The role of white matter tractography imaging in predicting the outcome of stroke patients.

A Thesis
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By

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Abstract

Background: Stroke can affect any part of the CNS leading to a wide variety of symptoms depending on the area that is involved. Diffusion Tensor tractography (DTI) is an emerging neuroimaging technique that allows us to measure the integrity of white matter tracts. . **Objectives**: to find out if brain imaging using DTI technique could help in predicting the functional outcome following stroke. **Subjects and methods:** Forty patients with acute ischemic stroke and another ten normal subjects were studied with DTI. Corticospinal tracts (CST) and fractional anisotropy (FA) of region of intrest (ROI) were identified. Patients were assessed on admission and after 3 months with both NIHSS and MRC scales. We categorized our patients according to the pattern of CST involvement, degree of FA reduction and according to the clinical scales**. Results:** FA reduction was correlated with both (MRC & NIHSS) on admission and after 3 months ($p<0.001$& $p=0.004$) ($p<0.001$ & $p=0.013$) , respectively. The pattern of CST involvement was associated with NIHSS and MRC after 3 months ($p=0.035$ & 0.001) respectively. **Conclusion:** DTI could be used as a useful tool for predicting long term post stroke disability.

(Key Words: Stroke, infarct, DTI, FA, MRC, prognosis, and weakness**).**

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List of Abbreviations

ACA: Anterior Cerebral Artery
ADC: Apparent Diffusion Coefficient
BA: Basilar Artery
CBF: Cerebral Blood Flow
CBF: Cerebral Blood Flow
CBV: Cerebral Blood Volume
CHD: Coronary Heart Disease
CHF: Congestive Heart Failure
NMDA: N methyl D aspartate
cm2 : centimeter squared
CRP :C reactive protein
CST: Corticospinal tract
CT: Computerized Tomography
CTA: CT Angiography
DBP: Diastolic Blood Pressure
DTI: Diffusion Tensor Imaging
DWI : Diffusion Weighted Imaging
FA map: Fractional Anisotropy map
FT: Fiber Tractography
HbA1c: Glycated Hemoglobin
Hcy: Homocysteine
HDL: High Density Lipoprotein
ICA: Internal Carotid Artery
IFOF: inferior fronto occipital fasiculus
LDL : Low Density Lipoprotein
MCA: Middle Cerebral Artery
MC: Motor cortex
MELAS: Mitochondrial Encephalopathy, Lactic Acidosis, and Stroke like episodes
MI: Myocardial Infarction
MRA: Magnetic Resonance Angiography
MRC: Medical Research Council
MRI : Magnetic Resonance Imaging
MTT: the mean transit time
NIHSS: National Institute of Health Stroke Scale
PCAs: Posterior Cerebral Arteries
PICA: Posterior Inferior Cerebellar Artery

PLIC: Posterior limb of internal capsule
PSH : Post stroke hyperglycemia
PWI: Perfusion Weighted Imaging
ROI: Region Of Intrest
rTPA: recombinant tissue plasminogen activator
SBP: Systolic Blood Pressure
tHcy: Homocysteine
TIAs : Transient Ischemic Attacks
TOF: Time of Flight
TTP: time-to- peak
WD: Wallerian degeneration

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Introduction

Stroke is one of the leading causes of death worldwide. It can be further divided into ischemic or hemorrhagic ***(Neil and Hakan, 2010)***. There are multiple risk factors that may lead to stroke these risk factors include age, sex, smoking, hypertention, hyperlipidemia, DM, genetics and hereditary blood disorders ***(Jacqueline et al., 2005)***. Stroke can affect any portion of the CNS leading to a wide variety of symptoms depending on the part that is involved ***(Virginia et al., 2006)***.

Disability affects many of stroke survivors enough to decrease their employability. Stroke can affect people physically, mentally, emotionally, or a combination of the three. The results of stroke vary widely depending on size and location of the lesion. Dysfunctions correspond to areas in the brain that have been damaged ***(Caroline et al., 2006).***

Being the importance to predict the outcome following stroke, many authors were relying on the size of the infarction on MRI but recently with the emergence of MRI tractography many suggest the location of infarction rather than its size to predict the prognosis following stroke ***(Maija et al., 2010)***.

Diffusion tensor imaging (DTI) is an MRI technique for evaluating brain structure by measuring tissue water diffusion in 3-dimensional (3-D) space. Diffusion tensor tractography (DTT) noninvasively visualizes the course of major white matter tracts which normally shows anisotropic diffusion in contrast to the grey matter thus DTI technique can be used to detect long patterns of orientation as well as integrity of white matter tracts ***(Paulo et al., 2007)***. In addition, it provides information about the course, the compression, displacement or interruption of white matter tracts in three dimensions thus it can be used to detect the prognosis following stroke ***(Jingsong et al., 2011).***

Aim of work

To find out if brain imaging using diffusion tensor tractography technique could help in predicting the functional outcome following stroke.

