Assessment of Patients with Lacunar Infarction: A Magnetic Resonance Spectroscopic and Psychometric Study

Mahassen A. Hassan¹, Sadek M. Helmy¹, Amany M. Rabah¹, Ayma I. Ameen², Hanan Helmy¹

Departments of Neurology¹, Radiology², Cairo University; Egypt

ABSTRACT

Background: Neuropsychological deficits after lacunar infarction, such as amnesia and memory loss, have been reported occasionally. Hypometabolism and hypoperfusion are sequelae of ischemia, and can have detrimental effects on cognitive functioning. Objective: To investigate the changes in cognitive functions and neurometabolites in patients with lacunar infarctions and the relation between ¹H-MRS results and cognitive deficit found by psychometric testing. Methods: This study included 30 patients with symptomatic lacunar infarction (18 males (60%) and 12 females (40%) with a mean age of 59.13±9.518 y) and 12 age and sex matched controls. They were subjected to clinical evaluation, complete laboratory testing, and a battery of neuropsychological testing, MRI and ¹H-MRS studies. Results: Patients had significantly lower scores of all psychometric tests, higher lactate/cr and lower NAA/cr and choline/cr in comparison to controls (p<0.05). Patients with multiple lesions had significantly lower scores of PWAT, digit span, Bender and vocabulary and higher lactate (p<0.05). Females and obese patients had significantly lower scores of psychometric tests. Lactate was significantly higher in males, smokers, obese and patients with multiple lesions (p<0.05). Hypertension severity and smoking index significantly correlated with psychometric results. Age, HTN degree and duration, degree of spasticity and muscle power as well as psychometric results is correlated with ¹H-MRS results (p<0.05). Conclusion: Despite that lacunar infarctions are small however, the neurometabolic changes with its effect on cognition extends far beyond the infarction area. Psychometric and neurometabolic changes correlated with the presence and severity of risk factors. (Egypt J Neurol Psychiatry Neurosurg. 2010; 47(1): 1-10)

Key words: lacunar infarction - ¹H-MRS - psychometric testing - neurometabolic changes.

INTRODUCTION

Lacunar infarction, accounts for about a quarter of ischemic strokes. To date, more than 20 distinct clinical syndromes have been associated with occurrence of a lacunar stroke, all sharing the assumption of preserved cognitive functioning¹. Nevertheless, definite neuropsychological deficits after a lacunar infarction, such as amnesia¹, transient memory loss⁴, neglect⁴, and aphasia⁴ have been reported occasionally.

Formal neuropsychological testing revealed chronic mild cognitive disturbances with lacunar infarction in the deep white matter⁴. Four explanations can be put forward: First; a disconnection resulting from damage to cortical pathways is responsible for the observed cognitive decline⁵. Second explanation is based on the possibility that a "bystander effect" encroaches on the adjoining gray matter⁴. Third concerns the emotional reaction to a stroke. Psychological distress related to the experience of a life threatening event and the fear of future strokes might have a negative influence on cognitive functioning⁶. Fourth explanation suggests that patients with a lacunar stroke suffer from neuronal damage beyond the immediate area of infarction⁷.

Therefore, patients may suffer from both localized and long distance effects. This implies that they may have changes in neurometabolites through the brain and this would be consistent with the observed pattern of cognitive decline. Neuropsychological tests may throw light on the pattern and degree of cognitive impairment that might occur with brain aging, mild cognitive impairment and their variability with different personalities⁸. Proton magnetic resonance spectroscopy (¹H-MRS) is an analytical technique that can identify chemical compounds without destruction of the sample and it can provide information on the nature and quantities of chemical compounds present in a sample. Thus, the technique has been adapted to acquire chemical and metabolic, rather than structural, information from human brain. In a healthy individual three peaks stand out clearly as being abundant⁹: N-acetyl aspartate (NAA); molecule exclusive to neuronal soma and axons. Creatine (Cr); a molecule...
associated with cellular energy metabolism. Choline (Cho): a compound of phospholipids present predominantly in cell membranes. The other less prominent include glutamate, glutamine, lactate, gamma-amino butyric acid. MRS has opened a new field of non-invasive pathophysiological studies on cerebral ischemia and infarction. The concentration of N-acetyl aspartate has been related to small changes in cognitive functioning both in sick and in healthy people. Hypometabolism and hypoperfusion are well known sequelae of ischemia, and can have detrimental effects on cognitive functioning12.

