Medical Research Journal

LONG-TERM NEUROLOGICAL AND SOCIAL OUTCOMES AFTER TRAUMATIC INTRACRANIAL HEMATOMAS: A CLINICAL AND PROGNOSTIC ANALYSIS

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Abstract. Traumatic brain injury (TBI) remains one of the most pressing challenges in modern neurosurgery and neurology due to its high mortality, long-term disability, and significant socioeconomic impact. Traumatic intracranial hematomas occupy a central position in the structure of TBI, as they frequently lead to brain compression syndrome, secondary ischemic injury, and persistent neurological deficits. The aim of this study was to evaluate the dynamics of neurological symptoms, functional recovery, and social adaptation in the long-term period following traumatic intracranial hematomas. A retrospective analysis of 197 patients with isolated traumatic intracranial hematomas was performed, with follow-up periods ranging from 1 to 22 years. Clinical-statistical, neurological, neuropsychological methods, computed tomography, and electroencephalography were used. The long-term period was characterized by a wide spectrum of maladaptive neurological syndromes, including focal cerebral, epileptic, and hypertensive-hydrocephalic syndromes. Reduced or lost working capacity was observed in 60% of patients. Early diagnosis, timely and radical surgical intervention, and delayed primary cranioplasty were associated with improved functional outcomes and higher quality of life. The findings emphasize the importance of early surgical management and long-term multidisciplinary rehabilitation in patients with traumatic intracranial hematomas.

Keywords: traumatic brain injury; traumatic intracranial hematomas; long-term outcomes; neurological deficits; quality of life; cranioplasty.

ДОЛГОСРОЧНЫЕ НЕВРОЛОГИЧЕСКИЕ И СОЦИАЛЬНЫЕ ИСХОДЫ ПОСЛЕ ТРАВМАТИЧЕСКИХ ВНУТРИЧЕРЕПНЫХ ГЕМАТОМ: КЛИНИКО-ПРОГНОСТИЧЕСКИЙ АНАЛИЗ

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Аннотация. Черепно-мозговая травма (ЧМТ) остается одной из наиболее актуальных проблем современной нейрохирургии и неврологии в связи с высокой летальностью, инвалидизацией и значительными социально-экономическими последствиями. Особое место в структуре ЧМТ занимают травматические внутричерепные гематомы, которые приводят к развитию синдрома сдавления головного мозга, вторичного ишемического повреждения и стойких неврологических нарушений. Целью настоящего исследования явилась оценка динамики неврологической симптоматики, функционального восстановления и социально-бытовой адаптации больных в отдаленном периоде после травматических внутричерепных гематом. Проведен ретроспективный анализ результатов лечения 197 пациентов с изолированными травматическими внутричерепными гематомами с длительностью катамнестического наблюдения от 1 до 22 лет. Использованы клинико-статистические, неврологические, нейропсихологические методы, компьютерная томография и электроэнцефалография. Установлено, что в отдаленном периоде формируется широкий спектр дезадаптирующих неврологических синдромов, включая церебрально-очаговый, эпилептический и гипертензионно-гидроцефальный. Снижение или утрата

трудоспособности выявлены у 60% пациентов. Показано, что ранняя диагностика, своевременное и радикальное хирургическое вмешательство, а также первично отсроченная краниопластика способствуют снижению выраженности инвалидизирующих последствий и повышению качества жизни больных. Полученные данные подчеркивают необходимость комплексного и длительного наблюдения пациентов с травматическими внутричерепными гематомами.
Ключевые слова: черепно-мозговая травма; травматические внутричерепные гематомы; отдаленные исходы; неврологическая симптоматика; качество жизни; краниопластика.

