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Tinnitus in Whiplash Injury

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INTRODUCTION

Nowadays, the neurosensorial disorders, which appreciably diminuate the quality of the life, are in a continuous increase all over the world. Some of the most frequent sensorineural disorders are the visual disorders, the hearing loss, the tinnitus and the vertigo.

Table 1 presents the main causes responsible for this phenomenon, as well as the extent to which they influence the increase of each type of neurosensorial disorders.The present work presents a certain neurosensorial disorder related to the head, namely the tinnitus of traumatic etiology. The incidence and variety of the head and neck injuries due to traffic accidents have extremely increased in recent years. By using seat belts, shoulder harnesses and head rests the amount of direct wounds and fractures are reduced in modern motor vehicles. However, the energy impact upon a person, sitting in a car involved in a traffic accident of the surprise-rear-end-collision type, is absorbed in the head and neck through an abrupt hyperextension and hyperflexion movement, which also is called the whiplash injury mechanism. These abrupt movements of the head and neck may have several morpho-functional consequences upon the cervical region, as well as upon the nervous and sensorial structures of the head.

In Germany during 1992, we had to deal with about 200,000 cases of whiplash injuries due to traffic accidents. The consequences of the trauma can appear immediately after the accident, but most frequently, the traumatic incident is followed by a period of more or less clinical silence and the symptoms become evident only after hours, days or months. Statistically, about 80% of the cases with whiplash injuries due to traffic accidents recover within a few months. However, about 15% - 20%, i.e., about 40,000 cases/year, develop the so-called "late whiplash injury syndrome" with many invalidating complaints including neck pain, headache, disturbances in the sphere of the head sensorineural systems, e.g., vertigo, vegetative symptoms, hearing loss, tinnitus, visual disturbances, as well as cerebral post-traumatic disturbances.

Despite these severe complaints, most of the cases are lacking of objective evidence. The orthopedic as well as the radiological findings mostly are unsatisfactory with respect to the neurosensorial disturbances. Therefore

Table 1. Causes of the neurosensorial disorders.

Causes	Visual disorders	Hearing loss	Tinnitus	Vertigo
Hereditary factors	x	x	x	x
Age	xxx	xxx	xxx	xxx
Special sensorial diseases	x	x	x	x
Cardiovascular diseases	xxx	xxx	xxx	xxx
Metabolic diseases	xx	xx	xx	xx
Tumors	x	x	x	x
Toxics	(x)	xx	xx	xx
Noise	-	xxx	xxx	(x)
Accidents (Trauma)	xxx	xxx	xxx	xxx

XXX - very frequent **XX** - frequent **X** - rare **(X)** - very rare **-** - never

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Table 2. Topodiagnostic differentiation of the post-traumatic syndromes following a whiplash injury.

Syndrome	Localization	Main symptoms
1. cervical syndrome	Neck	Neck pain, neck sprain, limitations of cervical motion including various degrees of blockades of flexion, extension and rotation, vicious positions of the cervical vertebral column.
2. cervico-brachial syndrome	Neck and shoulder-arm region	Additional to 1.: sensorimotor disturbances in the shoulder and arm area, shoulder and arm pain, and vegetative disorders.
3. cervico-medullary syndrome	Neck and spinal cord	Additional to 1.: alternating paralytic symptoms in arms and legs, vegetative disorders.
4. cervico-encephalic syndrome	Upper neck, brainstem, brain, head perception organs	Additional to 1.: headache, visual disturbances, hearing loss, *tinnitus*, vertigo, decrease invitality, difficulties of concentration, memoryloss, anxiety, restlessness, insomnia.

many of these patients are under suspicion of malingering, or their disturbances are considered as being of a psychic type. Problems of evidence also arise in compensation claims calling for an additional neurootological medical expertise.

