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MR Spectroscopy of the Brain in Cases of Carotid Artery Stenosis

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ABSTRACT

Background: stenosis or occlusion of the internal carotid artery (ICA) causes a reduction in arterial pressure distal to the stenosis or occlusion. This reduction leads to hypoperfusion which causes chemical changes in the brain and can be detected by proton magnetic resonance spectroscopy (^{1}H-MRS)**.**

Objective: The aim of the current study was to explore the value of proton magnetic resonance spectroscopy imaging in patients with internal carotid artery stenosis or occlusion.

Patients and Methods: This study included a total of 30 non infarcted patients with stenosis or occlusion of unilateral internal carotid artery, attending at the Department of Radiodiagnosis, Faculty of Medicine, Al-Azhar University (Al-Hussein) Hospital. Patients underwent MR spectroscopy to detect metabolic changes of the brain. **Results:** In 30 non-infarcted patients, there was decreasing in N-acetylaspartate (NAA) and increasing in choline in the hemisphere compared with the contralateral side. In addition, there was lactate peaks which found only in 8 patients. **Conclusion:** ^{1}H-MRSI can reveal abnormal metabolic changes which occur in cerebral tissues with no infarction. However, internal carotid artery may show stenosis or occlusion at an initial stage, which in turn may help guide management decisions and preoperative assessment.

Keywords: ^{1}H-MRS, MRI, Carotid artery stenosis, Stroke, ICA, Cerebral ischemia, Transaxial; Semiovale, VOIs.

INTRODUCTION

Patients with stenosis or occlusion of internal carotid artery might be suffer from transient neurological deficits. Patients with these symptoms are at high risk of upcoming stroke **(1)**.

Conventional magnetic resonance imaging (MRI) is difficult to assess the degree of cerebral ischemia before cerebral infarction happens, which is crucial for management decisions either medical treatments or revascularization.

MRI is less sensitive than 1H-MRS in revealing ischemic injury and measuring the metabolic changes that may occur before the morphological changes. As a result, 1H-MRS may provide important clinical data in the diagnosis and management of cerebral ischemia at a much earlier stage **(2)**.

The aim of current study was to explore the value of proton magnetic resonance spectroscopy imaging in patients with internal carotid artery stenosis or occlusion.

SUBJECTS AND METHODS

This study included a total of 30 non infarcted patients with stenosis or occlusion of unilateral internal carotid artery, attending at the Department of Radiodiagnosis, Faculty of Medicine, Al-Azhar University (Al-Hussein) Hospital. This study was conducted between December 2018 to May 2019.

Ethical approval:

The study was approved by the Ethics Board of Al-Azhar University. Written informed consent from all the subjects were obtained after explanation how much it is helpful in diagnosis and treatment.

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Inclusion criteria: All patients either male or female who are presented by suspected carotid artery stenosis.

Exclusion criteria: Patients who are known to have brain ischemia by conventional MRI.

Patients were 19 males and 11 females. Their ages ranged between 36 and 72 years. All the patients were subjected to the following: demographic and clinical data collection, which included patient's name, age, gender, full history taking, past history of related significance, color Doppler to detect the degree of stenosis. Cerebral metabolic changes of the brain were studied in the non-infarcted patients at the stenotic side of internal carotid artery and compared with the healthy side.

1H-MRSI was performed with a multivoxel technique, the volumes of interest (VOIs) were selected in the non-infarcted white matter of the bilateral centrum semiovale in patients with ICA stenosis or occlusion and taken away from cerebrospinal fluid in sulcus as far as possible.

MR Protocol:

MR investigations were performed on a 1.5 T whole body system (Magnetom Trio Tim; Siemens, Erlangen, Germany) and were composed of two parts: MRI and 1H-MRSI.

