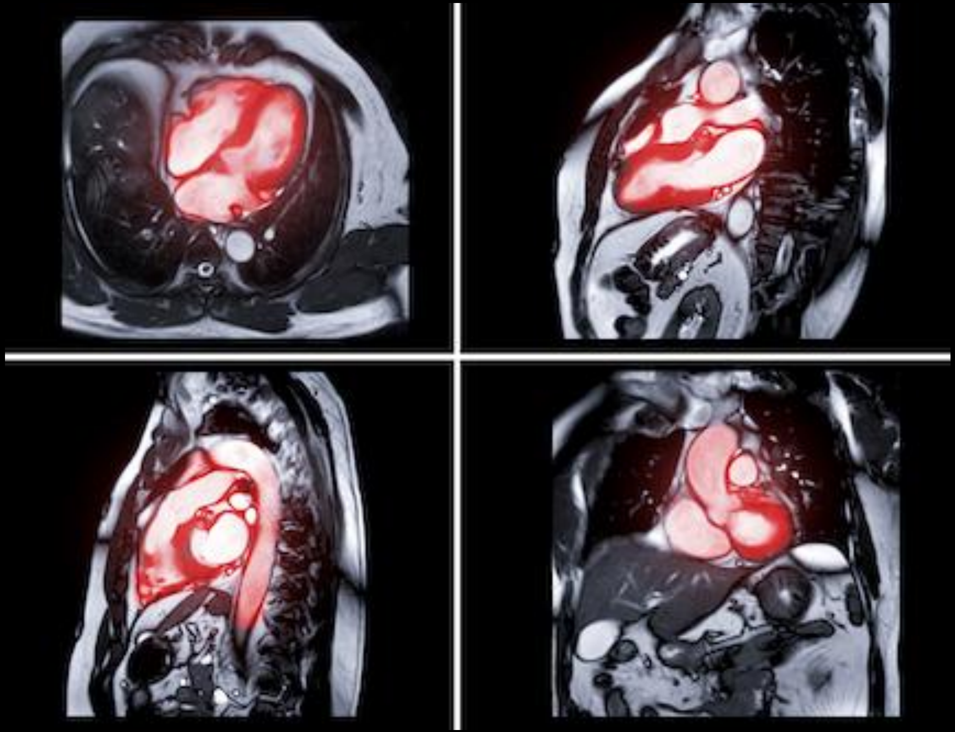
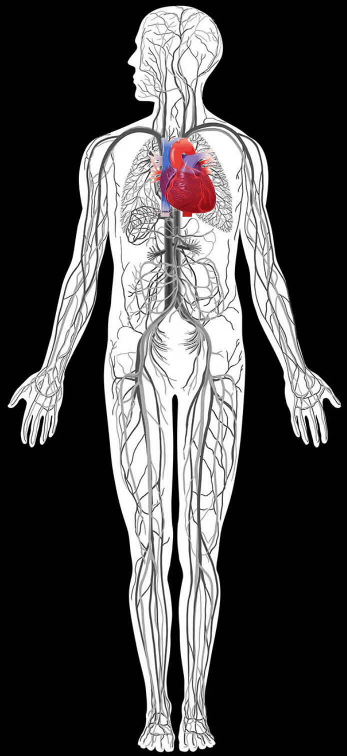
Cardiovascular Medical Imaging



National Biomechanics Day at CMU

Why should we care about cardiovascular system?



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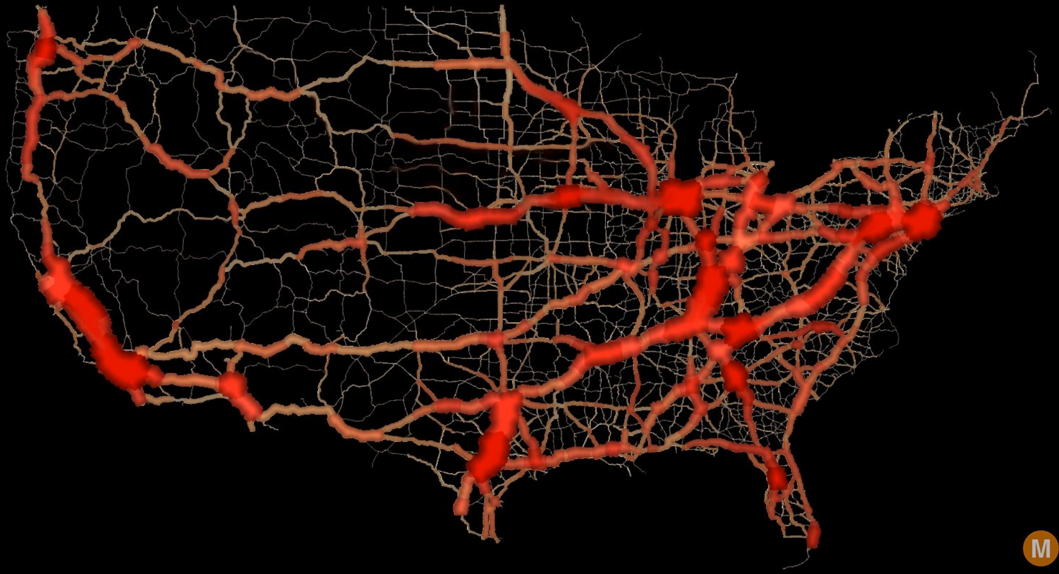
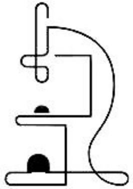
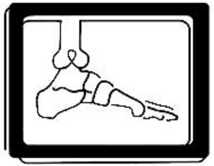
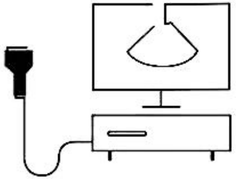




16th Century
Microscope was invented



1895
X-ray machine was invented

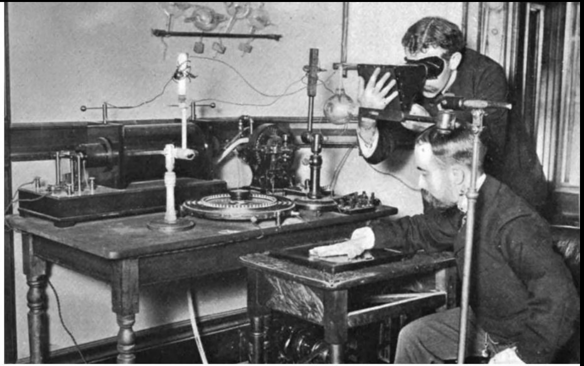


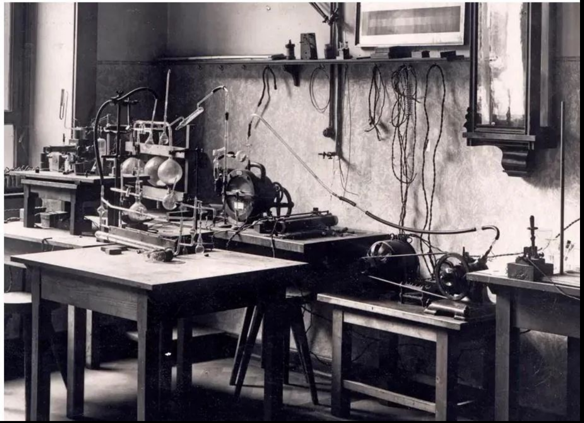
1956
Ultrasound was invented

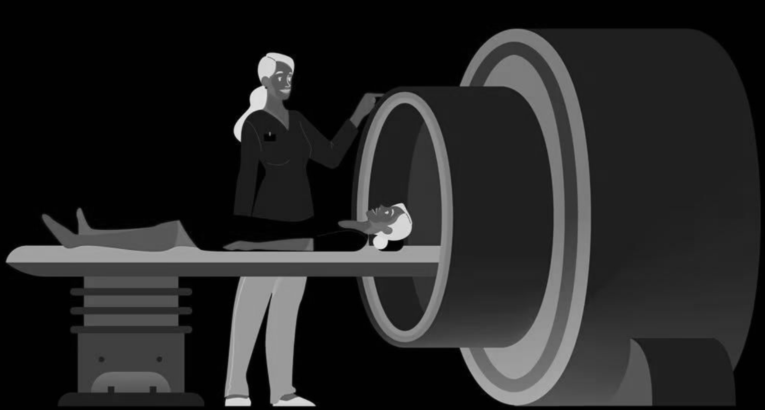
1972
CT was invented

1977
MRI was invented

X-ray imaging won the first nobel prize in physics!

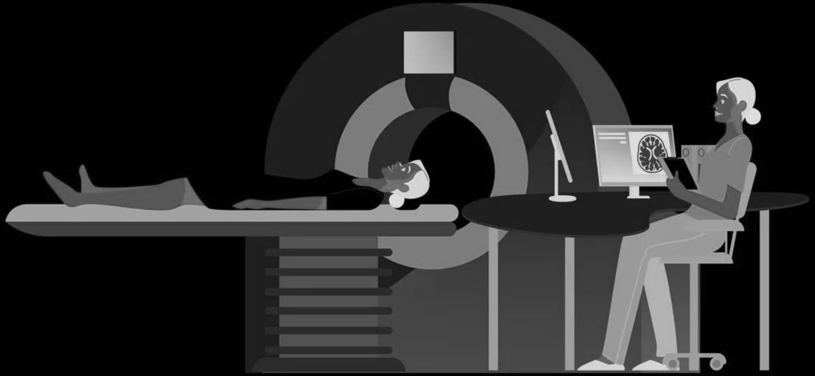






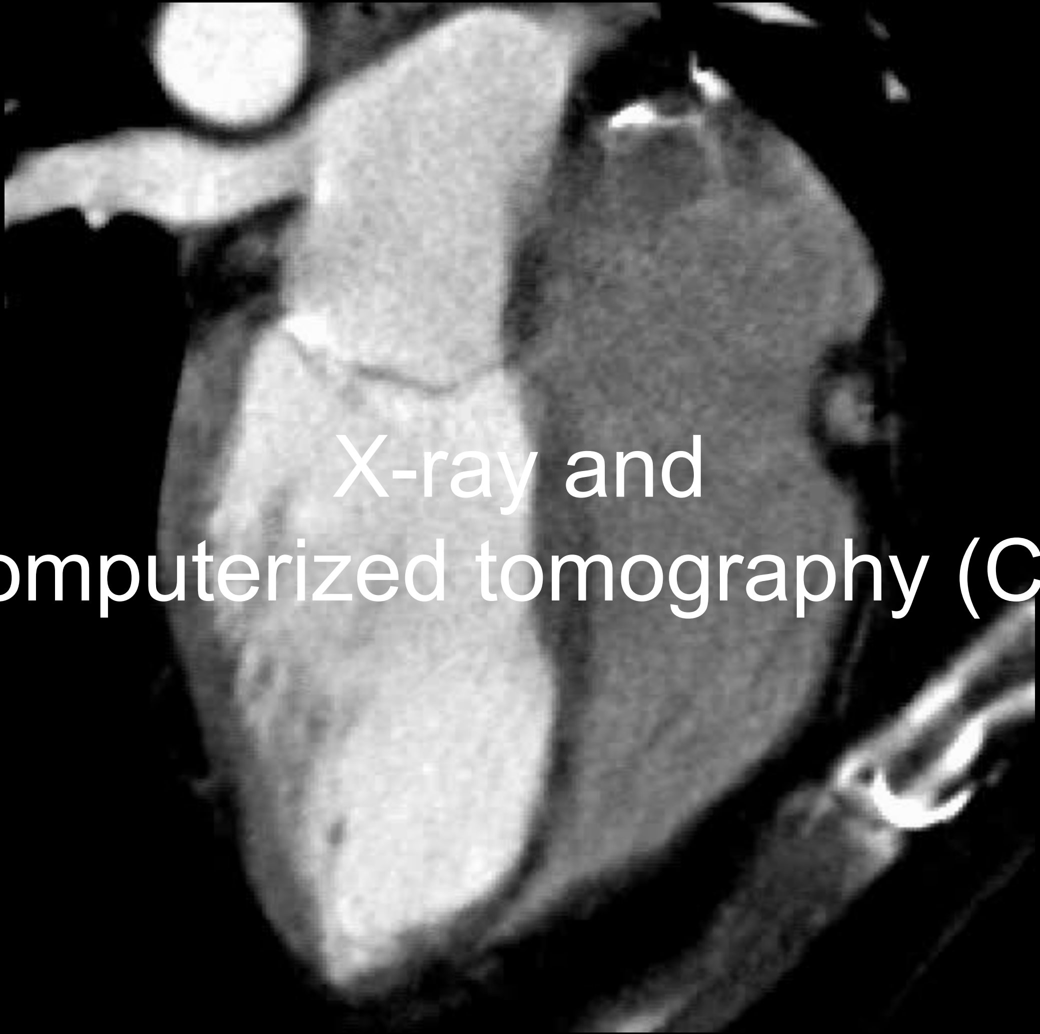
MRI

X-RAY



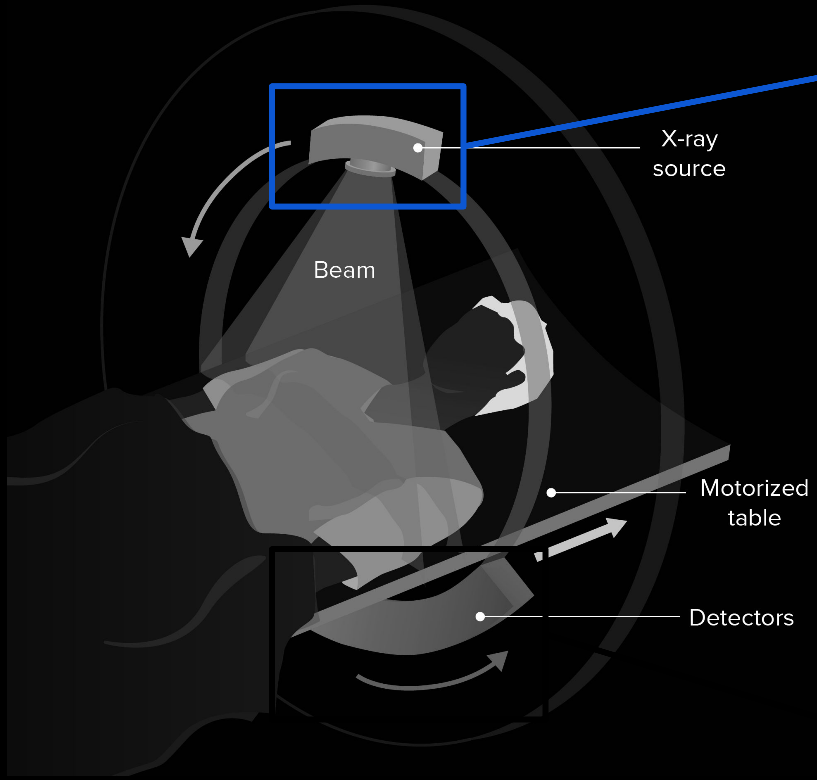
CT SCAN

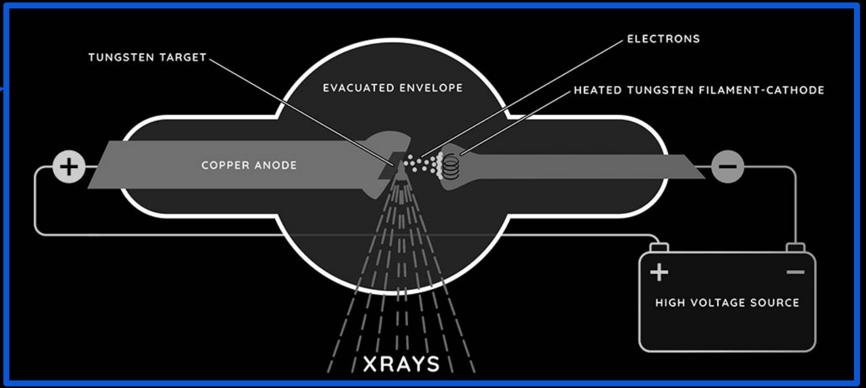
ULTRASOUND



X-ray and Computerized tomography (CT)

