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Case Report

T1-Weighted 3D-Black-Blood-Imaging in Giant-Cell Arteriitis Temporalis and Extracranial Arteritis: A Case Report

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Abstract:

Giant-cell arteritis (GCA) is a common vascular inflammatory disorder that often presents with clinical symptoms necessitating prompt diagnosis. Delay in diagnosis can lead to severe patient impairment. This case report highlights the utility of contrast-enhanced T1-weighted 3D-Black Blood (BB) imaging in the diagnostic work-up of GCA, along with its histological correlations. We present the case of an 81-year-old male patient with clinical symptoms suggestive of bilateral temporal arteritis. The patient underwent cranial magnetic resonance imaging (MRI) with contrast-enhanced T1-weighted 3D-BB sequence, which revealed wall-enhancement with perivascular "stranding" of both temporal arteries and their branches, luminal narrowing, and pathological enhancement of the vertebral and basilar arteries. Histological analysis after biopsy confirmed a diagnosis of temporal arteritis.

This case report emphasizes the valuable role of contrast-enhanced T1-weighted 3D-BB imaging in the diagnosis of GCA, providing higher resolution and flow signal suppression. The observed "perivascular stranding" and histological findings contribute to our understanding of the disease. Radiologists should consider incorporating this imaging sequence into their diagnostic protocols when GCA is suspected.

Keywords: Vasculitis, Giant-cell arteritis, CNS, Black-blood-imaging; Temporal artery; Vascular imaging.

Case Report:

Background:

Giant-cell arteritis was first described by Horton in 1937 and is characterized by systemic vasculitis. The inflammatory process involves activated T-cells, macrophages, and multinucleated giant cells, which form clusters at the internal elastic membrane. Commonly affected arteries include the ophthalmic, posterior ciliary, superficial temporal, occipital, and internal maxillary arteries (1). Due to the diverse clinical symptoms and limited utility of laboratory markers, the diagnostic work-up of extracranial vasculitis requires an interdisciplinary approach. Early and accurate diagnosis is crucial to prevent long-term damage (2). Contrast-enhanced T1-weighted 3D-Black Blood imaging (T1BB) is frequently used for evaluating inflammatory intracranial diseases, brain tumors, metastases, and cervical dissections (3, 4). The significant advantages of T1BB imaging lie in its superior resolution and ability to suppress vascular flow signals.

In this report, we present a case of giant-cell arteritis and highlight its T1BB imaging features. Furthermore, we demonstrate the correlation between imaging findings and histological observations.

Case Presentation:

We present the case of an 81-year-old male patient who was hospitalized in the geriatric department due to rehabilitative measures. During his inpatient stay, he developed severe bilateral temporal pain with jaw claudication, along with progressive vertigo. The patient had pre-existing medical conditions, including paroxysmal atrial fibrillation, mitral valve insufficiency, coronary heart disease and a history of left-sided ischemic stroke.

Based on the symptoms of pain and claudication bilateral temporal arteritis was suspected, necessitating further diagnostic work-up through cranial magnetic resonance imaging (MRI).

Magnetic resonance imaging:

The diagnostic work-up utilized a 3.0 Tesla MR scanner (Philips Achieva, Vienna, Austria), and the following sequences were performed: diffusion-weighted imaging (DWI) and apparent diffusion coefficients (ADC), T1-weighted fluid-attenuated inversion recovery (FLAIR), intracranial time-of-flight angiography (TOF-MRA) with maximum intensity projection reconstructions, unenhanced and contrast-enhanced

T1-weighted imaging of the intra- and extracranial vessels with multiplanar reconstructions, and contrast-enhanced T1-weighted 3D-Black Blood sequence.

The T1BB imaging in this patient revealed a pronounced enhancement of the lumina in both temporal arteries, along with perivascular soft tissue "stranding" and luminal narrowing [Figs. 1, 2, 3].

