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FORENSIC ASSESSMENT AND CRITERIA FOR DETERMINING THE SEVERITY OF BRAIN INJURIES IN CHILDREN AND ADOLESCENTS

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Abstract. A forensic assessment of the morphological and clinical manifestations and course of traumatic brain injury in children and adolescents is presented, and to objectify forensic medical examination in cases of resolving conflict issues, criteria for the severity of brain injuries in these age groups are defined.

The aim of the study. Conduct a forensic assessment and determine the criteria for the severity of brain injuries in children and adolescents.

Materials and methods. The study material was 112 “Expert Conclusions” from the archives of the Kyiv Regional and Kyiv City Clinical Bureau of Forensic Medical Examination, which related to forensic medical examinations (research) in cases of traumatic brain injuries of children and adolescents. The study design was built taking into account gender and age. Scientific research of expert cases and forensic assessment of the severity of TBI in children was conducted in accordance with the requirements of the Order of the Ministry of Health of Ukraine dated January 17, 1995 № 6 “On the Development and Improvement of the Forensic Medical Service of Ukraine”. Quantitative analysis was conducted using standard methods of variational statistics.

Scientific research. This study is the part of scientific research of the Department of Morphology, Clinical Pathology and Forensic Medicine of the P.L. Shupyk National University of Health Sciences "Scientific substantiation of modern pathomorphological diagnostics and establishment of clinical and morphological correspondences in various diseases" state registration number 0116U007906 (2021-2025).

Bioethics. Materials of the study were approved by the Bioethics Commission of the P.L. Shupyk National University of Health Sciences, (protocol 12/2, 11 of June 2025).

Results. The predominant causes of brain injuries in children in the study were domestic (including criminal), street and transport injuries. Comparative analysis of the course of various forms of traumatic brain injury in different age groups and study of the features of clinical symptoms and the course of non-fatal brain injuries in brain injuries in children and adolescents allowed to lay the foundation for establishing

criteria for forensic medical assessment of their severity and implementing the results obtained into practical expert activities.

Conclusions. Among non-fatal injuries of the face and brain in children of different age groups, craniocerebral injuries prevail. The course of mild forms of craniocerebral injury - concussion in children of younger and preschool age, concussion and mild cerebral contusion in children of younger and senior school age is characterized by predominantly rapidity objective neurological symptoms, with its regression after the injury, on average, on the 7-11th and 9-14th day, respectively, from the moment of the injury, with a high degree of correlation between the terms of regression of the indicated neurological symptoms and the duration of the health disorder. This gives reason to believe that the assessment of the degree of such injuries should be carried out according to the criterion of short-term health disorders in all age groups. In the case of a long-term course of mild forms of craniocerebral injuries or the presence of their consequences Forensic medical assessment of the severity of injuries should be based on a thorough neurological examination of the child and analysis of medical documentation, taking into account indications of an adverse course of labor, congenital malformations and inflammatory diseases of the nervous system in young children, chronic somatic diseases or intoxications in school-age children and adolescents. Severe forms of craniocerebral injuries (severe brain contusion, brain compression by subdural hemorrhages) in children of primary, preschool and primary school age notes the presence of bone fractures, mainly of the cranial vault (linear, pressed and fragment-pressed), in children of senior school age - both the presence and absence of fractures of the bones of the vault and base of the skull, with the development of disorders of vital functions, which pose a danger to the lives of the victims. Thus, the assessment of the severity of such forms of traumatic brain injuries should be carried out according to the criterion of danger to life.

Keywords: forensic medical examination, children, traumatic brain injury, bodily injuries, severity.

СУДОВО-МЕДИЧНА ОЦІНКА ТА КРИТЕРІЇ ВИЗНАЧЕННЯ СТУПЕНЯ ТЯЖКОСТІ ТРАВМ ГОЛОВНОГО МОЗКУ У ДІТЕЙ ТА ПІДЛІТКІВ

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Мета роботи: провести судово-медичну оцінку та визначення критеріїв ступеня тяжкості травм головного мозку у дітей і підлітків.

