EFFECT OF UNDESIRABLE SOUND (NOISE) ON CEREBRAL CIRCULATION

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RECENTLY, the pathophysiologic correlation between undesirable sound (noise) and psychosomatic disease gives rise to an important medicosocial problem among various kinds of environmental nuisances. Information as to this problem, however, from the viewpoint of cerebral circulation is scanty because of the methodological difficulty.

The author has previously presented a report on the ultrasonic Doppler apparatus equipped with a newly devised probe and on-line real-time data processing system, and the results of measurement of the blood flow change in several arteries in man simultaneously, continuously and non-operatively.

In this study, the effect of undesirable sound on the cerebral circulation in man in situ was investigated by means of this apparatus.

MATERIALS AND METHODS

The subjects were 4 normal young males and 6 normal elderly males over sixty years of age.

The blood flow change in the internal carotid artery and the vertebral artery was investigated in each subject by means of the ultrasonic Doppler apparatus before and during the administration of random noise reproduced from a tape recorder. In addition, the change of heart rate was also measured simultaneously by means of a Heart Rate Tachometer. Fig.1 and Fig.2 show the block diagram and a scene of the experiment, respectively.

RESULTS

Increase of cerebral blood flow was observed in all the subjects during the administration of the random noise. The increasing rate in the internal carotid artery and the vertebral artery was not coincident, i.e., increase in the internal carotid artery vs. no alteration in the vertebral artery, and vice versa. The frequency of both types was as follows, i.e., increasing type in the internal carotid artery, 4 cases and increasing type in the vertebral artery, 6 cases.

The interval between the onset of the noise and the appearance of the increasing blood flow pattern was as follows, i.e., within about thirty seconds, 5 cases, within about one minute, 3 cases, within about two minutes and about three minutes, one case, respectively.

The heart rate was as follows, i.e., slight increase, 8 cases and marked increase, 2 cases.

The alteration of the increasing blood flow pattern was as follows, i.e., sustaining type, in which the increasing blood flow pattern continued throughout the experiment, 8 cases and returning type, in which the increasing blood flow pattern returned to the control during the experiment, 2 cases.

As for the subjective symptom, headache and discomfort due to the noise were observed in all the subjects. In addition, disturbance of sleep was observed in two subjects. However, there seems to be no significant correlation between the subjective symptom and the alteration of the cerebral circulation. Typical examples are presented here.

Case 1 (Fig.3) — 70 years old

The blood flow in the internal carotid artery was conspicuously increased about one minute after the onset of the noise. No alteration of the blood flow was observed in the vertebral artery. The increased blood flow in the internal carotid artery was sustained throughout the experiment.

* Random noise resulting from the ultrasonic Doppler apparatus was recorded into a tape recorder. The intensity of the noise was about 100 phon.
The heart rate was slightly increased. Although headache and discomfort were observed throughout the experiment, these symptoms disappeared completely on termination of the experiment.

Case 2 (Fig.4)—64 years old
The blood flow in the vertebral artery was conspicuously increased about twenty seconds after the onset of the noise. No alteration of the blood flow was observed in the internal carotid artery. The increased blood flow in the vertebral artery was sustained throughout the experiment. The heart rate was almost unchanged. Although headache and discomfort were observed throughout the experiment, these symptoms disappeared completely on termination of the experiment.

Case 3 (Fig.5)—23 years old
The blood flow in the internal carotid artery was conspicuously increased about three minutes after the onset of the noise. A slight and transient increase of blood flow was observed in the vertebral artery. The increased blood flow in the internal carotid artery was sustained throughout the experiment. The heart rate was almost unchanged. Although headache and discomfort were observed throughout the experiment, these symptoms disappeared completely on termination of the experiment.

