

**NATIONAL ACADEMY OF MEDICAL SCIENCES OF UKRAINE
STATE INSTITUTION «O.S. KOLOMIYCHENKO INSTITUTE
OF OTOLARYNGOLOGY OF NATIONAL ACADEMY
OF MEDICAL SCIENCES OF UKRAINE»**

**ACOUSTIC TRAUMA IN ZONE
OF COMBAT ACTIONS.
MEDICAL CARE FOR SENSORINEURAL
HEARING IMPAIRMENT:
DIAGNOSTICS, TREATMENT,
PHASING, PREVENTION**

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PREVENTION.**

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INTRODUCTION

An influence of sounds of high intensity – acoustic trauma, can cause the considerable damage of the hearing system. Unfortunately, the frequency of occurrence of acoustic trauma in our country due to the situation on east of Ukraine grows, that actualize the question of timely diagnostics and purposeful treatment of such patients. The cases of injury of the hearing system grew as a result of mine-explosion and other variants of acoustic trauma. The questions of diagnostics and treatment of the violations of hearing function, related to the acoustic trauma, including one got in a real combat terms, are of great relevance.

Lately in SI «Institute of otolaryngology named of prof. O.S.Kolomiychenko NAMSU», medical institutions of MD, SSU and MIB of Ukraine medical care is provided to the people injured as a result of staying in the zone of realization of combat actions. There are fighters of the armed forces of Ukraine, National Guard of Ukraine and volunteer battalions, and peaceful habitants of these districts, that got under a fire. The researches of this contingent conducted by us showed the certain peculiarities of diagnostics and treatment of such patients not only comparatively to the professional hearing loss got as a result of the continuous chronic noise influence, but also even when compared to acoustic trauma of peace-time. Such situation demands timely and reliably to diagnose the violation in different structures of the hearing system in such cases and timely provide a purposeful help to the patients. It is important to prevent the development of heavy damages and invalidisation.

For the period 2014 – 2019 yy. to SI “O.S.Kolomiychenko Institute of otolaryngology of NAMS Ukraine”, clinic of otorhinolaryngology of Military medical clinical Center of south region, and also 61 mobile combat hospital about 1700 injured (fighters of AFU, National Guard of Ukraine and volunteer battalions, peaceful habitants that got under a fire in the zone of operation of allied forces) appealed.

Purpose

These methodical recommendations are recommended for the doctors-otolaryngologists of medical compartment of Armed forces of Ukraine and law enforcement agencies, and establishment of health protection of different level of accreditation of MOH and NAMS of Ukraine that provide help for the patients with violations of hearing function because of acoustic trauma.

Acoustic trauma is a specific injury of the hearing system because of action of sounds of high intensity. The peculiarities of such pathology is a rapid growth of violations in peripheral

(Receptor) and central (brainstem and cortex) parts of the hearing analyzer. Often such damages are irreversible, especially when medical care to the affected have not been provided timely. With acoustic trauma, both the elements of the system of sound perception and sound transmission are being damaged. However, the damage of structures of sound transmission can have a protective effect in some degree. Sensorineural violations of hearing with acoustic trauma can progress that is why there are in need to be observed. Often at acoustic trauma (especially acoustic barotrauma), the lesion of vestibular apparatus develops in parallel, and then the question is about cochleary-vestibular violations.

Influence of sound of any intensity is accompanied by the action of changes of pressure, however, at small intensities, it is very small, and at high, it becomes a leading damaging factor. Therefore, division to acoustic trauma, acoustic barotrauma is in some way conditional. It is considered that acoustic barotrauma comes when, when influence of shock wave becomes meaningful (therefore combat acoustics traumas practically always are acoustic barotraumas that is explained by the features of formation of powerful sound by a weapon). Acoustic trauma, caused by sounds that originated because of application of military armament, as a rule, has a component of rapid change pressure – shock wave.

At acoustic trauma, caused by the use of different armament (for example, at a mine-explosion) there is complex influence on the structures of organism and hearing system in particular. The components of such influence are impulsive mechanical energy, that arises up in the moment of explosion and the transmitter of which is the air environment, and also powerful sound effect. More slow distribution of sound-wave with low sound pressure stipulates circumstance that quite often influence of sound comes on structures on which a shock wave has influenced already, thus sound effect in such case comes in combination with an emergent vibration. The more meaningful is influence of mechanical component, the more destructive is a negative action of complex of factors at combat acoustic trauma.

The cases of acoustic trauma and acoustic barotrauma are very difficult clearly to divide clinically that creates terms for certain speculations. It is expedient to set the diagnosis of acoustic barotrauma in case of obvious signs of meaningful influence of changes of pressure – lesion of the structures of middle ear (tearing of eardrum, damage of chain of auditory ossicles) or a diagnosed contusion.

At considerable acoustic barotrauma both the system of sound transmission and of sound perception are being damaged. The violations of structures of trans-

mission lay in the origin of edema of tissues, tearing of eardrum; damages of transmission lever structure of middle ear up to the breakage of chain of auditory ossicles, there can be an increase of pressure (traumatic hidrops of labyrinth) and violation of circulation of inside-labyrinth liquid, and other. However not always the damage of the conductive system of middle ear – for example, as a tearing of eardrum, testifies the severity of the lesion of the hearing system overall. This mechanism is intended to be in some degree as protective, that is why quite often the tearing of eardrum, preventing thus to transmission on the structures of receptor apparatus of the hearing system irritations of excessive intensity (both the sound and pressure), provides greater safety of these structures.

As a rule, when a patient has influence of acoustic barotrauma, then next to perceptive violation of hearing, certain disorders of the system of sound transmission (from violations of protective mechanism of middle ear to the tearing of ear-drum and chain of auditory ossicles), lesion of vestibular apparatus, signs of violation of the stato-kinetic equilibrium. Also often such patients have signs of contusion – the concussion of tissues as a result of action of shock wave. This concerns both the structures of the hearing system and other organs, first, brain.

On the other hand, with acoustic trauma there is also direct influence on the central part of hearing analyzer, that should be considered in the diagnostics of the acoustic barotraumatic lesion of the hearing system. Quite often there are cases, when at insignificant changes in the receptor part of the hearing analyzer and moderate decline of hearing function from the data of subjective audiometry the expressed disorders take place in functioning of the brainstem and cortex structures.

Sounds are an adequate irritant for the hearing system, that is why an excessive influence of sound has such a sighting and heavy injuring influence that results in a damage and even destruction of structures of the hearing system.

The systematic action of sounds of high intensity is realizing not only on the structures of the hearing system but also on the whole organism of the affected, first of all it concerns central nervous and also cardiovascular system should be also considered. Therefore with acoustic trauma next to aurals (that concerns the state of different parts of the hearing system) take place and expressed extraaural disorders (from the side of organs and systems unconnected directly to the structures of the hearing system, but the state of which influences on the hearing function). First it concerns central nervous and cardiovascular systems (cerebral circulation of blood mostly). Thus quite often exactly the severity of extraaural changes determines a prognosis and severity of the condition of patients with a sensorineural hearing loss (SNHL), including with acoustic trauma. Quite often SNHL at acoustic trauma develops exactly in reply to vascular disorders (including those vascular violations, that appeared because of system action of noise of high

intensity, and stress factor, – for example, vasospasm) or on a background already existent violations in the cardiovascular system.

Will notice that a contusion is not the synonym to acoustic trauma. A contusion is a complex of lesion of human organism, first of all of CNS, as a result of action of shock wave and emerging concussion of tissues. It is a noncontact lesion, that can result to a concussion, contusion of tissues, first of all brain, CCBT. Also sensible can be internal organs; however on the first plan in such cases comes forward a symptomatology exactly from the side of CNS, as a brain is very sensible to such influences, concussions, contusions. However displays of damage of the hearing system because of acoustic trauma, acoustic barotrauma can be accompanied, or not by the contusion, both structures of the hearing system and other organs. On the other hand, contusion, as a lesion of CNS, can be also, accompanied by certain disorders from the side of the hearing system, such as stun, stuffiness of the ears, subjective noise, ringing in the head, certain coordination disorders. Such displays can disappear in time (at adequate neurological treatment), and injury of the hearing system cannot be much expressed. Therefore, we consider correlation of acoustic barotrauma and contusions of brain as the combined pathology that worsens the state of patient and strengthens the displays of each other.

Now a certificate about an event with pointing to the acoustic baro trauma fighters can get only at presence of mine-explosive trauma or contusion. But really characteristic complaints of servicemen, that were in corresponding circumstances (battle-field, combat-contact, pointers from a weapon, including on a polygon) already can testify about the possibility of acoustic traumatic lesion of the hearing system. If they have typical violations during the inspection, then it confirms the diagnosis of acoustic trauma. On the other hand, a contusion or mine-explosive trauma can be not accompanied by sensorineural violations of hearing.

In this work we foremost discuss the question of sensorineural violations of hearing function with acoustic trauma. In such case a basic diagnosis is a «sensorineural hearing loss». Acoustic trauma, acoustic baro trauma are marked as clarification of diagnosis. Sensorineural hearing loss (SHL) is an independent poli-etiological disease with difficult pathogenesis. Thus, acoustic trauma, as influence of sound (noise) is one of etiologic factors of origin of SHL.

The harmful influence of noise is one of leading etiologic factors of SHL. Among noise factors, in turn, the special place occupies influence of sounds of high intensity – acoustic trauma, that can cause the considerable damage of the hearing system. Exactly with influence of powerful sounds, that quite often is accompanied by a shock wave while using the different types of armament deal the serviceman during implementation of official duties that makes the acoustic

baro-traumatic lesion of the hearing system a professional pathology for this contingent.

Thus, the acoustic trauma is only one of reasons that cause SHL. However, having regard to specificity of lesion of the hearing system in such case, and also the presence of characteristic changes from the data of complex instrumental inspection, including objective methodologies, the presence of acoustic trauma it is expedient to represent in a diagnosis. In addition, there are features of providing help to such patients, and certain criteria in the plan of determination of heaviness and prognosis of disease. Having regard to a basic contingent with the acoustic traumatic lesion of the hearing system – service members, an important place is occupied by the questions of step-by-step help to the patients, expertise and professional suitability of affected.

Therefore, it is expediently in a diagnosis on the first point put the sensorineural hearing loss, but necessarily marking the etiologic factor – acoustic trauma. If sensorineural violations are accompanied by disorders of sound conducting, it must be represented in a diagnosis. Provide examples of formulations of diagnoses in such cases:

The sensorineural bilateral hearing (D>S) loss with violation of legibility of speech test. Violation in the receptor part of the hearing analyzer, phenomenon of PAGL. Acoustic trauma.

A left-side sensorineural hearing loss with attraction of central parts of hearing analyzer from data of AEP (auditory evoked potentials). Violation of the function of sound conducting on the left side. Cicatricial changes of ear-drum on the left.

Progressing bilateral expressed sensorineural hearing loss (D>S) with violation of legibility of speech test and disfunction of central parts of the hearing analyzer from data of SHL. Acoustic trauma.

Will notice that such diagnosis can set only specialist on the basis of data of instrumental research thus, 3 or 4 levels of providing help). That is why approximate diagnostic tasks on different levels can look like this:

1 level: determination of contingent with possible acoustic trauma, acoustic baro trauma for direction on a higher level

2 level: Acoustic trauma, acoustic baro trauma. Violation of hearing. Vestibular disfunction.

3 level: Perceptive, conductive or combined violation of hearing function. Sensorineural hearing loss with violation (or without) of legibility of speech test. Phenomenon of PAGL. Violation in the system of sound conducting. Determination of parameters of subjective ear noise. Acoustic trauma, acoustic baro trauma. Vestibular disfunction.

4 level: Final, concrete, extended diagnosis. Violation in the central parts of hearing analyzer. Acoustic trauma, acoustic baro trauma. Central vestibular syndrome.

As well as other forms of SHL, acoustic traumatic sensorineural hearing loss is divided into acute (to 1 month), subacute (to 3 months) and chronic (over 3 months). Thus, as well as at SHL of many other etiologies, a disease is prone to progressing and needs a supervision and periodic treatment with the aim of warning of worsening of the state of patient. At repeated acoustics trauma, sudden worsening in the state (activation of process, exacerbation) the treatment are provided as at acute as at subacute acoustic traumatic SHL. Treatment of acute, subacute and exacerbation of chronic combat acoustic trauma with perceptives component is provided in the conditions of hospital by a complex course (desirable on 3-4 levels) on the duration of 3 weeks, periodic treatment of chronic acoustic traumatic of SHL can be carried out in an ambulatory or in day hospital, depending on the severity of aural and extaaural violations.

The complication of diagnostics of acoustic trauma lays in the reason that at an external examination such violations practically are not evident. For determination of violations in the hearing system and degree of their severity the instrumental inspection of patients is needed. Really a general practitioner (or in the conditions of the armed conflict sanitar instructor, medical assistant, doctor of military subdivision) can be oriented only on the specific complaints of patients, data of acumetry (a patient is asked to repeat the words of whisper and speaking), signs of coordination disorders, stato-kinetic equilibrium. In addition, it is to notice an evolution of fluid or blood from the ear in small amount that can testify about the rupture of eardrum and damage of structures of middle ear. However, the presence of such sign does not testify about the severity of acoustic trauma. Conversely, often the rupture of eardrum protects the structures of internal ear from destruction. On the other hand, the signs of rupture of eardrum testify about the absolute presence of exactly baro-impact. It is also possible to investigate a nystagmus, some tests for determination of the state of stato-kinetic equilibrium for confirmation of the damage of vestibular apparatus (for example, finger-nose test, and sustainability in the pose of Romberg). That is why on some stages of evacuation the selection of patients is possible only by certain signs for a further inspection on the higher levels of providing help. It is also possible to implementate the certain base curative measures for warning of considerable violation of the hearing function in future.

A clinical inspection acquires a special importance on the first stages of providing medical care for the injured in the zone of operation of allied forces – by the physicians of soldiery parts, front-line combat hospitals and hospitals. There, as a rule, there is not the sufficient equipment and quite often time for inspection of

patients is limited before their evacuation in other curative establishments farther from the line of collision (what actualise the question of sorting of patients). In this plan of the special value acquires accenting of attention on the most characteristic complaints of patients, that got acoustic trauma (acoustic baro trauma).

In the plan of the first diagnostics of sensorineural violations of hearing with acoustic trauma the most common are clinical methods, careful analysis of complaints and data of anamnesis. It allows to chose the contingent for a further inspection. On the next stages depending on diagnostic possibilities of curative establishment instrumental inspections are conducted, including the objective methodologies. It is important to apply all present diagnostic potential to the aim of revealing of violations in different parts of the hearing analyzer, and extraaural disorders. As a rule, the instrumental specialized research can be provided on third level with the using of present in establishment equipment. On fourth level all spectrum of equipment that are used at modern world level in audiology are used.

The study of sensorineural violations of hearing undertaken by us at combat acoustic trauma, got in the zone of operation of allied forces, by means of complex clinical and instrumental examinations allowed to define the most informative indicators that characterize violations in different parts of the hearing analyzer in such patients.

The patients with combat acoustic trauma have considerably expressed complaints about subjective ear noise, unpleasant, including pain feeling in ears, stuffiness in ears, poor tolerance of loud sounds, dizziness, unbalance, stunned, decline of hearing function, expressed in a different degree. Many service members have subjective ear noise of permanent character with periodical increasing. Often it has «difficult» descriptions, for example, high-frequency tone on a background of noise of middle intensity. The intensity of ear noise sometimes reached to 10-15 dB above a threshold that inflicted to the patients suffering and substantially influenced on a general feeling. The inspected by us patients that got acoustic trauma in the zone of realization of combat actions, often had complaints on headache, increased irritability, heaviness in area of back of head, sleep disorders. Obviously, that significant quantity of present complaints represents violation of functioning of the central nervous system that affects the central parts of the hearing analyzer also. The presence of such complaints significantly influenced on the general feeling of patients and changed quality of their life.

According to our data, the most frequent and most expressed complaints in the examined by us patients with combat acoustic trauma were: decreasing of hearing function (100%), subjective ear noise (81,9%), headache (80,8%), heaviness in the head (59,3% of cases), stun (74,8%) and stuffiness of the ears (64,8%) immediately after acoustic trauma, dizziness (61,5%), disorders of balance, coor-

dination (42,5%), pain in the ears (41,9%) after acoustic trauma. Often (58,9%) of them mentioned that their get annoyed of loud noises, especially of high frequency. The duration and severity of such feelings as stun, stuffiness of the ears, dizziness, ear pain, imbalance (unsteadiness of gait), and the intensity of the noise should be taken into account. The long lasting stuffiness of the ears, stunning, dizziness, violation of coordination, the presence of intensive high frequency noise, according to our data, are unfavorable prognostic signs of the onset and progression of SHL in patients with the acoustic trauma. The longer, for example, stuffiness of the ears and stun after acoustic trauma continued, the more expressed sensorineural disorders developed in the future in this case. If the stuffiness of the ears, stun, pain in the ears, impaired balance disappeared quickly, the better was the prognosis in patients with acoustic trauma.

In order to optimize the process of examination of persons with acoustic trauma who suffered in the zone of operation of allied forces, we developed a questionnaire as a supplement to the patient examination map, medical history, outpatient card, which simplifies the work of the physician (Appendix 1). It focuses on the most informative features and systematize it that allows to identify patients with a possible damage of hearing and vestibular systems and to estimate in advance the severity of hearing impairment. The questionnaire can also be used by non-medical officer for prior estimation of the state of patients with acoustic trauma. We have experienced the filling these questionnaires by the service members themselves, which also contributes to a more rapid and precise retrieval of information by doctors.

We recommend applying the proposed questionnaire in all stages of providing medical treatment for those affected in the zone of the fighting with the possibility of damage of the hearing analyzer, if possible. The questionnaire for patients with acoustic trauma greatly facilitates the work of medical workers and paramedics, as well as service members themselves can fill it. The proposed method of organizing the data of the anamnesis and complaints, reflected in the questionnaire developed by us, allows selecting patients for further examination and providing targeted specialized medical assistance. When there is a suspicion of a possible acoustic trauma or acoustic baro trauma, it is advisable to conduct at least the minimum audiological examination as soon as the opportunity arises.

In case when the patient is unconscious, for the selection of affected with possible acoustic trauma you can focus on the following symptoms: discharge of blood, fluid from the auditory meatus; signs of head injury; injuries to the head; signs of increased intracranial pressure, eyewitness testimony about the impact of powerful shock waves.

On the 3 level of medical assistance diagnostics of disorders in the hearing system provides otolaryngologist, which can examine the patient competently. Sometimes such specialist may be on the 2 level. When conducting otoscopy, there is a dull eardrums, thickness of it; injection of the vessels in the course of the handle of the hammer in patients often. There may be some flattening of the contours and the reduction of the light reflex. Part of these patients revealed signs of traumatic rupture of ear drum (perforation, scarring). However, it should be noted that in the majority of patients with sensorineural disorders of hearing function due to the acoustic trauma there is no visible at normal otoscopy signs of damage. In addition, it is advisable to pay attention to the changes of nasal breathing, condition of the nasal cavity and paranasal sinuses, the hearing tube function in this contingent of patients. It is important because preserving satisfactory nasal breathing and active functioning of the hearing tube is of great importance for the implementation of protective mechanisms of the hearing system in acoustic trauma.

From the instrumental methods at the second and third level of medical care in the system of the MFU can be available evaluation of the hearing function according to psychoacoustic methods of subjective audiometry, although not always in full volume. Nowadays the subjective audiometry remains the most accessible and sufficiently informative method of research of hearing function. At least, usually it is possible to perform tone threshold audiometry.

We have analyzed the data of subjective audiometry in affected person who got acoustic trauma in the combat zone during the combat actions for 2014 – 2016 and asked for help in SI “O.S.Kolomiychenko Institute of otolaryngology of NAMS Ukraine”, clinic of otorhinolaryngology of Military medical clinical Centre of South Region. Information also based on the data of 61 mobile military hospital – there were altogether more than 650 people.

According to the data of subjective audiometry in patients with acoustic trauma obtained in real combat terms we revealed violation of sound perception, expressed in various degree, more often it was bilateral asymmetric lesion of the basal or mediobasal parts of the cochlea. The violation of hearing in examined patients of this contingent are often accompanied by disturbances of perception of speech test, slow growth of its legibility, cases of discomfort, reduced or relatively low DT of Luscher, especially in the region of 4 kHz, which indicates about the lesion of the receptor part of the hearing analyzer in such patients. It is worth noticing that servicemen with acoustic trauma feel discomfort in the perception of speech test already at an intensity of 70-80 dB with small disorders of hearing function. In general, amongst the examined patients with acoustic trauma obtained in the zone of combat activity, the violation of the speech legibility test was observed in 29,4%, low or reduced levels of DT of Luscher – 26,5%. It is known

that low DT in method of Luscher, and paradoxical drop and slow growth of the speech test indicates about the dysfunction of the cochlea and the presence of the phenomenon of accelerated growth of the loudness (PAGL). The presence of PAGL significantly affects on the health of patients and is a bad prognostic sign. In general, these or other signs of violations in the receptor part of the hearing analyzer were detected by us according to the subjective audiometry in the majority (79,6%) of the examined patients with acoustic trauma obtained in real combat conditions. It is worth noticing that according to the data of OAE at a frequency distortion products (DPOAE) in patients with combat acoustic trauma, objectively confirmed the violation of the receptor part of the hearing analyzer, first, the outer hair cells. This was manifested by the absence of registration, partly by a positive response of small amplitude, that indicates about the inhibition of the activity of the outer hair cells of the neuroepithelium of the cochlea.

During the systematization of the obtained data, we revealed that all the results of the examination of hearing function of the service members with perceptive hearing loss according to subjective audiometry fit into several characteristic types [9]. The largest group among all of the studied by us audiograms made top-down often – abrupt type of audiometric curve. Typical was the maximum increase in hearing thresholds for tones in the region of 4-8 kHz. Such cases of descending tone audiograms was 76,0%. Often patients with such descending curve had a kind of peak of higher thresholds at a frequency of 4 or 6 kHz, followed by some decline in the region of 8 kHz – typical “acoustic traumatic peak” (46,3% of cases among all of the analyzed audiograms and 60,8% amongst the descending). Many patients had characteristic acoustic traumatic “peaks” not only in the conventional range, but also in the curve in the high frequency range. In any case, the increasing of hearing thresholds to tones 4 and 6 kHz were observed in the vast majority of the examined patients with combat acoustic trauma. Many patients with acoustic trauma had “breaks” of the perception to tones in conventional frequencies (28,9%), and more often to tones 4 and 6 kHz, but sometimes it even started from 2-3 kHz.

