Pre-operative Localization of the Artery of Adamkiewicz Using Time-resolved Magnetic Resonance Angiography at 3.0T

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Introduction: The purpose of this work is to describe the use of time-resolved magnetic resonance angiography (TR-MRA) for presurgical localization of the great anterior radiculomedullary artery (GARA) (i.e. "artery of Adamkiewicz" (AOA)), for the purposes of surgical reimplantation at the time of thoracoabdominal and thoracic aortic aneurysm (TAAA/TAA) repair. Paraplegia from spinal cord ischemia (SCI) remains a dreadful complication of TAA/TAAA repair.[1] Although controversial, data increasingly suggests that preservation of blood flow to the AOA at the time of TAAA/TAA repair plays a key role in the prevention of SCI.[2-5] The location of the intercostal/lumbar artery that supplies the AOA, however, is highly variable (70:30 left:right, spinal levels=T7-L1).[6,7] Non-invasive localization of the AOA for the purposes of guiding surgical reimplantation of intercostal/lumbar arteries may contribute to the reduction in the post-operative paraplegia incidence.[5] Non-invasive imaging of the AOA, however, is technically challenging due to the small vessel diameter (0.5-1.0mm), its variable location requiring a large image field-of-view, its close spatial proximity to the similar appearing anterior radiculomedullary vein, and highly variable contrast dynamics in this patient population which limits conventional contrast-enhanced MRA techniques that rely on accurate bolus timing.[6]

Methods: An IRB-approved retrospective study was performed in 60 patients (33 male:27 female, age=19-87:mean 68) who underwent time-resolved spinal MRA prior to TAAA/TAA repair. All imaging was performed on a 3.0T MR scanner (HDx, TwinSpeed, GE Healthcare, Waukesha, WI) using time-resolved MRA (TRICKs) with a dedicated 8 element CTL spine coil.[8] Patients were administered 0.4mg sublingual nitroglycerine 5-10 minutes prior to scanning to maximally vasodilate the AOA. Imaging parameters included: sagittal acquisition covering T6-L2, TR/TE=4.4/1.7ms, fractional readout, "whole" gradient mode, flip=23°, BW=±50kHz, FOV=24x17cm, slice=1.4mm, 256x256 matrix with 54 slices, and 12 time phases. True spatial resolution was 0.9x0.9.x1.4mm^3, interpolated to 0.5x0.5x0.7mm^3. The average effective temporal resolution was 12.2s. 0.2mmol/kg of gadobenate dimeglumine (Bracco, Princeton, NJ) followed by 50ml of saline were injected at 2.0ml/s. Contrast injection and the TR-MRA acquisition were started at the same time, for all cases.

All cases were reviewed on a 3-D workstation (Vitrea, Vital Images, Minneapolis, MN) by two radiologists trained in vascular imaging (CCD, TAB). The AOA was identified and the location of the feeding intercostal artery (right vs left, spinal level) was ascertained. A five point confidence index (CI=1-5) was determined by consensus for each case. The CI was based upon the accurate visualization of the both the intradural and extradural segments of the AOA, visualization of the characteristic hairpin turn of the AOA and the correlation of the peak signal intensity of AOA with peak arterial enhancement of the aorta and anterior spinal artery. CI=3-5 were considered diagnostic, while CI=1-2 were considered non-diagnostic. The phases in which the AOA, aorta and anterior or posterior radiculomedullary vein demonstrated initial and peak enhancement were also recorded.

Results: The AOA and the location of the feeding intercostal/lumbar artery were identified with high confidence (CI = 3, 4, or 5) in 53 of the 60 cases (88%). The origin of 53 identified vessels varied as follows: 64% left, 36% right; range T6-L1. This distribution agrees with those in previous literature.[7]

The average phase which demonstrated peak enhancement of the AOA was phase #6 (range: 4-10), which corresponds to an approximate delay between injection and peak enhancement of 72.4 ± 16.8s (range: 38.3-109.0s). The average phase which demonstrated initial enhancement of the AOA was phase #3 (range: 1-8) [avg=38.8 ± 16.2s, range: 13.8-92.0s]. Peak venous enhancement of either the anterior or posterior radiculomedullary vein (GARV/GPRV) on average occurred during phase #8 (range: 4-12) [avg=96.1 ± 16.8s, range: 46.2-156.0s]. Initial venous enhancement occurred on average during phase #4 (range: 2-9) [avg=47.5 ± 15.0s, range: 23.1-100.3s].

