METHODS

A METHOD OF ONCOMETRY OF THE BRAIN

K. N. Badmaev

From the Laboratory of the Leningrad Academic Group of the AMN SSSR (Scientific Director – Active Member of the AMN SSSR V. N. Shamov)

(Received March 26, 1957. Presented by Active Member of the AMN SSSR V. N. Shamov)

In the experimental study of problems affecting the circulation of blood and CSF in the brain, when dealing with the question of edema and swelling of the brain the investigator makes use of the method of oncometry of the brain, which enables him to record the smallest variations in the volume of the organ and to trace them on the kymograph [1, 2]. In contrast to oncometry of other organs, in oncometry of the brain there is no need of a special bath in which to immerse the organ under examination; the function of this bath can be fulfilled successfully by the skull itself, with its perfectly hermetic walls [7, 8, 10]. Advantages of the method include its accuracy, simplicity and relative absence of trauma.

The simplest and undoubtedly the oldest method of recording the variations in the volume of the brain is by direct observation of the movements of the exposed brain. If, however, special devices are employed, the variations become more noticeable for observation. Sealing of a special oncometer hermetically in a drill hole in the skull, for instance, by making use of pneumatic transmission and a Marey's drum, enables the variations in the volume of the brain to be traced on a kymograph (the so-called pneumatic oncometer; [3-6, 8]). If the pneumatic transmission is replaced by hydrostatic, this dispenses with the necessity for hermetic sealing of the place of contact of the oncometer with the bone, and recording of the fluctuations of the brain is achieved by means of a glass funnel, the base of which is covered with a tightly fitting rubber membrane (water oncometer; [9]). The advantages and disadvantages of the various methods of oncometry of the brain are shown in the Table.

Variations in the volume of the brain undoubtedly represent one of the essential aspects of the dynamics of cerebral edema. By changes in the volume of the brain it is possible to judge reliably the successive stages in the development and course of cerebral edema, and its growth and diminution [10].

The method of oncometry of the brain which we have devised is as follows. In experiments of short duration on dogs under morphine-urethane anesthesia the right half of the vertex of the skull is exposed through a midline incision. A suture is passed through the substance of the temporalis muscle which is then divided at the base. In the parietal bone thus exposed a hole, 30 mm in diameter, is made by means of a hand-drill, and the dura mater is divided within the limits of this drill hole. Into this hole, after careful hemostasis, is inserted the cerebral oncometer, which is connected by a rubber tube to a water manometer for registration of the fluctuations of the brain on a kymograph.

The oncometer (Fig. 1) is a steel drum, the base of which is covered with a tightly fitting rubber membrane, while in the upper part is inserted a transparent acrylic plate through which the state of the brain can be freely observed. The diameter of the oncometer is 30 mm, to correspond to the diameter of the hole drilled in the skull; its height is 20 mm; the lateral surface is conical and is milled. The measurements of the cone are such that when the oncometer is inserted in the skull it does not penetrate deeper than the thickness of the bone, i. e. 2-3 mm. This allows firm fixation of the oncometer in the drill hole with support not on the brain but on bone. The upper part of the oncometer terminates in a projection which serves for attachment to the water manometer.

In order to obtain the most reliable curves in oncometry of the brain it is essential to ensure sensitivity

A Comparative Evaluation of the Methods of Oncometry of the Brain

Oncometry	Indications for use	Advantages	Disadvantages
Pneumatic	Registration of variations in the relative intracranial pressure	High sensitivity of recording of the variations in pressure	The necessity for strict hermetic sealing of the joint between the oncometer and the bone
Water	Registration of variations in the volume of the brain	No necessity to maintain strict hermetic sealing of the joint between the oncometer and the bone	Relatively lower sensitivity of recording of the variations

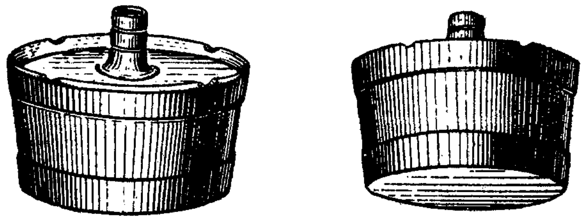

Fig. 1. The cerebral oncometer as constructed by the author. The base of the oncometer is covered with a tightly fitting rubber membrane.

of the recording system and accuracy of the registration itself.

The accuracy of registration of the variations in the volume of the brain is ensured by the following conditions:

1. Evenness and depth of anesthesia; changes in the level of anesthesia are undesirable since they lead to rapid changes in intracranial pressure.

2. Careful hemostasis; failure to observe this condition leads to accumulation of blood beneath the oncometer. In order to avoid bleeding the drill hole is made to the side of the midline (approximately three-quarters of a finger). Bleeding from the diploe is stopped with wax; vessels in the dura mater are caught with mosquito forceps and tied off.