TRAVMATIK INTRAKRANIAL GEMATOMALARDAN KEYINGI UZOQ MUDDATLI NEVROLOGIK VA IJTIMOIY NATIJALAR: KLINIK-PROGNOZ TAHLIL

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Annotatsiya. Bosh miya shikastlanishi (BMS) zamonaviy neyroxirurgiya va nevrologiyada eng dolzarb muammolardan biri bo‘lib, yuqori o‘lim ko‘rsatkichlari, nogironlik va jiddiy ijtimoiy-iqtisodiy oqibatlar bilan tavsiflanadi. BMS tarkibida travmatik intrakranial gematomalar alohida o‘rin egallaydi, chunki ular bosh miyaning siqilishi, ikkilamchi ishemik shikastlanish va barqaror nevrologik buzilishlarga olib keladi. Ushbu tadqiqotning maqsadi travmatik intrakranial gematomalardan keyingi uzoq muddatli davrda nevrologik simptomatika dinamikasi, funksional tiklanish va ijtimoiy-maishiy moslashuvni baholashdan iborat. 1 yildan 22 yilgacha bo‘lgan katamnez davriga ega bo‘lgan 197 nafar bemor retrospektiv tahlil qilindi. Klinik-statistik, nevrologik, neyropsixologik usullar, kompyuter tomografiya va elektroensefalografiya qo‘llanildi. Uzoq muddatli davrda miya-o‘choqli, epileptik va gipertenziya-gidrotsefaliya sindromlari kabi dezadaptatsiyalovchi holatlar aniqlangan. Bemorlarning 60 foizida mehnat qobiliyatining pasayishi yoki yo‘qolishi qayd etildi. Erta tashxis, o‘z vaqtida va radikal jarrohlik aralashuvi hamda birlamchi kechiktirilgan kranioplastika funksional natijalarni va hayot sifatini yaxshilashga yordam beradi. Tadqiqot natijalari travmatik intrakranial gematomali bemorlarni kompleks va uzoq muddatli kuzatish zarurligini ko‘rsatadi.
Kalit so‘zlar: bosh miya shikastlanishi; travmatik intrakranial gematomalar; uzoq muddatli natijalar; nevrologik buzilishlar; hayot sifati; kranioplastika.

Introduction. Traumatic brain injury (TBI) remains one of the most severe and socially significant forms of damage to the central nervous system, representing a major cause of mortality, long-term disability, and socioeconomic burden worldwide. Within the overall structure of traumatic injuries, severe traumatic brain damage accounts for approximately 30–40% of cases, as reported in classical clinical and epidemiological studies. Despite significant advances in neuroimaging, neurocritical care, and microsurgical techniques, traumatic intracranial hematomas continue to pose substantial diagnostic and therapeutic challenges, particularly with regard to their long-term consequences. Traumatic intracranial hematomas occur in 4–8% of patients with head injury and represent one of the most frequent causes of secondary brain injury due to mass effect, cerebral compression, and the development of intracranial hypertension and brain displacement syndromes [1,2]. These pathological processes initiate complex cascades involving ischemia, neuroinflammation, blood–brain barrier disruption, excitotoxicity, and delayed neuronal loss, which collectively determine the severity of neurological deficits and long-term functional outcomes.

The acute management of traumatic intracranial hematomas has been well studied, with clearly established indications for surgical intervention in most cases. However, considerably less attention has been paid to the long-term neurological, functional, and social consequences in patients who survive the acute phase. In clinical practice, neurosurgeons and neurologists frequently encounter patients who, despite technically successful evacuation of hematomas, develop persistent neurological syndromes leading to partial or complete loss of working capacity, limitations in self-

care, and reduced quality of life [5-7]. The long-term period following traumatic intracranial hematomas is characterized by a wide spectrum of residual neurological disorders, ranging from mild cognitive and emotional disturbances to severe focal deficits, epilepsy, hydrocephalus, and chronic intracranial hypertension. These conditions significantly affect patients' social integration, professional activity, and overall quality of life. Importantly, the severity and combination of these syndromes are influenced by multiple factors, including the type and localization of the hematoma, the rate of development of cerebral compression, the severity of the initial brain injury, the timing and extent of surgical intervention, and the adequacy of postoperative rehabilitation measures.

Given these considerations, systematic analysis of long-term outcomes in patients with traumatic intracranial hematomas is essential for improving prognostic assessment, optimizing surgical strategies, and developing individualized rehabilitation programs. Of particular interest is the role of early diagnosis, timely surgical decompression, and reconstructive neurosurgical procedures such as delayed cranioplasty in preventing long-term neurological disadaptation and enhancing functional recovery [4]. The present study aims to evaluate the dynamics of neurological symptomatology and social-domestic adaptation in the long-term period following traumatic intracranial hematomas, based on a large clinical cohort with extended follow-up periods.