Матеріали та методи. Матеріалом дослідження були 112 «Висновків

експерта» з архіву Київського обласного і Київського міського клінічного бюро судово-медичної експертизи, які стосувались судово-медичних експертиз (досліджень) дітей і підлітків у випадках черепно-мозкових травм з урахуванням статі та віку.

Науково-дослідна робота. Дослідження є частиною науково-дослідної роботи кафедри морфології, клінічної патології та судової медицини НУОЗУ імені П.Л. Шупика «Наукове обґрунтування сучасної патоморфологічної діагностики та встановлення клініко-морфологічних відповідностей при різних захворюваннях» № державної реєстрації 0116U007906 (2021-2025 рр.).

Біоетика. Матеріали дослідження схвалено комісією з питань біоетики НУОЗУ імені П.Л. Шупика (протокол 12/2 від 11.06.2025).

Результати. Переважними причинами виникнення травм головного мозку у дітей були побутова (в тому числі кримінальна), вулична і транспортна травми. Порівняльний аналіз клінічних симптомів та перебігу травм головного мозку у дітей та підлітків стали основою для критеріїв судово-медичної оцінки їх ступеня тяжкості травм головного мозку. Оцінка ступеня тяжкості таких форм черепно-мозкових ушкоджень має здійснюватись за критерієм небезпеки для життя.

Висновки. Серед травм головного мозку у дітей різних вікових груп переважали черепно-мозкові ушкодження. Перебіг легких форм черепно-мозкової травми - струсу головного мозку у дітей молодшого та дошкільного віку, струсу і забою головного мозку легкого ступеня у дітей молодшого та старшого шкільного віку, відзначається переважною швидкоплинністю об'єктивної неврологічної симптоматики, з її регресом в середньому, на 7-11 та 9-14 добу з моменту травмування, а також високим ступенем кореляції між строками регресу означених неврологічних симптомів та терміном розладу здоров'я. Це дає підстави вважати, що оцінка ступеня таких ушкоджень має здійснюватись за критерієм короткочасного розладу здоров'я у всіх вікових групах. При тривалому перебігу легких форм черепно-мозкових травм або за наявності їх наслідків, судово-медична оцінка ступеня тяжкості тілесних ушкоджень повинна базуватися на ретельному неврологічному обстеженні дитини та аналізі медичної документації, з урахуванням вказівок на несприятливий перебіг пологів, вроджених вад розвитку та запальних захворювань нервової системи у дітей молодшого віку, хронічних соматичних захворювань або інтоксикацій – у дітей шкільного віку та підлітків. Важкі форми черепно-мозкових ушкоджень (забій головного мозку важкого ступеня, стиснення головного мозку підоболонковими крововиливами) у дітей молодшого, дошкільного та молодшого шкільного віку супроводжуються переломами кісток переважно склепіння черепа (лінійних, втиснених та уламково-втиснених), у дітей старшого шкільного віку – як наявність, так і відсутність переломів кісток склепіння та основи черепа, з розвитком порушень вітальних функцій, які складають небезпеку для життя потерпілих. Оцінка ступеня тяжкості таких форм черепно-мозкових ушкоджень має здійснюватися за критерієм небезпеки для життя.

Ключові слова: судово-медична експертиза, діти, черепно-мозкова

травма, тілесні ушкодження, ступінь тяжкості.

Introduction. The relevance of this study is underscored by the current situation in Ukraine, where, in addition to the impact of the ongoing four-year war, there has been an increase in the proportion of domestic injuries among pediatric victims. This trend is driven by the widespread availability and accessibility of various tools and appliances to the population, as well as the automation of household processes, which pose a risk of injury to children of different age groups. Furthermore, a new type of injury associated with road traffic accidents – caused by the use of electric personal mobility devices, bicycles, and others – is becoming increasingly common [1-5].

