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THE USE OF THE DIFFUSE TOMOGRAPHY METHOD FOR RESEARCHING THE TIME OF HEMORRHAGE FORMATION IN THE SUBSTANCE OF THE HUMAN BRAIN

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Summary

As traumatic brain injury (TBI) causes the highest level of mortality and disability among all types of mechanical injuries, forensic authorities pay a lot of attention to investigating the circumstances of its receipt. In turn, in order to reproduce the events preceded death from TBI, investigative bodies need to know as precisely as possible the time of hemorrhage formation, which can often be close to the moment of death. Therefore, scientists in the field of forensic medicine are working on the development of express methods that would allow to geta quick and objective answer to the question of establishing the age of the formation of a hemorrhage in the substance of the human brain.

The purpose and tasks of the research. *To develop, within the framework of the statistical analysis of optical anisotropy maps, universal forensic medical criteria for the determination of time of haemorrages formation due to TBI, cerebral infarction of ischemic and hemorrhagic genesis by the method of diffuse tomography of the polycrystalline component of native histological sections of the brain with algorithmic reproduction of fluctuations in the value of linear birefringence.*

Research materials and methods. *Native slices of human brain from the parietal area were taken for the study from the dead with a known time of hemorrhage formation from 1 to 7 days, according to medical documents. The cause of death was traumatic hemorrhage – II group (n=100), ischemic cerebral infarction – III group (n=110), non-traumatic hemorrhage – IV group (n=105), acute coronary insufficiency – I group – control (n=20). In the laboratory of the Institute of Physical, Technical and Computer Sciences of the Yuriy Fedkovich Chernivtsi National University, studies of the obtained samples were carried out using a Stokes polarimeter by the diffuse tomography method of reproduction of fluctuations of linear birefringence (FLB).*

The evaluation of the obtained results was carried out by means of statistical (statistical moments of the 1st – 4th orders were determined) and informational analysis (the operational characteristics of the strength of the methods were determined: sensitivity, specificity and balanced accuracy).

The study was carried out in compliance with the main provisions of the GCP (1996), the Council of Europe Convention on Human Rights and Biomedicine (from 04.04.1997), the Helsinki Declaration of the World Medical Association on the ethical principles of conducting scientific medical research with human participation (1964-2013), order of the Ministry of Health of Ukraine No. 690 dated 23.09.2009, No. 616 dated 03.08.2012 at the Department of Forensic Medicine and Medical Law of Bukovinian State Medical University as a fragment of the complex research work of the Department of Forensic Medicine and Medical Law «Using modern morphological and physical methods for diagnosing the time and cause of death, the occurrence of bodily injuries, the development of their remote and immediate consequences in order to solve the urgent tasks of law enforcement agencies and current issues of forensic science and practice» 0123U101978. The author is a co-performer of the research work.

Research results. *As part of the statistical analysis of the data of the diffuse tomography method, universal forensic criteria (markers) for determining the age of the formation of hemorrhages were established – asymmetry and excess, which characterize the temporal transformation of the coordinate distributions of the random values of the optical anisotropy parameters for cases of TBI, death due to brain infarction of ischemic and hemorrhagic genesis. It was established that degenerative-dystrophic changes and necrotic destruction of the polycrystalline structure formed by optically active spatially structured protein fibers of nervous tissue are objectively manifested in statistically reliable linear (within 120 hours) changes in the magnitude of the statistical moments of the 3rd and 4th orders, which characterize the asymmetry and excess of distributions of random values of the FLB value of fibrillar networks with the increasing age of the formation of hemorrhages.*

