SUPPLEMENTAL MATERIAL

Appendix A:

The parameters used in ITK-Snap's segmentation growing algorithm are listed in full:

Thresholding parameters:

Lower threshold values were determined on a per-patient basis

Upper threshold: N/A

Smoothness: 3.00

ITK-Snap growth parameters

Intuitive Mode:

Region competition force: 1.000

Smoothing (curvature) force: 0.200

Math Mode:

Contour evolution equation: [standard expression]

α: 1.000

β: 0.200

Advanced:

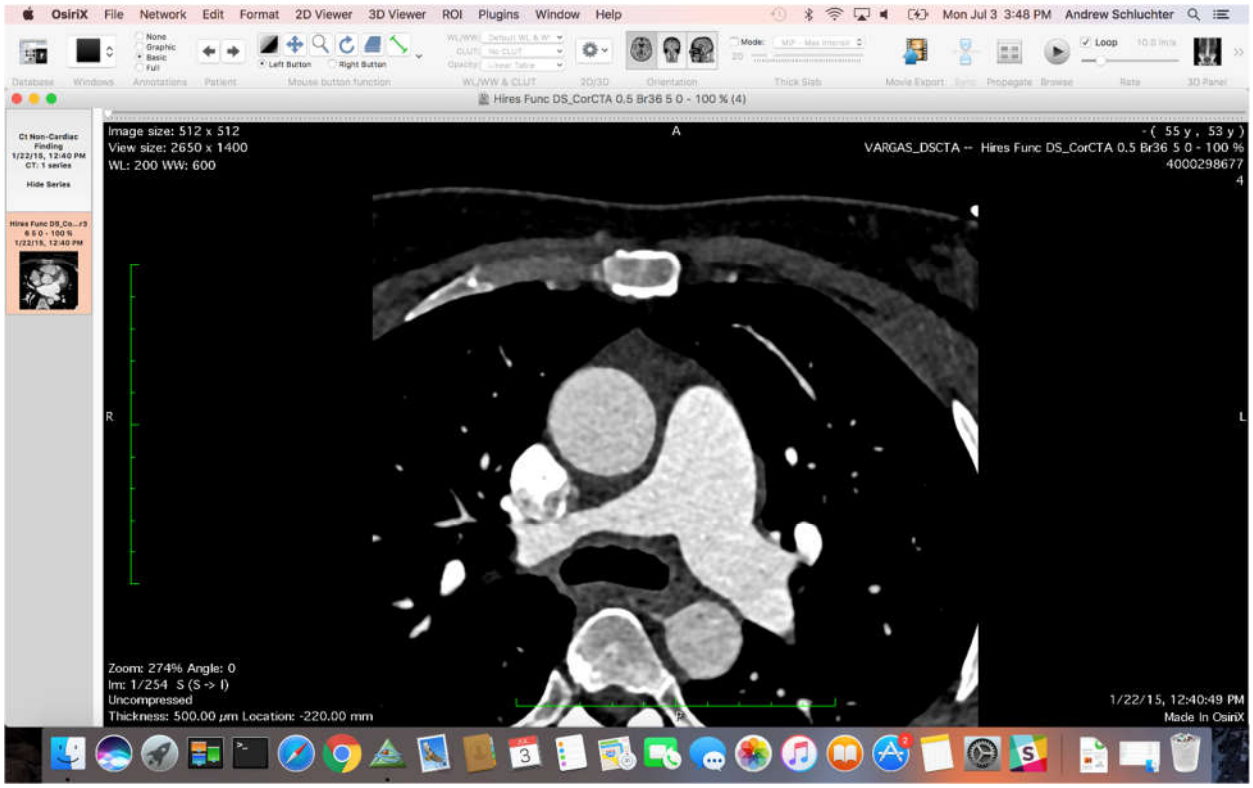
Speed-up factor: 1.000

20 Feb. 2019

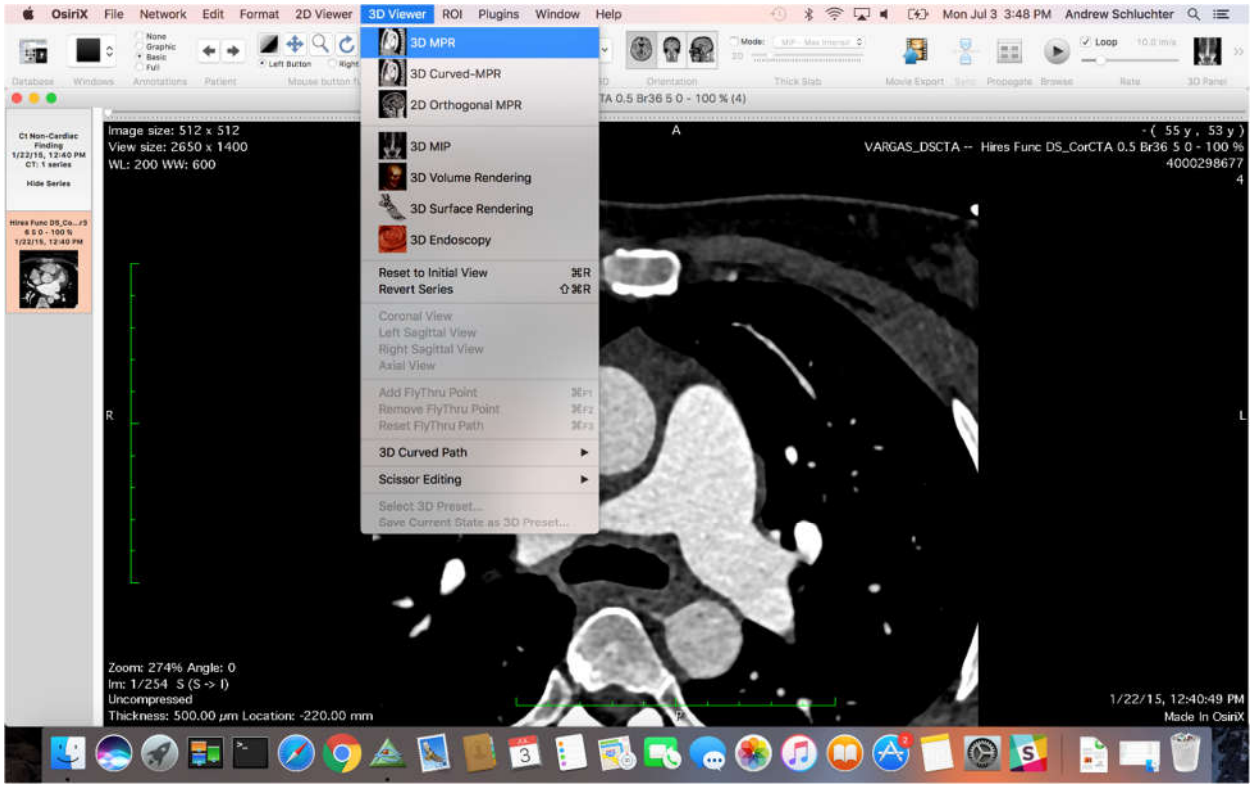
Appendix B: LAA Isolation Procedure for CT-Based Analysis

