

**Medicine.** — *Vestibular nystagmus caused by acoustic stimulation.* By  
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In 1803 ERASMUS DARWIN, in his "Zoonomia or the laws of organic life" mentioned an audible vertigo "as is known by the battement or undulations of sounds in the ear". After that many publications on vertigo, caused by more or less determined acoustic stimuli, appeared. BORRIES<sup>1</sup>), however, with good reason pointed to the fact that different persons often state very different sensations of their vertigo; from literature too it remains mostly unestablished whether these sensations are of vestibular origin.

We therefore chose for this communication the title "Vestibular nystagmus caused by acoustic stimulation" on purpose as we have the intention to discuss only those cases in which a vestibular reflex was indeed caused by acoustic stimuli.

The first paper about this affection, not a very supporting one, however, is found in the Arch. of Ohrenheilkunde 1881 (vol. 17, page 181). Here BÜRKNER, giving the report of his out-patient department in Göttingen communicated (case 9): "In einem Fall von langjähriger rechtseitiger Mittelohreiterung, der ein zwanzigjähriges Mädchen betraf, fiel mir, zuerst bei der Einführung des Ohrtrichters, später auch beim Spritzen auf, dass regelmäßig bei diesen Masznahmen Nystagmus der Augen eintrat. Eine genaue Untersuchung ergab schliesslich, dass sogar die Anstrengung des kranken Ohres bei den Hörprüfungen jedesmal zum Nystagmus führte. Die Kranke selbst merkte von den Bewegungen der Augäpfel nichts, die in der Augenklinik vorgenommene Untersuchung der Augen ergab nur negative Resultate".

In this case, however, it is very doubtful whether strictly speaking an acoustic reflex was present. We have the impression that this patient showed a so-called "readiness for nystagmus", which accounted for the fact that a nystagmus occurred after various sensible stimuli whatever the nature of these stimuli was. BÜRKNER emphasized the fact that not only after acoustic stimulation, but also after inserting an ear-tube or after syringeing the ear, this nystagmus developed.

URBANTSCHITSCH, in his "Lehrbuch der Ohrenheilkunde" 1901, wrote that sometimes he had been able to elicit a nystagmus by acoustic stimulation. Textually he wrote: "Nystagmus fand ich wiederholt durch akustische Einwirkungen ausgelöst vor, zuweilen durch bestimmte Schall-

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<sup>1</sup>) BORRIES, G. V. TH., Monatschr. f. Ohrenheilk., 57, 547 (1923).

einwirkungen oder durch einen bestimmten Ton". In later publications, a.o. in another edition of his book (1910)<sup>2)</sup> he only refers to the above-mentioned phrase of 1901, without any statement in which way his investigations were performed, on which tones his patients with nystagmus reacted and which form of nystagmus developed after the acoustic stimulation.

Nor do the symptoms observed by BÁRÁNY<sup>3)</sup> and SCHWARTZ in their patient belong to the purely acoustic reflexes. These investigators were able to elicit a non-vestibular undulating nystagmus by placing a (strongly) vibrating tuning-fork on the mastoid of the patient. It also appears from this communication that in this hysterica the same nystagmus could be elicited in another way, e.g. when the patient closed her eyes and BÁRÁNY himself tried to lift the upper eye-lid (test of STRANSKY). BÁRÁNY intended to write an extensive publication of this case. However, we could not find in literature a paper with more exact details.

RUTTIN<sup>4)</sup> published an important paper about two of his patients (1915). Both were suffering from a congenital lues and showed the so-called fistula-symptom of HENNEBERT, i.e. a nystagmus developing sometimes in patients with congenital lues, after changing the air-pressure in the auditory canal and middle ear by compression or aspiration.

Pronouncing the letter *M* and *N* one patient developed a dizziness and only a slight nystagmus; the other patient, however, showed a marked nystagmus.

RUTTIN attributed this nystagmus to an increased pressure, developing in the middle ear when pronouncing the letters *M* and *N* by which secondary the fistula symptom should be elicited. BORRIES<sup>5)</sup> rightly held that at the same time an acoustic stimulation may have played a part. This supposition is the more acceptable after the well-known experiments of TULLIO<sup>6)</sup> which were confirmed and extended by many other investigators (f.i. JELLINEK<sup>7)</sup>, HUIZINGA<sup>8)</sup>, BENJAMINS<sup>9)</sup>). TULLIO could elicit a nystagmus and body-reflexes in some animals (a.o. pigeons and rabbits)

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<sup>2)</sup> URBANTSCHITSCH, Lehrbuch d. Ohrenheilkunde, 106 (1901); 487 (1910). Nor are any convincing observations reported in his extensive communication (Ztschr. f. Ohrenheilk., 31, 234 (1897)). „Ueber Störungen des Gleichgewichtes und Scheinbewegungen“.

<sup>3)</sup> BÁRÁNY, Monatschr. f. Ohrenheilk., 42, 667 (1908).

