

Features of Clinical Course and Morphological Properties of Head Injuries in Children Caused by Blunt Objects

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Abstract The article presents the results of a review of contemporary literature on head injuries in children. It covers epidemiology, medico-social aspects, circumstances, peculiarities of progression, complications, and consequences of brachiocephalic trauma in children. Special attention is paid to the anatomical and physiological features of head structures in children. The necessity for improving forensic medical examinations of head injuries in children is emphasized.

Keywords Children, Head injuries, Clinical course, Morphological characteristics, Peculiarities, Forensic medical examination

1. Introduction

Head injuries, particularly cranioccephalic traumas (CCT), constitute a predominant portion of pediatric trauma (up to 40%), with approximately 75% of cases presenting as mild forms due to the vulnerability of the developing brain and its high compensatory capacity [Guzeva V.I., 2004; Gomazkov O.A., 2002; Massagli T.L., 1994]. Consequently, the consequences of head trauma may not manifest immediately but rather after a certain period, leading to delayed seeking of medical attention by children and their parents (Smirnova L.V. et al., 2007; Orel V.V., 2020; Asilbekov U.E., 2012; Guzeva V.I. et al., 2022).

The consequences of CCT in children can be divided into intermediate and long-term periods, characterized by pronounced and difficult-to-manage vegetative disturbances such as increased fatigue, irritability, tendency to limit external contacts, and disorders of the cardiovascular system, significantly impacting the social adaptation of affected children [Odinak M.M., 2005; Veina A.M., 2003]. According to Simonova L.V. et al. (2007), nearly all children experience headaches and cerebroasthenic disorders in the long-term period following head trauma, regardless of its severity. The onset of initial manifestations after the acute phase of brain injury ranges from 6 months to 1 year for brain contusions and from 1 month to 3-4 years for concussions. Therefore, children who have experienced head trauma, irrespective of its severity in the acute phase, require dynamic neurological monitoring for

timely diagnosis and treatment of trauma-related consequences (Smirnova L.V. et al., 2007). Approximately 81.43% of children exhibit the consequences of closed cranioccephalic trauma within a year, and about 20% of the affected children subsequently struggle to return to normal occupational activities.

The prevalence of head trauma in children varies across different countries. For instance, in the USA, annual CCT cases exceed 500,000, leading to around 60,000 emergency department admissions [Chen S., Peng J., Sribnik E.A., Zhu M., Xiang H., 2018]. Moreover, head trauma in the USA is a leading cause of death among children older than 2 years, with over 3,000 deaths attributable to CCT annually [Bowman S.M. et al., 2008; Ducrocq S.K., Meyer P.G. et al., 2006; Schunk J.E., Shutsman S.A., 2012].

Currently, head injuries are the most common cause of disability among children in African countries, particularly in South Ethiopia. It has been found that CCT accounted for 7.4% of 4,258 emergency department visits at the Hawassa University clinic within one year, with boys over 5 years old predominating (68.8%). The main causes of head injury in children were road traffic accidents (37.9%) and falls (32.8%). Mild, moderate, and severe CCT were observed in 95% of the affected children, while the remainder exhibited diffuse axonal injuries or intracranial hemorrhages. The mortality rate from head trauma was 3.2% (10 children) [Tuji Bedri, Henok Tadele, 2020]. According to Carpi P. and Orliage G. (2004), CCT occurred in 95% of children who sustained isolated or combined trauma in France. The authors emphasize that children with head trauma have a chance of survival if promptly transported and treated at pediatric trauma centers [Carpi P. and Orliage G., 2004].

