BLOOD SEROTONIN LEVEL WITH DEPRESSION SITUATION AND NEUROCOGNITIVE AS A REFLECTION OF NEURON CONDITION IN SIX MONTHS AFTER MODERATE BRAIN INJURY

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ABSTRACT

Brain injury is still a public health problem that causes a very serious long-term disability and death especially in children and young adults. Of all the events brain injury, in the 70-85% estimate is a moderate brain injury. Neurocognitive deficits that occur after brain injury would be to show an improvement in the first six months and a relative improvement will be slow and almost not visible in six to 12 months after brain injury. Serotonin is the neurotransmitter most often associated with depression and also a key to neurogenesis. This study is an observational analytic study using cross sectional study of patients who had suffered a brain injury six months ago and treated in hospital Dr. Soetomo Surabaya. The result is there is significant correlation between blood serotonin levels in patients with depression situation in six months after brain injury (p = 0.00). There is also significant correlation between blood serotonin levels with some neurocognitive parameters in patients six months after brain injury, namely verbal fluency are examined with the Verbal Fluency Test parameters / VFT (p = 0.015). But serotonin concentration has no significant relationships with several other neurocognitive parameters, namely the accuracy and speed of information processing or reaction time, working memory and the ability to interpret visual information, each of which is checked by using the parameters of Inspection Time Task (ITT, p = 0.083), Continuous Performance Task-identical pairs (CPT-IP, p = 0.071) and the Continuous Performance Task-Degraded Stimuli (CPT-DS, p = 0.242).

Keywords: serotonin, depression, neurocognitive, moderate brain injury.

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INTRODUCTION

Until now, the brain injury is still a public health problem that causes a very serious long-term disability and death especially in children and young adults. The incidence and degree of severe brain injuries increase along with technological developments and the increasing mobility of people who are not accompanied by improvement of discipline and obedience on the highway or in the activity (Arifin 2002, Partoatmodjo 2007, Sarajuuri et al. 2005).

Data in Dr. Soetomo shows the average number of patients with brain injuries is 2043 cases per year (Balafif & Kasan 1999). Almost 100% of people with severe brain injury and brain injury was 66%, causing permanent disability (Shepard & Talavera 2001).

Brain injury has been associated with known psychiatric disorders, ranging from the disruption process of thinking up with emotional disturbances. Changes in cognitive, behavioral, and several other psychiatric symptoms was found after brain injury. Depression is the most neuropsychiatric sequelae of brain injury cases, as shown by outpatients and inpatients, estimated that between 14-77% (Ashman & Gordon 2006, Partoatmodjo 2007). In some studies, most cases of depression are at moderate and severe brain injury, but patients with mild brain injury also have a risk of depression (Fann et al. 2000). At one month after the brain injury, evaluated with Hamilton Depression Rating Scale (HDRS) obtained 26% of patients experience depression (Simon & Olive 2007). Even after 50 years post head injury, major depression disorder prevalence of 11.2% in veterans with brain injury compared to 8.5% without previous brain injury with odds ratios of 1.63 and 95% CI = 1.07 to 2.50. While the lifetime prevalence of depression 18.5% compared to 13.4% without previous brain injury with odds ratio 1.54 and 95% CI = 1.17 to 2.04 (Holsinger 2002).

Physical disability, cognitive, emotional and behavior in the long term are all factors that most often limit the patients to get back into the environment and his work, so they will have difficulty in interpersonal relationships and difficult to live productive return (Partoatmodjo 2007, Sarajuuri et al. 2005).

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Of all the events brain injury, in the 70-85% estimate is a brain injury are (COS = Moderate Brain Injury). They rarely require treatment in hospital rehabilitation. Most of these patients with brain injury are cognitive and behavioral changes reported to show improvement in 3-6 months, 10-15% complained symptoms persist and continuously, such as physical complaints including headache, neck pain, vestibular symptoms, change in taste and hearing, attention and memory difficulties, anxiety, and sleep disturbances, thus affecting interpersonal relationships and work (Partoatmodjo 2007).

Neurocognitive deficits that occur after brain injury would be to show an improvement in the first six months and a relative improvement will be slow and almost not visible in six to 12 months after brain injury (Partoatmodjo 2007).