How computerized tomography (CT) imaging works

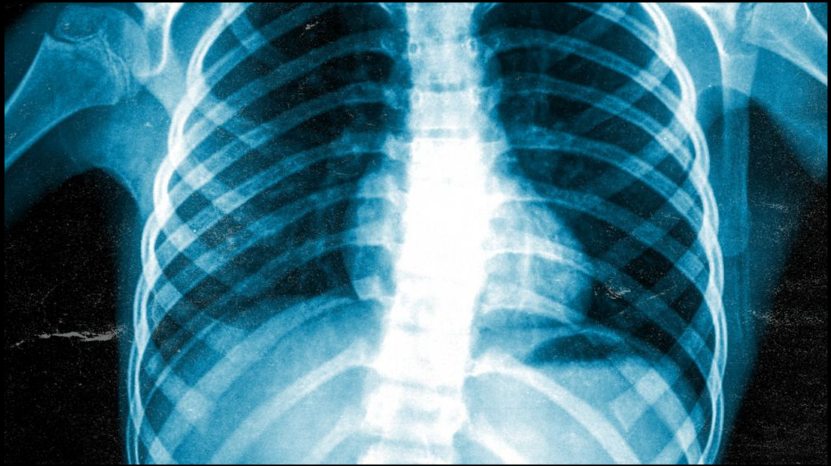




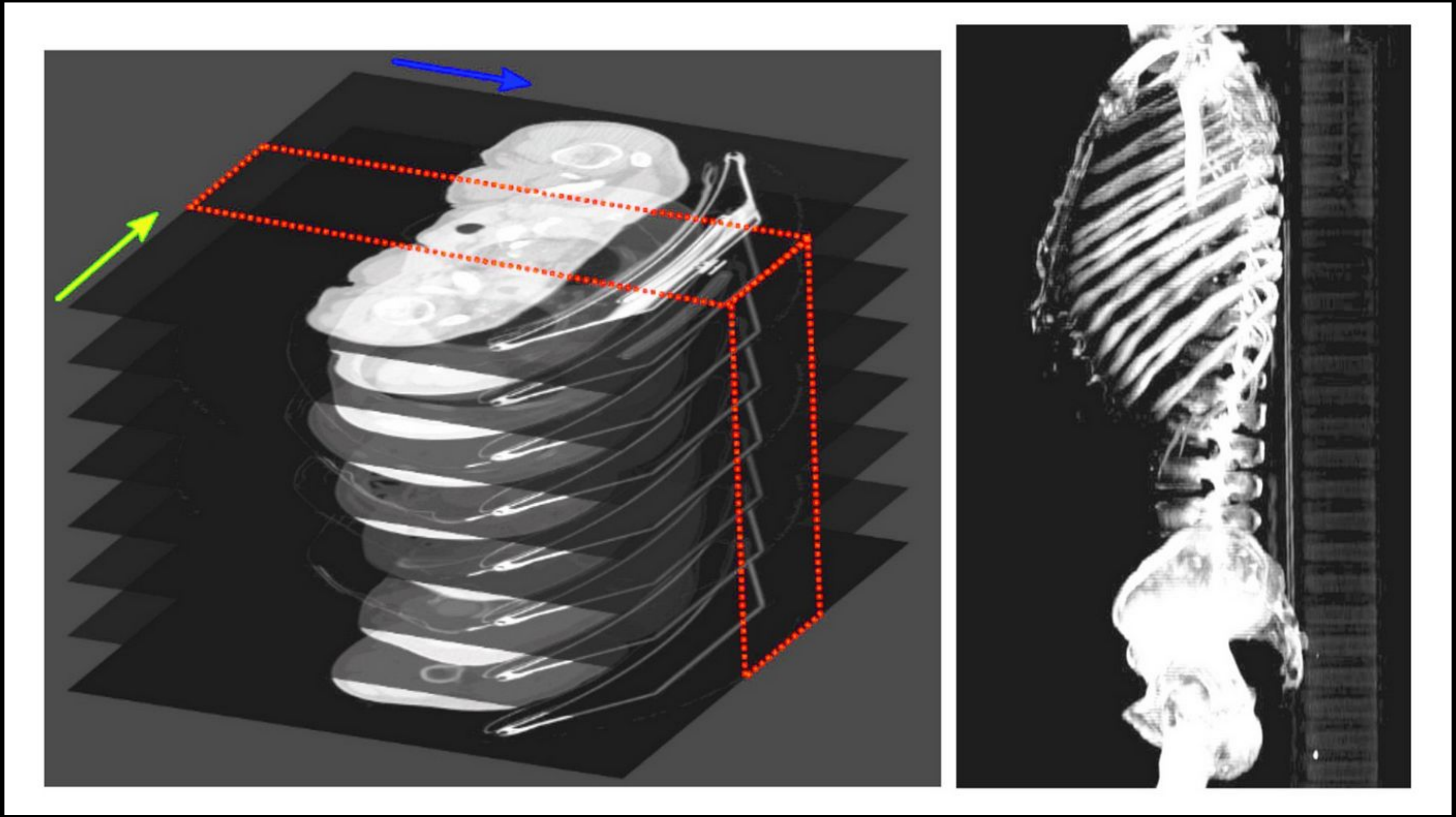
X-ray imaging is best for dense tissue, or soft tissue by using a radioactive dye

bones

Heart imaging



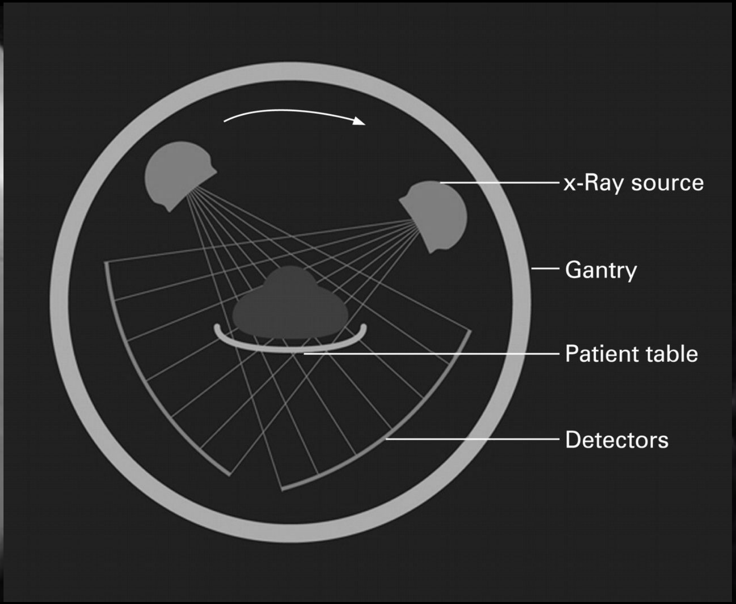
CT images are constructed from many X-ray photos



Process for obtaining cardiovascular CT images

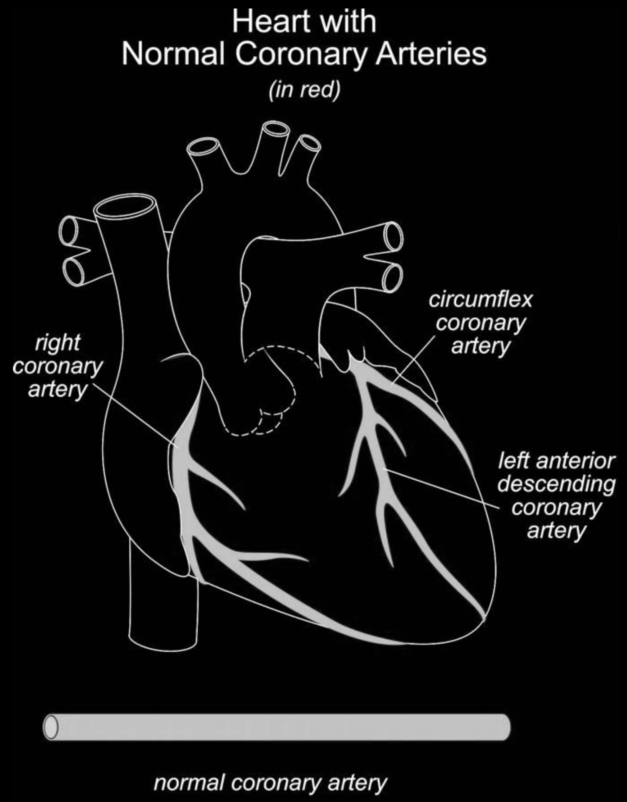
Inject dye into blood vessels

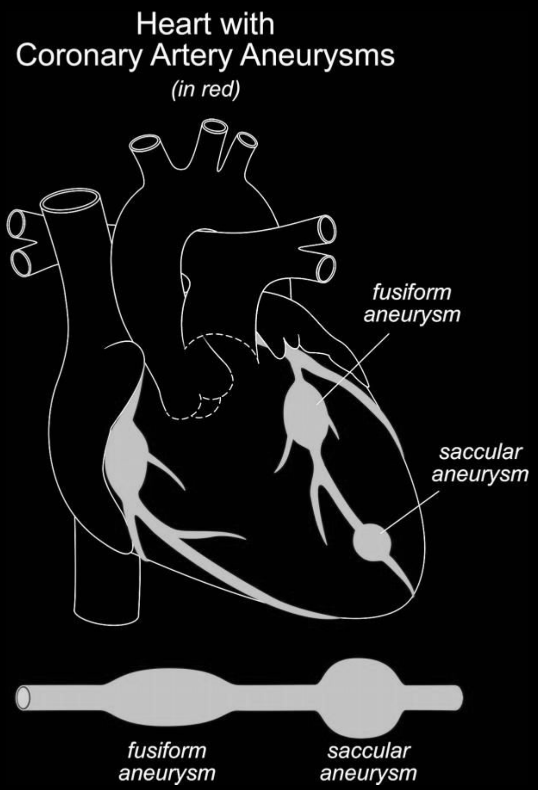
Take numerous x-ray images



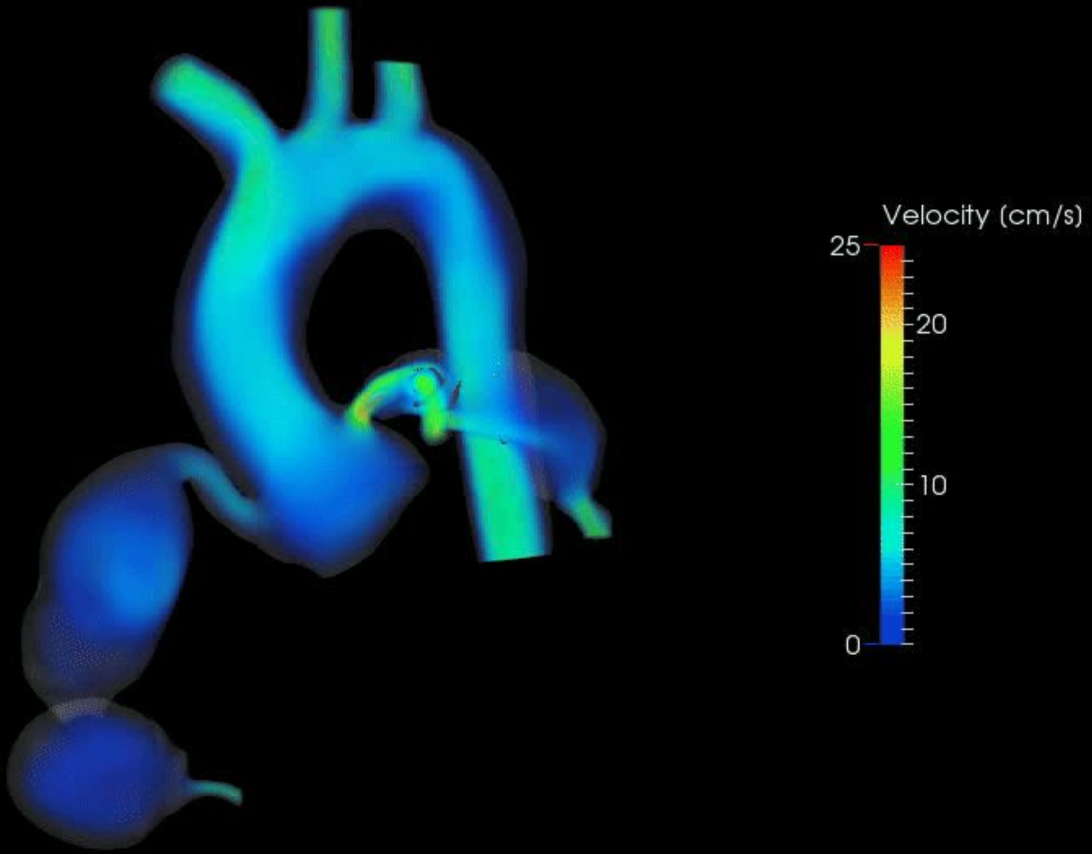
Create CT images

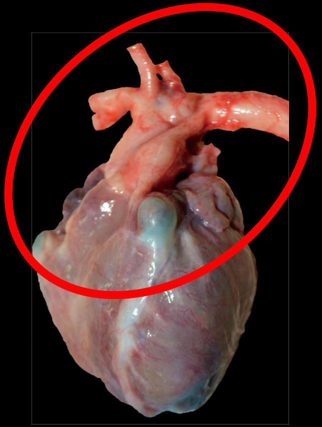
Using CT images to diagnose and understand disease