The hospital mortality rate among children with CCT ranges from 35% to 38%, with half of the survivors experiencing

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disability in infancy. Neuroimaging examinations of children reveal pathological changes in 34.57%, hematomas in 18.52%, and skull fractures in 13.58%. Post-traumatic epilepsy is diagnosed in 46.67% of children in the long-term period following severe head trauma. According to Gorbunov M.V. et al. (2015), the main clinical form of CCT in children is concussion (91.97%), and closed head trauma (95.85%) predominates. The main causes of CCT in children include domestic accidents (41.9%), street accidents (33.4%), and school accidents (15.7%), with boys being more affected than girls (Gorbunov M.V. et al., 2015). Talia D. Baird et al. (2021) conducted a retrospective analysis of severe CCT treatment outcomes in 195 children from the UK and Canada, with a 28% mortality rate observed among 55 children. According to American and Canadian researchers, this rate reaches 40-45% [Trowbridge A., Walter J.C., McConathy E., Morrison W., Feidtner K., 2017; McCallum D.E., Byrne P., Brewera E., 2000; Talia D. Baird et al. 2021].

Currently, cranioccephalic traumas in children represent a significant medical and social challenge in contemporary pediatrics, pediatric neurosurgery, and neurology [Orel V.V., 2020; Guzeva V.I., Maksimova N.E., Guzeva O.V., Guzeva V.V., Razumovsky M.A., Chokmosov M.S., 2016; Ivanov D.O. (Ed.), Orel V.V. (Ed.), Kim A.V., Sereda V.M., Gureva N.A., 2017; Shalkevich L.V., Lvova O.A., Kulagin A.E., Talabaev M.A., Ivashina E.N., Sulimov A.V., 2016].

Objective – identification of peculiarities in the clinical course and morphological properties of head injuries in children caused by blunt objects.

2. Materials and Methods

The scientific and educational literature of recent years devoted to the structure, frequency, and peculiarities of head injuries in children and issues of forensic medical examination of cranioccephalic trauma have been thoroughly studied.

3. Results and Discussion

The structure of children's heads has its own anatomical and physiological peculiarities, including the elasticity and mobility of the cranial bones, the presence of sutures and fontanels, the immaturity and high hydrophilicity of brain tissue, as well as relatively wide subarachnoid spaces and labile regulation of vascular tone. These characteristics of head structures may result in prolonged asymptomatic head injuries in children, followed by rapid onset of neurological disorders due to brain edema and displacement.

The periods of post-traumatic illness resulting from head injuries are conventionally divided into acute (2 to 10 weeks), intermediate (2 months to 2 years), and long-term (1.5 to 3-4 years). Various structural changes may occur as consequences of traumatic brain injury (TBI), including cysts, atrophy, scars, aneurysms, hygromas, hematomas, nerve damage, arachnoiditis, etc.

It has been established that TBI in children under 3 years old has more peculiarities compared to similar injuries in children over 3 years old, which is due to the high vulnerability of the brains of children of this age to minor traumas, such as even falls from their own height. Moreover, in the initial period of head injury, children of this age do not exhibit or have very few focal symptoms, and subsequently, generalized decompensation reactions develop rapidly.

Children under 3 years old with TBI present challenges in diagnosis due to their psychoemotional characteristics, inability to provide trauma history, complaints, and inadequate reactions. Therefore, computer tomography (CT) is considered the "gold standard" for diagnosing TBI in children of this age, although it carries a risk of developing oncological processes. Therefore, neurosonography is also recommended for this purpose.

Bobrova V.I. and Nikiforov S.N. (2007) systematized the following anatomical and physiological features of the head structure influencing the nature of TBI formation in children: the absence of a diploetic layer in the cranial bones implies linear fractures, including depressed ones, which may spontaneously resolve or remain unrecognized, becoming the cause of epileptic seizures; myelination of individual conducting pathways ends at different times, explaining the inability of children to differentiate painful points until the age of 7-8 years; the imperfection of coordination systems with the simultaneous expansion of motor capabilities often results in TBIs, which are not detected by those around them.

