INVESTIGATION OF THE COCHLEAR CIRCULATION OF THE INNER EAR IN ANIMALS BY A RHEOGRAPHIC METHOD

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A method of cochlear rheography is proposed and was tested under acute conditions on guinea pigs and cats. The term rheocochleography is suggested. Circular electrodes, 0.2 mm in diameter, were made from metal foil and fixed by means of a spring to the apex of the cochlea and to its base. The rheocochleogram of the cochlear vessels was recorded with a type RG-1-01 rheograph. The rhecochleogram showed definite changes after ligation of the internal auditory artery, injection of adrenalin and acetylcholine solutions into the perilymphatic space, and acoustic stimulation of the ear.

To determine the etiology and pathogenesis of some diseases of the inner ear and to choose rational pathogenetic treatment, it is necessary to be able to assess the state of the circulation in the labyrinth. This problem has not yet been adequately studied.

The method of labeled atoms [1], used to investigate the cochlear circulation, gives evidence only of the permeability of the cochlear vessels and of the blood-labyrinth barrier. The various morphological methods [8-10] do not reveal the dynamics of functional changes in the cochlear vessels.

Because of the disadvantages of these methods, the rheographic method was used to study the circulation in the inner ear. The rheographic method of investigation of the circulation is based on recording the electrical resistance of the living tissues due to fluctuations in the degree of filling of the vessels with blood and of the velocity of blood movement. This method has been extensively used to study the functional state of blood vessels in the brain [4-7], the eye [3], the dental pulp [2], and other organs.

A method of cochlear rheography was developed in acute experiments on animals. Since this method was being used for the first time, the name rheocochleography was given to it.

Investigations were carried out in guinea pigs and cats in which the cochlea is conveniently situated for electrode fixation. Under chloralose-hexobarbital anesthesia, the bony labyrinth and bulla were opened, so that one electrode could be fixed to the apex of the cochlea and the other to its base, slightly medially to the fenestra rotunda. Reliable fixation of the electrodes so that they could not move about during the experiments was ensured by means of special springs. The electrodes were made of metal foil and consisted of circular disks 0.2 mm in diameter. The rheogram of the cochlear vessels was recorded by means of a type RG-1-01 rheograph and a type EEChS-1 two-channel ink-writing electroencephalograph, the second channel of which was used to record the ECG in standard lead II.

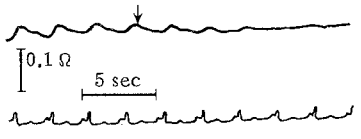

Fig. 1. Rheocochleogram before and after ligation of internal auditory artery. Upper curve shows rheocochleogram (arrow indicates moment of ligation of artery), lower curve shows ECG.

Tests were carried out by the method described above on 12 guinea pigs and 60 cats. A characteristic curve was recorded, with its waves synchronized with the ECG, and resembling a rheogram in shape. This curve can be assumed to reflect the degree of filling of the cochlear vessels with blood. To confirm this hypothesis, it was necessary to show whether the resulting curve in fact reflects the cochlear circulation and to ascertain the sensitivity of the method for

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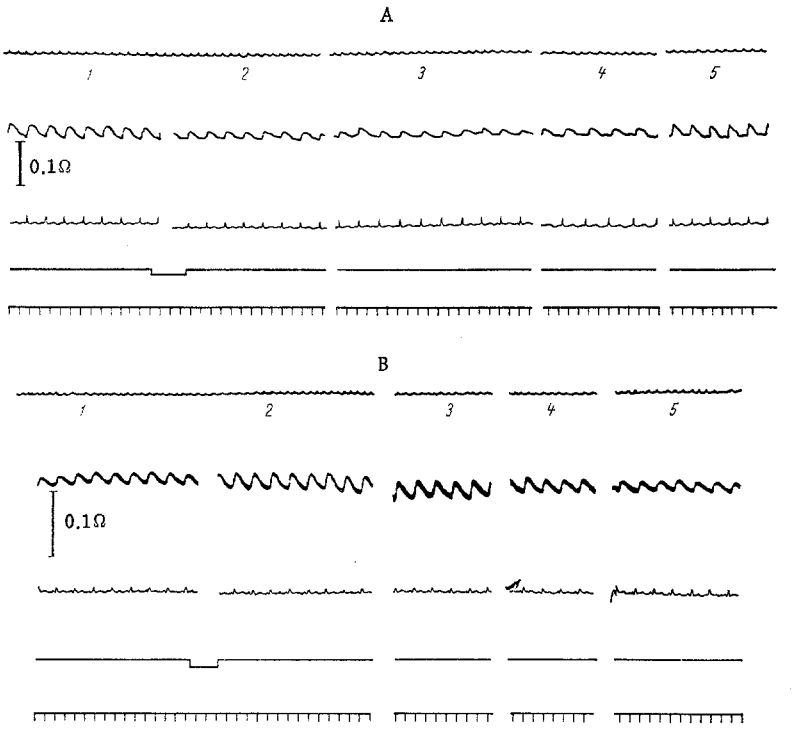