The «acoustic traumatic peak» is a very characteristic feature. It is looks like some kind of a peak of higher thresholds of hearing sensitivity at a frequency of 4 or 6 kHz, followed by some decline in the area of 8 kHz. It is easily recognized on the audiogram by all the doctors otolaryngologists (and not only) of any skill level. We consider it is possible to diagnose «acoustic trauma» in patients with acoustic traumatic peak on audiometric curve (of course, with accounting and other data) even with the absence of documentary evidence of acoustic trauma, contusion, mine-blast injury and other circumstances (if the servicemen were in a combat

zone and were in contact with the sounds of high intensity due to the use of military weapons).

Quite often the characteristic “peaks” of increasing of hearing thresholds is observed not only in conventional but also in the extended frequency range. Such changes are characteristic for acoustic trauma, especially in early stages. This feature can be used as one of the markers of acoustic traumatic injury of the hearing analyzer while deciding the expert questions. Subsequently, with the absence of adequate treatment and preventive measures, more profound violations are progressing in the hearing system and decreasing hearing function becomes more significant and involves a larger range of frequencies. Then acoustic traumatic peak may not be observed because often at these frequencies takes place a “break” of perception.

Many patients had characteristic acoustic traumatic «peaks» as in the conventional range, but also in the curve in the high frequency range. An example of such an audiogram is shown at Pic.1. This patient has another notable example such as «polygonal» curve.

The disorders of hearing function in examined patients with acoustic trauma were mostly bilateral (88,1%). Almost symmetrical of them were 26,0% of cases, asymmetrical 73,9%. The unilateral disorders of hearing function occurred in 11,8% of service members. Among all surveyed audiograms of servicemen zone of combat actions cases, asymmetrical disorders of hearing function (including one-sided) were 77,0%.

The data of high frequency audiometry is a study of auditory sensitivity to sounds of the extended (16-20 kHz) frequencies, which is possible to conduct only at the fourth level, in the examined patients with acoustic trauma were very heterogeneous; often sounds at this range were not perceived at all by the affected. According to the high frequency tonal audiometry, we often observed “breakage” – lack of hearing sensitivity to tones of the extended (9-16 kHz) frequency ranges, and often it were asymmetrical. At different frequencies the “breakage” was observed in 69,7% of cases among all patients who underwent threshold tonal audiometry in an extended frequency range.

So, here is a brief description of the types of audiometric curves, we selected patients with acoustic trauma obtained in actual combat conditions (Pic.2. Annex).

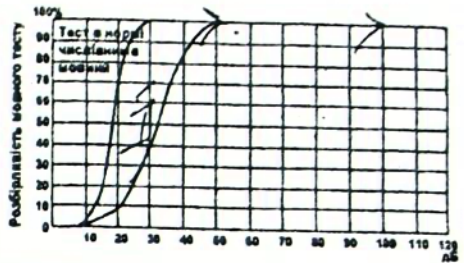
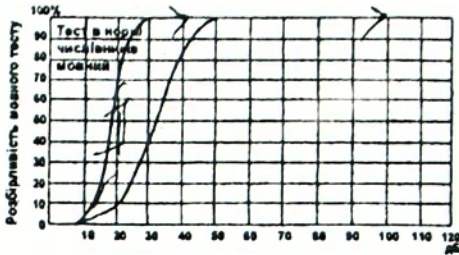
As it was noted above, the vast majority of analyzed by us audiograms of fighters from the zone of operation of allied forces had a descending type of tone threshold curve (76,0%). All patients with acoustic trauma that had descending type of audiograms, were divided by us into three groups according to the degree of severity of disorders of hearing function. Moreover, the separation occurred at

ПРАВЕ ВУХО

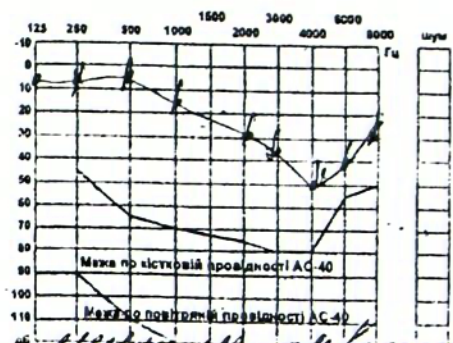
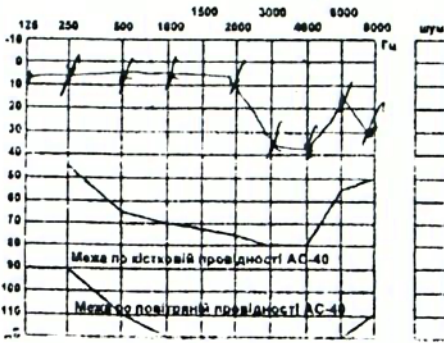
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			К С

ЛІВЕ ВУХО

ШМ	РМ	Дослід Бюга	Дослід Федорчи
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			К С



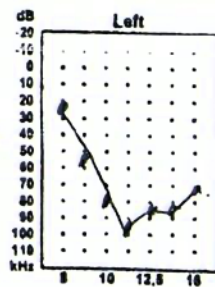
Дослід Вебера



Суб'єктивні шуми			Дослід Лихнера над порогом 20 дБ
40	20	08	
Суб'єктивні шуми			Дослід Лихнера над порогом 20 дБ
20	08	08	



High Frequency Audiogram



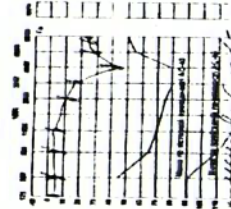
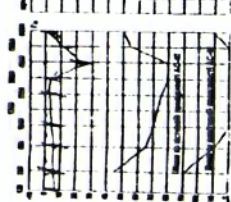
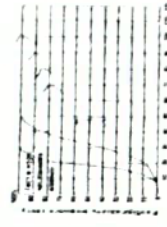
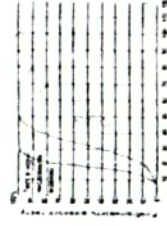
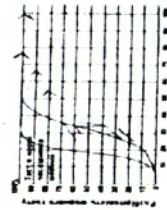
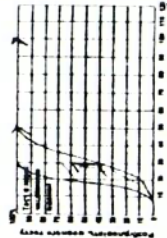
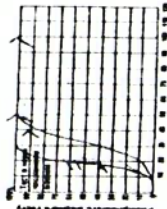
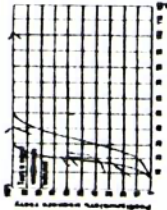
Pic.1. An example of audiometry in service members with a characteristic «peaks» of higher thresholds in conventional and extended frequency ranges with acoustic traumatic lesion of the hearing analyzer.

a frequency of similar changes that we observed in the examined affected in the zone of operation of allied forces, as well as with certain key differences.

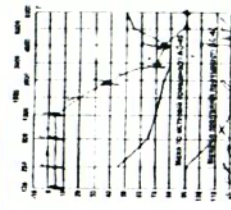
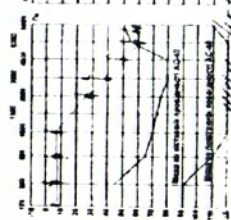
The first group consisted of patients who had unexpressed disorders of hearing function with a primary lesion of the basal part of the cochlea (37,9% of the total, 49,9% of all cases of downward type curve). The violations varied from the initial (small to 15-20 dB increase in hearing thresholds in the high frequency area of the conventional range, «characteristic peak» in the background of almost normal perception thresholds at other frequencies) to quite significant abrupt violations in the high frequency area and the significant characteristic peak with a maximum increase of hearing thresholds up to 50 dB. The violation of the hearing sensitivity mainly started from the frequency of 2-3 kHz. It is worth noticing that among patients in this group a characteristic peak in the audiogram was observed in 55,4% of cases, signs of slowing growth intelligibility of speech test in 23,1%, relatively reduced DT of Luscher at a frequency of 4 kHz at 77,4%.

The second group consisted of cases with descending type of audiometric curve and lesion of mediobasal part of the cochlea (higher thresholds of hearing sensitivity started from 1-2 kHz) or steep abrupt type with significant sharp violation in the high frequency area with higher thresholds of hearing sensitivity more than 50-60 dB. In some patients of this group (24,8%) increase in hearing thresholds began from tone of 500 Hz. Quantitatively, this group made up 26,8% of all examined patients with acoustic trauma, and 35,3% of all cases of downward type curve. Often patients in this group had breakage of perception at frequencies 6-8 kHz (45,7%). Patients in this group had often violation of the speech intelligibility test (51,9%), signs of discomfort (9,3%), violations according about threshold tests were relatively reduced and reduced DT at Luscher at frequency 2 and 4 kHz (91,5%). Among patients of this group characteristic peak on the audiograms occurred in 39,5%.

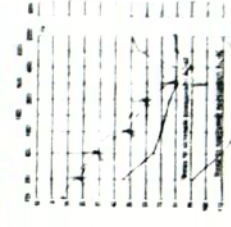
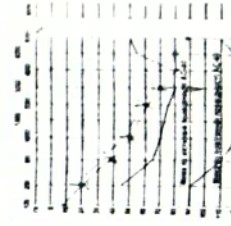
The 3 group consisted of affected with severe impairment of the hearing function, a descending type of audiometric curve, lesion of mediobasal part of the cochlea, often with breakage of perception to tones of a conventional range. Quantitatively, this group made 11,3% of the total number of examined, 14,8% of all cases of downward type curve. The increase in hearing thresholds of tones in patients started from 0,5-1 kHz (51,8%), or were observed throughout the all conventional tone-dial, and began from 0,125 kHz (35,2%). Often patients in this group had breakage of perception already from the frequencies of 1-3 kHz (9,3%). In general, breakage of perception in the conventional frequency range in fighters of 3 groups was observed at 87,0% of cases. Most patients of 3 groups had violations of the speech intelligibility test (94,4%), speech discomfort was 12,9% of



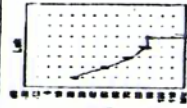
Handwritten notes and data for the first set of graphs, including 'IMPAZE BY20' and 'DRE BY20' labels.



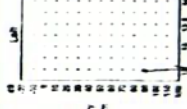
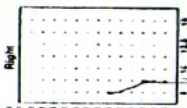
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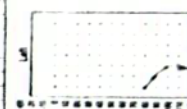
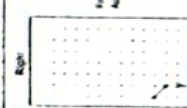
Handwritten notes and data for the third set of graphs, including 'IMPAZE BY20' and 'DRE BY20' labels.



Handwritten notes and data for the first set of small graphs, including 'Right' and 'Left' labels.



Handwritten notes and data for the second set of small graphs, including 'Right' and 'Left' labels.

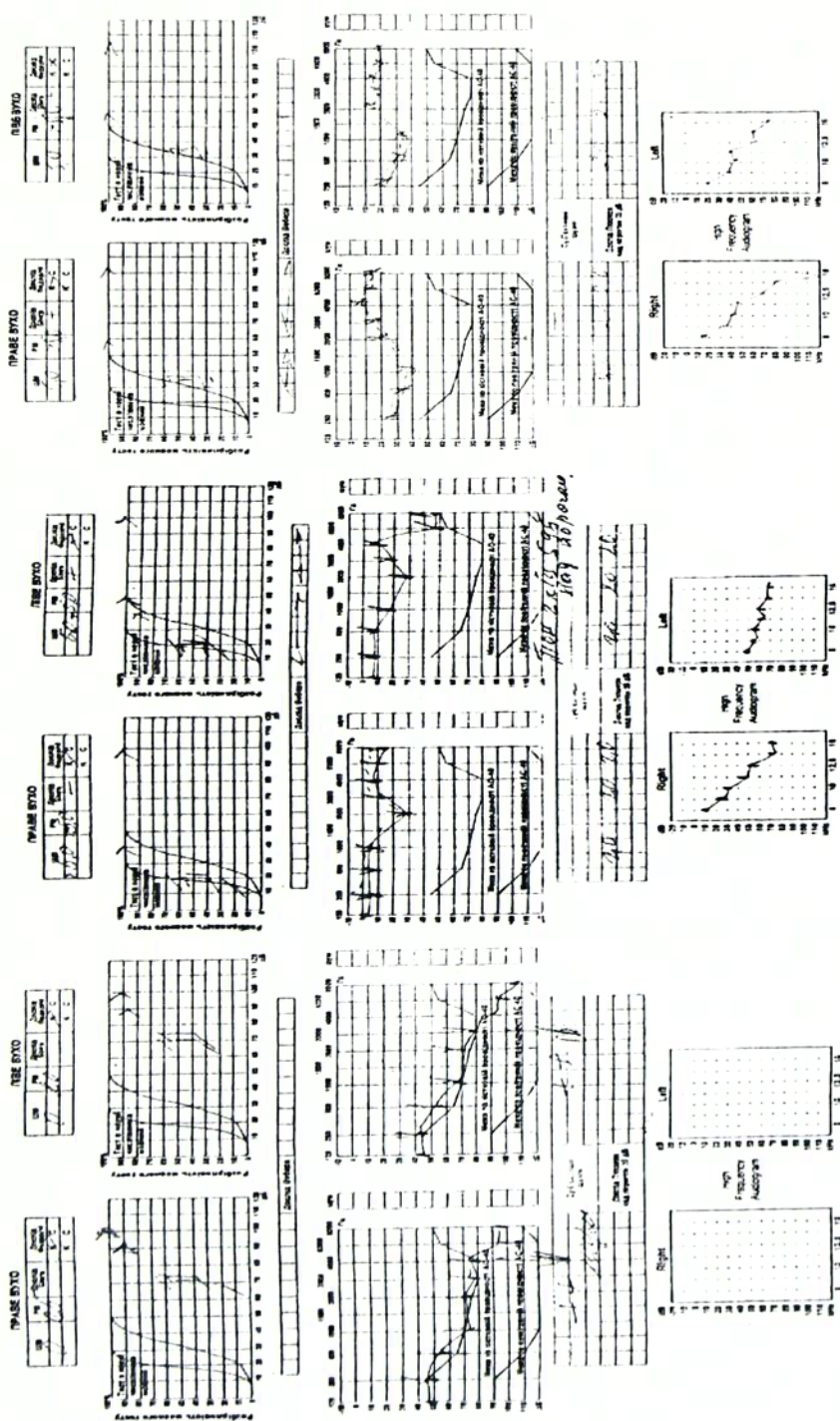


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1 type of audiometrical curve

2 type of audiometrical curve

3 type of audiometrical curve



4 type of audiometrical curve

5 type of audiometrical curve

6 type of audiometrical curve

Fig.2. The examples of date of subjective audiometry, that are characteristic to each of 6 selected by us group by the type of tonal audiometrical curve.

the patients. A relatively reduced and reduced DT of Luscher at frequencies 2 and 4 kHz were observed in all 3 groups of examined (100,0%).

To group 4 we have added affected with bottom going, almost horizontal type curve (14,8% of the total quantity). The hearing violations primarily concerned the whole tone scale, that started from the frequency of 0,125 kHz. The level of perception of thresholds of tones throughout the tone scale ranged in this group from 30-40 to 60-70 dB. The 71,8% patients of this group had violations of the speech intelligibility test, lower DT of Luscher at frequency of 2-4 kHz at 83,1%.

The 5 group included patients with acoustic trauma, who had an interesting type of curve in the form of «poligonal» line or with a peak of increasing threshold of audibility at frequency of 1-2 kHz «carhart-same» peak (7,5% of all analyzed audiograms). Obviously, as a result of a powerful sound comes specific lesions of the hearing system. At 36,1% of the patients in this group were found violations of the speech intelligibility test, 61,1% – reduced DT Luscher, mainly in the area of 4 kHz.

The 6 group consisted of patients with a local increase of the threshold of hearing sensitivity to tones of low frequency – with the lesion of the apical part of the cochlea (1,8% of the total number of observations). Violation of the speech intelligibility test were detected in one third (33,3%) of military personnel with this type of audiograms.

Therefore, more informative for determining sensorineural disorders of hearing function in individuals who received acoustic trauma in real combat conditions, according to the subjective methods of examination are:

- Complaints of hearing loss; deafening, congestion and pain in the ears after acoustic trauma; poor tolerance of loud sounds, dizziness, imbalance, headache, important symptom is subjective tinnitus, especially of high frequency. Moreover, the attention should be paid on the duration and severity of such feelings;

- increase of hearing thresholds for tones in the region of 4-8 kHz of conventional, as well as 14 and 16 kHz extended frequency range down to the type of tonal audiometric curve, often – abruptive. It is often takes place characteristic «peaks» of increase in hearing thresholds at the tonal curve with the greatest one in threshold at 4-6 kHz and 12 kHz – “acoustic traumatic” peak. It can be observed “breaks” of perception, especially in the extended range of frequencies;

- violation of the speech intelligibility test (often slow growth); the presence of discomfort, including speech, often without any other violations of intelligibility; the discomfort and the violation of intelligibility can be observed in the absence of significant disorders of hearing function (defined dissociation characteristics);

- Reduction of differential thresholds (DT) by method of Luscher, especially in the region of 4 kHz;

And on these indicators in the first place should be paid attention when examining the affected in order to identify violations of sensorineural hearing function due to acoustic trauma.

We have identified various degrees of dysfunction of the vestibular system in almost all patients affected by acoustic trauma received in a combat zone. Predominantly it was vestibular dysfunction in a way of central vestibular syndrome or mixed forms of lesions with different degree of compensation. Vestibular dysfunction is often accompanied by violations of stato-kinetic equilibrium, disritmic nystagmus according to the electroencephalography: many of the examined had the "mute" field. Often, such manifestation was asymmetric.

The most complex examination of changes in the hearing system, of course, is on the 4th level of medical care where there is a possibility to use all the essential spectrum of diagnostic equipment and the expertise of the appropriate level.

Recording of data of objective methods of complex audiological examination allows reliably, detailed and fully diagnose disorders in different parts of the hearing analyzer, as well as extraaural manifestations, contribute to a focused prescription of the complex treatment to the patients with acoustic trauma that were in the area of combat action', which increases its effectiveness. This allows to prevent the progression of hearing loss and the formation of severe SHL in this category of patients. Therefore, there is no doubt the feasibility of a complex examination of the servicemen with combat acoustic trauma, at the highest (3 and 4) levels of assistance and the timely application of a targeted therapeutic and preventive measures. This greatly increases the effectiveness of treatment of sensorineural disorders associated with acoustic trauma lesion of the hearing system in service members. So, of course it might be considered in the algorithm for providing care to this contingent in a way that they were as soon as possible evacuated on the 3rd and 4th level of medical care.

For the assessment of central (brainstem and cortex) parts of the hearing analyzer, we used the method of recording auditory evoked potentials (AEP): short-latent or brainstem (SLAEP, ABR) and long-latent (LLAEP) or cortex. It is a recognized objective method that allows to obtain accurate data about the state of the central parts of the hearing analyzer and closely located structures of the brain and it has widespread use in otolaryngology, otoneurology, neurology and neurosurgery. The method can reliably detect abnormalities in the functioning of the central parts of the hearing analyzer, including in the early stages of disease. Especially important is that this method allows to obtain information about early functional changes in the brain before structural changes in tissues, being noninvasive and not requiring active patient involvement in the research process (which, among other things, provides for the possibility of research in an unconscious state).

Our studies have shown that the central parts of hearing analyzer suffer because of the combat acoustic trauma. While studying the state of the central parts of hearing system according to the registration of hearing evoked potentials we have identified violations in the cortex part of the hearing analyzer according to LLAEP in all (100%) of the examined servicemen with acoustic trauma and in 86,4% of cases in brainstem structures according to SLAEP. Therefore, violations in the central parts of the hearing analyzer were detected in all the examined patients with combat acoustic trauma. These changes developed rapidly, were expressed in varying degrees and include cortical and subcortical structures, and a significant part of the examined had quickly attracted the brainstem parts of the hearing analyzer.

The significant alterations in the functional state of CNS in this contingent, adjustment disorder, PTSD (post traumatic stress disorder), acute stress reaction and other disorders that develop in servicemen in a combat zone, due to the extremely stressful situation causes the presence the lesions of the of the sensory systems in affected, including the central parts of the hearing analyzer.

The violations according to AEP manifest themselves in changes of the complex peaks (their smoothness, the presence of additional waves, decrease or, on contrary, the increase of the amplitude, the answer was unclear), as well as the elongation of the temporal characteristics of the latent period of the peaks of the waves (LPP) and inter-peak intervals (IPI). Often AEP data was somewhat asymmetrical. It is worth reminding that according to subjective audiometry, the vast majority of the examined patients with combat trauma also had an asymmetric impairment of the hearing function. Perhaps the change in the central parts of hearing analyzer in affected in the zone of operation of allied forces also occur asymmetrically.

In Pic 3 shown the entry of SLAEP of patient K.. It is seen, that left complex has smaller SLAEP amplitudes, the peaks are smoothed, and the latent periods of the peaks (LPP) II, III and V are elongated. On the right peaks are more clear, but it is clear elongation of LPP I, II and III of the SLAEP waves. Consequently, there is the asymmetry of the responses of brainstem structures by the shape of curve, amplitude and temporal characteristics of peaks.

In pic. 4 there is recordings of LLAEP of serviceman C.. It is seen, that the amplitude of the response is reduced, LPP components LLAEP primarily P_2 and N_2 are increased, there are additional waves in the complex, which confirms the prevalence of processes of excitation in the CNS. The significant lengthening of the LP N_2 LLAEP (over 300 ms) was registered.

Noteworthy that almost all (89,8%) of examined by us servicemen with acoustic trauma who have had violations in the cortex part of the hearing analyzer,

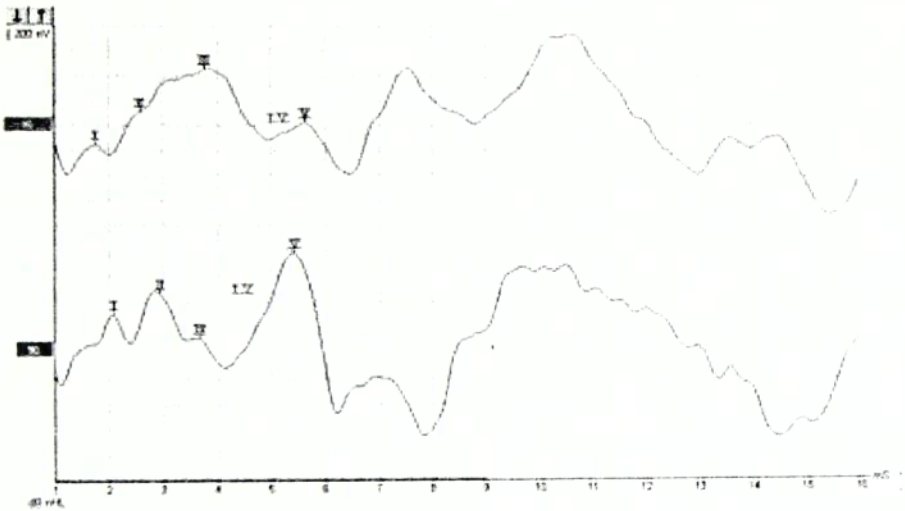


Fig. 3. The entry of SLEP of a serviceman K.

