HYDRANENCEPHALY AND ALLIED DISORDERS

A STUDY OF CEREBRAL DEFECT IN CHINESE CHILDREN

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It is proposed to present 11 cases of cerebral defect. Six of these can be classed as hydranencephaly, the others show varying degrees of cerebral mantle tissue loss. The diagnosis and aetiology of these defects will be discussed and pictorial evidence produced to show that hydranencephaly is probably the end result of a graduated series of cerebral cortical defects.

Hydranencephaly is defined by Potter (1952) as 'an abnormality consisting of a complete or almost complete absence of the cerebral hemispheres. The leptomeninges and dura are completely formed occupying their normal positions in the skull'. Although Bettinger (1940) attributes the name of the condition to Cruveilhier (1835), and although the latter describes the anomaly and illustrates his case with an excellent colour plate, he does not in fact use the word, remarking, 'Il y a deux espèces d'anencéphalies: l'anencéphalie hydrocéphalique et l'anencéphalie avec l'absence de la voûte crânienne, du plutôt avec déjettement et déformation des os de la voûte'. He continues, 'Dans l'un et l'autre cas l'absence du cerveau doit être produite par la même cause'. It seems that Spielmeyer (1905) was the first to use the word in the title of his paper, 'Ein hydranencephales Zwillingpaar'.

The number of reported cases is probably about 70. Reliable figures are difficult to obtain as various authors have not hesitated to extend the definition to suit their own specimens. Others, e.g. Picaza, Cardelle and Martin Jimenez (1955) who would abolish the term altogether, hide within their term 'hydroencephalodysplasia' undoubted cases of the classical condition. Yet others, like Kåss (1951),

erroneously describe their cases as being examples of gross hydrocephalus.

The classification of the condition, like many others whose aetiology is uncertain, is in dispute. Earlier authors were content to use the descriptive term 'hydranencephaly' and leave it at that. Yakovlev and Wadsworth (1946) after a detailed histological study of two cases suggest the name 'schizencephaly'. They considered the defect to be a true cerebral agenesis, with congenital clefts of the cerebral mantle, and hydrocephalus. Cohn and Neumann (1946) consider 'severe bilateral porencephalia'* to be the proper classification, while Picaza *et al.* (1955) coin the term 'hydroencephalodysplasia'. By this they connote any defect in the cerebral mantle associated with hydrocephalus. They describe 23 cases covering the range of specimens illustrated in this paper. Their series included three post-mortem examinations and 10 exploratory craniotomies. This classification has much to recommend it despite the clumsiness of name, as it links hydranencephaly with a wider range of similar disorders.

Crome and Sylvester (1958) suggest 'hydrencephaly' as being a more appropriate name, since, in fact, the lesion is quite unrelated to anencephaly.

Morbid Anatomy

Hydranencephaly. No two specimens of hydranencephaly are exactly alike. The average case shows at the base of the skull, sitting above the tentorium cerebelli, two prominent knuckles, representing the basal ganglia. From these, there sweeps forward into the anterior cranial fossa a thin membrane composed of immature nervous tissue elements and adherent pia-arachnoid (Bettinger, 1940): the membrana gliae limitans. This may peter out, or may continue closely applied to the pia-arachnoid

* Strictly porencephaly means a loss of cerebral substance resulting in a fistula between subarachnoid space and lateral ventricle. It is held that such fistulae are probably rare and most authors, including the writer, use the term largely to connote a loss of cerebral substance of such degree that the cavity of the lateral ventricle may be seen from the outside.

as a paper-thin sheet which passes posteriorly to join the posterior portion of the cerebral vestiges, thus enclosing the ventricular cerebrospinal fluid and separating it from the sub-arachnoid space. The cells in this membrane are immature and often contain a large connective tissue admixture. Moser (1952) suggests these few glial cells may survive by virtue of a better blood supply.

The lateral and third ventricles are absent, the choroid plexus lying free, posterior to the basal ganglia. Rarely the choroid plexus may be absent (Yakovlev and Wadsworth, 1946).

The olfactory nerves are usually present, although they may be represented by localized thickenings in the nervous tissue sheet mentioned above (Moser, 1952). Najman (1953) was unable to find a first nerve in his case.

The optic nerves are usually present; microphthalmia is common. Although the other cranial nerves are usually present, the fourth has been noted to be absent (Gerundo, 1955).

Detailed neuroanatomical and histological descriptions of the lesion are extant, those of Yakovlev and Wadsworth (1946) and of Moser (1952) being particularly valuable. The latter paper also contains an exhaustive review of the German language literature.

Porencephaly. The morbid anatomical picture of porencephaly varies with the extent of the cerebral defect. The range of defects commonly met with can be seen in the illustrations in this paper.

Causes

If one examines the literature one finds that hydranencephaly has been blamed on many agents, viral, chemical and vascular.

Kåss (1951) reports on a male infant who died at the age of 8 weeks with severe hydrocephalus and microphthalmia. The child had been delivered by caesarian section as the foetal skull had, on radiographic examination of the maternal pelvis, looked abnormally large. At birth it proved to be 46 cm. in circumference enlarging to 50 cm. just before death. Laboratory tests for toxoplasmosis and syphilis were negative. Necropsy revealed the typical picture of hydranencephaly: a normal cerebellum, pons and medulla, the cerebrum being represented by a mass of white tissue the size of a walnut. The mother of this child had suffered from epidemic hepatitis in the second and third months of pregnancy.

Ilberg (1901) found histological evidence of syphilis in the liver and spleen of his case.

Thelander, Shaw and Piel (1959) found the

meninges of the right frontal region to be diffusely infiltrated with small calcified flecks and suggested that a toxoplasma infection may have been responsible.

Conte, McCammon and Christie (1945), reviewing proven cases of congenital abnormality in children whose mothers had rubella in the first three months of pregnancy, found that four of the five cases which they had themselves collected, showed cerebral aplasia. Unfortunately, they do not state what they mean by this term.

Olive and DuShane (1953) describe a child whose mother had attempted at the fourth month of pregnancy to induce abortion by the intra-uterine injection of formaldehyde. At necropsy shortly after birth her child showed bilateral absence of the anterior halves of the cerebral hemispheres.

The mother of Case 3 of Yakovlev and Wadsworth (1946) had made repeated attempts to induce abortion by the ingestion of unspecified drugs. At autopsy the child, aged 21 months, showed the classical intracranial features of hydranencephaly.

