Functional Identification of Primary Motor Area by Corticospinal Tractography

Essay

Submitted for Partial Fulfillment of Master Degree in Radiodiagnosis

By Marwa Mohamed Mohamed Al-gerza

M B, B Ch
Faculty of Medicine
Tanta University

Supervised By

Prof. Dr. Mervat Tawfik Tantawy

Professor of Radiodiagnosis Faculty of Medicine Ain Shams University

D. Hossam Moussa Sakr

Lecture of Radiodiagnosis
Faculty of Medicine
Ain Shams University



Faculty of Medicine Ain-Shams University 2009

التعرف الوظيفى على المركز الحركى الأولى باستخدام تقنية التصوير للسبيل القشرى النخاعى

بحث

توطئة للحصول علي درجة الماجستير في الأشعة التشخيصية

مقدم من الطبيبة مروة محمد محمد الجرزة بكالوريوس الطب والجراحة كلية الطب – جامعة طنطا

تحت إشراف

أد ميرفت توفيق طنطاوي

أستاذ الأشعة التشخيصية كلية الطب- جامعة عين شمس

د. حسام موسى صقر

مدرس الأشعة التشخيصية كلية الطب- جامعة عين شمس



كلية الطب جامعة عين شمس

7..9



Acknowledgement



First, and foremost, all thanks and gratitude to **GOD**, most gracious and most merciful, for every thing especially for giving me the greatest gift in my life my cute daughter Maryam and for helping me in my steps I have been taking in my career.

I would like to express my deepest gratitude and sincere thanks to *Prof. Or.* Mervat Tawfik Tantawy, Professor of Radiodiagnosis, Faculty of Medicine-Ain Shams University for devoting much of her precious time, kind guidance and valuable advice for enriching this work. Her well known support goes beyond any evaluation.

I am extremely grateful to **Or. Hossam Moussa Sakr**, Lecture of Radiodiagnosis, Faculty of Medicine-Ain Shams University for his continuous guidance and valuable suggestions, saving no effort or time to read every word in this work.

Lastly but not least, I would never be able to thank my family enough, especially my parents, their encouragement motivated me much to proceed successfully in my study. Their inspiration shines through on each page of this study.

I deeply appreciate the sincere help of my dear husband for his patience, encouragement and great help to finish this work.



Contents

Subject	Page
Introduction	1
Aim of the work	3
• Structural and functional anatomy of the cerebrum.	4
• Imaging of functional brain activity	38
• Technique of corticospinal tractography	74
MR tractography manifestations of corticospinal tract affection	103
Summary and Conclusion	171
References	176
Arabic Summary	79

List of Figures

Fig.	Title	Page
1	The lateral aspect of the left cerebral hemisphere indicating the major gyri and sulci	10
2	Cadaveric specimen of the left cerebral hemisphere	11
3	Sagittal section of the brain, with the brain stem removed, showing the medial aspect of the left cerebral hemisphere	13
4	Cadaveric specimen of the brain, with the brain stem removed, showing the medial aspect of the right cerebral hemisphere	14
5	Basal aspect of the brain.	16
6	The corticospinal tract	18
7	Motor areas (primary, premotor and supplementary areas) viewed on the medial and lateral hemispheric surfaces	29
8	Virtual reconstructions of nerve fiber tracts crossing the corpus callosum in the human brain. The data have been obtained by diffusion-weighted MRI followed by fiber tractography	30
9	PET Image of the human brain showing energy consumption	40
10	PET scans detect the highest blood flow and glucose flow in the brain during certain activities.	41
11	A simple example for SPECT imaging	43
12	SPECT images of different brain surfaces showing different brain activities	44
13	Entrance to Magnetically Shielded Room (MSR), showing the separate shielding layers	53
14	Image of fMRI showing blood flow through the brain	62
15	Neuronal pathways identified by diffusion tensor imaging	68
16	Diffusion tensor imaging (DTI) data has been used to seed various tractographic assessments of this patient's brain	70
17	Fiber tracts from six segments of the corpus callosum providing interhemispheric linkage between specific cortical regions	73