Chapter 1

Vascular anatomy and Pathophysiology of ischemic stroke

Stroke is an abrupt disruption in cerebral circulation causing neurological deficits. It is mostly due to ischemia or intracranial hemorrhage ***(Frizzell, 2005).***

Stroke is classically defined as rapidly developing clinical signs of focal disturbance of brain function lasting more than 24 hours or leading to death with no apparent cause other than that of vascular origin ***(Elkind, 2006).*** Eighty per cent of strokes are ischemic, 15% are due to intracerebral haemorrhage, and 5% to subarachnoid hemorrhage ***(Wardlaw & Farrall, 2004; Van der Worp & Van Gijn, 2007).***

Stroke ranks second after ischemic heart disease as a cause of lost disability in high-income countries and as a cause of death worldwide ***(Lopez et al., 2006).***

Acute stroke is typically characterized by the sudden onset of a focal neurologic deficit, though some patients have a stepwise or gradual progression of symptoms. Common deficits include dysphasia, dysarthria, hemianopia, weakness, ataxia, sensory loss, and neglect ***(Van der Worp & Van Gijn, 2007).***

Cerebral infarction is focal brain necrosis due to complete and prolonged ischemia that affects all tissue elements, neurons, glia, and vessels ***(Agamanolis, 2006)***. However, clinically the term infarction describes a clinical diagnosis of observed loss of neurologic function due to ischemia following acute loss of circulation ***(Jauch et al., 2007).***

Lacunar infarction results from occlusion of the small penetrating arteries at the base of the brain, including the lenticulo- striate and thalamo perforating arteries. They are smaller infarcts(less than 1 cm) and are found in the basal ganglia, thalamus and brainstem ***(Hesselink, 2006).***

Vascular anatomy:

The anterior circulation of the brain describes the areas of the brain supplied by the right and left internal carotid arteries and their branches. The internal carotid arteries supply the majority of both cerebral hemispheres, except the occipital and medial temporal lobes, which are supplied from the posterior circulation. Ischemic strokes occurring in the anterior circulation are the most common of all ischemic strokes, accounting for approximately 70% of all cases ***(Baird, 2006) (Fig. 1).***

The bifurcation of the common carotid artery leads to the internal and external carotids. The internal carotid artery (ICA) further branches into the ophthalmic artery, posterior communicating artery, and anterior choroidal artery. The internal carotid ends by dividing the middle cerebral artery (MCA) and the anterior cerebral artery (ACA). The MCA is the largest intracerebral vessel, supplying the lateral aspect of frontal, parietal, and temporal lobes and the basal ganglia. The ACA supplies the medial part of the frontal and parietal lobes, most of the corpus callosum, the frontobasal cerebral cortex, deep structures, and the anterior diencephalon. The anterior choroidal artery supplies the part of the thalamus not supplied by the posterior circulation and the posterior limb of the internal capsule ***(Baird, 2006).***

The posterior circulation is comprised of the vertebral arteries which arise from the subclavian arteries, and as they course in the neck, they enter deep to the transverse process of the level of the 6th cervical vertebrae (C6). Then they ascend in the transverse foramen of each cervical vertebra the vertebral arteries travel across the posterior arch of C1 and through the suboccipital triangle before entering the foramen magnum.They enter the skull through the foramen magnum and merge at the pontomedullary junction to form the basilar artery (BA). Each vertebral artery usually gives off the posterior inferior cerebellar artery (PICA). At the top of the pons, the basilar artery divides into the posterior cerebral arteries (PCA) and the superior cerebellar arteries just inferior to the pituitary stalk. From the basilar artery arises the anterior inferior cerebellar artery (supplying the superior and inferior aspects of the cerebellum), as well as smaller branches for the supply of the pons (the pontine branches). ***(Kaye & Brandstater, 2008).***

The PCA supplies the occipital and medial temporal lobes of the cerebral hemispheres and parts of the midbrain, subthalamic nucleus, basal nucleus, thalamus, mesial inferior temporal lobe, and occipitoparietal cortices. The two main branches of the PCA are connected by the posterior communicating artery ***(Hewko, 2004).***

The anterior and posterior circulation at the base of the brain are connected by the circle of Willis ***(Hewko, 2004).***

The circle of Willis consists of a vascular communication of blood vessels at the base of the brain connecting the anterior and posterior circulations. The vessels of the anterior circulation are connected via the posterior communicating arteries to the posterior circulation ***(Baird, 2006) (Fig. 1).***