Johnson (1938) describes a 6½-month-old child who had always been weak, and whose weight gain since birth was but 420 g. Enlargement of the head and microphthalmia were the salient clinical features. The head showed the phenomenon of transillumination, air studies revealing an external hydrocephalus and a small brain. Necropsy confirmed the radiological picture, frontal lobes, fornix, mammillary bodies and the aqueduct of Sylvius being absent. The third ventricle was rudimentary. The mother, it transpired, had been given x-ray therapy 17, 24 and 32 days after the probable date of conception, receiving in all 1,150 r in air. The uterus, it was estimated, received 400 r.

Gerundo (1955) suggested, on histological grounds that the choroid plexus might be abnormally active, thus causing a severe internal hydrocephalus.

Marburg and Casamajor (1944) consider that venous thrombosis or stasis, especially of the deep cerebral veins is the most likely cause.

Spielmeyer (1905) found that the vessels on the surviving cortex, especially those of the cerebellum, were thin walled, dilated and showed a remarkable tendency to become confluent and form cavernous spaces.

It thus seems that either there may be a multiplicity of aetiological agents, or that all the maternal infections reported are fortuitous.

A major divergence of opinion exists as to whether the cortical tissue is laid down and then destroyed, or whether it is suppressed *ab initio*.

Crosby (1944) who examined Watson's (1944) Case 1 from an anatomical aspect, was of the

opinion, after she had lightly packed the covering membranes which lay over the rudimentary cerebral vestiges, that the brain had developed for some five months and then regressed. Edinger and Fischer (1913) described in their case convolution-like indentations of the pia-arachnoid and deduced that the cortical tissue had developed normally and then regressed. Picaza *et al.* (1955) describe in one of their cases pseudo-convolution-like markings on the skull bones but felt that they were due to pressure from the underlying fluid rather than showing any relationship with the cortex. Not all cases of hydranencephaly show a covering membrane, let alone convolutional markings.

Spatz (1935) describes experiments to show that foetal brain tissue reacts differently from that of the adult if subjected to gradual deprivation of blood supply, stating that such tissue liquefies leaving lacunae of cysts, whereas the adult would respond by 'fibrosis'. Becker (1949) injected into the carotid artery of newborn puppies a paraffin-olive oil mixture with a melting point of 40° C. Necrosis and gradual resorption ensued, the end result in a year or so being a smooth walled cavity enclosed by a 'hydranencephalic' membrane. Vogel and McClenahan (1952) occluded the major cerebral arteries of day-old chicks by electrocautery. By this means they produced marked retardation of cortical development, the forebrain in survivors often remaining as a thin walled cyst. Thelander *et al.* (1953) found in the liver and spleen of their case large collections of pigment which they believed must represent destroyed brain tissue. Gerundo (1955) noted that in the cytoplasm of the cells of the choroid plexus there were many pigment granules which he stated were haematogenous. Moser (1952) describes the thin layer of brain tissue present as having abundant haemosiderin deposits. Others such as Najman (1953) have been unable to find any haemosiderin, or, at most, a very little (Hunziker, 1947).

Yakovlev and Wadsworth (1946) point out that if the brain develops and is then destroyed, it would be reasonable to assume that the dependent cell stations would show secondary destruction or atrophy, e.g. the nuclei of origin of the thalamo-cortical projection fibres. They demonstrated that this is so in adult cases of porencephaly following cerebral thrombosis, while in hydranencephaly there is rather hyperplasia of these basal nuclei. They feel that the anatomical lesions are consistent with a primary inhibition of differentiation of the neural tube before the second month of intra-uterine life. This contention is supported by the timing of the foetal injury in the cases of Johnson (1938) and Kåss (1951).

A similar condition has been reported in calves (Whittem, 1957).

Racial Incidence. The condition has hitherto been reported, in the main, in persons of Caucasian stock. Picaza *et al.* (1955) found several cases among mulattoes; Montagné and Du'ong Bá-Bành (1950) found one in a Vietnamese infant; Gerundo (1955) found one in a Chamorro child in Guam. This paper records, for the first time, to the best of the author's belief, its occurrence in Chinese. Search of the autopsy records of the Singapore General Hospital for the past 10 years (over 20,000 autopsies) failed to reveal the condition in either Indians, Pakistanis, Sikhs, or Malaysians.

Clinical Features

Hamby, Krauss and Beswick (1950) suggest the following points as being of use in the systematic investigation of the condition.

(1) **Recognition of Characteristic Clinical Pattern.** Picaza *et al.* (1955) aptly described the condition as one of functional decortication. As this term could well be applied to any child under the age of 3 weeks it is not until this age is reached that suspicions that something is amiss may be aroused. The most constant feature is a hyper-irritability. Moro's, the startle, and grasp reflexes are usually present. The child may whine incessantly in a mechanical sort of way, presenting as it does so, an indifferent facies. The child usually suckles normally and feeding difficulties may not arise until shortly before death. The eyes are frequently affected showing inordinate movement, marked strabismus and nystagmus. Microphthalmia is not uncommon. The pupils react to light (Yakovlev and Wadsworth, 1946), the optic discs are, as a rule, pale. Simple optic atrophy was noted in half of the cases reported by Picaza *et al.* (1955). Dissociated movements were noted by Olive and DuShane (1953).

The most constant physical finding is enlargement of the head which usually occurs in the first few weeks, although this feature may not become apparent until about the third month. Some show this cranial enlargement at birth; in only one, however, had the enlargement required craniotomy to effect delivery (Hurowitz, 1936).

Various authors have from time to time described assorted concomitant findings. Both of Watson's (1944) cases were severely jaundiced. Picaza *et al.* (1955) found five of his hydroencephalodysplasia cases to be very cyanosed at birth. Half of his series showed convulsions, either generalized or Jacksonian, a feature not noted by any other author. Thelander

et al. (1953) noted difficulty in establishing respiration, while Edinger and Fischer (1913), Kåss (1951), and Moser (1952) noted that their cases had great difficulty in maintaining the body temperature. Such features, although they may assume importance in a particular child are of little consequence in diagnosis.

In short, the picture is one of little spontaneous activity, cranial enlargement and eye disturbances.

(2) **Transillumination of Head.** This simple test was first described by Strasburger (1910) who noted that in cases of severe hydrocephaly, i.e. those in which the residual brain tissue was less than 1.0 cm. thick, a light placed behind the child's head in a darkened room would cause it to glow red all over. Onsalo (1933) constructed a special box for this purpose. In recent years the test has been brought to the notice of paediatric workers by Hamby *et al.* (1950). They liken the colour obtained on transillumination to the orange-red light which emanates from an ornamental Japanese lantern. The mother of one of the cases of these latter authors noticed that her child's head glowed when it was brought near a table lamp.

