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CLINICAL AND AUDIOLOGICAL CHARACTERISTICS OF VARIOUS PERIODS OF CRANIOCEREBRAL TRAUMA

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Abstract: According to the WHO report "Global Road Safety," approximately 1.35 million people die every year in road traffic accidents, and up to 50 million people sustain non-fatal injuries. Accidents are the eighth leading cause of death in all age groups, and the first among those aged 5 to 29. More than 90% of all deaths occur in low- and middle-income countries (27.5 and 14.4 cases per 100,000 population, respectively), while in high-income countries, the mortality rate is much lower (9.3 cases per 100,000 population). The contingent of injured patients in 50-80% of cases consists of young men of working age..

Keywords: hearing, ear diseases, injuries, diagnosis, treatment.

Аннотация. Согласно отчету ВОЗ "Глобальная дорожная безопасность," ежегодно около 1,35 миллиона человек погибают в дорожно-транспортных происшествиях, до 50 миллионов получают не смертельные травмы. ДТП занимают восьмое место среди причин смерти во всех возрастных группах, а в группе от 5 до 29 лет - первое. Более 90% всех смертей происходят в странах с низким и средним уровнем дохода (27,5 и 14,4 случая на 100 000 населения соответственно), тогда как в странах с высоким уровнем дохода уровень смертности значительно ниже (9,3 случая на 100 000 населения). Контингент травмированных больных в 50-80% случаев составляют молодые мужчины трудоспособного возраста..

Ключевые слова: слух, черепно-мозговая травма, шум в ушах, диагностика, лечение.

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Annotatsiya. JSSTning "Global yo‘l xavfsizligi" hisobotiga ko‘ra, har yili 1,35 millionga yaqin odam yo‘l-transport hodisalarida halok bo‘ladi, 50 milliongacha odam o‘limga olib kelmaydigan jarohatlar oladi. YTH barcha yosh guruhlarida o‘lim sabablari orasida sakkizinchi o‘rinni, 5 yoshdan 29 yoshgacha bo‘lgan guruhda yesa birinchi o‘rinni egallaydi. Barcha o‘limlarning 90% dan ortig‘i past va o‘rta daromadli mamlakatlarda sodir bo‘ladi (100 000 aholiga mos ravishda 27,5 va 14,4 holat), yuqori daromadli mamlakatlarda yesa o‘lim darajasi ancha past (100 000 aholiga 9,3 holat) . Jarohatlangan bemorlar kontingenti 50-80% hollarda yosh, mehnatga layoqatli yoshdagi yerkaklardan iborat/

Kalit so‘zlar: eshitish, bosh miya jarohati, quloq shang‘illashi, tashxis, davolash.

Relevance of the problem: In recent years, a number of studies have been conducted in the Republic of Uzbekistan aimed at improving the diagnosis and correction of hearing impairments. The features of auditory function in newborns with perinatal CNS damage, the surgical stage of cochlear implantation, speech audiometry in the Uzbek language, hearing screening in preschool age, as well as the features of the CNS course in twins were studied. However, the majority of works are devoted to non-traumatic hearing pathology, and post-traumatic hearing loss is insufficiently studied.[2,4,5].

At the end of the 20th century, more than 80,000 Americans were hospitalized annually for traumatic brain injury (TBI) and were discharged home with trauma-related complications [2.4.] Currently, 5.3 million people in the United States are officially registered as disabled as a result of traumatic brain injury [1.3,6,7,].

Males accounted for 76.6% of the victims of traumatic brain injury (TBI), while females accounted for 25.4%. Accidents (60.9%), catastrophic injuries (13.1%), and dizziness (13.4%) are the leading causes of traumatic brain injuries, and the incidence and percentage of traumatic brain injuries in the dynamics of disability are increasing [9].

Among road traffic accidents, the average statistical indicator of disability with BMD is 235 cases per 100,000 people per year, the average mortality rate is 15 cases per 100,000 people per year, and the mortality rate is 2.7 percent [8,10].