The aim of the current study is to investigate the changes in cognitive functions using psychometric testing and neurometabolites using 1H-MRS in patients with lacunar infarctions and to find a possible relation between 1H-MRS results and cognitive deficit in those patients.

SUBJECTS AND METHODS

This study is cross sectional conducted on 30 patients with symptomatic lacunar infarction admitted to Neurology Department, Kasr El-Aini Hospital. They were 18 males (60%) and 12 females (40%). Their ages ranged from 45-75 years with a mean of 59.13±9.518 years. Sixteen patients (53.3%) can read and write and 14 (46.7%) were educated, where educational level ranged from primary school to university graduation. A group of twelve healthy volunteers were taken as a control group. They were 8 (66.6%) males and 4 (33.3%) were females. Their ages ranged from 44-74 years with a mean of 57.25±9.08 years with no significant difference in comparison to patients (p>0.05). Excluded from the study were clinically demented and aphasic patients, stroke onset less than one month from the study; patients with history of head trauma; patients with systemic disorders as renal or hepatic impairment; patients on psychoactive drugs and subjects older than 75 years.

Methods:
Complete, general, neurological and neurovascular examination with grading of muscle tone and muscle power was performed.
Laboratory tests: CBC, blood sugar, lipid profile, uric acid, liver and kidney function tests.

Neuropsychiatric tests:
All patients and control subjects were examined with a neuropsychological test battery, which consists of 10 tests and were completed in a single session;
* Mini-mental status examination MMSE:

Frontal lobe tests:
A- Drawing: The patient was told to copy and continue a specific sequence. Evidence of preservation or loss of sequence was recorded.
B- Alternating hand sequences: This is a motor alternation task that uses both hands. Reporting the records of the patient who is unable to maintain the alternating sequence.

Vocabularies: It measures the degree of old learning, it consists of 42 words and the patient is asked to tell the meaning of each-word. Example: capital, nuclear.

Similarities test: It measures the capability to abstract and conceptual reasoning. It consists of 5 pairs of things and patients are asked to find the similarities between them.

Digit span test: It measures attention and immediate memory. It consists of numbers starting with 3 up to 9 numbers. Examiner says the numbers and asks the patient to repeat it in the same order.

Paired word association test (PWAT): It measures short-term memory. It consists of 30 pairs of words: some are easy and some are difficult. The examiner reads the 30 points of words to the patient and after 5 minutes he tells the first word to the patient who should tell the second one.

Paced Auditory Serial Addition Task (PASAT): This test is a serial-addition task used to assess working memory, divided attention, and information processing speed.

Benton visual retention test: It measures the visual memory and perception of spatial relations. It consists of 10 cards, on each there is a geometrical figure or more. These figures increase gradually in number and difficulty. The card is shown to the patient for 10 seconds and then is asked to draw that figure and time required for whole test is about 5-10 minutes.

Bender Gestalt test: It measures the visual memory for newly learned material and the capability of recognition. The patient is asked to make copy of a drawing (copy). Then the drawing is removed after 3 minutes the patient is asked to draw the same drawing (recall). Accordingly normative data is: normal (15±5), functional (10±4.24) and organic (7.1±3.24).

Verbal fluency test: It measures the language function. The patient is told about two situations and requested to express himself in 3 minutes for each situation. The examiner writes the words of the patient. The scores are the number of related non-repeated words which are said by the patient.
1.5 S.D compared with the norms. If the subject scored below 1.5 SD compared with the norms, he or she received one deterioration point. If below 2 SD he or she received two points. At the base assessment, patients with 0-4 deterioration points were classified as (preserved cognitively) and patient above 4 points as (deteriorated cognitively).

**MRI/MRS examinations:**

All patients and control subjects underwent the same MR protocol. The studies were performed on a 1.5 T whole-body system. The 1H MRS investigations was performed with a single voxel technique (TR 2000 ms, TE 141, 2000 Hz spectral width, 4000 data points). The volume of interest (VOI), selected from the transaxial T2-weighted image, was placed. On the lacunar infarct in each subject, two equally sized VOIs were selected, one in the ipsilateral hemisphere and one in the contralateral hemisphere.