Conclusions. *Statistical analysis of temporal transformation of maps of optical anisotropy of nervous tissue revealed universal criteria (statistical moments of the 3rd and 4th orders) for forensic assessment of the age of formation of hemorrhages of various genesis. By monitoring the time change in the magnitude of statistical moments of the 3rd and 4th orders, which characterize the asymmetry and excess of distributions of random values of the magnitude of fluctuations in the manifestations of optical anisotropy of nervous tissue, were determine the duration (120 hours) and the ranges of linear changes in the values of the following universal detection parameters of occurrence of hemorrhages in case of TBI ($\overline{SM_4}$:0,33 − 3,31); brain infarction of ischemic genesis ($\overline{SM_3}$:0,33 − 2,21; $\overline{SM_4}$:0,48 − 3,5) and brain infarction of hemorrhagic genesis ($\overline{SM_3}$:0,28 − 1,96; $\overline{SM_4}$:0,39 − 2,7). Diagnostic accuracy is 1.5 h ± 20 min.*

Key words: *Traumatic Brain Injury; Forensic Medicine; Time of Formation of Hemorrhage; Diffuse Tomography*

Introduction

Since traumatic brain injury (TBI) causes the highest level of mortality and disability among all types of mechanical injuries, forensic authorities pay a lot of attention to investigating the circumstances of its occurrence [1,2]. Due to the high lethality and conditions of occurrence, almost all those who died from this type of injury are sent to the forensic medical examination bureau for an autopsy to clarify the mechanism and cause of death [3]. However, sometimes there are cases when, in the absence of external damage to the soft tissues of the head, internal examination of the membranes and hemispheres of the brain reveals sub- or supra-membrane hematomas and intracerebral hemorrhages. Or in the literature you can find descriptions of cases when a heart attack developed against the background of previously received craniocerebral injuries, and more often the situation develops on the contrary [4]. In such cases, in order to find out the circumstances preceding the death, the investigating authorities need to know as precisely as possible the time of the formation of hemorrhage, which can often be close to the moment of death [5,6]. Therefore, scientists in the field of forensic medicine are working on the development of express methods that would allow to get a quick and objective answer to the question of establishing the age of the formation of a hemorrhage in the substance of the human brain.

For a long time, the domestic forensic medical practice was satisfied with the data obtained through forensic histological examination, however, the obtained results usually gave superficial data on the age of the hemorrhage [7,8]. Computed tomography effectively diagnoses hemorrhage, but provides little information about its antiquity [9]. In addition, this is an expensive study that is not always possible to conduct.

Laser-optical methods [10-16] have demonstrated their effectiveness in determining the antiquity of processes in the tissues and fluids of the human body in the field of forensic medicine [10-16] research, which can testify to their effectiveness in diagnosing the antiquity of the formation of hemorrhages [17-19].

The purpose and tasks of the research

To develop, within the framework of the statistical analysis of optical anisotropy maps, universal forensic criteria for determining the age of hemorrhage due to TBI, death due to brain infarction of ischemic and hemorrhagic genesis by the method of diffuse tomography of the polycrystalline component of native histological sections of the brain with algorithmic reproduction of fluctuations in the value of linear birefringence (FLB) by means of multichannel linearly and circularly polarized laser probing followed by polarization filtering of a set of partial microscopic images of native biological preparations.

Research materials and methods. For research, native slices of human brain from the parietal area from the dead with a known time of hemorrhage formation from 6 h to 168 h, according to the data of medical documents. The cause of death was hemorrhages of traumatic genesis – II group (total number n=100), cerebral infarction of ischemic genesis – III group (n=110), hemorrhage of non-traumatic genesis – IV group (n=105), acute coronary insufficiency – I group – control (n=20).

The selected samples of brain substance were immediately subjected to quick freezing at a temperature of –70 °C, and further histological sections were made using a freezing microtome. In the laboratory of the Institute of Physical, Technical and Computer Sciences named after Yuriy Fedkovich, studies of the obtained samples were carried out with the help of a Stokes polarimeter by the method of diffuse tomography of reproduction of fluctuations in the value of linear birefringence.

