Voxel-based morphometry

Voxel-based morphometry (VBM) is a neuroimaging technique that investigates focal differences in brain anatomy. The core process of VBM is segmenting the brain into grey matter, white matter, and cerebrospinal fluid, warping the segmented images to a template space and smoothing.

Thereafter, statistical analysis is performed on the basis of the general linear model. Although the basis of VBM is constant, the algorithm has been changed. Classical VBM simply employed anatomical normalization, segmentation, and smoothing. This changed to optimized VBM, which normalized the brain using parameters derived from grey matter image normalization, cleaned up non-brain tissue images, and utilized Jacobian modulation. Further, a unified segmentation-a probabilistic framework that enables image registration, tissue classification, and bias correction to be combined within the same generative model-was introduced. The DARTEL algorithm then improved the accuracy of image registration. Currently, researchers can use an extension of unified segmentation with some features such as an improved registration model, an extended set of tissue probability maps, or a more robust initial affine registration. Those who utilize VBM must pay attention to the choice of the VBM algorithm, as data interpretation differs with each algorithm [1)]

<html><iframe width="560" height="315" src="https://www.youtube.com/embed/F6-HbSMjZ6I" title="YouTube video player" frameborder="0" allow="accelerometer; autoplay; clipboard-write; encrypted-media; gyroscope; picture-in-picture" allowfullscreen></iframe></html>

Dos Santos Silva Jet al. compared the accuracy of three volumetric methods in the radiological assessment of meningiomas: linear (ABC/2), planimetric, and multiparametric machine learning-based semiautomated voxel-based morphometry (VBM), and to investigate the relevance of tumor shape in volumetric error.

They included patients with a confirmed diagnosis of meningioma and preoperative cranial magnetic resonance imaging eligible for volumetric analyses. After tumor segmentation, images underwent automated computation of shape properties such as sphericity, roundness, flatness, and elongation.

Sixty-nine patients (85 tumors) were included. Tumor volumes were significantly different using linear (13.82 cm3 [range 0.13-163.74 cm3]), planimetric (11.66 cm3 [range 0.17-196.2 cm3]) and VBM methods (10.24 cm3 [range 0.17-190.32 cm3]) ($p < 0.001$). Median volume and percentage errors between the planimetric and linear methods and the VBM method were 1.08 cm3 and 11.61%, and 0.23 cm3 and 5.5%, respectively. Planimetry and linear methods overestimated the actual volume in 79% and 63% of the patients, respectively. Correlation studies showed excellent reliability and volumetric agreement between manual- and computer-based methods. Larger and flatter tumors had greater accuracy on planimetry, whereas less rounded tumors contributed negatively to the accuracy of the linear method.

Semiautomated voxel-based morphometry (VBM) for meningiomas is not influenced by tumor shape properties, whereas planimetry and linear methods tend to overestimate tumor volume. Furthermore, it is necessary to consider tumor roundness prior to linear measurement so as to choose the most appropriate method for each patient on an individual basis [2)]

Topographic analysis using voxel-based morphometry (VBM) provides useful information for differentiating PCNSL from Glioblastoma [3].

Patients with untreated Cushing's disease show a significant reduction of gray matter in the cerebellum and hippocampus. These changes can be analyzed and objectified with the quantitative voxel-based method [4].

1)
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2)
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3)
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4)
Burkhardt T, Lüdecke D, Spies L, Wittmann L, Westphal M, Flitsch J. Hippocampal and cerebellar atrophy in patients with Cushing's disease. Neurosurg Focus. 2015 Nov;39(5):E5. doi: 10.3171/2015.8.FOCUS15324. PMID: 26646929.