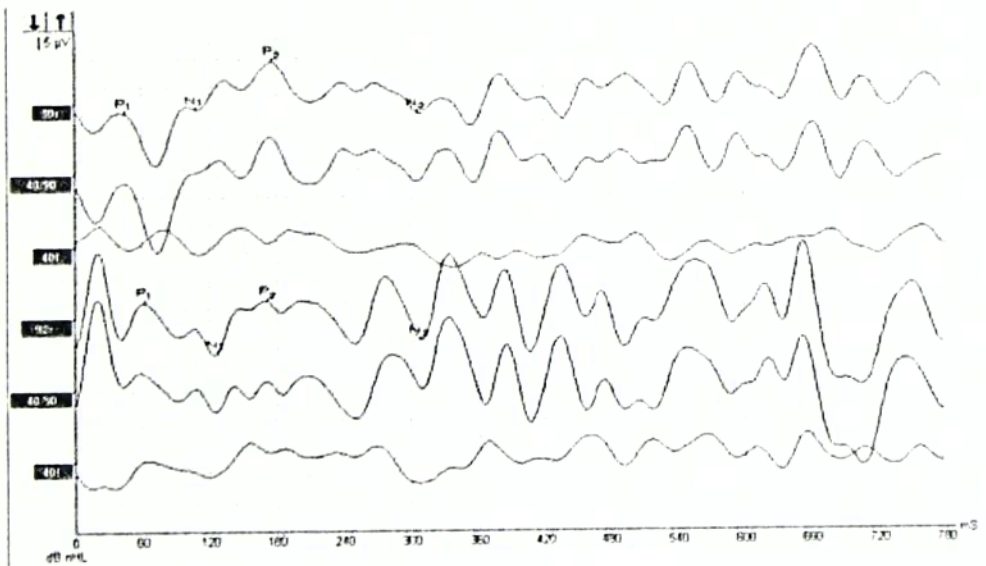


Fig. 4. Entry of LLAEP in patient with combat acoustic trauma C.

had the changes of LPP «late» components of LLAEP. It is known that in the modulation of late components P_2 and N_2 LLAEP participate limbic structures of the brain which are the integrative system of perception of stimuli through the sensory organs and support the tone of the cerebral cortex. These are the structure of reticular formation which are «responsible» for intracerebral communication, ensuring

communication and coordinated work of various sections and structures of the brain, perception of information coming from sensory systems, thus facilitating the implementation of complex functions, including the so-called «watchdog reflexes» and stress reactions. The development of severe progressive SHL in case of acoustic trauma observed on a background of violations in the central parts of the hearing analyzer and the limbic-reticular brain structures that may reflect on the disorder of the processes of central regulation of the hearing system, and the failure of compensatory mechanisms in the implementation of stress reactions in response to combat acoustic trauma.

So, according to AEP in servicemen who got acoustic trauma in the zone of operation of allied forces, we identified a significant impairment in cortex, subcortex, and brainstem structures of the hearing analyzer, as evidenced by significant lengthening of the LPP component P_2 and N_2 of LLAEP and II, III, IV and V of the SLAEP waves, and IPI I-V, respectively. Violations in the cortex parts of hearing analyzer according to LLAEP was detected in all (100%) patients with acoustic trauma that were in the zone of operation of allied forces, and in 89,8% of them had dysfunction of subcortex nuclei. The changes in the brain stem structures of the hearing analyzer took place according to SLAEP in 86,4% of the examined by us servicemen with combat acoustic trauma.

The analysis of data of AEP in 50 servicemen who received acoustic trauma during performance of professional duties in a zone of operation of allied forces (soldiers of the armed forces, National guard and volunteer battalions), with the most typical forms of audiometric curves (descending) and severe sensorineural hearing loss (at frequencies of 4, 6 and 8 kHz the values of the average hearing thresholds for tones were $(35,34 \pm 4,82)$, $(40,48 \pm 3,92)$ and $(49,84 \pm 3,85)$ dB, respectively), we obtained the following average data the temporal characteristics of SLAEP and LLAEP. So, LPP II wave of SLAEP in examined patients of this group made $(2,98 \pm 0,03)$ ms in the control value $(2,66 \pm 0,04)$ ms ($t=6,4$; $p<0,01$), LPP V (of $5,98 \pm 0,04$) ms at normal $(5,52 \pm 0,03)$ ms ($t=9,2$; $p<0,01$); IPI III-V formed in the examined patients $(2,18 \pm 0,04)$ ms in the control value $(1,89 \pm 0,03)$ ms, ($t=5,80$; $p<0,01$), and IPI I-V – $(4,28 \pm 0,04)$ ms at normal $(3,96 \pm 0,03)$ ms ($t=6,40$; $p<0,01$). As for the indicators LLAEP, the LPP component P_2 in the studied group of patients with acoustic trauma was $(189,6 \pm 2,4)$ ms while the value in the control group $(175,9 \pm 2,6)$ ms ($t=3,87$; $P<0,05$) and N_2 – $(302,2 \pm 3,8)$ ms at normal $(251,4 \pm 3,1)$ ms ($t=10,36$; $P<0,01$).

Thus, during combat acoustic trauma violations occur not only in peripheral but also in central parts of the hearing analyzer. According to hearing evoked potentials in patients with acoustic trauma from the zone of combat actions there are violations in the cortex, subcortex and brainstem structures of the hearing analyzer.

er, expressed in various degree. The central parts of the hearing analyzer, including deep brain structures is being rapidly attracted in these patients. The data obtained confirms the important role of state of brainstem and cortex parts of the hearing analyzer in the development of sensorineural disorders with acoustic trauma obtained in real combat conditions.

The method of registration of otoacoustic emission OAE is an objective method of assessment of receptor part of the hearing analyzer, based on the fact that the cochlea generates acoustic echo of low intensity in response to sound stimuli in individuals with normal hearing. This acoustic phenomenon is recorded using a special sensitive equipment. Today, there are several classes of otoacoustic emissions, among which the most oftenly used and the most informative are two types of methods – delayed (TEOAE), and the frequency of the distortion products (DPOAE). The last one has the greatest diagnostic value. The information obtained actually reflects the functional state of outer hair cells from base to apex of the cochlea.

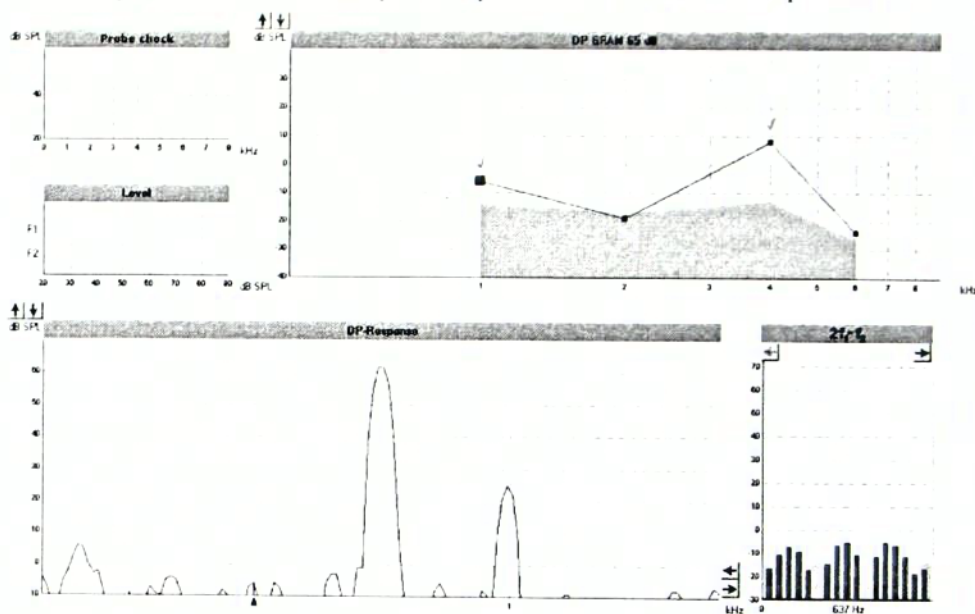
We conducted studies by the DPOAE in patients with acoustic trauma who were in the combat zone. In a significant part of the examined patients with combat acoustic trauma, the positive response of the OAE was not registered at all. Thus, during the analysis of data OAE of 50 servicemen from zone of combat actions with the most typical disorders of hearing function the type of the audiometric curve and the degree of severity (average) answer was not registered at 60.6% of cases. In 26,3% of cases was received a partially positive response of small amplitude, indicating that inhibition of the activity of the outer hair cells of neuroepithelium of the cochlea. A full response to all frequencies that was studied in these patients with acoustic trauma obtained in actual combat conditions was got only 13,1% of cases.

It is worth reminding that according to subjective audiometry in the examined by us patients with acoustic trauma obtained in the zone of operation of allied forces, often there are significant sensorineural hearing disorders with symptoms of recruitment, which indicates dysfunction of the receptor part of the hearing analyzer.

During the study of OAE in servicemen with combat acoustic trauma we have identified the specific feature in detected violations. For example, they often had such a paradoxical pattern of responses on the frequency of the distortion products (DPOAE). Although according to the data of subjective audiometry (pure tone threshold and subthreshold) of the examined servicemen revealed lesions of the hearing receptor system and the decline of hearing function mainly in the high frequencies of conventional range, especially in the area of 4-8 kHz, which indicates a lesion of the basal part of the cochlea, according to the OAE, we often

observed saving of response of the outer hair cells at the highest frequency with the absence at the lowest, or «selective» sensitivity «piecemeal». This result of the study indicates that sound and reaction of the external hair cells of Kortiev organ at a given (high frequency) area. Often preserved response of cochlea at the frequency of 4 kHz, contrary to expectations, according to data of tonal threshold audiometry. Note that in professional SHL of noise genesis, as a rule, OAE is the first to suffer in generation in the high frequency range.

On pic. 5 shown an example of a partial OAE in examined patient.



Pic. 5. Entry of OAE on the frequency of the distortion products in servicemen K.

Thus, our studies demonstrate the importance of research of OAE in servicemen with combat acoustic trauma. The obtained data are important for early detection of hearing impairment, objective statement of changes in receptor part of the hearing analyzer. Identified by the method of registration of otoacoustic emission changes in patients with acoustic trauma obtained in the zone of operation of allied forces, are essential to the objectification of early symptoms of sensorineural hearing loss, primarily violations in the receptor structures of the cochlea in such cases.

The acoustic impedance measurements (or impedance audiometry) is an objective method of examination of the hearing system, which consists of two methods – dynamic tympanometry and acoustic reflex inside-the-ear muscles (ARIM). First of all, the technique allows to assess the system of sound conduction and functional state of middle ear structures, however, the known diagnostic capabil-

ities of the characteristics of ARIM in the diagnosis not only of disorders of the middle ear, but also in pathology of sound perceptive part of the hearing analyzer from the cochlea to the brainstem.

We examined by means of acoustic impedance servicemen with acoustic trauma from the combat zone. In some patients the study was contraindicated due to the traumatic rupture of the eardrum. Part of these patients revealed various irregularities in the condition of the middle ear structures (the lesions in the transmission of level arm structure of the middle ear, sometimes until the break of the ossicular chain, scarring of the tympanic membrane, dysfunction of the hearing tube), which were reflected in the indicators of tympanometry and ARIM. However, one of the most serious consequences of acoustic trauma are sensorineural disorders of hearing function.

According to the acoustic impedance in patients with sensorineural hearing loss (SHL) as a result of acoustic trauma received in a combat zone, there are some changes. The data of tympanometry are not indicative of this contingent (we are not talking about combined damage of sound conduction and sound perceptive apparatus – in these cases, conduction disorders appropriately appear in the data tympanometry). So, we found that indicators of tympanometry in the majority of surveyed military personnel who got acoustic trauma in the zone of the zone of combat actions were in the normal range and did not significantly differ from those of the control group – more often it was tympanogram of type A, less often high-amplitude or on the contrary, such As, average values compliance in the normal range. We have not identified significant changes in threshold indicators of ARIM (in-the-ear acoustic reflex of the muscles) of the examined servicemen with combat acoustic trauma (except those with severe SHL).

As for the amplitude of the indicators ARIM, indicators of the amplitude of the ARIM of zone of combat actions servicemen had a heterogeneous distribution. For example, among the 50 examined servicemen with the standard form of the audiometric curve (descending type), and the most common degree of severity of disorders of hearing function (up to 50 dB at frequencies of 4-8 kHz) normal symmetrical indicators amplitude ARIM were registered only in 14,0% of cases. At 40,0% of servicemen with acoustic trauma occurred moderate symmetrical reduction in the amplitude of the ARIM from both sides when psi – and contra-lateral stimulation, at 14,0% of the servicemen had symmetrical decline. In 10,0% of examined were absent ARIM on both sides. It should be noted that according to the tonal threshold audiometry at 1 kHz they had thresholds of hearing for a tone that may well have provided the possibility of registration of an acoustic reflex. It is worth reminding that the data of tympanometry of the examined service members exclude the presence of pathology of the middle ear, which would interfere with

implementation, and therefore registration of ARIM. Consequently, the absence of reflexes in this category of examined can be explained not by the insufficient level of the stimulus (the intensity of the sound stimulus), or problems with middle ear structures, but other factors. At 18,0% of individuals took place asymmetry in amplitude of ARIM, and most of them had a significant reduction of the amplitude from the side of better hearing or normally hearing ear, and in 44,4% of them there were significant reduction in amplitude from poorly-hearing ear. Therefore, in examined patients with acoustic trauma received in a combat zone, violation of the ARIM implementation in many cases does not correlate with the degree of decrease of hearing function according to subjective audiometry. Identified 2% of individuals who had asymmetrical lack of ARIM on the one side, and the decline in hearing thresholds on this side according to the threshold tonal audiometry was small and indicated the presence of mild sensorineural disorders.

With regard to temporal characteristics of ARIM, we also detected changes of these data in the examined servicemen obtained in the zone of operation of allied forces in comparison with the results of the control group, partly of indicators were reliable. So, noteworthy significant ($p < 0,05$) lengthening of the latent period and growth period of ARIM, as well as reducing the validity period in the examined patients with acoustic trauma in comparison to the control group. Similar trends of changes in the temporal characteristics of ARIM observed as under ipsi and contralateral stimulation.

The changes of time indicators of ARIM allows to judge the presence of disorders at different levels of the acoustic reflex as reflex that closes at the level of the brainstem. Obviously, the changes in time characteristics of ARIM in examined patients with acoustic trauma obtained in real combat conditions testify about the presence of disorders in the implementation of protective acoustic reflex, and failure (or the depletion) of compensatory-adaptive mechanisms of the hearing system.

Thus, conducted examination showed that the vast majority of patients (86,0%) with the typical shape of the audiometric curve, which got acoustic trauma in a combat zone, had deviations from the norm according to impedance audiometry, especially of the amplitude and time characteristics of ARIM. At 10,0% cases ARIM were not registered at all (on either side), 4,0% had it from one side. More than half (56,0%) of patients had a reduction in the amplitude of ARIM, and at (16,0%), this decline was significant. This may indicate changes in the hearing system of the affected, who got combat acoustic trauma, including at the level of brainstem structures.

In addition, we revealed that the localization of the more significant violations, according to the impedance did not always coincide with that data of audi-

ometry at conventional and extended frequency ranges, there is a certain dissociation of indicators that can also complement the knowledge about the understanding of the mechanisms of action of acoustic trauma, acoustic baro trauma, blast injury on the hearing system. However, these data requires further research.

Thus, the indicators of impedance audiometry (primarily amplitude and time characteristics of ARIM) can serve as objective criteria for the diagnosis of certain disorders in the hearing system in individuals who got acoustic trauma in a combat zone.

Below is an example of data of audiometry with presentation of the results of subjective audiometry, obtained in the examined by us servicemen with combat acoustic trauma. Participant in the zone of operation of allied forces M., got mine blast injury. According to subjective audiometry there is bilateral sensorineural hearing loss, dysfunction of the sound perception in the area of high frequencies, almost symmetrical, slightly more significant on the left side. The tympanogram of type A is from the both sides. The ARIM on the right side is recorded in full volume with normal amplitude, on the left – ARIM at frequencies of 500; 1000; 2000; 4000 Hz is missing, although the indicators of tonal hearing at these frequencies allow us to obtain the reflex (Pic.6).

Therefore people who got acoustic trauma during combat actions are having violations both in peripheral and central parts of the hearing analyzer according to both subjective and objective methods of examination. The use of objective methods is of great importance in terms of decision of expert questions, definitions, and the objectification of the severity of the disease and evaluation of the effectiveness of therapeutic interventions in these patients.

The indicators of impedance audiometry, otoacoustic emission and hearing evoked potentials may serve as objective indicators of disorders in the hearing system in individuals who got acoustic trauma in a combat zone. The definition of such indicators during the examination will contribute to improving the quality of diagnosis and choice of targeted treatment tactics to these patients. Also, the obtained data will help in studying of the pathogenetic mechanisms of actions of acoustic trauma, acoustic baro trauma, including combat one, on the structure of the hearing analyzer.

Noteworthy is the predominance of bilateral asymmetric lesions of the various parts of the hearing analyzer in patients who got acoustic trauma in the zone of operation of allied forces, which can be traced in almost all the subjective and objective methods of examination. Note that the asymmetry of abnormalities may be characteristic feature of acoustic trauma obtained in real combat conditions. In patients with symmetrical pure tone threshold audiometric curve in conventional range we frequently observed asymmetrical violations according to the speech and

supra-threshold audiometry. But even in the case of the almost complete symmetry of the data in subjective audiometry we subsequently discovered asymmetry changes in different parts of the hearing analyzer according to objective methods of examination of acoustic impedance, otoacoustic emission (OAE) and auditory evoked potentials (AEP). The symmetric disturbances in the central parts of the hearing analyzer according to the AEP, we observed only in isolated cases. Such changes in the central parts of the hearing analyzer were frequently accompanied by asymmetric violations in cerebral circulation and functional state of the CNS according to rheoencephalography and electroencephalography, respectively. Violations in the vestibular system were often asymmetric. Note that the asymmetry of violations in different levels of the complex functional systems, which include hearing and vestibular analyzer, creates additional difficulties for their functioning, leading to excessive strain of the processes and efforts for balancing activities and determine additional reasons for the development of dysfunction. The presence of a high percentage of cases of asymmetric lesions of the hearing system in servicemen with acoustic trauma obtained in real combat conditions, may be explained by several factors. For example, an asymmetric lesion occurs while using the weapons by servicemen. Then more destruction takes place from the location of weapons (gun, grenade, mortar, etc..) Therefore, grenade launchers using the RPG have more severe violation on the left side. The asymmetric (one-sided) lesions may be due to the fact that the shock wave affected suffered from the site of the explosion and being affected to the traumatic effect of sound and pressure mainly from one side. In tankers and crews of infantry fighting vehicles, armored personnel carriers the severity of damage depends on the circumstances of the hit, the type of ammunition and the tightness of the internal space. If all the hatches are fully closed, lesions of the hearing system are more significant.

The conducted study demonstrates the advisability of the examination by method of OAE and AEP, as well as impedance audiometry, first of all registration of ARIM in patients with acoustic trauma got in real combat conditions. The use of objective methods is of great importance in terms of topical diagnosis, the decision of expert questions, definitions and the objectification of the severity of the disease in patients with combat acoustic trauma and in conducting of therapeutic and preventive measures. Recording of data of objective methods of complex audiological examination allows reliably, in detail and fully diagnose disorders in different parts of the hearing analyzer, contribute to a focused prescription of complex treatment in servicemen with acoustic trauma got in real combat conditions, which increases its effectiveness. This will allow to prevent the progression of hearing loss and the formation of heavy SHL in this category of patients.

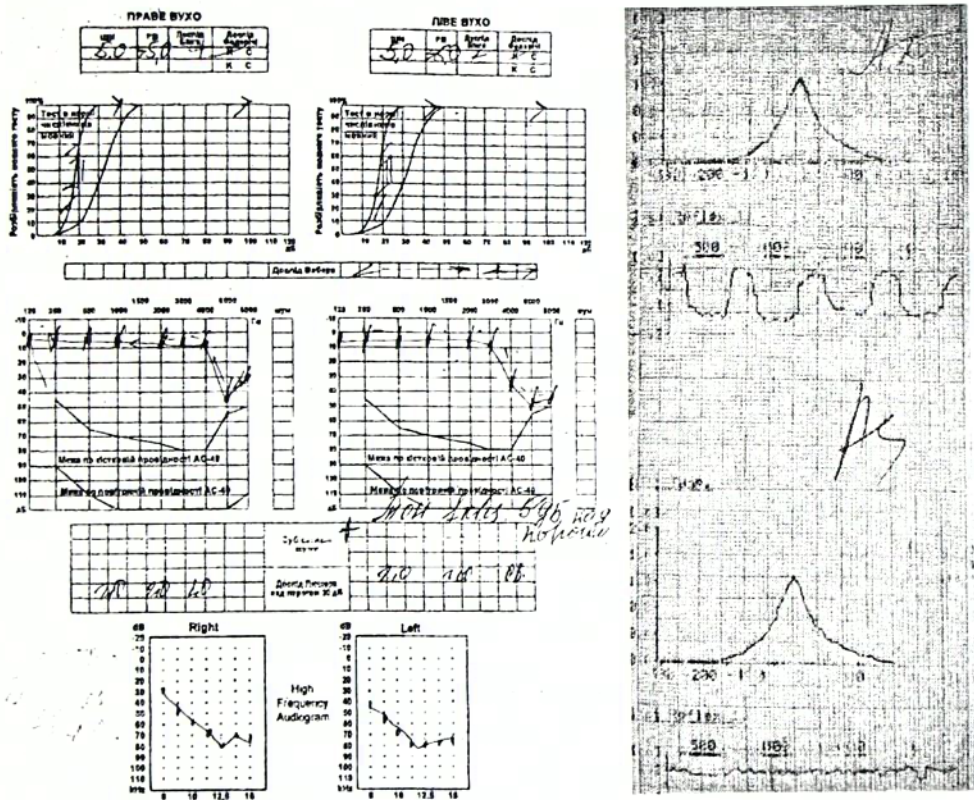


Fig. 6. Data of subjective audiometry and acoustic impedance in patient M. with combat acoustic trauma.