For the forensic assessment of the age of traumatic hemorrhage, cerebral infarction of ischemic and hemorrhagic genesis, the following research design and reconstruction of fluctuations in the parameters of the optically anisotropic polycrystalline structure of histological sections of experimental samples from all groups was developed and implemented [11-19]:

1) Mueller-matrix mapping of test samples using well-known biomedical and optical techniques [17] of multi-channel polarization laser probing and analysis of a series of polarization-filtered microscopic images followed by algorithmic acquisition of a series of Mueller-matrix images of the polycrystalline structure of test samples of all groups.

2) In the time interval from 6 h to 168 h, within each of the experimental groups II, III, IV, 10 partial subgroups were formed (for the following times (T, h) after the onset of death – 6; 12; 18; 24; 48; 72; 96; 144 and 168) with 10-11 samples each.

3) Within each partial subgroup, for each sample of a native histological section of the brain, the coordinate distributions of the elements of the differential matrix of the 2nd order were measured (the biophysical method of experimental measurements is presented in detail in a series of publications [17,18]) and on this basis the coordinate distributions (maps) random values of the FLB map of protein fibrillar networks were established.

4) Central statistical moments of the 1st to 4th orders ($SM_{i=1;2;3;4}$), which characterize the mean (SM_1), dispersion (SM_2), asymmetry (SM_3) and kurtosis (SM_4) of distributions of random values of the FLB were calculated.

5) For each of the ten (j = 1,2,…,10) «time» partial subgroups 10 partial subgroups (T_j, h - – 6; 12; 18; 24; 48; 72; 96; 120; 144 i 168) mean values $\overline{SM}_{i=1;2;3;4}$ and statistical errors $m_{i=1;2;3;4}$ of each of the four statistical moments $SM_{i=1;2;3;4}$ were calculated according to the following algorithms

$$\overline{SM}_{i=1;2;3;4}=\begin{cases}\overline{SM}_1=\frac{\sum_{j=1}^{n}(SM_1)_j}{n};\\ \overline{SM}_2=\frac{\sum_{j=1}^{n}(SM_2)_j}{n};\\ \overline{SM}_3=\frac{\sum_{j=1}^{n}(SM_3)_j}{n};\\ \overline{SM}_4=\frac{\sum_{j=1}^{n}(SM_4)_j}{n}.\end{cases}\text{ i } m_{i=1;2;3;4}=\begin{cases}m_1=\frac{s^2((SM_1)_j)}{\sqrt{n}};\\ m_2=\frac{s^2((SM_2)_j)}{\sqrt{n}};\\ m_3=\frac{s^2((SM_3)_j)}{\sqrt{n}};\\ m_4=\frac{s^2((SM_4)_j)}{\sqrt{n}}.\end{cases}$$

6) Within the limits of each partial group (as the time increases from the time of hemorrhage formation), the statistical reliability of the difference between the determined mean values $\overline{SM}_{i=1;2;3;4}$ and statistical errors $m_{i=1;2;3;4}$ were determined for values of each of the set of central statistical moments $SM_{i=1;2;3;4}$ by establishing the value of t – Student's criterion, which corresponds to the statistical measure p not less than 0,05 - $p \le 0{,}001 \div 0{,}05$.

7) On this basis, statistically reliable parameters (markers $\overline{SM}_i = (p \le 0{,}05)$) were determined within the set of central moments of the 1st to 4th orders $\overline{SM}_{i=1;2;3;4}$, which characterize temporal changes of the coordinate distributions of random values of the FLB value of native histological sections of the brain.

8) For such parameters, time dependences of changes in their values were determined $\overline{SM}_i = (T, p \le 0{,}05)$.

9) In the obtained time dependences of statistical markers $\overline{SM}_i = (T, p \le 0{,}05)$, linear sections were determined, according to the duration of which the antiquity of the formation of hemorrhage was found and the accuracy of its establishment was established.

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The evaluation of the obtained results was carried out by means of statistical (statistical moments of the 1st – 4th orders were determined) and informational analysis (the operational characteristics of the strength of the methods were determined: sensitivity, specificity and balanced accuracy).

