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Metabolic marker of acute cerebral circulation disorder in postmortal diagnosis

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Abstract
Postmortal biochemistry studies the patterns of development biochemical processes in the corpses, the correlation of lifetime and postmortal indicators, diagnostic criteria used to determine the causes of death. The aim of the research was to study the glucose and lactate content in cadaveric blood to develop a method for diagnosing acute cerebral circulatory disorders that does not depend on the duration of the post-mortem period. Biochemical blood analysis was carried out from 82 corpses, which were divided into 4 main groups (Mechanical asphyxia – suicide, mechanical asphyxia – murder, stroke, traumatic brain injury) and 2 comparison groups (Acute myocardial infarction and acute ethanol poisoning). To solve this problem, the glucose and lactate content were determined. The Delta-parameter was calculated, which is the difference in the total glucose and lactate content (in terms of glucose) between blood from the femoral vein and blood from the sinuses of the dura mater. In both comparison groups (Acute myocardial infarction and acute ethanol poisoning), the value of the Delta-parameter did not exceed 5.0 mmol/l. A significant (p =0.00000) increase in the Delta-parameter was found in all main groups with acute cerebrovascular accident – in persons who died as a result of stroke and traumatic brain injury and also in groups with mechanical asphyxia. A new metabolic marker of acute cerebrovascular accident is proposed - the Delta-parameter, which represents the difference in the total glucose and lactate content in terms of glucose between blood from the femoral vein and blood from the sinuses of the dura mater. The Delta-parameter exceeding 5.0 mmol/l indicates the onset of death as a result of acute cerebrovascular accident. At the same time, the reliability of the study (the value of the test) remains for a long post–mortem period – before the development of sharp putrefactive changes in the blood.

Keywords: Post-mortem diagnosis, mechanical asphyxia, acute cerebral circulatory disorders, blood, glucose, lactate

Introduction
Modern forensic medical diagnostics is complex in nature and based on the totality of the results of sectional, instrumental, laboratory studies and data of medical documents with the involvement in practical work of diagnostic methods that differ in expressiveness and evidentiary value. The use of biochemical methods for the purposes of thanatology constitutes a special section of biochemistry – postmortem biochemistry. Postmortal biochemistry studies the patterns of development biochemical processes in the corpse, the correlation of lifetime and postmortal indicators, diagnostic criteria used to determine the causes of death [1]. Despite the fact that in clinical practice today there are several hundred biochemical indicators of diagnostic significance, its use for post-mortem diagnosis is not always possible.
The experience of biochemical research has shown that the effectiveness of these methods and the reliability of the results largely depend on the rules of sampling and the condition of the objects delivered for research. Therefore, for a forensic thanatologist, the main thing is to observe the purity of taking the material, the place of taking the object and the delivery time to the laboratory.
Biochemical changes in the blood during mechanical asphyxia due to of compression of the neck organs by a noose are caused by an acute violation and cessation of cerebral circulation. A characteristic feature is a decrease glucose level in the blood flowing from the brain [2].
It is well known that after death, there is a persistent decrease in glucose, up to its complete absence by the end of 2-3 days, even when blood is stored at a low temperature.

The decrease in blood glucose level depends on the rate of metabolic processes in the shaped elements of the blood, mainly in red blood cells, which is associated with the rate of cooling of the corpse (low or elevated ambient temperature). In addition, it is known that the biochemical characteristics of blood have regional characteristics – the highest concentration of glucose is found in the hepatic vein, and the lowest – in the blood from the femoral vein.

Lactate is the product of glycolysis, so it is studied together with glucose. It should be noted that the lactate content in the blood of corpses is 20-30 folds higher than in living people and this is due to hypoxia in the agonal period and depends on the duration of the agonal period [3].

The aim of the research was to study the glucose and lactate content in cadaveric blood to develop a method for diagnosing acute cerebral circulatory disorders that does not depend on the duration of the post-mortem period.

Materials and Methods

These studies were conducted in the Regional Bureau of Forensic Medical Examination and Pathoanatomic Research (Perm, Russia). Biochemical blood analysis was carried out from 82 corpses, which were divided into 4 main groups and 2 comparison groups (Table 1).

To solve this problem, the total glucose and lactate content in the blood from two different parts of the venous system of the corpse was determined – from the peripheral vein (femoral or iliac) and in the blood from the sinuses of the dura mater.

Blood was collected by siringers in a volume of at least 5.0 ml from each department of the venous system of the corpse. Whole or hemolysed blood was treated with the addition of an equal amount of 1.2 M perchloric acid to precipitate proteins, centrifuged for 15 minutes at 1600 g. The aliquot amount of the infusion fluid was taken into a clean test tube and neutralized by adding 2 M of potassium carbonate at the rate of 0.2 ml per 1.0 ml of perchloric acid. Then tubes were centrifuged again at 150-200 g for 3 min. The resulting filler fluid was used for analysis. Quantitative determination of glucose and lactate was carried out by enzymatic methods – glucose oxidase and lactate oxidase.