In OSIRIX,

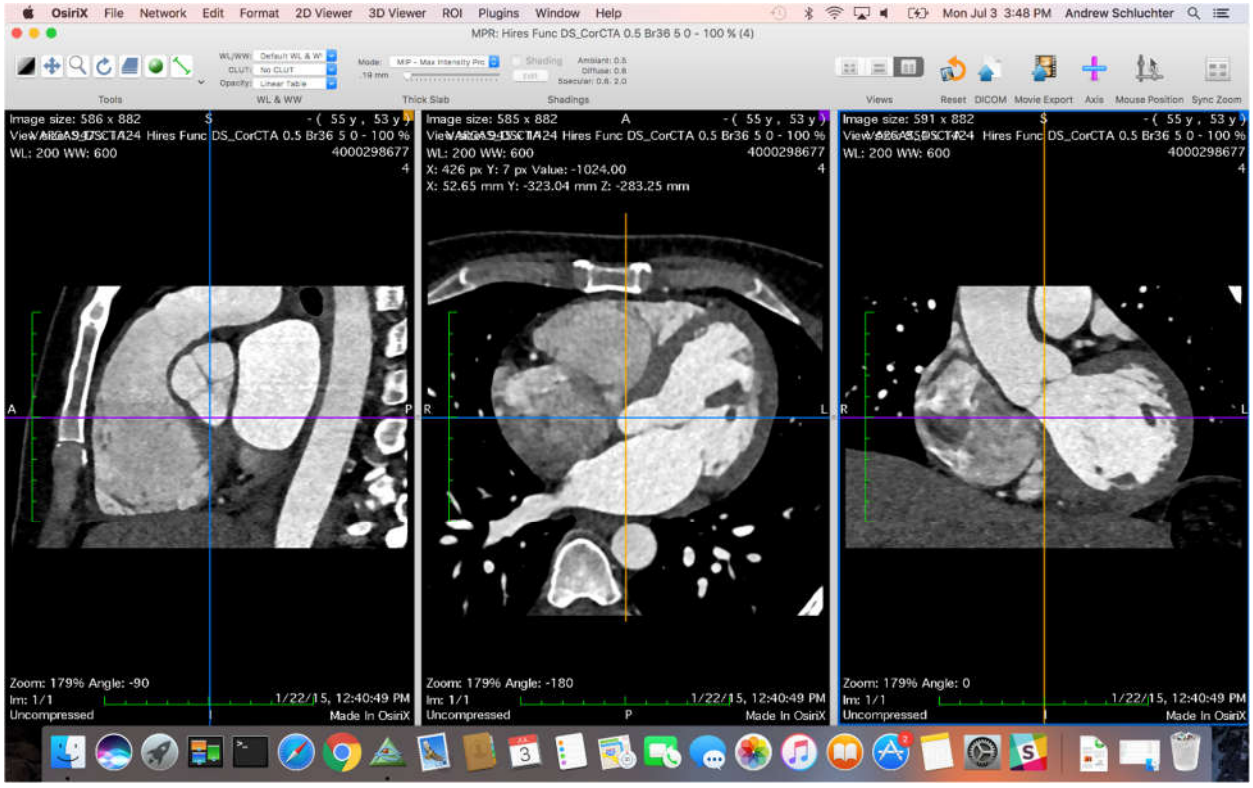
1. Load in the patient, time frames 1 through 20, or as appropriate. If contrast needs to be adjusted, adjust all time frames simultaneously to prevent different time frames from having different contrast levels.
To do the MPR for each time frame, double-click the MPR to open a new window.[1]



