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Three-Dimensional Visualization of Neurovascular Structures in the Posterior Cranial Fossa: A Potential Concept for Microsurgical Considerations in Aneursyms

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Abstract

3D visualization was established for noninvasive evaluation of neurovascular compression syndromes. MR-CISS (constructive interference in the steady state) is the most potent image source to depict neurovascular details. The purpose of this article is the conceptual view over the established technique of 3D visualization in the topography of aneurysms in the posterior circulation in relation to surrounding cranial nerves and the brainstem.

Keywords

3D Visualization, High-Resolution Mri, Neurovascular Relationships, Intracranial Aneurysm

1. Introduction

Image processing of CTA (CT-angiography) was performed for 3D visualization of aneurysms with direct volume rendering [1]. CT-angiography is a fast and noninvasive method. CTA is unable to show the relationships between aneurysmal structures, surrounding nerves and vessels. Especially vertebrobasilar aneurysms have relationships to the cisternal segments of the nerves, which are not delineated by CTA. 3D visualization was established by high quality 3D delineations of the relationships between nerves and vessels [2]. This article deals

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with the question whether the technique of 3D visualization could be implemented for evaluation of aneurysms in the posterior fossa with the focus on surrounding nerves and the brainstem.

2. Technique

MR-CISS is the most potent imaging modality of neurovascular structures [2]. 3D visualization of MR-CISS with direct volume rendering enables microsurgical assistance in the evaluation of neurovascular structures (**Figure 1**). The interactive evaluation of 3D representations of the relationships between nerves and vessels is very advantegeous for surgical planning of microvascular decompression. The method of 3D visualization with volume rendering could be applied in the visualization of vertebrobasilar aneurysms (**Figure 2**) to delinate the aneurysmal structures in relationship to the tiny and complex vasculature and adjacent cranial nerves at the ventral and ventrolateral surface of the brainstem. The surgeon could be able to see a pre-and intraoperative non invasive view over the expected and real microsurgical anatomy andvicinity of the interesting vascular and neural structures in all perspectives.

3. Discussion

CTA does not contain the relationships of aneurysmal components to the surrounding vessels and cranial nerves at the brainstem in vertebrobasilar aneurysms. The tiny relationships between vessels, brainstem and cranial nerves are depicted in high resolution with the application of MR-CISS sequence. It is possible to generate interactive, dynamic 3D representations based on the original MR-CISS data. A noninvasive technique of image processing such as the described 3D visualization should be essential for the planningof the surgical approach into the complex sites of vertebrobasilar aneurysms. One disadvantage of 3D visualization-which is not based on the 3D visualization by itself-includes pulsation artifacts around the large arteries as the basilar and vertebral arteries, which can aggravate detailed observation. Thus registration and image fusion of MR-CISS with MR-TOF (time of flight angiography) can compensate this problem. An accelerated image fusion of different MRI data such as MR-CISS with MR-TOF would lead to a maximally reachable result in the 3D visualization. This would be a great innovation in the surgical setup of aneurysm clipping to have a non invasive virtual neuroendoscopic tool that gives the surgeon the detailed individual anatomy. Intraoperative 3D visualization of the fused image data from MR-CISS and MR-TOF would support surgical planning, approach and clipping procedure.

