

# Measuring protocol: Basilar artery (BA) diameter

Short guide on how to efficiently and concisely measure the BA diameter in 3D Slicer.

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## Software: 3D Slicer and URL

Software intended to use is 3D Slicer v4.10.2 [<https://www.slicer.org/>]

Install is stand-alone on Linux, and may require a restart of the system to work properly.

## Getting started:

1. Load the data. [Not that easy.]
  - a. 3D TOF 3T images (nii.gz).
  - b. On Welcome screen, select “Load Data” -> “Choose File(s) to Add” -> [Chose the file you want] -> “OK”.
2. Select a useable view, e.g. “Conventional” 1 over 3 panels.
  - a. To the left in each panel there is a “Thumbtack” symbol which have options where you toggle visibility (Open/closed eye) of each slice in the 3D viewer. These must be turned on for each reboot of the program, not when changing images.

### Tools to use:

Locate the following tool(s) in the UI.

1. Ruler tool (Menu) --- At drop down button with a red circle with a blue up arrow.
  - a. Create new or edit existing measurement.
  - b. Visible mostly in that exact plane.

### 4.11.0 10.08.2020 considerations:

Use the line measuring tool found in the Markups module.

### Modules to use:

Can be found either using a drop-down menu or search function.

1. Data module (Menu or search)
  - a. Hierarchy of loaded images with added "Annotations".
  - b. No Exact measurements can be seen here.
2. Annotations module (Menu or search)
  - a. See or delete the measurements made by the "Ruler tool".
3. Reformat module (Search)
  - a. Adjust the sliders so that the image can be
  - b. Angling the Axial, Sagittal or Coronal plane with the visual assistance from the two others. This can be done in the "Rotation" sub-menu after selecting a slice.
4. Volume rendering (Menu or search)
  - a. Select MR-MIP preset to improve perpendicular aligning of slices to the vasculature with the reformat module.

Switch fast between modules using forward and backward buttons in the UI.

### 4.11.0 10.08.2020 considerations:

5. Markups module
  - a. To measure the line diameter with "Create line markup".

### Location(s) to measure BA diameter:

1. Measure BA diameter inferior to the SCA, or if the SCA is not visible, a few voxels inferior to the proximal PCA bifurcation.
  - a. The SCAs connection-part to the BA can still be visible even though their entire segments are not, be careful to avoid these while measuring the diameter.
2. Measure BA diameter superior to the Vertebral conjunction/anastomosis into the BA.

- a. Be careful to identify the correct junction, because there are other arteries that could be mistaken for both Vertebral arteries; e.g. out/in-going arteries on the BA.

**Excerpt from Fellgiebel (1):**

“Diameters of the cerebral arteries were measured within the TOF sequences using ConVis Dicom Viewer software (Version 2.9.6. Pro, 2006). The basilar artery diameter was defined as average of three measuring points: 1) caudal (shortly after the confluence of the vertebral arteries), 2) intermediate (in the middle of the basilar artery), and 3) rostral (just before the bifurcation). Measuring points were determined manually on the sagittal plane.”

Suggesting the need of a third middle point.

#### Rounding of BA diameter measurements:

The program provides accuracy down to the five decimals, but still our data is much coarser. We should therefore consider rounding to the closest 0,1mm at least or 0,5 mm at max.

#### Saving BA diameter measurements:

The ruler data can be saved via 3D Slicer and it is stored in an “mrml” file, and is found under the data tag “distanceMeasurement=”. This data tag is unique within our frame of work and may be automated.

Just make sure not to save the already loaded image again as that would drastically increase the storage used compared to only 30kB.

#### 4.11.0 10.08.2020 considerations:

When using the Markups module, -.mrk.json file(s) can be saved for each ID and for each measurement.

Accessing via the “mrml” files are still possible, but now under the tag: “MarkupsLine”.

#### Suggested data structure, example:

Create an Excel file (xlsx) with the following column fields and fill in manually or automatically.

ID	Inf_SCA	Sup_VA	Comment
13098	2,1	4,0	Not a mistake
123	2,6	NA	No VA
5213	4,0	4,1	
...	...	...	...

### Expected size of measurements:

1. TOF study (2) showed a BA diameter range of 0,8 mm to 4,6 mm. Corresponding median was 2,6 mm to 2,8 mm.
  - a. We will not be able to see anything with good detail below 0,8 mm to 1,0 mm. In most cases the BA is visible on our images.

Lower limit (circa) TOF	Median (circa) TOF	Upper limit (circa) TOF
0,8 mm	2,6 to 2,8 mm	4,6 mm

2. CT study (3) showed a BA diameter median at 3,2 mm and a diameter range from 1,6 mm to 6,14 mm. Supposed 95% CI at [1,85 to 4,53] mm.

### Priority of measurements:

Two cases should be considered under the assumption that the BA has an approximal constant diameter across its segment:

1. SCAs are missing or in the way, then prioritize the use measure #2. Leave #1 NA in this case.
2. One vertebral is completely missing or the image do not show any vertebral, then prioritize to use measure #1. Leave #2 NA in this case.

In general, we may want to use both measures in a mean summary.

### Wildly varying BA diameter estimates:

If the two BA diameter estimates vary wildly within a subject then we should measure it again. Alternatively, we can have a comment field to each subject to clarify any abnormalities.

### More “sophisticated” way of taking measurements: (4.11.0 10.08.2020 only)

Link to good explanation

<https://www.youtube.com/watch?v=yi07mjr3JeU>

Extensions for this way and 4.11.0 10.08.2020 version:

1. MarkupsToModel
2. Sandbox
3. SegmentEditorExtraEffects
4. SlicerVMTK

### References:

1. Fellgiebel A, Keller I, Marin D, Muller MJ, Schermuly I, Yakushev I, et al. Diagnostic utility of different MRI and MR angiography measures in Fabry disease. Neurology.

2009 Jan 6;72(1):63–8.

2. Mouches P, Forkert ND. A statistical atlas of cerebral arteries generated using multi-center MRA datasets from healthy subjects. *Sci Data*. 2019 Dec 11;6(1):29.
3. Smoker W. High-resolution computed tomography of the basilar artery: 1. Normal size and position. *AJNR Am J Neuroradiol*. 1986;