Intracranial extracerebral brain heterotopia

Case report

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The authors describe a case of intracranial heterotopic brain located on the medial one-third of the left sphenoid ridge, and enveloped in a huge cystic cavity. The heterotopic brain was resected successfully with satisfactory clinical results. The resected brain was 8 × 4 × 3 cm in diameter, of 7 or 8 months gestational age, and consisted of cerebrum, brain stem, and cerebellum. Anatomical and cytoarchitectural findings of the heterotopic brain are presented.

KEY WORDS □ congenital abnormality □ heterotopic brain □ hydrocephalus

Since the case reported by Wolbach in 1907, various cases of heterotopia within the central nervous system have been presented. In these reports, the heterotopic brain was included within the dura or the occipital scalp. The case presented here is particularly interesting because the heterotopic tissue, consisting of cerebrum, brain stem, and cerebellum, was found in the intracranial extracerebral space together with normal brain.

Case Report

This 27-day-old baby boy was referred to our department for evaluation of progressive enlargement of the head. He was delivered at full term; his weight was 3520 gm, height 50.6 cm, and head circumference 39.6 cm. He was placed under careful observation, and his head showed progressive enlargement, 40 cm at 10 days, 41 cm at 17 days, and 42 cm at 20 days. The fontanels were bulging markedly.

Examination. On admission, his physical development was normal except for a markedly enlarged head. The head circumference was 42.6 cm; the anterior fontanel measured 3.8 × 3.6 cm in diameter and was tense. The skull was asymmetrical with bulging of the left frontotemporal bone. There were no neurological deficits nor anomalies of the body. Routine laboratory tests were within normal limits. Karyotype was 46 XY. A plain skull film showed widely separated sutures and enlargement of the left cranial vault, which was transilluminated. Pneumoencephalogram showed displacement of the lateral ventricles toward the right, more prominently in the anterior part.

Operation. When the infant was 38 days old, a left frontotemporal craniotomy was performed, with a free bone flap.
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FIG. 1. Schematic illustration of the heterotopic brain and surrounding cyst (dotted line). Inset: Operative view of the heterotopic brain after the removal of the cyst membrane. A = frontal lobe; T = tentorium cerebelli; F = falx; M = middle fossa; b = brain stem of the heterotopic brain; c = cerebrum of the heterotopic brain.

incision and reflection of the dura, a thin membrane appeared underneath and was moderately adherent to the dura; a clear fluid was visualized through the membrane. Incision into the cystic membrane showed that the cavity was divided into two compartments by a septal membrane (Fig. 1). The fluid in the cystic cavities was identical with cerebrospinal fluid. The cyst occupied the frontal and anterior temporal fossae and was attached to the occipital lobe with loose arachnoid membrane. The lateral portion of the tentorium cerebelli was well formed; the left cerebral hemisphere was displaced postero-medially, but the cerebrum appeared normal except for a defective left olfactory tract. The septal membrane, which divided the cavity, adhered to the sphenoid ridge and was connected to a solid mass (heterotopic brain) situated on the medial one-third of the sphenoid ridge (Fig. 1). The heterotopic tissue adhered loosely to the brain at the Sylvian fissure. Several small feeding arteries, originating from the left C1, M1, and A1, supplied the heterotopic brain circulation and a few small vessels drained into the Sylvian vein of the normal brain.

The heterotopic brain was removed totally and the cystic membrane was stripped out, after which the brain stem, basilar artery, and upper cranial nerves were widely exposed in the enlarged tentorial incisura.

Postoperative Course. In the early postoperative stage, the infant developed convulsive seizures, which were controlled by an anticonvulsant. Progressive enlargement of the head was noticed and angiogram revealed an extensive subdural fluid collection. On the 26th day after the initial operation, a subdural-peritoneal shunt was inserted. Thereafter the child did well, and follow-up study for about 2 years showed satisfactory physical development, although mentally he appeared behind for his age.

Pathological Examination. The excised heterotopic brain measured $8 \times 4 \times 3$ cm, and weighed 55 gm. It was separated into two globular portions by a narrow peduncle-like structure that measured 1.5 cm in diameter (Fig. 2 A). One of the globular parts seemed
FIG. 2. A: Ventral surface of the heterotopic brain (compare with Fig. 1). Cerebrum (c) and brain stem are connected by a peduncle-like structure (p). A cerebellum (cb) and nerve fiber resembling cranial nerve (n) are also seen. X, Y, and Z indicate orientation of three sections (B, C, and D) in sagittal planes, which are presented to show gross anatomy. Klüver-Barrera, ×1.5. 1 = dentate nucleus; 2 = ependymal canal; 3 = cranial nerve; 4 = mammillothalamic tract; 5 = red nucleus; 6 = substantia nigra; 7 = neuropilgliomesenchymal dysgenesis; 8 = cerebellum; 9 = heterotopic foliar structure; 10 = olive; 11 = lateral ventricle; 12 = ependymal wall connected to cyst wall; 13 = pyramidal cells of Betz; 14 = cerebral sulcus; 15 = basal ganglia; 16 = fourth ventricle.