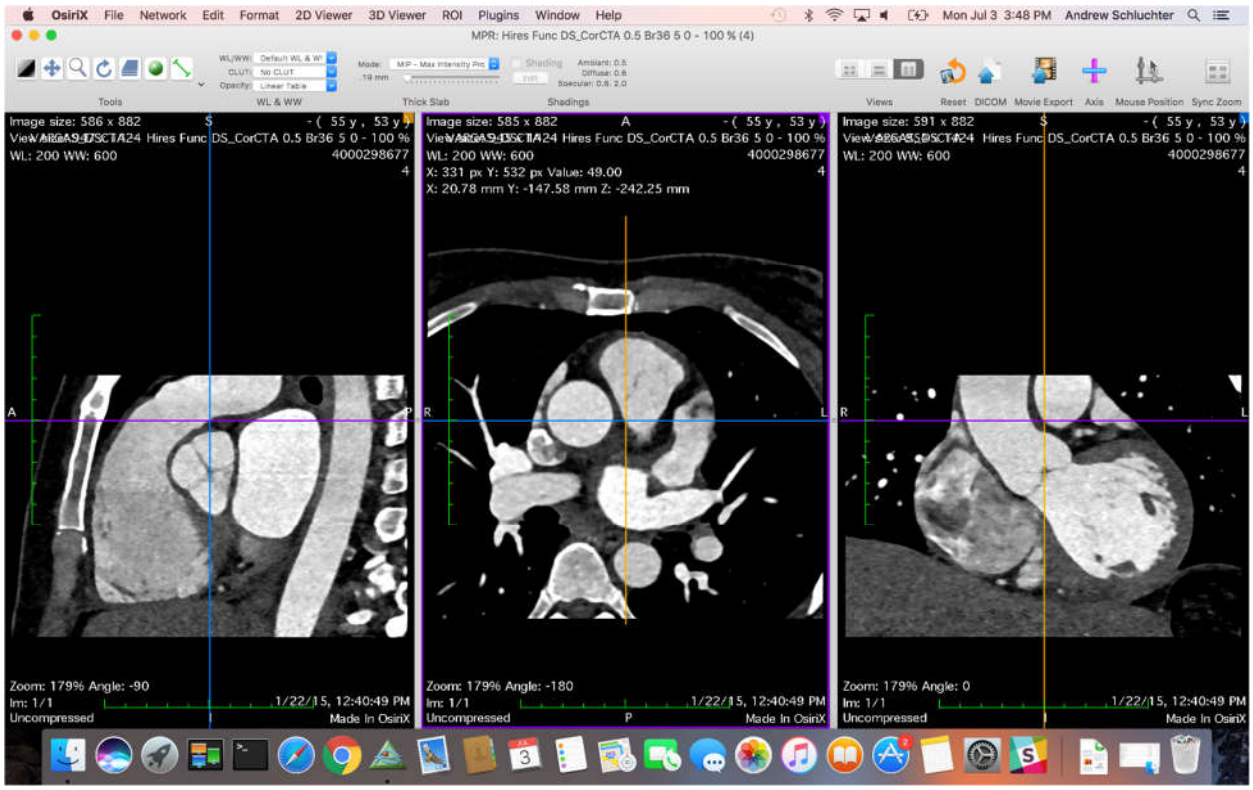
Then select “3D MPR” under “3D Viewer”.[2]