After receiving the results, the calculation was carried out according to the total content of glucose and lactate (in terms of glucose) in each department of the venous system: glucose + 1/2 lactate (since in the process of glycolysis, 2 moles of lactic acid are formed from 1 mole of glucose). The Delta-parameter was calculated, which is the difference in the total glucose and lactate content (in terms of glucose) between blood from the femoral vein and blood from the sinuses of the dura mater.

Results

The lowest indicator of the Delta-parameter was established in the second comparison group (acute ethanol poisoning) – the average indicator of which is about zero. In the first comparison group (acute myocardial infarction), the average was higher ($p=0.00212$), but the maximum content did not exceed 5.0 mmol/l (Table 1).

All cases of mechanical asphyxia as a result of neck compression with a noose were divided into two groups – suicide and murder (Table 1). In all cases of homicides, the Delta-parameter was higher than 5.0 mmol/l, and the average was significantly higher than both comparison groups.

Similar disorders of cerebral circulation were detected in traumatic brain injury and stroke. A significant ($p = 0.00000$) increase in the Delta-parameter was found in groups with acute cerebrovascular accident – in persons who died as a result of stroke and traumatic brain injury compared with both comparison groups (Table 1).

Table 1: The Delta-parameter in acute cerebrovascular accident

Observation group	n	M ± m (mmol/l)	min – Max (mmol/l)
Comparison group 1 (Acute myocardial infarction)	18	2,1 ± 0,5	-3,0 – 5,0
Comparison group 2 (Acute ethanol poisoning)	16	-0,3 ± 0,7	-5,4 – 4,2
Mechanical asphyxia (Suicide)	15	10,0 ± 1,9	1,3 – 27,0
Mechanical asphyxia (Murder)	7	11,3 ± 2,1	5,5 – 32,0
Stroke	11	11,4 ± 1,9	5,4 – 26,8
Traumatic brain injury	15	11,5 ± 1,4	5,5 – 28,3

Discussion

When hanging (Suicide) in 80% of cases, the Delta-parameter clearly indicated an acute violation of cerebral circulation. At the same time, in 20% of cases, the quantitative indicator of the Delta-parameter corresponded to normal values. This is obviously due to reflex irritation of the neck receptors (Death can occur in the first seconds), different duration of dying (Hanging with a jerk, smooth hanging), and can be observed in imitation of suicide [4, 5]. The practical use of this type of research is also advisable in cases of murders with strangulation with a soft loop (scarf) with a weakly pronounced strangulation furrow and in the differential diagnosis of *in vivo* compression of the neck or imitation of suicide [6].

Cerebrovascular pathology ranks 2nd among the main causes of death, however, this pathology is not recognized in about 60% of cases or is misdiagnosed as a traumatic brain injury in 50% of cases [7]. At the same time, the frequency of ischemic stroke is about 80%, and only 20% is accounted for by hemorrhagic stroke.

It is known that in traumatic brain injury, damage to the vessels of the brain leads to a decrease in blood flow by 30% and oxygen consumption by 70% [8]. In the first day of the post-traumatic period, secondary circulatory disorders in the brain are also manifested, which aggravates the severity of the injury [9]. The high content of blood lactate in living persons in the early stages of the post-traumatic period is an unfavorable prognostic indicator [10]. Thus, a traumatic brain injury can cause an acute violation of cerebral circulation, which was confirmed by our studies [11].

The proposed method allows for a quantitative assessment of acute cerebral circulatory disorders even with minimal morphological changes. The Delta-parameter also indicates the period of survivability after receiving a traumatic brain injury. The higher the value of the parameter, the longer the period of experience after injury. Thus, post-mortem diagnosis of acute cerebral circulatory disorders is possible when studying the Delta-parameter, which, in fact, is a parameter of acute cerebral hypoxia.

Examples of specific execution

Case 1: Deceased A., man, 58 years old. The diagnosis is acute myocardial infarction. Chronic ischemic heart disease. The duration of the postmortem period is 2 days.

Calculation of the total glucose and lactate content in whole blood

Femoral vein – 0,0 + (49,8 / 2) = 24,9 mmol/l
Sinuses of the dura mater – 0,0 + (43,9 / 2) = 22,0 mmol/l
The difference in the total value: 24,9 – 22,0 = 2,9 mmol/l
In this example, the Delta-parameter is less than 5.0 mmol/l. There is no acute violation of cerebral circulation.

Case 2: Deceased B., man, 40 years old. The diagnosis is acute ethanol poisoning. The duration of the postmortem period is 1 day.

Calculation of the total glucose and lactate content in whole blood

Femoral vein – 0,0 + (32,7 / 2) = 16,4 mmol/l
Sinuses of the dura mater – 0,0 + (34,1 / 2) = 17,1 mmol/l
The difference in the total value: 16,4 – 17,1 = - 0,7 mmol/l
In this example, the Delta-parameter has a negative value. Acute cerebrovascular accident was not detected.

Case 3: Deceased N., man 30 years old. The diagnosis is mechanical asphyxia from compression of the neck organs by a noose during hanging. The post-mortem period was 11 days. Due to the duration of the post-mortem period, the blood is hemolysed with a putrid odor.