Urbanization and industrialization have a direct impact on the increase in the number of personal vehicles among the population and the frequency of accidents, the occurrence of industrial emergencies, fires, domestic injuries, and military conflicts. In cities and large settlements, the majority of patients with combined injuries visit the emergency department in the evening, during non-working hours, and on weekends. T. Brinck et al. link these cases to the consumption of alcohol and other psychotropic substances in leisure time, which in most cases is the main cause of traffic and domestic injuries [6,8,12].

Therefore, the audiological consequences of TBI should be considered not only as a complication of the acute period but also as a potentially delayed manifestation of traumatic brain disease.

The pathogenesis of auditory disorders in TBI is multilevel and includes primary mechanical damage, secondary ischemia, microcirculatory disorders, neuroinflammation, oxidative stress, excitotoxic reactions, and neurometabolic dysregulation [160, 248–259].

An important feature is the simultaneous involvement of the peripheral and central parts of the auditory system; depending on the direction and energy of the traumatic force, the damage can extend from the outer and middle ear to the receptor apparatus of the cochlea, the auditory nerve, brainstem nuclei, thalamocortical projections, and the auditory cortex. A significant decrease in quality of life or disability was observed in 2/3 of the treated patients due to combined injuries.

Purpose of the study: studying the state of the auditory organ in the early stages of mild traumatic brain injury.

Research materials and methods: To meet the objectives of this study and accomplish the assigned tasks, an additional 258 patients with chronic inflammatory bowel disease (CIBD), aged 18-69, who presented to and were hospitalized at the Khorezm branch of the Republican Research Centre of Emergency Medicine (RRCEM) between 2023 and 2025 were enrolled. These patients were conditionally assigned to and studied as Group 3.

The mean age of the patients was 41.8±6.4 years; the cohort comprised 144 men and 114 women. The mean age was 44.2±4.8 years for men and 35.1±3.7 years for women. No statistically significant gender-based difference was observed in the incidence of CIBD ($\chi 2=3.49$; $p=0.062$).

Results: Among the somatic pathologies identified in the patients under examination, we found that cardiovascular and nephrological nosologies predominated, but no statistically significant differences were observed between them.

The most common somatic nosologies recorded were hypertension in 45 cases (17.44%), chronic pyelonephritis in 28 cases (10.85%), and chronic bronchitis in 23 cases (8.91%). Ischemic heart disease was identified in 18 (6.98%) of the subjects. Osteochondrosis of the cervical spine was observed in 9 patients (3.49%), chronic gastritis in 6 patients (2.33%), type 2 diabetes mellitus and prostate adenoma in 5 patients each (1.94%), and periodontitis and cataracts in 4 patients each (1.55%). Varicose veins of the lower extremities were less common, observed in 2 (0.78%) subjects from the main group.

In general, subjective audiological symptoms in moderate cerebral ischemic disease are characterized by a frequent combination of hearing loss and tinnitus, with a predominance of patients experiencing persistent noise. In contrast, Group I more frequently noted hearing loss and periodic, low-intensity noise. At the same time, the nature of the tinnitus itself did not show statistically significant intergroup differences.

The assessment of hearing impairment was based on subjective and objective audiological research methods. Acoumetry was performed on patients in Groups I and II who had effective speech communication. In Group I patients, the average distance for perceiving whispered speech was 3.86±0.18 m, and for conversational speech, it was 5.47±0.21 m. In Group II, the corresponding values were significantly lower, at 1.12±0.11 m and 3.84±0.17 m, respectively ($p<0.001$). The data obtained reflected an increase in hearing impairment with an increase in the severity of chronic cerebral ischemia.

In the case of asymmetrical CNS, the well-hearing and poor-hearing ears were analyzed separately. In Group I, asymmetric bilateral CNS was identified in 18 (39.13%) patients, and in Group II, in 96 (53.93) patients. In patients with the asymmetrical variant, the hearing thresholds in the well-hearing ear were lower than in the hard-of-hearing ear, but the less affected ear was not assessed as intact.

