CLINICAL INVESTIGATION OF INFANTILE SUBDURAL EFFUSION — SPECIAL OBSERVATION ON CT FINDINGS AND INTRACRANIAL PRESSURE —

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The existence of subdural effusion is harmful for the brain and it should be strictly warned to let it alone so as not to make the prognosis worse. With an aim to obtaining indexes to decide whether surgical treatment should be positively performed, or the clinical course should be carefully observed without giving surgical treatment, the authors have devised a method in which the record of ICP while patients are sleeping and changes through time of the morphology in the skull by CT scan can be quantitatively obtained.

INTRODUCTION

Subdural repeat tap and shunting operation are usually performed in surgical therapy of subdural effusion. But as there are cases which spontaneously disappear without surgical therapy, a sufficient examination should be done always, bearing mortality and morbidity due to surgical therapy in mind. For the sake of it, it is always necessary to perceive the changes in intracranial morphology and intracranial pressure (ICP) such as the quantity of effusion by means of CT scan, the size of the ventricles, etc. ICP was measured following the method of Wealthal and Smallwood (1974) by applying an applanation transducer via the anterior fontanelle atraumatically. As a result, it is thought that observation of ICP during REM (Rapid Eye Movement) and Non-REM stages becomes an index to evaluate the indication and prognosis of surgical treatment.

MATERIALS AND METHODS

The subjects are five suckling infants from three months to twelve months of age with subdural effusion.

Analysis of intracranial morphology by CT scan: Using EMI 1000 type, a sliced surface transversing the anterior horn and the third ventricle in parallel to the O-M line are scanned in 13 mm wide, and the areas of the cerebral parenchyma, ventricle, and subdural effusion were obtained by the print out data 80 × 80 matrix, then the ECR (Subdural Effusion-Cranial Cross Section Area Ratio) which is the occupying ratio of subdural effusion, the occupying ratio of the ventricle (VCR) (Ventricular-Cranial Cross Section Ratio), and the occupying ratio of the cerebral parenchyma (Brain Parenchyma-Cranial Cross Sectional Ratio) were calculated (Syneck and Reuben, 1976 a, 1976 b) (Fig. 1).

$$ECR = \frac{\text{Effusion cross - Sectional Area}}{\text{cranial cross - Sectional Area}} \times 100$$

$$VCR = \frac{\text{Ventricular cross - Sectional Area}}{\text{cranial cross - Sectional Area}} \times 100$$

$$BCR = \frac{\text{Brain parentyma cross - Sectional Area}}{\text{cranial cross - Sectional Area}} \times 100$$

Fig. 1. upper: Diagram showing the level of ECM "cuts"
lower: Calculation method of ECR, VCR and BCR

Measurement of ICP: ICP was measured following the method of Wealhall and Smallwood (1974) using an applanation transducer (Hewlett-Packard Co., APT-16) via the anterior fontanelle atraumatically for 3-5 hours continuously during asleep.

For the decision of REM stage, 1) the low voltage on electroencephalogram, 2) the disappearance of tonic muscular activity on electromyogram, and 3) the appearance of rapid eye movement (Dement and Kleitman, 1975) on electrooculography were used as indexes.

Case 1. 11-month-old boy. He was admitted to the hospital with complaints of enlarged head and irritability at the age of 8 month. With a diagnosis of postmeningitic subdural effusion, right subdural-peritoneal shunt was performed with a Holter's low pressure valve. ICP prior to the operation was 180 mmH₂O at Non-REM stage, and indicated 380 mmH₂O with plateau-

like wave during REM stage. In ICP performed on the 7th day after the operation, ICP decreased to lower than 200 mmH₂O without plateau-like wave during REM stage (Fig. 2). On the other hand, ECR before the operation was 11.5 %, VBR 7.4 % and BCR 83 %, and on the 7th month after the operation, ECR and VCR decreased to 4 % and 3.9 % respectively. BCR showing the size of the brain cerebral parenchyma increased to 92 % (Fig. 7-a). RI-cisternography revealed early ventricular reflux, early clearance from the ventricles and right sided convexity block.

Case 2. 3-month-old boy. He was admitted to the hospital with complaints of enlarged and irritability. With a diagnosis of bilateral subdural effusion due to an unknown cause, subdural repeat taps were done every 2 days for about one month and a half. ICP before the treatment was 140 mmH₂O during Non-REM stage, and elevated to 480 mmH₂O during REM stage showing a

CASE.1 ICP VIA FONTANLLE DURING REM PERIOD

1. Pre-treatment

2. 7 days after s-p shunting operation

Fig. 2. Pre and postoperative ICP during REM period indicating marked increase over 380 mmH₂O and plateau like waves compared to postoperative ICP gradual disappearance of right chronic subdural effusion and brain atrophy within 6 months after S-P shunting demonstrated on CT scan.

Fig. 3. showing gradual decrease of high ICP during REM period due to repeat tapping of subdural effusion and gradual disappearance of bilateral subdural effusion with remained brain atrophy seen on CT scan.