Basically, the following types of post-traumatic syndromes due to whiplash injuries can be differentiated, as there does not exist one single disease pattern (Table 2). Of a special interest for the present work are the disturbances described as the "cervico-encephalic syndrome." This group also frequently follows a whiplash injury. They develop as the result of the years long lasting cronification degenerative processes of the lesions induced by the trauma incident. By means of the modern functional neurootological network analysis we can nowadays contribute much to clarify and to verify the disabling complaints of the late whiplash injury syndrome. This also permits us to introduce a specifical neurootological therapy.

TINNITUS

Tinnitus occupy a special place between the complaints of the patients suffering from the Late Whiplash Injury Syndrome (LWIS).

Tinnitus is an acoustical phenomenon which is perceived without having an extrinsic source of sound. Tinnitus can be theoretically differentiated in objective ear noises and/or subjective tinnitus (see Table 3).

Already in 1994, Claussen has reported the results of a study, which compared the data from 206 cases of late whiplash injury syndrome, who were in medical attention only for treatment purposes, with those from 41 neurootological expertise cases after whiplash injury. In all the cases, the neurootological disorders were late complications of a whiplash injury. In both the groups only a small number of patients had a contact-trauma, i.e., a direct concomitant knock of the head against a hard surface inside of the car, during a traffic accident. Besides the traffic accidents, which represent 91% in the first group and 73% in the second group, there were found other causes of the head and neck injuries, e.g., falling down, striking the bottom of a swimming pool in head-jumps, etc.

The mean age was 52 years in the first group and 44 years in the second group.

Remarkable is that the incidence of the subjective complaints concerning the hearing disturbances was significantly higher in the first group, i.e., 93%, than in the second, medically expertised group, i.e., 68%.

The incidence of the post-traumatic tinnitus was 55.8% in the first group and 61.0% in the second one. In 44.7% of the patients from the first group and in 53.7% of the patients from the second group the phenomenon was already present for years.

Table 3. Differentiation of the so-called "Tinnitus phenomena".

Tinnitus group	Description
Objective noises (Bruits)	Vascular noises, muscular noises, effusion noises, Tuba aperta, temporomandibular joint noises.
Subjective tinnitus	
•Tinnitus aurium	Obstruction of the auditory canal, conductive hearing disturbances, perception hearing disturbances in the inner ear, as well as retrocochlearly.
•Tinnitus cranii sive cerebri	Cerebrovascular diseases, cerebral tumors, epilepsy, Slow Brainstem Syndrome, cortical cerebral dysfunctions.
Exogenously induced tinnitus	Syndrome of the hypersensitive ear (HES).

Table 4. Tinnitus characteristics in patients with whiplash injury, without and with neurootologic expertise, respectively.

Symptoms	Clinical whiplash injury cases in % (206 cases=100%)	Expertised whiplash injury cases in % (41 cases=100%)
Pulsating	4.4	2.4
Humming	12.6	4.9
Whistling	3.6	21.9
Hissing	0.5	12.2
Ear pressure	24.3	12.2
Ear pain	8.3	9.8
Rustling		17.1

INVESTIGATION OF 91 CASES OF LATE WHIPLASH INJURY SYNDROME (LWIS), WITHOUT A CONTACT TRAUMA

In the present work we concentrated our attention upon those cases of LWIS who were labeled and treated by numerous other doctors and representants of insurance companies as so-called "trifle-cases". For this reason we have selected 91 cases who suffered a whiplash injury without a contact trauma during a traffic accident, i.e., there was no direct knock of the head and/or neck against a hard surface inside of the car. Likewise, in none of these cases a cerebral commotion or a cerebral concussion could be established after the accident.

Table 5. General characteristics of a sample of 91 patients during accident litigation suffering from LWIS, without contact trauma, as well as without cerebral concussion or contusion.