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Research results

Fragments of a series of figs. 1-3 illustrate the maps (fragments (1), (3)) and histograms of distributions (fragments (2), (4)) of random values of the FLB value of optically active protein structures and networks of a set of histological sections of nerve tissue of patients who died from traumatic hemorrhage (Fig. 1), ischemic cerebral infarction (Fig. 2) and non-traumatic hemorrhage (Fig. 3) with different age of hemorrhage formation:

- mage (map) size, pixels – 1240920;
- Total number of pixels of the image (map)– 1140800;
- To build a histogram within the framework of the software product MATLAB R2022 100 columns were used, that is, a step X/100.

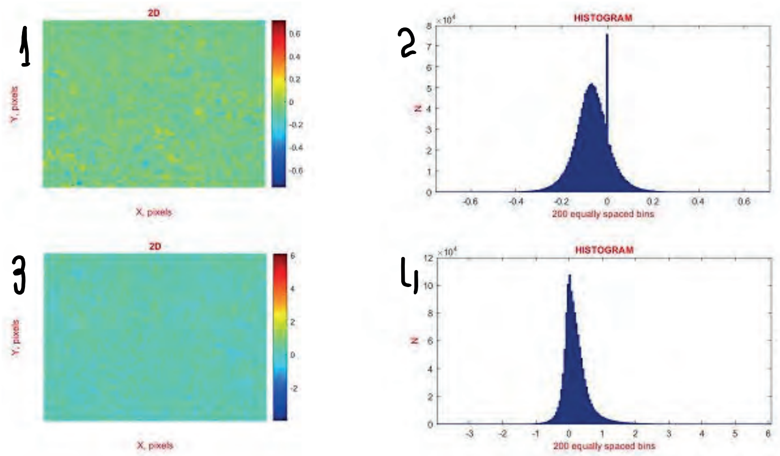

Fig. 1. **Maps ((1),(3)) and histograms ((2),(4)) of the distribution of FLB value of histological sections of the brains of the deceased from group 2 for the age of formation of hemorrhages of 6 ((1),(2)) and 24 h ((3), (4)).**

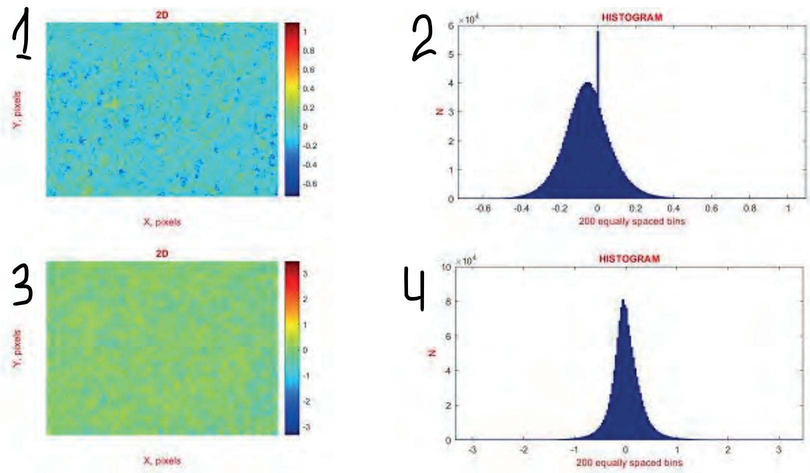

Fig. 2. **Maps ((1),(3)) and histograms ((2),(4)) of the distribution of FLB value of histological sections of the brains of the deceased from group 3 for the age of formation of hemorrhages of 6 h ((1),(2)) and 24 h ((3), (4)).**