In the diagnosis of sensorineural hearing loss it is important to examine the condition of those organs and systems that affect the state of the hearing analyzer (especially the state of the cerebral circulation and functional state of the CNS) to evaluate the so-called extraaural symptoms. For targeted treatment of SHL such data is especially important.

Everyone who dealt with the problems of providing help to affected in the zone of operation of allied forces, in different medical specialties, have paid attention to the significant violations in the functional state of CNS in individuals who got acoustic trauma in real combat conditions that necessitated the correction of such changes and involved treatment from the relevant specialists – neurologists, psychiatrists, psychologists. These patients often have disorders of adaptation, PTSD, acute stress reaction and other violations. This situation can be explained by extremely stressful situation, which makes the presence in suffered the lesions

of the psyche, central nervous system, sensory systems, including the central parts of the hearing analyzer.

We evaluated the functional state of the CNS in patients with acoustic trauma who were in a combat zone using an objective method of electroencephalography (EEG) and found significant violations of the bioelectrical activity of the brain expressed in different degrees in all patients. Electroencephalography is a reliable, universal, objective, non-invasive method of examination of the functional state of the CNS, based on registration of biopotentials of a brain with background recording (at rest) and using different functional loads.

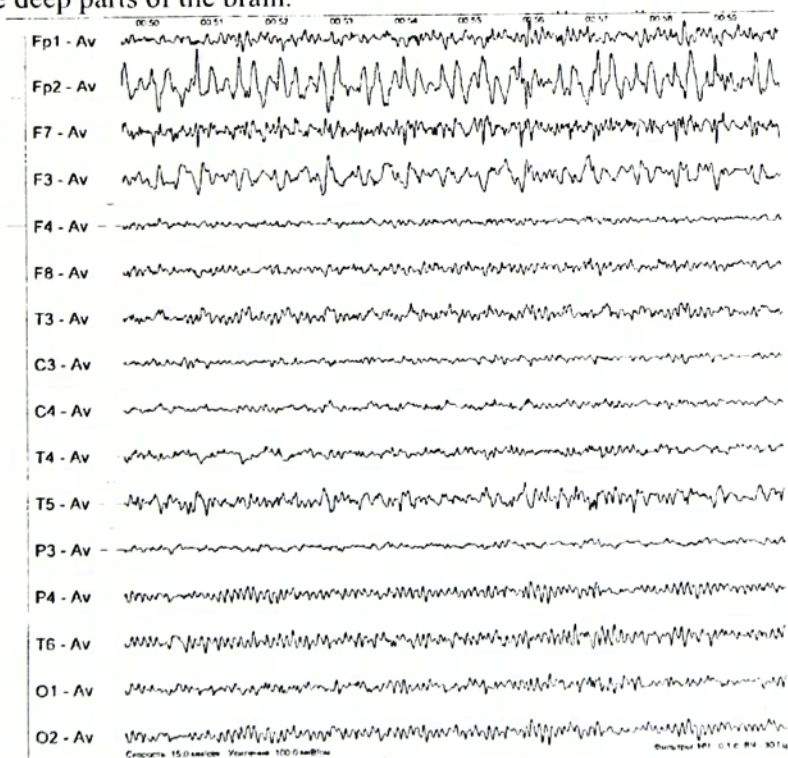
According to the EEG of the examined servicemen with acoustic trauma got during the combat action, were discovered irritational changes, as in the background sample, as at functional loads, especially hyperventilation, expressed in varying degrees. The most often have been identified: expressed disorganization and desynchronization of the rhythms, the tendency to smoothing or lack of zonal differences, the presence of sharp peaks and potentials, «acceleration» of the basic rhythms, the prevalence in the structure of the bioelectrical activity of beta-rhythm and a significant proportion of theta rhythm. In some patients there was an overall decrease in the bioelectric activity of the brain, expressed in varying degrees, especially in the temporal leads. These changes were primarily of totally-brain (generalized) character and were more significant in patients with more significant impairments in the hearing analyzer. In many cases, there were observed asymmetry of biotoks, mainly in backforehead, temporal and uphead leads, especially in cases when the patients had asymmetrical lesions of the hearing system with a significant difference in indexes of both parts. Also often in the examined individuals with combat acoustic trauma were observed outbreaks of hypersynchronous activity, including slow-waves elements, indicating a significant predominance of processes of excitation in the deep brain structures. In some of them were detected even post-traumatic epileptiform symptoms, such patients were treated under the supervision of a neurologist. In general, in all of the examined servicemen with acoustic trauma dominated the excitation processes, which is necessary to consider when assigning treatment.

The significant number of patients with acoustic trauma got in a zone of combat actions had irritation of cortical, diencephalic, diencephalico-brainstem and medio-basal structures of the brain. So disorders of cortical activity predominantly in the frontal, temporal and central leads were observed in 100% of patients. Significant signs of irritation of diencephalic brain structures, according to our data, were at 75,5% of patients with acoustic trauma obtained in the zone of operation of allied forces, diencephalico-brainstem – at 30,4%, and medio-basal – 11,9%.

We present for example, the variant pattern of EEG that was found by us in a patient with combat acoustic trauma.

On pic.7 is shown the background recording of EEG of the serviceman with acoustic baro trauma and severe concussion. There is observed significant irritation of the cortical and attraction of the mediobasal structures of the brain. The rhythms are disorganized, asymmetric and relatively disorganized slow wave activity in back-templates, occipital and parietal leads, more significant on the right. The record shows high-amplitude slow-waves activity in anterior regions of the brain, expressive asymmetry in almost all leads. There are signs of epileptiform activity, especially in frontal and temporal leads on the right.

Therefore, in examined individuals with acoustic trauma that were obtained in the zone of operation of allied forces were observed significant changes of the bioelectric activity of the brain primarily of irritative character with involvement of the deep parts of the brain.



Pic. 7. Background recording of EEG in serviceman with acoustic trauma got in real combat conditions.

The acoustic analyzer is very sensitive to vascular disorders, therefore assessment of changes in cerebral circulation is of great importance for the diagnosis and treatment of SHL of various origins. We evaluated the cerebral hemodynamics in patients with acoustic trauma that were in the area of combat actions, using the

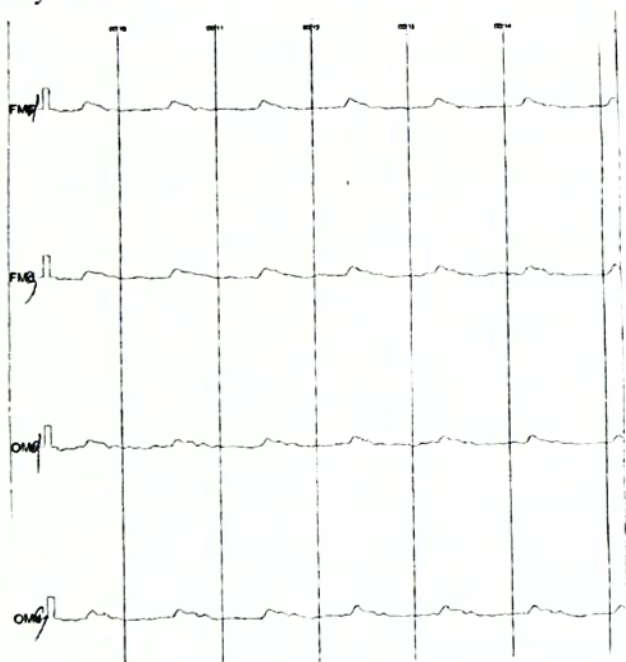
method of reoencephalography (REG) and ultrasound dopplerography (UD) of vessels of head and neck which is an objective methodology that allows to evaluate in full volume the functional state of hemodynamics of the brain.

Among the features of the state of cerebral circulation in patients with combat acoustic trauma is possible to distinguish cases of decrease of pulse blood filling in 72,1% of cases. Moreover, this decline occurred frequently in all standard leads (FM and OM), not only in the vertebrobasilar system, as it is often found in the SHL. We also observed a huge number of cases of decline of the vascular tone. Note that among all patients with any type of SHL, the percentage of such cases (decreased tone of cerebral vessels) is extremely low. But in 46,8% of cases in patients with combat acoustic trauma we observed unstable vascular tone with a tendency to its reduction, and in 9,4% cases the low one. There were frequent cases of atonic curve (18,3%). Often, in examined patients took place an expressed in considerable degree the obstruction of the venous outflow, especially in the vertebral-basilar pool (83,3%). Only in 24,1% of the examined servicemen of combat actions' zone, we observed increased tone of cerebral vessels, in 10,2% – with symptoms of vasospasm. Many of the examined servicemen with combat acoustic trauma had a sharp decrease in pulse blood filling, especially in the vertebral-basilar system (73,1%).

Previously, we carried out a study on cerebral hemodynamic violations in patients with acoustic trauma [7]. We have found significant violations of cerebral circulation according to REG in examined patients. In 17,9% of the cases of examined patients with acoustic trauma vascular tone was intermittent, sometimes with a tendency to decline, which distinguishes this group from patients with other forms of SHL of noise genesis. We have found that hemodynamic impairment of cerebral circulation and changes in the hearing analyzer in patients with acoustic trauma went parallel and can be the basis for the development of hearing disorders with acoustic trauma. We made the assumption that a weak tone of cerebral vessels may be the characteristic feature of extraaural changes with acoustic trauma. It should be noted that patients with combat acoustic trauma significantly more likely to have the phenomenon of unstable vascular tone, and it's decrease. In patients with acoustic trauma that was got during the combat actions, the number of patients with unstable vascular tone were 56,9%, with a downward trend 46,8% of cases, with a low – 9,4%.

Analysis of quantitative indicators of REG of servicemen with combat acoustic trauma revealed significant ($P < 0,05$; $P < 0,01$) compared with the control group (K) changes in the indicators α , β , DCI, DSI, Pi, which indicates about changes of the tone of cerebral vessels, obstruction of the venous outflow and a decrease in pulse blood filling, as in carotid and as in vertebrobasilar systems.

On pic. 8 is shows the entry of REG of patient with acoustic trauma obtained obtained in the zone of operation of allied forces. There can be seen a sharp decrease in pulse blood vessels in the carotid, and especially in vertebro-basilar system of cerebral circulation, significant obstruction of the venous outflow in the vertebro-basilar system.



Pic. 8. Record of REG in patient with combat acoustic trauma

We conducted a detailed analysis of qualitative and quantitative characteristic of REG in 50 servicemen with acoustic trauma obtained in actual combat conditions, with typical impairment of the hearing function, the most typical forms of audiometric curves (descending) and degree of severity of sensorineural hearing loss (at frequencies of 4, 6 and 8 kHz the values of the average hearing thresholds for tones were $(35,34 \pm 4,82)$, $(40,48 \pm 3,92)$ and $(49,84 \pm 3,85)$ dB, respectively). In the qualitative assessment of reograms in patients were identified circulatory disorders of the brain in carotid (FM) and vertebro-basilar (OM) systems. The normal indicators of cerebral circulation according to REG were not recorded in no one of with acoustic trauma. Only 4,0% of the examined servicemen who was in the zone of operation of allied forces in this group had a spasm of cerebral vessels. The difficulty of the venous outflow occurred in 90,0% of cases in carotid system and in 100,0% in the vertebrobasilar. Among the examined patients, we have also often the decreased tone of cerebral vessels (30,0%), cases of atonic

curve (22,0%). The significant was the part of patients with unstable vascular tone with its reduction (58,0%) in both systems of cerebral circulation. With regard to pulse blood filling, in patients with acoustic trauma had recorded (66,0%) of cases of decreased tone in carotid system and (84,0%) in the vertebro-basilar pool. In the vertebrobasilar system, service members with acoustic trauma also had asymmetry of REG – curves (up 8,0%). As has already been noted, examined patients had changes of tone of cerebral vessels and obstruction of the venous outflow and decrease in pulse blood filling, as in carotid and vertebrobasilar systems that have been reflected in quantitative indicators of REG. This was evidenced by a significant increase of diastolic (DCI) and diastolic (DSI) indices of REG-curve in carotid system ($57,20 \pm 2,2$)% ($t=2,26$, $P<0,05$) as the norm was – ($51,4 \pm 1,3$)% and ($63,05 \pm 0,70$)% ($t=1,96$, $P<0,05$) as the norm was – ($59,3 \pm 1,8$)%, respectively. In the vertebro-basilar system the corresponding values were: DCI – ($57,9 \pm 2,5$)% ($t=2,33$, $P<0,05$) as the norm was – ($51,2 \pm 1,4$)%, DSI – ($65,58 \pm 0,87$)% ($t=1,96$; $P<0,05$) with the norm ($61,20 \pm 2,08$)%. The reography index (Pi) in many patients with acoustic trauma who obtained in the zone of operation of allied forces, was reduced, especially in the vertebrobasilar system. So, the average value of Pi in carotid system was significantly less than normal and was ($0,75 \pm 0,02$) ($t=12,00$, $P<0,01$) as the norm was – ($1,21 \pm 0,03$); and in vertebro-basilar – ($0,63 \pm 0,02$) ($t=13,72$, $P<0,01$) as the norm was – ($1,19 \pm 0,03$). This indicates about reduced blood filling of brain vessels in the examined service members with acoustic trauma received in a combat zone, especially in the vertebrobasilar system.

Therefore, examined patients with acoustic trauma got in real combat conditions, had significant changes in cerebral circulation, especially in the vertebrobasilar pool, which have certain characteristics that must be considered during the treatment of these patients. Mainly was found the violation of the tone of cerebral vessels (increased tone, presence of spasm, unstable tone, decreased tone and atonic curves), venous outflow (obstruction of varying severity) and pulse blood (a decrease, sometimes sharp), which is confirmed by significant ($P<0,05$; $P<0,01$) changes in quantitative indicators REG (MTI, DSI, Pi). Moreover, among the examined individuals in considerable part were the cases with unstable or low tone of cerebral vessels, in contrast to other observations of sensorineural hearing disorders of various genesis.

Here is an example of the relationships of aural and extraaural changes according to the different methods of the examination of the servicemen with acoustic trauma. Thus, in pic. 9-11 are presented the results of the examination of National guard serviceman M. On the audiogram we see asymmetric hearing impairment – increased hearing thresholds from the left to the tones in the field (4-8 kHz), the decrease of DT by Luscher in the region of 4 kHz on the left, subjective

ear noise on the left. Also, the patient had asymmetric changes in REG (low tone cerebral vessels, reduction of pulse blood on the left in the vertebral-basilar system) and EEG (expressed irritative changes, asymmetry of biotoks in back-tempel and occipital leads, rhythms were disorganized with the presence of theta waves and sharp potentials).

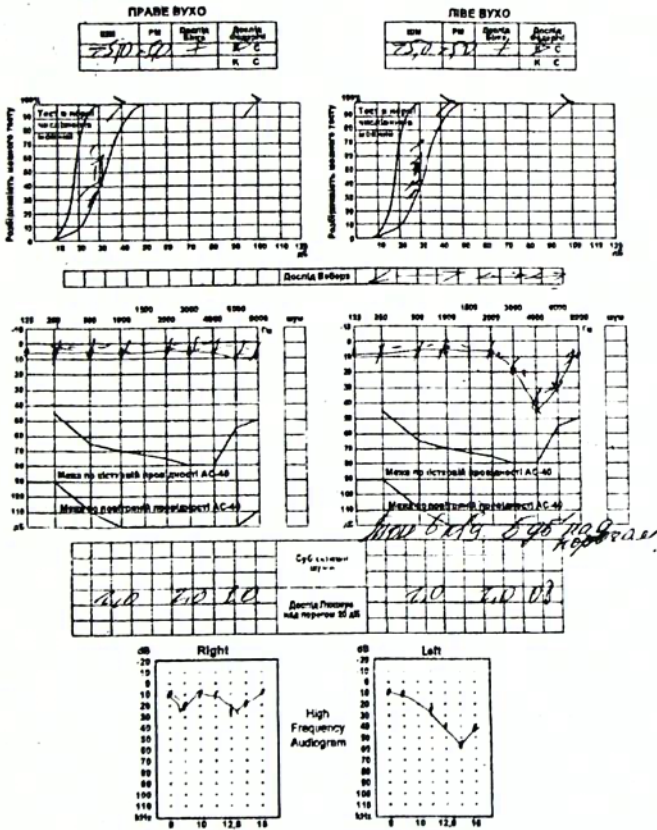
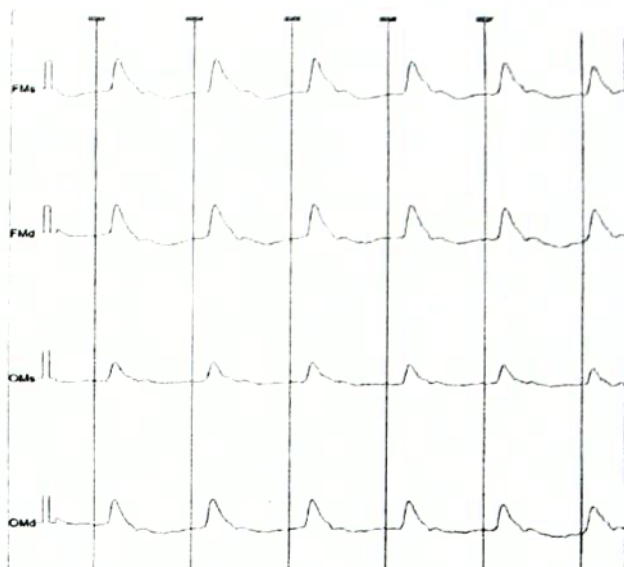
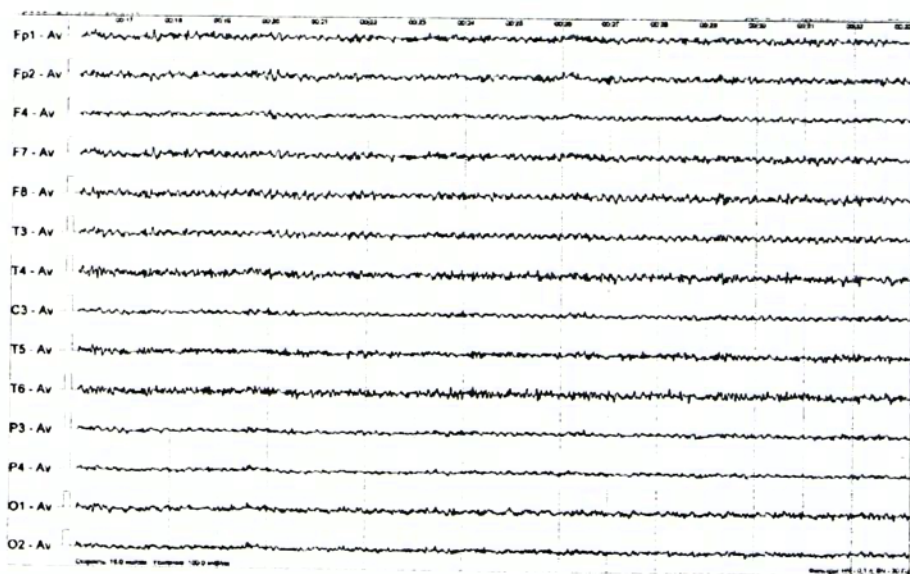


Fig. 9. Subjective audiometry of the patient M.

Thus, in complex examination of servicemen with combat acoustic trauma for a detailed assessment of extraaural violations, it is useful to study cerebral hemodynamics and functional state of the CNS. Patients with acoustic trauma got in the area of the combat actions, had significant extraaural disorders, especially in CNS and cerebral blood flow that determines the approaches to the treatment of such patients. Accounting the data of a complex instrumental examination allows to assess extraaural violations, contribute to a focused appointment of complex treatment to patients with combat acoustic trauma that increases its efficiency.



Pic. 10. The REG entry of the patient M.



Pic. 11. EEG picture of a serviceman M.

The analysis of the results of complex detailed instrumental examination allowed us to determine the most informative manifestations (signs) of aural and extraaural changes in acoustic trauma and then to form a list of the most significant diagnostic markers to determine the severity of disease, prognosis and evaluation

of treatment effectiveness of patients with acoustic trauma obtained in real combat conditions.

So, features of acoustic baro traumatic lesion of the hearing analyzer in real combat conditions are:

1. The complaints on hearing loss, subjective tinnitus, especially of high frequency; stunning, congestion and pain in the ears after acoustic trauma, poor tolerance of loud sounds; dizziness, imbalance; headache, heaviness in the head, sleep disturbance.

2. The descending often – precipitous type of tone threshold audiometric curve, with the maximum increase of hearing thresholds for tones in the region of 4-8 kHz. Some kind of a peak increase of thresholds at a frequency of 4 or 6 kHz, followed by some decline in the region of 8 kHz – typical «acoustic traumatic peak». Quite often the characteristic «peaks» increase of hearing thresholds are observed not only in conventional but also in the extended frequency range. Many patients with acoustic trauma (approximately one third) of the observed have “breaks” the perception of tones in the conventional range of frequencies, usually on tones 4 and 6 kHz, but sometimes even starting from 2-3 kHz. The “breaks” can also be observed on high frequency tones in over half of cases of all patients who underwent threshold tonal audiometry in an extended frequency range.

3. The violations in receptor part of the hearing analyzer takes place in about 80% of cases according to both objective and subjective methods of examination. And quite often they have the reversible character and function can be restored or improved with timely targeted treatment.

4. The reduction (including relative) DT method Luscher at a frequency of 4 kHz.

5. We also observed cases of a certain mismatch of tonal hearing and discomfort manifestations, PAGL (the phenomenon of accelerated growth of loudness). The service members with a slight impairment of the hearing function, noted the discomfort when the intensity of the stimulus increases, including the speech, complained on poor tolerance of loud noises, discomfort in the perception of loud speech. The servicemen with acoustic trauma had discomfort in the perception of speech test that may be registered with an intensity of stimulus 70-80 dB. The attention should also be paid on the complaints of service members with acoustic trauma on the periodic violation of the intelligibility of speech.