Despite its simplicity this test can give a very accurate picture of the intracranial contents as any residual brain tissue shows up as a dark patch. When the head is transilluminated the pupils appear to glow red. Most authors seemed convinced of the value of the test (Beswick, 1948; Najman, 1953).

(3) **Fontanelle Puncture.** Fontanelle puncture seems to yield little information and in the days before antibiotics was a sure passport to a septic meningitis (Johnson, 1938). The cerebrospinal fluid protein may be raised (Thelander *et al.*, 1953), or normal (Picaza *et al.*, 1955). There may be xanthochromia at the first tap; the cell count varies from child to child. Injection of a dyestuff into the spinal theca may show communication with the remnants of the ventricular system. The degree of agenesis is not related to the presence or absence of spinal block. When the fluid is withdrawn it may be replaced by air. If sufficient is injected the state of the cranial cavity may be very accurately determined, especially if the head be inverted when taking skiagrams. Watson (1944) counsels against this procedure as one of his cases had severe convulsions after the fluid was removed. Picaza *et al.* (1955) concur, remarking that air studies are not well tolerated, as if the degree of agenesis is severe they are not infrequently followed by respiratory syncope and infection.

(4) **Electroencephalography.** E.E.G. shows a characteristic complete absence of electrical activity over those areas which lack subjacent brain tissue. Relatively minor defects can be detected in this way. All writers seem agreed that this is a constant finding.

(5) **Angiography.** Angiography presents a pathognomonic picture. As the internal carotid is usually hypoplastic the operative procedure is difficult (Picaza *et al.*, 1955). Care should be taken not to mistake superficial temporal and meningeal arteries for cerebral vessels. Thelander *et al.* (1953) showed the circle of Willis to be intact but very small. They felt this was an effect, rather than the cause, of the lack of brain tissue.

Diagnosis ante-mortem is of importance if only to obviate the adoption of children suffering from this defect, as in Case 1 of this series. Beswick (1948) reports on a child who had been adopted at the age of 1 week having been pronounced normal by a competent paediatrician. Parents should be warned of the poor prognosis. Edinger and Fischer (1913) describe a child who lived to the age of 3½ years, the oldest on record.

Case Histories

Case 1.—J.J.N., a 2-week-old female Chinese, was admitted to the General Hospital, Singapore, on April 12, 1957, for investigation of jaundice and cranial enlargement. The child had been adopted on the fourth day of life. At that time the foster-mother had noticed mild jaundice. The child had suckled poorly, slept fitfully and 'lay crying all night'. Since birth the child had had several twitching attacks each lasting a few seconds. The birth weight was 8 lb., the child being delivered in hospital at term. The officiating midwife noticed no abnormality.

On admission the child was mildly icteric, the skull circumference 38 cm. The temperature was subnormal and remained so for the rest of the child's life. The pupils reacted to light sluggishly, the eyes remaining turned downwards at all times. There was a rough systolic murmur near the cardiac apex, the muscle tone was hypertonic, the tendon reflexes present.

The haemoglobin was 83% (Haldane); the blood group B Rh positive. Coombs direct test was negative, as was the Kahn. A subdural tap was performed, the fluid withdrawn being moderately xanthochromic. The protein level was 100 mg. %, the cell count four lymphocytes per c.mm. Cerebrospinal fluid obtained from the spinal theca gave identical results. Shortly after this procedure all the limbs became spastic. On April 22, 1957, the left eye was noted to be purulent. Despite treatment the process advanced and the cornea became ulcerated. Evisceration was recommended and carried out by Dr. K. Y. Wong. The child died on May 2, 1957.

An autopsy was performed (861/57). Externally the child was mildly jaundiced; the skull circumference was 41 cm. A small high interventricular septal defect was noted in the heart. The pulmonary valve was bicuspid. Both cerebral hemispheres were absent. Two small knuckles of white matter, 2 cm. in diameter, represented the basal ganglia. There were no lateral or third ventricles. The choroid plexus was stained a light brown, and was seen to lie posterior to and between the twin eminences of the basal nuclei. A thin membrane about 2 mm. thick swept forward from the basal nuclei into the anterior cranial fossa which continued, closely applied to the pia-arachnoid, across the vault of the skull, to rejoin the cerebral vestiges posteriorly, thus enclosing the cerebrospinal fluid. The optic and other cranial nerves were present (Fig. 1).

Medulla, pons, cerebellum and tentorium cerebelli appeared normal. The carotid vessels, although smaller than usual, appeared otherwise normal. The circle of Willis was intact, although anterior and middle cerebral vessels were practically vestigial, petering out after a centimetre or so.

The superior sagittal sinus was present, but the lumen was much smaller than is usual. The inferior sagittal sinus appeared normal.

HISTOLOGY. The membrane anterior to the basal nuclei varied considerably in thickness from place to place. Essentially it showed two fairly distinct layers: that in apposition to the subarachnoid space and its

attendant vessels was composed principally of large polyhedral cells with an abundant cytoplasm and a rich fibrillary network: that exposed to the intracerebral C.S.F. showed much fewer glial cells, a corresponding decrease in fibrils, and many more microglial cells (Fig. 2). There was no ependymal lining. No neurones were seen.

One small ependymal inclusion was present 2 mm. below the surface of the right basal nuclei.

Haemosiderin was present in moderate amounts in that part of the membrane near the subarachnoid space, and a great deal more in the tissues of the subarachnoid space themselves. Occasional haemosiderin and lipid-laden macrophages were seen throughout the nerve tissue of the basal nuclei.

Morphologically the choroid plexus appeared normal. The H. and E. section showed the choroidal cells to be masked by a light brown pigment. This proved to be haemosiderin.

Comment. Classical hydranencephaly, moderate amounts of haemosiderin present in addition to ependymal inclusions in the basal nuclei. The membrana gliae limitans is similar in structure to that described by others (Crome and Sylvester, 1958).

Case 2. S.M.K., a 9-day-old Chinese female infant, was admitted to the General Hospital, Singapore, on July 3, 1958, with a history of progressive jaundice since birth, associated with difficulty in feeding.

Examination revealed a marked jaundice and a slight pyrexia. Heart and lungs appeared normal. Reflexes and muscle tone appeared normal. Haemoglobin 100% (Haldane), W.B.C. 19,600 per c.mm., the differential count being within normal limits. The child died 12 hours after admission.

FIG. 1.—(P.M. 861/57). Skull hemisected in sagittal plane. Normal cerebellum, intact falx, and basal nuclei are clearly seen.