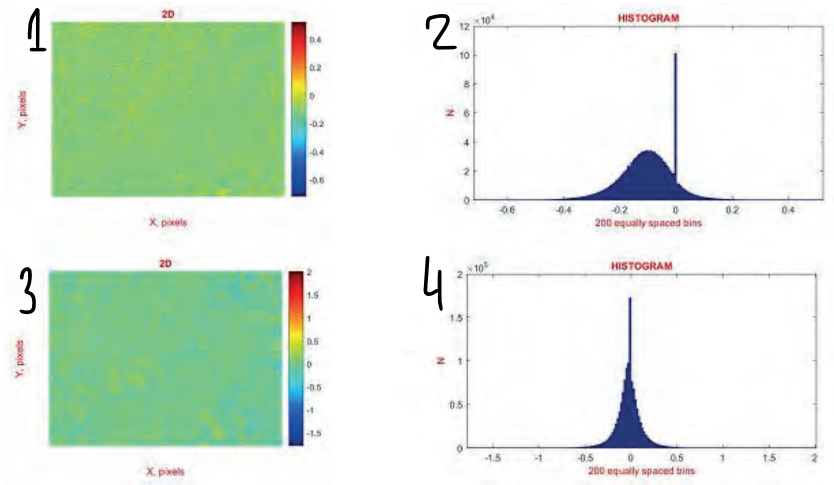

Fig. 3. Maps ((1),(3)) and histograms ((2),(4)) of the distribution of FLB value of histological sections of the brains of the deceased from group 4 for the age of formation of hemorrhages of 6 h ((1),(2)) and 24 h ((3), (4)).

Time dependences of statistically significant values of statistical moments $\overline{SM}_i = (T, p \leq 0{,}05)$ and statistical errors m_ and their determinations, which characterize necrotic degenerative-dystrophic changes in the coordinate distributions of random values of FLB (at an interval of 6 h – 168 h) of fibrillar networks of samples of histological sections of nerve tissue of the brain with different age of formation of hemorrhages are presented in tables 1-3: deceased within group 2 (table 1), group 3 (table 2) and group 4 (table 3).

Table 1

Temporal dynamics of changes in the statistical moments of the 4th orders, which characterize the distributions of the FLB value of the histological sections of the brains of the deceased from group 2

T, h	6	12	18	24	48
$\overline{SM}_4 \pm m_4$	0,33±0,014	0,65±0,023	0,81±0,035	0,96±0,039	1,59±0,11
p		*p < 0,05*	*p < 0,05*	*p < 0,05*	*p < 0,05*
T, h	72	96	120	144	168
$\overline{SM}_4 \pm m_4$	2,22±0,14	2,86±0,16	3,31±0,23	3,39±0,25	3,14±0,21
p	*p < 0,05*	*p < 0,05*	*p < 0,05*	*p > 0,05*	

Table 2

Temporal dynamics of changes in the statistical moments of the 3rd and 4th orders, which characterize the distributions of the FLB value of the histological sections of the brains of the deceased from group 3

T, h	6	12	18	24	48
$\overline{SM}_3 \pm m_3$	0,33±0,013	0,53±0,018	0,64±0,024	0,73±0,029	1,15±0,088
p		*p < 0,05*	*p < 0,05*	*p < 0,05*	*p < 0,05*
$\overline{SM}_4 \pm m_4$	0,48±0,015	0,81±0,033	0,95±0,039	1,11±0,053	1,73±0,078
p		*p < 0,05*	*p < 0,05*	*p < 0,05*	*p < 0,05*
T, h	72	96	120	144	168
$\overline{SM}_3 \pm m_3$	1,54±0,081	1,93±0,092	2,21±0,12	2,29±0,13	2,11±0,11
p	*p < 0,05*	*p < 0,05*	*p < 0,05*	*p > 0,05*	
$\overline{SM}_4 \pm m_4$	2.22±0,12	2,85±0,14	3,56±0,18	3,62±0,18	3,33±0,15
p	*p < 0,05*	*p < 0,05*	*p < 0,05*	*p > 0,05*	