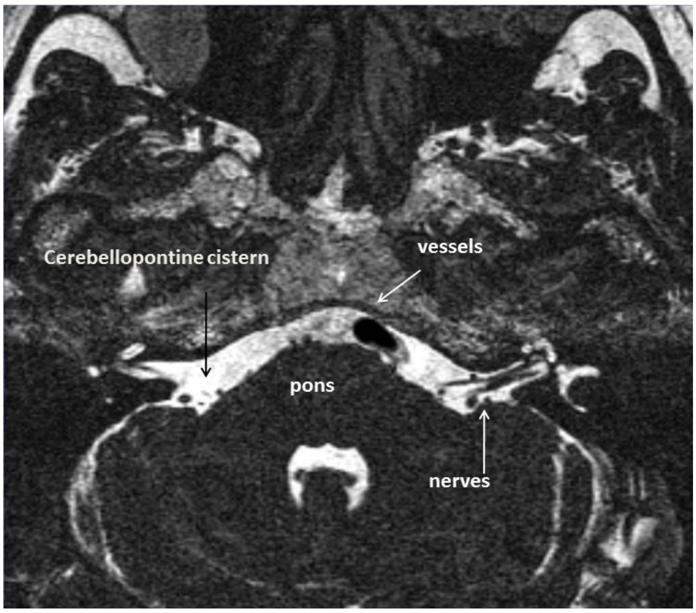

Figure 1. High-resolution T2 weighted isotropic MR CISS sequence (constructive interference in the steady state) with bright delineation of the CSF space containing the tiny vessels and corresponding cranial nerves. These sequences undergo semiautomatic segmentation and subsequent 3D visualization, s. **Figure 2**.

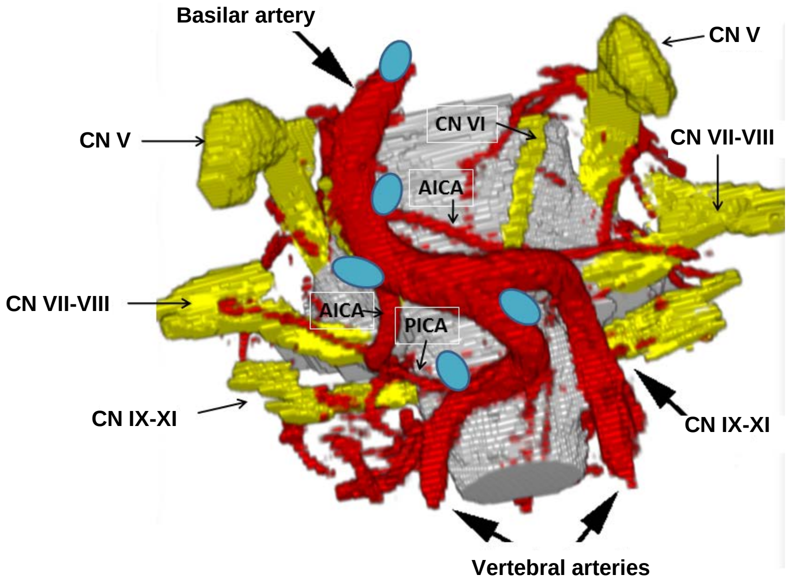

Figure 2. Interactive 3D visualization by direct volume rendering with detailed and real depiction of the individual neurovascular relationships in the posterior cranial fossa and representative aneurysm location sites in the posterior circulatation in bluish color (CN: cranial nerve, CN V: trigeminal nerve, CN VI: abducens nerve, CN VII: facial nerve, CN VIII: vestibulocochlear nerve, CN IX: glossopharyngeal nerve, CN X: vagus nerve, CN XI: accessory nerve, AICA: anterior inferior cerebellarartery, PICA: posterior inferior cerebellar artery).

Al Rhoton Jr. reports at the end of his manuscript [3]:

"The side for the suboccipital approach should be selected only after reviewing the angiogram, because aneurysms on one vertebral artery may lie on the side of the brainstem opposite the side of the vertebral artery from which it fills because of extreme turtuosity of these arteries."

Here one can see how difficult it can be to assess conventional angiograms without having any technical equipment to get a view over the individual neurovascular anatomy. We think that the concept of 3D visualization should be eligible to visualize intracranial aneurysms and their anatomical relationships (**Figure 2**). This can ensure planning and presurgical considerations for the approach to the site of the aneurysm. MR-CISS also delineates the distinct relationships between the optic nerve complex and surrounding arteries. An interactive 3D visualization of this information would show neurovascular relationships between possible aneurysms of the anterior communicating, anterior cerebral and internal carotid arteries and the optic nerve complex. We think that this concept would also contribute to teaching, neuroanatomical training and patient consultation.

4. Conclusion

We think that the 3D visualization of intracranial aneurysms with segmentation and direct volume rendering would generate a detailed anatomical delineation of the microsurgical relationships between aneurysms and adjacent topographical structures such as vessels and especially cranial nerves. This can contribute to a optimized noninvasive surgical planning, teaching and patient consultation.

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Abbreviations

MR-CISS: magnetic resonance imaging, constructive interference in the steady state; 3D: three-dimensional; CTA: computed tomography, angiography.