6. The quick involvement in process the central parts of the hearing analyzer or the primary lesion of the central structures of the hearing system (almost 100%). According to the registration of auditory evoked potentials (AEP) in patients with acoustic trauma got in real combat conditions, objectively confirmed the existence of irregularities in the central parts of the hearing analyzer – observed disorders of

functioning in cortex, subcortex, and brain stem structures of the hearing analyzer, including deep brain structures. Noteworthy is that almost all of the examined by us servicemen with acoustic trauma who were in a combat zone have the changes of LPP of "late" LLAEP components (P_2 and N_2). This may indicate changes in the limbic structures of the brain, the structures of the reticular formation, which are "responsible" for intracerebral communication, ensuring communication and coordinated work of various sections and parts of the brain, the perception of information from sensory systems, and violations of mechanisms of realization of complex functions, including the so-called "watchdog reflexes" and stress reactions in these patients.

7. The acoustic trauma received in combat conditions, can manifest disorders in the central parts of the hearing analyzer and in case of slight disorders of hearing function according to subjective audiometry. The expressed disorders in the central parts of the hearing analyzer, especially of brain stem, in servicemen with acoustic trauma obtained in the zone of operation of allied forces is an unfavourable sign and may indicate an aptitude for progression. These patients are very difficult for the treatment.

8. The violations according to the data of AEP manifest themselves in changes of the complex peaks (their smoothness, additional waves, a decrease or increase in amplitude) as well as elongation of time characteristics (latent periods of peaks (LPP) waves II, III, V SLAEP; P_2 and N_2 LLAEP; interpeak intervals (IPI) I-III and I-V SLEP). AEP data is often asymmetric.

9. The reversible (recoverable) violations of the receptor part of the hearing analyzer according to the OAE – if assistance is timely targeted it is often allow to restore registration of DOAE. Often there is a "dissociation" of data OAE and tonal audiometry – more often the response of the OAE are recorded at frequencies 4 and 6 kHz, with the lack of response at lower frequencies, while according to subjective audiometry on these frequencies (4 and 6 kHz) is observed the most significant reduction in hearing sensitivity.

10. In the overwhelming number of cases – about 80% – in patients with combat acoustic trauma disorders in hearing system are asymmetric. Even with a nearly symmetrical disorders of hearing function according to the tonal threshold audiometry are observed asymmetric violations according to the data of speech and subthreshold audiometry, asymmetric disorders in various structures of the hearing analyzer according to the acoustic impedance, OAE and AEP, as well as asymmetric violations in cerebral circulation and functional state of the CNS according to rheoencephalography and electroencephalography.

11. Unlike other cases of SHL in patients with combat acoustic trauma most lesions of the hearing system occur with normal or reduced AP, VSD (unstable AP), increase in AP is observed rarely.

12. The obvious violations of the functional state of the cerebral circulation. A significant percentage of unstable and decreased tone of the cerebral vessels, the presence of atonic curve according to REG. Almost all patients have the difficulty of the venous outflow and a decrease in pulse blood filling both in carotid and vertebral-basilar systems of cerebral circulation.

13. Violations of the functional state of the CNS, changes in the bioelectric activity of the brain. Significant violations of irritative character according to the EEG, hypersynchronic bursts, often – epileptiform post-traumatic changes. Many of the affected are having the desynchronization and disorganization of the basic rhythms, smoothed zonal differences, the increase in the content of slow-waves activity, especially theta rhythm in the anterior projections. Many patients have signs of involvement of diencephalon- brain stem and mediobasal structures of the brain.

If to systematize the obtained data of complex clinical and instrumental studies in the form of a table, it seems appropriate to us to note the following diagnostic characters (Appendix, tab. 1). If highlight the main specific «markers» – the most typical qualitative and quantitative parameters according to subjective and objective methods of examination of patients with combat acoustic trauma, monitoring of which allows to determine the effectiveness of therapeutic and preventive measures and solution of a number of expert questions, then the list looks like this (Appendix, tab. 2).

In our opinion, it is advisable to assess the presence and degree of sensorineural hearing loss in affected in the combat zone even in case of absence of complaints of hearing loss -demonstrative can also be complaints on noise and tinnitus in the ears, stuffiness of the ears, poor tolerance loud sounds, etc. You should consider the possibility of the lesion of the hearing system in case of injury, polytrauma, when firstly deal with the issues of general surgery. But at least a preliminary identification of those which may have violations of hearing , will allow to assign targeted treatment as soon as possible. And some measures, may be expedient to apply in parallel with the main treatment priority. Sometimes even easy, simple to follow, but targeted measures on early stages of development of acoustic traumatic lesion of the hearing analyzer could prevent severe irreversible changes in the hearing system. Yes, of course, at first it is necessary to save lives, and hearing loss are not dangerous for life, but then progressing SHL significantly affects the quality of people's lives.

Maybe it will be expedient during the “lull” period to provide for filling the questionnaires for personnel to identify risk groups and further examination. Further, where possible, should be determined the contingent with the possible lesion of the hearing system – sensorineural (perceiving), conductive or combined disorders of hearing function.

In our opinion, the number of affected with combat acoustic trauma are actually much more than that appears in official statistics. However, they remain outside the attention of the medical service because it was not accented effort on detection of this pathology, on the other hand, patients themselves do not notice the first manifestations of the disease sufficiently.

Inattention to the violations of hearing with acoustic trauma takes place because of the fact that it isn't life threatening, and as acoustic trauma isn't recognized as one of the major professional pathology among servicemen. There aren't no social benefits in this contingent for disability due to the serious hearing loss. The disability of hearing is considered with significant loss of hearing function, almost complete deafness. Usually by this time the service members is dismissed from service. However, the quality of life suffers. These patients often have subjective ear noise (painful feeling, at times unbearable), the violation of intelligibility of speech, the phenomenon PAGL (low tolerance to loud noises, discomfort until the pain sensations in response to sounds of even of not very high intensity), which contributes to the disorders of emotional state, violates the social adaptation and professional correspondence. PTSD creates a very serious state of the affected if combined with neurological and psychological disorders.

In our opinion, obligatory testing of hearing function (possibly delayed) need patients with acoustic trauma obtained in real combat conditions:

1. Everyone who received a “concussion”, brain injury get injured on the head.
2. Affected with complaints on hearing loss and subjective ear noise, poor tolerance of loud sounds, periodic stuffiness in the ears, dizziness; prolonged and significant stun, stuffiness in the ears, strong noise, tinnitus, headache after acoustic trauma.

Difficulties in the diagnostics and treatment of the acoustic trauma:

1. The attention is rarely timely paid on violations in hearing system with acoustic trauma in real combat condition. The medical staff do not have a focus on identifying such group of risk. The service members did not immediately ask for help, expecting until it will pass by itself. Often patients seek for help after repeated acoustic trauma. This disease is not life threatening, so attention for it paid at last. The command staff rarely consider acoustic trauma as a serious injury,

so service members are not provided with reference about the incident. Mainly in references the acoustic trauma indicated and when there was a contusion (although this diagnosis is not always correctly installed) or mine- explosive trauma.

2. The disorders in the hearing system are hard to detect by eye. Practically, it is possible to see (not always) only a discharge of blood, fluid from the auditory canal with rupture of the eardrum. To verify this examination by otorhinolaryngologist specialist (and this is a level 3 of medical aid) is required. Sensorineural disorders of hearing function is impossible to determine by external examination. They are detectible only by instrumental examination. Practically, on early stages you can focus only on characteristic complaints, data of anamnesis (that is why we have developed a questionnaire), the study of hearing by live speech (acoustimetry)

3. The irreversible changes in the structures of the hearing analyzer is developing quite quickly with acoustic trauma. The process involved as receptor as central parts of the hearing analyzer. Patients often have discomfort in the perception of sounds and speech, tinnitus, dizziness, impairment of balance, which influenced greatly on the quality of life.

4. The treatment of sensorineural disorders of hearing function with acoustic trauma (as with other perceptual disturbances) cannot be the same for all patients. It is necessary to consider at least the basic characteristics that creates certain fork for treatment – already on second stage. The effectiveness of the treatment largely depends on the accuracy of assignments, reasonability and commitment of therapy. It is desirable to have instrumental control over the efficiency and adjust treatment individually during the process. This can be done only on stage 3. The best efficiency is achieved when there is a full examination with the integrated individually selected treatment. So, for patients with acoustic trauma the optimal level for treatment is 3-4 level of medical aid (at least a detailed examination, precise diagnosis and treatment, and the treatment itself can be prescribed at lower levels).

5. Unfortunately, sensorineural violations of hearing with acoustic trauma are very difficult for treatment. Sometimes it is only possible to stop the progression of the disease, alleviate unpleasant symptoms.

6. Many patients with combat acoustic trauma also have associated traumatic lesions of the musculoskeletal apparatus, shrapnel wounds, CCT (craniocerebral trauma) and other injuries, and therefore first and foremost they need to have treatment by experts of other profiles that should be considered in the treatment by otolaryngologist.

The cases when patients did not pay attention to the violations of hearing function and noted it only after some time – in some cases are very frequent. It is happened because the injuries were severe and at first, it was “not actual”. The

hearing loss was firstly not significant, but over time it progressed and became noticeable only after some time, when the violations extended even to the “language” frequency, evolved phenomenon PAGL, the violations of intelligibility, increased subjective ear noise, et cetera. Unfortunately, the precious time got lost.

An important factor in terms of warnings of severe hearing loss due to combat acoustic trauma is the identification of groups of “risk”.

No less relevant when providing medical care to patients with acoustic trauma obtained in actual combat conditions, there are issues of expertise. The sensorineural disorders of the hearing analyzer in combat acoustic baro trauma prone to progression, so it is necessary to carry out the examination of such patients in time. On the basis of the complex research we can detect individuals, who have prognostically unfavourable course or progression of the disease in case of repeated acoustic trauma. We determined on the basis of the analysis of complex instrumental examination of patients with acoustic trauma obtained in real combat conditions, certain characteristic features of changes in various structures of the hearing analyzer, which can be used as criteria for prediction, detecting of severity, expertise, examination of sensorineural disorders of hearing function in these patients (see table. 2).

An important issue is the determination of the contingent of the persons with acoustic trauma, where the prognosis is adverse in terms of progression of disorders of hearing function and for whom further contact with the sounds of high intensity are contraindicated. Note that in this regard, is extremely important to appreciate PRIV and their severity in this contingent. With the presence of such signs, it is contraindicated for such patients being in the noise environment and in contact with the sounds of high intensity, because it leads to rapid progression and development of severe, irreversible damages of the hearing analyzer, especially its receptor part. Such patients during treatment need the regime of silence. Service members with acoustic traumatic injury of the hearing analyzer and the presence of such manifestations, considerable lesion of the receptor of the part of the hearing analyzer reads in detentions “antitestimony contact with the sounds of high intensity”. We believe that the future direction those in real combat conditions can lead to severe hearing loss and even deafness as a result of repeated acoustic baro trauma.

It is necessary to remember that with acoustic trauma in real combat conditions violations occur not only in the hearing system (aural changes), but also in other organs and systems, state of which has a direct impact on the hearing analyzer – the so-called extraaural changes. This concerns primarily the cardiovascular and central nervous systems. Often the severity of extraaural changes determines the prognosis of the disease and the severity of patients condition.

Therefore, persons with acoustic trauma who suffered in the zone of the combat action, have violations both in peripheral and in central parts of the hearing analyzer, as well as significant extraaural changes that are confirmed by objective methods of examination that requires consideration during their treatment. The conducted study demonstrates the feasibility of the examination by method of registration of the OAE, SHL and ARIM, as well as EEG and REG in patients with acoustic trauma who were in the combat zone. The use of objective methods is of great importance in terms of topical and differential diagnosis of hearing disorders, determining the presence and severity of extraaural manifestations, the decision of expert questions, definitions and the objectification of the severity of course of the disease in patients with combat acoustic trauma, its forecasting, and also conducting the preventive measures and evaluating their effectiveness.

So, sensorineural hearing loss in combat acoustic trauma have a number of characteristic features of aural and extraaural manifestations according to subjective and objective methods of examination that can be used in the differential diagnosis and for decision of expert questions. There are abnormalities in receptor and in central parts of the hearing analyzer. The most informative methods for assessment of various structures of hearing analyzer in patients with acoustic trauma got in combat zone is subjective audiometry in full volume (required DT method Luscher, speech audiometry, determination of the subjective characteristics of noise, preferably high-frequency audiometry), registration of auditory evoked potentials AEP (short – and longlatent), registration of DPOAE. The most informative methods for determining extraaural manifestations in patients with acoustic trauma obtained in real combat conditions, is rheoencephalography (REG) and electroencephalography (EEG), which allow to estimate the functional state of cerebral hemodynamics and bioelectric activity of the brain, respectively.

The use of objective methods in patients with acoustic trauma get in real combat conditions is of great importance in terms of topical and differential diagnosis of sensorineural disorders of hearing function, definition and objectification of severity of disease, its prognosis, decision of expert questions, as well as evaluation of the effectiveness of therapeutic and preventive measures.

A full diagnosis of sensorineural disorders of hearing function with acoustic trauma get in real combat conditions can be carried out only on 3 and 4 levels of medical care, so these patients should be directed at the highest levels at once.

Treatment of sensorineural hearing violations is a difficult task for medical science not only in Ukraine but all over the world. Its effectiveness, unfortunately, is not always sufficient. Considering the diversity of manifestations of sensorineural hearing loss (SHL), as aural (on the part of the hearing system), and extraaural (not associated directly with the structures of the hearing system), the treatment

of such diseases should be complex, taking into account the results of audiological and additional methods of examination ensuring an individual approach. It is known that perceptual hearing loss especially severely expressed are very difficult to treat. However, early diagnosis and timely application of preventive and curative measures in many cases can prevent the development of severe forms of sensorineural hearing loss.

In our belief, the treatment of SHL of any genesis, including acoustic trauma requires a complex approach and individualization of treatment plan. The lesions of hearing system and extraaural manifestations with SHL, due to acoustic trauma get in real combat conditions, have certain characteristic features that must be considered when implementing preventive measures.

While developing the approaches of treatment the patients with combat acoustic trauma we took into account the results of complex clinical and instrumental studies. It's important to consider aural and extraaural manifestations, the results of both subjective and objective methods of examination and evaluation by the patient their own health condition. Patients with acoustic trauma who were in a combat zone have significant extraaural violations, especially from the vestibular system, central nervous system and cerebral circulation, which determines approaches to the treatment of such patients.

Taking into account the data of different methods of complex examination allows reliably, in detail and completely to diagnose the disorders in different parts of the hearing analyzer and to assess the severity of extraaural manifestations, contribute to a focused appointment of complex treatment to patients with combat acoustic trauma that increases its efficiency. The proposed by us approaches to the treatment of SHL obtained in the zone of operation of allied forces based on the analysis of possibly complete diagnostic data. The proposed method allows to obtain a positive effect in many cases [8]. Accounting aural and extraaural changes according to complex instrumental examination determines the choice of treatment for sensorineural hearing loss in combat acoustic trauma.

Note that the examined patients that got acoustic trauma in a combat zone, is often had repeated acoustic trauma and they came to us for examination after repeated damaging effects of noises of high intensity. We cannot exclude, in this case, the ability to "overlay" effect from each of the following acoustic trauma, which leads to substantial lesions of structures of hearing analyzer and expressed extraaural symptoms. Such cases are definitely much more difficult for treatment.

The damage of the hearing analyzer with acoustic trauma caused during the combat actions often causes irreversible hearing loss. However, the treatment started within the first hours or days after injury, promotes recovery of hearing function. The certain actions can be carried out even with a minimal set of medi-

cines. There may be simple but purposeful steps that will not solve the problem, but will improve the situation, will prevent a significant lesion of hearing analyzer and create opportunities for further targeted specialized treatment on subsequent stages of medical aid for the affected. The timely and targeted aid can improve its effectiveness and avoid significant violations of hearing function and disability of patients in future.

In the complex treatment of the sensorineural hearing loss in persons who get acoustic trauma in the zone of combat operations group of drugs are used that directly or indirectly affect the state of the hearing analyzer, central nervous and cardiovascular systems, as well as the vestibular analyzer. First, these are nootropics, cardiovascular and drugs of metabolic action. However, there are certain features for their application. For example, in acute period of the disease the use of nootropics is often generally contraindicated and in the future the using of it is expediently in small doses; antispasmodic drugs should be administered with caution because of the risk of bleeding, etc.

The proposed steps of drug therapy used for the treatment of patients with sensorineural violations of hearing due to acoustic trauma get in actual combat conditions, are presented in details and systematically in table.3 (Annex).

Note that often patients come for special examinations after the end of treatment by other specialists, when in fact attention was drawn to a reduction in hearing functions. This greatly affects the effectiveness of the treatment of acoustic traumatic lesions of hearing system, because time got lost and irreversible changes are developing in the structures of hearing analyzer.

The first, of course, there are measures for providing aid for the wound which are dangerous to life. They require management of shock, stop bleeding, urgent surgical care, etc. These activities are determined by the nature and severity of the lesions and are provided by specialists at appropriate stages. Further, where possible, the contingent with possible lesions of auditory system should be determined. The determination of the presence of sensorineural (percepting), conductive or combined disorders of hearing function is carried out using the maximally possible methods of examination at this stage of providing help. We consider the issue of treatment of specifically sensorineural hearing loss associated with acoustic trauma among people who have been in the area of combat actions. It is important to divide all the efforts in providing assistance on various stages.

The stages of providing medical assistance for the servicemen has its own logic, features and clear sequence [2, 3].

The acoustic trauma is not life threatening. Therefore, the majority of preventive measures are the deferred aid (when sorting the labeling is in green). However, for a complete diagnosis and pathogenetically grounded treatment is necessary

instrumental examinations, since treatment has certain peculiarities depending on the detected changes and cannot be completely unified. On early stages, some assistance can be provided for the stabilization and prevention of complications. Consequently, the affected should be directed to the highest level for an adequate examinations and determination of remedial measures as soon as possible.

It should be noted that patients with significant damage of structures of the middle ear and vestibular apparatus (and therefore with the impact of acoustic baro trauma) have certain limitations in terms of emergency events. So, they should be transported in the horizontal position, because during the evacuation on the aircraft at high altitude may develop complications, during the take off/landing is necessary to ensure the nasal passages (nasal breathing satisfactory), to make a swallowing movement to improve the function of hearing tube. For some patients with severe vestibular dysfunction before the flight is advisable to appoint antiemetic drugs, antispasmodics, medicine for motion sickness. So, there are certain indications/contraindications for evacuation by air transport for patients with considerable acoustic baro trauma. During the evacuation by ground transport, it is desirable to provide the maximally possible state of rest – with the sharp movements motion sickness is possible, as well as the stimulation of the labyrinth.

The treatment of sensorineural disorders of hearing function with combat acoustic trauma has a number of features and complexities. Therefore, the treatment of SHH with acoustic trauma (as with other perceptual violations) may not be the same for all patients. It is necessary to consider at least the basic characteristics that create certain forks for the way of treatment – already on early stages. The effectiveness of treatment largely depends on the accuracy of assignments, reasonability and commitment therapy. It is desirable to have instrumental control over the efficiency and individually adjust treatment in the process. The best efficiency can be accomplished with a full examination with the complex individually selected treatment. Therefore, for patients with acoustic trauma 3-4 level of care is the optimal (at least a detailed examination, precise diagnosis and treatment, and the treatment itself can be carried out on lower levels).

It is necessary to pay attention on mobile hospitals, the function of which is somewhat different from the conventional stages of medical care. During the escalation of hostilities these hospitals work like companies of 2 levels, providing immediate expert help and guidance after sorting the patients to institutions, more distant from the line of contact. But in periods of “calm” it practically function as garrison hospital, providing help for the military personnel of the appropriate military unit in a planned manner. There are to some extent are “representatives” of the 3 levels of assistance (not having the whole set of diagnostic and therapeutic

equipment of appropriate level, however, there have a staff of representatives specialties, and therefore, can provide certain aspects of specialized care for patients.

The complexity of the pathogenesis of sensorineural hearing loss with acoustic trauma, the multi-level impact of powerful sound on human body, the presence of disorders in many structures of hearing analyzer and significant extraural manifestations, the rapid development of irreversible changes and possible destruction of certain areas makes the problem of treatment of acoustic traumatic SHL extremely difficult. The treatment should be started as early as possible, giving preference to purposeful actions. Also, to achieve a satisfactory efficiency of preventive measures a barrier is the inability to promptly obtain the results of instrumental examinations, and effective "scheme" the same for all the patients in this disease does not exist. Therefore, therapeutic measures on the first level are very limited, these are the basic actions that will not harm in any way. On level 2, should be considered at least some of the features that direct therapeutic action in certain direction (based on at least some criterias – for example, complaints, AP). On 3-4 level, the individualized treatment is based on the data of complex instrumental examination.

In our view the optimal structure of providing medical care for patients with sensorineural hearing loss with acoustic trauma on stages are presented in table. 4 (Appendix).

In case when there is no possibility for using all the diagnostic and therapeutic measures while providing medical assistance in the zone of operation of allied forces, should be used any available methods of inspection and medical history and simple but purposeful steps of treatment. Thus our proposed questionnaire for patients with acoustic trauma in zone of combat actions greatly facilitates the work of medical workers and paramedics, as well as can be filled by servicemen themselves. The proposed method of organizing the data of anamnesis and complaints, reflected in the questionnaire developed by us, allows to select patients with acoustic trauma for further examination and provide targeted specialized medical assistance (see Annex). When possible acoustic baro trauma is suspected it is advisable to conduct at least the minimum audiological examination as soon as the opportunity arises. If the hearing loss was not detected timely and the preventive and curative measures were not taken may develop irreversible violations in different parts of the hearing analyzer, progressing SHL.

It is therefore important to provide focused care for patients with sensorineural hearing impairment already on early stages of rendering medical aid in zone of carrying out combat actions. With regard to specific therapeutic interventions, certain actions can be carried out even with a minimal set of medicines. Of course, if necessary, on first place is emergency – hemostatic and anti-shock therapy, an-

ti-edema measures, detoxification etc.. However, if possible, we recommend that on first level based on at least the examination, measurements of AP and general clinical examination, make the decision to use these drugs:

1. L-lysine aescinat i/v drip 5-10mg, № 1-3 in 50-100 ml of physiological solution

2. Dexamethasone 4-8 mg i/m or i/v drip in 200,0 physiological solution № 1-3

3. Vitamin C (ascorbic acid) 5% 2,0 i/v in 40% solution of glucose (if normal blood sugar) № 3-5 (up to 10 per course). If you cannot eliminate elevated levels of blood sugar – vitamin C 5% 2,0 v/m № 3-5 (15-20 per course)

4. Mildronate (Meldonin) 10% 5,0 №. 3-5 v/m or/in (do not use in reduced AP, can increase heart rate)

5. Stugeron (Cinnarizine) 1t. x 3 times/day for 3-4 weeks

6. Cavinton (Vinpocetine) 2,0 or 4,0 in/v drip slowly in 200,0 of physiological solution № 3-5 or 1 t. 3 times a day for 3-4 weeks

7. Nootropil (piracetam) 5,0 in/m №5-10 in the absence of signs of brain injury, asymptoms, serious injury, expressed excitement.

