

Thoracic Outlet Syndrome on Tim 4G Systems

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Introduction

Thoracic outlet syndrome (TOS) is a condition in which nerves, arteries or veins are compressed. This can lead to pain, weakness, and occasionally loss of muscle at the base of the thumb. Further symptoms may include coldness and paleness of the arm. TOS can result from trauma, repetitive arm movements, tumors or just abnormal anatomy [1].

At our institution, we rarely use MRI in cases of TOS; these patients are typically imaged with CT. However, occasionally, these cases are referred to MRI and I would like to share my experience of how such scans can be performed easily, efficiently, and accurately on Tim 4G systems (3T MAGNETOM Skyra, 1.5T MAGNETOM Aera etc.).

Equipment and positioning

Perform this exam in the feet-first supine position. Remember to position the patient's feet as far as possible toward the head end of the table. This is due to the spine coil elements on the table that we want to use in combination with one Body Matrix coil.

This exam is divided in two parts: Part 1 with the patient's arms by their side. In part 2, the patient's arms are raised above the head.

Part 1: Arms by the patient's side

Position the patient's arms by their side using pads underneath the elbows and hands with a pillow under the legs for comfort and a small pillow under the head (Fig. 1). Avoid using a large pillow as we want the neck region to be as close to the table as possible for optimal signal contribution from the spine coil elements in this area. If a patient is lying comfortably, they are more likely to remain still, thus increasing the likelihood of a successful exam.

Part 2: Arms above the patient's head

Position the patient's arms raised above their head with a pillow for support, a small pillow under the head, and a pillow under the legs (Fig. 2).

Sequence and contrast timing

Sequence

We use a 3D FLASH sequence for contrast-enhanced MRA (Table 1). Extracellular contrast agent (0.5 mmol/ml) is administered in two doses (0.2 mL/kg x 2): one dose for each part of the exam.

Contrast timing

Test bolus timing was used in this case. CARE Bolus technique could, however, also be used but will not be explained in detail here. We begin part 1 of the exam



Figure 1:
Patient positioning for part 1 of the exam with the patient's arms by their side.



Figure 2:
Patient positioning for part 2 of the exam with the patient's arms above the head.

The statements by Siemens' customers presented here are based on results that were achieved in the customer's unique setting. Since there is no 'typical' hospital and many variables exist (e.g., hospital size, case mix, level of IT adoption), there can be no guarantee that other customers will achieve the same results.

3D FLASH CE MRA	
Orientation	Coronal
Phase enc. dir.	R-L
Phase oversampling	21%
Slice oversampling	7.1%
Slice per slab	112
TR	3.07 ms
TE	1.05 ms
Averages	1
Flip angle	30 deg
FOV read	380 mm
FOV phase	100%
Slice thickness	1.19 mm
Base resolution (matrix)	320
Phase resolution	75%
Slice resolution	62%
Phase partial Fourier	6/8.
Slice partial Fourier	6/8.
PAT mode	GRAPPA
Accel. Factor PE	3
Ref. lines PE	24
Accel. Factor 3D	1
Bandwidth	450 Hz/Px

Table 1: 3D FLASH CE MRA parameters for 1.5T MAGNETOM Aera.

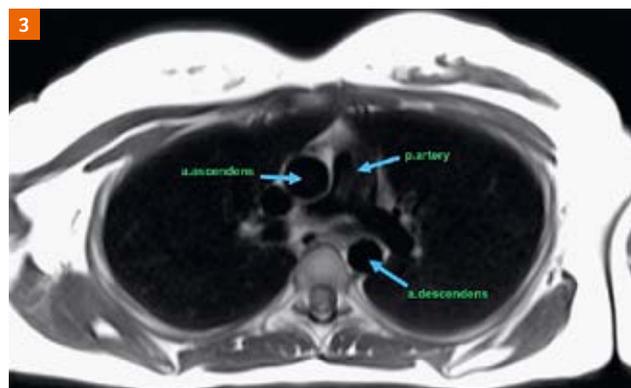


Figure 3: Area of test bolus

with the patient’s arms by their side. Prior to the test bolus, a 3D pre-contrast measurement is performed. We then position the test bolus slice transversal to the area in which the aorta ascendens/descendens and the pulmonary arteries are visible (Fig. 3).