Neurotransmitter that is often associated with neuropsychiatric disorders is serotonin, noradrenaline, dopamine and GABA. Among these neurotransmitters, serotonergic dysfunction is the neurotransmitter most often associated with various mental disorders (Susanto & Mawardi 1994). Serotonin is found in cell bodies in the midbrain raphe nucleus that play a role in emotion regulation and cognitive as well as the hippocampus and limbic system and the frontal cortex (Zenab & Turhan 2005).

Ramesh and Raghupati found that in mice, found an increase in serotonin levels in the cortex as a whole on one side of the hemisphere is experiencing head trauma. Serotogenik system alleged role in such traumatic circumstances. Twenty-four hours after brain injury are, levels of serotonin in the blood will increase, while the 15-22 days and then serotonin levels would be decreased (Ninel et al. 2000).

Serotonin is the neurotransmitter most often associated with depression. There are changes in serotonin levels that occur in patients with depression, which can be measured in urine, blood or cerebrospinal fluid (CSS) (Saddock & Alcott 2003).

Serotonin is a key to the process of neurogenesis. Increased production of new neurons by serotonin through 5-HT1A receptor activation. It's very meaningful for the individual brain injury because of damage to neurons can theoretically occur regeneration of new tissue in the hippocampus (Zafonte & Cullen 2002). Take place throughout the period of neurogenesis occurs in two places ie adult mammalian brain olfactory bulb and girus dentatus. This situation is possible only with the existence of neural stem cells (NSC) in the adult brain is multipoten cells that can repair itself, such as nerve cells, astrocyte and oligodendrosit (Taupin & FHGage 2002, Yudiarto 2007).

Therefore in this research may provide important data about the condition of patients after six months of brain injury was ever treated in Dr. Soetomo hospital. By knowing the relationship between blood levels of serotonin with depression and neurocognitive state in patients 6 months after brain injury is, it is expected will be able to provide a snapshot of the situation after six months of the neurons of the brain injury was, so it will be as early as possible in anticipation of the occurrence of depression and disturbances in patients with post-injury neurocognitive brain.

MATERIALS AND METHODS

This study is an observational analytic study using cross sectional study of patients who had suffered a brain injury was six months ago and treated in hospital Dr.Soetomo Surabaya. Before blood sampling, patients in recommend fasting for ± 6-8 hours. Blood samples were taken between the hours of 9:00 to 10:00 pm with a needle disposibel 5 cc and stored in sealed bottles. Then left at room temperature for 15 to 30 minutes. After that is done in centrifuge (3000 rpm) for ± 10 minutes, then taken serum. Serum obtained stored in a temperature-20oC. Having collected all blood samples as the number of samples is required (for a ± 6 months), there were 34 samples, and in doing the examination of blood serotonin levels using enzyme immunoassay (EIA), type BA10-0900. Serotonin EIA kit provides the material to determine quantitatively serotonin derivatives in the serum. By using acylation reagents, serotonin in derivatisasi quantitatively into N-acylsertotonin. Serotonin bound on solid phase using microtiter plate. Antibodies that bind to the solid phase serotonin is detected by peroxidase. The number of antibodies that bind to the solid phase serotonin is inversely proportional to the concentration of serotonin sample. Serotonin concentration of serum samples can be read directly from a standard curve that has been available.

RESULTS

Number of patients with brain injury were ever treated in the infirmary section of Dr neurosurgical sciences. Soetomo according to a register of patients since July 1, 2007 until December 2007 as many as 176 people. The number of patients who succeeded in check and meet the inclusion criteria and agreed to be included in the study from January 2008 to June 2008 totaled 34 people.
In this research, it appears that the average age of the sample was 28.68 years with a standard deviation of 9.00 years. The largest age group is aged 18-25 years, and as many as 19 people (56%) followed by 34-41 years age group as many as nine people (26%), and 42-50 year age group as many as four people (12%) and age group 2 people 26-33 years (6%). Based on gender, in this study in getting 26 men (76%) and eight women (24%).

Most of the educational level of the sample was graduated from high school that is counted 15 people (44%) followed by junior high education level is counted 11 people (32%) and SD of 6 people (18%), while graduate and diploma levels respectively as a person (3%). Most samples are unemployed or are not working, as many as 19 people (55%) and partly working as employees, entrepreneurs and individual farmers as much as seven people (21%), 6 person (18%) and two women (6%).