Materials and Methods. This study represents a retrospective clinical and statistical analysis of 197 patients who were treated for isolated traumatic intracranial hematomas and subsequently observed in both the acute and long-term periods. The duration of follow-up ranged from 1 to 22 years, allowing for comprehensive assessment of delayed neurological outcomes and long-term functional adaptation. The study population consisted predominantly of males, accounting for 78% of cases, which reflects the well-known epidemiological predominance of traumatic brain injury among men. The majority of patients were of working age, younger than 60 years at the time of injury, emphasizing the significant socioeconomic implications of post-traumatic disability in this cohort. According to the morphological type of hematoma, patients were distributed as follows: subdural hematomas were diagnosed in 102 cases, epidural hematomas in 40 patients, combined epi-subdural hematomas in 17 cases, intracerebral hematomas in 21 patients, combined subdural and intracerebral hematomas in 13 cases, and combined epidural and intracerebral hematomas in 1 patient. This distribution reflects the predominance of subdural hematomas among traumatic intracranial hemorrhages, particularly in cases associated with diffuse brain injury and venous bleeding.

Based on the rate of development of cerebral compression syndrome, hematomas were classified into acute, subacute, and chronic forms. Acute hematomas, defined as those manifesting within the first 72 hours after trauma, were observed in 151 patients. Subacute hematomas were identified in 17 cases, while chronic hematomas were diagnosed in 29 patients. This classification was used to assess the influence of temporal factors on neurological outcomes and long-term adaptation. All patients underwent comprehensive clinical and instrumental evaluation, including detailed neurological examination, neuropsychological assessment, and neuroimaging studies. Computed tomography (CT) of the brain was the primary imaging modality used for diagnosis, localization, and volumetric assessment of hematomas, as well as for evaluation of brain displacement, ventricular compression, and secondary ischemic changes. In selected cases, electroencephalography (EEG) was performed to assess cortical functional activity and to identify epileptiform discharges, particularly in patients with post-traumatic seizures.

Neurological status was evaluated in both the acute and long-term periods using standardized clinical criteria, with special attention to focal neurological deficits, cognitive impairment, epileptic manifestations, and signs of intracranial hypertension or hydrocephalus. Functional outcomes and quality of life were assessed using validated scales, including the Barthel Index for activities of daily living and the Pulse scale for overall functional status. Surgical treatment consisted of evacuation of the hematoma using standard neurosurgical approaches appropriate to the hematoma type and localization. In the long-term period, a subset of patients underwent delayed cranioplasty as part of reconstructive and rehabilitative neurosurgical management. The impact of this intervention on neurological recovery and social adaptation was analyzed.

Statistical analysis included descriptive statistics and comparative evaluation of outcomes based on hematoma characteristics, severity of initial brain injury, timing of surgery, and long-term follow-up duration.

Results. In the long-term period following surgical removal of traumatic intracranial hematomas, a wide variety of neurological symptoms and syndromes were identified. These residual manifestations differed significantly in severity and impact on patients' social and occupational functioning. Based on their influence on social and labor adaptation, the observed neurological syndromes were conditionally divided into those causing severe disability, moderate disability, and those compatible with good functional recovery. A proportion of patients demonstrated substantial recovery of neurological functions and were able to return to independent living and professional activity. However, in a considerable number of cases, persistent neurological deficits resulted in partial or complete loss of working capacity.

Analysis revealed that patients who were in a state of clinical subcompensation during the acute period of TBI and who underwent earlier and more radical surgical intervention showed significantly better long-term outcomes. In this subgroup, recovery or development of syndromes associated with moderate disability was more frequent compared to patients who presented in a state of severe clinical decompensation at admission [9-13]. These findings underscore the critical importance of early diagnosis and timely surgical decompression in preventing irreversible secondary brain damage. Early surgical intervention was associated with a reduced risk of developing disabling neurological syndromes in the long-term period. Conversely, delayed diagnosis or postponement of surgery in patients with progressing cerebral compression often led to more pronounced and persistent deficits, reflecting the cumulative effects of prolonged intracranial hypertension and ischemia [10].

The clinical course of the long-term period was characterized by a combination of maladaptive neurological syndromes. The most frequently observed was the cerebral focal syndrome, identified in 19% of patients, manifesting as persistent motor, sensory, speech, or cognitive deficits depending on the localization of the hematoma and associated brain injury. Epileptic syndrome was diagnosed in 8% of cases and was confirmed by clinical features and EEG findings. Hypertensive-hydrocephalic syndrome was also observed in 8% of patients and was associated with ventricular dilation, impaired cerebrospinal fluid circulation, and symptoms of chronic intracranial hypertension. An important observation was that the severity of maladaptive syndromes tended to decrease with increasing duration of follow-up and ongoing treatment, including medical therapy and rehabilitation measures. This suggests a degree of neuroplasticity and functional compensation even years after the initial injury, although complete recovery was not universal. In the long-term period following traumatic intracranial hematomas, reduction or loss of working capacity was documented in approximately 60% of patients. This highlights the profound impact of such injuries on patients' professional and social lives, particularly given the predominance of working-age individuals in the study population [8].