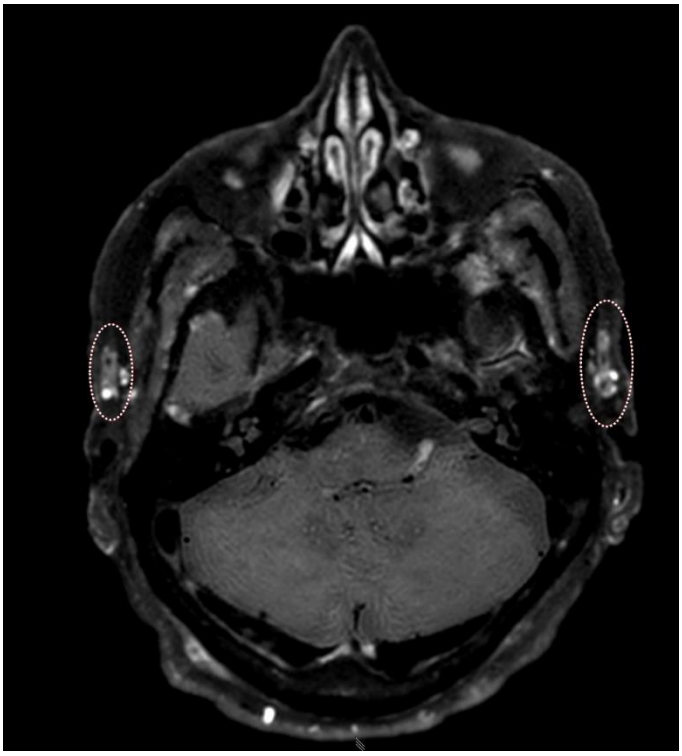

Fig. 1: Axial 3.0 Tesla contrast-enhanced T1-weighted Black-Blood imaging, Bilateral enhancement of the temporal arteries with slight perivascular stranding

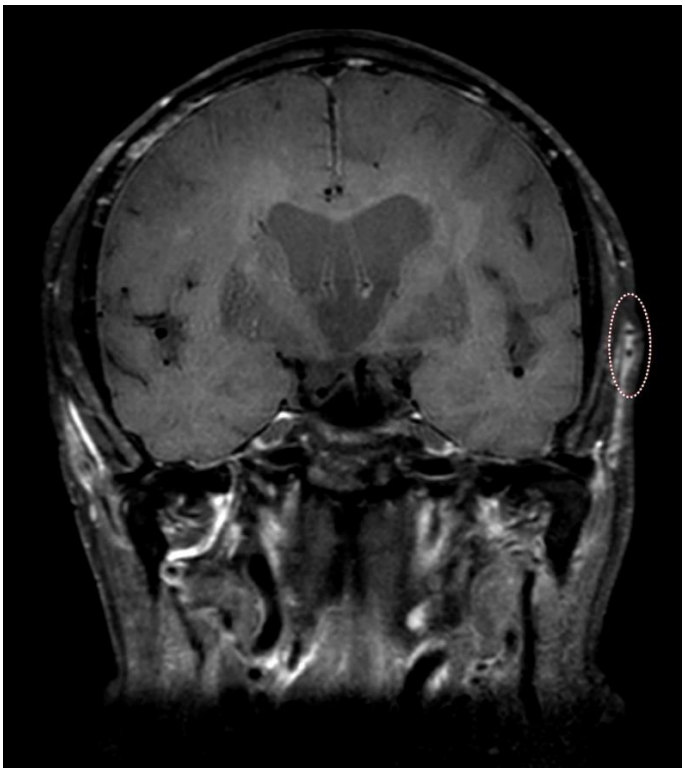

Fig. 2: Coronar 3.0 Tesla contrast-enhanced T1-weighted Black-Blood imaging, Enhancement of the left temporal artery with slight perivascular stranding