CT can be used to create high quality blood flow models





Careers in CT imaging

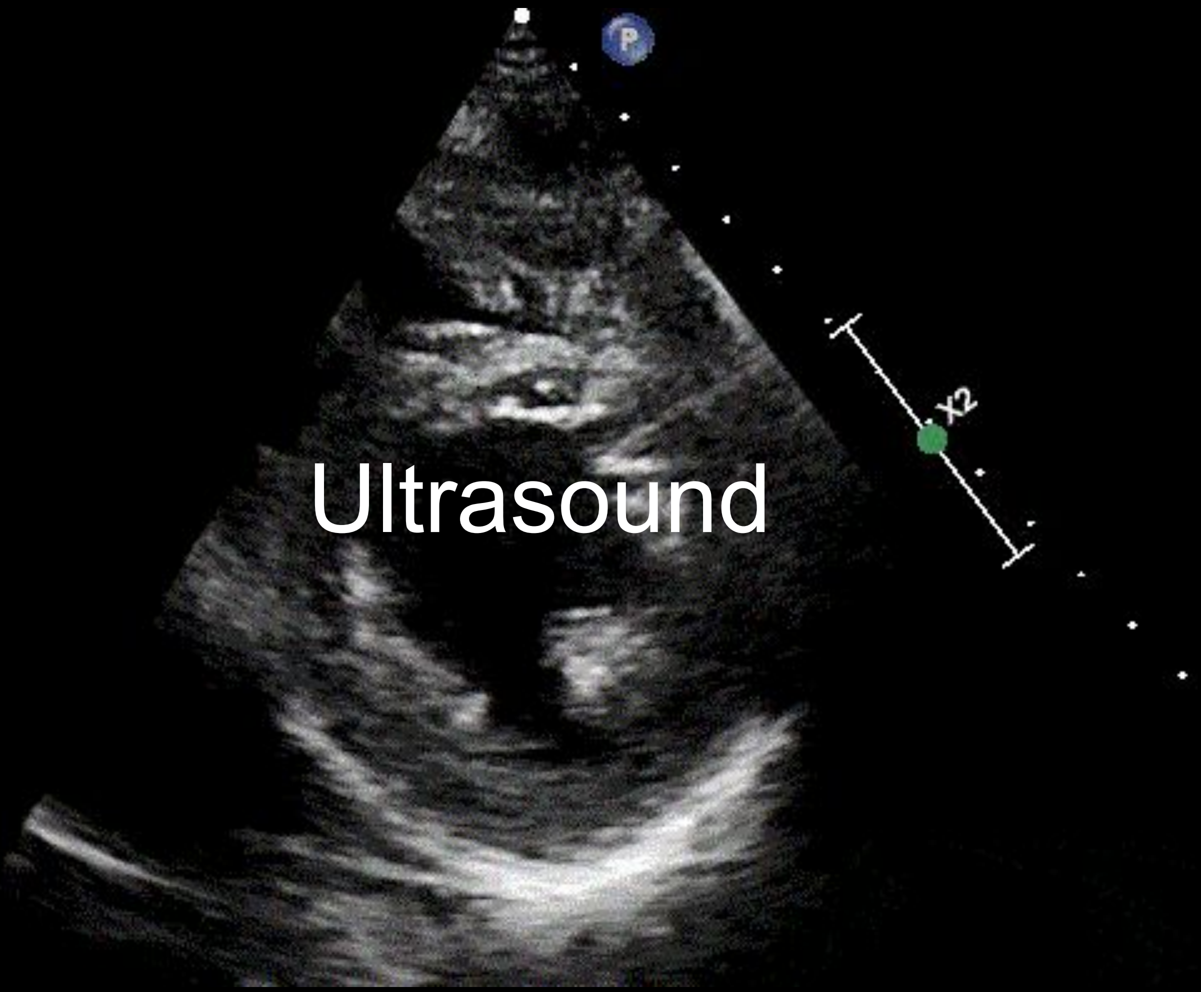
cardiologist

radiologist

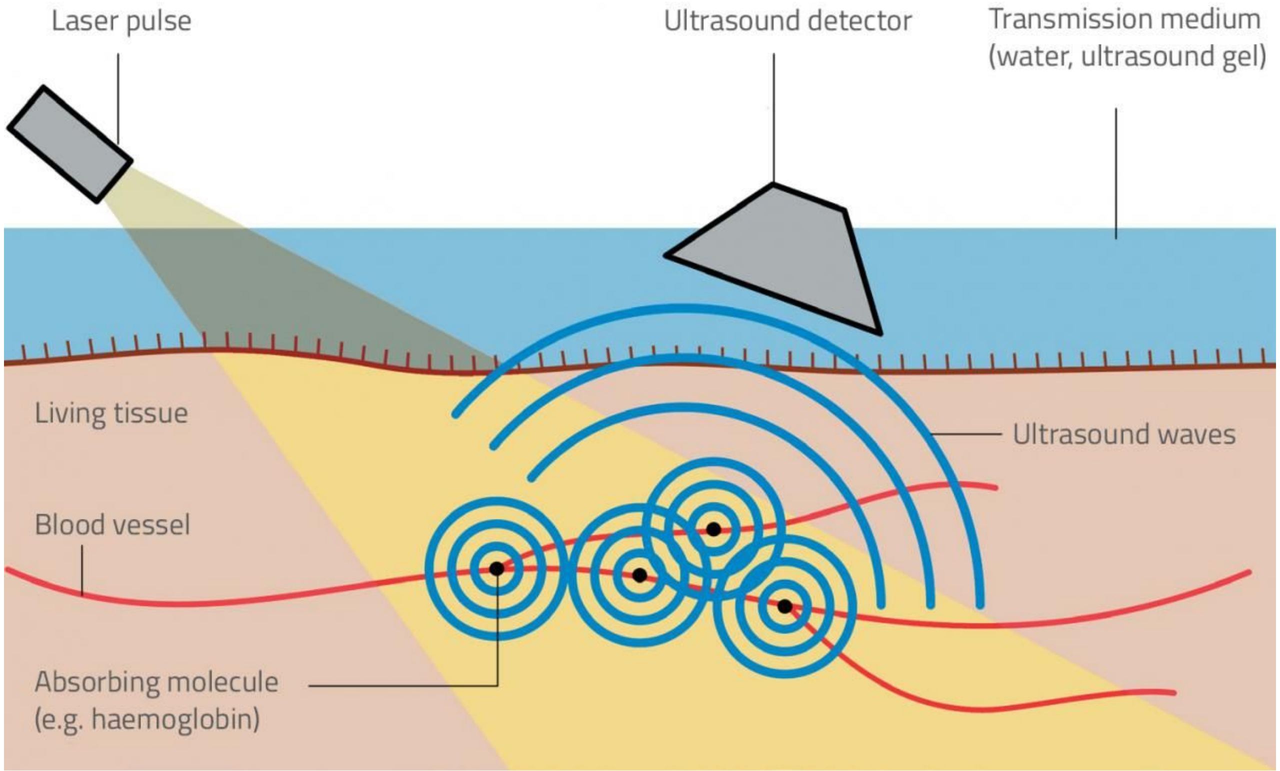
X-ray/CT Technologists

Medical device engineer

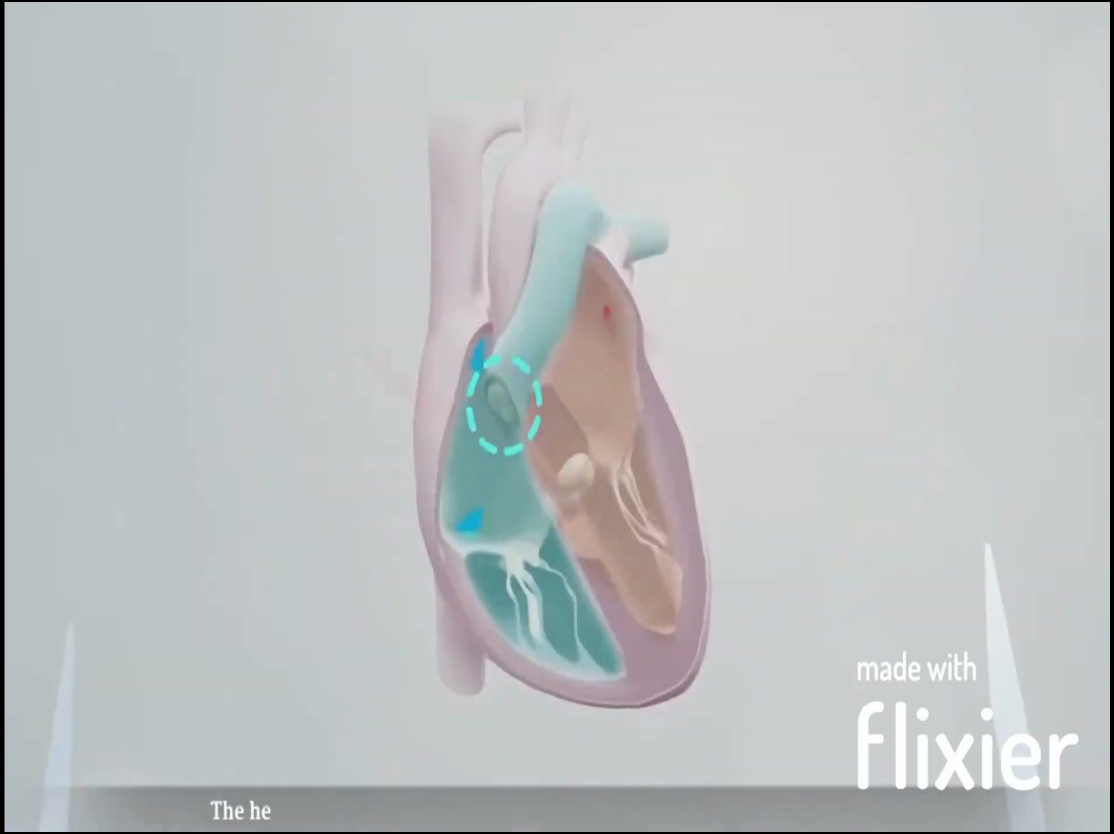
Ultrasound



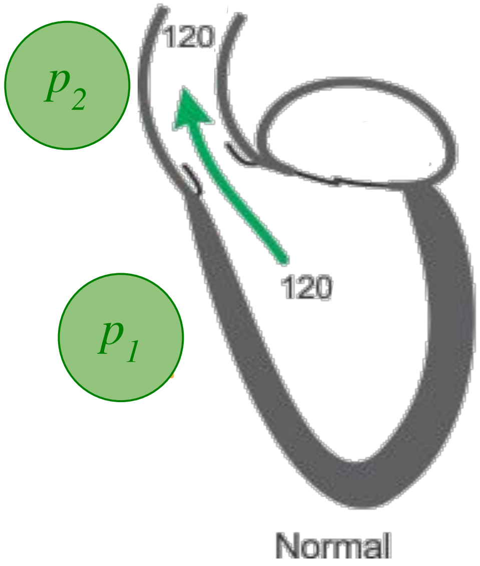
How ultrasound imaging works



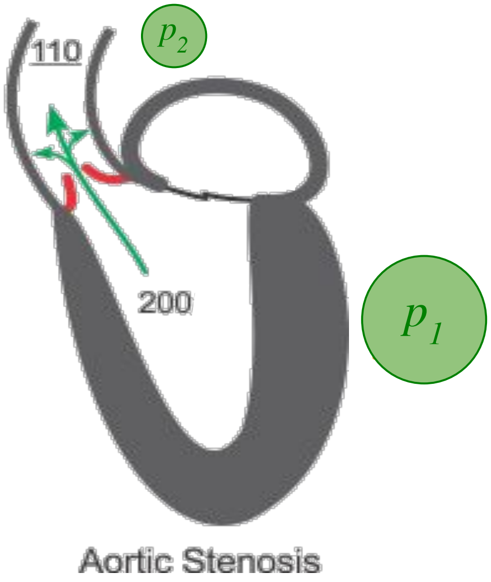
Aortic valve stenosis



Aortic valve stenosis



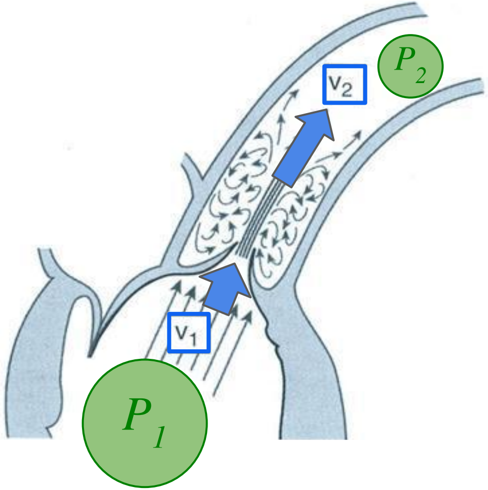
$$p_1 - p_2 = 120 - 120 = 0\ mmHg$$



$$p_1 - p_2 = 200 - 110 = 90\ mmHg$$

Measuring pressure inside someone’s heart is **hard!**

Application of Bernoulli's Principle



Echocardiography uses sound waves to create images of our heart and to measure blood velocity (**Doppler effect**)

We can measure v_1, v_2 !

