INTRACRANIAL HAEMORRHAGE IN THE NEW-BORN

A study of diagnosis and differential diagnosis based upon pathological and clinical findings in 126 cases

BY

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Hitherto interest in intracranial haemorrhage in the new-born has been centred mainly upon etiology and pathology. More recently symptomatology has received increasing attention. While the pathology of the subject in its relation to etiological factors has received considerable attention, few attempts have been made to correlate pathological with clinical findings. The present paper is based upon both clinical and pathological observations made by the writer in connexion with 126 new-born infants in whom intracranial haemorrhage was found at autopsy. Of the 126 infants, 110 were born in the Royal Maternity Hospital and ten in the Western General Hospital, Edinburgh. Six infants were born at home, four being subsequently admitted to the Royal Maternity Hospital and two to the Western General Hospital. Infants born in hospital were under observation from the time of birth and were examined daily following the first evidence of failure to progress or of disturbed health. Clinical findings were recorded at the time of examination. A similar routine was adopted in the case of infants born at home and subsequently admitted to hospital. Post-mortem examinations were carried out within thirty-six, forty-eight and seventy-two hours of death in the case of ninety-five, twenty-four and seven infants respectively.

A pathological basis has been considered as best suited to the study of the present series. Intracranial haemorrhage found post mortem in the 126 cases included in the investigation differed according as it had taken place into the subdural space, the subarachnoid space, the ventricular system or into the brain substance. Cases have been grouped according to the distribution of the

intracranial bleeding, and clinical observations and pathological findings are discussed in relation to each group.

Subdural haemorrhage

Subdural haemorrhage was found at sixty-two autopsies. Nineteen infants were premature, thirty-four were born at term and nine were post-mature. First pregnancies numbered forty-four. There were twenty-five spontaneous deliveries, including eight breech presentations. Forceps were applied in thirty-six cases, in sixteen of which application followed manual or instrumental rotation of the head, and in two of which application was to the after-coming head in breech deliveries. There was a history of eclampsia in two and of pre-eclamptic symptoms in four mothers. The late stages of two pregnancies were characterized by hyperemesis and of one by slight ante-partum haemorrhage. Two mothers, of whom one was known to be suffering from gonococcal infection, received ante-natal treatment for leucorrhoea.

Pathological findings.—Bleeding arose from different types of injury. Rupture of the superior longitudinal sinus was associated with gross overlapping of the occipital by parietal bones in one case ; tearing of veins opening into this sinus was the cause of haemorrhage in three cases in which over-riding of the parietal bones was a feature. Haemorrhage was a sequel to sinus thrombosis (aseptic) in four premature infants. The superior longitudinal sinus was involved in one and the straight sinus in three cases. Bleeding arose from vessels involved in tentorial tears in forty-two cases (fig. 1) ; tears of the falx cerebri were rare, did not occur alone and did not give rise to haemorrhage. The source of the bleeding was not discovered in two infants. In ten cases the only finding was extensive haemorrhage between the dural layers of the tentorium or falx cerebri or both (fig. 2).

There was variation in the extent and distribution of the haemorrhage. The blood at autopsy was semi-fluid or clotted. Bleeding from the superior longitudinal sinus (and tributaries) and the straight sinus did not extend below the level of the tentorium ; infratentorial haemorrhage arose in every instance from tentorial tears usually involving the free crescentic margin. Haemorrhage from tears situated more laterally in the tentorium collected in the cranial fossae and, sometimes, spread upwards over the cerebral hemispheres, and gravitated below the tentorium only when massive. Pressure by masses of blood clot upon the medulla was a common finding in cases of infratentorial haemorrhage ; in several cases similar pressure on the fourth ventricle had resulted in considerable ventricular dilatation.

The findings in three cases of tentorial tears pointed to there having been a recurrence of haemorrhage ; the cranial fossae contained a large amount of red fluid blood, removal of which exposed old blood clot, brown in colour and adherent to the dural surfaces (fig. 3).