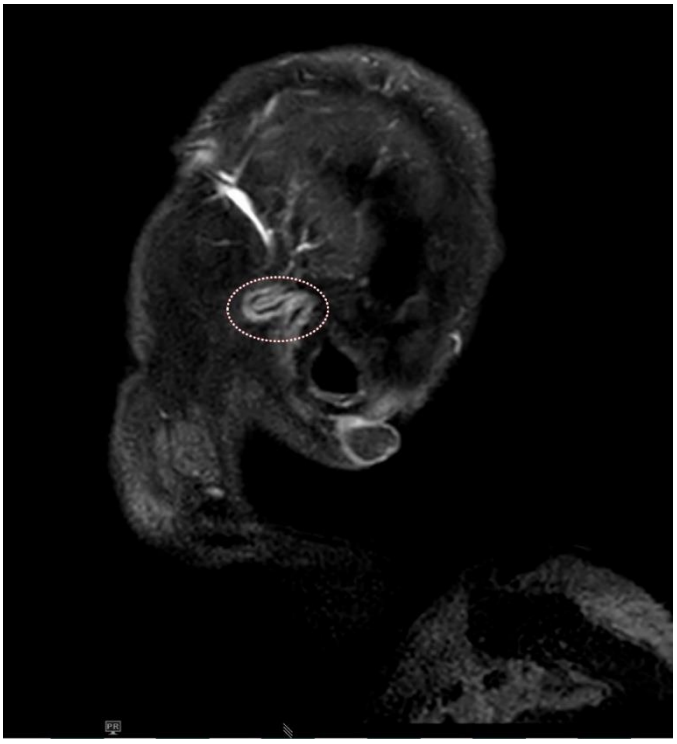

Fig. 3: Sagittal 3.0 Tesla contrast-enhanced T1-weighted Black-Blood imaging, Contrast-enhancement of the left temporal artery with perivascular "stranding"

Consistent with recent studies (2) we also observed vascular enhancement of the vertebral artery in the V3 and V4 segments, indicative of arteritis [Figs.4, 5]. Additionally, a slight enhancement was noted in the middle third of the basilar artery [Fig. 6].

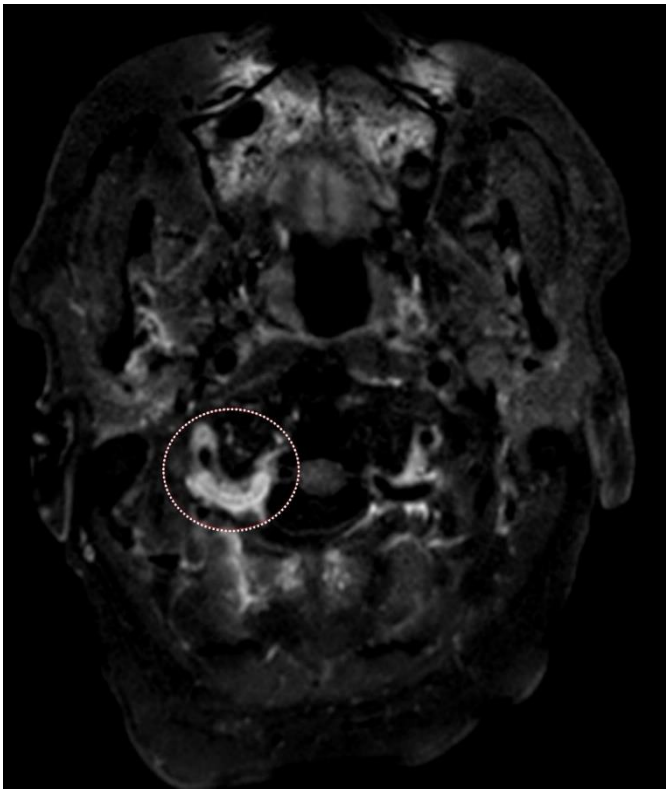

Fig. 4: Axial 3.0 Tesla contrast-enhanced T1-weighted Black-Blood imaging, Contrast-enhancement of the right vertebral artery in the V3-segment with strong perivascular "stranding" and narrowing of the lumen