FIG. 2.—(P.M. 861/57.) The membrana gliae limitans, folded over on itself in this section, is composed of two fairly distinct layers: an outer cellular, in apposition to the subarachnoid space, and an inner less cellular, in contact with the intracerebral C.S.F. H. and E. $\times 110$.

At autopsy (1283/58) a few minor areas of collapse were noted in both lungs, principally at the free margins of the lower lobes. The skull was of normal external diameter (29·8 cm.). Removal of the calvarium revealed a classical case of hydranencephaly. There was complete absence of the cortex.

The dura was covered by a thin brownish, relatively tough layer of tissue which showed numerous dimples and lacunae (Fig. 3).

FIG. 3.—(P.M. 1283/58.) Absence of cerebral hemispheres, a distorting band of membrane in right middle cranial fossa, and numerous dimples, or ulcers, in dura.

FIG. 4.—(P.M. 1283/58.) Cross-section of one of the ulcers seen in Fig. 3. Dense layer on surface represents membrana gliae limitans, below which subarachnoid space is obliterated, all being densely adherent to dura. H. and E. $\times 35$.

In this membrane were numerous focal collections of mid-brown amorphous pigment, the largest measuring about 0·5 cm. across.

The basal nuclei were very small. Between them and attached medial to them was a prolongation of the brown layer of tissue mentioned above, which swept up over the basal nuclei to merge with that flooring the cranial fossae. At the right antero-lateral margin a strand of tissue distorted this funnel shaped opening to the right so that on casual inspection the basal nuclei were not visible. At the base of this opening lay the choroid plexus and the opening of the aqueduct of Sylvius. Beneath the membrane lay well formed optic and olfactory nerves. The remainder of the cranial nerves and the pituitary gland appeared normal. The circle of Willis was intact although the blood vessels were very small. The middle cerebral vessel passed just posterior to the chiasma to ramify on the inferolateral surfaces of the funnel mentioned previously.

HISTOLOGY. In the region of the basal nuclei the dura was lined on its inner surface by varying thicknesses of primitive nerve cells, heavily infiltrated with microglia. From place to place there were breaks in the dura, resulting in small undermined 'ulcers' corresponding to the dimples seen with the naked eye. The lumina of these hiatuses were filled with haemosiderin-laden foamy macrophages (Figs. 4, 5). In the floor of the lesion numerous other haemosiderin-laden cells were present, in addition to a few capillary vessels. An occasional calcified area was present. In the six sections taken from varying areas of the cranial fossae, the subarachnoid space was for the most part obliterated.

The choroid plexus appeared normal, showing light haemosiderin deposits in the choroidal cells.

No ependymal inclusions were seen in the sections taken.

FIG. 5.—(P.M. 1283/58.) The floor of another such ulcer is lined, and lumen filled, by foamy haemosiderin laden macrophages. Perls' stain $\times 375$.

Comment. Partial obliteration of the subarachnoid space has been noted by Crome and Sylvester (1958). This specimen shows classical hydranencephaly associated with massive haemosiderin deposits.

Case 3. L.K.E., a 6-day-old female Hylam child, was admitted to the General Hospital, Singapore, on February 11, 1958, with a history of refusal to take feeds since birth. Three days after birth the child was noticed to be jaundiced, the pigmentation deepening rapidly, till on the seventh day the serum bilirubin was 20 mg. %. Examination of the spinal cerebrospinal fluid revealed a yellowish fluid whose protein level was 200 mg. %, the other findings being within normal limits. The child declined rapidly, dying on March 1, 1958.

An autopsy was performed (396/58). Externally the child was deeply jaundiced. The liver was enlarged soft and greenish in colour. The spleen appeared normal.

The cranial cavity showed classical hydranencephaly (Fig. 6). The basal nuclei were rather small, the left being 15 mm. across, the right 10 mm. There was a vestigial hippocampus on the right side only, with a few rudimentary gyri on the under-surface. On the same side, adjacent to the right pituitary fossa, was a small pedunculated mass of nerve tissue 15 mm. in diameter. Between the basal nuclei lay the floor of the third ventricle and the choroid plexus.

A thin tenuous sheet of nerve tissue swept forward from the anterior aspect of the basal nuclei into the anterior cranial fossa. The olfactory nerves were represented by cord-like localized thickenings in the sheet. The optic and other nerves were present. The eyes appeared normal. The circle of Willis was present, but all vessels, including the posterior cerebral artery, were very small.

HISTOLOGY. The choroid plexus showed brownish discolouration, but otherwise appeared normal. Stains for haemosiderin revealed heavy deposits within the choroidal cells.

Sections of basal nuclei and hippocampus showed haemosiderin to be present not only on the surface, but within the brain substance. The liver was congested, the sinusoids appearing wider than is usual. The portal tracts were normal, containing a few focal collections of nucleated cells. There were moderately large amounts of haemosiderin within all the liver cells. The spleen was congested and showed moderate amounts of haemosiderin.

Comment. Classical hydranencephaly with heavy intracranial, and moderate intrahepatic deposits of haemosiderin.

Case 4. N.M.K., a 2-year-old Chinese female infant was admitted to the General Hospital, Singapore, on May 9, 1958, complaining of difficulty in feeding. During the previous two days there had been episodes of epistaxis, associated with a mild fever.

The head was much enlarged, being 42 cm. in circum-

ference. There was bleeding from the mouth and nose, deep cyanosis of the lips, and marked pallor of the mucous membranes. The child was flaccid and in coma. Crepitations were heard at the lung bases. Death occurred four hours after admission.

An autopsy was performed (891/58). A confluent bronchopneumonia was found in all lobes of both lungs. The spleen was multilobulate, being represented by nine spleniculi held together by delicate connective tissue strands.

FIG. 6.—(P.M. 396/58). The intracranial appearances of classical hydranencephaly. Probe is in aqueduct of Sylvius, and is flanked on either side by choroid plexuses.

The brain showed a lesser degree of defect than the previous specimens. A fine membrane enclosed 580 ml. of cerebrospinal fluid and was attached to the lips of the defects. On the left there was a thin rudimentary hippocampus with normal appearing gyri on the under surface. The convolutions on the upper surface were broad, indistinct and flattened. On the right side was a lobe which was neither truly temporal nor occipital measuring 3×2 cm. Both lobes showed numerous areas of brownish deposit, both on the surface, and within their substance, measuring up to 5 mm. across. The cranial nerves were present. The eyes were very small. The choroid plexuses appeared normal. The cerebellum was represented by a large single cyst, which contained within its lumen the choroid plexus of the fourth ventricle.

The circle of Willis was present although the vessels were all very small. The vertebral, basilar and posterior cerebral vessels appeared normal. The sagittal sinuses appeared normal.