8. Kokarnint in/m 1 ampoule № 3-5 in a day. Requires a clear definition of indications!

9. Papaverine 2% 2,0 in/m in the presence of a significant increase of vascular tone, spasm, № 3-5

10. AP normalization

11. Sedatives

12. If there is bleeding, exudation from the ear to prevent the ingress of dirt, water, as the rupture of eardrum is possible. Prevention of infection, avoidance of inflammation. The use of antibiotics is possible.

13. If severe vestibular dysfunction takes place it is necessary to provide the horizontal position and rest. With expressed manifestations (dizziness, nausea, possible vomiting, impaired coordination) is necessary to consider the appointment of betagistin in dose of 8-16 mg (for example, betaserc, etc..)

These simple steps can prevent a significant violation of the hearing analyzer and create opportunities for further targeted treatment on the subsequent levels of rendering medical aid. The contraindications for its application should be taken into account. For example, in case of bleeding, severe injuries, including craniocerebral etc.

Of course, this does not mean that for all servicemen should be prescribed the same treatment, but from this list is possible to choose the medicine according to the indications and opportunity. It should also be noted that in case of injury, polytrauma, and the presence of comorbidity, the treatment must be agreed with

experts of other medical professions and considered contraindications and drug interactions.

If it is not possible at least a minimum evaluation of the patient's condition on stage I can be recommended supporting basic activities: dexamethasone 4-8 mg i/m; vitamin C 5% 2,0 v/m; Cavinton (Vinpocetine) tablets.; stugeron (Cinnarizine) tablets.; sedatives (sibazon 0,5% 2,0 i/m or gidazepam 0,002 tab.). It is a set of tools, which have less factors of contraindications and are relatively safe for using in absence of results of examinations and the impossibility of more specific assessment of state of patient.

In case where opportunities for diagnosis and treatment are expanding, we recommend to complement this basic course application for indications of nootropics, vascular drugs, physiotherapeutic methods etc. (see table. 3).

Unfortunately, sensorineural hearing loss with acoustic trauma is very difficult to treat. Sometimes it is only about stopping the disease progression, alleviate unpleasant symptoms.

It should be noted that many of the examined by us patients with combat acoustic trauma also had associated traumatic lesions of the musculoskeletal apparatus, shrapnel wounds, SBT and other injuries, and therefore primarily, they received treatment from specialists of other profiles that should be considered in the treatment of otolaryngologist. Often patients come to otolaryngologic examination and treatment after treatment by other specialists, after finally focusing attention on the hearing loss. From our experience, this greatly affects on the effectiveness of treatment of acoustic trauma because the time got lost and irreversible changes in the structures of the hearing analyzer are developing. Mostly this was due to the priority provision of medical aid to injuries, dangerous to lives of patients and this approach is justified. However, there are cases when on the violation of hearing function (even if available) attention was paid much later, when the servicemen already went to rehabilitation and by that time many of them were not even the primary examined by otolaryngologist. This happened either due to the lack of appropriate specialists (otolaryngologists) on previous level of medical aid, or as a result of insufficient attention to complaints of tinnitus, hearing loss etc., or the fact that the primary disorders of hearing function was insignificant, and progressed over time and only then when noticed by the servicemen themselves, this prompt them to seek for medical attention. Unfortunately, by this time in many cases can develop permanent hearing loss that are difficult for correction. Such cases are very unpleasant, because sometimes even unburdensome simple for realization purposeful measures on early stages of development acoutraumatic lesion of the hearing analyzer could prevent irreversible changes in the hearing system.

Note that sensorineural hearing violations of any origin are very difficult for treatment. This is a problem not only in Ukraine but all over the world. Acoustic traumatic sensorineural hearing loss is one of the most difficult in this plan because with this type of SHL, irreversible changes (serious damage and destruction) are developing in parts of hearing analyzer, and there is the tendency to progression. According to some authors, perspective be the treatment only when it began in the first 24-48-72 hours after acoustic trauma, some believe the critical first 5 days. A very important factor for the treatment of acoustic trauma is the timeliness of assistance; therefore, it is necessary to provide sufficiently fast directing of such patients to the appropriate level on the stages. However, no less important is the question of targeting and the adequacy of diagnostic and treatment activities. An important factor is that the vast majority of cases, with acoustic trauma disorders of hearing function, even not expressed, accompanied by a subjective noise, vestibular disorders, expressed disorders of the central nervous system that aggravate the quality of patient's life and significantly affect their quality of life. However, early diagnosis and timely application of preventive and curative measures, in many cases, creates the opportunity for prevention of the development of severe forms of sensorineural hearing loss in this contingent. All of this can best be provided in the state institution «Institute of otolaryngology named. for Prof. O.S. Kolomiychenko NAMS of Ukraine» (the 4th level of medical care) if provided timely direction.

Unfortunately, on our (4) level patients come very later. Practically, we state the violation, provide high-tech expertise of state of the hearing analyzer and severity of extraaural manifestations. With these documents, the servicemen then go to the commission to determine fitness for further service. The treatment that we prescribe on the basis of the analysis of a complex examination, unfortunately, rarely implemented in hospitals. Often in hospitals, the MD, MIB and the SSU dominate stereotypical unified approaches. However, in this contingent some of the most common approaches (not always reasonable, but stable stereotypes) can be not only ineffective but also very harmful. Despite the fact that acoustic trauma generally difficult to treat, it's a shame.

Realizing the need for a certain standardization of therapeutic and preventive measures that should be realized when providing medical assistance to servicemen, we develop a more specific, simplified guidelines that will not harm patients, while retaining the elements of an individual approach.

As you know, the SHL treatment is not always effective. The efficiency of treatment of violations of sound perception depends on many factors. The most important are pathogenetic substantiation of the chosen tactics, integrated approach, accounting as complete as possible information on aural and extraaural violations,

the date of starting the treatment, the general condition of each patient, presence of adverse prognostic characteristics and comorbidities, providing an individual approach in each case. In patients with SHL, who suffered in the zone of combat operations, an important factor is a powerful stress factor, often physical and emotional exhaustion, the presence of wounds, injuries etc.. This greatly affects the effectiveness of their treatment. However, despite the fact that in some cases it is possible to return hearing function, and in other only to facilitate a condition of patients with severe disease or to stop its rapid progression, it is necessary to treat all patients with SHL, who get acoustic trauma in the zone of operation of allied forces. It is nortworting try to achieve at least a minor effect even in poor prognostic cases. Due to the fact that preserved hearing function influences greatly on quality of human life. The decrease of the intensity of noise, improving intelligibility, and sometimes just stopping of the progression of hearing loss – any progress on this difficult path has value. After all, the improvement of speech intelligibility and the decrease of effects of phenomenon of accelerated growth of loudness (PAGL), for example, offers the prospect of effective rehabilitation of patients with hearing violations using hearing protezes.

Here are some examples of treatment of patients with acoustic trauma that were in the zone of operation of allied forces.

Fighter G, scout, came to us with complaints on hearing loss, impaired speech intelligibility, subjective tinnitus, headache, dizziness, loss of coordination, instability of movement, sleep disorders, meteopathy, anxiety, memory decline, irritability. Patient had disturbance on periodic vegetative crises. A serviceman received severe acoustic baro trauma during the bursting of mine, that was accompanied by the loss of consciousness, CCBT, concussion the year before. Neurologist: post-traumatic hypertensive encephalopathy, severe syndrome of hematopoetic discirculation with vegetative-vascular paroxysms in type of sympathoadrenal crises; moderate vestibulo-atactic syndrome; expressed asthenoneurotic syndrome. The treatment about the violation of hearing function was not conducted. Subjective audiometry (Pic. 12) – a severe violation of the function of sound perception on both sides, the violation of intelligibility of speech test. EEG significant irritation of cortical and diencephalic structures of brain. The total-brainly character of the changes of biocurrents. REG – instable vascular tone, with a tendency to decrease, low pulsive blood filling in all leads, in the vertebral-basilar system – sharp decrease. A significant difficulty of venous outflow in vertebrobasilar pool. Vestibulometry: central vestibular syndrome with a violation of stato-kinetic equilibrium, disrhythmic spontaneous nystagmus, disrhythmic postmortem nystagmus on the background of disharmonic vegetative-sensory responses. The received treatment was: Nootropil 5,0 i/m № 15, then 400 mg 2 times a day (morning and

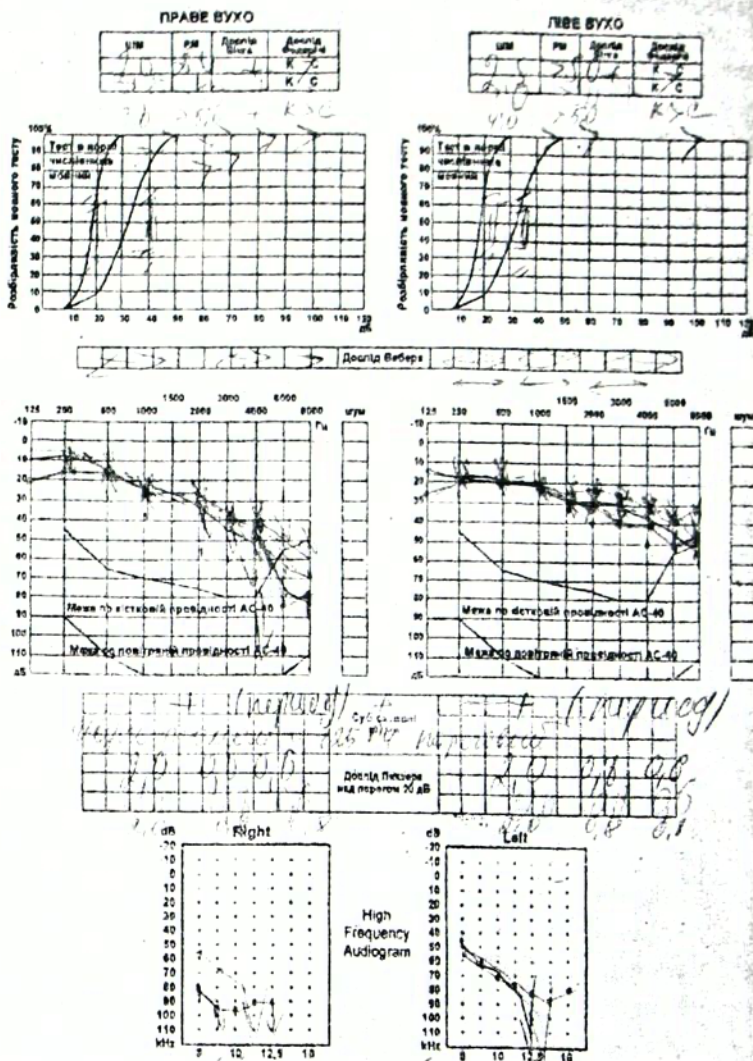


Fig. 12. Data of subjective audiometry of service members G in dynamics of treatment.

afternoon) for 3 weeks, Cerebrolysin 2.0, i/m № 20, ATP 2.0 i/m № 20, Actovegin 2.0 i/m № 15, Stugeron 1 t. 3 times a day for 1 month, Preductal MR 1t. 2 times for 1 month, Cavinton 1t. 3 times a day for 1 month, sedatives (tincture of Valerian, tincture of motherwort, Novo-passit). Unfortunately, the patient had passed this course, not all at once, there was a break in the course of treatment and not all medicines were used at once (this was due to the capabilities of the medical institution in which the servicemen was treated and also because of parallel treatment

of other diseases). However, we have achieved some success in the treatment. Despite the remoteness of the process and the presence of concomitant injuries, tonal hearing was not significantly improved, however, the patient mentioned the decrease of manifestation such as subjective ear noise (it's intensity was reduced, periods when he did not feel it at all increased), patient was less annoyed by loud sounds (decreased signs of PAGL that, in particular manifested in the increase of DT of Luscher at a frequency of 4 kHz), the intelligibility improved significantly, which contributed to improving the quality of life and communication. Also, the patient noted the improvement in general condition – sleep has improved, the intensity and frequency of headaches decreased, the dizziness and impaired coordination reduced. So, we believe it is necessary to treat even the most severe, complicated forms of combat acoustic baro trauma with delayed recourse.

The patient V. Came to us after acoustic baro traumatic lesion due to a grenade explosion in a week. He complained on hearing loss, especially on the right side, severe noise in the right ear, headache, dizziness, poor sleep. AP 130/80 mmHg. Audiometrically – bilateral dysfunction of the sound perception, on the right – significant (Pic.13).

On AEP – violations in brain stem and cortex parts of hearing analyzer, more significant on the right. On EEG is significantly reduced bioelectrical activity of the brain, signs of significant irritation of the cortex and diencephale brain-stem structures. On REG – instable vascular tone, with a tendency to increase, in carotid system there are signs of it's significant increase. In vertebrobasilar system there is severe decline of pulse blood filling, more significant on the right, the difficulty of venous outflow. The conducted treatment: Papaverine 2% 2,0 with Dibazol 1% 1,0 i/m № 7; Nootropil 5,0 i/m № 15, then 400 mg 2 times a day (morning and afternoon) for 3 weeks, Cerebrolysin 2,0 i/m № 25, ATP 2,0 i/m № 25, Actovegin 2,0 i/m № 20, Mildronate 10% 5,0 i/v № 10, Stugeron 1 t. 3 times a day for 1 month, Preductal MR 1 t. 2 times a day for 1 month, UFF endoaurally with fraksiparini № 10; sedative medicine. Since the patient came to us quite quickly after acoustic trauma, we managed effectively to restore his hearing. After treatment the hearing function improved significantly, the tinnitus has almost disappeared, the periodic subjective noise of minor intensity disturbed rarely. We have managed almost restore hearing function on the right and to normalize on the left, mainly because of the timely treatment, detailed examination and targeted treatment as soon as possible after acoustic trauma.

Service member Z. was wounded and got acoustic trauma. In August 2014, got the treatment in hospital about feet injury. The attention was paid to the hearing loss and treatment was prescribed to the the service member much later. It was not effective and the patient was sent for examination to the state institution

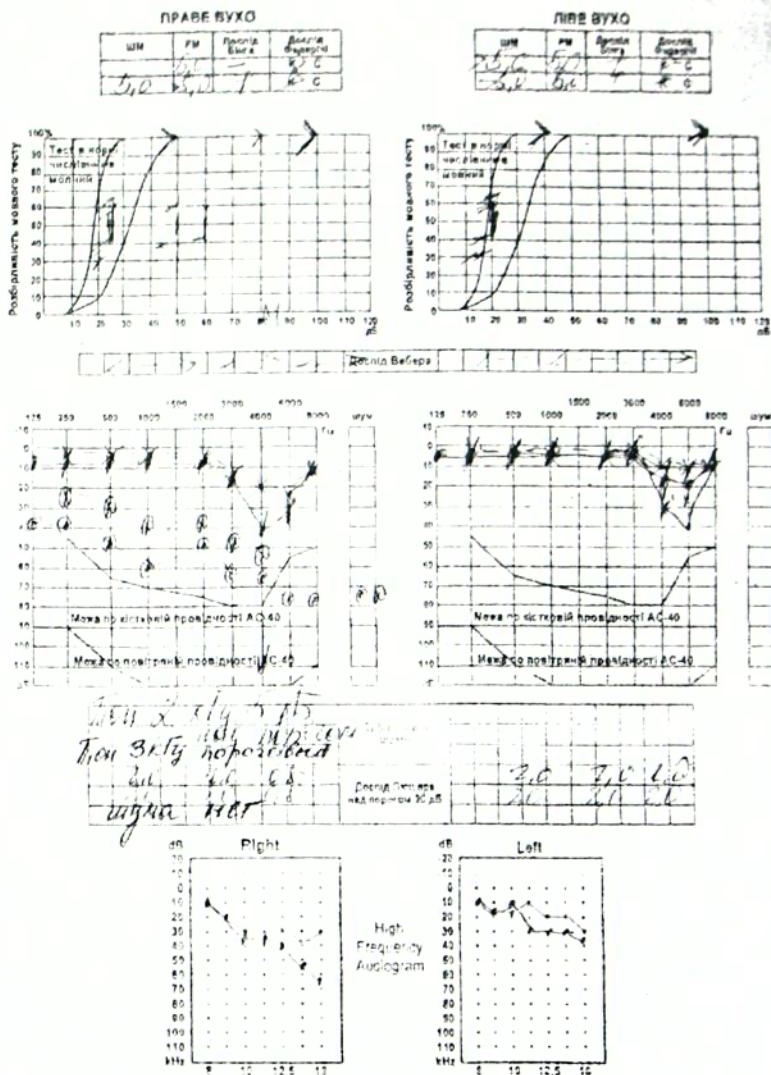


Fig. 13. the audiogram of patient V. in dynamics of treatment.

«Institute of otolaryngology NAMSU». At the time of contacting us servicemen had complaints on hearing loss, intense noise in both ears, poor tolerance of loud sounds, reducing intelligibility, headache, dizziness, poor sleep. AP was 120/70 mmHg. While examining in the Institute audiometrically was diagnosed bilateral SHL with violation of the speech intelligibility test, discomfort, low DT on both sides (Pic. 14). According to the AEP took place expressed violations in brain stems and cortex parts of hearing analyzer. OAE was not recorded. According to

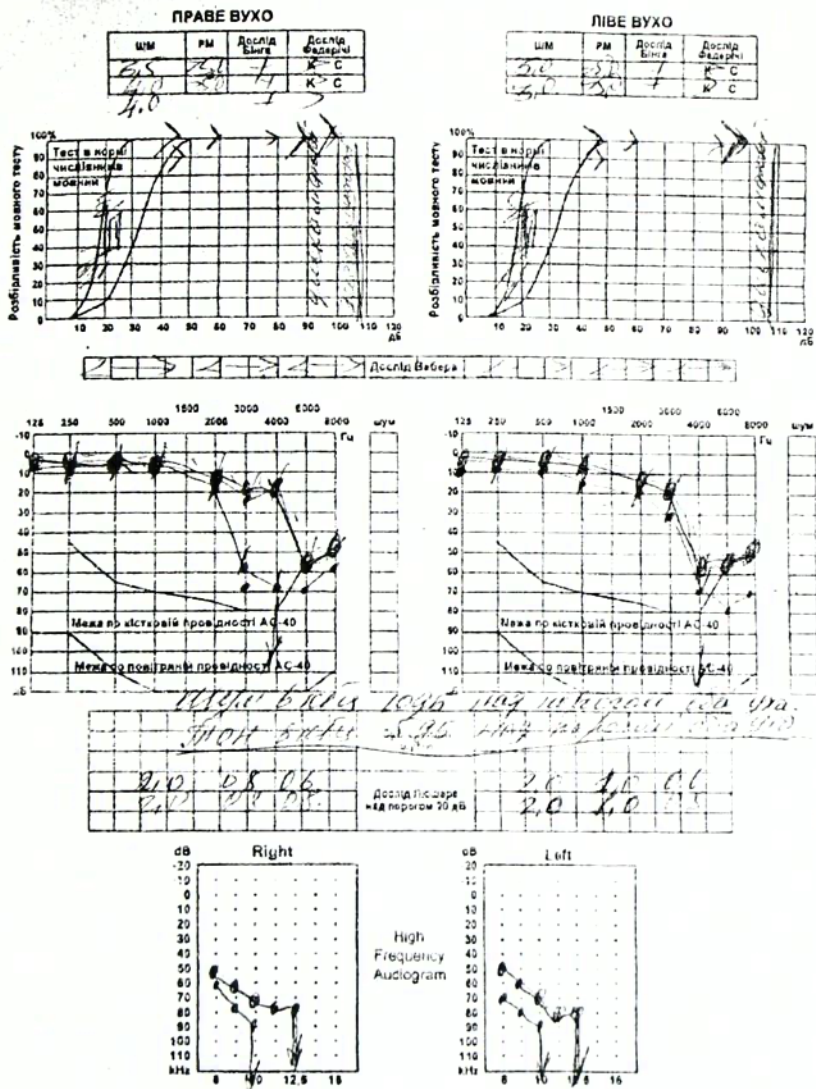
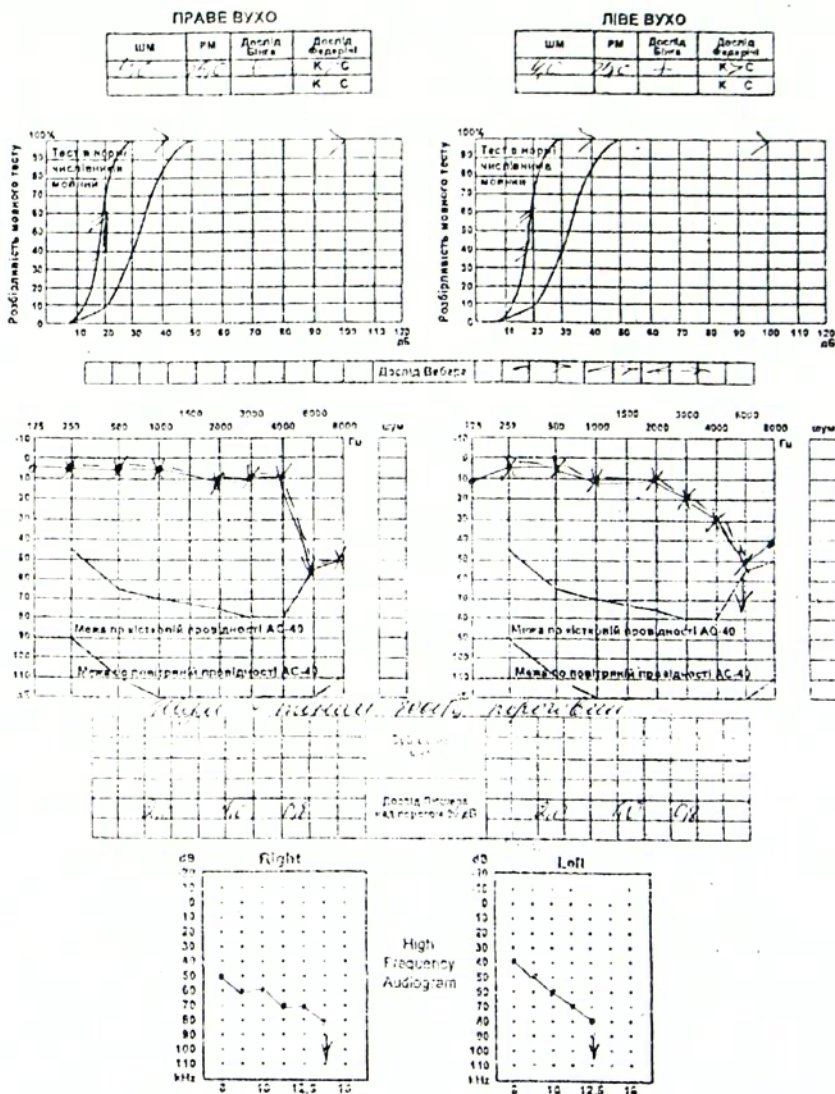


Fig.14. The audiogram of patient Z. in the dynamics of treatment.

vestibulometry: central vestibular dysfunction, violation of stato-kinetic equilibrium, expressed sensoric and vegetative reaction, nystagmus disrhythmic, the silent fields were registered. REG – decreased tone of cerebral vessels. EEG significant irritation of the cortex and diencephale brain-stem structures of the brain. The patient was assigned to such treatment: Nootropil 5,0 i/m № 15, then 800 mg 2 times a day for 3 weeks; Cerebrolysin 2,0. i/m № 25, ATF 2,0 i/m № 25, Actovegin 2,0 i/m № 20, Stugeron 1 t. 3 times a day for 1 month, sedative medicine. After the

first course of assigned treatment the hearing function has improved, including intelligibility of speech, the intensity of subjective ear noise reduced, the general condition improved significantly.