There was evidence of arrested haemorrhage and partial absorption in five infants. Death in these cases occurred during the second and third week of life and was due to gastroenteritis (three), septicaemia following dermatitis (one)

FIG. 1.—Case No. 43. Case of subdural haemorrhage in which bleeding had originated from the tentorial tear marked with arrow and gravitated below the level of the tentorium. The upper surface of the subtentorial clot is seen projecting above the margins of the tear.

FIG. 2.—Case No. 74. Case of subdural haemorrhage. Haemorrhage is mainly supratentorial and the clot lying on the tentorium conceals the tentorial tear from which bleeding originated. The dense portions of the falx cerebri correspond to an extensive haemorrhage enclosed by the two dural layers.

FIG. 3.—Case No. 198. A case of subdural haemorrhage arising from tentorial tears in which apparent clinical recovery from severe symptoms was followed by a recurrence of massive haemorrhage, which was associated with a return of symptoms on the thirteenth day and followed by death on the fourteenth day. At autopsy the brain surfaces were covered and the cranial fossae filled by fluid and partially clotted blood which when removed revealed old, changed blood clot which was adherent to the dural surfaces as shown in the figure.

FIG. 4.—Case No. 86. Renal infarction in a case of cerebral haemorrhage. Bleeding has extended into the interstitial tissues and red blood cells are present in the tubules. Leucocytic infiltration is limited.

and pyelonephritis (one) ; in one case it followed an operation for volvulus. In each instance haemorrhage had arisen from a tentorial tear : old altered blood still remained attached to the dura lining the cranial fossae ; neighbouring structures were slightly pigmented and in three cases blood clot was attached to the lacerated tissues. Microscopically, there was active phagocytosis of degenerate red blood corpuscles.

Pathological evidence of asphyxia was a frequent finding in the form of right-sided cardiac dilatation and petechiae in relation to the heart, great vessels and thymus ; it was a constant finding in cases living only a few hours, and was seen in a large proportion of those with infratentorial haemorrhage. Some degree of atelectasis was present at all autopsies, and pneumonia and/or intrapulmonary haemorrhage in twenty-three cases ; renal infarction (fig. 4) and suprarenal haemorrhage were each found in five cases. During the period of the investigation dural tears of limited extent, not associated with bleeding, were found at fourteen autopsies not included in this series.

Clinical observations

(A) INFANTS DYING WITHIN THIRTY-SIX HOURS OF BIRTH.—Ten infants are included in this group. All were severely shocked at birth and a condition of complete collapse persisted until death. Colour remained pale but was subject to transient, deep, cyanotic changes, ; respirations were rapid, shallow and often irregular ; occasionally breathing was gasping in character and sometimes noisy as a result of mucus collected in the trachea. The pulse was imperceptible and the temperature subnormal. Tendon and conjunctival reflexes were absent or only elicited with difficulty ; there was no response (normal or abnormal) to external stimuli and no evidence of motor irritation ; the fontanelle was neither depressed nor bulging. A cry was heard in three infants ; it was weak and whimpering. Death occurred after a phase indistinguishable from coma. The intracranial bleeding was massive in all ten cases and in eight had collected in large subtentorial clots around the brain stem. Pulmonary lesions (haemorrhage or pneumonia) were present at six of the autopsies.

(B) INFANTS SURVIVING MORE THAN THIRTY-SIX HOURS.—Fifty-two cases fell into this category. They include the ten infants in whom intracranial findings at autopsy were limited to haemorrhage between the layers of the tentorium or of the falx cerebri. Death in these cases resulted from conditions related to other parts of the body ; the intracranial condition gave rise to no symptoms or signs, and these ten cases have not been included in the discussion that follows.

Of the remaining forty-two infants thirty-five were distressed at birth : in some there was definite asphyxia, in others considerable exhaustion, but in no case was there extreme shock. There was no appreciable improvement in the general condition of two infants. In the case of forty infants there was gradual and eventually complete recovery from the state of post-natal depression except in so far as there was no apparent inclination for fluids. Vomiting was a common early feature : it usually occurred on the first or second day of