Fig.	Tītle	Page
18	Axial tractographic image demonstrates white-matter tracts in the brain in the left-right (red), anterior-posterior (green), and superior-inferior (blue) directions	80
19	Multiple regions of interest are used with the FACT algorithm to delineate the corticospinal tract in addition to the internal capsule and cerebral peduncle regions	86
20	Isolation of corticospinal tract (CST) on diffusion tensor imaging tractography	90
21	(A and E) Comparison of histological findings, (B and F) drawings, (C and G) DTI-based gray maps, (D and H) DTI color maps showing the midbrain and the pons	94
22	MRI scans showing the results of tract tracking superimposed on the three dimensional T1-weighted images using colored tracts	96
23	Transverse and sagittal T1-weighted MRI scans. (A) of 50 years old male patient with right parietal cavernous haemangioma and (B) of 74 years old female patient with glioblastoma in the parieto-occipital lobe. The corticospinal tractography indicates the location of the CS (white arrows) and PMA.	98
24	ROIs were placed at 5 different locations along the primary motor cortex to depict the different fiber tracts of the pyramidal tract	105
25	Locations of the ROIs for corticospinal tract (CST) on two axial slices (a and c) and their locations in the mid-sagittal slice (b and d)	105
26	Showing the course of the corticospinal tract. A, Illustration. B, Coronal directional DTI map. C, Tractogram	106
27	Typical pattern of somatotopic organization of corticospinal tracts at cerebral peduncle	108
28	Intermixing of fibers from lateral regions of interest	109
29	(A-F) corticospinal tract displacement by tumor	113
30	A 23-years old male with ganglioglioma in the right thalamus. A well-demarcated hypointense tumor mainly in the right thalamus with mild, ring-like Gd- DTPA enhancement. In addition to Diffusion-tensor imaging-based tractography data demonstrated that the CST was adjacent to the tumor and slightly shifted anteriorly	114

Fig.	Title	Page
31	The previos patient A: Diffusion-tensor imaging—based tractography data indicating that the CST has shifted anteriorly. B: Three-dimensionally reconstructed CST voxels clearly demonstrating the CST profiles in both hemispheres	115
32	The patient postoperative T2-weighted MR images with the superimposed CST demonstrating that the preserved CST remains anterior to the tumor cavity	115
33	DTI: normal anisotropy, abnormal location or orientation. (A) T2-weighted MR image, (B) contrast- enhanced T1-weighted image, (C) directional maps in axial and (D) coronal planes, and (E) coronal tractogram of bilateral corticospinal tracts	116
34a	An invading brain stem lesion that extends to the right cerebellar hemisphere through the middle cerebellar peduncle in a 40-year-old man who presented with left sixth cranial nerve palsy	118
34b	Tractography (G, H) demonstrate that the main brain stem fiber tracts are preserved.	119
35	A non-enhancing hyper-intense on T2WI insular anaplastic astrocytoma lesion in a 56-year-old man	120
36	(A, B) An expansive and infiltrating lesion in a 73-year-old man with left hemiparesis and seizures, with the diagnosis of glioblastoma multiform. (C, D) Coronal DTI-FA maps show that the lesion dislocates and infiltrates the CST and the SLF	122
37	A 57-year-old man with glioblastoma multiforme presented with right hemiparesis and seizures show dislocation and disruption of the main fiber tracts, such as the anterior and posterior portions of the internal capsule and the SLF	124
38	(A-C) Complete corticospinal tract disruption with a focal mass lesion in the left corona radiata and basal ganglia	125
39	Automated fiber tracking reconstruction results in brain tumor patients	125
40	(A, B) Tracts traversing through edema. DTI in a patient with a large right frontal lobe mass lesion (glioblastoma multiforme) seen on a T2W axial image	126

