An Atlas of Brainstem Connectomes from HCP Data

Presented During: Poster Session
Tuesday, June 27, 2017: 12:45 PM - 02:45 PM

Stand-By Time
Tuesday, June 27, 2017: 12:45 PM - 2:45 PM

Submission No:
1653

Submission Type:
Abstract Submission

On Display:
Monday, June 26 & Tuesday, June 27

Authors:
Yuchun Tang1,2, Wei Sun1, Arthur Toga1, John Ringman3, Yonggang Shi1

Institutions:
1Laboratory of Neuro Imaging, USC Stevens Neuroimaging and Informatics Institute, Los Angeles, CA, 2School of Basic Medical Sciences, Shandong University, Jinan, China, 3Department of Neurology, Keck School of Medicine of USC, Los Angeles, CA

First Author:
Yuchun Tang - Lecture Information | Contact Me
Laboratory of Neuro Imaging, USC Stevens Neuroimaging and Informatics Institute|School of Basic Medical Sciences, Shandong University
Los Angeles, CA|Jinan, China

Introduction:
The brainstem contains many critical structures but is a challenging area to study with neuroimaging (Alberto: 12). It holds the reticular activating system and is the primary relay center for efferent and afferent connections between the cerebral cortex, spinal cord, and cerebellum (Nolte: 2008). Fiber pathways in the brainstem are critically important for sensory and motor functions, and connect nuclei implicated in the pathogenesis of a wide spectrum of neurological disorders (Manisha:13). Although studies using two-dimensional histological sections and staining methods have been performed to investigate the anatomy of the brainstem (Haines:12), the orientation and three-dimensional anatomical locations of individual tracts, and their spatial positions relative to adjacent pathways are difficult to comprehend. The development of modern imaging techniques and fiber tracking methods facilitate the exploration of the three-dimensional imaging and detailed delineation of the brainstem tracts in vivo (Antonio:16). Using cutting-edge imaging data from the Human Connectome Project (HCP), we propose a novel protocol to generate a total of 29 major tracts in the brainstem and construct a comprehensive population-based probabilistic atlas of brainstem connectivity. Our results will be helpful for the understanding of neuroanatomy of the brainstem, and the pathogenesis of neurological disorders.

Methods:
High quality diffusion imaging data of twenty subjects with minimal susceptibility distortion were selected from the HCP (Van Essen: 12). We reconstructed the brainstem tracts and built a probabilistic tractographic atlas of the brainstem connections. Firstly, the fiber orientation distributions (FODs) were computed using our novel algorithm for analyzing multi-shell HCP data (Tran: 15). Secondly, tract labels were drawn by two experienced neuroscientists, T1- and T2-weighted MR images as well as histological sections were used to assist the labels of region of interest (ROI) and interpretations of tract locations and trajectories. FOD-based probabilistic tractography was then performed to reconstruct the brainstem tracts after positioning the ROI in agreement with the known course of each tract. The tract density image (TDI) (Calamante: 10) of all tracts were warped to the standard MNI152 space using the ANTS software for atlas construction. For each bundle, the warped TDI was normalized and averaged across the 20 subjects to calculate its probabilistic atlas in the MNI152 space.

Results:
For each subject, we reconstructed 29 bundles of the major brainstem pathways. They can be schematically divided into three groups: 1. The major motor tracts running principally on the ventral surface of the brainstem(Fig.1a), including the corticospinal tract (CST), the frontopontine tract (FPT) and the parietooccipitotemporo-pontine tract (POTPT). 2. The cerebellar peduncle(Fig.1b), including the superior...
cerebellar peduncle (SCP) which was mainly composed of the anterior spinocerebellar tract (SCPSCT), the cerebellorubral tract (SCPCRT) and the cerebellothalamic tract (SCPCRTT and SCPCRTT), the middle cerebellar peduncle (MCP) and the inferior cerebellar peduncle (ICP), which was mainly composed of the posterior spinocerebellar tract (ICPSCT), the olivocerebellar tract (ICPOCT) and the vestibulocerebellar tract (ICPVCT). 3. The major sensor tracts (Fig. 1c), including the medial lemniscus (ML), the trigeminothalamic tract (TTT), the spinothalamic tract (STT), and the lateral lemniscus (LL). The probabilistic atlas from a subset of reconstructed brainstem bundles were overlaid on the MNI152 space and plotted in Fig. 2.

![Brainstem bundles](https://ww5.aievolution.com/hbm1701/index.cfm?do=abs.viewAbs&abs=2419)

**Figure 1.** Brainstem bundles generated in our study. (a) The major motor tracts including CST, FPT and POTPT. (b) The anterior view of the three cerebellar peduncles: SCP, MCP and ICP. (C) The lateral view of major sensory tracts including ML, TTT, STT and LL.
Figure 2. The probabilistic atlases of some selected tracts are shown in the standard MNI coordinate space. For all the tracts except MCP, left tracts are shown in red and right ones are shown in green.

Conclusions:

The tractography and definition of these tracts are helpful not only for exploring the neuroanatomy of the brainstem from imaging data, but can also contribute to the understanding of the pathogenesis of neurological disorders and for planning neurosurgical approaches.

Informatics:

Brain Atlases

Neuroanatomy:

White Matter Anatomy, Fiber Pathways and Connectivity

Poster Session:

Poster Session - Tuesday
Keywords:

Brainstem
Tractography
White Matter
WHITE MATTER IMAGING - DTI, HARDI, DSI, ETC

1/2 Indicates the priority used for review

Would you accept an oral presentation if your abstract is selected for an oral session?

Yes

I would be willing to discuss my abstract with members of the press should my abstract be marked newsworthy:

Yes

Please indicate below if your study was a "resting state" or "task-activation" study.

Other

By submitting your proposal, you grant permission for the Organization for Human Brain Mapping (OHBM) to distribute the presentation in any format, including video, audio print and electronic text through OHBM OnDemand, social media channels or other electronic media and on the OHBM website.

I accept

Healthy subjects only or patients (note that patient studies may also involve healthy subjects):

Healthy subjects

Internal Review Board (IRB) or Animal Use and Care Committee (AUCC) Approval. Please indicate approval below. Please note: Failure to have IRB or AUCC approval, if applicable will lead to automatic rejection of abstract.

Yes, I have IRB or AUCC approval

Please indicate which methods were used in your research:

Structural MRI
Diffusion MRI

For human MRI, what field strength scanner do you use?

3.0T

Which processing packages did you use for your study?

FSL
LONI Pipeline
Free Surfer

Provide references in author date format

Alberto, P.G. (2012), 'Functional Anatomy of Subcortical Circuits Issuing from or Integrating at the Human Brainstem', Clinical Neurophysiology, vol. 123, no.1, pp. 4-12