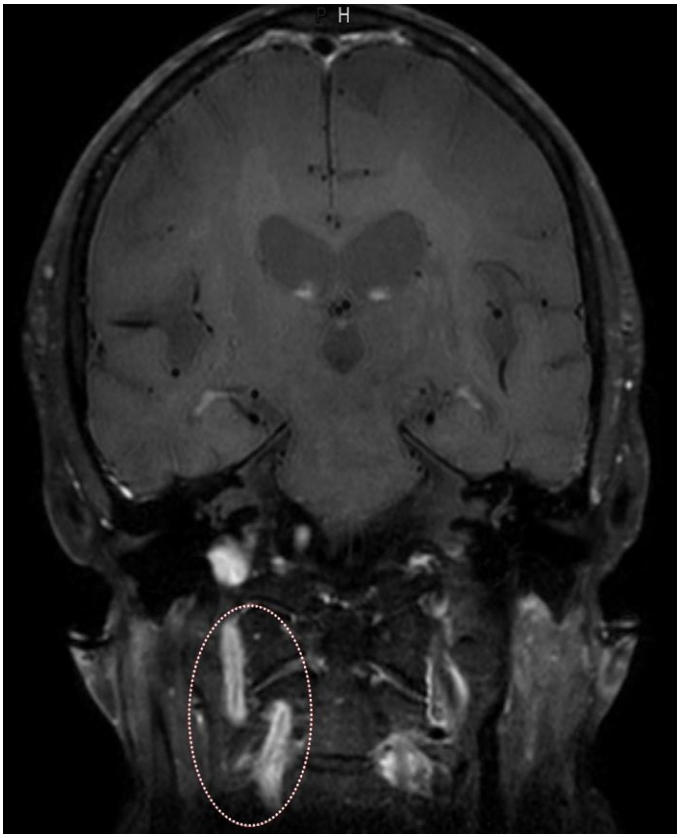

Fig. 5: Coronar 3.0 Tesla contrast-enhanced T1-weighted Black-Blood imaging, Contrast-enhancement of the right vertebral artery in the V3-segment with strong perivascular "stranding“ and narrowing of the lumen

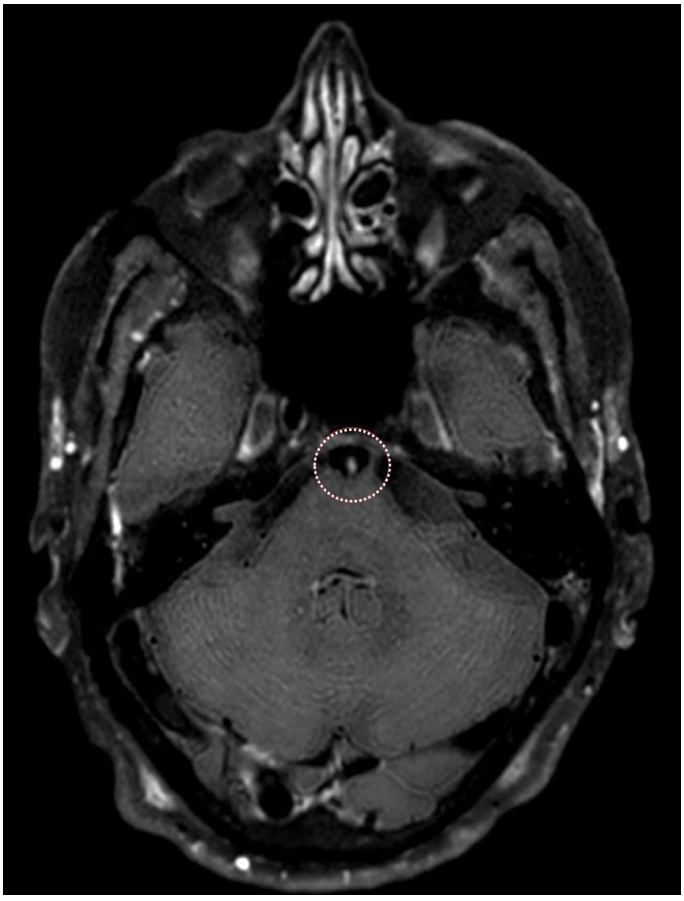

Fig. 6: Axial 3.0 Tesla contrast-enhanced T1-weighted Black-Blood imaging, slight contrast-enhancement of the basilar artery

Based on the results from neurosonology, there was suspicion of right vertebral artery occlusion, which was subsequently confirmed through MR angiography and maximum intensity projection reconstructions [Figs. 7, 8]. The occlusion was found to involve the V1 and V2 segments, with retrograde filling of the V3 and V4 segments via the basilar artery. No ischemic intracranial lesion was identified. Notably, a cavum velum interpositii, considered an anatomical variant, and high-grade parenchymal atrophy were observed. Furthermore, numerous confluent subcortical white matter lesions consistent with grade III on the Fazekas scale were present.

