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Fortgeschrittene 3D-Visualisierung Neurovaskulärer Kompressionssyndrome

Advanced 3D-Visualization of Neurvascular Compression Syndromes

Peter Hastreiter[1]

[1]Neurocenter, Dept. of Neurosurgery, University of Erlangen-Nuremberg, Germany

Purpose

Neurovascular compression syndromes are caused by a pathological contact between vessels and the root entry or exit zone of cranial nerves. They are associated with a number of neurological diseases such as trigeminal neuralgia, hemifacial spasm, glossopharyngeal neuralgia and also to essential hypertension. The representation of all relevant structures is obtained with MRI using the strongly T2 weighted CISS sequence revealing high contrast between the vascular structures and the cerebrospinal fluid. In order to achieve an improved delineation of vessels, fusion with MR angiography was applied. Additionally, an approach of automatic 3D visualization and video generation based on predefined flight paths was leading to a standardized evaluation of the fused data.

Material & Methods

In all cases MR-FLAIR (Fluid Attenuated Inversion Recovery), MR-T2, MR-angiography (TOF: time of flight) and MR-CISS (Constructive Interference in the Steady State) data were acquired with a Siemens MR Magnetom Sonata 1.5 Tesla scanner. The MR-CISS and -TOF volumes consisted of 384x512x(62-128) voxels with an average size of 0,39x0,39x0,7 mm. For the MR-FAIR and MR-T2 datasets 408x512x23 voxels with a size of 0,45x0,45x6,0 mm were obtained.

A standard PC (Intel 2,4 GHz) with NVidia GeForce4 graphics card providing 128 Mbytes of graphics memory was used for the 3D visualization using direct volume rendering based on 3D texture mapping. The same platform was also applied for the remaining computations.

Aiming at an optimized spatial understanding of neurovascular compression syndromes, coarse structures of the MR CISS data were explicitly segmented with a semi-automatic strategy: (1) background, (2) CSF volume with all embedded vascular information, (3) cranial nerves, (4) brainstem. Then, the segmented subvolumes were attributed with specific masks of different tags ensuring unambiguous differentiation with direct volume rendering. Additionally, vascular structures in MR-TOF were labeled. In order to treat critical locations and to improve the level of detail within the MR-CISS data, the grey value and mask information from MR-TOF volumes were selectively integrated after hardware accelerated rigid registration based on mutual information. Thereafter, we used a new approach of automatic direct volume rendering supporting efficient standardized visualization of the target structures.

Results

Having performed pre- and postoperative 3D analysis of NVC syndromes in more than 150 ases the presented approach was so far applied in 44 cases (27 patients with trigeminal neuralgia, 5 patients with hemifacial spasm and 12 patients with hypertension). In all cases, meaningful 3D visualizations for the comprehensive analysis of neurovascular compression syndromes was provided demonstrating the brainstem, the small vessels (PICA, AICA, SCA) and the cranial nerves. The necessary time for the entire procedure of the presented approach ranges from 3-4 hours. Thereby, fusion with MR-TOF reduced the time-consuming segmentation of MR-CISS data to 2-3 hours.

Conclusion

The presented approach contributes significantly to an optimized 3D understanding of vascular compression syndromes. Overall, this strategy is robust and comparatively fast showing its usefulness for clinical application.