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed

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as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

The following tests were done:

- Independent-samples t-test of significance was used when comparing between two means.
- Chi-square (x^2) test of significance was used in order to compare proportions between two qualitative parameters.
- The confidence interval was set to 95% and the margin of error accepted was set to 5%. The p-value was considered significant as the following:
- Probability (P-value)

- P-value <0.05 was considered significant.
- P-value <0.001 was considered as highly significant.
- P-value >0.05 was considered insignificant.

RESULTS

Three groups of results were found in this study as shown in figure (1):

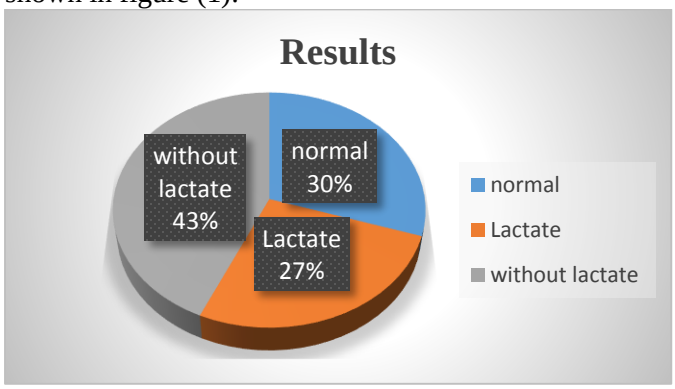

Figure (1): Result finding.

Group A: 30% normal patients with no changes in NAA and choline compound compared with healthy side, figure (2).

Figure (2)

Group B: 43% abnormal patients with increasing of NAA, decreasing of choline compound compared to healthy side with no appearance of lactate which predict future ischemia, figure (3)

Figure (3)

Group C: 27% abnormal patients with increasing of NAA, decreasing of choline compound compared to healthy side with slightly appearance of lactate which predict future ischemia (highly risk), figure (4).

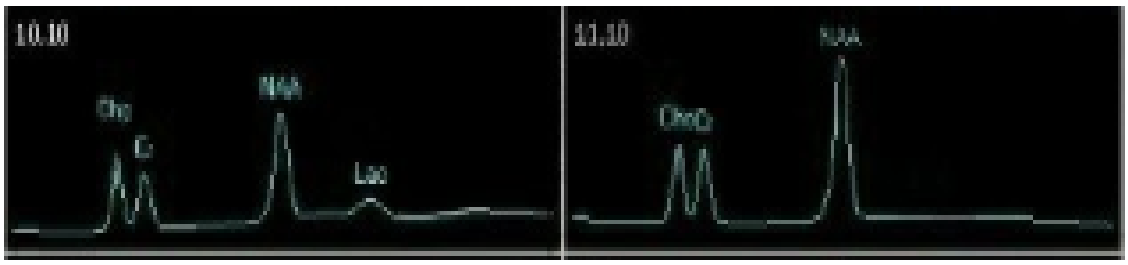

Figure (4)

According to this study the average range of carotid artery stenosis detected in normal patients was 39 % whereas 61 % as abnormal, so with increasing the degree of carotid artery stenosis the brain tissues is more susceptible to be infarcted, figure (1).

Table (1): Illustrate relation between the degree of carotid stenosis and the findings

Degree of stenosis	Normal	Abnormal
	39 ± 7 degree	61 ± 12 degree

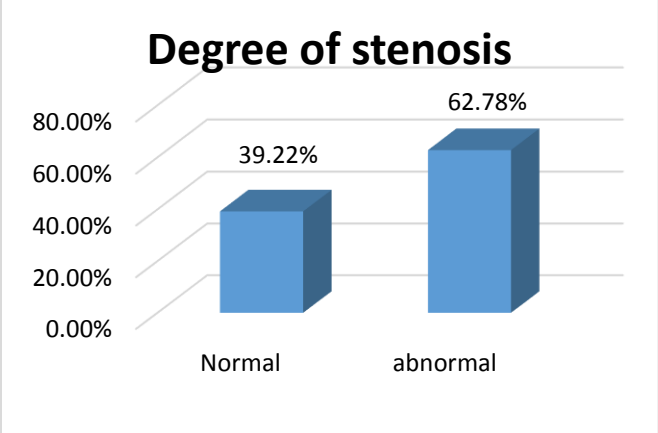

Figure (5): Demographic percentage of findings.