According to literary sources, injuries to the skull and brain predominate in terms of prevalence and severity among the total number of injuries in children. Traumatic brain injury (TBI) is the leading cause of violent death in children in at least 40% of cases [6-10], including those resulting from domestic abuse [11-13].
Analysis of literature data on mortality from injuries and accidents among children provides grounds for identifying the following main groups: 1) in children aged 1 to 4 years, domestic injuries prevail, primarily associated with inadequate childcare or harsh treatment; 2) in older age groups, the range of injuries expands, with domestic and transport injuries dominating [14]. Traumatic lesions of the central nervous system, particularly traumatic brain injuries (TBI), hold a leading place in the structure of childhood trauma. Currently, they account for up to 37.6% of traumatic cases in children and, according to WHO data, show a tendency to increase by 1-2% per year [15-18]. Over the past decade, there has been no trend towards changing this situation, which defines childhood trauma as an extremely urgent medical and social problem.

Therefore, the information presented above indicates the significant relevance of the problem of traumatic brain injuries in children and adolescents. It requires a meticulous study of its morphological and clinical features not only for therapeutic purposes but also for the objectification of forensic medical examinations in resolving contentious issues.

The aim of the study. To conduct a forensic assessment and determine the criteria for the severity of brain injuries in children and adolescents.

Materials and methods. The study material consisted of 112 "Expert Reports" from the archives of the Kyiv Regional and Kyiv City Clinical Bureau of Forensic Medical Examination, pertaining to forensic medical examinations of children and adolescents in cases of traumatic brain injury (TBI), taking into account gender and age. The scientific study of expert cases and the forensic assessment of the severity of pediatric TBI were conducted in accordance with the requirements of the Order of the Ministry of Health of Ukraine dated January 17, 1995, No. 6 "On the Development and Improvement of the Forensic Medical Service of Ukraine". Quantitative analysis was performed using standard methods of variational statistics.

Scientific research. This study is the part of scientific research of the Department of Morphology, Clinical Pathology and Forensic Medicine of the P.L. Shupyk National University of Health Sciences "Scientific substantiation of

modern pathomorphological diagnostics and establishment of clinical and morphological correspondences in various diseases" state registration number 0116U007906 (2021-2025).

Bioethics. Materials of the study were approved by the Bioethics Commission of the P.L. Shupyk National University of Health Sciences, (protocol 12/2, 11 of June 2025).

Results. To substantiate the expert criteria for the forensic assessment of non-fatal brain injuries in children and adolescents and to further determine the criteria for their severity, a comparative analysis of the course of various forms of TBI in different childhood age groups was conducted.

In cases of cerebral concussion, the analysis was performed based on the following parameters: severity of general cerebral symptoms (impaired consciousness, presence of vomiting, headache), behavioral disorders, time to regression of objective neurological symptoms, and duration of health impairment. The analysis showed that with increasing age of the child, disturbances of consciousness (short-term loss of consciousness) and single vomiting were more frequently observed; in younger children, conversely, the presence of single vomiting was not noted. Furthermore, the younger the child, the more frequently multiple vomiting occurred (observed mainly in children under 3 years of age; multiple vomiting was not observed in high school-age victims). As the age of the victims increased, headache and vestibular-stem disorders were observed more often.

The conducted studies did not reveal a significant difference in the average duration of health impairment among children of different age groups. However, they indicated a longer regression period of objective neurological symptoms in high school-age children compared to preschool-age victims ($P < 0.05$). Thus, despite existing differences in the clinical course of the "acute period" of this form of TBI, the justified criterion for forensic assessment in cases of cerebral concussion in children of all age groups was the duration of a short-term health disorder.

In cases of brain contusion of clinically undetermined severity, a comparative analysis was carried out based on parameters such as: severity of general cerebral (impaired consciousness, presence of vomiting, headache) and focal symptoms (presence of hemi- and monoparesis, cranial nerve damage), behavioral disorders, presence of skull bone damage, time to regression of objective neurological symptoms, and duration of health impairment.