3. Arrangement of the zero point of the manometer at the same level as the membrane of the oncometer (Fig. 2); the least disturbance of this relationship distorts the readings of the manometer.

4. Evenness of contact of the membrane of the oncometer with the surface of the brain in all parts of the membrane. This is achieved by observance of the following requirements: a) in selection of the animals puppies under 6 months old are not advised; at this age the brain does not entirely fill the cranial cavity in the regions close to the midline, and an even contact of the oncometer membrane with the brain can hardly be expected in these conditions; b) the oncometer membrane must be stretched evenly, without creases which would allow accumulation of fluid underneath the membrane; c) the oncometer must be fixed strictly in the plane of the drill hole in the skull; should it be inclined, erroneous manometer readings will be obtained.

Sensitivity of the recording system is ensured by observance of the following conditions:

1. Maximum shortening of the transmission system (the shorter the system the more sensitive it is) together with maximum lightness of the writing parts. The cork float of the manometer is carefully ground and coated with paraffin wax. The pivot of the float, as fine and short as possible, is cut from bamboo; the nib is cut from a piece of motion picture film.

2. Maximum cleanliness of the water manometer and of the liquid in it. The manometers used in the experiment are cleaned the night before with a chromic mixture and with distilled water.

3. Careful hermetic sealing of the whole system. This is filled with physiological saline (by a siphoning method). The hermetic sealing of the membrane is tested by inflating it under water. The material used for the

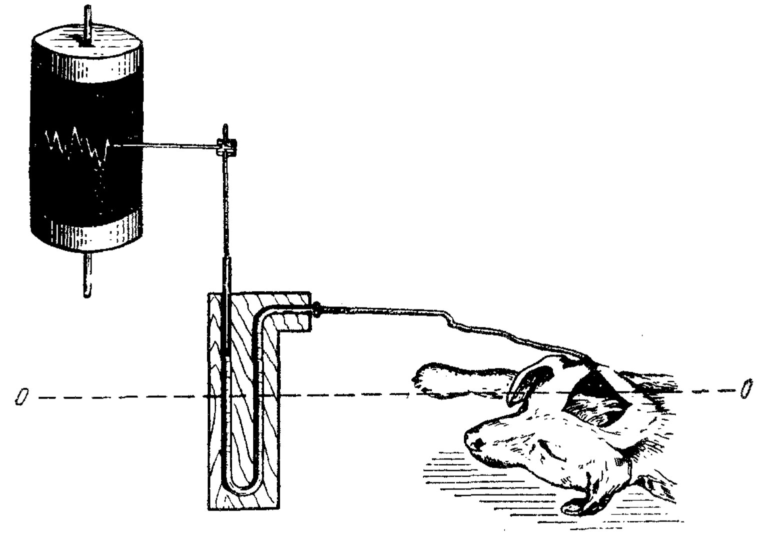

Fig. 2. Scheme of the experiment. The zero point of the water manometer is arranged to be at the same level as the membrane of the oncometer.

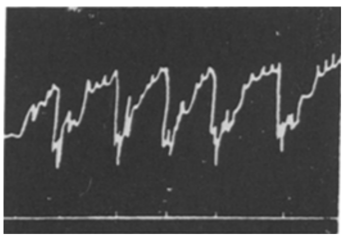

Fig. 3. Oncometric curve of the normal brain. Respiratory and pulse waves (more frequent) are seen.

membrane is thin rubber. Its tension is controlled as follows: a piece of rubber is placed over the base of the upturned oncometer, smoothed out and fixed without tension by means of two turns of thread to the rim of the oncometer. The rest of the rubber is cut off. While it is being filled with physiological saline the oncometer is placed with its base downwards on the edge of the table. Through the upper projection of the oncometer warm saline is injected by means of a syringe, so that it fills the interior of the oncometer, the projection and the rubber connecting tube. A clamp is placed on the latter, after which the oncometer is transferred to the skull and inserted in the drill hole, with gentle movement to the depth of two turns. In order to avoid damage to the membrane from the edge of the bone, the latter is carefully smoothed and the least roughness or traces of bone dust are removed.

After fixation of the oncometer the clamp is taken off the tube leading to the manometer and a recording of the fluctuations of the brain is made on the kymograph.

The normal curve of oncometry of the brain consists of a complex wave-like line (Fig. 3). Three types of periodic movement of the brain can be distinguished. In the most frequent rhythm appear the pulse waves, dependent on the activity of the heart. Respiratory waves have a slower rhythm and are formed as a result of the interaction of fluctuations in venous and arterial pressure. Finally, the slowest rhythm of all is shown by waves of the third order, or undulations, due to spontaneous processes in the vasomotor center.