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Table 3

Temporal dynamics of changes in statistical moments of the 3rd – 4th orders, which characterize the distributions of the FLB value of the histological sections of the brains of the deceased from group 4

T, h	6	12	18	24	48
$\overline{SM}_3 \pm m_3$	0,28±0,13	0,46±0,19	0,57±0,21	0,64±0,025	0,99±0,041
p		$p < 0,05$	$p < 0,05$	$p < 0,05$	$p < 0,05$
$\overline{SM}_4 \pm m_4$	0,39±0,014	0,63±0,022	0,75±0,031	0,87±0,036	1,34±0,11
p		$p < 0,05$	$p < 0,05$	$p < 0,05$	$p < 0,05$
T, h	72	96	120	144	168
$\overline{SM}_3 \pm m_3$	1,35±0,11	1,71±0,13	1,96±0,14	2,01±0,15	1,92±0,14
p	$p < 0,05$	$p < 0,05$	$p < 0,05$	$p > 0,05$	
$\overline{SM}_4 \pm m_4$	1,84±0,11	2,31±0,18	2,72±0,22	2,81±0,23	2,66±0,22
p	$p < 0,05$	$p < 0,05$	$p < 0,05$	$p > 0,05$	

Statistical analysis of temporal transformation of maps of optical anisotropy of nervous tissue revealed universal criteria (statistical moments of the 3rd and 4th orders) for forensic assessment of the age of formation of hemorrhages of various genesis. By monitoring the time change in the magnitude of statistical moments of the 3rd and 4th orders, which characterize the asymmetry and excess of distributions of random values of the magnitude of fluctuations in the manifestations of optical anisotropy of nervous tissue, were determine the duration (120 hours) and the ranges of linear changes in the values of the following universal detection parameters of occurrence of hemorrhages in case of TBI ($\overline{SM}_4$: 0,33 − 3,31); brain infarction of ischemic genesis ($\overline{SM}_3$: 0,33 − 2,21; $\overline{SM}_4$: 0,48 − 3,56) and brain infarction of hemorrhagic genesis ($\overline{SM}_3$: 0,28 − 1,96; $\overline{SM}_4$: 0,39 − 2,72).

The following ranges of change have been identified

The error in determining the age of hemorrhage by comparing the time dependences $\overline{SM}_{i=3;4} = (T, p \leq 0,05)$ determined by us and experimental data with unknown age of hemorrhage does not exceed ± 20 min with an accuracy of up to 1.5 hours.

The established regularities of the temporal change (growth) of the value of statistical markers $\overline{SM}_{i=3;4}(T, p \leq 0,05)$ within the framework of the biophysical theory [19] of the necrotic transformation of the optical anisotropy of the biological tissues of human organs can be related with the following objective factors:

1) the maximum level of optical anisotropy of protein networks is determined by the degree of consistency of their spatial and angular orientation and the distribution of transverse geometric dimensions of fibrils [19] of healthy (intact) tissue. Statistically, this is revealed in the individual for different types of biological tissues, but the maximum values of the mean $\overline{SM}_1$ and dispersion $\overline{SM}_2$, which characterize the distributions of fluctuations of optical anisotropy parameters. Statistical moments of higher orders $\overline{SM}_{i=3;4}$, which are inversely proportional to $\overline{SM}_2$ ($\overline{SM}_3 \sim \frac{1}{(\overline{SM}_2)^3}, \overline{SM}_4 \sim \frac{1}{(\overline{SM}_2)^4}$), have the minimum possible values;

2) degenerative-dystrophic and necrotic changes in biological tissue morphologically lead to disorder in the spatial-angular orientation of fibrils and their geometric thinning. Within the framework of the statistical approach, such changes are quantitatively revealed in the reduction of the mean $\overline{SM}_1$ and dispersion $\overline{SM}_2$. Accordingly increase the values of asymmetry and excess of distributions of random values of fluctuations in the optical anisotropy of fibrillar networks of native histological sections of the brain;

3) with the increase in the age of the formation of hemorrhages, the degree of degenerative-dystrophic and necrotic changes in the optically anisotropic component of the brain tissue consistently increases and within the limit reaches a certain and constant or fluctuating level of its degradation. Quantitatively, such processes in our specific studies are detected in a linear increase in the value of statistical moments of higher orders $\overline{SM}_{i=3;4}$ at a certain time interval (up to 120 hours). Next, the temporal change of values $\overline{SM}_{i=3;4}(T)$ is transformed into non-informative fluctuating statistically unreliable dependencies.