HDRS is known as much as 17 people (50%) experienced mild depression, 12 persons (35%) were depressed and two women (6%) experienced severe depression and depression are not as many as three people (9%). Neurocognitive state by using the Neurocognitive Test (NCT).

It appears that verbal fluency tests checked with the Verbal Fluency (VF) showed that as many as 23 people (68%) is in the scores that pertained less, eight people (23%) categorized as fairly and three women (9%) classified as very good . On examination of the immediate and delayed verbal memory with the Rey Auditory Verbal Learning-Immediate and Delayed Test (RAVLT-I and RAVLT-D) shows that in RAVLT-I trial I showed as many as 22 people (65%) are at levels of less, 11 people (32%) categorized as fairly and one person (3%) classified as very good. In the second trial seems there may be increased, where 21 people (62%) pertained to the level enough, 12 people (35%) or less and one person (3%) is very good. In the third trial it appears that 19 people (56%) are at sufficient levels, eight people (23%) pertained less, six people (18%) categorized as good and 1 person (3%) classified as very good. On examination of delayed verbal memory with RAVL-D showed 22 people (65%) classified as adequate, eight people (23%) pertained less and four people (12%) are at a good level.

The accuracy and speed of information processing or reaction time with Inspection Time Task (ITT) showed 21 people (62%) classified as adequate, 10 people (29%) classified as missing, three people (9%) is fair. Working memory with the Continuous Performance Task-identical pairs (CPT-IP) shows that 23 people (68%) classified as adequate, eight people (23%) pertained less, two people (6%) classified as very good and 1 person (3%) is fair. And the ability to interpret visual information with the Continuous Performance Task-Degraded Stimuli (CPT-DS) show that 27 people (79%) are in class enough, four people (12%) or less, two people (6%) good and 1 person (3 %) is very good. Normal serotonin levels for women is 80-450 ng / ml and boys 40-400 ng / ml. Using SPSS, data showed that of 26 men, average levels of serotonin were 239 ng / ml with a standard deviation of 125 ng / ml, while the eight women gained an average rating of serotonin levels 218 ng / ml with standard deviation of 95 ng / ml.

From the research it appears that the levels of serotonin research sample were mostly within normal limits, ie in males were 21 people (81%) and in women as many as seven people (87.5%). While that is above the normal of each three people (11%) in men and women do not exist. Serotonin levels in the samples under study as many as two normal people (8%) men and one women (12.5%) women.

<table>
<thead>
<tr>
<th>Table 1 The Relationship Between Blood Serotonin Levels in Depressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Serotonin</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>N</td>
</tr>
<tr>
<td>Under Normal</td>
</tr>
<tr>
<td>Normal limit</td>
</tr>
<tr>
<td>Above Average</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>


In Table 1, showed that out of 28 people with normal serotonin levels, 15 men (88.8%) experienced mild depression, 10 persons (83.3%) were depressed, two men (66.7%) were not depressed, and one person (50%) experienced severe depression. Of the three people with serotonin levels are below normal, two men (11.8%) were depressed and one person (50%) experienced severe depression. While the three men with a serotonin levels are above normal, two men (11.8%) experienced mild depression and one person (33.3%) did not experience depression.

Results of analysis using Spearman correlation test showed a significant correlation between blood serotonin levels with state of depression with p = 0.00 (p < 0.05), and the strength of correlation (rs) is -0.615, which means the lower the blood levels of serotonin the degree of depression was more severe.

Table 2 Relationship of Blood Serotonin Levels with Neurocognitive Based on Spearman Correlation Test

<table>
<thead>
<tr>
<th>Neurocognitive</th>
<th>Serotonin Levels</th>
<th>rs</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal Fluency</td>
<td></td>
<td>0.414</td>
<td>0.015</td>
</tr>
<tr>
<td>RAVLT-I.1</td>
<td></td>
<td>0.527</td>
<td>0.001</td>
</tr>
<tr>
<td>RAVLT-I.2</td>
<td></td>
<td>0.584</td>
<td>0.000</td>
</tr>
<tr>
<td>RAVLT-I.3</td>
<td></td>
<td>0.597</td>
<td>0.000</td>
</tr>
<tr>
<td>RAVLT-D</td>
<td></td>
<td>0.523</td>
<td>0.002</td>
</tr>
<tr>
<td>ITT</td>
<td></td>
<td>0.301</td>
<td>0.083</td>
</tr>
<tr>
<td>CPT-IP</td>
<td></td>
<td>0.313</td>
<td>0.071</td>
</tr>
<tr>
<td>CPT-DS</td>
<td></td>
<td>0.206</td>
<td>0.242</td>
</tr>
</tbody>
</table>