The size and placement of the VOI were chosen in such a way that it contained primarily white matter and no subcutaneous fat. The typical dimensions of the VOI were 50 mm in the anterior-posterior direction, 20 mm in the left-right direction and 10 mm in the cranial-caudal direction.

Total Cho, NAA (referenced at 2.01 ppm), total Cr and lactate peaks were identified by their chemical shifts. To distinguish lactate resonances from lipid resonances at a TE of 144 ms, lactate was defined as an inverted resonance at 1.33 ppm with a signal-to-noise ratio larger than two and a clearly identifiable 7 Hz J-coupling.

Since no absolute metabolic concentrations could be measured, the peak heights of NAA, Cho and Cr were expressed as a NAA/Cr ratio, Cho/Cr ratio and a lactate/Cr ratio for each VOI. The use of ratios has the advantage of being insensitive to possible CSF or gray matter in the VOI. For each control subject, a mean NAA/Cr ratio, Cho/Cr ratio and lactate/Cr ratio were obtained by averaging the values of the left and right hemisphere.

The absence of hyperintensities and infarcted cerebral tissue in the VOIs justifies the use of the creatine peak as internal reference for NAA, Cho and lactate. Consequently, a change in the NAA/Cr ratio can be interpreted as a change in NAA concentration.

**Statistical Analysis:**

Statistical analysis was done according to Ingelfinger et al. Descriptive statistics was presented as Mean±SD, and number and percentage (frequency distributions). Analytical tests used included unpaired student t-test (two sided) for comparing two groups. Analysis of variance (F-test) for comparing more than 2 groups. Post hoc test for comparing each two groups. Non-parametric testing was also used to confirm significance. Chi-square test for contingency table analysis and Fisher’s exact testing for 2 x 2 tables. Significance level of 0.05 and 0.01 was used throughout all statistical tests within this study.

**RESULTS**

**Risk factors:**

- **Hypertension:** all patients were hypertensive (100%). Systolic blood pressure ranged from 160-215 with a mean of 184.87±15.29 mmHg while diastolic blood pressure ranged from 100-125 mmHg with a mean of 110.87±8.04 mmHg. Duration ranged from 1-30 years with mean of 9.80±7.34 years.

- **Other risk factors:** 14 patients (46.7%) were diabetics, 10 (33.3%) were hypercholesterolemic, 8 (26.7%) were obese, 4 (13.3%) had hyperuricemia, 4 (13.3%) had ischemic heart disease while 16 (53.3%) were cigarette smoker. Smoking index ranged from 150-1200 with mean 500±404.7.

**Results of MRI:**

- **Number of lesions:** 22 patients (73.3%) had single lesion while 8 (26.7%) had multiple lesions.

- **Side of lesion:** 14 patients (46.7%) had right sided lesions while in 16 (53.3%) lesions are left sided.

- **Site of lesion:** Lesions were frontal in 4 (13.3%) patients, parietal in 12 (40%), internal capsule in 8 (26.7%) and medullary in 6 (20%).

**Results of Psychometry:**

Patients (n=30) had statistically significant lower values of psychometric results in comparison to controls (n=15) (p<0.05) (Table 1). The percentage of patients with abnormal results in frontal lobe tests was significantly higher in patients (Table 3).

Patients with multiple lesions (n= 8) had significantly lower values of paired word association, digit span, Bender copy and recall and vocabulary in comparison to those with single lesion (n=22) (p<0.05) (Table 1). No significant difference was found in frontal lobe tests (p>0.05) (Table 3).

Females (n=12) had significantly lower scores of PASAT, vocabulary, Bender%, copy and recall in comparison to males (n=18) (p<0.05) (Table 2). No significant difference was found in frontal lobe tests (p>0.05) (Table 3).

A significantly lower scores of PWAT and verbal fluency was found in obese patients (n=8) in comparison to non-obese patients (n= 22) (p<0.05) (Table 2).

Comparison between patients with right and left sided lesions showed no statistically significant
Correlation of psychometric tests:

**Hypertension:** a significant negative correlation was found between the mean blood pressure and Benton correct and error \((r = -0.454, \ p = 0.012)\), digit span \((r = -0.466, \ p = 0.009)\), PASAT \((r = 0.500, \ p = 0.005)\), PWAT \((r = -0.645, \ p = 0.000)\) and vocabulary \((r = -0.661, \ p = 0.000)\).