Parameter	**Number Total=91**	**Percent (91=100%)**
Males	51	56.0
Females	40	44.0
	Mean value	**± STDev**
Age	45.6	13.5
Weight	75.0	15.3
Height	171.6	8.6
Systolic blood pressure	129.0	17.7
Diastolic blood pressure	79.0	11.5
Years passed since the accident	6.0	5.1
Number of previous medical findings	11.8	11.3
Number of previous medical expertises	3.4	3.6
Number of previous medical findings/diagnoses	0.8	0.7
Number of DD confirmations	2.4	2.5
Maximal value of DD	0.5	0.4
Minimal value of DD	0.1	0.2
Number of the different medical specialities	5.0	2.4

The main descriptive data of this sample are presented in Table 5. As Table 5 shows, these patients had complaints of the LWIS for a long time, and were repeatedly investigated by many different medical specialists prior of coming to us. The degree of disability (DD), was established several times, in most of the cases. The difference between the maximal and the minimal mean values of the DD established for the same case, i.e.; 0.50 and 0.09 respectively, shows the great discordance between different medical expertises and appears to be unacceptable. Once more it reflects the uncertainty of the doctors as it concerns the neurosensorial disturbances, and appeared as late complications of the whiplash injury.

From the main sample of 91 cases with LWIS, we extracted three distinct subsamples. The first comprised all the cases who subjectively complained of tinnitus.

In the second subsample were included those cases in whom the presence and the characteristics of tinnitus could be objectivated through an audiometric method, i.e., the masking of the tinnitus.

In the third subsample were included those cases who suffered from the so-called Hypersensitive Ear Syndrome (HES) (Claussen 1985). In this syndrome, the appearance of the pathological ear noise, i.e., tinnitus, is caused by extrinsic noises. Therefore, the audiological investigations by the tinnitus masking method mostly cannot determine the presence of the tinnitus at the moment of the examination. On the other hand, it can be demonstrated through audiometrically measurable changes of the bandwidth of the acoustical dynamics, that in these patients the exposure to stronger noises or/and sounds induces an extremely intensive and painful tinnitus.

The audiometrical results then were underpinned through analyses of the acoustical pathway.

The subdivision of the main sample from the point of view of the above described criteria is presented in Table 6.

All the patients were investigated through a detailed and systematic history. The percentage distribution of the most important non-acoustical subjective symptoms in the above described samples of patients is presented in Table 7.

Table 7 shows that in all the samples other sensorial disturbances are considerably present.

Table 8 combines the data concerning the hearing disturbances with those concerning the tinnitus. In the HES-group not all the patients suffered from tinnitus at the time of investigation.

Table 6. Classification of 91 patients suffering from LWIS from the point of view of the type of the ear noise.

Sample	Total number	Males	Females
LWIS	91	51	40
Subjective tinnitus	73	41	32
Maskable tinnitus	19	12	7
HES	34	17	17

Table 7. Percentage distribution of the most important non-acoustical subjective symptoms in four samples of patients with LWIS.

Complaint	LWIS (91=100%)	Subjective ear noises (73=100%)	Maskable tinnitus (19=100%)	HES (34=100%)
Headaches	92.3	91.8	94.7	100.0
Decrease of efficacy	84.6	83.6	94.7	97.1
Decrease of awareness	78.0	80.8	89.9	91.2
Depressions and agitations	59.3	61.6	57.9	67.6
Vertigo symptoms	94.5	95.9	94.7	94.1
Vegetative symptoms	83.5	90.4	100.0	88.2
Vertigo trigger mechanism	95.6	97.3	100.0	94.1
Diplopia	28.6	28.8	36.8	38.2
Oscillopsy	53.8	60.3	68.4	64.7
Facial paresthesia	18.7	17.8	26.3	29.4
Paralytic symptoms	8.8	8.2	5.3	11.8
Paresthesias	57.1	61.6	63.2	67.6

Table 8. Percentage distribution of the most important acoustical subjective symptoms in four samples of patients with LWIS.

