Volumetric segmentation

Volumetric segmentation of subcortical structures, such as the basal ganglia and thalamus, is necessary for noninvasive diagnosis and neurosurgery planning. This is a challenging problem due in part to limited boundary information between structures, similar intensity profiles across the different structures, and low contrast data.

Volumetric assessment of meningiomas represents a valuable tool for treatment planning and evaluation of tumor growth as it enables a more precise assessment of tumor size than conventional diameter methods. This study established a dedicated meningioma deep learning model based on routine magnetic resonance imaging (MRI) data and evaluated its performance for automated tumor segmentation.

The MRI datasets included T1-weighted/T2-weighted, T1-weighted contrast-enhanced (T1CE) and FLAIR of 126 patients with intracranial meningiomas (grade I: 97, grade II: 29). For automated segmentation, an established deep learning model architecture (3D deep convolutional neural network, DeepMedic, BioMedIA) operating on all four MR sequences was used. Segmentation included the following two components: (i) contrast-enhancing tumor volume in T1CE and (ii) total lesion volume (union of lesion volume in T1CE and FLAIR, including solid tumor parts and surrounding edema). Preprocessing of imaging data included registration, skull stripping, resampling, and normalization. After training of the deep learning model using manual segmentations by 2 independent readers from 70 patients (training group), the algorithm was evaluated on 56 patients (validation group) by comparing automated to ground truth manual segmentations, which were performed by 2 experienced readers in consensus.

Of the 56 meningiomas in the validation group 55 were detected by the deep learning model. In these patients the comparison of the deep learning model and manual segmentations revealed average dice coefficients of 0.91 ± 0.08 for contrast-enhancing tumor volume and 0.82 ± 0.12 for total lesion volume. In the training group, interreader variabilities of the 2 manual readers were 0.92 ± 0.07 for contrast-enhancing tumor and 0.88 ± 0.05 for total lesion volume.

Deep learning-based automated segmentation yielded high segmentation accuracy, comparable to manual interreader variability [1)].

Manual segmentation

see Manual segmentation.

1)
Laukamp KR, Pennig L, Thiele F, Reimer R, Görtz L, Shakirin G, Zopfs D, Timmer M, Perkuhn M, Borggrefe J. Automated Meningioma Segmentation in Multiparametric MRI : Comparable Effectiveness of a Deep Learning Model and Manual Segmentation. Clin Neuroradiol. 2020 Feb 14. doi: 10.1007/s00062-020-00884-4. [Epub ahead of print] PubMed PMID: 32060575.