In the first test bolus, 1 mL of contrast agent is administered. We use an Excel™ sheet to record information to calculate the delay and optimal flow rate (Fig. 4). This method is simple as long as the right values are entered into the white fields. Optimal bolus length is half the scan time, whereas flow rate is controlled by the contrast dosage / optimal bolus length. The value for time to center of the CE MRA can be found in the Angio-Common tab card. Circulation time is the value derived from the test bolus when the contrast reaches a peak signal intensity in the area of interest, i.e. aorta ascendens (Fig. 5). When all the values are entered, you can calculate the delay. The delay is calculated using the following equation:

$$\text{Delay} = \text{circulation time} + 50\% \text{ injection time} - \text{time to center}$$

This may seem very advanced; however, in our daily practice we set only the white field values to find the optimal flow rate and perform a test bolus to determine the delay. Other color areas in the sheet are locked so that no one can change the equation. This method is both fast and robust as there is no need to remember the equation. Any radiographer can use this sheet with ease without needing to know the background to the equation.

The scan and test bolus injection are started simultaneously while the patient is breathing normally. When the contrast arrives at the area of interest, the scan can be halted. Go to the Patient Browser, select the test bolus measurement, and load it into Mean Curve. Position the ROI in the area of interest and calculate. The test bolus slices are acquired at 1 image per second, which means

Scan time (s)	Contrast dosage (mL)	Optimal bolus length (s)	Flow (ml/s)
17	13.5	8.5	1.6
Time to center	Circulation time (s)	Injection time (s)	
7.6	23	8.5	
Delay (s)	19.7	Delay = circulation time + 50% injection time - time to center	

Figure 4: Extract from Excel™ sheet recording values used to calculate the delay and optimal flow rate for the given exam. This sheet was created by Rolf Svendsmark.

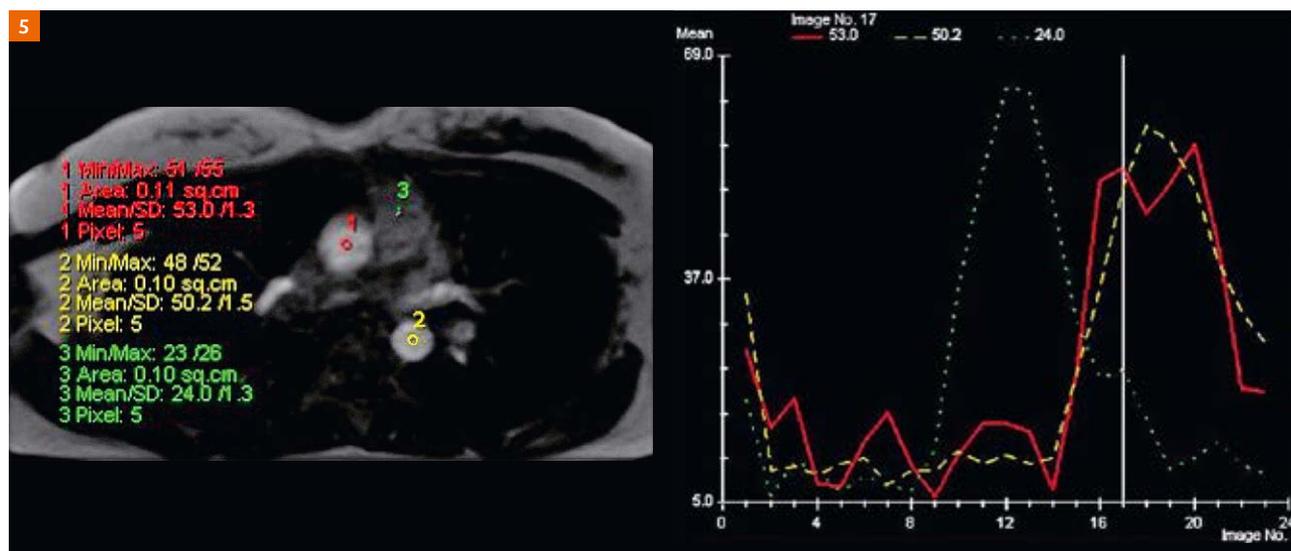


Figure 5: Signal intensity at the ROI (aorta ascendens)



Figure 6: Two measurements are configured with a 20-second break after the first scan.



Figure 7: Delay configured directly on the injector for the first measurement using the value from the Excel™ sheet (Delay: Scan).

that peak signal intensity in the aorta ascendens occurs at image 17 in this case. In other words, circulation time is 17 seconds. This is why it is important to start the scan and the test bolus measurement at the same time.