This patient passed several courses of treatment and eventually the discomfort in speech audiometry disappeared, the range of tone perception of high frequency range extended, the subjective noise was preserved, but its intensity decreased and even it occasionally disappeared (Pic.15).



Pic.15. the audiogram of the patient Z. after treatment.

Service member T. periodically got acoustic traumas during the fighting, after which was a temporary deafening, stuffy ears, ringing in the ears. But these feelings passed after a while and the patient has not sought help. In 2015 he came under mortar shelling and the explosion happened nearby. After mine-explosive injury he felt hearing loss, deafening, stuffy ears, severe tinnitus – severe ringing, dizziness, loss of coordination, felt poor tolerance of loud sounds. Subsequently, stuffy ears, deafening passed, but other symptoms remained. However, he asked for medical help only in February 2017. By this time the periodically received acoustic traumatic impact of medium intensity. Therefore, the patient asked for help long after a few acoustic trauma of varying intensity. At the time of treatment he had complaints on hearing loss, permanent high-frequency noise in the ears, which increased periodically, poor tolerance of loud sounds, periodic loss of coordination, dizziness, especially at sharp movements, sleep disturbance, irritability. During the examination according to REG – increased tone of cerebral vessels with the phenomena of angiospasm in all leads. In carotid system is moderate, in vertebrobasilar – significant obstruction of the venous outflow. The pulse blood filling in vertebral-basilar pool is decreased. On EEG significant irritation of cortex and diencephalic structures of the brain. The overall cerebral character of the changes of biocurrents. The treatment was prescribed: Papaverine 2% 2,0 i/m № 10; Nootropil 5,0 i/m № 15, and then 600 mg orally 2 times a day morning and afternoon for 3 weeks; Cerebrolysin 1,0 i/m № 25; ATP 2,0 i/m № 25; Cinnarizine 1 t. 3 times a day for 4 weeks.; Sermion 10 mg 3 times a day for 1 month.; Valerian extract 2 t. 3 times a day for 1 month. After treatment, the patient had the normal hearing function (both in conventional and extended frequency range!) according to subjective audiometry (Pic.16), significantly decreased subjective ear noise - it became “background”, didn’t bother severely, disappeared periodically at all, the sleep has improved, the dizziness didn’t disturb, just minor symptoms of transient dizziness that took place rarely, the manifestations of poor coordination during sudden movements have disappeared. The example demonstrates that it is possible to achieve a positive effect in treatment of acoustic traumatic lesion of hearing analyzer even when patient has accessed via a long time. Therefore, in our opinion, it is desirable trying to treat all patients with combat acoustic trauma, regardless of time of treatment after acoutraumatic effects, including the repeated one.

Therefore, in treatment of acoustic traumatic SHH in participants of combat actions it is possible to achieve a positive effect, even with repeated acoustic trauma and after a long time, and it is necessary to aspire to this.

In our opinion, the correction of disorders of hearing function should be included in the rehabilitation program of affected in a combat zone, since such violations, are though not to be life threatening, but affect quality of life.

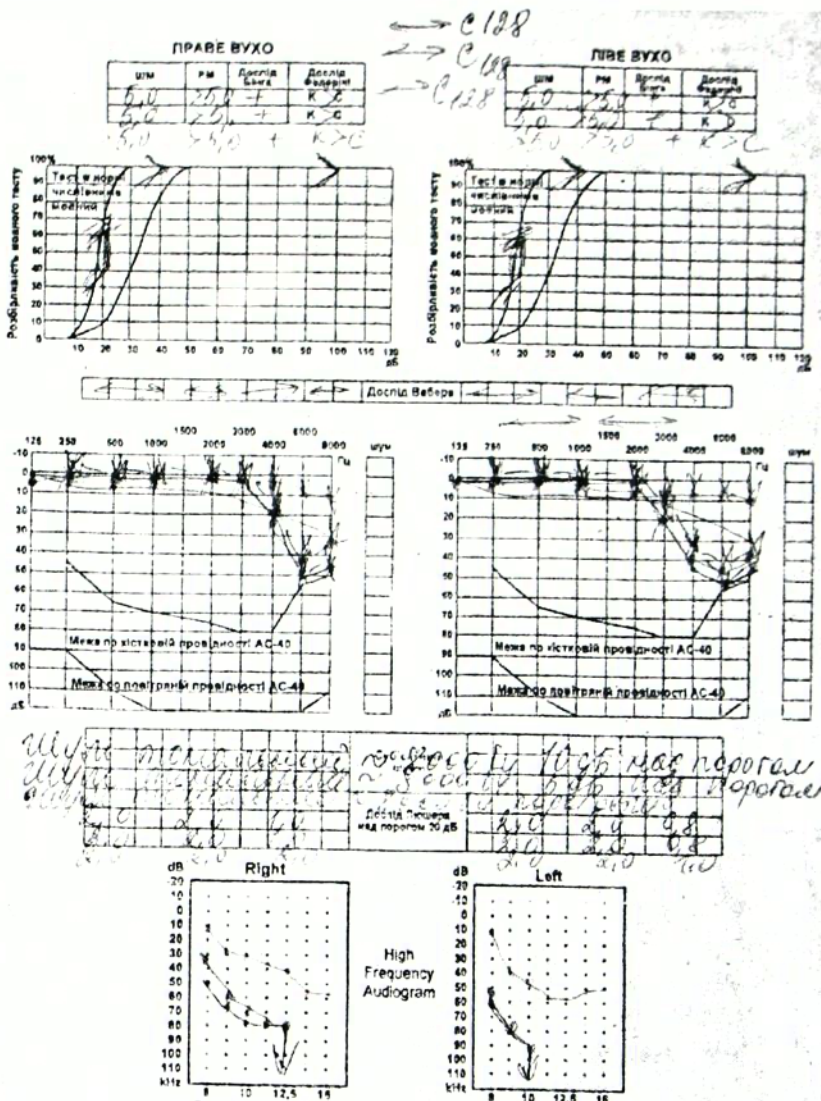


Fig.16. Data of subjective audiometry of service member T. in dynamics of treatment.

The prevention of sensorineural hearing loss with acoustic trauma get in real combat conditions are very important. There is an opinion, that the only effective method of prevention of SHL is the reducing of the impact or eliminating the damaging effects of etiological factors on hearing analyzer, however, this is rarely possible; therefore, in the first place in terms of SHL is early diagnosis of it. Thus, the main measures of prevention of severe hearing loss with combat acoustic trauma is the timely identification of sensorineural disorders of hearing

function in patients with acoustic trauma on early stages and targeted treatment and preventive measures.

The timely identification of groups of risk, individuals who are more sensitive to the effects of powerful sounds can help to avoid significant acoustic traumatic lesions of hearing system. In this respect, an effective is assessment of individual sensitivity of hearing system of the servicemen to sound load including the damaging effect of high-intensity sound on the basis of analysis of complex instrumental examination. During the studies of professional hearing loss of «noise» genesis have been identified certain signs that indicated about the vulnerability of hearing system to noise effects, which can be applied in case of acoustic trauma. Also more sensitive to acoustic trauma there are individuals with dystonia, instable vascular tone, changes in the functioning of central nervous system, diseases of cardiovascular system. The definition of contingent of individuals who are more sensitive to such lesions may be helpful in preventing the increase of number of affected by acoustic trauma. Persons who belong to groups of risk, are not advisable to be send in divisions where there is an increased possibility of contact with sounds of high intensity.

Also an effective can be the usage of personal protective equipment (tactical headphones, earplugs, helmets, etc.) at least where possible – gunners, grenade throwers, tanks, etc. There is also a clear need to develop certain specific preventive approaches, taking into account features of application of various types of weapons. The development of such measures requires further research in this direction.

Also, it should be considered that to patients with symptoms of PAGL are contraindicated the contacts with the sounds of high intensity, because there is a risk of significant damage of hearing system and the rapid progression of SHL. Therefore such patients during treatment require regime of silence, and after treatment they are contraindicated to staying in a noisy environment, require avoiding of contact with powerful sound effects..

The identifying the cases of severe course of the disease, definition of clear criteria for progression SHL and timely application of targeted preventive measures also helps prevent the development of significant hearing disorders with acoustic trauma got in real combat conditions and disability of patients.

According to our observations, the most difficult for treatment are the patients with acoustic trauma, which have the changes in brain stem and limbic-reticular parts of the hearing analyzer according to SLAEP and LLAEP. Also the cases where on EEG there are changes in diencephalo-brain stem and mediobasal parts of the brain, especially on the background of reduced bioelectrical activity. Severe acoustic traumatic SHL takes also place with significantly reduced pulse blood

filling in the vertebrobasilar system, with significant spasm and increased tone of cerebral vessels, atonic curve, a significant difficulty of venous outflow according to REG. In such cases, it is necessary to provide long-term complex targeted treatment taking into account as many factors as possible. Of course, special attention should be paid to the affected with combined injuries, wounds, depression, PTSD, related diseases. The efficiency of treatment is lower in patients with repeated acoustic trauma.

So, issues of early diagnosis, treatment and prevention, as well as the features of rendering of medical aid at the stages with combat acoustic trauma is relevant and requires the implementation and further improvement. The treatment that begins timely and is targeted and based on the condition of the various parts of the hearing analyzer and extraaural changes can prevent the progression of sensorineural hearing impairment and the formation of heavy SHL in patients with acoustic trauma get during combat actions and in some cases, improve hearing function in these patients.

Thus, military personnel who get combat acoustic trauma should be as soon as possible prescribed targeted treatment. The patients who get acoustic trauma in a combat zone, should have complex treatment based on the data of instrumental examinations, so it is advisable to direct such patients as quickly as possible to higher (3-4) level of medical care.

Patients who get acoustic trauma in real combat conditions, have a number of peculiarities caused by specificity of some aural and extraaural manifestations in such cases, that dictates the necessity of accounting such changes during treatment. Assisting patients with sensorineural hearing loss due to combat acoustic trauma in military terms has its own specific phasing and sequencing. It is necessary to ensure a clear sequence of preventive measures on the stages.

A list of recommended literature

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A LIST OF SYMBOLS, ABBREVIATIONS

AEP	– auditory evoked potentials
ABR	– auditory brainstem response
ARIM	– acoustic reflex of the muscles inside the ear
AP	– arterial pressure
DCI	– diacrotic index
DSI	– diastolic index
DT	– differential threshold
LLAEP	– long-latent auditory evoked potentials
EEG	– electroencephalography
ENG	– electronystagmography
AFU	– the armed forces of Ukraine
SLEP	– short-latent auditory evoked potentials
LPP	– the latent period of the peaks
IPI	– inter peak interval
OAE	– otoacoustic emission
PDS	– paradoxical drop in speech intelligibility
REG	– rheoencephalography
Pi	– pulse blood filling index
AEP	– auditory evoked potentials
SHL	– sensorineural hearing loss
PAGL	– the phenomenon of accelerated growth of loudness
CNS	– central nervous system

**Application (questionnaire) to the map of examination of patient with
acoustic trauma, acoustic baro trauma**

Name, Surname _____

History (the circumstances in which occurred acoustic trauma, acoustic baro trauma)

Related lesions during acoustic trauma: no, yes; head injury, contusion, wound, other _____ Loss of consciousness, nausea, vomiting.

Acoustic trauma first, repeated _____ .How much time has passed after acoustic trauma _____.

Treatment for hearing loss as a result of acoustic trauma before that time, yes, no.

Stun after acoustic trauma: no, yes, minor, moderate, significant, long _____

Ear pain: no, yes, unilateral, bilateral; appeared at the time of acoustic trauma how long _____ slight, moderate, marked. Now no, yes, _____ .

Discharge from the ear: blood, fluid, single-sided, from both sides immediately after acoustic trauma

Congestion in the ears: no yes; unilateral, on both sides; slight, moderate, severe, appeared immediately after acoustic trauma, long _____; appeared later, after _____ . Now no, yes, associated with _____

Hearing loss: no, well, one-sided, both sides; slight, moderate, marked, appeared immediately after acoustic trauma, later _____. Hearing loss was not until acoustic trauma: yes, no; increased after acoustic trauma. The hearing eventually worsened, improved, unchanged.

The violation of intelligibility: no, yes; minor, moderate, significant; unilateral, both sides; appeared immediately after acoustic trauma, later _____, then worsened, improved, unchanged.

Loud sound feel normally, bad, high frequency, low frequency, appeared immediately after acoustic trauma, later _____, protractedly __ now no, yes.

Distorted perception of sounds, also, an unnatural feeling of sound some (of which _____) of sounds, after acoustic trauma, later _____, protractedly _____ now no, yes.

Subjective noise: no, yes; unilateral, bilateral, in the head; slight, moderate, significant; appeared immediately after acoustic trauma, later, after _____, lasted _____, permanent, periodic, homogeneous, inhomogeneous, high-

frequency, low frequency, whistling, ringing, other _____.
Over time, the noise disappeared, increased, varied in intensity, frequency, quick, slow; remained about the same.

Now: no, yes, constant, intermittent, slight, moderate, significant; unilateral, both sides, in the head; homogeneous, inhomogeneous. high-frequency, low frequency, background, whistling, ringing, other _____ varies throughout the day in intensity, in tone depends on _____.

Headache: no, yes; appeared immediately after acoustic trauma; lasted _____; appeared later _____ slight, moderate, significant; "pulsating", a fit of pain, long; mostly in the forehead, temples, crown, nape, migrating throughout the head; unilateral, bilateral. Over time, decreased, increased, no change. Or bothered to acoustic trauma: no, yes. Now: yes, no, often, seldom, almost always, minor, moderate, significant, "ripple", a fit of pain, long; forehead, temples, crown, nape, migratory; unilateral, bilateral; associated with stress: physical, emotional, atmospheric fluctuations, _____.

Dizziness: no yes; appeared immediately after acoustic trauma how long _____, appeared later, after _____, minor, moderate, significant; accompanied by nausea, vomiting, and "fly" before the eyes, darkening of the eyes. Or bothered to acoustic trauma: no, yes. Now: no, yes, a slight, moderate, marked; long, short; often, seldom; is associated with __AP, headache, atmospheric fluctuations, fatigue, sharp head turns, sharp movements, other _____ accompanied by nausea, vomiting, and "fly" before the eyes, darkening of the eyes _____.

Impaired coordination and balance: no, yes; minor, moderate, significant; unsteadiness of gait, uncertain movements, appeared after acoustic trauma, continued _____; appeared later, after _____. Or bothered to acoustic trauma: no, yes.

Now: no, yes, are slight, moderate, marked; associated with _____.

A feeling of heaviness in the head: no, minor, moderate. expressed, appeared immediately after, acoustic trauma, continued _____, appeared later, after _____, in the area of forehead, temples, occiput all over the head. Or bothered to acoustic trauma: no, yes

Now: no, yes, often rare; minor, moderate, significant; in the forehead, temples, diffuse all over the head associated with _____.

Sleep disorders: no, yes; superficial, sleeps badly, wakes up in the night, in the morning feels no rest; came after acoustic trauma; later, after _____, how long does _____. Or bothered to acoustic trauma: no, yes

Memory impairment, attention: no, yes, minor, moderate, expressed, appeared immediately after acoustic trauma, later, after_____. Now:no, yes. Or bothered to acoustic trauma: no, yes

Other complaints: general weakness, fatigue, irritability, increased emotionality, meteopathy, anxiety _____

Arterial pressure: working _____, a tendency to raise, reduce, unstable, ГХ_____, ВСД _____

Otolaryngology-examination _____

Ds _____

Notes: _____

Below is an example of a more simplified version of the questionnaire for patients with acoustic trauma, acoustic baro trauma.

A questionnaire of the patient with acoustic trauma, acoustic baro trauma

Name, Surname _____

The circumstances under which occurred acoustic trauma, acoustic baro trauma

Hearing loss, there is slight, moderate, marked, appeared for the first time after acoustic trauma; before, after acoustic trauma increased.

The feeling of discharge from the ear immediately after acoustic trauma, blood, fluids; unilateral, both sides

Stun after acoustic trauma: yes, no, slight, moderate, marked, long _____

Ear pain: no, yes, unilateral, bilateral; appeared at the time of acoustic trauma, how long _____ slight, moderate, pronounced. Now: no, yes.

Congestion in the ears: no yes; unilateral, on both sides; slight, moderate, severe, appeared immediately after acoustic trauma, long _____ now: no, yes

The violation of intelligibility: no, yes; minor, moderate, expressed, appeared immediately after acoustic trauma; later, after _____; unilateral, on both sides.

Now: no, yes.

Loud sound carries poorly, normally, appeared immediately after acoustic trauma; later, after _____. Now: no, yes.

Subjective noise: no, yes; unilateral, bilateral, in the head; slight, moderate, significant; homogeneous, inhomogeneous, high-frequency, low frequency, whistling, ringing, other _____; appeared immediately after acoustic trauma, lasted _____, appeared later _____. Eventually disappeared, increased, no change.

Headache: no, yes; appeared immediately after acoustic trauma; lasted _____; came then through _____, slight, moderate, significant; mainly in the forehead, temples, crown, nape, migrating throughout the head; unilateral, bilateral. Over time, decreased, increased, no change.

Dizzy: no, yes, minor, moderate, significant; appeared immediately after acoustic trauma, continued _____, accompanied by nausea, vomiting, and "fly" before the eyes, darkening of the eyes. Dizziness came over time (after ____). Now: no, yes

Impaired coordination, balance, unsteadiness of gait, uncertain movements, also, slight, moderate, marked, appeared after acoustic trauma, continued _____; appeared over time (after ____). Now: no, yes

A feeling of heaviness in the head: no, yes; minor, moderate, significant; in the forehead, temples, diffuse all over the head; it appeared immediately after acoustic trauma, continued _____, appeared over time (after _____). Now: no, yes.

Memory impairment, attention: no, yes; minor, moderate, expressed, appeared after acoustic trauma. Over time, decreased, increased, no change.

Other complaints: general weakness, fatigue, irritability, increased emotionality, sleep disturbance _____

Acoustic trauma first, repeated. How much time has passed after acoustic trauma

The presence of contusions, wounds, traumatic brain injury, other _____

The most characteristic diagnostic signs and emergency extraaural manifestations in acoustic trauma get in real combat conditions, according to clinical and instrumental methods of examination

Examination methods	The most informative diagnostic indicators (qualitative and quantitative indicators)
Data history, complaints	Typical complaints: hearing loss; stun, congestion and pain in the ears after acoustic trauma, poor tolerance loud sounds; an important symptom is subjective tinnitus, especially of high frequency; dizziness, imbalance; headache, heaviness in the head, irritability, sleep disturbance. Moreover, should be paid attention on the duration and severity of such feelings
Clinical methods (Otolaryngology-examination)	Dull tympanic membranes, their thickness; injection of the vessels in the course of the handle of the hammer. The particular smooth outlines and reduced light reflex. Signs of traumatic rupture of ear drum (perforation, scarring)
Subjective audiometry	The increase in hearing thresholds for tones, mainly in the region of 4-8 kHz of conventional, as well as 14 and 16 kHz of extended frequency range down to the type of tonal audiometric curve, often – rupturally. It is often characterized by "peaks" increase in hearing thresholds at the tonal curve with the greatest increase in threshold at 4-6 kHz and 12 kHz "acoustic traumatic" peak*. Can be observed "breaks" the perception of tones, especially in the extended frequency range; impaired speech intelligibility test (often stunted growth); the presence of discomfort, including speech, with stimulus intensity of 100 dB, but sometimes at 70-80 dB, often without other violations of intelligibility; the discomfort and the violation of intelligibility can be observed at the absence of significant disorders of hearing function (defined dissociation symptoms); reduction of differential thresholds (DT) method Lüscher, especially in the region of 4 kHz; the asymmetry. Often bilateral, asymmetrical disorders of hearing function
Registration AEP	Changes of the complex peaks (their smoothness, additional waves, a decrease or increase in amplitude) and temporal characteristics. The elongation of the latent periods of the peaks of the waves (LPP), especially II, III, V and interpeak intervals (IPI) I-III and I-V SLEP. Increase LPP "late" components LLEP P ₂ and N ₂ . The asymmetry of response. Disorders in the central parts of the hearing analyzer are observed in case of slight disorders of hearing function according to subjective audiometry.
OAE	"Dissociation" of data OAE and tonal audiometry is often a response of the OAE are recorded at frequencies 4 and 6 kHz, with no response to lower, while according to subjective audiometry to these tones is the most marked reduction in hearing sensitivity. Asymmetry. OAE is often not recorded at all, on any of the frequencies. However, if it is timely targeted treatment there is a chance to get answer from the outer hair cells. Consequently, reversible changes

Impedance audiometry	The change of amplitude (a decrease, sometimes sharp) and time (prolonged latent period and the period of recession and reduction period) characteristics of the acoustic reflex of the muscles in-the-ear (ARIM). Asymmetry. Localization is more obvious violations are not always identical according to audiometry at conventional and extended frequency ranges, a certain dissociation of indicators. Often there is a lack of ARIM with sufficient conditions for this level of the hearing thresholds and the absence of pathology of the middle ear. Tympanogram often not significant. Often observed tympanogram of type A, less the high-amplitude or vice versa, the low amplitude (type As).
Vestibulometry	The presence of spontaneous or positional nystagmus according to the registration of elektronistagmography (ENG). Violation of the stato-kinetic equilibrium according to the index cephalography, disruption of the dynamic equilibrium (the most informative is a sample of the flank gait and walking test Fukuda). According to the experimental nystagmus (rotational test at Barani) Central vestibular dysfunction of varying severity, which provokes mismatch between parameters of experimental nystagmus, disritmia nystagmus, the presence of "silent" fields. Predominantly central vestibular syndrome, sometimes combined with vestibular dysfunction. The degree of decompensation of the second level. The asymmetry of indicators.
EEG	Violation of irritative character, hypersynchronous bursts, often – epileptiform post-traumatic changes. Desynchronization and disorganization of the basic rhythms, smoothed zonal differences, the increase in the content of slow-waves activity, especially in theta rhythm, often in the front projection. Signs of attraction of diencephale brain stem and mediobasal structures of the brain. Asymmetry.
REG	Often a weak and low tone of cerebral vessels, atonic curve. Can be greatly increased tone, spasm of cerebral vessels. The difficulty of the venous outflow in almost all patients. The decrease in pulse blood, often in all leads, not only in vertebral-basilar pool. Asymmetry.