Complaint	LWIS (91=100%)	Subjective ear noises (73=100%)	Maskable tinnitus (19=100%)	HES (34=100%)
Hearing impairment	74.7	82.2	89.5	76.5
Tinnitus	80.2	100.0	100.0	79.4
Tinnitus complications	14.3	17.8	36.5	17.6

Table 9. Percentage distribution of the qualitative subjective characteristics of tinnitus and other ear-complaints in four samples with LWIS.

Parameter	LWIS 91 = 100%	Subjective ear noises 73 = 100%	Maskable tinnitus 19 = 100%	HES 34 = 100%
Pulsating right ear	1.1	1.4	5.3	0.0
Pulsating left ear	4.4	5.5	10.5	5.9
Rustling right ear	18.7	23.3	31.6	20.6
Rustling left ear	19.8	24.7	31.6	29.4
Humming right ear	8.8	11.0	10.5	5.9
Humming left side	8.8	11.0	10.5	5.9
Whistling right ear	31.9	39.7	57.9	35.3
Whistling left ear	33.0	41.1	52.6	41.2
Hissing right ear	5.5	6.8	5.3	5.9
Hissing left ear	7.7	9.6	5.3	5.9
Right ear pressure	12.1	15.1	15.8	11.8
Left ear pressure	13.2	16.4	10.5	11.8
Right otalgia	9.9	12.3	15.8	8.8
Left otalgia	7.7	9.6	10.5	5.9
Other feelings	8.8	11.0	10.5	0.0

When analyzing the qualitative characteristics of the ear sensations, the highest incidence of the complaints is found in the sample of patients with maskable tinnitus (Table 9).The clinical experience showed that in the case of the LWIS, symptoms like otalgia or pressure in the ear may accompany tinnitus. Their presence can be due to traumatical changes induced during the accident in the maxillary sinuses, as well as in the temporo-mandibular joints.

Many patients could also give details about the temporal variations of the tinnitus, i.e., their duration and/or the moment when they most frequently occurred (Table 10). Many patients reported the presence of several complaints and disturbances which we considered as being complications of the tinnitus (Table 11).

All the patients were asked to make a personal subjective estimation of the evolution of their complaints, since the moment of the accident (Table 12)

Table 10. Percentage distribution of the data concerning the moment of appearance and the duration of tinnitus in four samples of patients with LWIS.

Parameter	LWIS 91 = 100%	Subjective ear noises 73 = 100%	Maskable tinnitus 19 = 100%	HES 34 = 100%
Permanent tinnitus	22.0	24.7	63.2	14.7
Alternating tinnitus	55.0	68.5	42.1	58.8
Maximum in the morning	1.1	1.4	0.0	0.0
Maximum in the evening	2.2	2.7	5.3	2.9
Tinnitus with fluctuating Intensity	8.8	11.0	15.8	11.8

Table 11. Percentage distribution of the data concerning the tinnitus complications in four samples of patients with LWIS.

Parameter	LWIS 91 = 100%	Subjective ear noises 73 = 100%	Maskable tinnitus 19 = 100%	HES 34 = 100%
Tinnitus complications altogether	14.3	17.8	36.8	17.6
Difficulty in falling asleep	8.8	11.0	26.3	11.8
Sleep disturbances	4.4	5.5	15.8	2.9
Depressions	4.4	5.5	10.5	2.9
Suicide tendency	1.1	1.4	5.3	0.0
Acute hearing loss	5.5	6.8	10.5	2.9

Table 12. Percentage distribution of the subjective estimation of the evolution of the neurootological complaints following a trauma, in four samples of patients with LWIS.

Parameter	LWIS 91 = 100%	Subjective ear noises 73 = 100%	Maskable tinnitus 19 = 100%	HES 34 = 100%
Able to make an estimation	97.8	98.6	100.0	97.1
Unchanged	69.2	67.1	57.9	55.9
Slightly improved	7.7	8.2	0.0	5.9
Significantly improved	1.1	1.4	0.0	0.0
Slightly worsened	8.8	8.2	15.8	14.7
Significantly worsened	11.0	13.7	26.3	20.6

Table 13. Percentage distribution of the results obtained through the pure tone audiometry investigation of the right ear, in four samples of patients with LWIS.