The results of the clinical picture comparison showed that the features of the course of brain injuries accompanied by skull fractures depended on the child's age. Injuries to the calvarial bones (linear fractures with the development of subaponeurotic hemorrhages) were most common in younger children; as the age of the victims increased, the number of brain injuries accompanied by skull bone damage decreased. In turn, impaired consciousness (loss of consciousness) and headache were more frequently noted in children over 7 years old, i.e., these signs were observed more often with increasing age of the victims.

It should also be noted that, according to the results of the medical records review, loss of consciousness and complaints of headache were not recorded in young children; 17 victims (63%) in this group had an asymptomatic or mildly symptomatic

course of brain contusion. Focal brain lesions were found in a small number of cases among younger and preschool-age victims and were more common in children of older age groups (younger and senior school age). Conversely, the presence of behavioral disorders decreased with the increasing age of the victims, occurring more frequently in younger children than in children over 7 years of age ($P < 0.05$). The presence of "short" regression periods for objective neurological symptoms and the duration of health impairment were observed mainly in younger children, while this period increased in children of older age groups, especially senior school-age children ($P < 0.05$; $P < 0.001$).

Thus, the analysis proves the existence of differences in the course of this form of TBI in children of different age groups and specifics in substantiating the criteria for forensic assessment. In younger children, in the presence of calvarial bone damage, despite the "short" periods of regression of objective neurological symptoms and duration of treatment, the justified criterion for assessing the severity of bodily injuries is the danger to life at the time of injury. In children of other age groups, in the absence of skull bone lesions, the criterion is the duration of a predominantly short-term health disorder.

A study of the features of mild brain contusion revealed that in younger and preschool-age children, in all cases, the course of this form of TBI was characterized by the presence of linear fractures of the calvarial bones, the transient nature of general cerebral symptoms of brain damage, and short treatment periods (from 5 to 16 days). In turn, in primary and high school-age children, skull bone damage was not observed, and the course of mild brain contusion was distinguished by the presence of short-term vestibular-stem disorders and symptoms of focal brain damage with a prolonged regression period of the aforementioned objective neurological symptoms and a duration of health impairment of up to 21 days. As in cases of brain contusion of clinically undetermined severity, this indicates differences in the course of this form of TBI in children of different age groups and specifics in substantiating the criteria for forensic assessment, which should be performed according to the same principles.

The analysis of the features of the "acute" period of severe brain contusion was carried out based on parameters such as: presence of bone fractures, behavioral disorders, impairments of vital functions, signs of focal brainstem lesions, and prolonged consciousness disorders. No significant differences in these parameters were found among children of different age groups, except for consciousness disorders. The frequency of consciousness disorders increased in children older than 7 years, which is confirmed by the comparative analysis of this feature in children of primary and lower school age ($P < 0.05$).

Thus, in all childhood age groups, the course of this form of TBI was marked by damage to the skull bones, signs of focal brainstem lesions, and impairments of vital functions, which constitute a danger to the lives of the victims.

A comparative analysis of cases of brain compression by subdural hemorrhages revealed the presence of depressed, comminuted, and comminuted-depressed fractures of the calvarial bones in children of all age groups, accompanied by the development of consciousness and behavioral disorders, symptoms of general and

focal brain damage, and vital disturbances (hemodynamic disorders), all of which constitute a danger to life. Therefore, in cases of brain compression by subdural hemorrhages, the justified criterion for expert assessment in children of all age groups is the danger to life at the time of injury.

Analysis of medical records aimed at clarifying the consequences of non-fatal facial and brain injuries showed that in most cases (61.3%), they were observed in children who had sustained traumatic brain injuries. Notably, despite the prevalent asymptomatic and mildly symptomatic course of brain contusion, the transient nature of objective neurological symptoms of brain damage, and their short regression periods, adverse consequences were observed in both younger and preschool-age children. During repeated comprehensive (clinical and instrumental) examination of younger and preschool-age victims, adverse consequences of TBIs – such as the development of cerebrospinal fluid-hypertensive syndrome with ventricular dilatation, post-traumatic hydrocephalus and skull deformation, as well as post-traumatic atrophy of the brain substance (according to computed tomography) - were observed mainly as a result of brain contusion with calvarial bone damage. According to statistical calculations, the time for re-examination ranged from 3 to 7.8±1.1 months.