Note: * "autramatic peak" - a very characteristic feature. Looks like some kind of a peak, the higher thresholds of hearing sensitivity at a frequency of 4 or 6 kHz, followed by some decline in the area of 8 kHz. She easily recognized on the audiogram by all the doctors otolaryngologists (and not only) of any skill level. The diagnosis of "acoustic trauma" to servicemen with presence of acoustic-traumatic peak on audimetric curve, if the patients were in a combat zone and have been in contact with the sounds of high intensity due to the use of military weapons (of course, the accounting and other data) is not difficult.

The most typical qualitative and quantitative parameters according to subjective and objective methods of examination of patients with combat acoustic trauma that can be used as markers to resolve expert issues, determining severity of disease, prognosis and evaluation of treatment effectiveness.

Qualitative and quantitative indicators	Prognostically unfavourable, severe	A positive trend, a sign of the effectiveness of treatment
The complaint of subjective ear noise, poor tolerance loud sounds, deafening, congestion and pain in the ears after acoustic trauma; dizziness, balance disorder, sleep disorder, headache, heaviness in the head	The feeling after a long acoustic trauma, severity of complaints is significant	The decrease in intensity of the symptoms, the disappearance of it
The intensity of subjective ear noise *	5-10 dB above the threshold, permanent, periodically amplified	The decrease in the intensity periodically disappears, disappears completely
Frequency response of the subjective ear noise*	High-frequency, "complex", permanent	A reduction in the frequency, periodically disappears, disappears completely
Manifestations PAGL	Expressed	Reduced, absent
The presence of discomfort in the perception of a speech test	There is, even in case of slight disorders of hearing function according to the tonal threshold audiometry, may be logged even when the signal intensity of 70-80 dB	No discomfort in the perception of a speech test
DT at Luscher at a frequency of 4 kHz*	Low or lowered 0,4 – 0,8 dB	Normalization, increased to more acceptable values
The presence of PPR and PPR concealed	Expressed	Reduction of manifestations, the lack of it
Violations of the speech intelligibility test (stunted growth, failure to reach 100%), including periodic disruption of speech intelligibility (for the complaints of patients) The hearing thresholds for tones 4, 6, 8 kHz (or the decrease in thresholds after treatment)*	Expressed Increased significantly, "break" perception	Reduction of manifestations, the lack of it Reduced, the reduction of thresholds in the dynamics of treatment

LPP II SLEP*	Lengthening of LPP more than 2.8 ms	The decrease in LPP from the increased values, normalization
LPP V SLEP*	Lengthening of LPP more than 5.9 ms	The decrease in LPP from the increased values, normalization
IPI I-III SLEP*	Lengthening of IPI more than 2.3 ms	The decrease in IPI from the increased values, normalization
IPI I-V SLEP*	Lengthening of IPI more than 4.2 ms	The decrease in IPI from the increased values, normalization
LPP P ₂ LLEP*	Lengthening LPP more than 180,0 ms	The decrease in LPP from the increased values, normalization
LPP N ₁ LLEP*	Lengthening of LPP more than 300,0 ms	The decrease in LPP from the increased values, normalization
Registration DPOAE, especially at frequencies 4 and 6 kHz *	Absents	Existing
The intensity of the DPOAE signal at frequencies 4 and 6 kHz *	Low does not exceed "noise"	Growing, sufficient for constation of a positive response.
The decrease in the amplitude ARIM *	Expressed, the amplitude below is 0,011 cm ³	The growth of the amplitude
The lack of ARIM sufficient to check the levels of the thresholds of hearing	Missing ARIM	ARIM is registered
Changes in temporal characteristics of ARIM (lengthening of the latent period and period of recession, as well as reducing the validity period)	Yes, expressed	A decrease in the manifestations
The presence of imitation diencephale-stem or mediobasal brain structures on the EEG *	Yes, expressed	Slightly marked, missing
Alpha -index of EEG *	Less than 40%	Growing, is more than 50%
The percentage of the theta rhythm in temporal leads of the EEG*	More than 20%	Decreases, does not exceed 15%
The amplitude of the alpha-rhythm of the EEG *	Low (less than 40 mV) or high (more than 130 mV)	The normalization values, the amplitude in the range of 60-100 mV)

The phenomenon of the disruption and desynchronization of basic EEG rhythms	Available, expressed	Unexpressed, synchronized bioelectrical activity, rhythm is organized
The absorption of the imposed rhythms of the EEG	Missing (areactivity). weak	Satisfactory
Zonal differences of EEG	Missing, smooth	Conserved
Reaction to opening the eyes of the EEG	Missing, poorly expressed	Conserved, expressed
The presence of sharp peaks, sharp potentials, complexes "peak-slow wave", "spikes", etc. signs on EEG	Yes, a considerable quantity already for background recording	No, the decrease in the number and severity of
Hypersynchronised spikes on EEG	Yes	No
Signs of epileptiform activity	Yes	No
Focal manifestations on EEG	Yes	No
Atonic curve of REG	Yes	No
The decrease in pulse blood filling, Pi according to REG *	Yes, a significant in both systems (carotid and vertebral-basilar), Pi less than 0,6	No, is only moderate in the vertebral-basilar system. Pi are close to the norm
Difficulty of venous outflow according to REG, DSI (vertebral-basilar system)*	Yes, expressed, in both systems, so far more than 70%	No, is only moderate in the vertebral-basilar system
Spasm of brain vessels, increased tonus, DCI	Yes, the expressed spasm, a significant increase in tonus, DCI more than 60%	No, moderate tonus increase
Instable vascular tonus according to REG	Yes	No
Central vestibular syndrome	Expressed	Unexpressed, missing
Stage subcompensation	Low (III), middle(II)	High (I)
Violations of static equilibrium (index cephalography)*	Index CPG >6,1 con. unit	Missing
Violations of dynamic equilibrium (sample flank gait, walking Fukuda test)*.	Deviations in the course of >1,5 m, rotation >60-70°	Missing
Disritmia nystagmus, the presence of "silent" fields	Yes	No

Note: * - indicators, changes of which allow to evaluate the effectiveness of treatment during the follow-up, including objectively

Measures of drug therapy used for the treatment of sensorineural hearing violations in acoustic trauma get during combat actions

<p>Desintoxicacion, hemostatic and anti-shock therapy. Emergency help.</p> <p>L-lysine aescinat/drip 5-10mg. №. 1-3 50-100 ml of physiological solution</p> <p>Dexamethasone 4-8 mg i/m or i drip in at 200,0 physiological solution №. 1-3</p> <p>Vitamin C (as ascorbic acid) 5% 2,0, i/v drip 5% or/in trickle to 20,0 40% glucose solution (assuming normal levels of sugar in the blood) if you cannot exclude high blood glucose levels - vitamin C 5% 2,0 i/m</p>	<p>If there is evidence of these actions starts the course of treatment in the early stages</p> <p>Anti-edema effect, reduces the pressure of the lickvore. Contraindicated in the risk of bleeding, high AP</p> <p>Decongestant, anti-inflammatory effect. Effective only in the first days after acoustic baro trauma, shown if there are signs of acoustic baro trauma</p> <p>Dehidration, detoxifying, adaptogenic effect</p>
<p>Drugs that contribute to the improvement of the functional state of the central nervous system (nootropic drugs that stimulate the nervous metabolism, especially brain tissue)</p> <p>Nootropil (piracetam) 5,0 i/m №.10-15, inside 400-800 mg 2 times a day (morning and evening) for 3 weeks</p> <p>! Large doses of nootrope for this group of patients is contraindicated. Strengthens the processes of excitability of the nervous system</p> <p>Cerebrolysin 1,0 or 2,0 i/m course №.20-30 (short courses ineffective)</p>	<p>The use of drugs of this group substantiated significant changes in the central hearing analyzer and violations of the functional state</p> <p>Nootropil does not apply in the accute period of SBT, it is absolutely contraindicated in any form of convulsive readiness, epileptiform manifestations (and it is often seen in the injured in a combat zone). Therefore it is not shown in the early period after acoustic baro trauma, contusions, head trauma. In the case of significant irritative changes in brain activity (as manifested in the vast majority of patients with combat acoustic trauma) it should be used very carefully and in small doses.</p> <p>Nootropil partially acts on the cerebral cortex, improving associative functions. It boosts the energy metabolism of brain cells, developing their potential neurophysiological abilities, especially when their failure Cerebrolysin can be used in point period of SBT.</p>

	<p>It has a limit of application only in the case of epileptic manifestations. Cerebrolysin promotes the protein synthesis and affects the respiration of nerve cells. It is specific for the brain drug and has a unique multi-modal mechanism of action, based on the interaction of biologically active neuropeptides. Cerebrolysin has a significant neurotrophic and neuroprotective action by increasing the efficiency of aerobic energy metabolism, which affects the protein synthesis of neurons and a decrease in the level of lactic acid.</p>
<p>Stugeron (cinnarizine) 1 t. 3 times a day for 3-4 weeks May cause drowsiness!</p>	<p>Tonpatients with vascular disorders, vertigo, central vestibular dysfunction (which is often observed in patients with acoustic trauma). Stugeron enhances the activity of regulatory centres of the central nervous system, reducing a tonus of vessels of a brain and relieves their spasm, reduces vertigo, and improves the resistance of tissues to hypoxia. In addition to direct effects on the cerebral vessels and blood rheology has also an antihistamine, decongestant and soothing effect. Stugeron improves coronary circulation and the function of the vestibular analyzer, normalizes the bioelectrical activity of the brain, reduces the noise in the ears.</p>
<p>Cavinton (Vinpocetine) 1 t. 3 times a day for 3-4 weeks or i/v in the slow drip in physiological solution 2,0 or 4,0 at 200,0 ang solution №. 5-7.</p>	<p>Vascular disorders, obstruction of the venous outflow Cavinton expands the blood vessels of the brain, enhances its circulation, first and foremost, improves venous outflow, improves the supply of oxygen to the brain, contributing to its interstitial transport, but also causes an increase in the content of catecholamines in tissues of the brain and the metabolism of its structures, enhances the absorption and utilization of glucose and oxygen brain tissue. Cavinton improves rheological properties of blood, reduces systemic arterial pressure, has an antioxidant effect, increases the resistance of neurons to hypoxia, have a neuroprotective effect. Effective in obstruction of cerebral venous outflow, dizziness, autonomic symptoms.</p>

<p>Sermion (nicergolinum) 10 mg 1 t. 3 times a day for 3-4 weeks</p>	<p>Sermion improves both cerebral and peripheral circulation, reduces the tone of cerebral and peripheral vessels, reduces systemic arterial pressure, reduces cerebro-vessel resistance, inhibits the aggregation of thrombocytes. Sermion activates metabolism in the brain, has a stabilizing effect on the activity of the central nervous system, improves cognitive function. It has a nootropic and neuroprotective effect, improves trophic tissues, promotes energy metabolism.</p>
<p>Endoaural ultraphonophoresis with streptokinase, fragmen or fraksiparinom № 10 on the affected ear. The intensity of ultrasonic oscillations in the practice of treatment is usually 0,2 – 0,4 W/cm², an exposure time of 5 minutes, a course of 10-12 procedures. Phonophoresis can be applied topically (on cerastone peri-ear region) and endoaural using special emitters.</p>	<p>This method is very effective in the acute phase, and in the progression of SHL. Thanks to UFF medicines penetrate deep into tissue and provide a high concentration approximate to structures of the auditory analyzer. These drugs improve blood circulation in the small diameter vessels that feed the inner ear. In addition there is a private direct influence of the physical method, which improves microcirculation and tissue trophism in a selected area.</p>
<p>ATP 1,0 or 2,0 i/v № 10-20 1,0 in normal and reduced AP. The 2,0 – elevated AP</p>	<p>The metabolic influence of vascular action ATP (adenosine triphosphate) is a part of the human body and animals, is involved in many metabolic processes. It provides a strong and long-lasting decrease of vascular tone, increases cerebral and coronary circulation, increases blood circulation in the vessels of the inner ear. It is a universal carrier and a source of energy necessary for cellular metabolism.</p>
<p>Sedatives (drugs Valerian, mint, lemon balm, Passiflora, hops etc..) It is important to assign a rate not less than 3-4 weeks In the early stages may be appropriate sibazon of 0,5% to 2,0 i/m; diazepam 0,002 tab. 2 times a day. In the future these drugs can be prescribed by a neurologist</p>	<p>Shown in almost every case, when need for more effective special drugs are prescribed by the neuropsychiatrist.</p>
<p>Mildronate (Melidoni) Injection i/m or i/n 5-10, or capsules 250-500mg 10-14 days Can cause changes of blood pressure often reduced one, increase heart rate!</p>	<p>The drug is well established in cases of exhaustion (physical and emotional), increases the body's ability to withstand significant loads.</p>

<p>Vitamin C (as ascorbic acid) 5% 2,0 i/m № 10-20, i/v drip in 5% 200,0 №. 3-5 or in bolus at 20,0 40% glucose solution № 5-10 (subject to normal blood sugar levels)</p>	<p>Has as a general tonic as desintoxicative effect. Also improves elasticity of the vascular wall, is effective in a low tone, atonic state of the vessels and reduced AP</p>
<p>Drugs that normalize the AP</p>	<p>It is important to maintain normal levels not only in hypertension, but also hypotension and in patients with instable AP, VSD.</p>
<p>Kokarnyt i/m №. 3-5 day. Requires a clear definition of indications! Short course (maximum 6 times) at the beginning of inpatient treatment according to indications. Effective in the first 3 months after acoustic trauma (repeated acoustic trauma)</p>	<p>Contraindicated in patients with spasm of the cerebral vessels, a significant increase in their tone; in acute period of SBT. Has antioxidant effect, anti-hypoxic action, promotes the normalization and activation of metabolic and energy processes in tissues, stimulates regeneration processes, improves trophic properties of nervous tissue, increases tolerance to physical stress.</p>
<p>Antispasmodic drugs (if there is much spasm and increased tone of cerebral vessels). Papaverine 2% 2,0 i/m № 3-7 (up to 10)</p>	<p>As, unlike the SHL of another origin, in large parts of affected in the zone of combat actions with acoustic trauma takes place the decrease in the tonus of cerebral vessels, often on the background of low AP, atonic curve, without examination and confirmation of the presence of spasm or increase of tone, this item is not used. Also if there is a risk of bleeding drugs that widen the vessels are contraindicated.</p>
<p>Actovegin 2,0 i/m № 5-15 May cause allergic reactions! introduced slowly.</p>	<p>Can be prescribed in the acute period, including SBT, and with the planned treatment. Improves trophic of affected tissues, has a permeability to the centres of ischemia. While using Actovegin can be compensated the lack of blood flow and metabolism of nerve cells. It increases the access and utilization of oxygen, improves the transport and use of glucose.</p>
<p>Hyperbaric oxygenation 5-10 sessions of 40 minutes</p>	<p>There is a positive application experience. Adaptogenic effect, toning effect on metabolic processes; regulatory influence on the CNS, in particular deep brain structures.</p>

Table 4

Diagnostic and medical and preventive measures with the acoustic trauma on the stages of evacuation

Level of medicare	Who given assistance	Volume of help diagnostic actions	Diagnostic signs that can be defined on the stage	Medical and preventive measures on the stage
Base (paramedical, first medical)	Sanitary instructor, paramedic, medical assistant	Determination of the contingent with possible acoustic trauma, acoustic barotrauma, including a high-risk group -contusion, craniocerebral injury (CCI), loss of consciousness, wound in the area of head	Characteristic complaints: the deterioration of hearing; stunned, ear congestion and pain in ears after acoustic trauma; dizziness, imbalance; bad tolerance of loud sounds; headache, an important symptom is a tinnitus especially of high frequency. Thus important to pay attention on duration and severity of such feeling). Vestibular dysfunction, violations of coordination, equilibrium, unsteadiness of step, nausea, dizziness, possible vomiting. Signs of CCI. In case when the patient is unconscious, for the selection of groups of risk with acoustic trauma is possible to pay attention on such signs: discharge of blood, liquids from auditory channel; signs of CCI: a wound in the area of the head; signs of increased intracranial pressure, eyewitness accounts about the influence of powerful shock wave.	If bleeding takes place, discharge of liquid from ear - to prevent the hit of dirt, water, as tearing of ear-drum is possible If vestibular dysfunction - laying position, resting state Hemostatic, antishock, antiseptic measures
1 first medical	General practitioner, medical assistant	Determination of contingent with acoustic trauma, acoustic barotrauma, that heads for a higher level	Measuring of AP, questioning (anamnesis, characteristic complaints), determination of vestibular disorders - steadiness in the pose of Romberg, finger-nose test. Acumetria (reduction of index of whisper language).	Prescribing of base medicines. Normalization of AP. Prevention of hit of water, infection, contamination, avoidance of inflammation in case of tearing of ear-drum.
2 qualified	Doctor-surgeon	Realization of diagnostic actions accessible on this stage. Direction on 3 level, some patients at once on 4 levels.	Measuring of AP, questioning (anamnesis, characteristic complaints), determination of vestibular disorders - steadiness in the pose of Romberg, finger-nose test. Revealing of bleeding, discharge of liquid from an ear. Acumetria (reduction of index of whisper language)	Measures of previous medical therapy.

			<p>more often an answer to OAE registers itself on lower frequencies, while from data of subjective audiometry there is more severe decline of auditory sensitivity exactly to these tones; with the effective treatment registration recommences. REG – difficulty of venous outflow, presence of unsteady and lowered tone of cerebral vessels, or, vice versa a considerably increased tone, cerebral vasospasm. Presence of atonic curve. A decline of the pulse blood filling in all leads. EEG – violation of irritative character, hypersynchronous splashes, quite often – epileptoid post-traumatic changes, desynchronization and disorganization of basic rhythms, increase of content of slow-waves activity, especially – lethargic rhythm, signs of involvement of diencephalic stem and mediobasal structures of brain. Vestibulometry – mainly central vestibular syndrome, sometimes – combined vestibular dysfunction. Degree of subcompensation of II level. A presence of spontaneous or position nystagmus from data of registration of electronystagmography (ENG). Violations of stato-kinetic and dynamic balance</p>	<p>Medical therapy taking into account these instrumental inspections, prescribed on the 3–4 levels</p>
5 rehabilitation		<p>Maximally possible renewal of the lost functions. Providing of "sensory" rehabilitation of injured, with the aim of maintenance of satisfactory quality of their life.</p>		

Expertise	Doctor otolaryngologist, audiologist (3-4 levels)	Question of expertise – fitted /not fitted for continuation of military service	On the basis of analysis of data of complex instrumental examination/
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Acoustic trauma is not dangerous for life. Therefore most medical and preventive measures are the deferred assistance (at sorting the marking of green color). However for complete diagnostics and pathogenetically justified treatment an instrumental examination is necessary, as treatment has certain features depending on the educed changes and can not be fully compatible. On the first stages a certain help can be given for stabilization and prevention of development of complications. Treatment can be given on 3 levels with instrumental control, but if for 10 days of treatment the effect is absent (improvement of auditory function, reduction of manifestations or even stop of progressing of hearing loss), injured are directed for a higher (4) level. If possible, a diagnosis on higher level is being specified and the treatment is being prescribed, for the treatment – return on level 3.

If patient with acoustic trauma has other wounds, including surgical profile, foremost given the assistance for the more dangerous defeats. However it should be noted in maps in order to pay attention to violation of hearing, when it will be possible. In some occasion medical and preventive measures are conducted in parallel with the aim of prevention of development of severe hearing loss. For providing the maximal efficiency of medical and preventive measures and prevention of development of heavy violations of auditory function all injured with the signs of heavy acoustic barotrauma must be at once evacuated on the specialized level. At presence of contusion of the brain, especially heavy one, on specialized level of treatment is being realized together by otolaryngologist and by neurologist (neuro-surgeon).

It should be noticed that the extended diagnosis can be established only by specialist on the basis of data of instrumental examination (thus, 3 or 4 levels of medical help) That is why approximate diagnostic tasks on different levels can look like this:

1 level: determination of contingent with possible acoustic trauma, acoustic barotrauma for direction on a higher level

2 levels: Acoustic trauma, acoustic barotrauma. Violation of hearing, Vestibular dysfunction.

3 levels: Perceptive, conductive or combined violation of auditory function. Sensorineural hearing loss with violation (or without) of legibility of language. Phenomena of accelerated increase in volume (AIV). Violations in the system of sound conductivity. Determination of parameters of tinnitus. Acoustic trauma, acoustic barotrauma. Vestibular dysfunction.

4 levels: Final, a concrete diagnosis is extended. Violations in the central parts of auditory analyzer. Acoustic trauma, acoustic barotrauma. Central vestibular syndrome.

Obligatory examination of auditory function is necessary for such servicemen with possible acoustic trauma:

1. All, who got a "contusion"; CCI, wound in the area of head

2. Injured with complaints about the decline of hearing, tinnitus, bad tolerance of loud sounds, periodic ears congestion, dizziness, long lasting and expressed stunning, severe tinnitus, ringing, headache after acoustic trauma.

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