Ongoing Coarctation Study

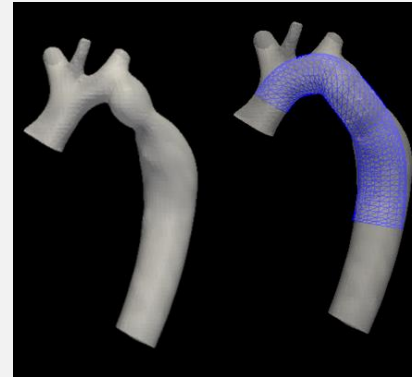
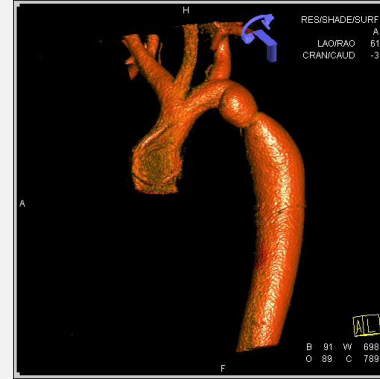
Coarctation patients

↓
3DRA

↓
CFD to predict PSEG

↓
Stent + Virtual Stent

↓
CFD to predict PSEG



NATIONWIDE CHILDREN'S
When your child needs a hospital, everything matters.™

Ongoing Coarctation Study

Coarctation patients

↓
3DRA

↓
CFD to predict PSEG

↓
Stent + Virtual Stent

↓
CFD to predict PSEG

- *Hypothesis:* Siemens CFD processor will calculate PSEGs that will correlate with those obtained by direct catheter measurement with an absolute error of < 5 mmHg

Ongoing Coarctation Study



Quantity	Peak-to-Peak (mmHg)	Average (mmHg)
Computed ΔP	107.0	55.0
Measured ΔP	48.0	29.1



Ongoing Coarctation Study



Quantity	Peak-to-Peak (mmHg)	Average (mmHg)
Computed ΔP	28.2	6.7
Measured ΔP	24.0	9.7



Conclusions

- CFD is feasible and fast, using angiographic CT alone, without the need for MRI or standard CT
 - *Not to replace MRI for CFD*
- Further studies are needed to validate this technique, using MRI as a gold standard
- The greatest advantage may be patient-specific virtual interventions

Collaborators

- Siemens Collaborators:
 - Viorel Mihalef, PhD
 - Saikiran Rapaka, PhD
 - Tiziano Passerini, PhD
 - Gouthami Chintalapani, PhD
 - Puneet Sharma, PhD, Head of Research Group, Siemens Corporate Technology
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 - Jeff Zampi, MD, University of Michigan, Ann Arbor
 - Henri Justino, MD, Texas Children's Hospital, Houston