Case 4 (Fig.6)—70 years old
The blood flow in the vertebral artery was conspicuously increased immediately after the onset of the noise. No alteration of the blood flow was observed in the internal carotid artery. The increased blood flow returned to the control during the experiment. The heart rate was almost

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unchanged. Although headache and discomfort were observed throughout the experiment, these symptoms disappeared completely on termination of the experiment.

Case 5 (Fig.7)—31 years old
The blood flow in the vertebral artery was conspicuously increased immediately after the onset of the noise. The blood flow in the internal carotid artery was slightly altered. The increased blood flow was sustained throughout and two minutes after the experiment. The heart rate was prominently altered. Conspicuous alteration of the blood flow in the vertebral artery was observed in response to the alteration of the heart rate. Headache, discomfort and disturbance of sleep were observed even on termination of the experiment.

DISCUSSION
Audible sound (frequency 16–20,000 Hz) is transmitted from the outside to the auditory area on the temporal lobe (area 42 by Brodmann) throughout the middle and internal ears and the cochlear nerve. The audible stimulation, moreover, is transmitted into the interbrain, especially the hypothalamus in which the autonomic nervous center is located. The above physioanatomical characteristic suggests that severe audible stimulation gives rise to abnormal activation of the auditory area as well as dysfunction of the autonomic nervous system.

It is well known that photo stimulation or visual stimulation, i.e., stroboscopic illumination, reading and looking at picture etc., provoke increase of blood flow and metabolic demand on the optic area (area 17) and its adjacent area. As for the mechanism, it is considered that the

Fig.3. Effect of undesirable sound (noise) on cerebral circulation.

optic stimulation, which is transmitted from the outside to the occipital lobe throughout the retina and the optic nerve, is chiefly concerned.

The finding in this study is theoretically coincident with that of optic stimulation. As for the increase of the cerebral blood flow, the following two mechanisms are generally considered: (1) Primary increase due to the direct dilatation of the cerebral blood vessel. (2) Secondary increase due to the activation of cerebral metabolism. Of the two, the secondary increase of the cerebral blood flow is believed to be more logical.

The dissociation of the blood flow change between the internal carotid artery and the vertebral artery is a conspicuous contrast as compared with the blood flow change in the two arteries after the administration of a cerebral vasodilator such as papaverine, i.e., increasing rate of blood flow in the internal carotid artery and the vertebral artery after intravenous papaverine was significantly correlated.

As for the mechanism of the dissociation, the
The blood to the audible area and the hypothalamus is supplied by the internal carotid artery and the vertebral artery consisting the Willis's circle. Moreover, it seems that the blood to the audible area is supplied by the middle cerebral artery in which the internal carotid artery mainly participates, and that the blood to the hypothalamus is supplied by the posterior cerebral artery in which the vertebral artery mainly participates. Therefore, the dissociation of the blood flow change between the internal carotid artery and the vertebral artery may depend upon the most activated area in the brain.

To summarize, the prominent finding in the present experiment was the increase of the cerebral blood flow and the emotional disorder in all the subjects. This fact suggests that severe and repeated random noise induces an abnormal stimulation of the cerebral circulation and metabolism, and dysfunction of the autonomic nervous system.

**SUMMARY**

The effect of undesirable sound (random noise of ca 100 phon) on the cerebral circulation was investigated by means of the ultrasonic Doppler apparatus in 10 normal young and elderly males.

Increase of the blood flow was conspicuously observed in all the subjects after the onset of the noise. The increasing rate of the blood flow in the internal carotid artery and the vertebral artery was not coincident. The dissociation of

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*Fig. 6. Effect of undesirable sound (noise) on cerebral circulation.*

*Fig. 7. Effect of undesirable sound (noise) on cerebral circulation.*

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the blood flow change in the two arteries is discussed.

Headache and discomfort due to the noise were observed in all the subjects. Moreover, disturbance of sleep was observed in two cases.

The above facts suggest that severe and repeated noise induces abnormality of cerebral circulation and various kinds of psychosomatic diseases.

REFERENCES