Single Photon Emission Computed Tomography of Neonatal Periventricular Leukomalacia

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Accepted for publication on February 16, 1993

ABSTRACT. We describe herein single photon emission computed tomography (SPECT) with ^{99m}Tc HM-PAO of a patient with neonatal cystic periventricular leukomalacia (PVL). The patient, who was a low birth weight infant of 27 weeks gestation weighing 1,290 g, had suffered from respiratory distress syndrome. Following surfactant replacement therapy, mechanical ventilation were carried out six days after birth. Serial cranial ultrasonography (US) showed periventricular high-echoic lesions followed by cyst formation at three weeks of age. Although cystic PVL was markedly observed on both cranial US and MRI, a SPECT study initially revealed no abnormal distribution of rCBF. A chronological SPECT study at nine months of age revealed decreased rCBF of 10% in the left hemisphere as compared to the contralateral side. At the time decreased rCBF was observed on SPECT, periventricular cyst formation tended to disappear on simultaneous MRI. It is known that PVL is an infarction which affects all the cellular elements of the white matter and may lead to abnormal myelination. SPECT studies may also useful to clarify the cerebral function in neonatal PVL.

Key words: periventricular leukomalacia — SPECT — regional cerebral blood flow

With recent advances in diagnostic techniques using encephaloultrasonography (US) and magnetic resonance image (MRI), it has become possible to make a detailed evaluation of neonatal periventricular leukomalacia (PVL).[1,2] It is well known that PVL may lead to neurodevelopmental disturbances. Therefore, chronological neuroradiological study should be done to predict the neurodevelopmental outcome in preterm infants.[3,4] At present, the use of single photon emission computed tomography (SPECT) is widely accepted for the estimating of brain function and cerebral blood flow in various kinds of neurological disorders.[5-7] ^{99m}Tc-labeled hexamethyl-propylen-amineoxime (HM-PAO) is a cerebral blood flow imaging agent which allows regional cerebral blood flow imaging similar to N-isopropyl-[^{123}I] piodpamphetamine (IMP). Recent investigators have found ^{99m}Tc HM-PAO SPECT to be effective for the evaluation of neonatal brain perfusion.[6,7] However, there have been few SPECT studies of neonatal PVL. Here we report on ^{99m}Tc HM-PAO SPECT of a patient with neonatal PVL and on follow up MRI studies.

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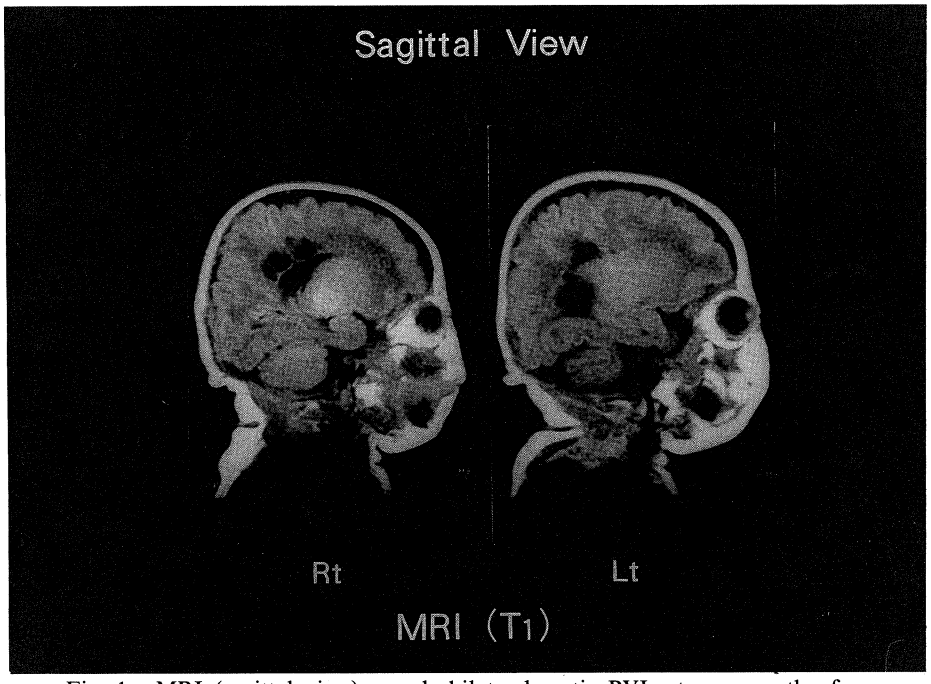

Fig. 1. MRI (sagittal view) reveals bilateral csytic PVL at one month of age.