In patients of both groups, the data of the chameron examination mainly corresponded to the CNS. In Group I, the average absolute sound duration of the C128 tuning fork was 34.82±7.14 s for air permeability and 19.28±4.12 s for bone permeability. In Group II, these indicators were lower—29.76±5.13 and 16.99±4.12 seconds, respectively ($p<0.001$). In Group I patients, the average time for receiving C128 in an asymmetrical auditory canal in the hearing impaired ear was 31.10±5.15 seconds for air permeability and 17.82±4.13 seconds for bone permeability, while in the hearing impaired ear, it was 38.54±7.15 and 20.74±5.02 seconds, respectively. In Group II, the corresponding values were 21.23±5.12 and 13.78±4.11 seconds in the deaf ear, and 38.27±6.13 and 20.51±4.12 seconds in the deaf ear.

In Group II, in the presence of hemothympanum, the SR was averaged at a distance of 0.75±0.14 m, and the RR was 3.10±0.58 m; in patients without hemothympanum, the corresponding values were 1.25±0.21 and 4.09±0.66 m.

At the same time, in Group II patients, a more pronounced acometric hearing loss persisted regardless of the presence of hemotympanum, indicating the combined effect of local post-traumatic changes in the middle ear and more pronounced sensorineural damage to the auditory analyzer in moderate MCA.

The results of Tonal Threshold Audiometry (TTH) also showed that the severity of hearing loss depends on the severity of the MCI. In Group I, the average VP threshold in the range of 125–8000 Hz was 41.89±8.04 dB, while in Group II, it was 54.54±12.76 dB. In the range of 250–8000 Hz, the average CP threshold was 38.73±7.42 and 49.95±11.68 dB, respectively. Intergroup differences in CP and CP thresholds were statistically significant ($p<0.001$).

In the speech frequency range of 500–4000 Hz, the mean CP threshold in Group I was 41.23±7.86 dB, the CP threshold was 37.18±7.14 dB, and the mean bone-air interval was 4.06±1.61 dB. In Group II, the corresponding values were 53.70±12.38 dB, 48.09±11.21 dB, and 5.61±2.27 dB, respectively ($p<0.001$), which corresponded to the predominantly sensorineural nature of hearing loss with a significant increase in both the air and bone thresholds in Group II patients.

In Group I, the LV threshold in asymmetrical CNS increased from 38.47±8.17 dB at 125 Hz to 52.36±10.08 dB at 8000 Hz, while in symmetrical CNS, it increased from 35.42±7.08 to 47.62±9.14 dB, respectively. In Group II, the corresponding values were 49.16±11.07–66.38±13.42 dB for asymmetric TNT and 45.63±10.14–61.74±12.06 dB for symmetric TNT.

According to TPA data, the mean threshold for CP in the 500–4000 Hz speech frequency range was 59.84±13.05 dB in Group II patients with hemotympanum, while in patients without hemotympanum, it was 51.62±11.45 dB, corresponding to a statistically significant difference of 8.22±1.59 dB ($p<0.001$). In Group I, where Hemotimpanum was detected in only 2 patients, the result should be considered characteristic.

A comparison of acumetry and TPA data revealed signs of tonal-speech dissociation in 5 (10.87%) patients in Group I and 43 (24.16%) patients in Group II. As the severity of the MCI increased, a decrease in the reception distance of the CR and CR, a decrease in the absolute timing of the C128 tuning fork, an increase in tonal thresholds, and an increase in CNS expression were noted, manifested by a high frequency of tonal-speech dissociation.

The strongest positive correlation was found between the average hearing threshold for speech frequencies and the degree of hearing loss ($rS=+0.82$; $p<0.001$), which confirmed the internal consistency between pure-tone audiometry and the clinical classification of hearing deficit severity. A strong positive correlation was also established between speech-frequency and high-frequency thresholds ($rS=+0.73$; $p<0.001$), indicating the combined involvement of the speech and high-frequency ranges in patients with post-traumatic SNHL.