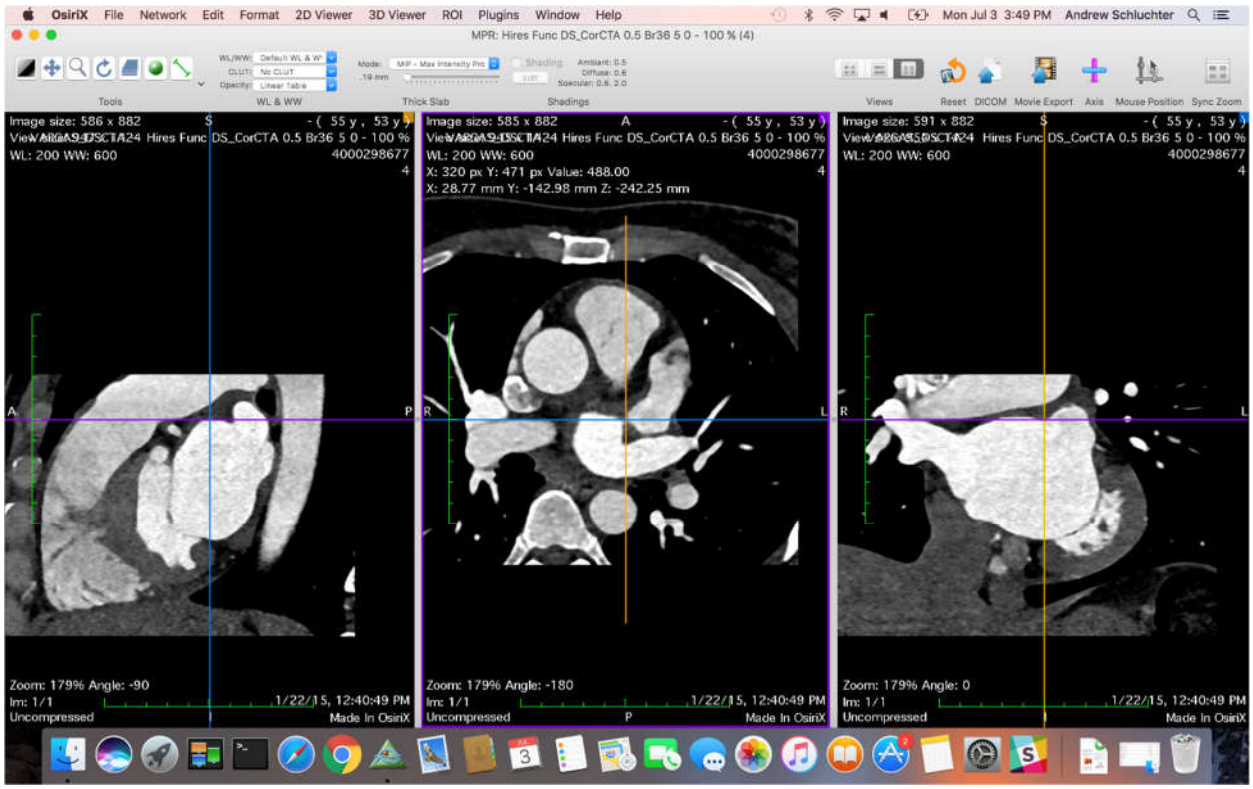
2. Beginning from your initial view[3],



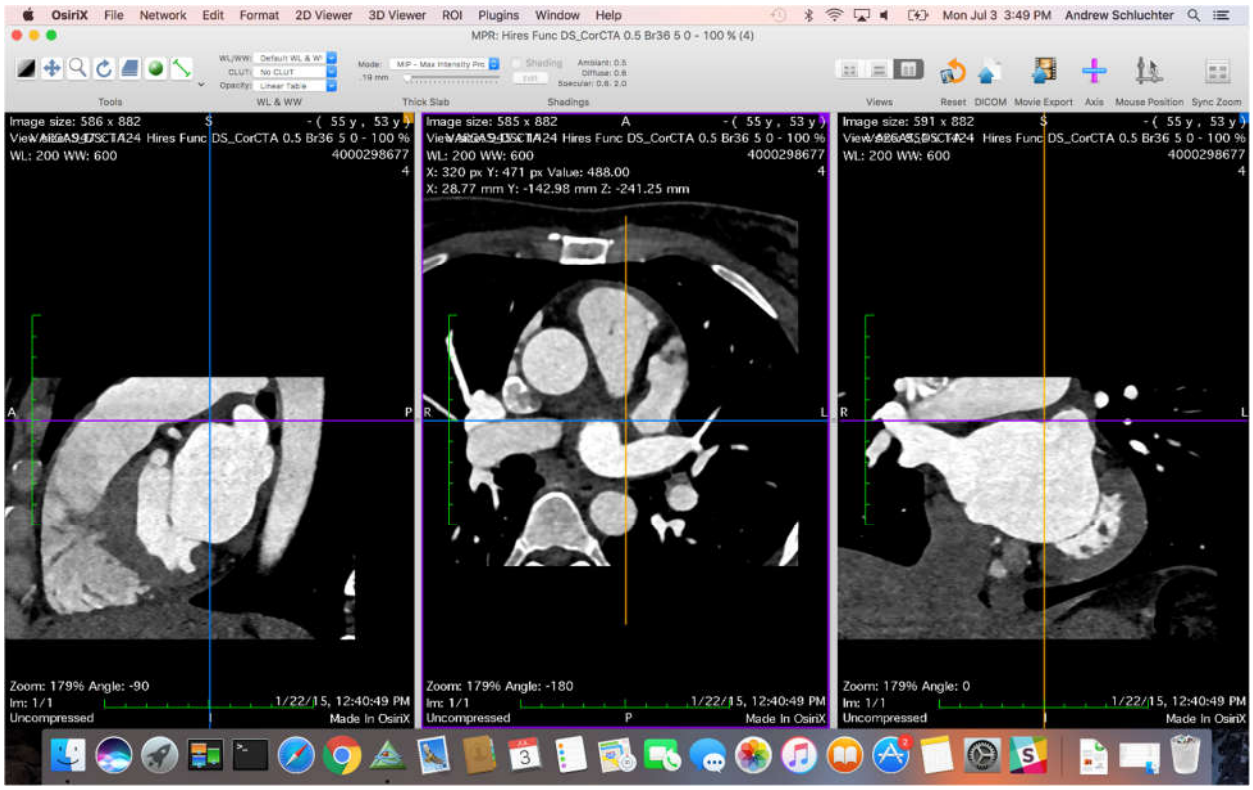
scroll through the transverse (middle) window, starting from near the top of the heart (careful not to scroll too high in OSIRIX, or the angle may change automatically), and moving downward.[4]



Stop when you start to see the LAA make a connection to the LA (even just a faint trace from LA to LAA). Drag and place the crosshairs in the center of that connection.[5]