Spencer K. et al (2021) from the USA, to assess the frequency of skull fractures in children, who came into contact with cranial sutures in violent and accidental traumas, conducted a retrospective review of head CT scans performed for head trauma in a tertiary-level pediatric hospital from 2012 to 2019. They found that 89% of violent skull fractures (51 out of 57) involved contact with cranial sutures: 69% touched two or more sutures, and 12 touched three or more sutures. 78% of accidental skull fractures (42 out of 54) involved sutures; only 7% touched two sutures, and none touched more than two sutures ($p < 0.001$).

According to Michelle J. Haydel et al (2022), pediatric TBI can be considered as primary injury occurring at the time of impact and secondary injury, which may be caused by a combination of consequences, including intracranial hematomas, edema, inflammation, ischemia, vasospasm, and hypoxemia.

As noted earlier, the main causes of head injury in children are sports, falls, and road traffic accidents. Additionally, non-accidental injuries (NAI) are distinguished. Falls leading to head injuries are more common in young children due to their undeveloped movement skills, disproportionately large heads, and displaced centers of gravity along with immature neck muscles.

Signs of non-accidental trauma (NAT, or shaken baby syndrome) in children include: multiple injuries at different stages of healing on various parts of the body; retinal hemorrhages; bilateral chronic subdural hematomas; significant

neurological damage with minimal signs of external trauma in children. Additionally, leptomeningeal cysts (growing skull fractures) and "ping-pong" fractures may be observed.

The mortality rate in children with severe head trauma ranges from 20-39%. However, shaken baby syndrome is the most common cause of death in children who have experienced NAT. Complications of this trauma depend on the severity of the head injury and can range from mild vegetative disturbances to seizures, prolonged neurological deficits, and death. Other complications in the post-traumatic period may include pneumonia, deep vein thrombosis, pulmonary embolism, etc.

Clinical aspects, as well as the frequency and outcomes of post-traumatic periods in children observed after TBI, are insufficiently reflected in the literature. Meredith L. et al. (2023) analyzed the results of head trauma in children admitted to pediatric emergency departments in Australia and New Zealand from 2011 to 2014. They found that out of 20,137 children with head trauma, 336 (1.7%) had post-traumatic seizures, with an average age of 4.8 years. Post-traumatic seizures were rare in children with TBI admitted to emergency departments compared to those admitted to other pediatric departments. According to the authors, post-traumatic seizures were more common in younger children (up to 3 and 5 years old).

According to Asilbekov U.E. (2012), 63-75% of children who have experienced TBI develop various syndromes in the long term, such as delays in physical and psychological development, significantly affecting social, educational, and later employment adaptation. Children of different age groups react differently to head trauma, which is crucial for diagnosis, treatment, and rehabilitation of affected children, as well as for forensic medical qualification of the severity of the injury. Specifically, in infants, traumatic brain injuries with compression are less common (17.2%) than in preschool (26.6%) and school-age children (37%). Additionally, in infants, a satisfactory condition is more often maintained (31%) after TBI, while loss of consciousness in preschoolers can last from several minutes to several days, and seizure syndrome is more common in school-age children than in other age groups.

4. Conclusions

1. Injuries to the soft tissues of the head, skull bones, and traumatic brain injuries (TBI) in children remain one of the most important medical and social problems of modern medicine to date, constituting one of the leading causes of mortality and disability among children.
2. Injuries to all structures of the head in children, compared to similar injuries in adults, differ in clinical and morphological manifestations, degrees and courses, as well as in consequences, which are determined by the anatomical and physiological characteristics of the growing organism, particularly the anatomical and physiological properties of the structure of children's

heads.

3. Cranio-cerebral traumas in children, especially in younger children, in most cases (about 75%) are mild, which is why the symptoms and consequences of the injury may manifest over time, leading to the development of various vegetative disorders in the intermediate and distant periods after the trauma.
4. The above points are of great importance for the forensic medical examination of head injuries in children. Despite this, the forensic medical aspects of head injuries in children are insufficiently reflected in modern literature, which is why further research in this direction is required.

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