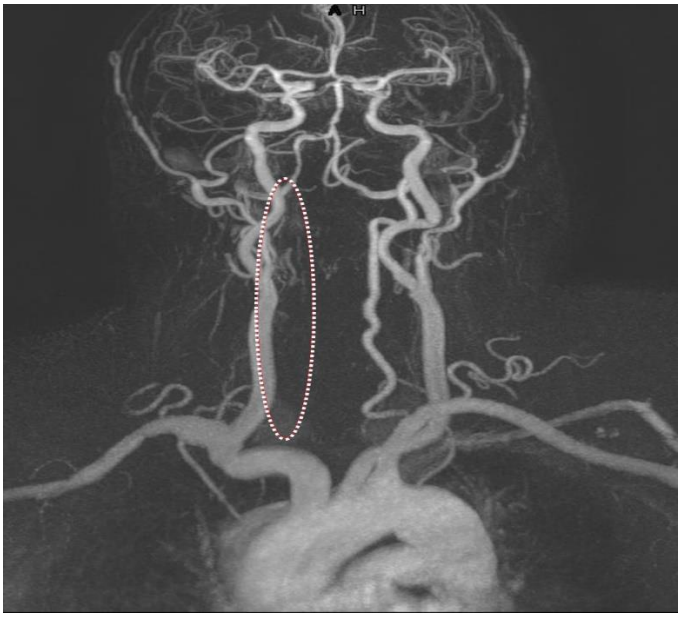

Fig. 7: MIP reconstruction revealed blockage of the right vertebral artery in the V1 and V2 segments. The V3 and V4 segments were filled retrogradely.

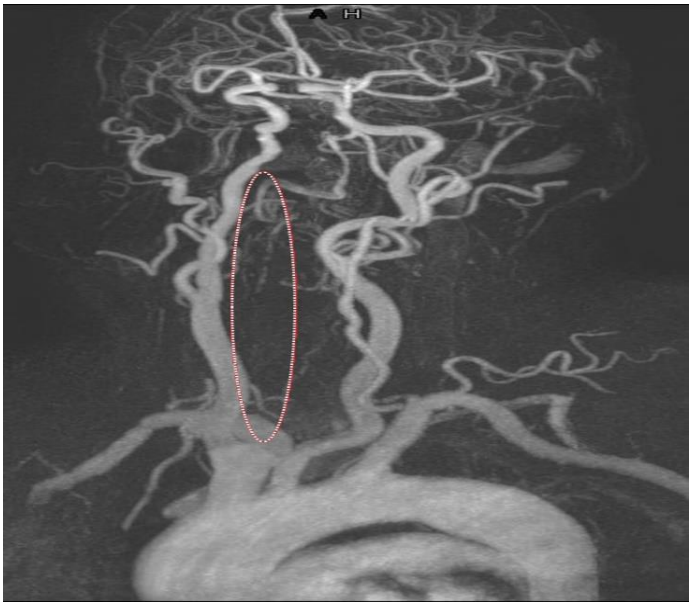

Fig. 8: Oblique view of a MIP reconstruction revealing blockage of the right vertebral artery in the V1 and V2 segments. The V3 and V4 segments were filled retrogradely.

Histological examination:

Following biopsy of the left temporal artery, histological examination revealed focal thickening with significant

narrowing of the vascular lumen. The intima showed thickening, fibrosis, and focal accumulation of fibroblast-like cells and macrophages. Microcalcifications were observed at the transition from the intima to the media. Lymphocytic accumulations were predominantly found in the media and adventitia, surrounding the vasa vasorum of the adventitia. Histology also demonstrated giant cells of the antibody type and macrophages in parts of the media [Fig.9].