A closer acquaintance with the kymograms demonstrates the enormous variety of types of oncometric curves, reflecting the complex dynamics of brain activity. A characteristic property of all the curves is the height of the initial level of the curve in relation to the zero line. As has been pointed out, the float of the manometer is arranged to be at the same level as the membrane of the oncometer, and in this position the zero line is marked on the paper on the drum of the kymograph. The subsequent removal of the clamp from the manometer is accompanied by a rise in the curve to a definite level which corresponds to the magnitude of the cerebral pressure (from 25 to 135 mm of water).

As the observations show, the level of the oncometric curve depends primarily on the degree to which the brain is filled with blood. Such manipulations as, for example, lifting the animal's trunk, or infusing into its vein a large dose of isotonic solution, are accompanied by a rise in the oncometric curve. Conversely, manipulations leading to a reduction in the degree of filling with blood of the brain (for example, lowering the animal's trunk, hemorrhage, compression of the arteries of the neck) are accompanied by corresponding falls in the level of the oncometric curve.

Another essential factor determining the type and character of the oncometric curve is the act of breathing. In inspiration the oncometric curve of the brain is a line in a downward direction, and in expiration, a line directed upwards.

The amplitude of the oncometric curve is determined by the depth of the respiratory movements. The deeper the respiration the wider the range of respiratory movements of the brain, and the entire curve takes on the appearance of a bold, white band. On the other hand, shallow breathing is accompanied by very slight fluctuations of the brain, and in this case the curve has the appearance of a narrow band with small indentations. Holding the breath leads to disappearance of the respiratory excursions of the brain. Artificial respiration, carried out at this moment, is accompanied by restoration of the respiratory movements of the brain.

Pathological respiration of the Cheyne-Stokes, Kusmaul, etc. types is also reflected in the curve of oncometry of the brain. In Cheyne-Stokes breathing, for instance, periods of increasing amplitude of the respiratory movements alternate with periods of their diminution. After pauses of 3-4 seconds follow occasional superficial respiratory movements, gradually becoming much deeper and frequent. Having reached their maximum intensity, the respiratory movements again become shallow and infrequent. This type of breathing is associated, as we know, with lowered excitation of the respiratory center and it is observed in disorders of the cerebral circulation. In the period of infrequent respiratory movements the level of the oncometric curve characteristically rises; this is evidently associated with the development of stasis of the blood in the jugular and cerebral veins, thanks to the weakening of the aspirating action of the thorax during these periods.

An example of the combined effect of circulatory and respiratory factors is the oncometric curve of the premortal period. Most typically here there is a gradual and continuous fall in the level of the oncometric curve, parallel to the progressive fall in the arterial pressure, together with a weakening of the activity of the heart and respiration. A rarer type of oncometric curve in this period is a rising type with a maximum rise at the moment of death of the animal. An explanation of this phenomenon must evidently be sought in the appearance of congestive hyperemia of the brain. Thus the height and character of the oncometric curve of the brain are subject to fluctuation and this depends on the degree of filling of the brain with blood, the character of respiration and the general condition of the animal.

Results showing the possibility of using the method of oncometry of the brain in studying problems relating to edema and swelling of the brain, and also in elucidating the mechanisms of action of hypertonic solutions were given in our previous reports [1, 2].

SUMMARY

The author developed a method of oncometry of the brain in experiments on dogs. He used an original membrane oncometer. This method guarantees precise graphic registration of variations in the brain volume measured in mm of water. The method appeared to be useful in the study of the problems of cerebral circulations of blood and cerebrospinal fluid, edema and swelling of the brain, as well as in osmotherapy.

LITERATURE CITED

[1] K. N. Badmaev, Biull. Eksptl. Biol. i Med. 6, 30-35 (1956).

[2] K. N. Badmaev, Arkh. Patol. 4, 35-40 (1957).

[3] I. A. Vetokhin and G. V. Pervushin, Izvest. Akad. Nauk Belorussk. SSR; Otdel. Estestv. Nauk 4, 113-124, Minsk (1940).

[4] E. I. Eselevich, Biull. Eksptl. Biol. i Med. 20, 6, 22-24 (1945).

[5] V. V. Zikeev, Scientific Reports of the Kazakh Medical Institute 8, 207-214 (1941).

[6] S. Istamanov, The Effect of Stimulation of Sensory Nerves on the Vascular System in Man, Dissertation, St. Petersburg (1885).*

* In Russian.

[7] I. N. Ishchenko, On the Pathogenesis and Treatment of Acute Cerebral Pressure Syndromes of Traumatic Origin, Dissertation, Kiev (1940).*

[8] K. Nagel', Variations in the Blood Volume of the Brain Under Different Conditions, Dissertation, Moscow (1899).*

[9] I. R. Petrov, All-Russian Conference of Pathologists, 165-167, Moscow-Leningrad (1935).*

[10] A. L. Fisanovich, Fifth Meeting of the Neurosurgical Council, 63, Moscow-Leningrad (1940).*

[11] A. L. Fisanovich, Vrach. Delo 10, 650-652 (1940).

* In Russian.