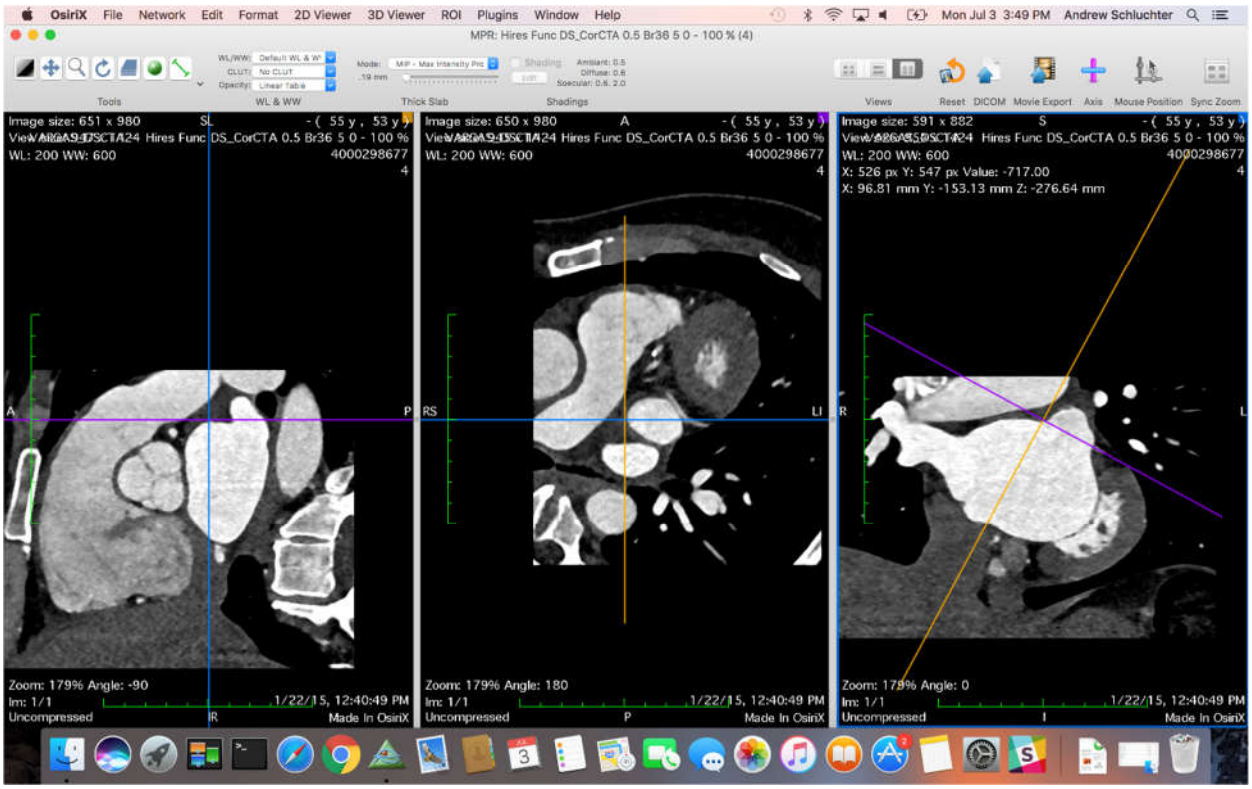


Then scroll the mouse wheel up 1 tick or press the ‘up’ arrow key once (depending on the computer you’re using), in order to advance the transverse view just above that LA/LAA connection and “break” the connection.[6]



This will ensure that the LAA is separate from LA in the MPR and segmentations. On the coronal window (right), the crosshairs should be centered such that they are just barely inside the cardiac tissue. In fact, it may even be easier in some instances, where the “break” in the connection between the LAA and LA is not clear, to simply place the cursor over the connection, and watch the right window while scrolling in the middle window, ensuring that the cursor is (just barely) inside the LA/LAA wall.

3. In coronal window (right), grab the right side of the purple crosshair and rotate the crosshairs in such a way that the purple axis intersects center of the LCX.[7]