**Smoking index:** a significant negative correlation was found between smoking index and PWAT \((r = -0.591, \ p = 0.026)\), Bender copy \((r = -0.682, \ p = 0.007)\), Bender % \((r = -0.620, \ p = 0.018)\).

Proton Magnetic Resonance spectroscopy (H-MRS) results:

Lactate/creatine metabolite was significantly higher on the ipsilateral side in patients group compared to controls \((p<0.05)\). Also, Choline/creatine metabolite on both sides and NAA value on the ipsilateral side was significantly lower in patients compared to controls \((p<0.05)\) (Table 4).

Male patients compared to females and patients with multiple lesions compared to patients with single lesion had significantly higher lactate level on the ipsilateral side \((p<0.05)\) (Table 4).

Obese patients compared to non-obese and smokers compared to non-smokers had significantly higher lactate and lower choline values on the ipsilateral side \((p<0.05)\). Also, obese patients had significantly lower choline on the contralateral side compared to non-obese \((p<0.05)\) (Table 4).

Comparison between diabetics and non-diabetic patients showed no statistically significant difference \((P>0.05)\).

Correlation of MRS results:

**Age:** a significant negative correlation was found between age and choline metabolite values on ipsilateral \((r = -0.415, \ p = 0.022)\) and contralateral side \((r = -0.417, \ p = 0.022)\) of lacunar infarction.

**Hypertension:** a significant positive correlation was found between diastolic blood pressure and lactate metabolite on the ipsilateral side of infarction \((r = 0.450, \ p = 0.020)\). The duration of hypertension showed a significant negative correlation with NAA value \((r = -0.393, \ p = 0.032)\).

**Degree of spasticity:** a significant positive correlation was found between spasticity grade and lactate \((r = 0.620, \ p = 0.000)\) and a significant negative correlation with NAA \((r = -0.750, \ p = 0.000)\) on the ipsilateral side.

**Grade of muscle power:** a significant negative correlation was found between muscle power grade and lactate on the ipsilateral \((r = -0.403, \ p = 0.027)\) and contralateral side \((r = -0.413, \ p = 0.023)\).

**Psychometric results:** the correlation between results of psychometry and MRS metabolite results is shown in Table (5).

Table 1. Comparison between patients and controls, and patients with single and multiple lesions in psychometric test results.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Patients Mean±SD</th>
<th>controls Mean±SD</th>
<th>Single p</th>
<th>Multiple p</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASAT</td>
<td>30.7±12.3</td>
<td>57.8±1.9</td>
<td>0.000**</td>
<td>33.0±11.6</td>
<td>24.5±13.1</td>
</tr>
<tr>
<td>PWAT</td>
<td>23.3±5.0</td>
<td>29.0±1.2</td>
<td>0.003**</td>
<td>24.5±4.90</td>
<td>19.7±3.33</td>
</tr>
<tr>
<td>Similarity</td>
<td>4.13±2.2</td>
<td>9.7±0.62</td>
<td>0.000**</td>
<td>4.45±2.40</td>
<td>3.25±1.39</td>
</tr>
<tr>
<td>Digit span</td>
<td>4.93±2.3</td>
<td>8.9±0.29</td>
<td>0.001**</td>
<td>5.45±2.44</td>
<td>3.50±1.19</td>
</tr>
<tr>
<td>Benton correct</td>
<td>4.40±2.3</td>
<td>8.75±1.14</td>
<td>0.000**</td>
<td>4.82±2.42</td>
<td>3.25±1.39</td>
</tr>
<tr>
<td>Benton error</td>
<td>5.60±2.3</td>
<td>1.25±1.13</td>
<td>0.000**</td>
<td>5.18±2.42</td>
<td>6.75±1.39</td>
</tr>
<tr>
<td>Bender%</td>
<td>73.9±12.7</td>
<td>97.4±2.01</td>
<td>0.002**</td>
<td>75.7±14.5</td>
<td>68.9±1.80</td>
</tr>
<tr>
<td>Bender copy</td>
<td>5.67±3.17</td>
<td>22.9±1.76</td>
<td>0.000**</td>
<td>8.55±3.30</td>
<td>5.37±0.88</td>
</tr>
<tr>
<td>Bender recall</td>
<td>5.57±3.18</td>
<td>21.3±1.70</td>
<td>0.000**</td>
<td>6.45±3.25</td>
<td>3.50±1.80</td>
</tr>
<tr>
<td>Verbal fluency</td>
<td>12.2±5.28</td>
<td>19.1±1.24</td>
<td>0.004**</td>
<td>12.7±4.45</td>
<td>10.7±7.30</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>34.3±8.05</td>
<td>40.2±1.34</td>
<td>0.018*</td>
<td>36.7±28.7</td>
<td>28.8±9.50</td>
</tr>
</tbody>
</table>