Parameter	LWIS 91 = 100%	Subjective ear noises 73 = 100%	Maskable tinnitus 19 = 100%	HES 34 = 100%
Normal hearing	15.4	12.3	5.3	11.8
Pancochlearly impaired hearing	19.8	23.3	15.8	8.8
Low tone affection	5.5	4.1	0.0	8.8
Middle tone affection	7.7	6.8	0.0	14.7
High tone affection	49.4	52.0	73.7	58.8
Deafness	2.2	2.7	5.3	0.0

Table 14. Percentage distribution of the results obtained through the pure tone

Parameter	LWIS 91 = 100%	Subjective ear noises 73 = 100%	Maskable tinnitus 19 = 100%	HES 34 = 100%
Normal hearing	11.0	8.2	0.0	11.8
Pancochlearly impaired hearing	13.2	15.1	15.8	5.9
Low tone affection	8.8	8.2	0.0	5.9
Middle tone affection	6.6	6.8	0.0	11.8
High tone affection	56.0	58.9	84.2	67.6
Deafness	3.3	2.7	0.0	0.0

Two of the 91 patients were not able to make a personal estimation concerning the evolution of their disease.
In all, the patients were given complete neurootometrical, i.e., audiometrical and equilibriometrical investigations. The results of the pure tone audiometry investigation were classically classified in normal hearing, pancochlearly impaired hearing, low tone hearing loss, middle tone hearing loss, high tone hearing loss, deafness, for each, i.e., right and left ear. Thereby taken into consideration only hearing losses of perception type, assessed by the bone conduction testing. The results are presented in Table 13 for the right ear and in Table 14 for the left ear.All the patients were reviewed with speech, reflex and dynamic audiometrical tests. The characteristics of the ear noises were specifically investigated through the tinnitus masking method. The state of the acoustical pathways was investigated by means of the acoustically evoked brain stem potentials as well as the acoustically evoked late (cortical) potentials. The results are presented in Table 15.
For functionally verifying and differentiating the site and the type of the lesion, we performed in every case very complex objective and quantitative equilibriometric investigations, e.g., the vestibulo-ocular, the retino-ocular, and the vestibulo-spinal tests, as well as the eye movement coordination test and the visually evoked cortical potentials (VEP). The vestibulo-ocular and retino-ocular reactions are investigated by the method of polygraphic electronystagmography and the vestibulo-spinal reaction by cranio-corpo-graphy with simultaneous computer analysis. The vestibulo-vegetative reactions are permanently monitored by a simultaneous EKG-registration.

Table 15. Percentage distribution of the pathological brain stem and cortical acoustically evoked potentials in four samples of patients with LWIS (ABEP=Acoustic Brainstem Evoked Potentials; ALEP=Acoustic Late (Cortical) Evoked Potentials)

Parameter	LWIS 91 = 100%	Subjective ear noises 73 = 100%	Maskable tinnitus 19 = 100%	HES 34 = 100%
Right side disturbance of ABEP	64.8	67.1	89.5	58.8
Left side disturbance of ABEP	65.9	67.1	94.7	67.6
Right side disturbance of ALEP	58.2	57.5	47.4	64.7
Left side disturbance of ALEP	53.8	53.4	63.2	58.8

Table 16. Average incidence of the identified and proven functional sensorial disturbances

Parameter (Average ± Standard Deviation	**LWIS 91 = 100%**	**Subjective ear noises 73 = 100%**	**Maskable tinnitus 19 = 100%**	**HES 34 = 100%**
Altogether identified disturbances	7.3 ± 4.3	7.3 ± 4.2	7.8 ± 5.4	8.8 ± 4.7
Disturbances induced by the trauma	7.1 ± 4.2	7.1 ± 4.1	7.6 ± 5.2	8.4 ± 4.7

The state of the cerebral arteries was searched by Doppler sonography and in certain cases supplementary tests, e.g., olfactometry, rhinomanometry, chemogustometry and electrogustometry were also performed.