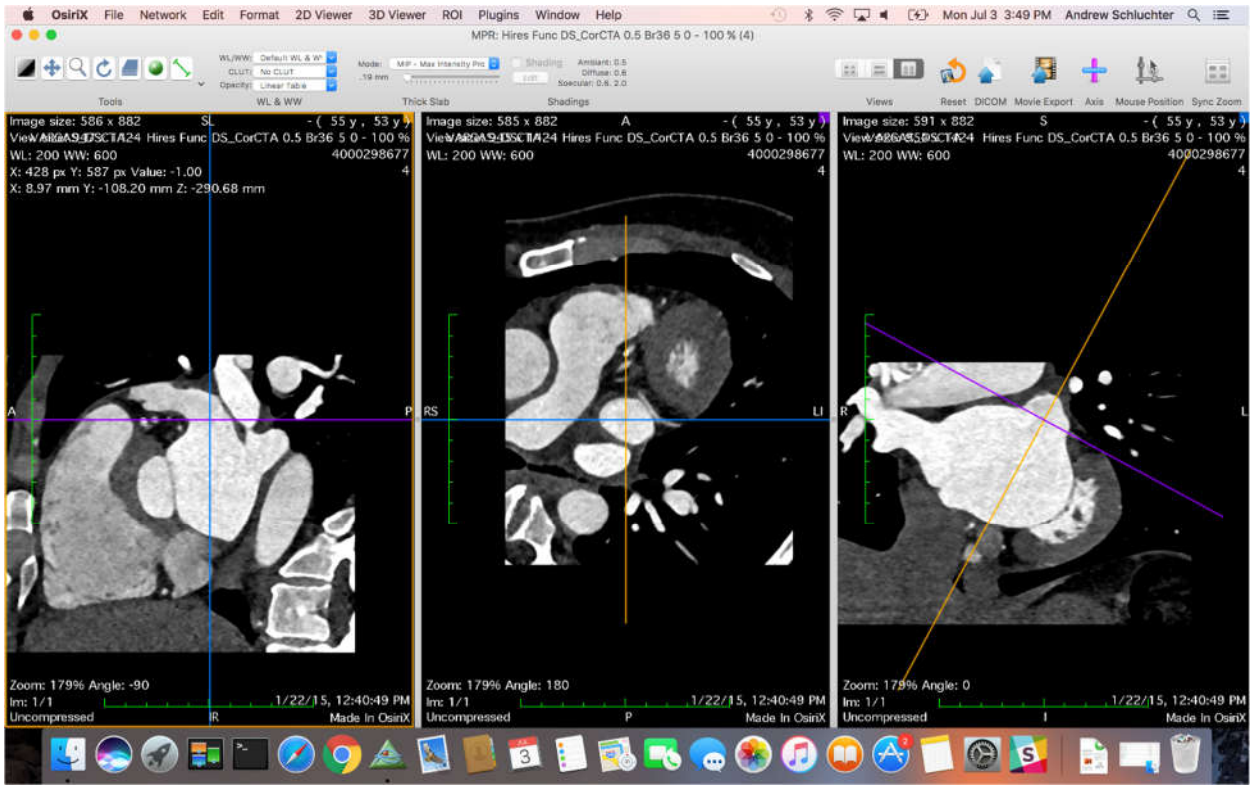


If unsure about which vessel in the right window is the proper vessel to use, hover the mouse over the right window and scroll posteriorly to the heart. The vessel which continues to remain in view in the right window (and thus, runs around the LAA posteriorly to the heart) should be used consistently throughout the MPR process for the current patient. Note that which vessel it is may not be universal between all patients, and that to maintain consistency, the proper vessel to use should be identified as early as possible in the procedure, as again, it must be used consistently while processing the patient.

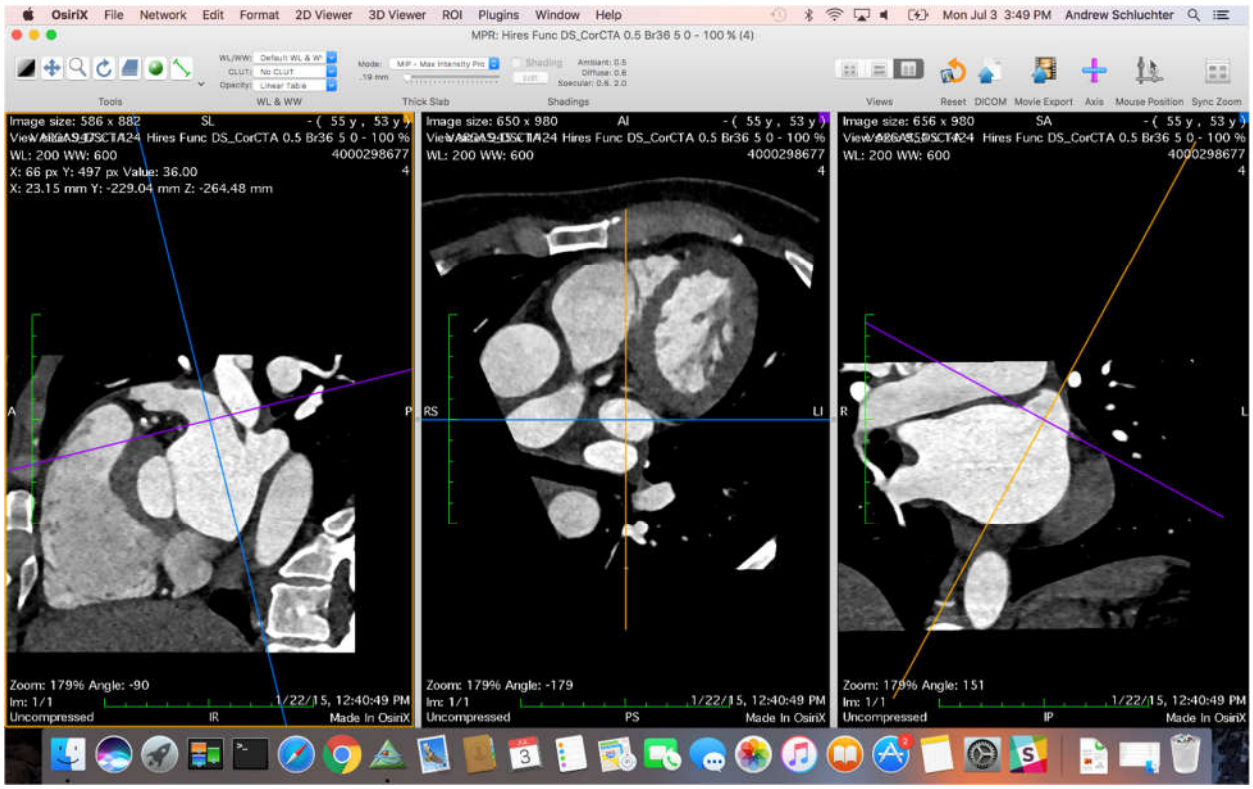
Alternatively, you can simply rotate the axis of the right window while viewing the middle window, allowing you (potentially) to trace the path of the circumflex artery, and differentiate the directions of the vessel branches.

Special case: If the LCX diverges from beneath the LAA and cannot be seen in the coronal window (right), preventing intersection by the crosshairs: tilt the crosshairs such that the descending LCX is "most visible" in the transverse (middle) window.

In the sagittal window (left), scroll the mouse wheel until the crosshairs are centered in the middle of the LAA opening on the coronal (right) window.[8]