* Significant  ** Highly significant
Table 2. Comparison between males and females and obese and non-obese patients in psychometric test results.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obese</th>
<th>Non-obese</th>
<th>p</th>
<th>Males</th>
<th>Females</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean±SD</td>
<td>Mean±SD</td>
<td></td>
<td>Mean±SD</td>
<td>Mean±SD</td>
<td></td>
</tr>
<tr>
<td>PASAT</td>
<td>25.7±13.2</td>
<td>32.5±11.8</td>
<td>0.187</td>
<td>35.3±10.8</td>
<td>23.8±11.5</td>
<td>0.010**</td>
</tr>
<tr>
<td>PWAT</td>
<td>20.0±6.27</td>
<td>24.4±4.03</td>
<td>0.029*</td>
<td>24.7±3.88</td>
<td>21.2±5.95</td>
<td>0.061</td>
</tr>
<tr>
<td>Similarity</td>
<td>4.75±2.31</td>
<td>3.90±2.2</td>
<td>0.369</td>
<td>4.22±2.32</td>
<td>4.0±2.17</td>
<td>0.794</td>
</tr>
<tr>
<td>Digit span</td>
<td>4.75±2.66</td>
<td>5.00±2.27</td>
<td>0.800</td>
<td>5.22±2.26</td>
<td>4.50±2.47</td>
<td>0.416</td>
</tr>
<tr>
<td>Benton correct</td>
<td>4.00±2.00</td>
<td>4.55±2.40</td>
<td>0.572</td>
<td>4.56±2.38</td>
<td>4.17±2.21</td>
<td>0.656</td>
</tr>
<tr>
<td>Benton error</td>
<td>6.00±2.00</td>
<td>5.45±2.40</td>
<td>0.572</td>
<td>5.44±2.38</td>
<td>5.83±2.21</td>
<td>0.656</td>
</tr>
<tr>
<td>Bender%</td>
<td>75.2±2.33</td>
<td>73.4±13.7</td>
<td>0.369</td>
<td>77.6±8.95</td>
<td>68.4±15.8</td>
<td>0.049*</td>
</tr>
<tr>
<td>Bender copy</td>
<td>7.87±2.74</td>
<td>7.64±3.38</td>
<td>0.859</td>
<td>7.67±2.8</td>
<td>6.25±3.3</td>
<td>0.039*</td>
</tr>
<tr>
<td>Bender recall</td>
<td>5.75±2.33</td>
<td>5.64±3.22</td>
<td>0.933</td>
<td>6.67±2.57</td>
<td>4.17±3.34</td>
<td>0.033*</td>
</tr>
<tr>
<td>Verbal fluency</td>
<td>9.00±7.05</td>
<td>13.3±4.07</td>
<td>0.043*</td>
<td>12.3±3.76</td>
<td>12.0±7.19</td>
<td>0.869</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>30.0±8.98</td>
<td>35.9±7.28</td>
<td>0.075</td>
<td>38.3±5.04</td>
<td>28.3±8.15</td>
<td>0.000**</td>
</tr>
</tbody>
</table>

* Significant  ** Highly significant

Table 3. Comparison between patients and controls, males and females and patients with single and multiple lesions in frontal lobe test results.

<table>
<thead>
<tr>
<th>Group</th>
<th>Frontal drawing</th>
<th>Frontal alternating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Can (%)</td>
<td>Can’t (%)</td>
</tr>
<tr>
<td>Patients</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>Controls</td>
<td>100</td>
<td>66.7</td>
</tr>
<tr>
<td>Single</td>
<td>16</td>
<td>72.7</td>
</tr>
<tr>
<td>Multiple</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td>Males</td>
<td>12</td>
<td>66.7</td>
</tr>
<tr>
<td>Females</td>
<td>8</td>
<td>66.7</td>
</tr>
</tbody>
</table>

* Significant  ** Highly significant

Table 4. Comparison between patients and controls and different subgroups of patients in the results of MRS.