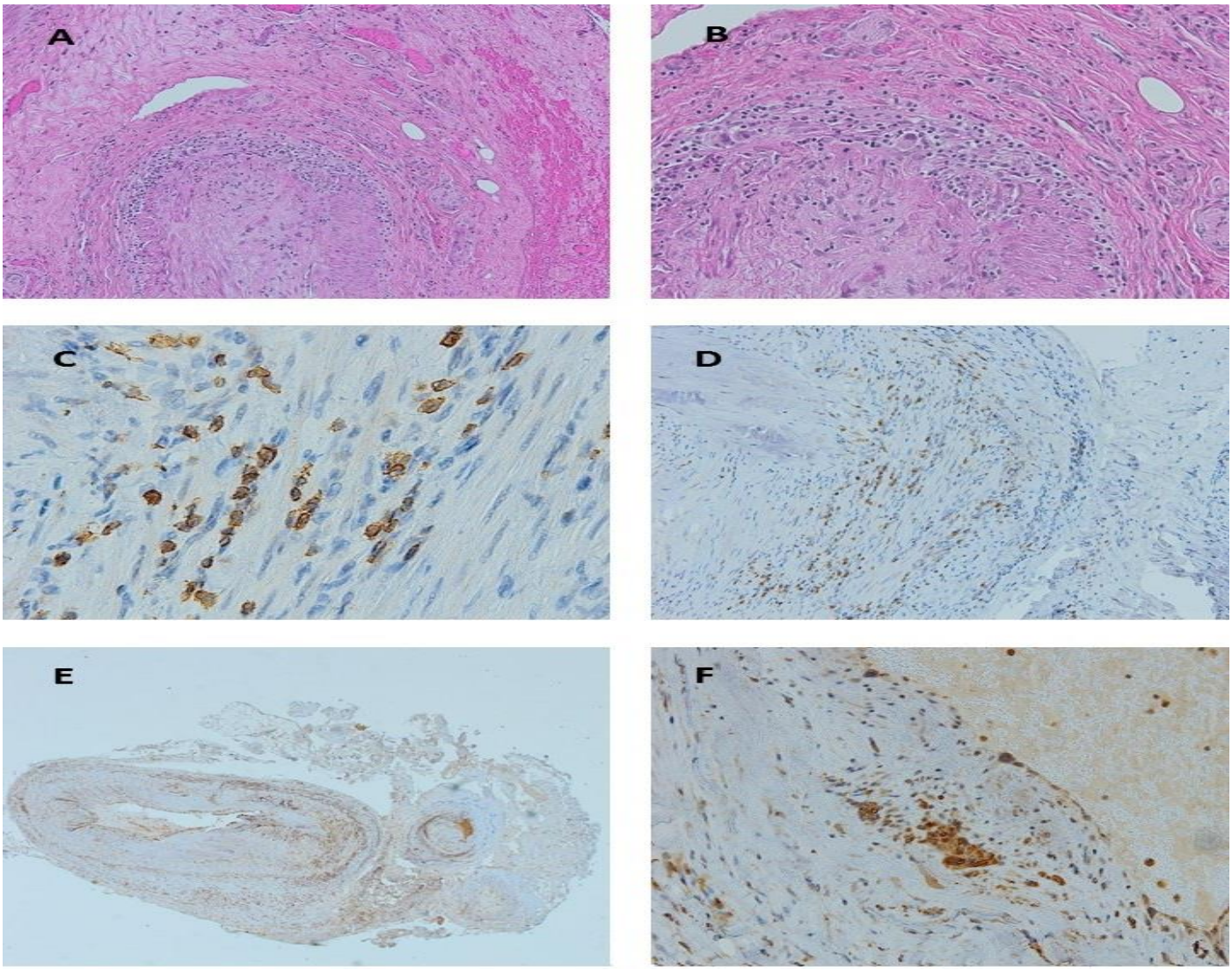

Fig. 9: Section showing a thickened vessel wall with presence of lymphocytes and multinucleated giant cells (a, b); the lymphocytes are T-cells as shown by immunohistochemistry (c, d); numerous macrophages are found clustered throughout the vessel wall (e, f)

Immunohistochemistry analysis revealed CD3-positive lymphocytic infiltrations, consistent with T-lymphocytes. Additionally, the giant cells and multinucleated giant cells (MGCS) of the antibody type showed immune reactivity for CD68. In summary, the histological findings confirmed the diagnosis of Horton's temporal arteritis.

Discussion:

The clinical presentation of this elderly male patient was typical of GCA and required further diagnostic work-up by MRI. In this patient pronounced wall-enhancement of both temporal arteries, along with perivascular soft tissue "stranding" and luminal narrowing was observed using T1BB imaging. Furthermore, vascular enhancement of the right vertebral artery were observed using this advanced MR imaging technique.

The "black blood" technique known as Motion-Sensitized Driven Equilibrium (MSDE) utilizes a combination of RF pulses and gradients to serve as a black blood prepulse, effectively suppressing blood signal in the entire volume of interest during 3D acquisitions.