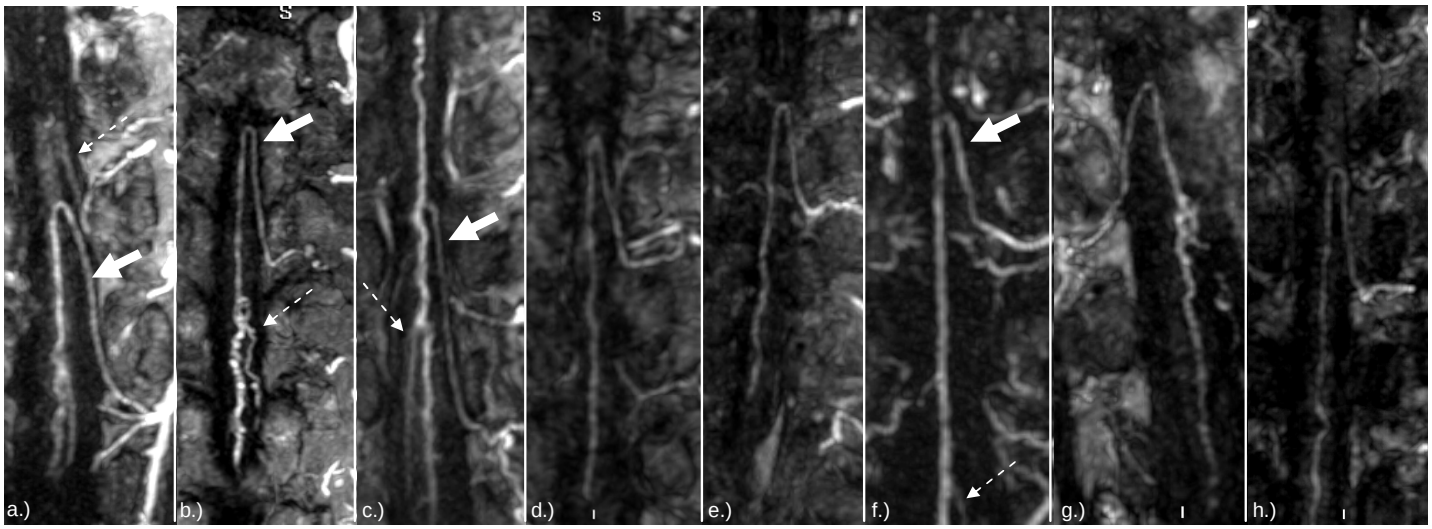

Figure 1(a-h): *Eight examples of oblique thin slab MIPs that clearly visualize both the intradural and extradural segments of the artery of Adamkiewicz (AOA). Each AOA demonstrates the characteristic "hair-pin" turn. The great anterior radiculomedullary vein (dotted arrow) is visualized in examples (a), (b), (c) and (f) and can be delineated from the AOA (solid arrow) by its differential contrast enhancement (a), serpentine morphology (c) or low lumbar origin and larger vessel diameter (c&d).*

Discussion

Time-resolved MRA is an effective method for presurgical localization of the intercostal/lumbar arteries that feed the AOA. The time to peak enhancement of the AOA and radiculomedullary veins is highly variable in the setting severe aortic pathology (large aneurysms, dissections) that greatly altered contrast dynamics, making conventional timing techniques very difficult. TR-MRA eliminates the need for bolus timing and provides additional temporal information which can be used to more accurately identify the AOA and GARV. High spatial resolution imaging at 3.0T using a dedicated spine coil, double dose contrast, and nitroglycerine were additional steps taken to maximize visualization of the AOA, which was successful in 88% of patients.

References

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