$$p_1 - p_2 = \frac{1}{2}\rho(v_2^2 - v_1^2)$$

Careers in ultrasound imaging

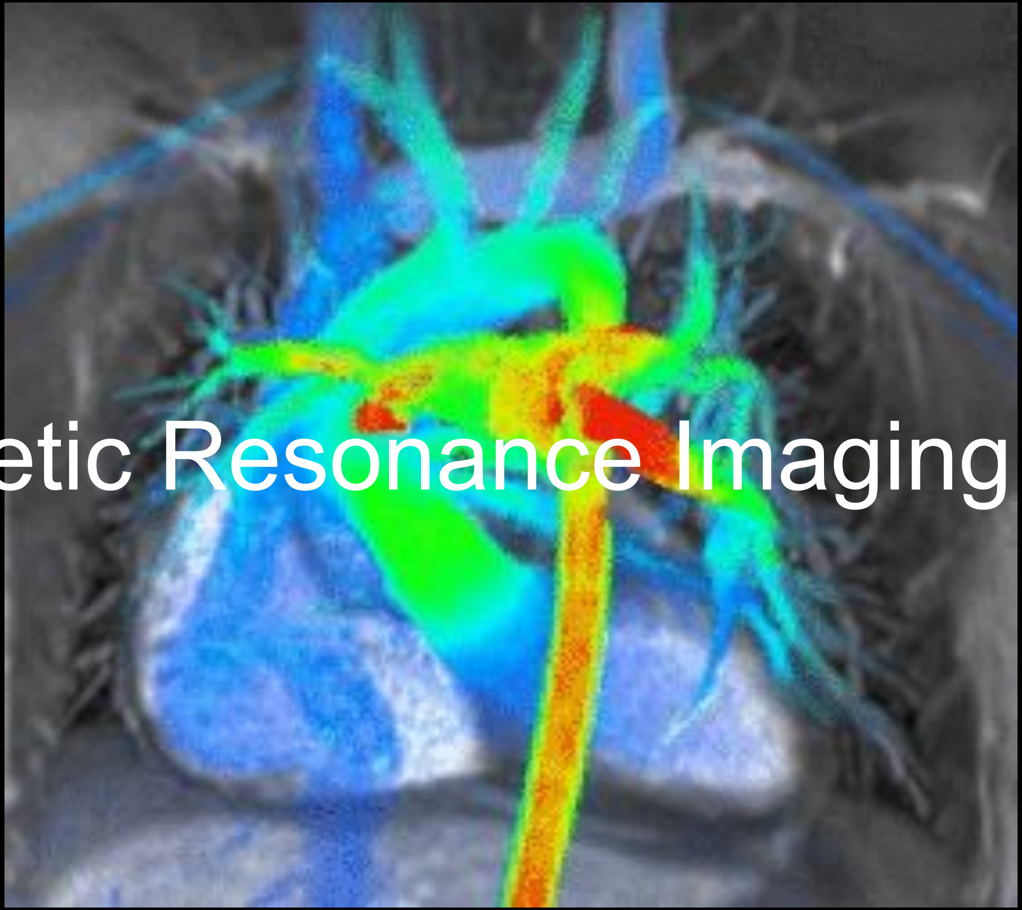
cardiologist

sonographer

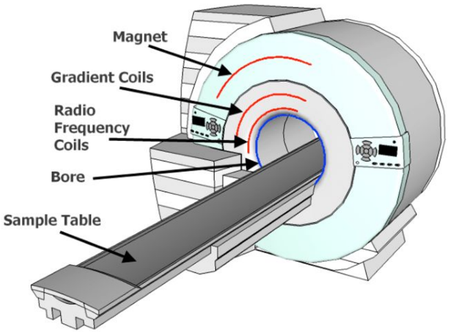
technician

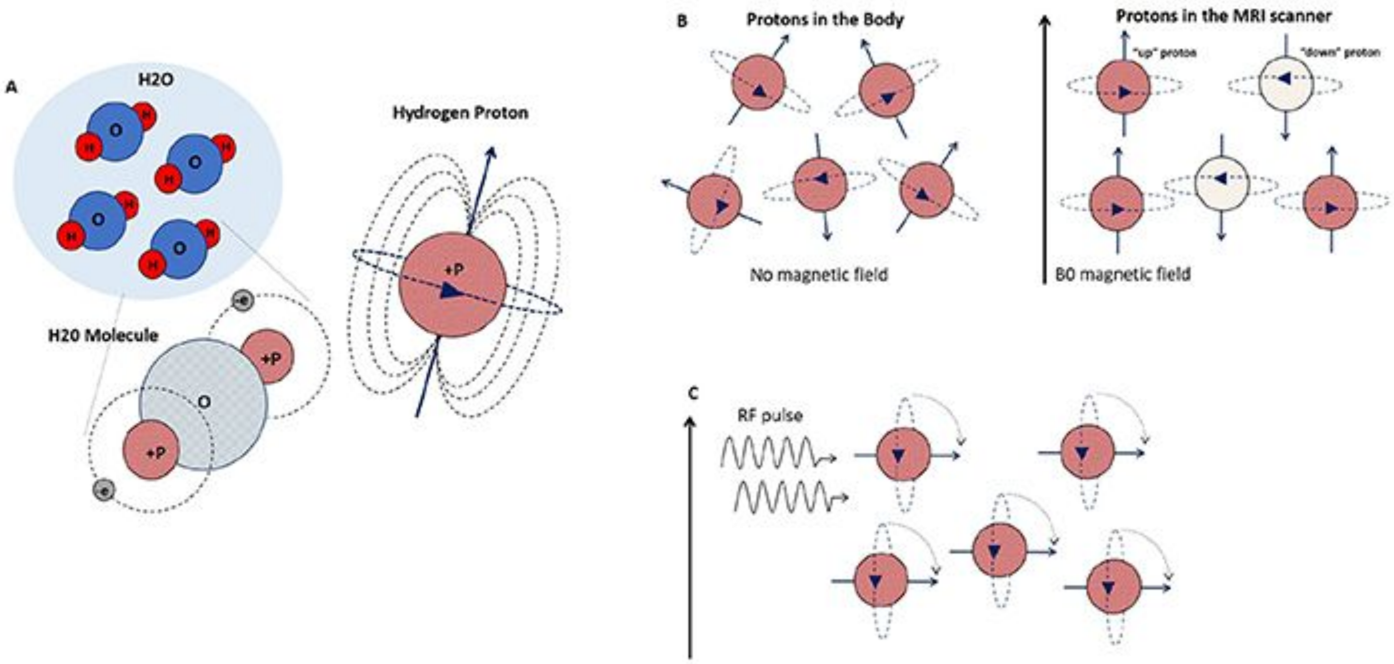
Medical device engineer

Magnetic Resonance Imaging (MRI)



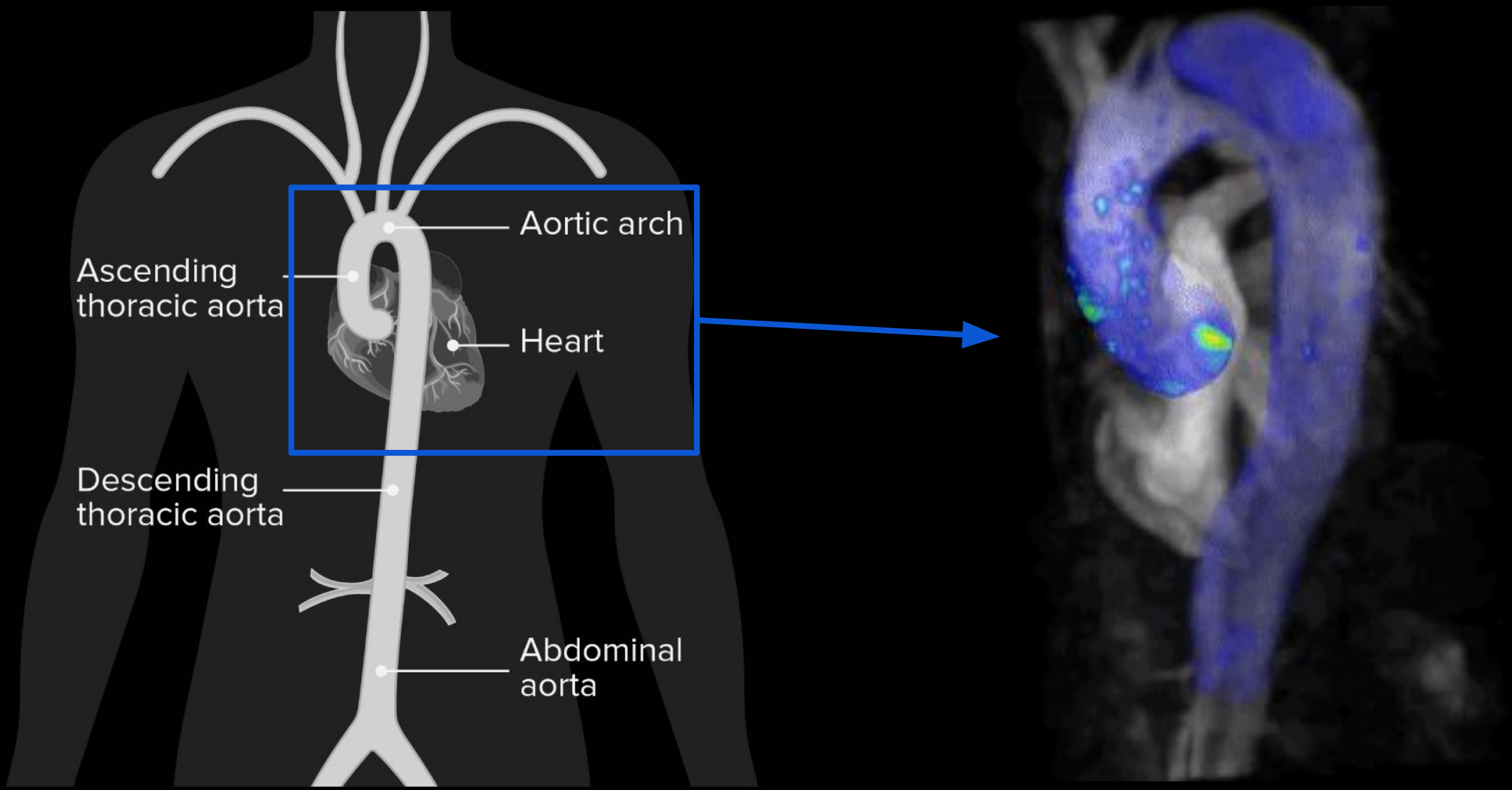
The physics behind magnetic resonance imaging (MRI)