The results of these complex and sensorial investigations showed that in nearly all the patients tinnitus was not an isolated phenomenon, being mostly associated to other multisensorial neurootological functional disturbances. Because of the medical expertise questioning, a clear differentitation between the disturbances brought about the accident and those already pre-existing or having other causes must be done for each of the cases. In our study, the multisensorial neurootological disturbances were caused in nearly all the patients, by the whiplash injury (Table 16).

As all the cases come to us with a very rich medical, hospital, litigation, and expertise documentation accumulated in the period of time following the accident, however, including also pre-accidental patient information, we get complete information about the evolution of the disease, the intermediary symptoms and the pre-existing medical results and diagnosis.

DISCUSSION

The problem of tinnitus as a consequence of whiplash injury is intensively discussed in the neurootological literature since 1928.

In 1928 tinnitus is mentioned by Barré and Lieou as being the most frequent symptom in the patients with cervico-spinal injury. Decher reports in 1966, that 41% of 500 patients with a history of cervico-spinal injury complain of tinnitus. In a statistical study from 1983 we found an even higher percent, i.e., 56.9% from 452 patients with whiplash injury had tinnitus.

In 1949, Bärtschi-Rochaix reports that the variety of the ear noises described by the patients with cervico-spinal injury is very great, e.g., "singing, buzzing, humming, whizzing, pulsating, rustling, whistling, hissing, etc." He also remarks that the characteristics of the tinnitus can very much depend on certain positions of the head.

In most of the patients investigated by these authors, tinnitus appears as a result of the so-called "degenerative cervico-spinal injury syndrome". In many cases the disturbances are also caused by vascular problems in the posterior cranial fossa, due to a narrowing of the vertebral artery in the cervical region.

In a recent neurootological study from 1991, Oosterveld et al. report that 14% of a sample of 262 patients with simple whiplash injury, complained of tinnitus. 86% of these patients had also vertigo complaints. These cases were classified and treated as "trifle-and minor-traumas" by all the doctors and experts who have seen them prior to him. For this Dutch team, the neurootological investigations are of an exceptional importance for a correct judgement of the patients with whiplash injury, as namely they can reveal the long lasting degenerative and cronification processes following the trauma. Their studies and conclusions are based upon the numerous pathological electronystagmographical findings, and also the corresponding pathological audiological results.

Shulman, who is considered as one of the pioneers and an exceptional specialist in the field of the tinnitus research, shows in his book about the modern diagnosis and therapy of tinnitus, that the severe, disabling tinnitus is usuall1y associated with anxiety psychosis. Because of their permanent presence, the ear noises often become intolerable and are seriously disturbing the daily personal life. The degree of the psychical impairment is directly depending on the intensity of the tinnitus.

The observation of Shulman, that in most of the tinnitus cases, there coexists a high tone sensorineural hearing loss, is valid for the patients investigated by us, too.

Further on, Shulman shows that about 20% of the patients with severe tinnitus also have vertigo complaints. We also frequently find this stato-acoustical combination in our tinnitus patients with a cervico-encephalic syndrome, due to a whiplash injury.

Based upon the numerous observations from all over the world, concerning the late complications of the whiplash

injury, we can affirm that even the simple, non-contact whiplash injury can be the cause of long lasting, cronic polisensorial disturbances. As it was shown above, tinnitus plays a special role in the complex mosaic of these multisensorial neurootological functional disturbances. By means of the modern functional neurootological network analysis we can contribute much to clarify and to verify the disabling complaints which appear in the late whiplash injury syndrome. This is very important on one side for the medical expertise and on the other hand for the correct diagnostic and therapeutical evaluation of these patients.

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