From Table 2, serotonin levels have shown that the correlation was significant (p <0.05) on the Verbal Fluency (rs = 0.414, p = 0.015). RAVLT-I. 1 (rs = 0.527, p = 0.001). RAVLT-I. 2 (rs = 0.584, p = 0.000), RAVLT-I. 3 (rs = 0.597, p = 0.000) and RAVLT-D (rs = 0.523, p = 0.002). The higher blood serotonin levels then the Verbal Fluency. RAVLT-I. 1. RAVLT-I. 2. RAVLT-I. 3 and RAVLT-D, the better. While at ITT, CPT-IP and CPT-DS not correlate significantly with levels of serotonin with p values >0.05. Blood serotonin levels does not affect the state of ITT, CPT-IP, and CPT-DS.

Table 3 State Relations Based on the Neurocognitive State of Depression with Spearman Correlation Test

<table>
<thead>
<tr>
<th>Neurocognitive</th>
<th>Depression</th>
<th>rs</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal Fluency</td>
<td></td>
<td>-0.501</td>
<td>0.03</td>
</tr>
<tr>
<td>RAVLT-I.1</td>
<td></td>
<td>-0.612</td>
<td>0.000</td>
</tr>
<tr>
<td>RAVLT-I.2</td>
<td></td>
<td>-0.779</td>
<td>0.000</td>
</tr>
<tr>
<td>RAVLT-I.3</td>
<td></td>
<td>-0.717</td>
<td>0.000</td>
</tr>
<tr>
<td>RAVLT-D</td>
<td></td>
<td>-0.552</td>
<td>0.001</td>
</tr>
<tr>
<td>ITT</td>
<td></td>
<td>-0.674</td>
<td>0.000</td>
</tr>
<tr>
<td>CPT-IP</td>
<td></td>
<td>-0.388</td>
<td>0.23</td>
</tr>
<tr>
<td>CPT-DS</td>
<td></td>
<td>-0.206</td>
<td>0.242</td>
</tr>
</tbody>
</table>

From Table 3 seen that the state of depression have a significant correlation (p <0.05) on the Verbal Fluency (rs = -0.501, p = 0.03). RAVLT-I. 1 (rs = -0.612, p = 0.000). RAVLT-I. 2 (rs = -0.779, p = 0.000). RAVLT-I. 3 (rs = -0.717, p = 0.000) RAVLT-D (rs = -0.552, p = 0.001) and ITT (rs = -0.674, p = 0.000). The more severe state of depression, the more bad Verbal Fluency. RAVLT-I. 1. RAVLT-I. 2. RAVLT-I. 3. RAVLT-D. and ITT.

While at CPT-IP and CPT-DS not correlate significantly with depression (p > 0.05). State of depression did not affect the results of the examination and CPTDS CPTIP.

**DISCUSSION**

At this study investigates the relationship of blood serotonin levels with state of depression and neurocognitive state in six months after moderate brain injury.

The result showed that patients with brain injuries were mostly happens to the 18-25 years age group. This is due to the high mobility of this age group than in other age groups. Discipline or level of compliance on the highway which is also a factor less high levels of brain injury was at that age. As in previous studies mentioned that the peak incidence of brain injury due to trauma occurs between the ages of 15 to 24 years. with males 2-3 times more than women (Arifin 2002).

In this study also obtained data that patients who suffered a brain injury is largely male-sex. The incidence of brain injury in males more than females. This is likely due to the mobility of men higher than women in daily activity.

In measuring the degree of depression in the research sample found that the average value of HDRS is 16.06 with standard deviation 5.421. With a minimum of six and a maximum value of 27. Most of the research sample, the amount that is counted 17 people (50%) experienced mild depression. 12 persons (35%) were depressed and two women (6%) experienced severe depression and depression are not as many as three people (9%). This shows that within six months of brain injury are still many who suffered mild and moderate depression.