Fig.	Title	Page
41	Orthogonal axial/coronal (A) and axial (B) projection of T1-weighted MR images with fiber tracts depicted in color in the healthy volunteer. (C) The results are shown from conventional DT tractography (in orange) as well as from fMRI-based fiber tracking with region-of-interest placement in the PMA	128
42	Tracking was initiated in the motor cortex within the fMRI-evoked seed areas. The reconstructed fibers correspond to the left and right cortico-spinal connections.	129
43	Orthogonal axial/sagittal projection of a T1-weighted MR image with overprojection of the hand PMA and the hand fibers of the CST	130
44	A 50 years old male with right hemiparesis and headache (a) Axial T2-W image shows a large parenchymal haematoma at the level of left basal ganglia. (b): DTI-based colour map with MR tractography shows preservation of the left corticospinal tract which is displaced by mass effect from the haematoma.	135
45	A 56 years old female with right hemiparesis (a) DWI shows left cortical and subcortical chronic infarction. (b) MR tractography shows the full extent of the left corticospinal tract	135
46	A 73 years old male with right hemiparesis and dementia (a) DWI shows a large chronic infarction in the left middle cerebral artery distribution. (b) MR tractography shows complete disruption of left corticospinal tract.	136
47	Tractography-based reconstruction of the corticospinal tract (CST) in patient showing relation between structural integrity and functional reorganization after stroke	137
48	Axial images in a 14-year-old female who suffered a left middle cerebral artery stroke	139
49	DTI in periventricular white matter injury	141
50	Mean normalized FA for each ROI for the mild traumatic brain injury (MTBI) and moderate to sever traumatic bran injury (M/STBI)	146
51	Mean normalized axial (λII) and radial (λ^{\perp}) diffusivity for the MTBI and M/STBI.	147

Fig.	Title	Page
52	Cortical dysplasia in a 22-year-old woman with motor seizure disorder of the left hand	151
53	Heterotopia in an 18-month-old girl with delayed development	153
54	An 8-month-old girl with alobar holoprosencephaly	157
55	A 1-month-old boy with semilobar holoprosencephaly	158
56	Transverse color maps derived from diffusion tensor MR imaging at the level of the pons in patients with lobar (left), semilobar (middle), and alobar (right) holoprosencephaly	159
57	Cerebral palsy in a 6-year-old boy with spastic quadriplegia and periventricular leukomalacia	161
58	Cerebral palsy in a 20-month-old girl with spastic hemiplegia	162
59	Transverse images obtained from a 62 years old woman show findings of hypertensive intracerebral haemorrhage at the right basal ganglia and thalamus	164
60	Transverse images obtained from a 32 years old woman show findings of hypertensive intracerebral haemorrhage at the left basal ganglia on a gradient echo image of magnetic resonance	165
61	A 23-year-old right-handed woman presented with complete paralysis of the right extremity at the onset of a spontaneous ICH. (a) T2-weighted images showing a hematoma in the left cerebral peduncle. (b) T2-weighted images showing a haematoma in the left mid to lateral portion of the cerebral peduncle.	166
	(c) Results of 3-D diffusion tensor tractography of the previous patient	167
62	CST in normal volunteers and ALS patients	169
63	Tractography in (a) a patient with amyotrophic lateral sclerosis and (b) a healthy subject.	170

List of Tables

Table	Title	Page
1	Different modalities used in functional brain imaging	60

List of Diagrams

Diagram	Title	Page			
1	Schematic drawing showing the topographic representation of different body parts in the motor cortex.	25			
2	Schematic drawing showing Broadmann's functional areas on the medial and lateral surfaces of the brain	34			
3	Showing photomultiplier tubes surrounding the head	47			
4	Showing one second of EEG singal of normal brain activity	49			
5	Showing EEG alpha waves	49			
6	Showing EEG beta waves	49			
7	Showing EEG sensorimotor rhythm (Mu rhythm)				
8	Showing generation of the magnetic field of the brain				
9	fMRI BOLD overview.				
10	Showing neuronal activity lead to overcompensation for oxygen consumption by local blood flow, oxygen level in arterial blood is elevated, larger MR signal	59			
11	Showing isotropic diffusion in free fluids or gray matter	77			
12	Showing diffusion ellipsoids. Defining an ellipsoid using the eigen-values of the diffusion tensor as half-diameters reveals a spherical appearance	78			
13	Showing diffusion ellipsoid. Three eigenvectors are demonstrated, with the principal eigenvector along the Z direction	79			
14	Schematic demonstrating the FACT algorithm	86			