<table>
<thead>
<tr>
<th>Group</th>
<th>Ipsilateral side</th>
<th>Contralateral side</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Choline</td>
<td>Lactate</td>
</tr>
<tr>
<td>Patients</td>
<td>1.13±0.09</td>
<td>0.06±0.029</td>
</tr>
<tr>
<td>Controls</td>
<td>1.21±0.03</td>
<td>0.01±0.004</td>
</tr>
<tr>
<td>p value</td>
<td>0.009**</td>
<td>0.000**</td>
</tr>
<tr>
<td>Males</td>
<td>1.11±0.10</td>
<td>0.04±0.004</td>
</tr>
<tr>
<td>Females</td>
<td>1.17±0.08</td>
<td>0.009±0.004</td>
</tr>
<tr>
<td>p value</td>
<td>0.099</td>
<td>0.002**</td>
</tr>
<tr>
<td>Single</td>
<td>1.13±1.12</td>
<td>0.05±0.04</td>
</tr>
<tr>
<td>Multiple</td>
<td>1.13±0.05</td>
<td>0.31±0.48</td>
</tr>
<tr>
<td>p value</td>
<td>0.982</td>
<td>0.017*</td>
</tr>
<tr>
<td>Obese</td>
<td>1.11±0.09</td>
<td>0.34±0.47</td>
</tr>
<tr>
<td>Non-obese</td>
<td>1.20±0.08</td>
<td>0.05±0.04</td>
</tr>
<tr>
<td>p value</td>
<td>0.016*</td>
<td>0.006**</td>
</tr>
<tr>
<td>Smokers</td>
<td>1.09±0.10</td>
<td>0.01±0.005</td>
</tr>
<tr>
<td>Non-smokers</td>
<td>1.17±0.08</td>
<td>0.009±0.004</td>
</tr>
<tr>
<td>p value</td>
<td>0.036*</td>
<td>0.004**</td>
</tr>
</tbody>
</table>

* Significant  ** Highly significant
The development of cognitive impairment after lacunar infarction is a matter of concern in the long-term follow-up. In the present work, patients had significantly lower scores in psychometric testing and lower NAA/Cr (ipsilateral) and Cho/Cr ratios (both sides) and higher lactate (both sides) in comparison to control group (p<0.05). This was in agreement with Van Zandvoort et al., where they found significantly lower NAA/Cr ratio in the ipsilateral hemisphere of stroke than control groups. This change signifies low NAA rather than increase creatine. The decrease in NAA indicates that neurons, as well as dendrites and axon suffer from ischemic like changes even in areas at considerable distance from the infarction. In addition, Bakker et al. suggested that higher lactate ipsilateral to diseased side was associated with cognitive impairment.

Age of our patients had significant negative correlation with choline metabolite value (P<0.05). It is postulated that the central nervous systems of older people appear less capable of choline uptake, which may explain why past attempts to treat dementia with choline-containing compounds have failed. On the contrary, Van Zandvoort et al. didn't find any correlation between age and choline or any of brain metabolites.

In the present work, females had significantly lower scores in Bender Gestalt test, PASAT and vocabularies which are the tests for memory, recognition and sustained attention. This in accordance with Ewoud et al. study, who said that females had higher risk of marked subcortical white matter lesions progression and incidental lacunar infarcts than men, therefore, more cognitively affected than males. Also, Towafighi et al. found that women aged 45 to 54 years had twice the risk of having experienced a stroke compared with men of the same age. Against our results Fure et al. showed that males were more affected by small vessel disease and lacunar infarcts, as they are at higher risk of developing cognitive deficits than females. Males in our study had significantly higher lactate ipsilaterally compared to females (P<0.05). On the other hand, Van Zandvoort et al. found no relation between sex and HMRS neurometabolites.