The strength of gradients in three directions plays a crucial role in determining the level of blood suppression. The gradient strength required to suppress flowing blood depends on the velocity of blood flow. Slower flowing blood necessitates stronger gradients to eliminate the blood signal. This can be achieved by increasing the gradient amplitude, duration, or a combination of both, taking into account system performance and SAR (Specific Absorption Rate) limitations. On the other hand, faster flowing blood experiences larger phase shifts, allowing for blood signal suppression using smaller gradient amplitudes and/or shorter durations. In MSDE imaging, the gradient strength is adjusted relative to the flow velocity of the blood by adapting the velocity encoding in three

directions. The efficiency of blood flow suppression is influenced by the gradient direction and the direction of blood flow. Blood flowing perpendicular to the net gradient experiences minimal phase shift and, consequently, is not effectively suppressed. Conversely, blood flowing parallel to the gradient experiences a significant phase shift and is effectively suppressed. In MSDE, the suppression of flowing blood occurs before the imaging sequence (T1-TSE).

The Black Blood sequence, distinct from regular T1-weighted imaging, incorporates fat suppression, flow suppression, a slice thickness of 0.8mm (compared to 1.0mm in T1-weighted imaging), and a voxel size of $0.8mm^3$. As a result, it provides higher resolution of vascular structures and soft tissue. This represents a significant advantage over other sequences or imaging modalities. When compared to T1BB images of non-pathological vessels, which exhibit regular vascular diameter, no signs of perivascular inflammatory reaction, and a thin, non-thickened vessel wall [Fig. 10], the T1BB sequence precisely visualized the pathological luminal and perivascular artery inflammation in this patient. In this case, T1BB also excellently depicted the pathological changes in affected arteries, such as the vertebral and basilar arteries.

