Comprehensive Magnetic Resonance Imaging of Hands Vasculature at 3 Tesla: Preliminary Clinical Results

U. Bozlar[1,2], P. T. Norton[1], A. M. Housseini[1,3], T. Huerta[1], H. E. Daniel[1], B. Chhabra[4], D. B. Drake[5], P. B. Arnold[5], and K. D. Hagspiel[1]

[1]Department of Radiology, University of Virginia Health System, Charlottesville, Virginia, United States, [2]Department of Radiology, Gulhane Military Medical Academy, Ankara, Turkey, [3]Department of Radiology, Suez Canal University, Ismailia, Egypt, [4]Department of Orthopaedics, University of Virginia Health System, Charlottesville, Virginia, United States, [5]Department of Plastic Surgery, University of Virginia Health System, Charlottesville, Virginia, United States

Introduction

Despite improvement in imaging technologies, noninvasive evaluation of the hand vasculature remains challenging, particularly in the distal arteries (1-4). However, recent advances in magnetic resonance angiography (MRA), particularly the introduction of clinical 3 Tesla (T) MR scanners, have improved the ability to visualize small caliber target vessels (1-4). The purpose of the study is to evaluate multilevel arterial conspicuity using a comprehensive MR protocol that combines high resolution time resolved contrast enhanced MRA (tr-ceMRA) and volumetric interpolated breath-hold examination (VIBE) in a population with clinical evident disease. To the best of our knowledge, there is no published study which evaluates the hand vasculature at 3T in such a population.

Materials and Methods

Clinical and MR angiographic findings were reviewed in 8 patients (3 males, 5 female patients; mean age 45+/-29 years; range 3-78 years) who underwent a total of 11 MR studies (11 hands) in whom there was a clinical suspicion of vascular pathology. All imaging studies were performed on a 3T commercial scanner (Trio, Siemens Medical Solutions, Malvern, PA) using a 6 channel body matrix RF coil in combination with a built in spine coil. 10 hands were evaluated with both tr-ceMRA and VIBE. In one hand, only tr-ceMRA was performed. High spatial resolution tr-ceMRA acquired 11 consecutive 3D datasets within 2 minutes employing a 3D-FLASH sequence with parallel imaging (GRAPPA) as follows: TR 3.59 ms, TE 1.49 ms, flip angle 25 deg, FOV 230 mm, receiver bandwidth 620 Hz/Px, GRAPPA acceleration factor 4, which yielded a special resolution of 0.6 x 0.6 x 1.0 mm and temporal resolution of 9 s per data set. 20 ml of gadobenate dimeglumine (Multihance; Bracco Imaging, Milan, Italy) was injected at a flow rate of 2 ml/sec with initiation of tr-ceMRA 4 s after beginning injection. Subsequently, high spatial resolution VIBE with parallel imaging was performed: TR 4.38 ms, TE 1.75 ms, flip angle 13 deg, FOV 230 mm, GRAPPA, acceleration factor 2, receiver bandwidth 510 Hz/Px yielding a spatial resolution of 0.5 x 0.5 x 0.5 mm. Image analysis of the arterial segments was performed by two observers in consensus. The following arterial segments were analyzed: arteries proximal to the wrist (ulnar and radial), palmar arch, common digital, proximal proper digital, mid proper digital, and distal proper digital. Segmental arterial conspicuity was assessed for both tr-ceMRA and VIBE on a 4 point Likert scale (0= nondiagnostic, 1=poor data quality, diagnostic impairment, 2=suboptimal arterial signal, no diagnostic imparement, 3=good arterial signal). Segments were assessed for motion artifacts (0=absent, 1= present, but not effecting image interpretation, 2= present and affecting image interpretation, 3=severe). Contrast to noise ratio (CNR) was measured for each segmental level when possible (CNR = $[SI_{vessel} - SI_{adjacent\ soft\ tissue}]$/noise; SI=signal intensity, noise=standard deviation of SI outside the body). For each hand, reviewers considered the ability to come to a confident final radiologic diagnosis based on tr-ceMRA alone and on VIBE alone. Arterial conspicuity scores are reported as mean ± standard deviation.