<sup>4)</sup> RUTTIN, Monatschr. f. Ohrenheilk., 40, 267 (1915).

<sup>5)</sup> BORRIES, C. V. Th., Monatschr. f. Ohrenheilk., 57, 547 (1923).

<sup>6)</sup> TULLIO, P., Das Ohr und die Entstehung der Sprache und Schrift (Urban und Schwarzenberg, Berlin—Wien, 1929).

<sup>7)</sup> JELLINEK, Monatschr. f. Ohrenheilk., 62, 241 (1928).

<sup>8)</sup> HUIZINGA, Verslagen Ned. Keel-, Neus-, Oorheelkundige Vereeniging, Mei 1934, Mei 1936 en Mei 1938. (Ned. tijdschr. v. Geneesk. 79, 1319 (1935); 81, 1083 (1937); 83, 2389 (1939).

Pflügers Arch., 234 665 (1934).

<sup>9)</sup> BENJAMINS, Verslagen Ned. Keel-, Neus-, Oorheelkundige Vereeniging, Nov. 1936 en Nov. 1938 (Ned. tijdschr. v. Geneesk., 81, 2557 (1937) en 83, 3646 (1939)).

by delivering very hard tones directly to the ears. However, as in these tests tactile stimulations may play a part<sup>10)</sup> other examinations are of more importance. In these tests, after making a fistula in one of the semi-circular canals a marked nystagmus developed when less distinct tones were produced at a distance. TULLIO held that under these circumstances the acoustic waves radiate to the endolymph in the semi-circular canals and in this way should stimulate the cristae without intervention of cochlear reflexes.

One must assume then that under normal circumstances i.e. when a fistula is absent, the ordinary sounds only penetrate to the cochlea and not in a sufficient intensity to the cristae, because the sound-waves are already deadened before reaching the cristae. After making a fistula in the semi-circular canal a penetration to the cristae is possible because with this new opening a turning-aside is obtained which can be compared with the foramen rotundum in the cochlear system (HUIZINGA).

In the experiments of TULLIO it is quite or nearly impossible to elicit the vestibular symptoms by the influence of a sound when the cochlea has been destroyed before. This was the reason why many investigators thought that the cochlear reflexes should play the principal if not the only part. HUIZINGA, however, could refute this conception in performing very exact experiments on pigeons. When destroying the cochlea without impairment of the conducting apparatus, tympanic membrane or columella, the reflexes of TULLIO appeared to be impaired to a small degree by this operation. HUIZINGA, with good reason, now thought, that the above-mentioned disturbances, found by other investigators after removal of the cochlea, must be attributed to a simultaneous lesion of the tympanic membrane and the ossicles. To sum up, it seems very probable that the vertigo and the nystagmus, developing in the patients (with a fistula symptom) of RUTTIN, when pronouncing the *M* and *N*, are also due to acoustic reflexes.

The same holds true for the patient of BENJAMINS<sup>11)</sup> in which case also a fistula symptom and the reactions of TULLIO were present. These disappeared after a radical middle ear operation by which the transmission apparatus for the sound was also removed. This completely agrees with the above-mentioned experiments of HUIZINGA.

More difficult to explain are the vestibular symptoms caused by sound-stimulations, developing in patients without fistula symptom and in whom

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<sup>10)</sup> The same holds true for the eye-movements observed by FRÖSCHELS, (Monatschr. f. Ohrenheilk., 60, 883 (1926) and 61, 776 (1927) after delivering the tones of the harmonica of URBANTSCHITSCH by means of an otoscope directly into the auditory canals of deaf-mutes. There remains a doubt as to whether in these cases a vestibular symptom was present. For FRÖSCHELS states that in one child the labyrinths could not be stimulated calorically and on turning. Another patient, examined when a caloric and a turning nystagmus were present, showed both forms of eye-movements, the one developing independently of the other.

<sup>11)</sup> Loco cit. S. also QUIX, F. H., L'oto-rhino-laryngologie intern. 21. Juillet 1933.

complete absence of other acoustic and vestibular disturbances exist. BENJAMINS reported a typical observation <sup>11)</sup>).

This patient, 28 years of age, developed a dizziness as soon as a certain noise was produced. Acoustic, vestibular, internal and neurological examinations revealed no disturbances: only the vertical semi-circular canals were more difficult to stimulate than the horizontal ones. The serological reactions for lues were negative. Only in the region of 1600—3000 V.D. a vestibular reaction developed at an intensity of 84—98 decibel. This reaction consisted of a vertical nystagmus (the direction was not indicated by BENJAMINS). BENJAMINS pointed to the fact that the marked reactions developed with sounds in the resonance region of the external auditory canal (2500—3000 V.D.).