Calculation of the total glucose and lactate content in whole blood

Femoral vein – 0,0 + (41,4 / 2) = 20,7 mmol/l
Sinuses of the dura mater – 0,0 + (23,0 / 2) = 11,5 mmol/l
The difference in the total value: 20,7 – 11,5 = 9,2 mmol/l

In this example, the Delta-parameter has a sharply positive value, despite the beginning of putrefactive transformation of blood, which indicates an acute violation of cerebral circulation caused by mechanical asphyxia as a result of compression of the neck organs with a loop.

Case 4: Deceased K., woman, 75 years old. The diagnosis is hemorrhagic stroke. Chronic ischemic heart disease. Diabetes mellitus. The post-mortem period is 2 days.

Calculation of the total glucose and lactate content in whole blood

Femoral vein – 35,4 + (59,3 / 2) = 65,1 mmol/l
Sinuses of the dura mater – 11,5 + (53,5 / 2) = 38,3 mmol/l
The difference in the total value: 65,1 – 38,3 = 26,8 mmol/l

In this example, a high blood glucose content is associated with the presence of diabetes mellitus during the life of the victim. The Delta-parameter is sharply increased, which indicates an acute violation of cerebral circulation resulting from a stroke.

Case 5: Deceased B., man, 82 years old. The diagnosis is a traumatic brain injury. Car injury. The post-mortem period is 2 days.

Calculation of the total glucose and lactate content in whole blood

Femoral vein – 1,6 + (36,0 / 2) = 19,6 mmol/l
Sinuses of the dura mater – 0,5 + (25,0 / 2) = 13,0 mmol/l

The difference in the total value: 19, 6 – 13,0 = 6,6 mmol/l
In this example, an increase in the Delta-parameter is observed, which indicates an acute violation of cerebral circulation resulting from a traumatic brain injury.

Case 6: Deceased N., woman, 45 years old. The diagnosis is mechanical asphyxia from compression of the neck with a noose. Murder. Morphological signs of the strangulation furrow are weakly expressed. The post-mortem period is 3 days.

Calculation of the total glucose and lactate content in whole blood

Femoral vein – 0,0 + (42,0 / 2) = 21,0 mmol/l
Sinuses of the dura mater – 0,0 + (3,7 / 2) = 1,9 mmol/l
The difference in the total value: 21,0 – 1,9 = 19,1 mmol/l

In this example, there is a sharp increase in the Delta-parameter, which indicates an acute violation of cerebral circulation, which was the result of mechanical asphyxia as a result of compression of the neck with a loop.

Conclusion

A new metabolic marker of acute cerebrovascular accident is proposed - the Delta-parameter, which represents the difference in the total glucose and lactate content in terms of glucose between blood from the femoral vein and blood from the sinuses of the dura mater. The Delta-parameter exceeding 5.0 mmol/l indicates the onset of death as a result of acute cerebrovascular accident. At the same time, the reliability of the study (the value of the test) remains for a long postmortem period – before the development of sharp putrefactive changes in the blood.

Conflict of Interest

Not available

Financial Support

Not available

References

1. Dezhinova TA, Popov VL, Zaslavskiy GI. Sudebno-biokhimicheskie issledovaniya. S.-Peterburg. (In Russ.); c2003.
2. Akimov PA, Terekhina NA. Method for diagnosing mechanical asphixia cases caused by neck organs compression with loop. RU Patent No. 2302001. (in Russ.); c2007.
3. Terekhina NA, Akimov PA. Biochemical analysis of the vitreous body of the eye in post-mortem diagnosis of diabetic coma. Pathological physiology and experimental therapy. (In Russ.). 2005;(2):24-25.
4. Molin YuA. Sudebno-medizinskaya ekspertisa povesheniya (Doctoral dissertation, S.-Peterburg (In Russ.); c1996.
5. Mishin ES. Sudebno-medizinskaya ekspertisa udavleniya petley (Doctoral dissertation, S.-Peterburg. (In Russ.); c1997.
6. Molin YuA Sudebno-medizinskaya ekspertisa

povesheniya. S.-Peterburg: Professional; c2014. (In Russ.).
7. Gomonova Iyu. On the problem of unexpected death resulting from a disease of the central nervous system. Sudebno-meditsinskaya ekspertiza. (In Russ.). 2013;56(2):52-55.
8. Gruzman AB, Khapiy KhKh. Carbohydrate metabolism in the brain during coma. Mechanisms of gluconeogenesis. Russian journal of anaesthesiology and reanimatology. (in Russ.). 1991;36(3):17-20.
9. Guseinov GK, Fetisov VA, Bogomolov DV. Forensic medical evaluation of tanatogenesis in survivors of a craniocerebral injury. Sudebno-meditsinskaya ekspertiza. (In Russ.). 2010;53(4):8-9.
10. Terekhina NA, Akimov PA, Anisimov GV. Diagnostic value of determination of blood lactate content in craniocerebral injury. Journal of New Medical Technologies. (In Russ.). 2012;19(4):58-59.
11. Akimov PA. Method of postmortal diagnostics of acute cerebral circulation dysfunction. RU Patent No. 2449284. (In Russ.); c2012.

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