Intracranial Pressure in a Case of Isolated Fourth Ventricle

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Summary: Since the report by Lundberg (1960), the importance of analysis of pressure waves has been recognized with respect to the intracranial pressure, apart from the level of pressure. More recently, various instruments for measuring the intracranial pressure have been developed and measurements of the extradural and intraventricular pressure have become relatively easy. At the same time, efforts to analyse pressure waves are equally intensive. Since the skull of a newborn or infant is not closed and the intracranial environment is considerably different from those of an adult skull, the pressure waves themselves, rarely behave as classified by Lundberg (1960). Recently during the treatment of hydrocephalus due to intraventricular hemorrhage, in a pre-mature infant, there was a complication causing the so-called isolated fourth ventricle, after ventriculoperitoneal shunt. When the intracranial pressure was measured in this case using our "Fontanometer" (NEC, Sanei Co.), B-waves, so named by Lundberg (1960), were clearly observed. From the results in this case, the mechanism of occurrence of the B-wave will be discussed based on our experience and previously published reports.

Key words: Hydrocephalus—Intracranial pressure—Cerebrospinal fluid—Isolated fourth ventricle—aqueductal stenosis.

Introduction

Probable complications after shunt operations for hydrocephalus include occlusion and infection of the shunting apparatus, secondary craniostenosis and narrow spinal canal, slit ventricle and isolated fourth ventricle; the problems related with the shunt operation are countless. We recently experienced a case of shunt malfunction occurring in the isolated fourth ventricle; we measured the intracranial pressure and studied changes in the pressure waves of the intracranial pressure before and after remedying the shunt malfunction. Periodically repeating B-waves were observed before but were eliminated after the operation. In the present case, where hydrocephalus was directly related to the brain stem and was supplemented by a disturbance in cerebrospinal fluid circulation due to the shunt malfunction, the intracranial pressure was continuously measured via the anterior fontanelle for a specified period, and interesting results were obtained.

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**Case Material**

**Case: Four-month-old male**

The chief complaints were irritability, sleepiness and vomiting. The boy was born prematurely by vacuum extraction after 32 weeks and two days of gestation and weighed 1,657 g. at birth. Irritability and difficulty in respiration were noted after birth and a ventricular hemorrhage associated with expansion of the ventricle, was observed by CT scan on the second day. Thereafter, the ventricular dilatation continued to progress and a V-P shunt was attempted on the 23rd day after birth. In the follow-up CT scan, the expansion of lateral ventricles began to decrease until a slit was recognized during the fourth month. The fourth ventricle, however, expanded independently and significantly (Fig. 1). Suddenly bulging of his anterior fontanelle was discovered, and repeated vomiting and drowsiness became apparent; the infant was immediately hospitalized. At the time of admission, CT scanning disclosed dilatation of both lateral ventricles, which had been only slits in the previous CT scan, and also revealed periventricular lucency in the white matter in the periphery of the anterior horns of both sides; the other fourth ventricle was also dilated (Fig. 2). As a treatment, V-P shunt revision was performed for shunt malfunction. As consciousness became clearer, other clinical symptoms improved.

The intracranial pressure was measured

*Fig. 1. After V-P shunt for posthemorrhagic hydrocephalus, CT scan shows slit lateral ventricles and marked expansion of the fourth ventricle, suggesting “isolated fourth ventricle”.*

*Fig. 2. CT shows dilated lateral ventricles with periventricular lucency and further expansion of the fourth ventricle because of shunt malfunction.*
Fig. 3. Intracranial pressure during shunt malfunction indicates rhythmic fluctuation, representing B-waves.