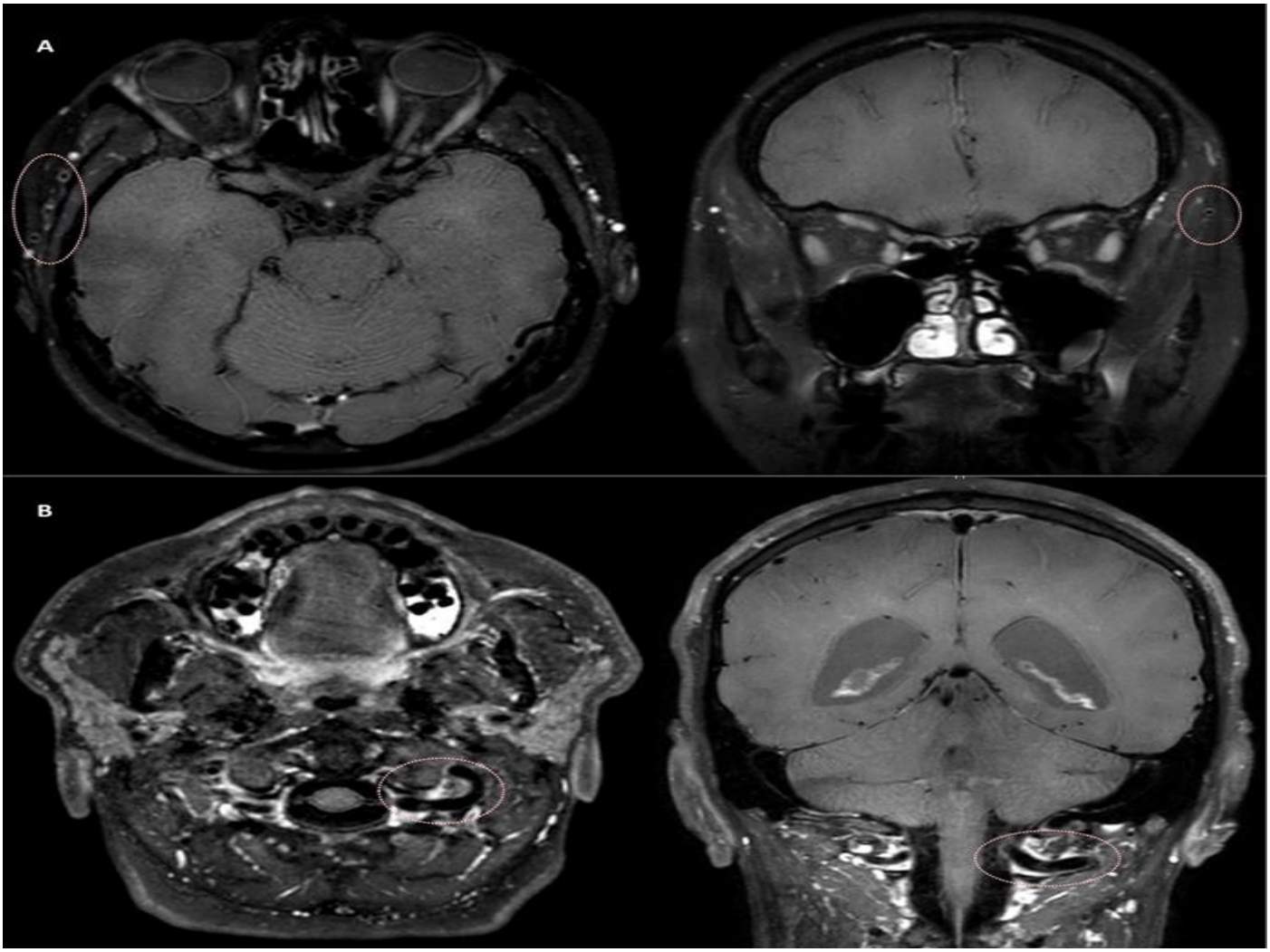

Fig. 10: (a) Non-pathological arteries on T1BB showed a normal depiction of the temporal artery without enhancement. (b) Non-pathological arteries on T1BB demonstrated a normal depiction of the vertebral artery without enhancement, along with narrowing of the lumen.

Changes to the vessel wall and perivascular soft tissue are characteristic for GCA and typically, yet invasively confirmed using direct biopsy of the corresponding vessel and histological examination including immunohistochemistry (5).

Ultrasound can effectively demonstrate an increased diameter of the superficial temporal arteries with hypoechoic wall thickening or luminal stenosis. Computed tomography findings in giant-cell arteritis can reveal wall thickening, stenosis, occlusions, dilations, or aneurysms. In comparison, contrast-enhanced cranial MRI can provide the aforementioned findings and additional crucial changes, such as the described vessel wall and perivascular inflammation with corresponding contrast enhancement. MRI is a reproducible and non-invasive tool that offers valuable information about affected areas, which is essential for early and accurate diagnosis.

Therefore, non-invasive diagnostic methods such as MRI imaging with T1BB can be a possible supplement to the existing diagnostic methods or, in the case of strong clinical suspicion and contraindications for a biopsy, an alternative diagnostic method to affirm the diagnosis of GCA and initiate targeted therapy. Our findings support the final diagnosis, which was confirmed by biopsy, the gold standard for verifying giant-cell arteritis.

Conclusion:

In conclusion, T1BB imaging could enhance the diagnostic accuracy for giant-cell arteritis. Additionally, T1BB demonstrated focal "stranding" of the perivascular soft tissue, which we believe giant cell and lymphocytic infiltration of the vasa vasorum. Radiologists should be aware of these findings when the suspicion of giant-cell arteritis arises and we recommend the incorporation of T1BB imaging in the diagnostic work-up of temporal artery inflammation and giant-cell arteritis

Abbreviations:

T1BB: Contrast enhanced T1-weighted black blood imaging, GCA: Giant-cell arteritis, CNS: Central nervous system, RF: Radiofrequency, MGCS: Multinucleated giant cells, MIP: Maximum intensity projection images, MSDE: Motion-Sensitized Driven-Equilibrium, MRI: Magnetic resonance imaging, FLAIR: Fluid-attenuated inversion recovery, TOF-MRA: Time-of-flight angiography, ADC: Apparent diffusion coefficients, DWI: Diffusion-weighted imaging, SAR: Specific Absorption Rate

Declarations

Conflict of interest:

W. Wallner,J. Grimm, Hruby G, Steinbacher J. and M. McCoy declare that they have no competing interests. J. Pfaff reports personal fees from Boehringer Ingelheim AG & Co. KG, other from CERENOVUS (Johnson & Johnson Medical Products GmbH) outside the submitted work.

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Ethical standards:

Informed consent was obtained from the patient for the publication of this case report and any accompanying data.

Availability of data and material:

All data generated or analyzed during this study are included in this published article.

Author contributions:

All authors contributed to this case report. Material preparation, data collection and analysis were performed by W. Wallner, J. Grimm, J. Steinbacher, Hruby G., M. McCoy and J. Pfaff. The first draft of the manuscript was written by W. Wallner and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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