HISTOLOGY. The lateral margin of the superior surface of the hippocampus showed the point of attachment of the thin nervous tissue sheet. This contained a few nerve cells and moderate numbers of microglia. This sheet became closely applied to the substance of the occipital lobe, blending with the underlying tissue, yet it could be followed as a separate entity on account of linear deposits of calcium. These corresponded more or less, but not entirely, to the haemosiderin deposits. Multinucleate macrophages were seen in relation to these calcium deposits (Fig. 7). Elsewhere within the lobe haemosiderin lay in two forms, either loosely scattered or within foamy macrophages several of which were multinucleate.

FIG. 7.—(P.M. 891/58.) Several multinucleate giant cells surrounded by calcium deposits. H and E. $\times 375$.

A similar appearance was seen in the temporal lobe and in the basal nuclei. Many foamy haemosiderin-laden macrophages were to be found in the Virchow-Robin spaces of small blood vessels (Fig. 8).

FIG. 8.—(P.M. 891/58.) Numerous foamy macrophages in a Virchow-Robin space. H. and E. $\times 375$.

The wall of the cystic cerebellum was thin, and showed some post-mortem change. Within it there were numerous blood vessels, in whose Virchow-Robin spaces there were large aggregations of haemosiderin-laden foamy macrophages. In several of these areas cholesterol clefts were seen (Figs. 9, 10).

FIG. 9.—(P.M. 891/58.) Haemosiderin-laden macrophages in cerebellum. Perls' stain $\times 35$.

FIG. 10.—(P.M. 891/58.) Cholesterol clefts within aggregations of macrophages. H. and E. $\times 110$.

The choroid plexuses appeared normal, although heavily laden with haemosiderin (Fig. 11).

In a few places the retina showed various degrees of focal atrophy, the ganglion cells being absent and the nuclear layers represented by one or two cells. Elsewhere, although the retina had stripped off the pigment epithelium, appearances were normal. No haemosiderin was seen.

Comment. Classical hydranencephaly showing massive intracranial deposits of haemosiderin. In

addition, in this case, there is a cerebellar lesion and mutilobulation of the spleen.

Case 5. T.S.H., a 2-year-old female Teochew, was admitted to the General Hospital, Singapore, on March 12, 1958, with a complaint of inability to eat for the past

FIG. 11.—(P.M. 891/58.) Heavy deposits of haemosiderin within choroidal cells. Perls' stain $\times 375$.

four months. The child was very emaciated, and had multiple septic sores on the scalp. Crepitations were heard at the right lung base. The child died eight hours after admission.

An autopsy was performed (475/58). The lungs showed early bronchopneumonic change. The brain showed the appearance of hydranencephaly (Fig. 12). The basal nuclei were very much enlarged measuring $3.5 \times 2 \times 2$ cm. Towards the occiput were rudimentary hippocampi. From the anterior end of the basal nuclei a thin sheet of nerve tissue sprang forward to blend imperceptibly with the pia and enclose the cerebrospinal fluid. The circle of Willis was intact although anterior and middle cerebral vessels were very small. The eyes appeared normal.

HISTOLOGY. Sections taken at intervals of 2 mm. through the basal nuclei showed that the medial aspect was clothed by an incomplete flattened ependymal layer of cells. Beneath this lay a rather condensed layer of glial tissue at the under surface of which numerous blood vessels were seen. Within the substance of the grey matter at one place about 20 ependymal rosettes were present (Fig. 13).

Haemosiderin was present in very small amounts, not in the superficial layers but deeper down within the basal nuclei, principally in paravascular macrophages.

More posteriorly in the basal nuclei several larger vessels were found just beneath the surface and in this region haemosiderin was much more prominent, although by no means heavy.

Section of the hippocampus showed haemosiderin in moderate amounts deep within the remnant, more superficially, and within the walls of the attached membrana gliae limitans. A small ependymal inclusion was present.

Comment. Classical hydranencephaly occurring in an older infant, showing ependymal inclusions in the basal nuclei and hippocampus. Haemosiderin is present in small quantities.

Case 6. T.S.S., a 1-month-old female Teochew child, was admitted to the General Hospital, Singapore, on July 19, 1957, and was immediately placed on the dangerously ill list. The mother stated that the child's head had started to enlarge rapidly two weeks after birth. The child, a first baby, had been delivered in hospital, weighed 7 lb. 5 oz. at birth and had been regarded as quite normal. Feeding, as is common in Singapore, had been on condensed milk. Twenty-four

FIG. 12.—(P.M. 475/58.) Gross enlargement of basal nuclei and rudimentary hippocampi.

FIG. 13.—(P.M. 475/58.) Ependymal rosettes within basal nuclei. H. and E. $\times 110$.

hours before admission the child had become fevered, had vomited and then passed several loose stools.

The nutritional state of the child was poor, the pharynx inflamed; auscultation over the lung bases revealed many crepitations. The tendon reflexes were present although muscle tone and power were poor. Despite treatment with antibiotics the child died next day.

An autopsy (1543/57) was performed. The lungs showed patches of bronchopneumonic consolidation. The circumference of the skull was 42 cm. The cranial cavity contained about 500 ml. of clear cerebrospinal fluid. There was complete absence of the cerebral hemispheres (Fig. 14). The basal nuclei were much enlarged measuring on the right $2 \times 1.5 \times 1.5$ cm., and on the left $3 \times 1.5 \times 1.5$ cm. Posterior to the enlarged basal nuclei, partially filling the posterior cranial fossa,

FIG. 14.—(P.M. 1543/57.) Appearances of hydranencephaly, the thin membrane being particularly well seen in this specimen.

were imperfectly formed hippocampi, attached to the margin of which was a thin tenuous membrane which enclosed the cerebrospinal fluid. The under-surface of the hippocampi showed a few incomplete gyri. Between the hippocampi there emerged from two foramina, separated by a thin antero-posterior band of nerve tissue, the choroid plexuses. Running from the anterior end of this band a cord of nerve tissue 2 mm. thick ran to find attachment to the crista galli. The blood vessels although small appeared normal. The cranial nerves appeared normal.

HISTOLOGY. The basal nuclei appeared normal. Covering them was a dense glial layer some 2 mm. thick which showed, from place to place, focal collections of round cells, mainly close to small ependymal inclusions

(Fig. 15). The nuclei were not covered by ependyma. Haemosiderin was present in large amounts about 1 mm. beneath the surface, and deeper within the grey matter. A small amount of haemosiderin was seen beneath the surface of the hippocampi remnant.

