Imaging The Human Brainstem In Vivo: Techniques and Applications

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The human brainstem is a densely packed, complex but highly organised structure. It not only serves as a conduit for long projecting axons conveying motor and sensory information, but also is the location of multiple primary nuclei that control or modulate a vast array of functions, including homeostasis, consciousness and reflexive behaviours. These include the specialised neuromodulatory systems (dopaminergic, serotonergic, cholinergic, and noradrenergic), that are involved in a range of widely studied processes such pain, reward and arousal. Additionally there is now emerging evidence for the early involvement of brainstem nuclei in several neurodegenerative disorders, such as Parkinson's, Alzheimer's and Motor Neuron Disease, which precede the traditionally recognised clinical syndromes by many years. Despite its importance in understanding normal brain function and neurodegenerative processes, it remains sparsely studied in the neuroimaging literature. In part, this is due to the difficulties in imaging the internal architecture of the brainstem in vivo in a reliable and repeatable fashion.

In recent years there have been considerable advances in non-invasive in vivo brainstem imaging. Novel sequences have emerged that enable increasing levels of detail to be captured, and strategies developed to tackle the technical problems for both for fMRI and structural imaging. Furthermore, improvements in pre-processing and analytical methods now allow detailed functional and quantitative structural analysis in vivo.

The aim of this symposium is to provide an overview into brainstem functional systems and pathology, with a focus on the optimised design of MRI studies that are applicable to both 3T and 7T systems.

Learning Objectives:

1. To characterise the challenges of imaging the human brainstem in vivo, and describe potential methods available to address these known issues.
2. To demonstrate the techniques and applications of fMRI brainstem analysis.
3. To demonstrate approaches for quantitative structural analysis of the brainstem in vivo at 3T and 7T..

Functional imaging of the brainstem: problems and solutions
Jonathan Brooks, PhD, CRiCBristol, University of Bristol, Bristol, United Kingdom

Multimodal quantitative analysis of the Human Brainstem at 3T: Methods and Applications
Christian Lambert, MD/PhD, St Georges University of London, Stroke and Dementia Research Group London, United Kingdom

Resting-state functional connectivity of brainstem nuclei
Florian Beissner, Somatosensory and Autonomic Therapy Research, Hannover Medical School, Hannover, Germany

Quantitative Susceptibility Mapping: A New Contrast for High-Resolution MR Imaging of the Human Brain and Brainstem
Jürgen Reichenbach, Medical Physics Group, Institute of Diagnostic and Interventional Radiology 1, Jena University Hospital, Jena, Germany