life, rarely later, and in any one case only on a few occasions and at long intervals. It was not related to feeds or to the swallowing of mucus, and was moderately forcible. The vomitus was blood-stained in several instances. The facial expression became increasingly one of mental restlessness and distress, and contrasted with the existing physical inactivity. This early characteristic change was appreciable on the first day of life in three cases, on the second day in sixteen, and on the third, fourth and fifth days in five, four and one respectively ; it occurred as the first evidence of trouble in the second week of life in the two remaining cases. These infants lay awake with widely opened eyes for prolonged periods : their eyes followed moving objects or were directed towards the sources of sudden or loud sounds. The apparent interest of these infants in their surroundings was unnatural ; their expression conveyed an impression of apprehension and was that of children several months old rather than of new-born infants. These were very constant findings, as were those relating more particularly to the eyes. Blinking was common. The majority of cases showed darting, lateral movements of the eyes which were frequently stimulated or aggravated by sudden fright (e.g. due to noise). True nystagmus subsequently developed in a proportion of these cases. Other occasional findings included ptosis and strabismus. Ptosis was present at birth and tended to lessen in prominence ; strabismus developed sometime after delivery and became more pronounced. Inequality of the pupils was common. Small conjunctival haemorrhages occasionally appeared on the second or third day, but these were not confined to infants suffering from intracranial conditions.

Convulsive movements were seen in half the children included in this group and were usually preceded by a cry ; they occurred as terminal events in five cases. Eleven infants had generalized convulsions ; in six there was only slight twitching of the extremities or face. Physical examination, feeding and sudden noises all on occasion provoked fits. In only three cases was a relation established between the localization of the twitching and the distribution of the haemorrhage. Other abnormalities were athetoid movements of the arms in four and a persistent fine tremor of the hands in two infants.

Crying was not a constant finding. It was present in 50 per cent. of cases ; was shrill or piercing ; occurred in infants in whom abnormal fullness of the fontanelle had been previously detected ; and frequently heralded the onset of convulsions. 'Sponginess' of the fontanelle was more common than great tension. Extensive haemorrhage over the vertex was a feature of three of the five cases in which bulging of the fontanelle was appreciable during life. Retraction of the head and nuchal rigidity were rare and limited to cases with infratentorial haemorrhage.

The condition of the tendon reflexes varied in different subjects and in the same subject. Usually they were diminished in the early stages, exaggerated during the period of mental restlessness and absent during the terminal phase. Increased muscular tone developed in a large number of cases and persisted throughout life. It was most marked in the upper limbs and to a lesser extent in the legs ; in severe cases the fingers were firmly flexed over the thumbs and the arms were kept in a state of spastic flexion over the chest. Although tested

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for as a routine, facial irritability was detected on only three occasions : twitching of the upper lip upon tapping the tip of the nose (Catel's sign) was obtained more frequently, but was of doubtful significance. An observation of greater diagnostic value was the repeated, quick, darting protrusion of the tongue seen in a number of these infants. The rapid movements have given rise to the term 'adder tongue' : they are readily distinguished from the more sluggish and less precise movements of the tongue in thirsty or dehydrated infants.

Pallor was a common and cyanosis a constant finding. Cyanosis appeared at different stages in the clinical course of the condition : it was subject to spasmodic aggravation and was occasionally diminished by the administration of oxygen. It was most pronounced in infratentorial haemorrhage (fig. 5).

The character of the pulse varied, although always rapid and soft in the

FIG. 5.—Case No. 47. Subdural haemorrhage below the tentorium in a first child delivered by forceps after previous instrumental rotation of the head. Symptoms of cerebral haemorrhage were present on the day of birth and persisted throughout life. At autopsy a large tentorial tear and extensive pneumonia were found.

FIG. 6.—Case No. 161. Subdural haemorrhage above the tentorium in a first child delivered by forceps after previous manual rotation of the head. The presence of intracranial haemorrhage was suggested on the day of birth by the facies and confirmed by the appearance, during the next forty-eight hours, of confirmatory signs which persisted throughout life. An extensive tentorial tear was found at autopsy.

terminal phases : its most constant characteristic was a deliberation resulting from slowness and fullness. In the early stages respirations were slow and shallow, later they deepened, but again became shallow with an increase in rate. In a number of cases urinary excretion was limited. Fever was uncommon and never exceeded 102° F. (fig. 6). It was recorded in twelve cases : in three it was attributable to urinary infection and in four as a sequel to convulsions. In the remaining five cases the temperature rose on the second or third day and fell within forty-eight hours without increase in fluid intake.