Table (2): Illustrative relation between patients and risk factors:

Abnormal people	HTN	Diabetic	Smoker	Obesity
	100 %	28.1 %	62 %	71.5%

DISCUSSION

The white matter in centrum semiovale is particularly susceptible area to hypoperfusion because it is the most distal white matter part which perfused by the cortical branches of carotid arteries. This area is most likely one of the first to have ischemic injury affection when blood flow decrease [(3)].

From a technical point of view, the centrum semiovale is suited for performing accurate spectroscopy of white matter without contamination by gray matter or subcutaneous fat [(4)].

Findings of 1H-MRSI in patients with symptomatic internal carotid artery stenosis or occlusion revealed a decrease in the NAA and an increase in the choline in cerebral white matter on the stenosed or occluded side.

The creatine peak is a multi-composed peak comprising of creatine and phosphocreatine. This peak may be used as a control value because it remains fairly stable even in circumstances of disease. Creatine peak cannot be used as an internal reference in some occasions such as cerebral infarction, because its concentration differs with the anerobic tissue conditions as in this study. Many authors have found a decrease in the concentration of creatine in infarcted areas [(5)].

For this reason we had used the peak area of NAA, choline, and creatine (rNAA, rCho, and rCr) as a parameters contrary to NAA/creatine and choline/creatine, when we studied metabolic changes and compared them between the affected side and contralateral side of the patients who had no infarction.

As there was no detectable infarction on MRI in patients with internal carotid artery stenosis or occlusion, we believe that the creatine peak may be presumed to be fairly stable and it is acceptable to use it as a control value in these patients [(6)].

A decrease in NAA is generally viewed as a neuronal loss, as NAA is mostly considered a neuronal marker [(7)]. Since neurons do not regenerate, this is considered as an irreversible damage [(8)].

However, previous studies have reported that NAA decrease in the hemisphere ipsilateral to the symptomatic ICA stenosis or occlusion revealed a trend toward recovery due to gradually improved collateral circulation [(9)].

We assume that the NAA reduction in these patients is not caused merely by a loss of neurons. The observed reduction may have been caused by changes in the axonal volume in the white matter or by a reversible mitochondria dysfunction, since NAA is synthesized in mitochondria [(6)].

We observed an increase in choline in the hemisphere ipsilateral to ICA occlusion or stenosis. The main parts of choline peak involved choline, phosphocholine, and glycerolphosphocholine, which are involved in membrane synthesis. The main source of free choline is breakdown in cells [(10)].

In our study, lactate peaks were observed in 8 of 30 patients with ICA stenosis or occlusion.

Lactate appears in ischemic brain and indicates a switch from oxidative metabolism to anaerobic glycolysis [(5)]. Lactate production is a sensitive marker of brief local hypoperfusion [(11)].

The increased lactate detected in the hemisphere ipsilateral to stenosed or occlused ICA could be clarified by an increase in the anerobic glycolysis triggered by hypoperfusion. This hypoperfusion would appear to be long enough to bring about significant changes in the anerobic metabolism, but not enough to yield infarction. The regions with lactate may be at particular risk for cerebral infarction if perfusion further decreases.

The subjects with a lactate signal are at high risk for infarction. The absence of lactate signals in some patients may be referred to a few factors. The

hypoperfusion may not be severe enough to elicit anerobic glycolysis and the lactate concentration may be very low due to transient anaerobic glycolysis [(12)].

CONCLUSION

^{1}H-MRSI can reveal abnormal metabolic changes which occur in cerebral tissues with no infarction. However, the internal carotid artery may show stenosis or occlusion at an initial stage, which in turn may help guide management decisions and preoperative assessment.

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