Fig. 2. Changes in rheocochleogram after injection of solutions of noradrenalin (A) and acetylcholine (B) into the cochlear perilymphatic space. From top to bottom: spontaneous respiration; rheocochleogram; ECG; time of injection of noradrenalin; time marker 5 sec. 1) Before injection; 2, 3, 4, 5) 1, 3, and 10 min respectively after injection.

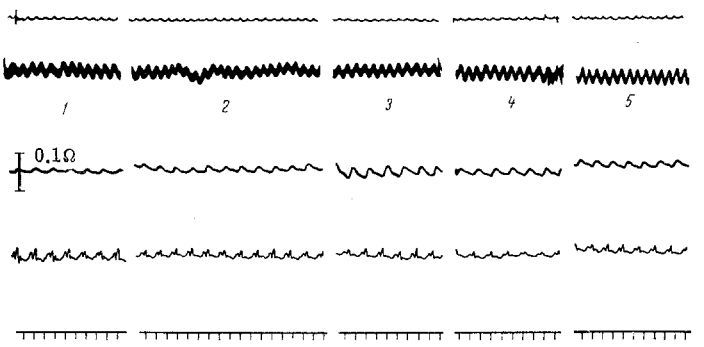

Fig. 3. Changes in rheocochleogram under influence of acoustic stimulation (1000 Hz, 50 dB). From top to bottom: spontaneous respiration; systemic arterial pressure; rheocochleogram; ECG; time marker 5 sec. 1) Before acoustic stimulation; 2, 3, 4) 15, 25, and 40 sec respectively after acoustic stimulation; 5) 10 min after stopping acoustic stimulation.

testing the effects of various external stimuli on the cochlear vessels. The most suitable method of testing reflection of the cochlear circulation on the rheogram is by ligating the blood vessel supplying the cochlea.

For this purpose, a ligature was applied to the internal auditory artery supplying blood to the cochlea, after which the rheocochleogram was recorded before and after the ligature was drawn tight around the artery. The results of this test are given in Fig. 1, which shows that after ligation of the internal auditory artery, the rheographic wave disappeared.

The sensitivity of the method was tested by application of solutions of noradrenalin and acetylcholine to the inner ear. The results of these tests showed that injection of noradrenalin solution (0.2 ml, 0.001% solution) through the secondary tympanic membrane into the perilymphatic space reduced the amplitude of the rheogram (Fig. 2A), while injection of 0.2 ml of a 0.001% solution of acetylcholine, on the other hand, increased the amplitude of the rheographic wave (Fig. 2B). Since, in these experiments, no changes occurred in the systemic arterial pressure, or the heart and respiration rates following local application of these pharmacological agents, the changes in amplitude of the rheogram observed are an index of the degree of filling of the cochlear vessels with blood.

Acoustic stimulation is the most adequate and physiological form of stimulation of the inner ear. It was therefore decided to study the changes in the cochlear circulation produced by an acoustic stimulus. The increase in amplitude of the rheographic wave under the influence of acoustic stimulation (1000 Hz, 50 dB) is clearly visible in Fig. 3. The increase in amplitude of the rheographic wave thus obtained in response to acoustic stimulation must evidently be regarded as reflecting an increase in the cochlear circulation, whereas the pulse and respiration rates and the systemic arterial pressure remained unchanged.

It can accordingly be concluded that changes in the amplitude of the rheographic wave reflect the degree of filling of the cochlear vessels with blood. The responses of the cochlear vessels in all these tests corresponded to the character of the stimuli applied.

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