All our patients are hypertensive (100%). This goes with the results of Ewoud et al., who found that hypertension is the most frequent vascular risk among lacunar infarction patients occurring in 66% of their patients. A significant negative correlation was found between severity of hypertension and PASAT, PWAT, Benton test, digit span and vocabularies (P<0.05). This agreed with the study of Seux and Forrette, who detected a negative correlation between systolic blood
pressure and neuropsychological tests. Randomized placebo-controlled trials demonstrated that treating hypertension may effectively reduce morbidity and mortality rates in the elderly. In elderly, hypertension leads to reduction in NAA/Cr ratios in the insula and the thalamus, possibly due to a decrease in blood flow through small perforating and cortical arteries. Reduced NAA reflects changes in neuronal mitochondrial activity associated with reduced neuronal activity. A significant negative correlation was found between hypertension duration and NAA on contralateral side (P<0.032) and a significant positive correlation between diastolic blood pressure and lactate metabolite (P=0.020). This supports the hypothesis that hypertension causes vascular alterations that determine lacunar infarcts and leukoaraiosis which would be responsible for cognitive decline which may be explained by unifier theory which stated that aging and hypertension act together to cause cerebral capillary degeneration, mitochondrial disruption, reduced glucose oxidation and reduced ATP synthesis so the consequence is neuronal death.

No, statistically significant difference was found between diabetic and non-diabetic patients in their psychometric performance or in the results of 1H-MRS in the present work. This was in agreement with Hayden et al., who reported that diabetes doesn't increase the risk of Alzheimer disease or find an association between them. On the contrary, Katzman et al. found that diabetes was a significant predictor for the development of vascular dementia, in non demented elderly population and Luchsinger et al., who observed slower decline in cognitive performance with diabetes because type II DM is associated with atherosclerosis and increased risk of Alzheimer disease.

Smoking index showed a significant negative correlation with Bender Gestault copy and PWAT (P<0.05). This goes with previous studies which showed that smoking increase the cognitive decline among elderly and that heavy smoking is associated with memory decline. Astrid et al. found decline (1.9) in memory, (2.4) in cognitive flexibility and (1.7) in global cognitive function over 5 year follow-up period in smokers greater than among never smokers and noticed dose response effect and the degree of cognitive decline over follow-up. Also, it was found that cigarette smoking is an independent risk factor associated with abnormal and excessive decrease in cerebral perfusion and that cessation of smoking independently restore cerebral perfusion toward normal. Smokers in our study had significantly higher lactate and lower choline metabolite value ipsilaterally in comparison with non smokers (P<0.05). This is explained by the effect of chronic hypoperfusion which lead to anaerobic glycolysis and so production of more lactate.

Obese patients had significantly lower values in PWAT and verbal fluency (P<0.05), and significantly higher lactate and lower choline in comparison to non-obese patients (p<0.05). This goes with Severine et al., who found poorer MMSE scores and executive function in obese and the major increase in BMI predicts lower performance on executive function tests. Vascular disease is likely to underline the association between obesity and cognition. Cumulative burden of cerebrovascular lesion could result from the number of lesions, with multiple strategically located infarcts causing cognitive impairment and cognitive decline. In the present study, patients with multiple lesions had significantly worse performance in PWAT, digit span, Bender Gestault test and vocabularies and significantly higher lactate value ipsilaterally in comparison to those single lesion (p<0.05). This was in agreement with Bakker et al., who found that lactate was high in the hemisphere ipsilateral to lacunar infarction and symptomatic internal carotid artery occlusion, where they had a significantly higher cognitive impairment score, indicating more severe cognitive impairment than those with low lactate level. This was explained by anaerobic glycolysis produced by chronic hypoperfusion produces lactate which reflects impact of hemodynamic impairment on cognitive functioning.

There was statistically significant positive correlation between NAA and verbal fluency, PASAT and vocabularies (P<0.05). This was in agreement with Amy et al., who found that NAA in control subjects was correlated with verbal memory and abstraction and in patients at 3 years follow up there was a significant correlation between frontal NAA/Cr and cognitive domains. Also, Van Zandvoort et al. found significant correlation between NAA/Cr on ipsilateral and contralateral side of infarction and overall cognitive functioning in his patients. The influence of white matter NAA on cognitive functioning may be explained by its role in interconnections between association cortices critical to neuropsychological performance. N-acetylaspartate is thought to not only reflect neuronal viability, but also involved in myelin synthesis and/or maintenance of myelin. Reduced NAA is an index suggestive of decreased neuronal viability or demyelination or both, consistent with frontal morphological changes with aging. The combined decrease in NAA and increase in creatine, a marker of energy metabolism, may be an early indicator of further disruption of the fronto-subcortical circuits that is important for cognitive function and likely to be affected by stroke.