Fig. 4. Record of intracranial pressure after V-P shunt revision shows absence of B-waves.

continuously for 6-8 hours from the anterior fontanelle by using the "Fontanelle pressure sensor" (F.P. sensor) (Honda et al. 1982) developed by us. As is shown in Fig. 3, the intracranial pressure after V-P shunt had a basal value of 180-200 mm H₂O, and it repeatedly rose to over 600 mm H₂O rather rhythmically at a frequency of 1.5 times a minute. The amplitude of the fluctuations in basal pressure was about 100 mm H₂O, and it increased to about 200 mm H₂O at the time of onset of the pressure wave. This phenomenon corresponds to the B-waves named by Lundberg (1960) (Fig. 3). On the 3rd day after the shunt, the basal pressure was 60-80 mm H₂O as shown in Fig. 4, and the amplitude of its fluctuations was only 40 mm H₂O; the definite B-waves, observed before operation, were not observed during the continuous measurement, and only irregular pressure waves, of 30-50 mm H₂O, were occasionally detected (Fig. 4).

Discussion

As one of the complications after shunt operation for hydrocephalus, the state of isolation and abnormal expansion of the fourth ventricle was called "isolated fourth ventricle" by Hawkins et al. (1978). Similar states have been known by various other terms (Raimondi et al. 1969; Zimmerman et al. 1978; Foltz and DeFeo, 1980). The associated clinical presentations are varied neurological signs, mainly due to compression of the posterior fossa, such as ataxia and double vision. Since the measurement of intracranial pressure is not difficult today with the development of various transducers, pressure waves and pulse waves can be analyzed closely and the types and the clinical significance of the pressure waves, as classified by Lundberg (1960), can be investigated. The possible mechanisms of their occurrence have been studied by many investigators. Recently, much has been reported on the intracranial pressure of the newborn and infants and new facts have been revealed. For example, since the elasticity of the skull differs between adults and infants, there is a certain difference in the mode of expression of pressure waves corresponding to the changes in the intracranial environment. The pressure waves classified by Lundberg (1960) are not
always obtained and may be rather rare (Anegawa et al. 1981). In addition, changes in brain stem function and the occurrence of pressure waves have been examined (Hoff and Breckenridge, 1954; Lundberg, 1960). The case of isolated fourth ventricle presented here is interesting because it is a disorder directly affecting the brain stem. Lundberg’s so-called B-waves (1960) are said to be pressure waves elevating the intracranial pressure (by about 11 mmHg) at a frequency of 1/2 to 2 times every minute. According to this definition, in our case the intracranial pressure before the shunt should be categorized as B-waves. Martin et al. (1971) emphasized that such a pressure wave (B-Wave) is clinically significant only if it occurs regularly within a specified period of time and they warned that occasional B-wave like changes could be a physiological phenomenon. Ecker (1955) indicated that B-waves tend to be observed in cases showing relatively high intracranial pressures, such as head injury, cerebrovascular disturbance and brain tumor. On the other hand, Symon et al. (1972) reported that the B-wave is a characteristic pressure pattern observed in normal pressure hydrocephalus and proved that the high basal pressure was not always directly related with the occurrence of the B-wave. Moreover, as in the present experience of an open anterior fontanelle in an infant, the appearance of the B-wave, in a case in which the basal pressure is not so high, gives the impression that regular fluctuations of intracranial pressure can be caused by a certain factor acting as a "pacemaker" which is not affected by the elasticity of the skull or the level of pressure. Venes (1979) stated that the B-wave is caused by a disorder of the circulation, occurring at the capillary level which possesses the ability to act as a vascular bed, according to the increase in the intracranial volume, when the intracranial environment becomes a state of low compliance (tightened cranium). He suggested that these changes are related to a certain intrinsic neural mechanism. Sayama and Auer (1982) continuously measured the diameter of pial vessels, and discovered that the occurrence of the B-wave coincided with an increase in their diameter. This means that the B-wave is probably caused by fluctuations in the cerebral blood volume, and this finding supports the proposal of Venes (1979). However, the mechanism of increase in the cerebral blood volume is not yet known. When a temporary weakness of respiration is considered as one of the other parameters of the occurrence of B-wave, it is also important to find a "pacemaker", so-called by Lundberg (1960), in the brain stem. In our present case, the abnormal expansion of the fourth ventricle near the brain stem is believed to have triggered the B-wave but the fact that the B-wave was eliminated after the shunt operation suggests that the disturbance of CSF fluid circulation may play an important role in the occurrence of the B-wave. That is, the change in the brain stem function and the increase of intracranial volume seem to act in concert to initiate the B-wave.

References