It was evidently difficult for BENJAMINS to explain these symptoms. He interpreted them as TULLIO-reactions and looked for another explanation as the patient showed no fistula symptom. He thought that this was found if one assumed that an air-bubble had entered the perilymphe. BENJAMINS writes "it is not only theoretically but also experimentally established. HUIZINGA <sup>12)</sup> found in his experiments that when an air-bubble had entered the fistula canal and when afterwards this fistula was blocked with wax, the reaction of TULLIO remained present, whereas occlusion without air in the canal made the reaction disappear. It remains a matter of dispute how this air-bubble has developed in this patient".

The explanation of BENJAMINS, however, is a very hypothetic one. Not only is it obscure to us how the air-bubble has developed, but also that the patient had had his complaints for rather a long time: the air-bubble should be resorbed after a short time!

BENJAMINS probably made his hypothesis under the impression that the symptoms shown by his patient only could be TULLIO-reactions. However, this is not necessary. Besides the reflexes of TULLIO other reflexes exist which exert influence directly from the cochlea upon the vestibular region.

Our experiments, not published up to now showed that on registering a vestibular nystagmus in rabbits by the TOPOLANSKI-BARTELS method, this nystagmus can be influenced by different sound-stimuli which change the size and velocity of the nystagmus.

Considering these facts it seems more probable that in the above-mentioned case of BENJAMINS the dizziness and nystagmus of his patient were elicited by direct cochlear reflexes and must not be considered to be TULLIO-reactions.

This could be confirmed by an observation made by us. This patient showed the same symptoms as the patient of BENJAMINS. It is hardly to be believed that here too an air-bubble in the perilymphe was present, the more so as above-mentioned explanation is more obvious and acceptable.

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<sup>12)</sup> Loco cit.

Miss S., 35 years of age, told that in pronouncing the letter *N*, she became dizzy. This was especially the case if she looked to the left at the same time.

Extensive acoustic and vestibular examination showed no disturbances. The whispering voice was normal at either side. The fistula symptom could not be elicited. Spontaneous nystagmus in different lookings and the different forms of position nystagmus were completely absent.

Examination of the horizontal and vertical optocinetic nystagmus gave normal results both for the cortical and subcortical forms in all directions. The horizontal and rotatory turning nystagmus were, after turning to the right and to the left, normal and of equal duration. The vertical turning nystagmus downward was more marked than the one upward (19 × turning to the right in right lateral position: vertical after-nystagmus upward: 11 movements in 8"; 10 × turning to the left: vertical after nystagmus downward: 38 movements in 13"). Stimulation of both the labyrinths with cold and warm water was equal and normal.

The tilting reactions of RADEMAKER and GARCIN around the bitemporal and longitudinal axis were not disturbed. Pronouncing the letter *N*, especially when pronouncing the Dutch word „Niemand” accentuating the *N* and on looking to the left, a rotatory nystagmus appeared; sometimes a deviation of the eyes upward was seen. Once a nystagmus consisting of both components, directed with its quick component downward, could be noticed. After provoking different tones by the audiometer, with the patient at a distance of about a metre from this instrument, to exclude tactile influence by the air, eye-movements also developed. These eye-movements appeared when the tone sounded or when the tone was interrupted.

The protocol is as follows:

Tuning fork, 64 vibr.: no eye-movements.

Audiometer, 128 vibr.: „ „ „

512 vibr.: „ „ „

1024 vibr.: on looking to the left a marked vertical nystagmus with its quick component upward developed when the tone was sounded or interrupted; looking forward also caused marked nystagmus movements upward.

2048 vibr.: sounding and interrupting of this tone caused a nystagmus movement upward which only lasted a short time more pronounced on looking downward. Sometimes quick movements of the head in the saggital region developed.

4096 vibr.: same as in 2048 vibr.

It is remarkable that penetration of the acoustic stimulation into the tuba (pronouncing the *N*) caused a nystagmus partly directed vertically downward, whereas the opposite direction of the nystagmus was seen if the auditory canal served as an acoustic conduction.

The patient herself recognized the eye-movements which developed: she indicated the rotatory movements as lateral, the vertical ones as movements in the vertical region.

The brother of the patient stated that he also became dizzy and lost his equilibrium when marked and low tones sounded.

Up to now we were not able to examine this patient.

Summarizing we see that:

1. Acoustic stimulation can elicit vestibular symptoms, e.g. a nystagmus, in certain patients.
2. The acoustic stimulation propagates directly to the cristae if a fistula is present in one of the semi-circular canals. This could be demonstrated

experimentally by TULLIO, JELLINEK, and HUIZINGA; in man this phenomenon was reported by BENJAMINS.

3. Acoustic reflexes can cause a nystagmus from the cochlea upon the vestibular system. This was experimentally proved in rabbits; the symptoms found in two patients without fistulae and with normal hearing (one patient of BENJAMINS and one patient in our clinic), could be explained in the best way by these facts.

The explanation of BENJAMINS of the symptoms found in his patient, did not prove to be a convincing one.

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