Once we have calculated the delay, we can continue with the post-contrast measurement. We simply acquire two measurements with a 20-second break in between (Fig. 6). We enter the first delay value from the Excel™ sheet into the injector (Bayer, Medrad® Spectris Solaris®) (Fig. 7). This is then followed by the second delay lasting 20 seconds, which we configure in the measurement sequence. When there are approximately 6–7 seconds left before the second measurement starts, we instruct the patient to hold their breath.

When the CE MRA is finished, we reposition the patient's arms for part 2. The patient is asked to lie still while we remove the body coil, position the arms above the head, and reposition the body coil. Apart from this, there is no need to move the patient. A new fast localizer is performed for part 2 of the exam.

Part 2 starts with a pre-contrast measurement as in part 1 followed again by a 1 mL test bolus to determine the delay when the patient's arms are raised. In theory, there is no need for a further test bolus if we assume the delay will be the same. However, this may not always be the case – in this patient, when arms were by the side, circulation time was 17 seconds, whereas circulation time with the arms above the head was 15 seconds (Fig. 9). It is not easy



Figure 8:
Part 1 scan images along with postprocessing of MIP and VRT.
Notice the high signal intensity of the carotids, using only spine coil elements.

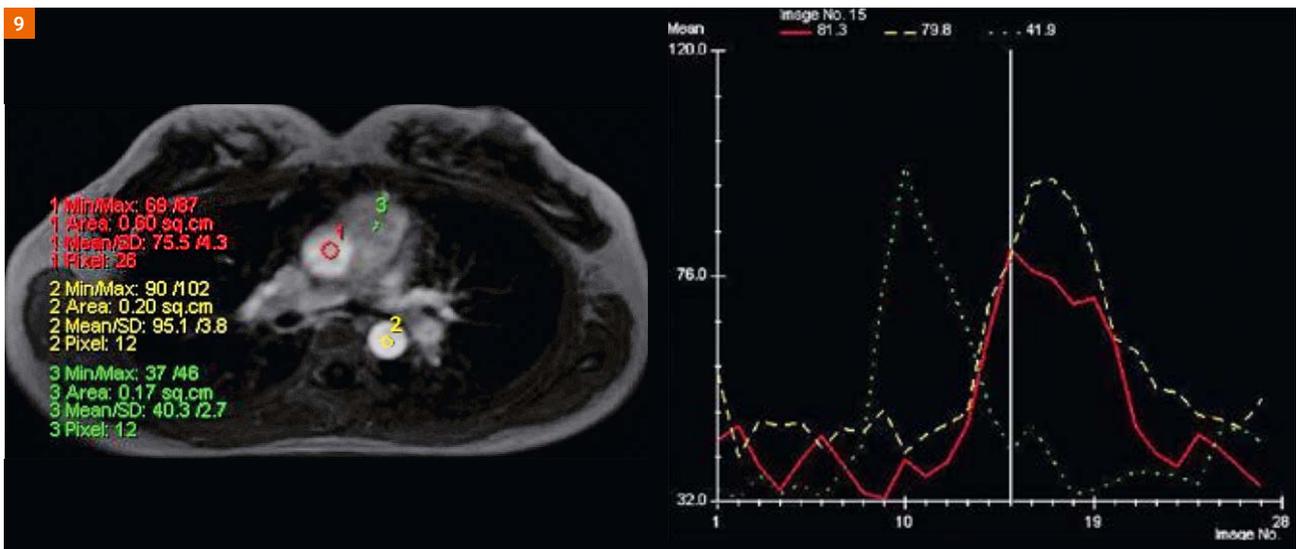


Figure 9: Part 2 shows a 15-second delay with the patient's arms above the head compared with a 17-second delay with the patient's arms by the side.



Figure 10:
Part 2 scan images along with postprocessing of MIP and VRT.
Note the remarkable signal intensity of the carotids, using only spine coil elements.

to explain why the delays were different as a number of factors may be involved. While two seconds may not seem significant, this can affect the results of the arterial phase. As such, you might consider to run a second test bolus.

Conclusion

The intent of this article was to show how easy it is to perform examinations with arms by the patient's side and above the head. If you have good CE MRA protocols and good routines for successful CE MRA exams, then I advise you not to change anything. Just keep in mind these tips on hardware and notes on how to position the patient optimally. One last take-home message on our technique of choice, TWIST. This time-resolved technique requires no timing and enables high temporal resolution. Make sure that the first measurement is without contrast for subtraction purposes.

Acknowledgments

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References/ further reading

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