Conclusion

1. Conducted research in forensic medical practice on the effectiveness of the method of diffuse tomography of depolarizing histological sections of the brain and computer reproduction of topographic distributions (maps) of optical anisotropy fluctuations and their polycrystalline structure demonstrated a high level of effectiveness in determining the age of traumatic hemorrhages, ischemic and hemorrhagic brain infarctions.

2. Statistical analysis of temporal transformation of maps of optical anisotropy of nervous tissue revealed universal criteria (statistical moments of the 3rd and 4th orders) for forensic assessment of the age of formation of hemorrhages of various genesis.

3. By monitoring the temporal change in the magnitude of the statistical moments of the 3rd and 4th orders, which characterize the asymmetry and excess of the distributions of random values of the magnitude of the fluctuations of the manifestations of optical anisotropy of the nervous tissue the time duration (120 hours) and the ranges of the linear change in the values of the following universal parameters were determined to detect the time of the formation of next cases: traumatic brain injury ($\overline{SM}_4$: 0,33 − 3,31); cerebral infarction of ischemic genesis ($\overline{SM}_3$: 0,33 − 2,21;

$\overline{SM}_4$: 0,48 − 3,56); cerebral infarction of hemorrhagic genesis ($\overline{SM}_3$: 0,28 − 1,96; $\overline{SM}_4$: 0,39 − 2,72).

4. The error in determining the age of hemorrhage formation by comparing the time dependences $\overline{SM}_{i=3;4}$ $(T, p \leq 0{,}05)$ determined by us and experimental data with unknown age of hemorrhage does not exceed 20 min with an accuracy of up to 1.5 h.

Prospects for further research

In the future, it is possible to improve the informativeness of traditional, well-tested methods of Mueller-matrix mapping of histological sections of biological tissues against the background of the distorting effect of depolarization of laser radiation.

Therefore, it is urgent to further develop and test the latest methods of laser tomography to improve the indicators of forensic medical practice and to study the depolarizing laser radiation of brain samples of the deceased.

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ВИКОРИСТАННЯ МЕТОДУ ДИФУЗНОЇ ТОМОГРАФІЇ ДЛЯ ДОСЛІДЖЕННЯ ДАВНОСТІ УТВОРЕННЯ КРОВОВИЛИВІВ У РЕЧОВИНУ ГОЛОВНОГО МОЗКУ ЛЮДИНИ

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Резюме.

Так як черепно-мозкова травма (ЧМТ) серед усіх видів механічних пошкоджень спричиняє найвищий рівень смертності та інвалідизації, тому судово-слідчі органи приділяють багато уваги розслідуванню обставин її отримання. Для з'ясування обставин, що передували смерті від ЧМТ, органам слідства необхідно знати якомога точніший час утворення крововиливу, який нерідко може бути наближеним і до моменту настання смерті. Тому науковці у галузі судової медицини працюють над розробкою експрес-методів, які б дозволили швидко та об'єктивно відповісти на питання встановлення давності утворення крововиливу у речовину головного мозку людини.

Мета і завдання дослідження. Розробити в рамках статистичного аналізу мап оптичної анізотропії універсальні судово-медичні критерії визначення давності утворення крововиливів внаслідок ЧМТ, смерті внаслідок інфаркту мозку ішемічного та геморагічного генезів методом дифузної томографії полікристалічної складової нативних гістологічних зрізів мозку з алгоритмічним відтворенням флуктуацій величини лінійного двопроменезаломлення.