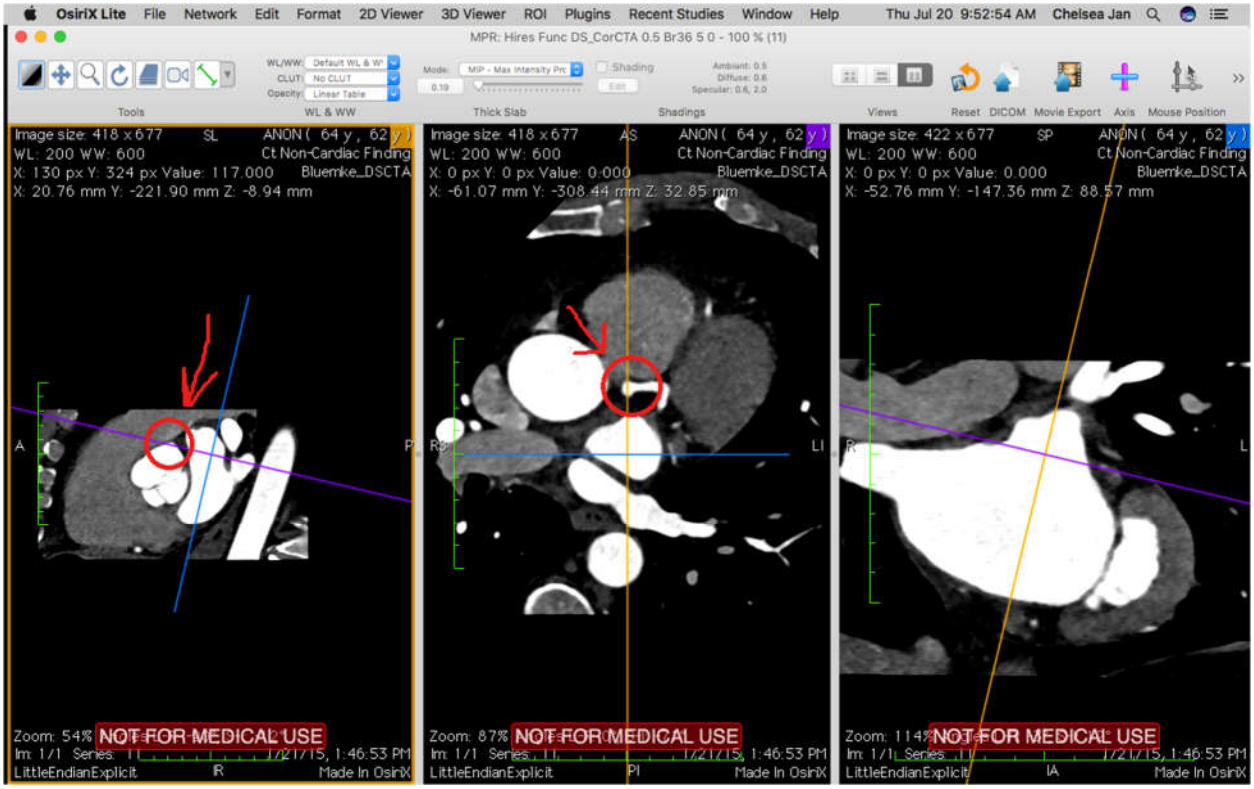


4. In the sagittal window (left), grab and rotate the left side of the purple crosshair until the purple axis intersects the center of the LCX in the sagittal window.[9]



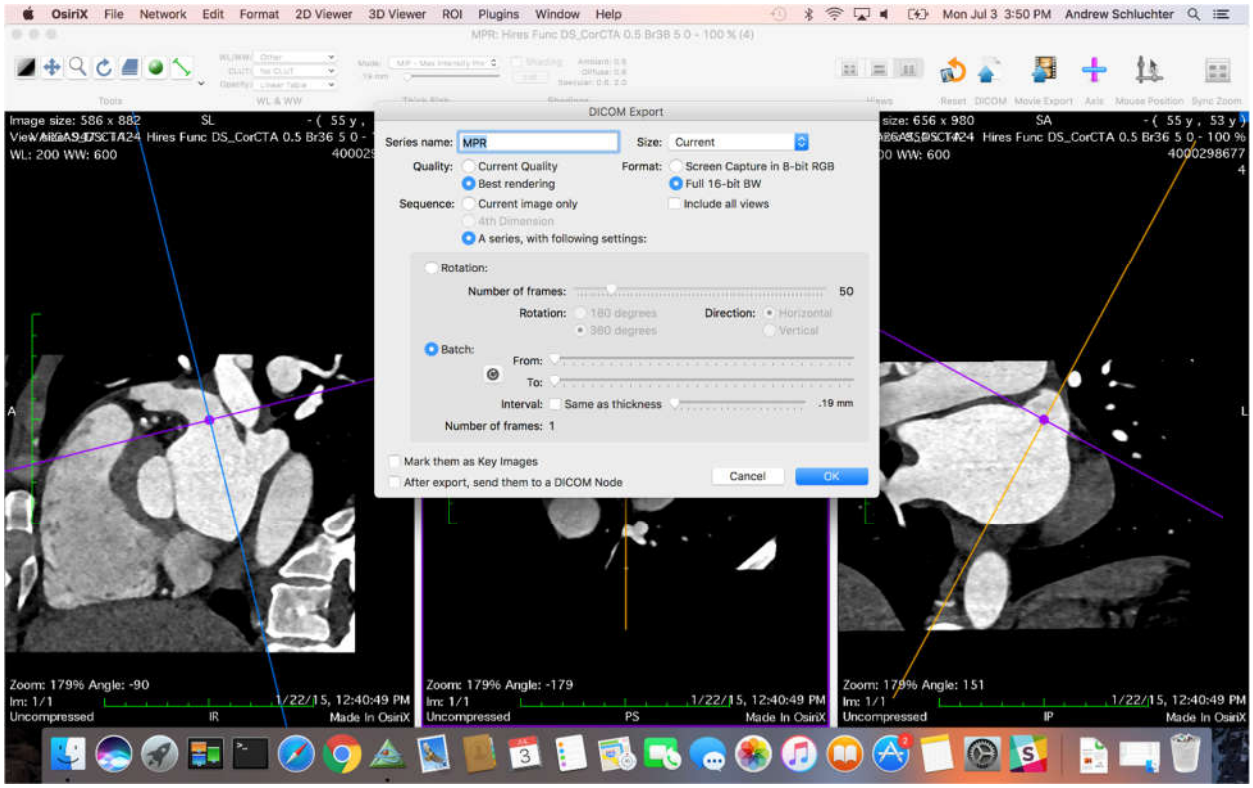
Special cases:
a. If the LCX isn't visible on the sagittal view and can't be centered on the transverse view (due to obstruction by merging with the aorta), adjust the purple crosshair to be level with the top of the aorta (from within the sagittal window).