CASE.3 ICP VIA FONTANELLE DURING REM PERIOD

1. pre-treatment

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Fig. 4. ICP record showing high ICP over 320 mmH₂O during REM before S-P shunting. Bilateral calcified cortex and massive subdural effusion developing hydrocephalus following the operation demonstrated on CT scan.

plateau-like wave. But after the last tap, ICP was 150 mmH₂O during Non-REM stage, and decreased to 250 mmH₂O during REM stage showing no plateau-like wave (Fig. 3). After 8 months, ECR decreased from 14.8 % to 5 %, VCR decreased from 7.4 % to 6.1 %, and BCR increased from 78 % to 89 % (Fig. 7-b). On RI-cisternography before the treatment, a bilateral convexity block was observed.

Case 3. 4-month-old girl. She was admitted to the hospital with complaints of frequent seizures. Diffuse calcification of the cerebral cortex was observed by CT scan and the circumference of the head was rather small. With a diagnosis of postmeningitic bilateral subdural effusion, subdural-peritoneal shunt was performed at the age of 6 months. ICP before the operation showed 140 mmH₂O during Non-REM stage, and 320 mmH₂O during REM stage showing the appearance of a plateau-like wave (Fig. 4). After the operation, there was in addition an enlargement of the cerebral ventricle and the clinical manifestations became worse. On CT scan, ECR showed a somewhat decrease from 39 % to 32 %, but VCR increased from 25 % to 55 %, and BCR decreased from 55 % to 41 % (Fig. 7-c).

Case 4. 10-month-old boy. The diagnosis was left traumatic subdural effusion. No neurologically abnormal findings were observed excepting vomiting. ICP was 100 mmH₂O during Non-REM stage and 140 mmH₂O during REM stage, remaining in the normal range (Fig. 5). Thus, no surgical therapy was given, while the course was carefully observed. After 4 months, ECR decreased from 9 % to 4 %, VCR stayed at around 5 % without change, BCR increased from 85 % to 90 %, and the

disease was cured without any clinical change (Fig. 7-d).

Case 5. A 3-month-old boy. He was referred to the hospital due to head trauma without disturbance of consciousness. On admission, there were no neurological abnormalities, and no symptoms of intracranial hypertension were observed. On CT scan, bilateral subdural effusion which were indicated as low density areas at the frontal region were shown. ICP were 100 mmH₂O during Non-REM stage and 140 mmH₂O during REM stage (Fig. 6). Four months later, ECR decreased spontaneously; however, VCR was almost unchanged. Further, BCR was increased about 5 % because of the decrease of ECR (Fig. 7-e).

The values of ICP and ECR, VCR and BCR by CT scan and the outcome of each of the above-mentioned cases are shown in Table 1.

The difference of ICPs between Non-REM stage and REM stage were calculated and it was called as "pressure gradient" (P.G.). In cases 1 and 2, the P.G. were as high as 200 and 340 mmH₂O respectively, decreases of ECR and VCR as well as the increase of BCR due to surgical therapy were observed, and the clinical manifestations also markedly improved. The prognosis of Case 3 which had complicated severe cerebral damage and the disturbance of CSF circulation due to bacterial meningoencephalitis and complicated the obstructive hydrocephalus was bad. On the other hand, the P.G. in Cases 4 and 5 were lower than 80 mmH₂O, and both diseases were completely cured without giving surgical therapy (Table 1).

DISCUSSION

Subdural fluid collection in infants

CASE.4 ICP VIA FONTANELLE DURING REM PERIOD

1.non-treatment

Fig. 5. showing mild increase of ICP within 200 mmH₂O during REM period and disappearance of thin subdural effusion without treatment.

CASE.5 ICP VIA FONTANELLE DURING REM PERIOD

1.non-treatment

2.

Fig. 6. showing mild increase of ICP within 170 mmH₂O during REM and disappearance of subdural effusion without treatment.

Fig. 7. Changes of ECR, VCR and BCR in all cases with chronic subdural effusion.

TABLE 1
*Change of ICP and CT findings the clinical course of
 the patients with chronic subdural effusion*

	Pre-treatment					Post-treatment or natural course					Clinical signs
	ECR	VCR	BCR	ICP	Pressure gradient	ECR	VCR	BCR	ICP	Pressure gradient	
* Case 1	11.5%	7.4%	83%	REM : 380mmH ₂ O Non-REM: 180mmH ₂ O	200 mmH ₂ O	3.9%	3.9%	90%	REM : 200mmH ₂ O Non-REM: 150mmH ₂ O	50 mmH ₂ O	improved
* Case 2	14.8%	7.4%	78%	REM : 480mmH ₂ O Non-REM: 140mmH ₂ O	340 mmH ₂ O	5.0%	6.1%	89%	REM : 250mmH ₂ O Non-REM: 150mmH ₂ O	100 mmH ₂ O	improved
* Case 3	38.7%	5.9%	55%	REM : 320mmH ₂ O Non-REM: 140mmH ₂ O	180 mmH ₂ O	32%	27%	41%			exag-gerated
** Case 4	6.7%	5.8%	87%	REM : 200mmH ₂ O Non-REM: 120mmH ₂ O	80 mmH ₂ O	2.4%	4.1%	93%			un- changed
** Case 5	9.4%	5.0%	86%	REM : 140mmH ₂ O Non-REM: 100mmH ₂ O	40 mmH ₂ O	4.3%	5.7%	90%	REM : 170mmH ₂ O Non-REM: 120mmH ₂ O	50 mmH ₂ O	un- changed