Depression is the most psychiatric symptoms that occur related to brain injury. it is estimated between 14-77% (Ashman and Gordon, 2006. Partoatmodjo, 2007). Even after 50 years after brain injury, depression lifetime prevalence of 18.5% compared to 13.4% without
previous brain injury with odds ratio 1.54 and 95% CI = 1.17 to 2.04 (Holsinger 2002).

Causes of depression until recently not clearly known. The factors that play a role in the occurrence of depression is a genetic factor, biogenic amin. and life events are stressors (Life Event Stress). Therefore in this study tried to determine how big the role of biologic amen. mainly affecting the occurrence of serotonin in depression. In this study, the average sample rarely or only occasionally eat food that contains tryptophan and within one week prior to sampling at the recommend patients not to eat many foods that contain tryptophan. so that less dietary factors play a role in affecting serotonin levels patients. Genetic factors. which are known from the existence of a family history of mood disorder. depression not included in this study, so that genetic factors may influence the occurrence of depression could be the Holly.

In this study, Holmes and Rahe score taken if less than 150. so it can get some samples are more homogeneous. thus the existence of psychosocial stressors that may affect the occurrence of depression can be reduced.

Regarding relations with the state of blood serotonin levels of depression showed significant correlations (p <0.05) with the power korelasii (rs) -0.615. This shows that the lower the blood levels of serotonin. the more severe depression experienced by patients who six months ago suffered a brain injury is.

Serotonin is a monoamine neurotransmitter synthesized in serotonergic neurons in the central nervous system. Outside the brain. serotonin contained in platelets. mast cells. cells of the digestive tract enterochromaffin. glia cells. macrophages. smooth muscle cells of the uterus. Blood platelets can retrieve. store and release 5-HT by the same mechanism with the central nervous 5-HT (Rang et al. 2003).

Decrease in serotonin levels alleged role in the occurrence of depression. From the results of research using brain imaging showed reduction in the number pascasinap 5 HT1A receptors and 5 HT2A. There is also a decrease in 5-HIAA (Hydroxindolacetic acid). the metabolism of serotonin. in cerebrospinal fluid. This suggests that the presence of serotonin in depression disorder (Amir 2005).

In table 1. data showed that of 28 people with normal serotonin levels. there are 15 people (88.8%) experienced mild depression. 10 persons (83.3%) were depressed. This suggests that in addition to serotonin. there are still other factors that play a role in the occurrence of depression. such as an imbalance of other neurotransmitters. neuroendocrine disorders. changes in neurophysiology and other psychosocial factors. such as not getting a job. many of which have encountered (55%) in this sample.

In an analysis of the relationship of blood serotonin levels with neurocognitive circumstances. show that serotonin levels have a significant correlation in some cognitive parameters. namely verbal fluency are examined with the parameters of Verbal Fluency Test (VFT). immediate and delayed verbal memory in check by using the parameters Rey Auditory Verbal Learning Test-Immediate and Delayed (RAVLT-I and RAVLT-D). Serotonin levels have no significant correlation of the accuracy and speed of information processing or reaction time using the parameters of Inspection Time Task (ITT). working memory and the ability to interpret visual information assessed by the Continuous Performance Task test-identical pairs (CPT-IP) and the Continuous Performance -Degraded Stimuli Task (CPT-DS).

Serotonin (5-Hydroxytryptamine / 5-HT) associated with the short term signaling in neurons via modulation of cAMP and Ca levels in neurons. Estimated 5-HT to work to increase levels of BDNF (Brain derived neurotrophic factor). which is one that works endogenous neuromodulator signaling. set the long term survival and differentiation of specific neurons during development and maintain the viability of neuronal cells and neuroplasticity. BDNF is also required to serotonergic axon sprouting after ischemic (Yudiarto 2007).

BDNF also behave as a neurotransmitter that modulates like Long Term Potentiation (LTP) as a response of hippocampal synaptic plasticity essential for learning and memory processes (Yudiarto 2007).

The results of this study show that serotonin levels have no significant correlation of the accuracy and speed of information processing or reaction time. working memory and the ability to interpret visual information. This can be caused due cognitive deficits is an accumulation effect of focal or diffuse brain injury. Cognitive sequelae depending on various factors. such as the degree of diffuse axonal injury. loss of consciousness and duration of post-traumatic amnesia. the dysfunction of brain stem injury time. location and size of the focal hemisphere injury (Rao & Lyketsos 2002).