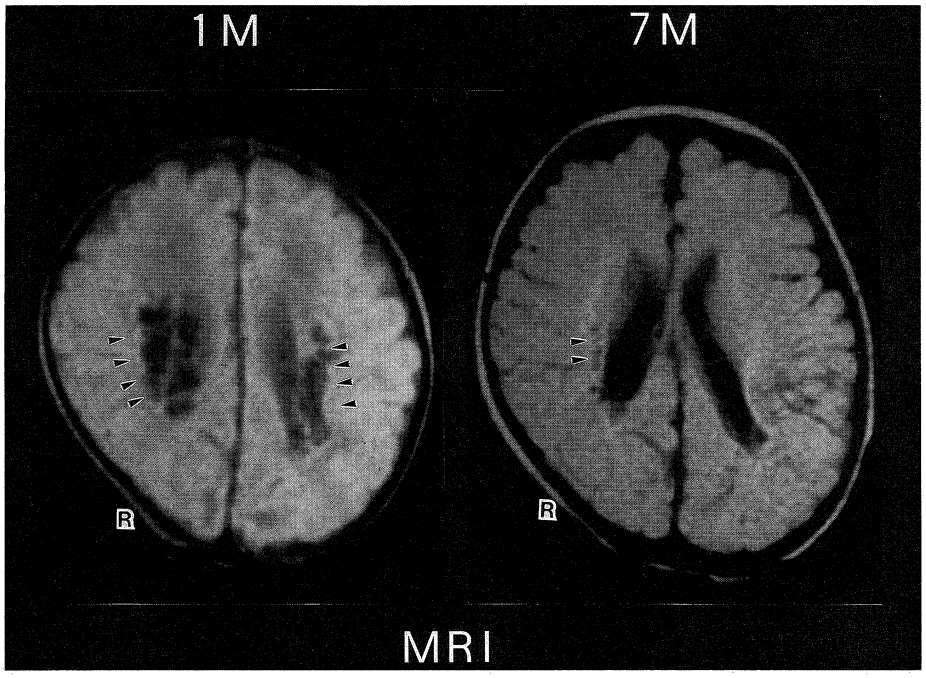

Fig. 2. At the age of seven months. Periventricular cysts appeared to be decreasing.

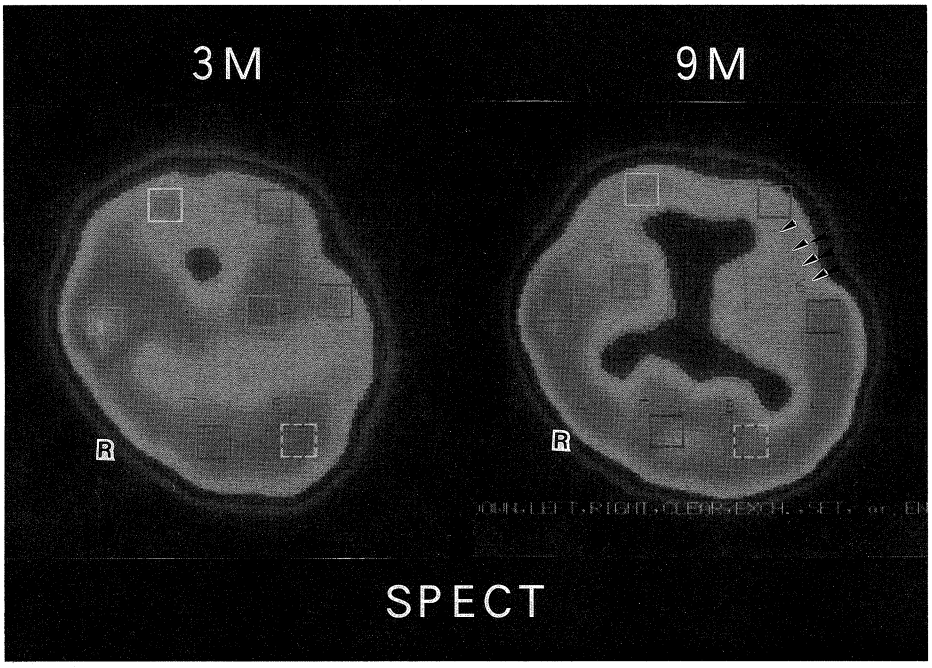

Fig. 3. The first SPECT at three months of age demonstrated symmetrical hemispheric blood flow. At the age of seven months (gestational age of 51 weeks), SPECT showed decreased rCBF in the left hemisphere as compared to the right hemisphere.