MRI allows us to see soft tissue, like muscles and blood vessels

MRI also lets us view the blood flow in large blood vessels



Careers in ultrasound imaging

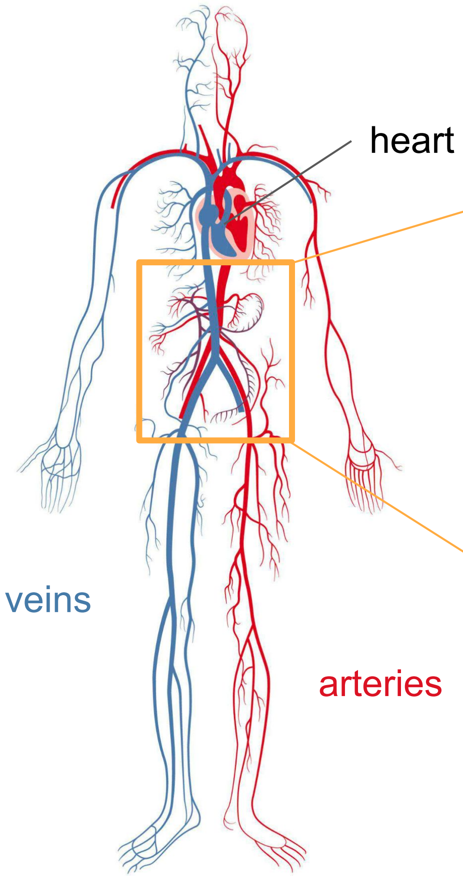
cardiologist

radiologist

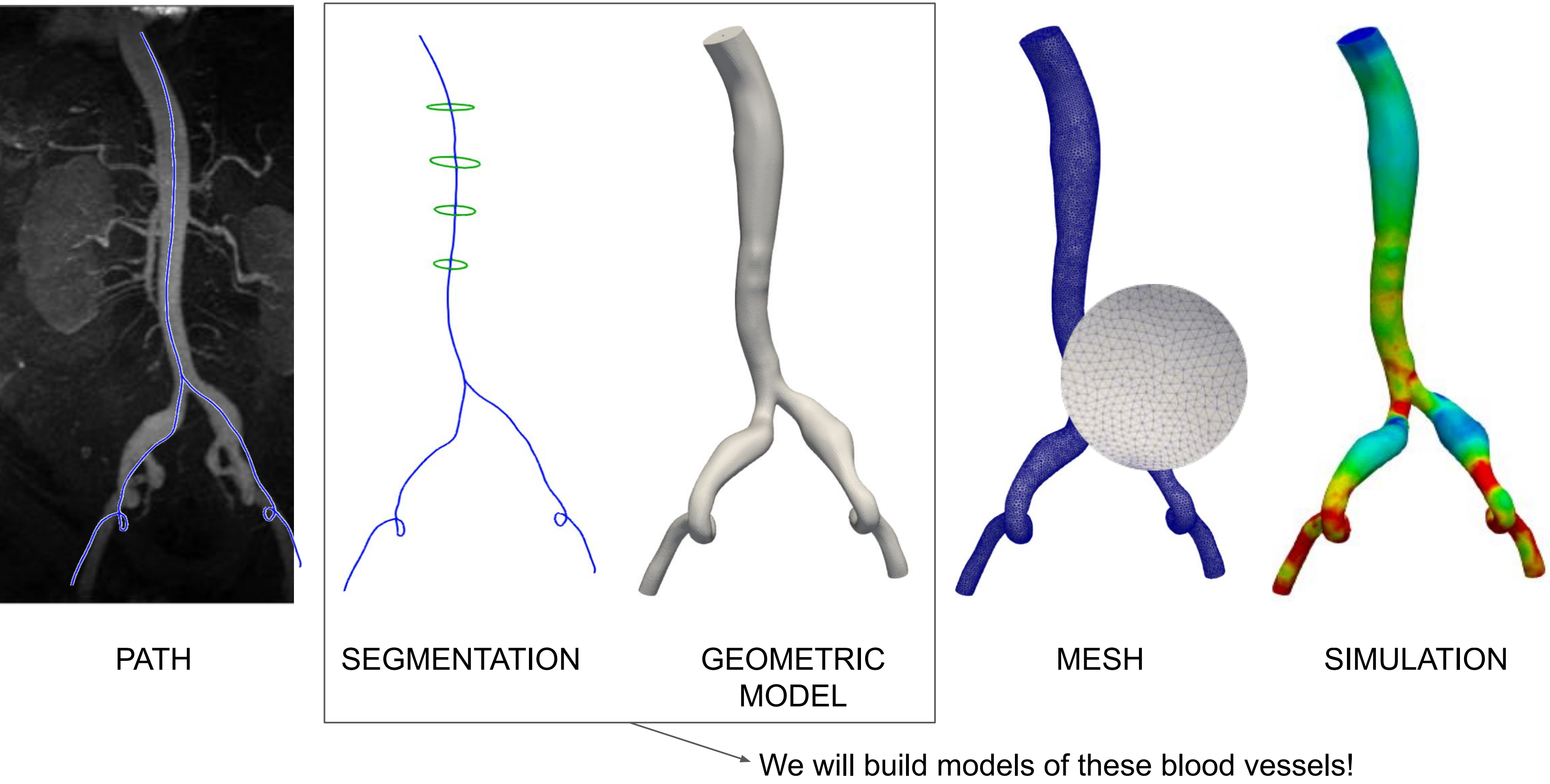
MRI Technologists

Medical device engineer

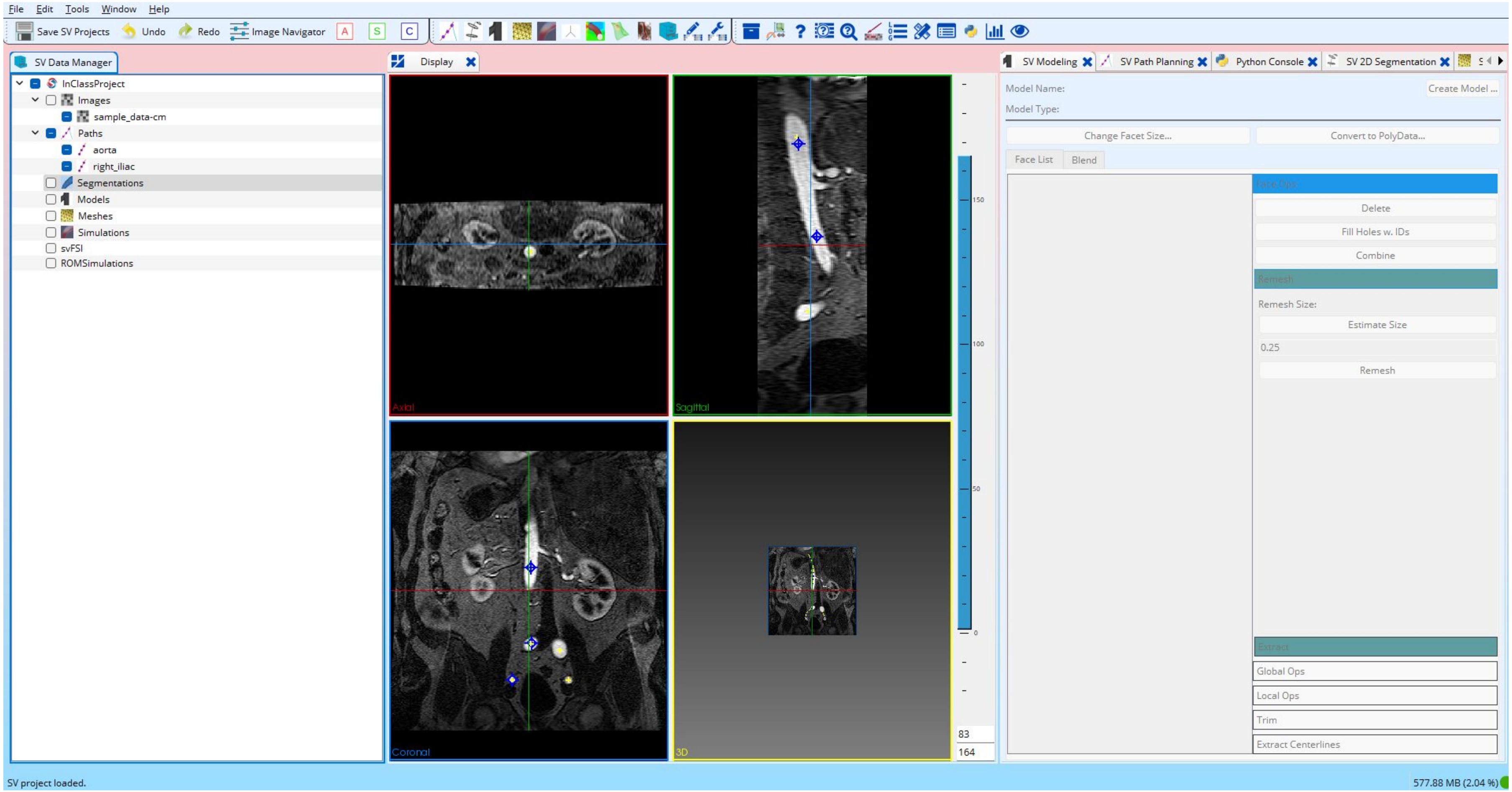
SimVascular

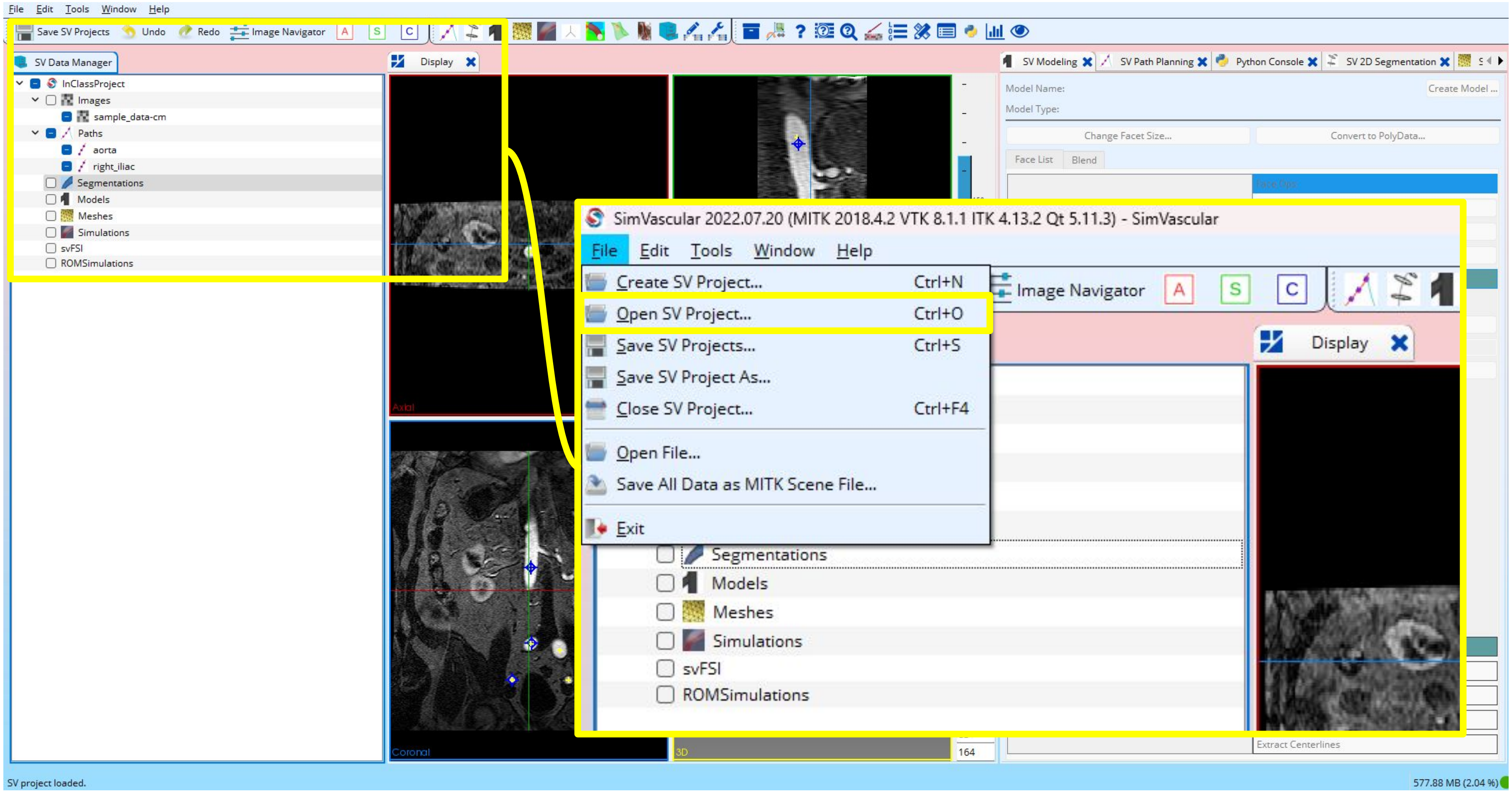


X-Ray images of aorta and iliac arteries


PATH
SEGMENTATION
GEOMETRIC MODEL
MESH
SIMULATION
We will build models of these blood vessels!

SimVascular




File Edit Tools Window Help
Save SV Projects
Undo
Redo
Image Navigator
SV Data Manager
Display
SV Modeling
SV Path Planning
Python Console
SV 2D Segmentation
InClassProject
Images
sample_data-cm
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aorta
right_iliac
Segmentations
Models
Meshes
Simulations
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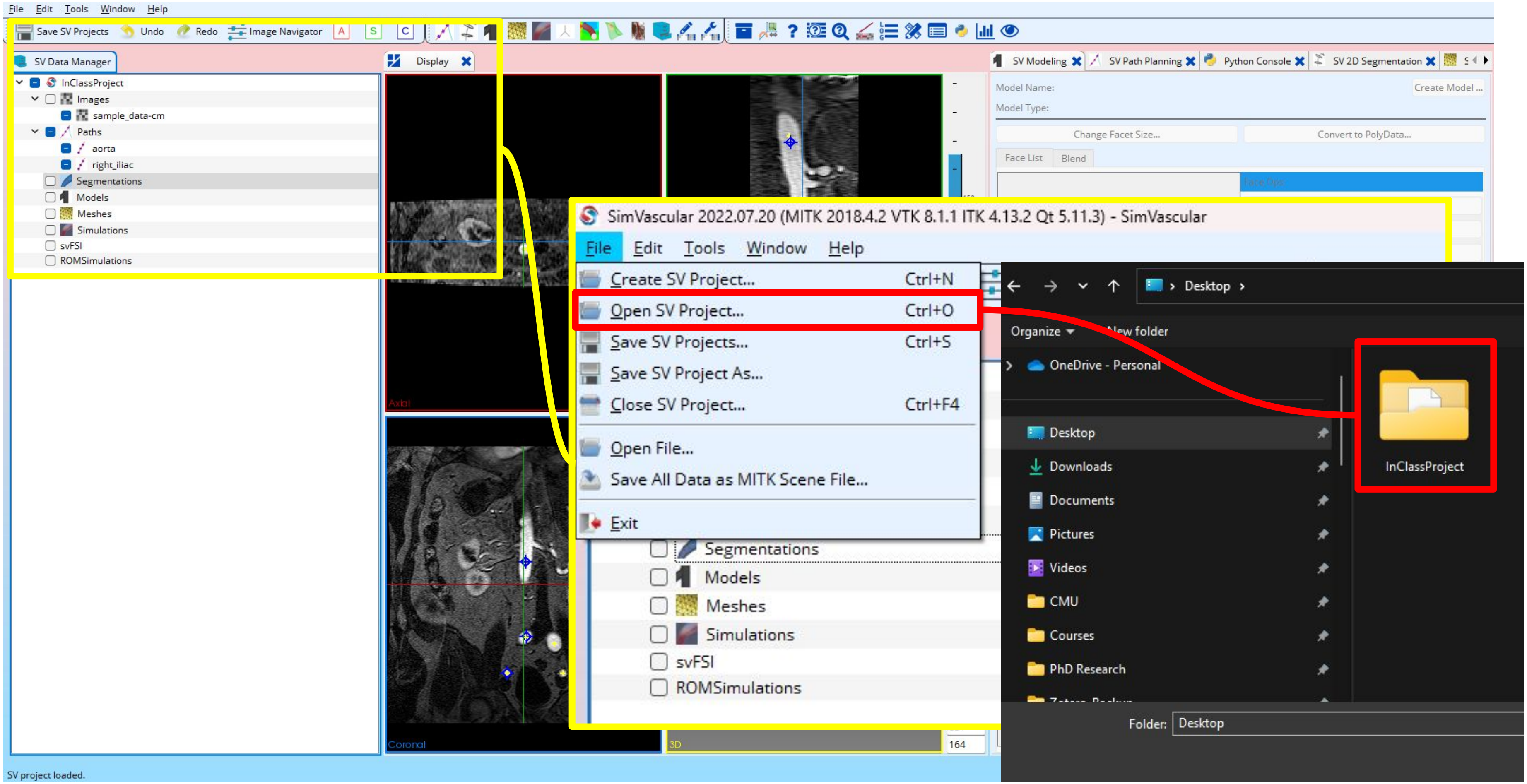
ROMSimulations
Model Name:
Model Type:
Create Model ...
Change Facet Size...
Convert to PolyData...
Face List
Blend
Axial
Coronal
3D
164
Extract Centerlines
SimVascular 2022.07.20 (MITK 2018.4.2 VTK 8.1.1 ITK 4.13.2 Qt 5.11.3) - SimVascular
Create SV Project... Ctrl+N
Open SV Project... Ctrl+O
Save SV Projects... Ctrl+S
Save SV Project As...
Close SV Project... Ctrl+F4
Open File...
Save All Data as MITK Scene File...
Exit
SV project loaded.
577.88 MB (2.04 %)



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Create Model ...
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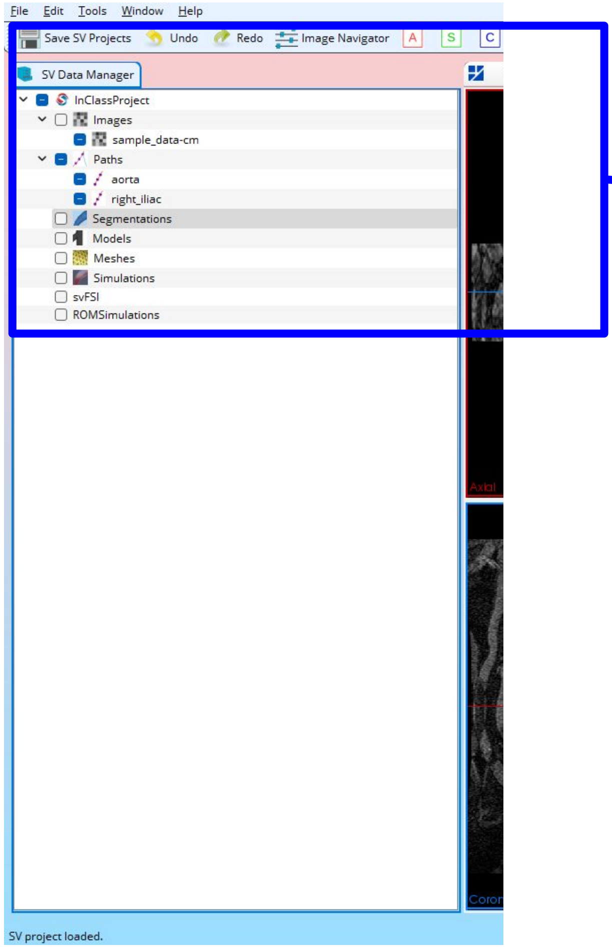
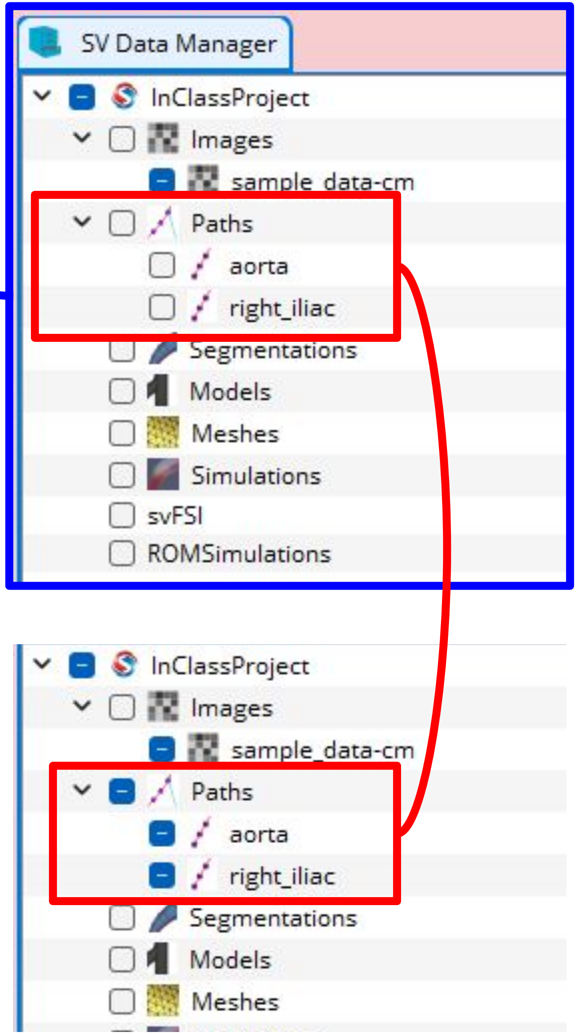
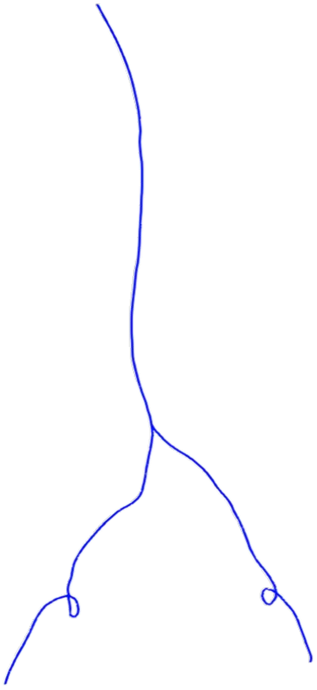
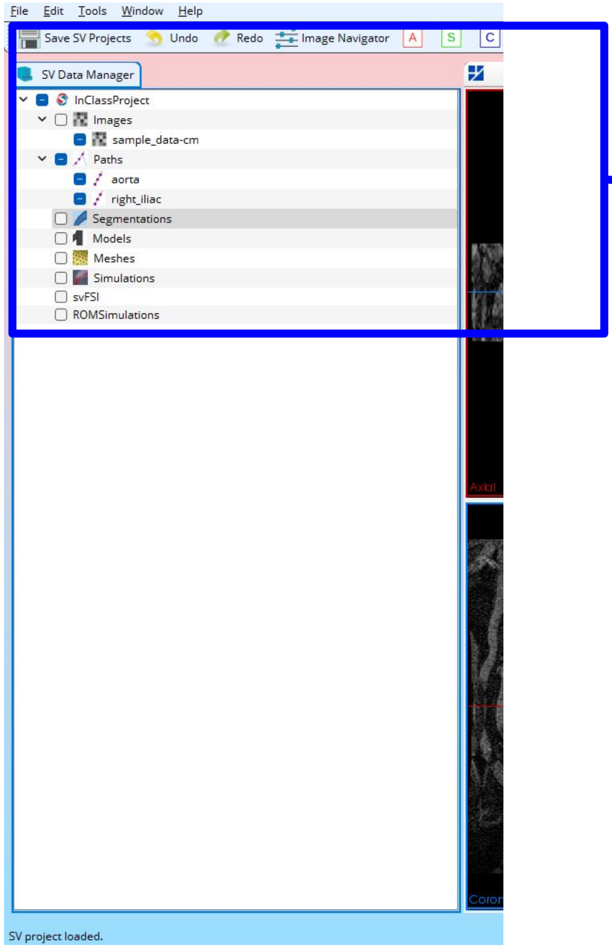
SimVascular 2022.07.20 (MITK 2018.4.2 VTK 8.1.1 ITK 4.13.2 Qt 5.11.3) - SimVascular
Create SV Project... Ctrl+N
Open SV Project... Ctrl+O
Save SV Projects... Ctrl+S
Save SV Project As...
Close SV Project... Ctrl+F4
Open File...
Save All Data as MITK Scene File...
Exit
Desktop
Organize
New folder
OneDrive - Personal
Downloads
Documents
Pictures
Videos
CMU
Courses
PhD Research
InClassProject
Folder: Desktop
Axial
Coronal
3D
164
SV project loaded.