Quality of life assessments demonstrated a strong correlation with hematoma localization and the severity of hypertensive-hydrocephalic syndrome. Patients with hematomas located in functionally non-dominant or "non-critical" brain regions exhibited better quality of life indicators. In this subgroup, the Barthel Index reached an average of 70 points, and Pulse scale scores averaged 9 points, reflecting relatively preserved independence and functional status.

In contrast, patients with hematomas localized in functionally significant brain areas, such as motor cortex, speech centers, or deep subcortical structures, showed significantly worse outcomes. In these cases, the Barthel Index often fell below 60 points, and Pulse scale scores reached up to 24 points, indicating substantial limitations in daily activities and social participation. Delayed primary cranioplasty performed in patients with post-traumatic cranial defects emerged as one of the key neurosurgical methods of early rehabilitation. This intervention contributed to improved cerebral hemodynamics, normalization of intracranial pressure dynamics, and enhanced neurological recovery. Patients who underwent cranioplasty demonstrated more pronounced restoration of motor and cognitive functions and better overall adaptation compared to those who did not receive reconstructive surgery.

Discussion. The results of this study confirm that traumatic intracranial hematomas represent not only an acute neurosurgical emergency but also a condition with profound and long-lasting consequences for neurological function and quality of life. The long-term period following such injuries is characterized by a complex interplay of residual structural damage, secondary neurodegenerative processes, and adaptive or maladaptive plastic changes within the central nervous system. One of the key findings is the decisive role of early diagnosis and timely surgical intervention in determining long-term outcomes. Rapid evacuation of hematomas before the development of irreversible ischemic and dislocation-related damage significantly improves the likelihood of favorable neurological recovery. These findings are consistent with the concept of "secondary brain injury prevention," which emphasizes minimizing the duration and severity of intracranial hypertension and cerebral compression [14,15,16].

The observed association between the severity of acute clinical decompensation and long-term disability highlights the importance of early clinical stratification and aggressive management of high-risk patients. Individuals presenting with signs of severe decompensation require particularly urgent intervention to prevent catastrophic neurological sequelae. The identification of specific maladaptive syndromes, such as focal cerebral deficits, post-traumatic epilepsy, and hypertensive-hydrocephalic syndrome, underscores the need for long-term multidisciplinary follow-up of patients with traumatic intracranial hematomas. Neurologists, neurosurgeons, rehabilitation specialists, and neuropsychologists must collaborate to address the diverse and evolving needs of these patients [17-20].

The high prevalence of reduced working capacity observed in this cohort reflects the broader social and economic impact of traumatic brain injury. Loss of productivity, long-term disability benefits, and the need for ongoing medical care place a substantial burden on healthcare systems and society. Therefore, strategies aimed at improving long-term outcomes have implications far beyond individual patient care. The demonstrated benefits of delayed cranioplasty support its role as an integral component of post-traumatic rehabilitation. Restoration of cranial integrity not only has cosmetic significance but also contributes to functional recovery by improving cerebral perfusion, cerebrospinal fluid dynamics, and neurophysiological function. These findings align with growing evidence supporting early reconstructive interventions in selected patients. Finally, the observed gradual reduction in the severity of maladaptive syndromes over time suggests that long-term rehabilitation efforts can yield meaningful improvements even years after injury. This highlights the importance of sustained therapeutic engagement and challenges the notion that recovery plateaus within the first months after trauma.

Conclusion. Traumatic intracranial hematomas are associated with a high risk of long-term neurological impairment and social maladaptation. The localization of the hematoma, the severity of hypertensive-dislocation syndrome, and the timing of surgical intervention are key determinants of long-term outcomes. Early diagnosis, prompt surgical treatment, and the use of delayed primary cranioplasty play a crucial role in preventing the development of disabling neurological syndromes. Comprehensive long-term management focused on neurological recovery and social reintegration significantly enhances patients' quality of life and functional independence.

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