In this research did not analyze the existence or non-surgical operation and the types and lesinya. which is another factor that may affect the monoamine path damage. Focal and diffuse injury is a major cause of
neurological disorders. In diffuse brain injury occurs widespread brain dysfunction. This is caused by many factors, including blood-brain barrier damage (SDO), impaired cerebral blood flow (CBF), metabolic disorders and brain cell ion homeostasis, hormonal disorders, spending neurotransmitters and Reactive Oxygen Species (ROS), infection and acidosis (Arifin 2002). Surgery causing brain ischemia. In brain ischemia there is a series of pathologic events that will cause damage that can occur SDO functions and edema can occur due to damage the integrity of transformation hemorrhagic SDO and the basal lamina and activation of plasminogen-plasmin system by endogenous plasminogen activator (EPA). Plasminogen activator plays a role in central neuronal activation in response to stimulation of corticotropin releasing factor (CRF) through CRF-RI receptor signaling is important in behavioral responses, autonomic and hormonal. Also play a role in neuroplasticity, learning processes and processes for certain anxiety that the process is not yet known (Fenny 2006).

Language disorders caused by post traumatic head injury in frontal, and temporal areas. The high percentage of individuals with head trauma on the frontal lobe or frontal systems, are generally high level of disruption or disturbance of thinking executive functions, whereas memory in connecting with Temporo-hippocampal region, and attention to the subcortical frontoparietal system (Ashman & Gordon 2006). This is consistent with observations in this study, that approximately 45% research sample who had focal brain injury in frontal and temporal regions showed less (≤ 25th percentile) on the examination of verbal fluency with the parameters of Verbal Fluency Test (VFT), verbal memory immediate and delayed in check by using the parameters Rey Auditory Verbal Learning Test-Immediate and Delayed (RAVLT-I and RAVLT-D).

Depression can cause neurocognitive deficits. Impaired attention and concentration, and decreased ability to think, including short-term memory and learning process is a symptom of depression associated with impaired neurocognitive function. In its analysis on the relationship of depression with neurocognitive conditions. shows that depression has a significant correlation in some cognitive parameters, namely verbal fluency are examined with the parameters of Verbal Fluency Test (VFT), the process of learning in the form of immediate and delayed verbal memory in check by using the parameters Rey Auditory Verbal Learning Test-Immediate and Delayed (RAVLT-I and RAVLT-D), and the accuracy and speed of information processing or reaction time using the parameters of Inspection Time Task (ITT). But the state of depression have no significant correlation to the ability to maintain attention and concentration, working memory and the ability to interpret visual information assessed by the Continuous Performance Task test-identical pairs (CPT-IP) and the Continuous Performance Task-Degraded Stimuli (CPT-DS). This could be due to the greatest number of the study sample amounted to 50%. mild depression, which was followed by depression, which is 35%. so the disturbance ability to maintain attention and concentration is not too prominent.

CONCLUSION

Patients who suffered brain injuries are a natural by many in the 18-25 year age group. there were 19 people (56%) with male gender that is counted 26 people (76%). This incident indicates a higher risk factor in these age groups for brain injury than any other group. This is because the high mobility and the level of discipline or obedience on the highway is lacking in these age groups.

There is significant correlation between blood serotonin levels in patients with depression the situation six months after brain injury (p = 0.00).

There is significant correlation between blood serotonin levels with some neurocognitive parameters in patients six months after brain injury. namely verbal fluency are examined with the Verbal Fluency Test parameters / VFT (p = 0.015), immediate verbal memory is checked by using the parameters Rey Auditory Verbal Learning Test-Immediate (RAVLT-I, 1, 2 and 3 respectively p = 0.001, 0.000, and 0.000) and delayed verbal memory in check by using the Rey Auditory Verbal Learning TestDelayed / RAVLT-D (p = 0.0020).

Serotonin concentration has no significant relationships with several other neurocognitive parameters. namely the accuracy and speed of information processing or reaction time. working memory and the ability to interpret visual information, each of which is checked by using the parameters of Inspection Time Task (ITT. p = 0.083 ). Continuous Performance Task-identical pairs (CPT-IP. p = 0.071) and the Continuous Performance Task-Degraded Stimuli (CPT-DS. p = 0.242).

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Blood Serotonin Level with Depression Situation and Neurocognitive as a Reflection of Neuron Condition. (Ifa Tunisya et al.)