The membrana gliae limitans contained large numbers

FIG. 15.—(P.M. 1543/57.) Ependymal inclusions just below surface of basal nuclei. H. and E. $\times 110$.

of glial cells with an abundant cytoplasm and a rich fibrillary network. A small number of microglial cells were seen. The subarachnoid space, and the interstitial tissues around it, contained moderate numbers of haemosiderin laden macrophages.

The choroid plexus, which contained large amounts of haemosiderin, was otherwise normal.

Comment. Classical hydranencephaly. The basal nuclei show small ependymal inclusions. A moderate amount of haemosiderin is seen throughout.

Case 7. T.O.P., an 18-month-old female Chinese child, was admitted to the General Hospital, Singapore, on May 22, 1958, with a complaint of diarrhoea, cough and fever of two days' duration.

She was a small undersized child with a cleft palate. Temperature 99° F. Harsh rales were heard at the lung bases. The child died four days after admission.

An autopsy was performed (1002/58). There was a patent foramen ovale in the heart. Both lungs showed advanced bronchopneumonic change.

On opening the skull, a most bizarre abnormality was encountered (Fig. 16). There was complete absence of occipital, parietal and temporal lobes. In the region of the frontal lobes the anterior cranial fossa was partly filled by an oval plaque of cortical tissue. This showed no division into right and left lobes, gyri traversing the anterior surface from side to side without vestige of interruption. The superior and lateral edges of the brain tissue were rolled over, and attached to the margin of the defect posteriorly was a thin tenuous, often

FIG. 16.—(P.M. 1002/58.) The peculiar frontal remnant with its folded-over posterior edge. The cerebellum and mid-brain are seen more posteriorly.

FIG. 17.—(P.M. 1002/58.) Ependymal inclusion within cortical tissue at folded-over edge seen in Fig. 16. H. and E. $\times 110$.

collecting convoluted tubules a dark brown granular pigment which did not take up the iron stain.

Comment. Bizarre anomaly with preservation of an anomalous frontal lobe. Ependymal inclusions seen, and small amounts of haemosiderin present.

incomplete membrane. Apart from this vestige there was no other brain tissue above the tentorium cerebelli. Through the hiatus in the anterior portion of the tentorium a small portion of pons was visible, in the middle of which was a small foramen, the opening of the aqueduct of Sylvius.

Rudimentary optic nerves were present, but no olfactory nerve was seen. The cerebellum and pons appeared normal. The choroid plexus of the fourth ventricle was present and appeared normal; that of the lateral ventricle was not seen. The crista galli was absent. The falx cerebri was absent. The lateral and sigmoid sinuses were in their correct places. The circle of Willis was intact. The middle cerebral vessels were vestigial. The anterior cerebral vessels ramified over the frontal remnant.

HISTOLOGY. Sections of the cervical cord and pons appeared normal.

A section taken from the left lateral edge of the remnant in the anterior cranial fossa showed relatively normal cortical tissue, the cells being of the size, shape and orientation of those normally seen in the cortical areas. The inner aspect of the folded over posterior edge was lined by ependyma. Immediately subjacent to this lining several small ependymal inclusions were present (Fig. 17). Stains for haemosiderin revealed a few scattered focal collections of the iron containing pigment scattered, apparently at random, throughout the cortical tissue. The haemosiderin was for the most part present within macrophages.

Section of the kidney showed within the cells of the

Case 8. O.G.S., a male Hokkien aged 4 years, was brought to the General Hospital, Singapore, by his father on April 5, 1953, and died on his way from admission room to the ward. He had had a fever for several days and had vomited several times on the day of admission. The referring general practitioner had noted the temperature to be 100.2° F., slight rigidity of the neck, enlarged inflamed tonsils, harsh breath sounds, and had made a diagnosis of bronchopneumonia.

An autopsy was performed (581/53). The lungs showed a patchy bronchopneumonia. The right cerebral hemisphere seemed to be slightly enlarged, with a dilated lateral ventricle. The left cerebral hemisphere was represented by a rudimentary occipital lobe and hippocampus (Figs. 18 and 19). Along the free margin of the defect there was a fine sheet of nerve tissue which spread laterally from the large basal nuclei (2.5×4 cm.) to peter out after some 2 cm. This nervous tissue sheet was supported by the pia arachnoid. The cerebellum appeared normal. The cerebral peduncles were present and appeared to be equal in size. The choroid plexus was normal. The circle of Willis was present, the vessels on the left being very small, the middle cerebral vessel running laterally as far as the edge of the nerve tissue sheet.

HISTOLOGY. The basal nuclei were covered by a thin layer of white matter, beneath which numerous small blood vessels ran parallel to the surface. There was no ependymal covering, or ependymal inclusions. Small focal collections of haemosiderin were present throughout, principally in relation to small blood vessels.

FIG. 18.—(P.M. 581/53.) Lateral view of brain showing absence of left frontal, temporal and parietal lobes.

The roof of the exposed posterior horn of the left lateral ventricle was not lined by ependyma. Very small amounts of haemosiderin were present.

The cells of the choroid plexus looked somewhat degenerate. Haemosiderin was present in moderate amounts.

Sections of the right and left middle cerebral arteries revealed no abnormality, that on the right being approximately double the size of the other.

Comment. In this specimen there is agenesis of the left cerebral hemisphere only. The portions remaining are those supplied by the posterior cerebral artery. Moderate amounts of haemosiderin are present in the brain tissue near the defect, there being no evidence of fibrosis.

Case 9. L.L.P., an 8-year-old Chinese girl, was admitted to the General Hospital, Singapore, on September 13, 1958, with a complaint of cough, fever, dyspnoea, and fits of one day's duration. The temperature was 103.6° F. Numerous coarse crepitations were heard at the lung bases. The child was noted to be a mental defective, and was the size of a 3-year-old. She died shortly after admission.

An autopsy was performed (1821/58). The principal lesion in the brain was the presence of two defects on the supero-lateral aspects of both frontal lobes. The defect on the right was the smaller, being 3 cm. long and approximately 1 cm. wide. Around the defect was an area of microgyria extending over the greater part of the hemisphere. A similar appearance obtained on the left. Here the defect was larger, measuring 3 cm. by 2 cm. and was again surrounded by microgyri (Fig. 20). Only the occipital lobe on this side showed gyri that approached normal.

Both defects communicated with enlarged lateral ventricles, the septum pellucidum being absent. The corpus callosum was present. The inner walls of the ventricles were irregular and showed several rests of grey

FIG. 19.—(P.M. 581/53.) Same brain as in Fig. 18, seen from above. Note the large basal nuclei.

matter, principally around the defects. This irregularity of the inner surface extended into the posterior horns. The circle of Willis was normal. The end branches of the left and right middle cerebral arteries ramified over the surface of the brain posterior to the defects.