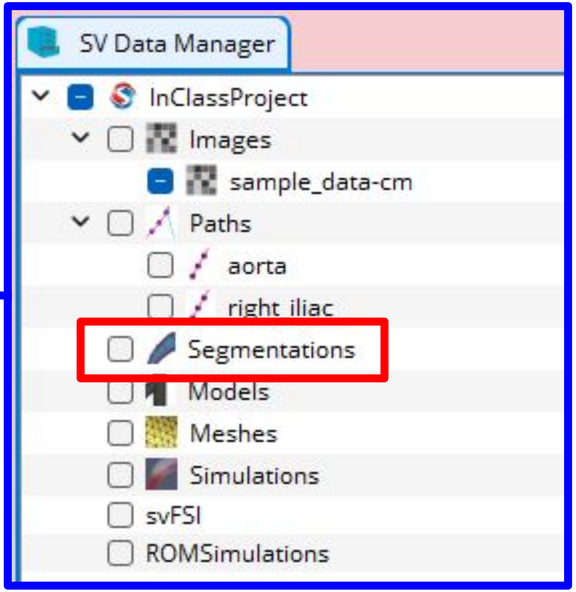


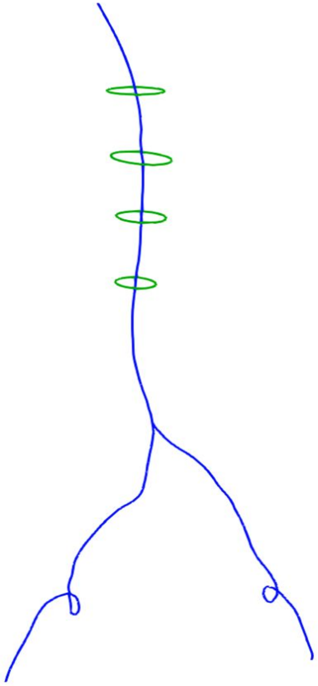




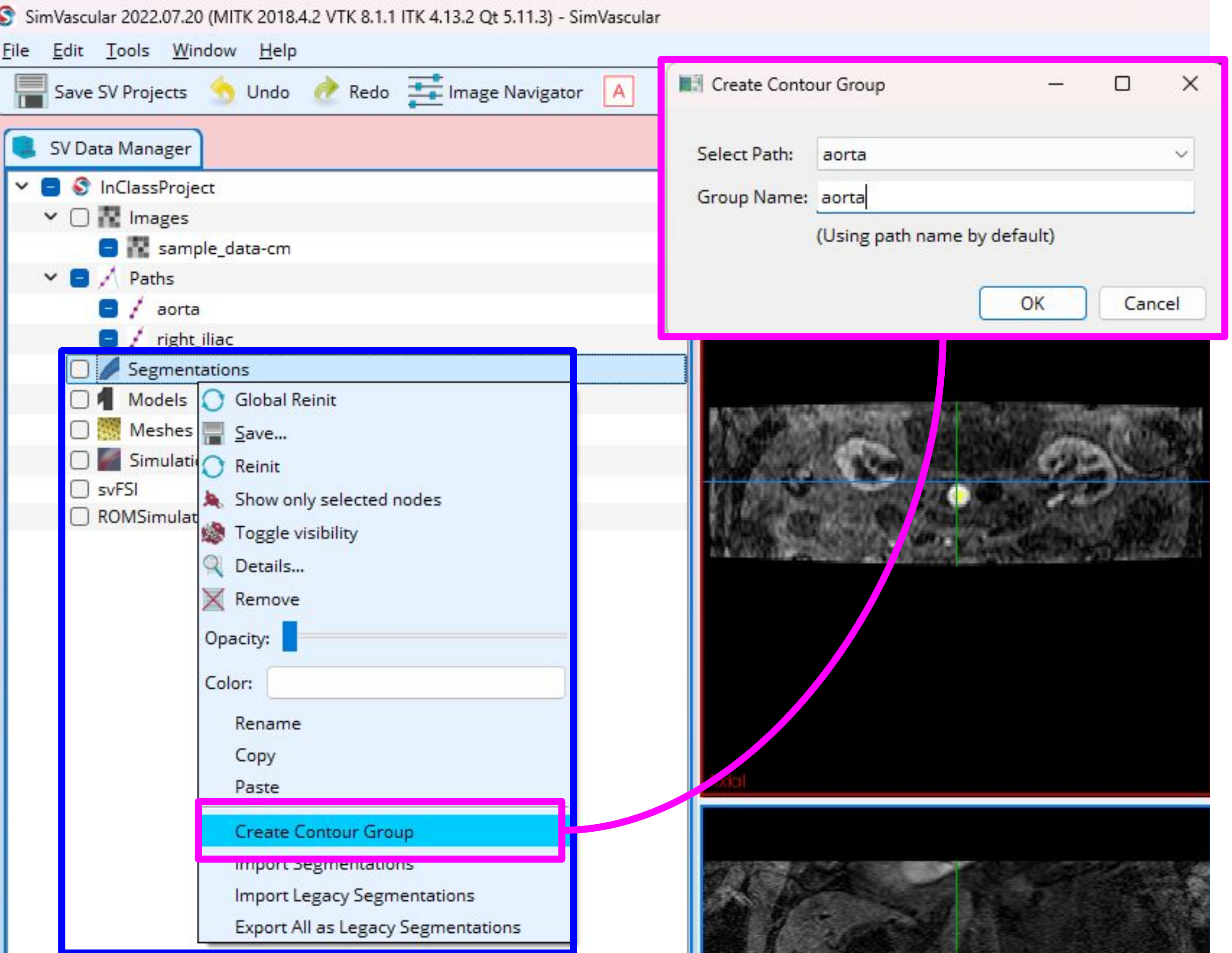
Click the empty box besides **Paths**







We will create segmentations of the aorta and right iliac arteries


SimVascular 2022.07.20 (MITK 2018.4.2 VTK 8.1.1 ITK 4.13.2 Qt 5.11.3) - SimVascular
File
Edit
Tools
Window
Help
Save SV Projects
Undo
Redo
Image Navigator
SV Data Manager
InClassProject
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sample_data-cm
Paths
aorta
right_iliac
Segmentations
Models
Meshes
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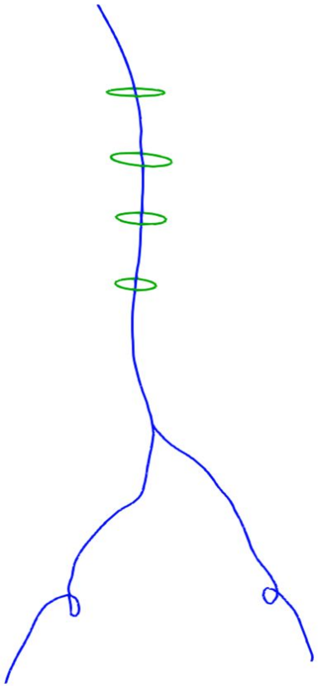
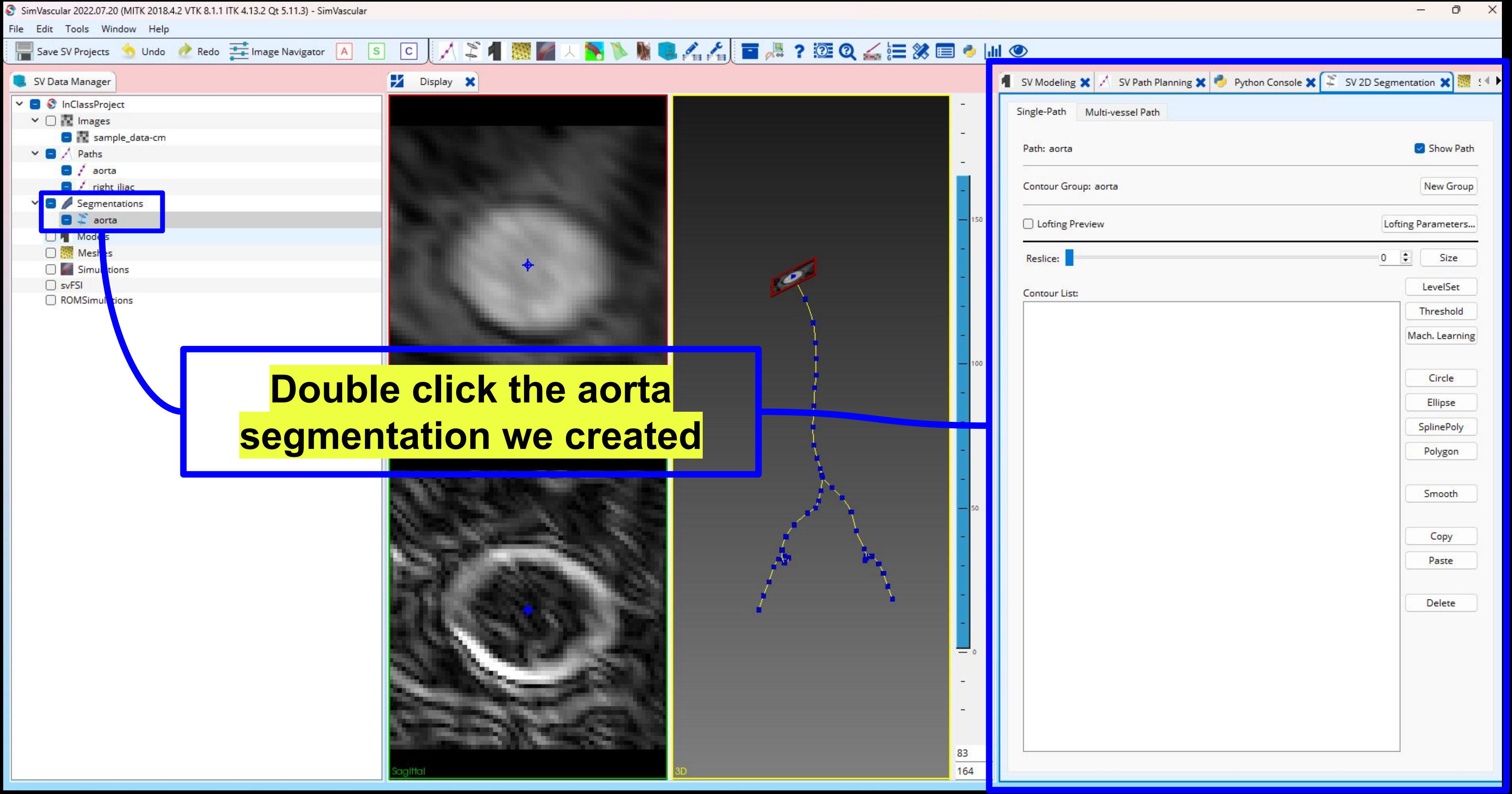
svFSI
ROMSimulat
Global Reinit
Save...
Reinit
Show only selected nodes
Toggle visibility
Details...
Remove
Opacity:
Color:
Rename
Copy
Paste
Create Contour Group
Import Segmentations
Import Legacy Segmentations
Export All as Legacy Segmentations
Create Contour Group
Select Path:
aorta
Group Name:
aorta
(Using path name by default)
OK
Cancel