In turn, in children of "older" age groups (younger and senior school age), adverse consequences were associated with severe forms of TBIs (severe brain contusion due to depressed and comminuted-depressed fractures of the calvarium, compression by subdural hemorrhages). Analysis of medical records revealed the development of post-traumatic cortical-focal syndrome, mnestic disorders, post-traumatic atrophy of the brain substance and skull deformation, and post-traumatic damage to sensory organs (retinopathy, cranial nerve damage).

The manifestation and development of post-traumatic cerebrostenia, vegetative-vascular dystonia, astheno-neurotic syndrome, and post-traumatic arachnoiditis, according to the studied medical documentation, occurred in children of primary and secondary school age with mild forms of TBI (concussion, mild brain contusion). However, in these cases, the duration of treatment was not changed or extended. Therefore, the nature of the consequences of these forms of TBI is important in resolving the issue of cause-and-effect relationships between the injury and its outcome.

Discussion. The results of the systematic review and meta-analysis demonstrated that in children under 3 years of age, preschool age, and senior school age, domestic and street injuries prevailed. In primary school-age children, street and transport injuries dominated. In most cases, the injuries were caused by blows from blunt objects or collisions with them. In this regard, our data coincide with the results of other authors [19-23]. An increase in the number of road traffic accident-associated injuries is observed in many economically developed countries, driven by the active use of electric personal mobility devices, as well as bicycles, scooters, etc. [24-26].

The identified features of brain injuries in children are directly causally linked to the anatomical and physiological characteristics of the child's body, namely: - Predominantly small stature, which, on the one hand, leads to a greater number of

skull injuries in traffic accidents due to initial contact with protruding parts of a moving vehicle, and on the other hand, results in a relatively small volume of brain damage when falling on a flat surface due to the short trajectory of the fall; - Markedly pronounced elasticity of the skull bones, which increases the impact time and realizes the impact energy at the points of force application, significantly limiting the possibility of contrecoup brain tissue injuries [27].

The study of the characteristics of clinical symptoms and the course of non-fatal brain injuries in children and adolescents has laid the foundation for establishing criteria for the forensic assessment of their severity and for implementing the obtained results into expert practice.

Conclusions.

1. Among brain injuries in children of different age groups, traumatic brain injuries (TBI) predominated. The course of mild forms of TBI – cerebral concussion in younger and preschool-age children, and cerebral concussion and mild brain contusion in younger and senior school-age children – is characterized by the predominantly transient nature of objective neurological symptoms, with their regression occurring on average on days 7-11 and 9-14 post-injury, respectively, and a high degree of correlation between the regression periods of these neurological symptoms and the duration of health impairment. This provides grounds to assert that the assessment of the severity of such injuries should be based on the criterion of a short-term health disorder in all age groups.

2. In cases of a protracted course of mild forms of TBI or the presence of their consequences, the forensic assessment of the severity of bodily injuries should be based on a thorough neurological examination of the child and analysis of medical documentation, taking into account indications of an adverse course of childbirth, congenital malformations, and inflammatory diseases of the nervous system in young children, and chronic somatic diseases or intoxications in school-age children and adolescents.

3. Severe forms of TBI (severe brain contusion, brain compression by subdural hemorrhages) in children of younger, preschool, and primary school age are accompanied by fractures of the skull bones, predominantly of the calvarium (linear, depressed, and comminuted-depressed). In senior school-age children, these severe forms may be accompanied by either the presence or absence of fractures of the calvarial and basal skull bones, with the development of impairments of vital functions that pose a danger to the lives of the victims. The assessment of the severity of such forms of TBI should be carried out according to the criterion of danger to life.

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