FIG. 20.—(P.M. 1821/58.) Brain viewed from above shows white plastic rod passing into one porencephalic defect and out of another on opposite side.

The choroid plexuses and the remainder of the brain appeared normal.

HISTOLOGY. At the edge of the lateral lip of the defect on the left side, on the superior aspect of the brain, was an area composed of glial fibres and blood vessels. No fibrous tissue was seen. This region was heavily infiltrated with microglia. Small amounts of haemosiderin were present, principally lying free in the subjacent brain. The walls of these blood vessels were heavily stained by a brownish pigment of uncertain nature.

Small petechial haemorrhages were seen in the basal nuclei. Within the left basal nucleus, running laterally, and well removed from the aqueduct of Sylvius were a series of small ependymal inclusions (Fig. 21). The choroid plexus was normal. No haemosiderin was present.

FIG. 21.—(P.M. 1821/58.) Ependymal cells deep within left basal nucleus. H. and E. $\times$ 375.

Comment. Bilateral porencephaly. The micro-polygyria suggests pre-natal origin (Greenfield, Blackwood, McMenemey, Meyer and Norman, 1958). Very small amounts of haemosiderin present, also peculiar ependymal inclusions.

Case 10. N.P.K., a male Teochew, aged 7 years, was brought to the General Hospital, Singapore, on February 7, 1952. Investigation by H.M. Coroner revealed that the boy, who had been in apparent good health, had fallen when running about with his friends. He lost consciousness and died on his way to hospital.

An autopsy was performed (191/52). The contents of the thoracic and abdominal cavities appeared normal. Externally the head, which appeared larger than usual, showed a contusion 3 cm. in diameter over the right forehead. Under the scalp there was a haematoma corresponding in size to the surface contusion. The left lateral ventricle communicated with the subarachnoid space through an opening about 2 cm. in diameter in the region of the Rolandic fissure some 1.5 cm. from the

vertex (Fig. 22). The subarachnoid space over the left cerebral hemisphere was distended with blood-stained cerebrospinal fluid. The sulci of the right hemisphere were less prominent than usual. The left middle cerebral vessel passed between the temporal and frontal lobes to gain the surface of the brain and then passed upwards in the sulcus below the defect. No thrombosis or other lesion was seen in the vessel. There was no septum lucidum but the corpus callosum was present.

HISTOLOGY. A section taken from the lip of the defect showed that at the under-surface of the lip within the brain substance there were large collections of macrophages containing haemosiderin. In this area the Virchow-Robin spaces of several of the small blood vessels showed a dense cellular infiltrate composed of round cells and larger macrophages (Fig. 23). No fibrous tissue was seen in the region.

The right middle cerebral artery showed no abnormality. The choroid plexus contained small amounts of haemosiderin.

FIG. 22.—(P.M. 191/52.) Single left sided porencephalic defect. Note smooth edge. (Cf. Fig. 25.)

FIG. 23.—(P.M. 191/52.) The lip of the porencephalic defect contains many macrophages, a large number of which are within the Virchow-Robin spaces. H. and E. $\times$ 110.

Comment. Unilateral porencephaly with haemosiderin laden macrophages at the lip of the defect.

Case 11. G.H.W., a 3-year-old male Teochew child, was admitted to the General Hospital, Singapore, on November 7, 1957, with a complaint of cough and fever of five days' duration. The child appeared to be a mongol. Crepitations were heard over the lung bases. There was a rough systolic murmur maximal in intensity over the third left interspace. Despite treatment the child died three days later.

An autopsy was performed (2331/57). The lungs showed a well marked bronchopneumonia. There appeared to be early bronchiectatic change in the right upper lobe.

The heart was enlarged, weighing 85 g. There was marked hypertrophy of the right ventricle and a marked dilatation of the right auricle associated with a large atrial septal defect and a high ventricular septal defect. The ductus arteriosus was patent.

FIG. 24.—(P.M. 2331/57.) A well marked parietal lobe defect. The covering membranes have been largely removed to show sclerogryria at lip of defect, and tough dense membrane separating sub-arachnoid space from lateral ventricle.

The left cerebral hemisphere showed a large defect of the temporo-parietal region 8 × 5 cm. in size (Fig. 24). This defect had a well marked sclerosed rim to which a thickened, dense, highly vascular, pia arachnoid was firmly adherent. The fibrous tissue which bridged the defect was closely applied to a very thin layer of nerve tissue approximately 1 mm. thick, thus separating the membranes from the cavity of the lateral ventricle.

Search for a left middle cerebral artery failed to reveal even the vestiges of such a vessel, although the anterior and posterior cerebral vessels were present in their usual situations. The vessels on the right side of the circle of Willis were normal.

There was no other intracranial abnormality.

HISTOLOGY. A section taken through the middle of the defect in the coronal plane revealed a dense fibro-vascular membrane firmly adherent to the lip. This blended imperceptibly with the subjacent white matter (Fig. 25) which in consequence contained many capillaries and much fibrous tissue. Large numbers of foamy macrophages were present in this area. The membrane was continued downwards closely applied to a thin nervous tissue septum which separated it from the cavity of the lateral ventricle. This septum was lined on the ventricular aspect by ependyma. Stains for haemosiderin showed the region of sclerogryria and the subjacent brain tissue and the membrane to contain much iron, both free and in macrophages, the latter being grouped round vessels and in the Virchow-Robin spaces. Elsewhere the membranes appeared normal.

Comment. Defect in temporoparietal region associated with apparent absence of middle cerebral artery. This lesion is probably post-natal in origin.

FIG. 25.—(P.M. 2331/57.) Interlacing fibrous tissue within brain substance at edge of defect. Note numerous capillaries. Picro-Mallory × 375.

Discussion

If one assumes that there is a primary inhibition of differentiation of the primitive nervous tube before the end of the second month of intra-uterine life, the mechanism of production of the subsequent defects is easily explained. This was realized as long ago as 1889 by Schattenberg who wrote, 'if one assumes that in the area of the cerebral mantle corresponding, for example, to the future central convolutions, there occurs in the cerebral wall an arrest of growth in thickness, then in the course of continual growth of the brain the surrounding parts will first overhang this area and then will eventually develop a pit formed by the rolled in surface of the brain'. The larger the area affected the more likely is it that pressure of the ventricular cerebrospinal fluid will

force the cerebral remnants against the membranes. Thus the larger the area initially damaged, the more like classical hydranencephaly and the less like porencephaly will the end result be.