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Save SV Projects Undo Redo Image Navigator
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aorta
right iliac
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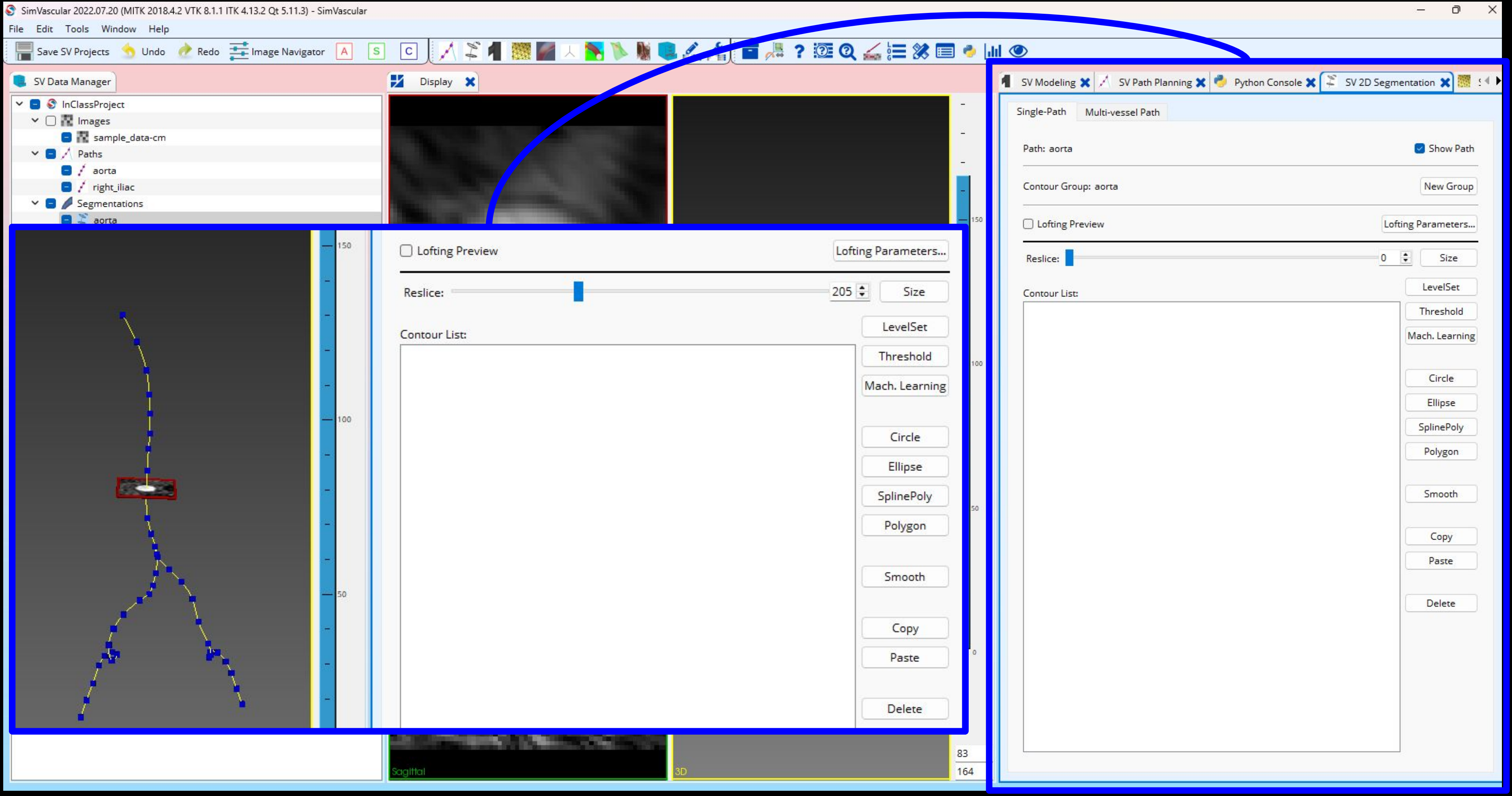
aorta
Display
Sagittal
3D
SV Modeling
SV Path Planning
Python Console
SV 2D Segmentation
Single-Path
Multi-vessel Path
Path: aorta
Show Path
Contour Group: aorta
New Group
Lofting Preview
Lofting Parameters...
Reslice:
Size
Contour List:
LevelSet
Threshold
Mach. Learning
Circle
Ellipse
SplinePoly
Polygon
Smooth
Copy
Paste
Delete
Double click the aorta segmentation we created


SimVascular 2022.07.20 (MITK 2018.4.2 VTK 8.1.1 ITK 4.13.2 Qt 5.11.3) - SimVascular
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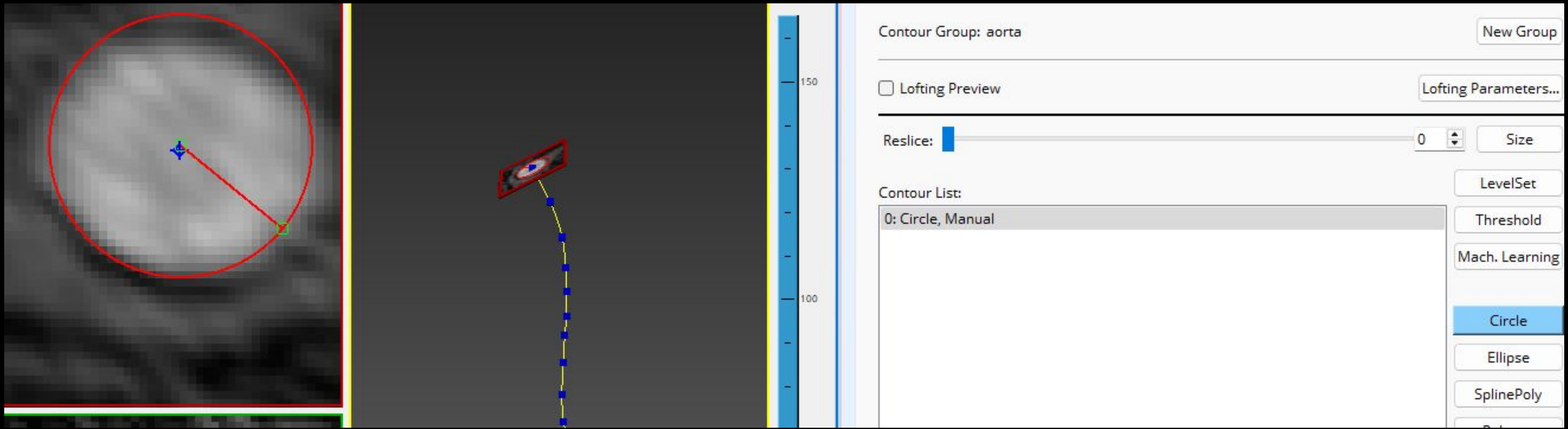
Polygon
Smooth
Copy
Paste
Delete



150
100
Contour Group: aorta
New Group
Lofting Preview
Lofting Parameters...
Reslice:
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Size
Contour List:
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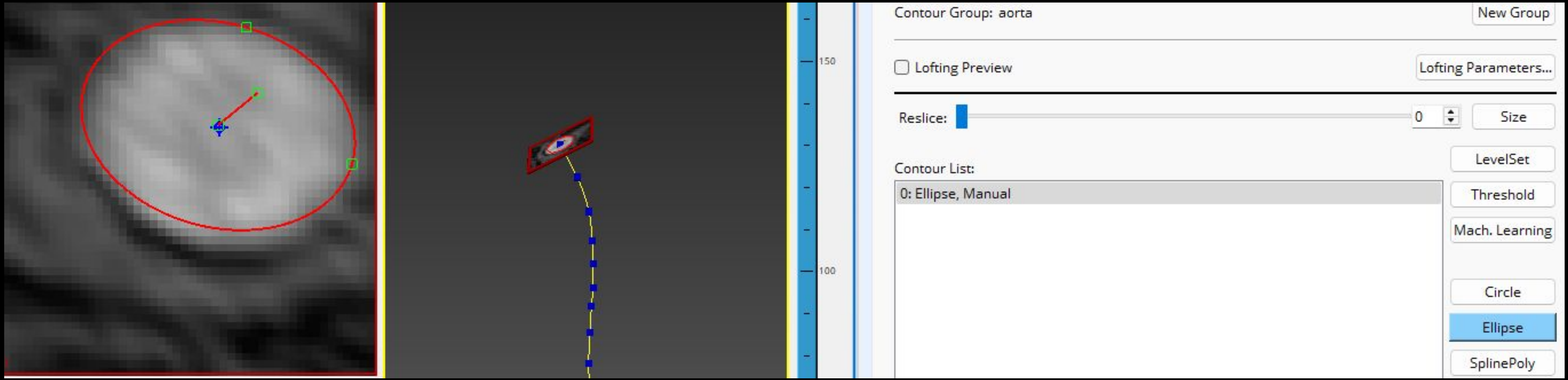
LevelSet
Threshold
Mach. Learning
Circle
Ellipse
SplinePoly



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New Group
Lofting Preview
Lofting Parameters...
Reslice:
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LevelSet
Threshold
Mach. Learning
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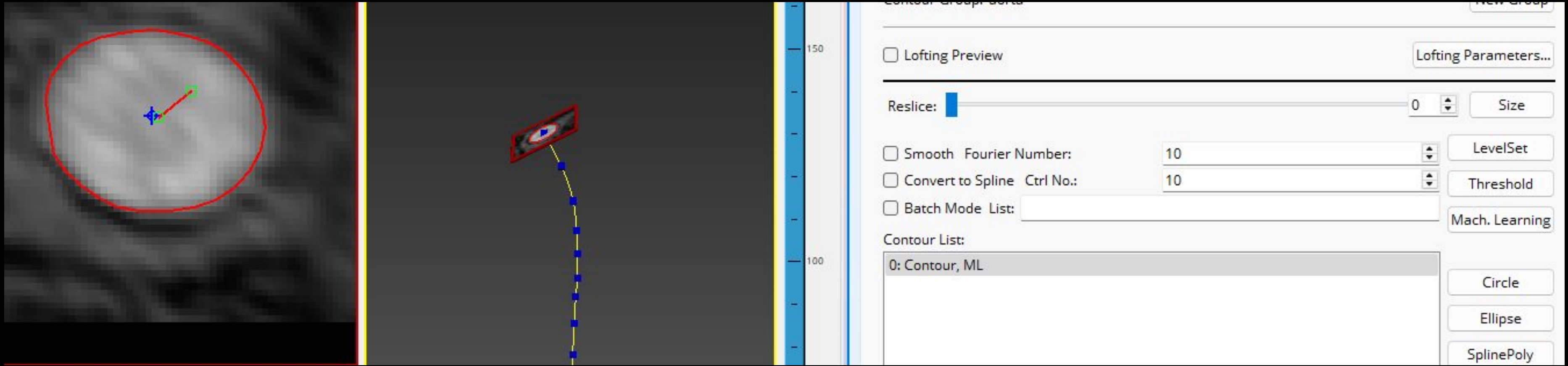
SplinePoly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100
Lofting Preview
Lofting Parameters...
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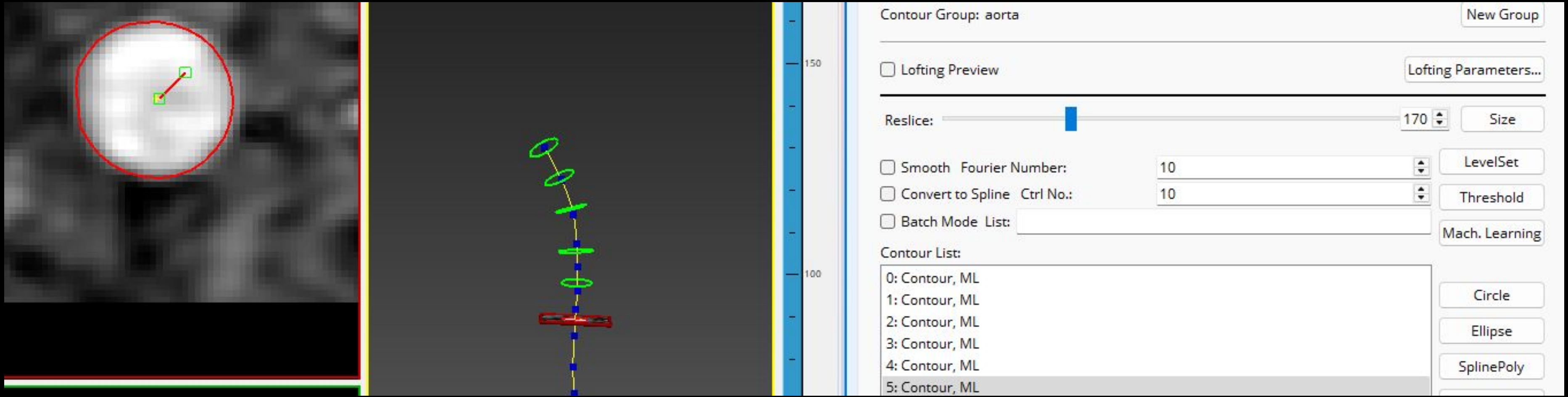
0
Size
Smooth
Fourier Number:
10
LevelSet
Convert to Spline
Ctrl No.:
10
Threshold
Batch Mode
List:
Mach. Learning
Contour List:
0: Contour, ML
Circle
Ellipse
SplinePoly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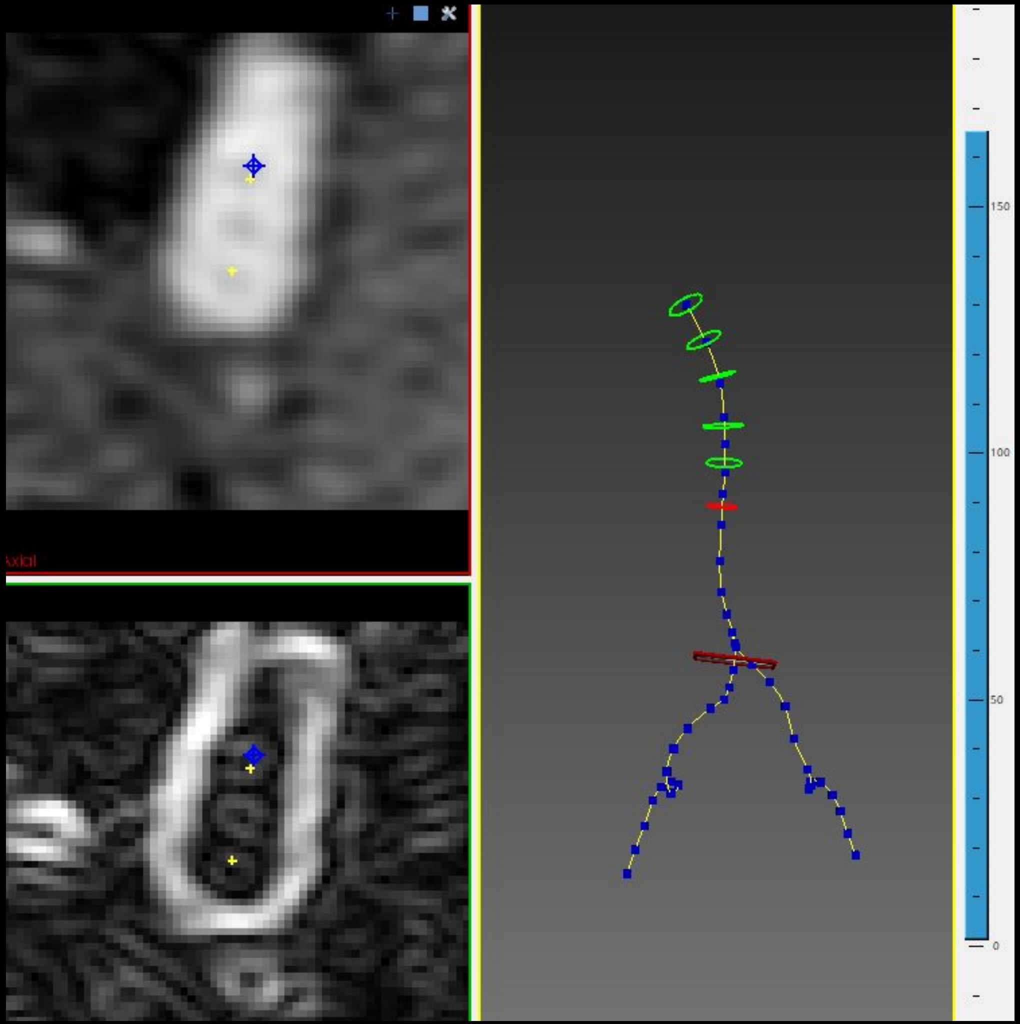
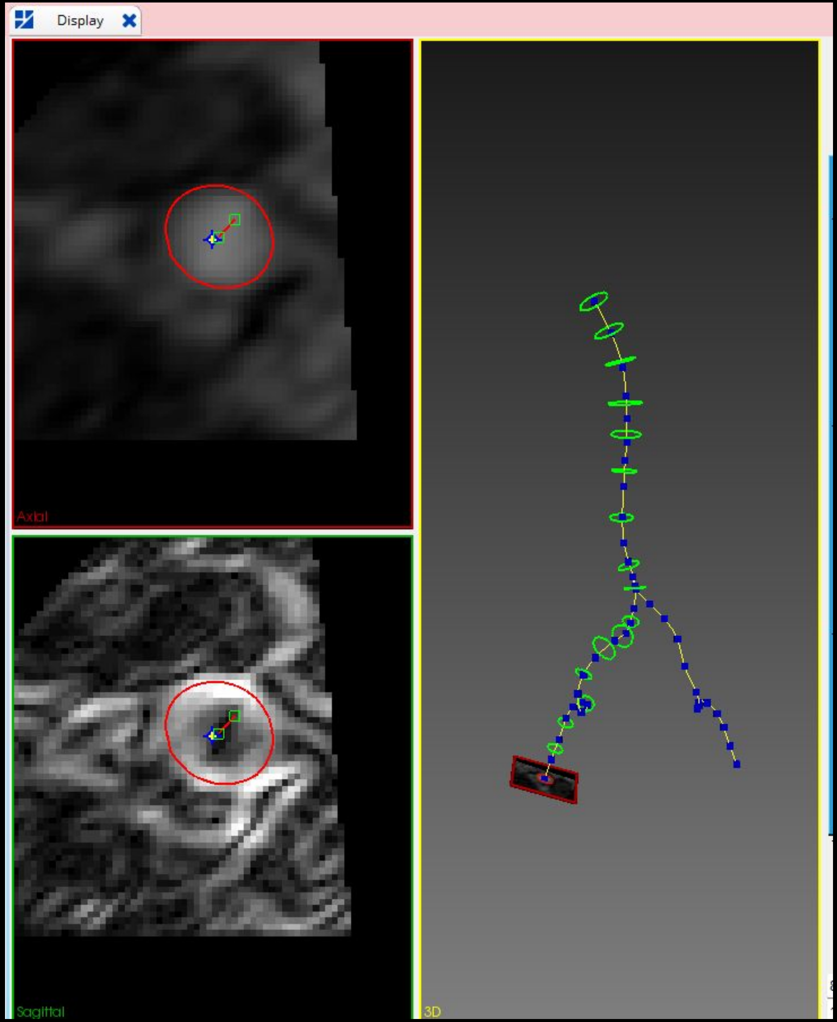
100
Contour Group: aorta
New Group
Lofting Preview
Lofting Parameters...
Reslice:
170
Size
Smooth
Fourier Number:
10
LevelSet
Convert to Spline
Ctrl No.:
10
Threshold
Batch Mode
List:
Mach. Learning
Contour List:
0: Contour, ML
1: Contour, ML
2: Contour, ML
3: Contour, ML
4: Contour, ML
5: Contour, ML
Circle
Ellipse
SplinePoly