(* with treatment, ** without treatment)

occurs due to various causes such as head trauma, inflammation, defect in vitamin C or K, after shunting operation, hemorrhagic tendency (Ferguson et al, 1968), etc., and cases due to unknown causes are not rare. Therefore, the manifestation of the disease varies according to each background. Thus, it is not so simple as to think that indiscriminate surgical resection can cure all cases. But the existence of effusion is clearly harmful for the brain and it should be strictly warned to let it alone so as not to make the prognosis worse (McLaurin et al, 1971; McLaurin and Timperman, 1972). With an aim to obtaining indexes to decide whether surgical treatments such as subdural tap, shunting operations, and so on should be positively performed, or the

course should be carefully observed without giving surgical treatment, the authors have devised a method in which the record of ICP while patients are sleeping and the changes through time of the morphology in the skull by CT scan can be quantitatively obtained.

An applanation transducer same as the method of Wealhall and Smallwood was applied for atraumatic ICP measurement via the anterior fontanelle. The reason why the measurement of ICP done while patients were sleeping lies in the fact that ICP elevates during REM stage (Chawla and Cooper, 1957; DiRocco et al, 1975; Maira and Rossi, 1974) and observing the difference between ICP during REM stage and ICP at Non-REM stage, an evaluation as to whether the damping effect

against the variation of ICP in each case is sufficient or not can be done. Namely, in the cases accompanying severe brain damage or in the normal cases with wide spacial compensation system of the skull, even when intracranial blood volume increases at REM stage, the elevation of ICP is small. On the other hand, in operative cases in which brain damage is slight and brain expansion exist, these cases place at the break point (Granholm and Löfger, 1976) from pressure-volume relationship due to subdural effusion. It is thought that ICP elevates markedly due to pressure-volume relationship (Langfitt, 1969) at REM stage. Further, ICP at Non-REM stage of normal infants is 72-147 mmH₂O, and elevates by 70 ± 15 mmH₂O at REM stage comparing with that at Non-REM stage, and pulsation amplitude also increases by 30-40%. In cases 1 and 2, few findings on brain atrophy were observed by CT scan, the volume of subdural effusion was large, and furthermore, ICP markedly increased at REM stage, which resulted in a large pressure gradient. Findings on RI-cisternography of these 2 cases showed poor convexity filling. Consequently, it is thought that the existence of subdural effusion provokes circulatory disturbance of cerebro-spinal fluid, which resulted in ICP exasperation. In the cases such as these 2 cases in which ICP at Non-REM stage is originally high and moreover ICP largely increases at REM stage, it is thought that the circulation of the cerebro-spinal fluid and also the venous return are affected adversely. Therefore, a surgical treatment should be performed positively for the subdural effusion in order to prevent secondary brain damage due to mass effect. In Case 3, the organic change of the brain due to inflammation was strong in addition to subdural effusion, and be-

cause of the complication with hydrocephalus due to cerebro-spinal circulatory disorder, a marked elevation of ICP was observed. Even bilateral subduro-peritoneal shunt did not make the effusion disappear, to the contrary, the cerebral ventricle enlarged further and the clinical manifestations aggravated in spite of the treatment. It goes without saying that the prognosis of the cases showing severe organic changes of the brain (Cadman et al, 1968, McLaurin, R. L. and McLaurin, K. S, 1966) already established is not favorable.

Both Cases 4 and 5 are traumatic subdural effusion showing slight clinical manifestation from the beginning of receiving lesion, and no findings of intracranial hemorrhage and brain atrophy were observed even by CT scan. As ICP of both cases at Non-REM stage were lower than 130, and pressure gradient remained in the normal range as 80 mmH₂O, careful observation of the clinical course of both cases resulted in spontaneous cures. It is presumed that the reasons for the spontaneous cure are: i) communication with the subarachnoid cavity exists in traumatic subdural effusion, and ii) hydrostatic pressure which accelerates the leakage of protein component via the premature capillary of the subdural membrane is restored to the normal along the course (Rabe et al, 1962), but most fundamentally, the existence or not of organic cerebral damage due to traumatism is important.

From the above-mentioned results, on the cases with high ICP at REM stage and with large differences between ICP at REM stage and ICP at Non-REM stage, it is thought that surgical therapy should be positively performed to normalize ICP.

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