Choline as a precursor of acetylcholine is an important component of many of the phospholipids essential to cell membranes in the central nervous system. The loss of cholinergic neurons and cells is known to contribute to Alzheimer's disease and...
dementia. No significant correlation was found between choline and other psychometric tests in our study (P>0.05). This was in agreement with Van Zandvoort et al.31,32, study who did not find any relation between Cho/Cr ratio and cognitive functioning which support the interpretation that decrease in NAA and not an increase in creatine level as reported in aging studies, is related to cognitive decline.

The presence of higher lactate metabolite value in infarcted and surrounding brain areas is explained by anerobic glycolysis caused by chronic hypoperfusion35. In our study, a significant negative correlation was found between lactate with PASAT and verbal fluency (P<0.05), which was in agreement with Bakker et al.4, who found that the presence of lactate to be a stronger correlate of cognitive impairment than MRI-detected lesions. On the contrary, Van Zandvoort et al.32 did not found any relation between lactate/Cr and neuropsychological performance.

In conclusion, despite that lacunar infarctions are small however, we found alteration in the neurometabolites inside the lesion and white matter distance from it and these alterations was significantly related to decrease in cognitive capacity in these patients. The presence and severity of risk factors is linked to occurrence of cognitive and neuro-metabolic changes in the brain.

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تقييم مرضى الجلطات الدقيقة: دراسة باستخدام الرنين المغناطيسي الطيفي والقياس النفسي

بعد الجلطة الجوية وقائي الأداء المعرفي عادة لا تتأثر في المرحلة الحادة، ولكن ظهور تدهور الإدراك المعرفي هو موضوع ذو أهمية على المدى الطويل. تهدف هذه الدراسة إلى تقييم التغييرات التي تحدث في بعض المواد الكيميائية خلال علاج مرضى الجلطة الدقيقة. وجدت هذه الدراسة أن النظام الغذائي المغذي يؤدي على مرضى 48 سنة مصابين مجتمع الذين بدأوا 12 سنة بعد الأصابات. وقد أجريت الفحوصات التالية للمريض والمجموعة الضابطة: فحص إلكتروني شامل للجهاز العصبي، مقياس القدرة المعرفية باستخدام حالة الذكاء للغوثانتن لاستخدام البليمار. فحوصات للأداء في الاختبارات النفسية باستخدام نسخ اختبارات آبعة بالرنين المغناطيسي على المخ ورنين مغناطيسي طيفي لقياس التغييرات الكيميائية بالمخ. مادة الآن است번호، الكولين، واللاكونات، والكريبتين. هذه وقد أظهرت النتائج التالية:

1- المرضى لديهم أداء أقل ذو دلالات إحصائية في الاختبارات المعرفية بالمقارنة بالمجموعة الضابطة.
2- نقص في Lac/ Cr وNAA/ Cr ذو دلالات إحصائية بالمقارنة بالمجموعة الضابطة.
3- السيدات والمرضى ذو الوزن الزائد والمريض ذو النحاس المتعدد لديهم أداء أقل في الاختبارات المعرفية.
4- توجد علاقة عكسية ذات دلالات إحصائية بين معدل التدخين ومستوى ضغط الدم من مثبطات الأدلاة في الاختبارات المعرفية من ناحية أخرى.
5- السيدات والمرضى ذو الوزن الزائد والمريض ذو الوزن المتعدد والمدخنين لديهم مستوى أعلى من الالكات.
6- توجد علاقة ذات دلالات إحصائية بين نتائج الاختبارات اليفوية في اختبارات النسيان المغناطيسي الطيفي.
7- توجد علاقة ذات دلالات إحصائية بين المريض ومستوى ضغط الدم ودورة العضلات من ناحية وفي نتائج الرنين المغناطيسي الطيفي من ناحية أخرى.

من هنا يمكن أن: مرضى الجلطة الجوية بمرور بعضها يعتبر من الدلالات الدقيقة في أمراض الأوعية الدموية وذلك لتأثيره على الوظائف المعرفية التي تحدث على المدى الطول. فحوصات الرنين المغناطيسي الطيفي تعتبر أفضل مقياس لقياس الرنين المغناطيسي الطيفي حيث أن الرنين المغناطيسي العام لا يوضح التغييرات التي تحدث في الإدراك المعرفي مقارنة بقياسات التغييرات الكيميائية باستخدام الرنين المغناطيسي الطيفي.