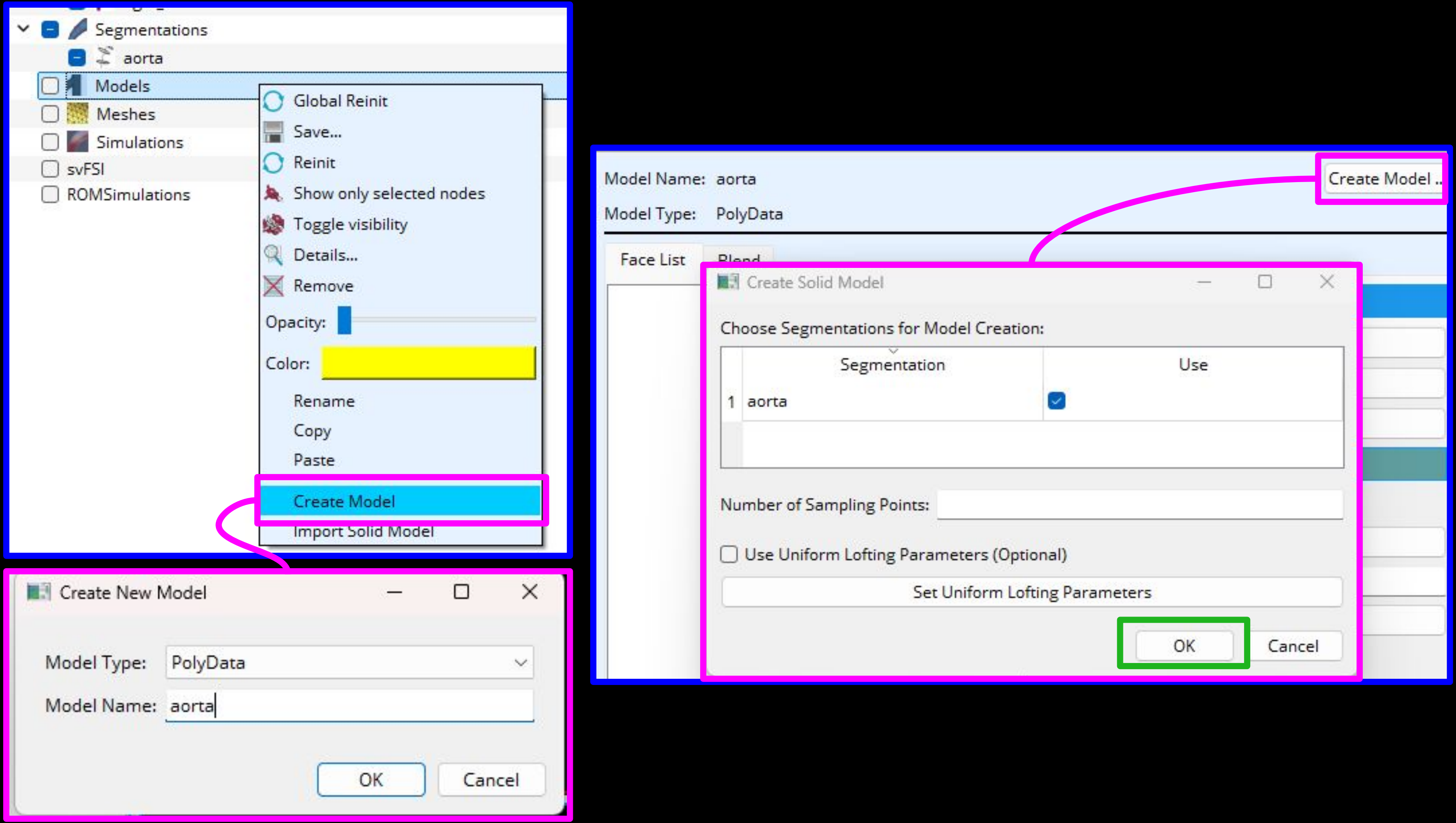


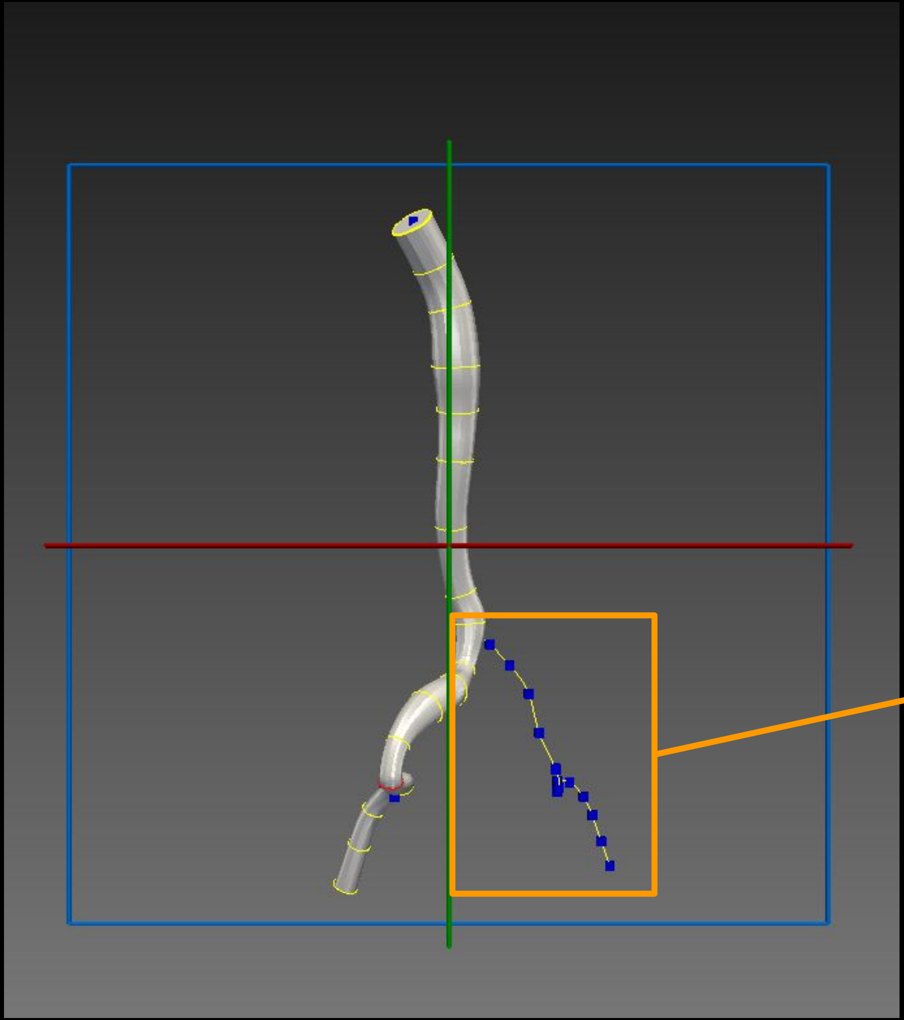
Sometimes, it is hard to tell where the blood vessels are in CT images!

Let's try to skip past them.



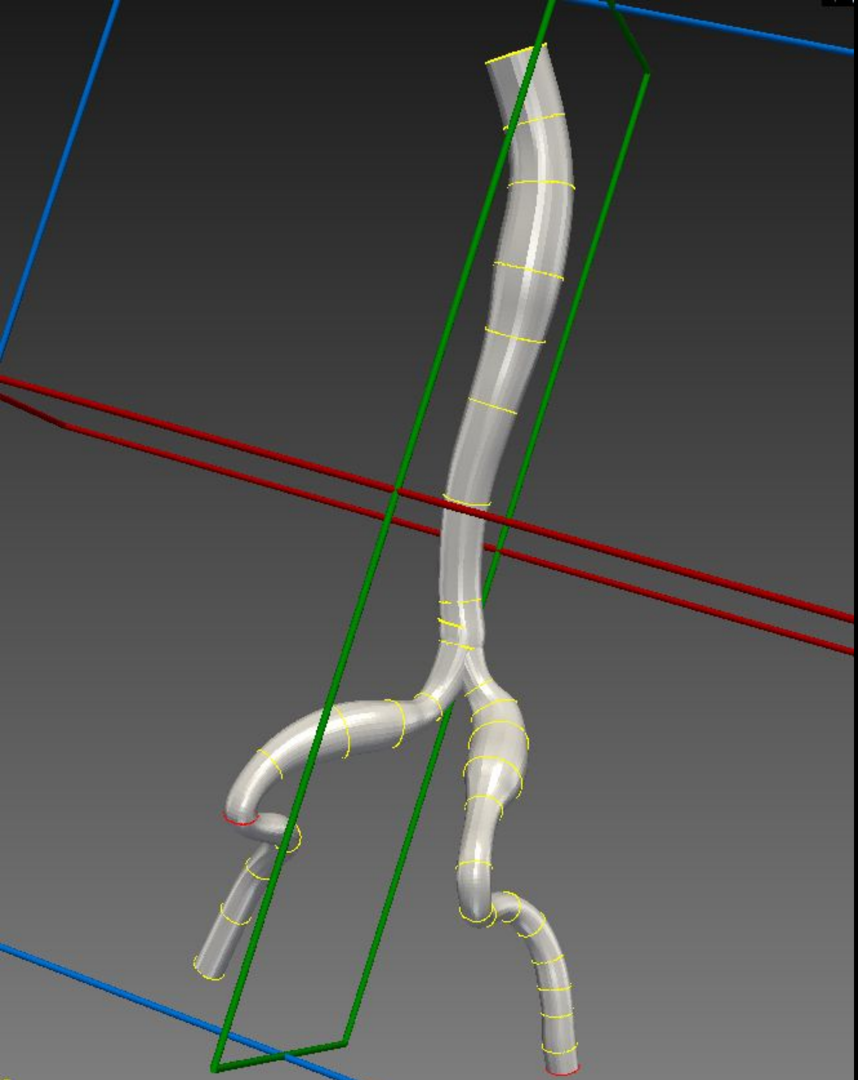
Once we have added enough segmentations, we will build our model for the aorta


Segmentations
aorta
Models
Meshes
Simulations
svFSI
ROMSimulations
Global Reinit
Save...
Reinit
Show only selected nodes
Toggle visibility
Details...
Remove
Opacity:
Color:
Rename
Copy
Paste
Create Model
Import Solid Model
Create New Model
Model Type: PolyData
Model Name: aorta
OK
Cancel
Model Name: aorta
Model Type: PolyData
Create Model ..
Face List
Create Solid Model
Choose Segmentations for Model Creation:
Segmentation
Use
1 aorta
Number of Sampling Points:
Use Uniform Lofting Parameters (Optional)
Set Uniform Lofting Parameters
OK
Cancel



We have built our first model!

Now, we need to repeat this process for the right iliac artery



How do we make a model of both arteries? We select both segmentations!