Results

In 6 of 8 patients (75%), the final clinical diagnosis was primarily vascular in etiology including vasculitis, Raynaud's disease, hobnail hemangiomas, lymphovascular malformation, and traumatic injury. In 2 of 8 patients (25%), the final clinical diagnosis was attributed to soft tissue infection. All MR exams were of diagnostic quality. Arterial conspicuity scores on a segmental basis for both tr-ceMRA and VIBE are as follows, respectively: proximal to wrist [2.9 ± 0.3, 2.4 ± 0.7], palmar arch [2.6 ± 0.5, 1.8 ± 0.9], common digital [2.1 ± 0.5, 1.9 ± 1.0], proximal proper digital [1.1 ± 0.7, 2.2 ± 0.8], mid proper digital [0.8 ± 0.7, 2.0 ± 1.2], and distal proper digital [0.3 ± 0.5, 1.1 ± 0.8] **(Fig 1)**. In the proximal arteries (proximal to wrist, palmar arch, common digital), mean conspicuity score is greater for the tr-ceMRA technique. In the distal arteries (proximal through distal proper digital), mean conspicuity score is greater for VIBE. Remarkably, there were no artifacts related to motion (mean rank = 0). Mean CNR measurements demonstrate progressively diminishing signal with more distal segments. The VIBE sequence produced greater CNR for all segments as compared to tr-ceMRA technique **(Fig 2)**. In 7 of 11 (63%) tr-ceMRA exams and 6 of 10 (60%) exams VIBE exams, reviewers felt that the respective sequence alone was insufficient to arrive at a confident final radiologic diagnosis.

Discussion

Combined tr-ceMRA and VIBE imaging of the vasculature of the hand at 3 T provides assessment of both larger and smaller target vessels, albeit, with different techniques for different imaging conditions. tr-ceMRA excels in imaging of the proximal arterial segments as compared to VIBE, despite the inferior CNR, due to the reliable separation between arterial and venous/enhancing structures which are closely related, particularly in proximal hand. Additionally, tr-ceMRA provides dynamic flow information, which allowed for confident diagnosis of a low flow lesion in the lymphovascular malformation case. However, due to the superior CNR of VIBE and the larger anatomic separation of arterial and venous structures in the fingers, VIBE excels at imaging these small target vessels. VIBE also provides additional information in regards to soft tissue pathologies which are not easily discernable on tr-ceMRA such as tenosynovitis, abscess collections, and small hemangiomas **(Fig 3)**. The reviewers' inability to arrive at a confidence diagnosis in the majority of cases base on one sequence alone support the need for a combine imaging protocol.

Conclusions

A comprehensive MR imaging protocol of the hand at 3T employing complementary techniques of tr-ceMRA and VIBE allows for assessment of both proximal and distal vessels in patients with symptoms attributable to vascular pathologies.

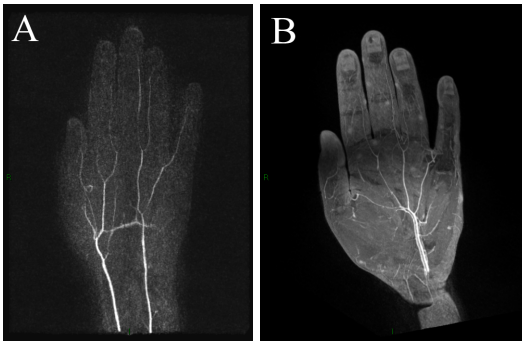

Figure 3. Patient with Hobnail hemangiomas. **(A)** tr-ceMRA full volume MIP clearly demonstrates proximal arteries without venous contamination. There is reduced conspicuity distally, with questionable areas of disease. **(B)** Sub-volume MIP VIBE demonstrates hemangiomas not visualized on tr-ceMRA and patency of distal arteries. (MIP=maximum intensity projection).

References

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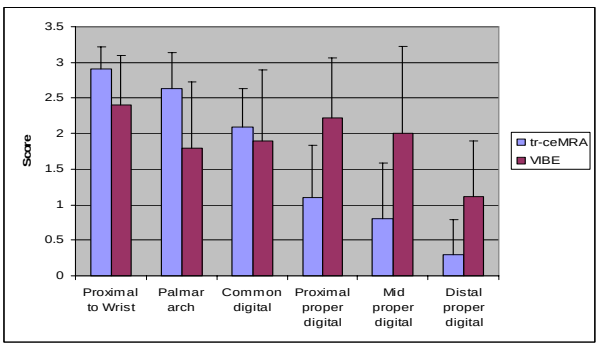

Figure 1. Segmental arterial conspicuity score with standard deviation bars

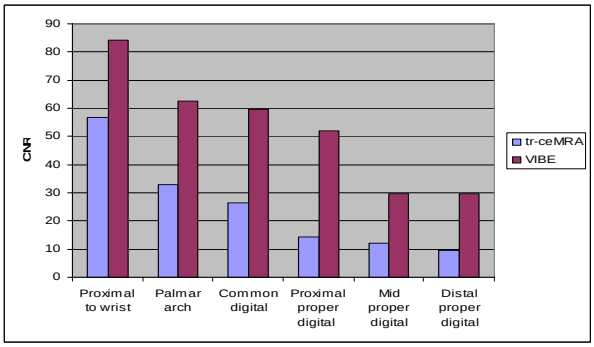

Figure 2. Segmental arterial contrast to noise ratio (CNR)