The heterotopic brain was fixed by 10% formaldehyde and embedded in paraffin. Multiple sagittal sections were examined histologically with H & E, PAS, PTAH, Klüver-Barrera, Woelke, Bodian, Holzer, and van Gieson staining. Correlation of each slice was illustrated in Fig. 2 A.

Cyst membrane consisted of connective tissue lined with ependymal cells on the inner surface. Choroid plexus could be identified in some areas, attached to tissue corresponding to ventricular wall (Fig. 2 C, 12).

In the cerebrum of the heterotopic brain there were small slits with a layer of ependymal cells appearing as lateral ventricles (Fig. 2 C, 11). Formation of the cerebral gyri and sulci was not evident. Cytoarchitectural characteristics of the cerebral gray matter were identified in the heterotopic cerebrum, although the laminar arrangement was not obvious in some places. In the white matter, myelination was so poor that the distinction between the gray and white matter was difficult in many places. Neuroglial heterotopias in the white matter were also seen. Large neuronal cells resembling the pyramidal cell of Betz were demonstrated (Fig. 2 C, 13). Groups of neurons resembling the basal ganglia (Fig. 2 D, 15) were seen. Arachnoid membrane and pia mater were abnormally thick, and glial and neuronal elements were intermingled where the arachnoid membrane merged into gray matter in some places. This
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neuropilgliomesenchymal dysgenesis was also found in the brain stem (Figs. 2 B, D, and 3 A).

In the brain stem and cerebellum, development of the cytoarchitecture was better than that of cerebrum (Fig. 2 B and Fig. 2 D). The dentate nucleus seemed to be well formed; however, it appeared spherical and its foldings were incomplete, indicating immaturity (Fig. 3 B). Neuropilgliomesenchymal dysgenesis was also seen more frequently than in the cerebrum. The cerebellum was most mature of all, but its folia were narrow, and abundant vessels were seen in it. Thick external granular layers remained (Fig. 3 C). Purkinje cells were well formed. Myelination of axons was better than that of cerebrum, but was still poor. Inside the cerebellum and in the dorsal part of the brain stem were heterotopic folial structures (Fig. 3 D) in which granular cells, mature Purkinje cells, and nerve fibers were mixed together. Ependymal canals were formed near the cerebellum and distal part of the brain stem resembling a cerebral aqueduct (Fig. 2 B, 2) and fourth ventricle (Fig. 2 D, 16), but the canals did not connect. In the distal part of the brain stem, a structure like the olivary complex was noted. There were no neoplastic cells or degenerative changes.

**Discussion**

Various types of heterotopias of the central nervous system have been reported, such as subependymal cortical heterotopia of the lateral ventricle\(^1\) or fourth ventricle,\(^2\) subpial glial nests,\(^3,4,9\) and cerebellar heterotopia in association with trisomy.\(^10,11\)

In 1969, Moriyasu, *et al.*,\(^8\) recorded a case of encephalochoristoma, which was found in the occipital subcutaneous tissue and was
connected to the brain through the skull by fatty tissue. Histologically, it contained well formed cerebral white matter and it was differentiated from an occipital encephalocele. Farhat and Hudson recorded a rare case of heterotopic brain encased in its own dura, arising in the left temporoparietal lobe of a newborn infant. The case described here is extremely unusual and we have found no similar case reported. The heterotopic brain was composed of cerebrum, brain stem, and cerebellum; in short, it took the form of a central nervous system.

The developmental stage of this heterotopic brain was considered to be 7 or 8 months gestational age, because there was a thick external granular layer of cerebellum, whereas the proliferating zone had disappeared. The dentate nucleus was well developed, but its folding was still incomplete. On the contrary, organization of the cerebrum was more delayed, which was as expected in the infant’s normal developmental stage. It can therefore be concluded from the morphological characteristics that a heterotopic brain of about 7- or 8-month gestational age existed in the intracranial extracerebral space of this 1-month-old child together with his macroscopically normal brain. The heterotopic brain had no proper dural covering.

With regard to the pathogenesis, Farhat and Hudson postulated that the glial protrusion, which was “punched off” from the neuraxis, became established within the subarachnoid space, and then the heterotopic brain caused the formation of a separate dura. It has been said that the first phase of the formation of the neural tube is accomplished up to Stage XII. During this stage, some piece of the neural fold could presumably have separated and migrated. The ectopic tissue might have survived in the cerebrospinal fluid, and structural organization taken place up to the 7- or 8-month gestational stage.

Willis classified heterotopias into four types: 1) supernumerary or accessory organ; 2) transference of an accessory organ; 3) dislocation; and 4) heterotopia or anomalous differentiation. From its histological findings, our case can be classified as a supernumerary heterotopic organ. Some of the reported cases were associated with other anomalies of the central nervous system, such as microencephaly, maldevelopment of the corpus callosum, cerebellar dysgenesis, and aqueductal stenosis. Neuroradiological and surgical findings indicated that this patient had no other anomalies in craniofacial development. Clinical follow-up study of this child should be of great interest.

References