The degree of hearing loss had a moderate positive correlation with a high SISI index ($rS=+0.61$; $p<0.001$), absent or significantly reduced OAEs ($rS=+0.58$; $p<0.001$), the bilateral nature of the lesion ($rS=+0.53$; $p<0.001$), tinnitus severity ($rS=+0.47$; $p<0.001$), and impaired acoustic reflex ($rS=+0.45$; $p<0.001$). An increase in the degree of hearing loss is associated primarily with the cochlear component of the lesion, with involvement of the reflex and central parts of the auditory analyzer.

Speech intelligibility in noise had moderate negative correlations with the main indicators of auditory dysfunction: the average speech-frequency threshold ($rS=–0.64$; $p<0.001$), degree of hearing loss ($rS=–0.58$; $p<0.001$), high-frequency thresholds ($rS=–0.55$; $p<0.001$), absent OAEs ($rS=–0.48$; $p<0.001$), bilateral lesion ($rS=–0.46$; $p<0.001$), high SISI index ($rS=–0.45$; $p<0.001$), and tinnitus severity ($rS=–0.43$; $p<0.001$). A decrease in speech intelligibility, especially in noise, is associated with an increase in pure-tone perception thresholds on the audiogram and with complex disorders of peripheral and central sound processing.

Among the ABR parameters, an increase in wave V latency and/or the I–V interpeak interval showed weak positive correlations with acoustic reflex impairment (rS=+0.46; p<0.001), speech frequency thresholds (rS=+0.40; p<0.001), degree of hearing loss (rS=+0.39; p<0.001), and high-frequency thresholds on the audiogram (rS=+0.36; p<0.001), and a weak negative correlation with speech-in-noise intelligibility (rS=–0.42; p<0.001), demonstrating the contribution of the brainstem level of the auditory pathway to the formation of residual functional deficit.

CAEP parameters also had statistically significant, predominantly weak, correlations, showing a negative correlation with speech-in-noise intelligibility (rS=-0.37; p<0.001) and positive correlations with speech frequency thresholds (rS=+0.35; p<0.001), degree of hearing loss (rS=+0.34; p<0.001), and ABR parameters (rS=+0.41; p<0.001). This demonstrates the involvement of impairments in brainstem and cortical sound processing mechanisms alongside peripheral impairments.

Temporal bone pyramid fracture demonstrated significant positive correlations with the degree of hearing loss (rS=+0.49; p<0.001), average speech frequency threshold (rS=+0.45; p<0.001), high-frequency thresholds (rS=+0.43; p<0.001), absence of OAE (rS=+0.42; p<0.001), a high SISI score (rS=+0.40; p<0.001), and bilateral hearing loss (rS=+0.38; p<0.001), meaning that damage to the temporal bone pyramid is one of the leading factors in severe and persistent post-traumatic SNHL.

Correlation analysis identified the most informative signs for prognostic modeling of SNHL risks: fracture of the temporal bone pyramid, degree of hearing loss, bilateral hearing loss, high-frequency hearing deficit, tinnitus, decreased speech-in-noise intelligibility, high SISI, absence of OAE, impaired acoustic reflex, and changes in ABR wave V.

Conclusion. Audiological examinations proved effective in evaluating the function of the auditory analyzer after TBI. In the intermediate period, Grade I hearing loss was predominant among patients with hearing impairment, identified in 82 out of 138 cases (59.42%). Grade II was found in 45 cases (32.61%), Grade III in 10 cases (7.25%), and Grade IV in 1 case (0.72%). Additionally, high SISI test values of 70-100% persisted in 102 out of 138 patients (73.91%), which indicates the predominance of the cochlear component of the damage. In the early stages of mild sensorineural hearing loss, pure-tone threshold audiometry is an effective method for detection and diagnosis.

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