CASE REPORT

The patient was born as the first gravida after 27 weeks of gestation by a prompt delivery. The mother did not visit the hospital during her pregnancy. The patient's birth weight was 1,296 g and his Apgar scores at one and five minutes were 5 and 7, respectively. After 20 minutes, he was admitted to our neonatal intensive care unit because of prematurity and respiratory distress. On admission, a diagnosis of respiratory distress syndrome (RDS) was made from both clinical features and chest X-ray findings. He required intubation and exogenous surfactant therapy. Following surfactant replacement therapy, mechanical ventilation was performed until six days after birth. However, from 7 days to 12 days after birth, he required mechanical ventilation again because of the occurence of frequent apneic episodes. A nasal-CPAP was done until 18 days after birth. At one and half months of age at a birth weight of 2,038 g, he demonstrated hyperirritability and an increase in deep tendon reflexes in the lower limbs followed by spasticity. Currently, at the age of one year, he has displayed spastic diplegia and is mentally retarded.

NEURONAL IMAGING

Cranial US was performed using a 5 MHz transducer through the open fontanelle. Both T1 and T2 weighted and proton density MRI were evaluated using the 0.5 Tesla system (YOKOKAWA Medical Co. Ltd.). SPECT was

performed using a rotating large field of view gamma camera (HITACHI Co. Ltd., GAMMA VIEW 2000H-40). ^{99m}Tc HM-PAO SPECT data acquisition was performed in natural sleep state and was started two minutes after an intravenous injection of 4MBq/Kg ^{99m}Tc HM-PAO. The data in the SPECT images were collected on 64 frames. By the third week after birth, cranial US showed bilateral cystic PVL which was detected dominantly in the right periventricular area. Simultaneous MRI also indicated multiple cyst formation in the bilateral periventricular area and especially in an area adjacent to the centrum seniovale. The first SPECT study was performed at the age of three months but significant abnormal distribution was not seen. At the age of seven months, periventricular cysts appeared to be decreasing on MRI but simultaneous SPECT images showed decreased cerebral blood flow of 10% (using the RI counts ratio) in the left hemisphere as compared to the right hemisphere.

DISCUSSION

Recently, reserchers have reported that major neurodevelopmental sequelae are closely related to the presence of PVL during neonatal period.[1,2] The value of both cranial US and MRI in predicting neurological outcome has also been stressed.[3,4] Fawer *et al.*[1] noted that although frontal PVL developed normally, major sequelae were closely related to frontal-parietal PVL and frontal-parietal-occipital PVL. They also found a relationship between the size and site of lesion and the type and severity of the handicap. Van de Bor *et al.*[4] find significant correlation between neurodevelopmental outcome and both US findings and the stage of myelination. Numerous studies have been published regarding neuroradiological findings of PVL, but there has been written little about SPECT of PVL and/or other ischemic insults. In positron emission tomography (PET) studies of asphyxiated term infants, Volpe *et al.*[8] noted that parasagittal rCBF was generally 25 to 50% lower than that/those for the sylvian cortex although in normal or near normal infants, parasagittal rCBF was only approximately 10% lower than that/those for the sylvian cortex. They suggested that such decreased rCBF of the parasagittal area reflects tissue injury secondary to systemic hypotension occurring in association with perinatal asphyxia. In other studies using the ^{113}Xe clearance technique, Lou *et al.*[9] postulated that the rCBF of 20 ml/min/100 mg or less in the neonate was critical. Consideration of normal distribution in neonatal cerebral blood flow is necessary to evaluate neonatal SPECT. Using both PET and ^{99m}Tc HM-PAO SPECT, the localization pattern of normal neonatal cerebral blood flow exhibited higher blood flow in the sensorimotor cortex, thalamus, brain stem and cerebellar vermis.[6,7,10]

In addition, physiologically, low rCBF was noted in the frontal, parietal and temporal cortices. The first SPECT performed at three months of age demonstrated symmetrical hemispheric blood flow, although MRI showed apparent cyst formation. At the age of seven months (gestational age of 51 weeks), SPECT showed decreased rCBF in the left hemisphere as compared to the right hemisphere; especially in an area adjacent to the thalamus. Simultaneouse MRI indicated that the cyst formation appeared to have decreased but myelin formation was seen only in the area of the pons, around the fourth ventricle, the vermis, the cerebellar hemisphere and sturctures

adjacent to the basal ganglia. These MRI findings suggested disturbance of the myelination process.

We believe that examination of distribution of cerebral blood flow change during neuronal development using chronological SPECT along with MRI may provide a detailed picture of the brain function neonatal PVL.

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