Матеріали та методи дослідження. Для дослідження відбиралися нативні зрізи речовини головного мозку людини зі скроневих та тім'яної ділянок від померлих із відомим часом утворення крововиливу від 1 до 7 діб, згідно даних медичних документів. Причиною смерті були крововиливи травматичного ґенезу (КТҐ) – ІІ група (n=100), інфаркт мозку ішемічного генезу (ІІМ) – ІІІ група (n=110), крововилив нетравматичного ґенезу (КНҐ) – ІV група (n=105), гостра коронарна недостатність – І група – контроль (n=20). У лабораторії Інституту фізико-технічних та комп'ютерних наук Чернівецького національного університету імені Юрія Федьковича були проведені дослідження отриманих зразків за допомогою Стокс-поляриметра методом дифузної томографії відтворення флуктуацій лінійного двопроменезаломлення (ФЛД).

Дослідження виконане з дотриманням основних положень GCP (1996 р.), Конвенції Ради Європи про права людини та біомедицину (від 04.04.1997 р.), Гельсінської декларації Всесвітньої медичної асоціації про етичні принципи проведення наукових медичних досліджень за участю людини (1964-2013 рр.), наказу МОЗ України № 690 від 23.09.2009 р., № 616 від 03.08.2012 р. на кафедрі судової медицини та медичного правознавства Буковинського державного медичного університету як фрагмент комплексної науково-дослідної роботи кафедри судової медицини та медичного правознавства «Використання сучасних морфологічних та фізичних методів для діагностики часу та причини настання смерті, виникнення тілесних ушкоджень, розвитку віддалених та наближених їх наслідків з метою вирішення нагальних завдань правоохоронних органів та актуальних питань судово-медичної науки та практики» 0123U101978. Автор є співвиконавцем науково-дослідної роботи.

Оцінка отриманих результатів проводилася шляхом статистичного (визначалися статистичні моменти 1-го – 4-го порядків) та інформаційного аналізу (визначалися операційні характеристики сили методів – чутливість, специфічність і збалансована точність).

Результати дослідження. В рамках статистичного аналізу даних методу дифузної томографії установлені універсальні для випадків ЧМТ, смерті внаслідок інфаркту мозку ішемічного та геморагічного генезів, судово-медичні критерії (маркери) визначення давності утворення крововиливів – асиметрія і ексцес, які характеризують часову трансформацію координатних розподілів випадкових значень величини параметрів оптичної анізотропії Установлено, що дегенеративно-дистрофічні зміни і некротична руйнація полікристалічної структури, сформованої оптично активними просторово-структурованими протеїновими волокнами нервової тканини об'єктивно виявляються у статистично достовірних лінійних (на протязі 120 год.) змінах величини статистичних моментів 3-го і 4-го порядків, які характеризують асиметрію та ексцес розподілів випадкових значень величини ФЛД фібрилярних сіток з часом зростання давності утворення крововиливів.

Висновки. Статистичний аналіз часової трансформації мап оптичної анізотропії нервової тканини виявив універсальні критерії (статистичні моменти 3-го і 4-го порядків) для судово-медичного оцінювання давності утворення крововиливів різного генезу. Шляхом моніторингу часової зміни величини статистичних моментів 3-го і 4-го порядків, які характеризують асиметрію та ексцес розподілів випадкових значень величини флуктуацій проявів оптичної анізотропії нервової тканини, визначено часову тривалість (120 год.) і діапазони лінійної зміни значень наступних універсальних параметрів з детектування давності утворення випадків ЧМТ (); інфаркту мозку ішемічного () та геморагічного () генезів. Точність діагностики становить 1,5 год ± 20 хв.

Ключові слова: черепно-мозкова травма; судова медицина; час утворення крововиливу; дифузна томографія.

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