b. If the LCX isn't visible on the sagittal view and can't be centered on the transverse view (due to obstruction by merging with the aorta), BUT a small nub is visible on top of the aorta, adjust the purple crosshair to intersect that nub (from within the sagittal window). This is the origin of the left coronary artery that will become the LCX.

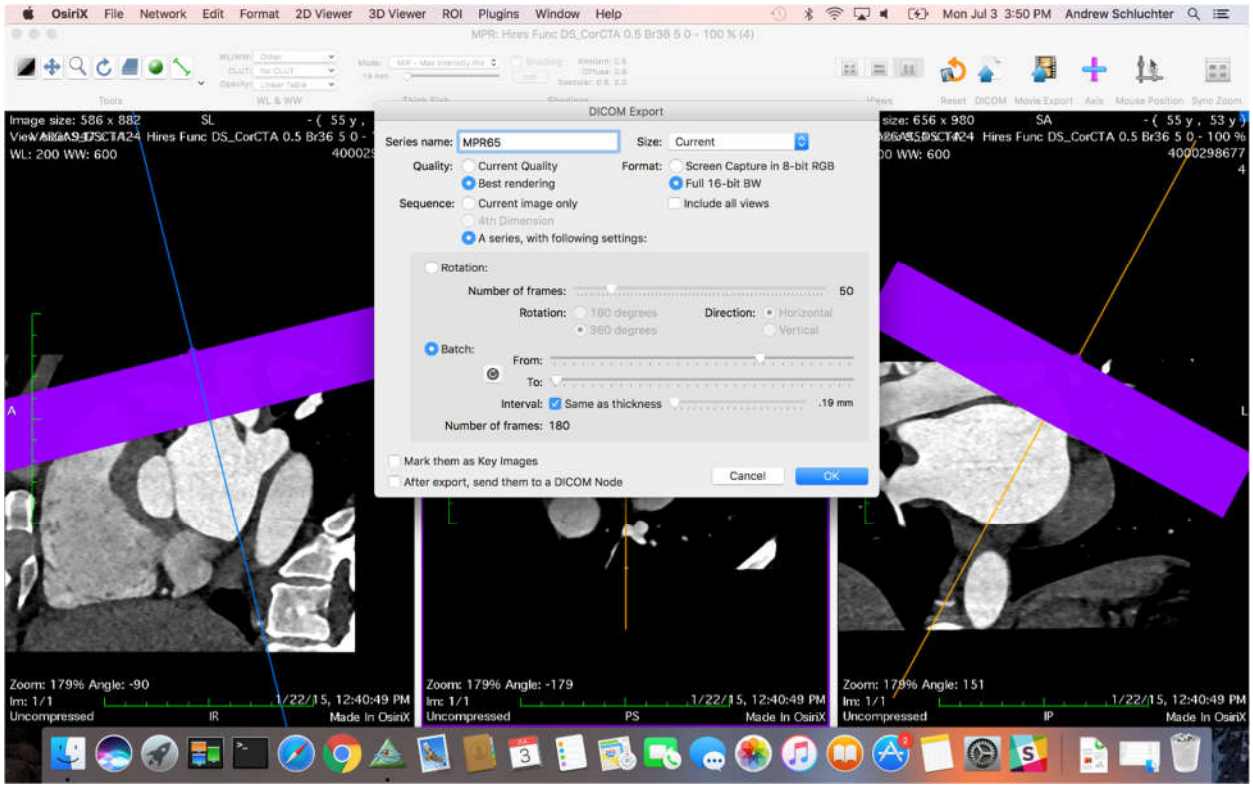


5. Verify that the LAA diameter in the transverse window (middle) is reasonable. The blue and orange crosshairs should both intersect the LCX. If this was not possible, then the LCX should at least be visible in the transverse (middle) window, as well as a clear LAA orifice. The orifice should not be continuous with any part of the LA, but this may still occur, and can be corrected in post-processing.

6. Perform the MPR as follows:
Click on the transverse (middle) window.
Go to File -> Export -> Export to DICOM file(s)[10]



Name the MPR as the current time frame. For example, for time frame 1, enter “MPR00”, for 0%. For time frame 10, enter “MPR45”, indicating 45% of the heart cycle has elapsed.
Set interval => check “same as thickness” box.
Use 1 slice back from the orifice (“To: “), and as many slices forward (“From: “) as needed to cover the remainder of the LAA. Excess space is fine.[11]



Select “OK”

Repeat for each time frame.

Notes:
Visibility of the LCX often increases after systole. Therefore, observing the heart cycle around time frame 14 or so will typically allow for easier viewing of the LCX. You may wish to scroll through the patient around this time frame first, to get a better view of how their LCX is oriented. Depending on the person, the LCX may fully circumnavigate the underside of the LAA, or it may diverge and continue down the side of the heart.

When importing folders into OSIRIX, only import time frames 1-20, NOT folder 21. OSIRIX may try to combine 0% and %100 together into 1 image set, which is incorrect.