This theory assumes that some toxin or viral agent causes the initial lesion. It is true that many neurotropic viruses have a predilection for particular parts of the mature nervous system, and there seems no reason why a foetal brain should not similarly be affected. If this thesis be accepted, then one must envisage a process with local death of a relatively small amount of developing nervous tissue, perhaps a cubic centimetre for a foetus up to the second month of intra-uterine life, and at most a small amount of local haemorrhage. One would not, if an adherent of this hypothesis, expect to see small, let alone large, amounts of haemosiderin in the cranial cavity, or elsewhere at autopsy. This theory does, however, neatly explain the presence of ependymal cells within the caudate nucleus or at the margin of a porencephalic defect as being a portion of the original pia-ependymal seam of a cleft in the cerebral mantle (Yakovlev and Wadsworth, 1946).

The contention that the damage occurs before the end of the second month is supported indirectly by the finding of a multilobulate spleen in Case 4.

Hitherto, this very rare malformation has been recorded only in association with gross anomalies of the heart and great vessels (Miller, 1925; Greenberg 1957). As the splenic primordium, an area of thickening in the dorsal mesogastrium, is first seen when fusion of the atrio-ventricular cushions is taking place about the thirty-sixth day after conception, it has been held that the factors interfering with the proper fusion of the cushions may also affect the developing spleen. If this be so, then it may be that such an agent acting about this time could also damage the developing brain.

If one accepts Yakovlev and Wadsworths' interpretation of the significance of ependymal inclusions (as in Cases 1, 5, 6, 7 and 9) and the supporting evidence of the multilobulate spleen, then it becomes clear that the defects in fact do have their origin at an early date. The presence of considerable amounts of haemosiderin in such cases is, however, very difficult to explain away.

As Kundrat (1882) has pointed out in his study of porencephaly, the distribution of most of these defects is within that of the Sylvian arteries. This fact, he felt, was in itself sufficient grounds for believing that all such defects were due to softenings, the end result of local circulatory disturbances.

This is an attractive theory. In substantiation one would expect to find either diseased blood vessels,

or at least organized thrombi within their lumina, such as Yakovlev and Wadsworth (1946) were able to demonstrate in their Case 5. While it is true that complete recanalisation might occur after a thrombotic episode, that no trace should be found of such a lesion in any of the vessels in this series stretches credibility. The presence of haemosiderin could easily be explained as haemorrhage from damaged blood vessels in the area of softening might well be expected. The later in intra-uterine life the episode occurred, and the more extensive it proved to be, the larger the amount of haemosiderin one might expect to see. Similarly if death occurred a long time after birth much of the haemosiderin originally found might be metabolized.

In this series the presence of various amounts of haemosiderin in all of the specimens has been amply demonstrated; no arterial or venous lesions have been, however, found.

An intracranial haemorrhage, subsequent to softening, or as a primary event, would be associated with local destruction of nervous tissue. The liberated blood pigments, and lipids, would be taken up either by surviving microglia, or by blood-borne macrophages. Much of the free pigment in the ventricular space would percolate into the Virchow-Robin spaces with the cerebrospinal fluid to become fixed there in macrophages (Figs. 8, 9, 23) some of the remainder being fixed by the macrophages in the meninges. Much of the rest could pass into the blood stream via the Pacchionian bodies, after passing through the fourth ventricle and the aqueduct of Sylvius, and thence become trapped in liver and spleen.

The small amount of lipid seen in the sections may be accounted for by the imperfect myelination of the foetal brain.

Much stress has been laid on the survival of the basal ganglia. If it be remembered that the basal nuclei receive blood not only from the anterior cerebral artery, which supplies the anterior portion of the putamen, but also by the middle cerebral artery, via its medial striate branches, and by the postero-medial central branches of the posterior cerebral artery (Gray, 1954) it will be readily appreciated that this portion of the brain is in a much better position to withstand loss of a portion of its blood supply than most others. It will have been observed that, with the exception of Case 7, the portions of brain missing are, in the main, those supplied by the anterior and middle cerebral arteries. In Case 8 with unilateral absence of a portion of the left hemisphere, the parts remaining are the cuneus, lingual gyrus, uncus, hippocampal gyrus, and the interior temporal gyrus, a textbook description

of the distribution of the posterior cerebral artery.

This predilection for those areas of the brain which do not receive blood from the vertebral system, might suggest some anomaly of the carotid system. Although hypoplastic, no anomaly was found in these vessels in this series. Granted many of the carotid vessels were small in calibre, but with the exception of Case 11 (which is discussed separately below), all were present, patent and appeared normal on histological examination. The hypoplasia is almost certainly secondary to the loss of cerebral substance.

The choroid plexus was in all cases normal. Apart from a superficial deposition of haemosiderin nothing could be found that would in any way support the contentions of Gerundo (1955) that there might be an excessive production of cerebrospinal fluid.

Case 11 shows many features not found in other specimens: an absent blood vessel, and a defect in the cerebral substance covered by a dense vascular fibrous tissue sheet firmly welded to a rim of distorted nerve tissue. This sclerogryia is very suggestive of repair following some vascular disturbance. Although Yakovlev and Wadsworth (1946) maintain that such a disturbance occurring either before or after birth may give rise to the same end result, it is felt that in the light of descriptions by others, such as that of Raskin (1958), a picture such as is seen in Case 11 is much more likely to be the result of birth trauma to a vessel.

Rabson (1952) describes a case of porencephaly in a newborn baby in which abnormally large blood vessels were present in the brain tissue at the margin of the defect. Numerous haemosiderin-laden macrophages were present in the ventricular cavity and in the overlying meninges. He does not state whether there was any lesion of the blood vessels supplying the area affected. The absence of fibrous tissue around this defect which must have been there before birth, suggests that it is only in the post-natal lesion of vascular origin that fibrous tissue will be formed at the edge of such a defect.

While Yakovlev and Wadsworth (1946) considered that both hydranencephaly and porencephaly might have two origins, some in which there was a primary agenesis, and others caused by some encephaloclastic process, ante-natal or post-natal, the author feels that such a division is not entirely satisfactory having demonstrated features of both haemorrhage and agenesis in several of his specimens.

Summary

Six cases of hydranencephaly, and five of lesser

degrees of cerebral defect, occurring in Chinese children, principally female, are presented.

The clinical diagnosis of hydranencephaly is discussed.

Various aetiological theories are discussed in the light of the gross and microscopic appearances of the specimens.

It is concluded that (a) hydranencephaly and the porencephalies represent varying degrees of the same pathological process, and (b) the evidence available does not support any one cause for the lesions to the exclusion of another.

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