A return of symptoms after a quiescent period varying in length from three to eight days was noted in six infants (fig. 7). In two instances convulsions occurred when the infant was put to the breast for the first time, in one after 'lifting' of the infant and in another during bathing. Constipation appeared to be an aggravating factor in a fourth case.

Death occurred suddenly in the three cases in which evidence of recurrence of haemorrhage was present at autopsy : in others it was preceded by a period of semi-coma in which the eyes became glazed, the breathing stertorous and the body cold. Thirty-four infants died during the first six days of life ; the longest duration of life was nineteen days. In the eight infants living more than one week death followed a recurrence of haemorrhage in two, and in one the clinical course suggested that gross bleeding did not occur until after the

FIG. 7.—Case No. 198. Subdural haemorrhage in a first child delivered with forceps after previous instrumental rotation of the head. Symptoms of intracranial trauma were present on the day of birth : persisted for three days : were followed by a week of progressive improvement and recurred suddenly on the thirteenth day, death occurring within thirty-six hours. At autopsy a recent massive, supratentorial haemorrhage was found in association with extensive, old, changed, blood clot (see also fig. 3).

first week. Death was due to causes other than intracranial haemorrhage in five cases and extensive pulmonary lesions (pneumonia or haemorrhage) were present in seventeen infants.

Subarachnoid haemorrhage

Extensive haemorrhage into the subarachnoid space was found at autopsy in thirty-six infants, of whom seven were born at term and twenty-nine were premature. Delivery was spontaneous in thirty cases including five breech presentations. It was instrumental in the case of three, and in the remaining three cases Caesarean section was performed. The series included eighteen first pregnancies. A history of pre-eclamptic toxæmia was obtained in connexion with five mothers. Hydramnios was a feature of three, threatened abortion of two and hyperemesis of one pregnancy. Other morbid antenatal conditions recorded in connection with the mothers included chronic cardiac disease in three, gastric ulcer in one and acute pyelitis in another.

Pathological findings.—Bleeding resulted from capillary oozing and not from any localized intracranial injury. The haemorrhage varied in extent and distribution. In some cases it was most marked over the vertex ; more

FIG. 8.—Case No. 140. Naked-eye appearance of subarachnoid haemorrhage. The photograph was taken in a preserved specimen and the appearance of the haemorrhage is less striking than that seen at autopsy.

FIG. 9.—Case No. 11. Extensive subarachnoid haemorrhage associated with localized patches of early softening of the superficial cortical layers and slight oedema of the cerebral substance. There is considerable distension of, but no haemorrhage from the larger veins. An excess of large endothelial macrophages was present in the meninges indicative of early active phagocytosis of extravasated red blood cells.

commonly it was related to the occipital and posterior parietal surfaces ; usually bilateral, it was limited to one cerebral hemisphere in a few cases.

The picture of severe leptomenigeal haemorrhage was characteristic. Cerebro-spinal fluid was present in excess and the brain was completely enclosed within a reddish-yellow layer of jelly-like consistence (fig. 8). The meninges were sodden and congested, and floated on a heavily blood-stained fluid separating them from the brain substance. Specimens were difficult to preserve :

FIG. 10.—Case No. 35. Extensive subarachnoid haemorrhage. The pia arachnoid has been removed. There are a number of minute cortical haemorrhages which have originated from capillaries or small venules and of which the majority are situated in the superficial layers of the cortex.

the gentlest handling usually denuded the brain of its jelly-like covering, and specimens in which this did not occur failed to retain their characteristic colour. Fig. 9 and 10 show the microscopic appearance of subarachnoid haemorrhage. There is slight venous congestion of the brain substance and early softening near the surface. In other cases the brain substance was slightly oedematous and there were minute haemorrhages in the cortex.

Atelectasis and evidence of asphyxia were constant findings : haemorrhage into the lungs or pneumonia or both were present in seventeen infants and other

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haemorrhages found included bleeding into the intestinal wall (three), into serous sacs (two) and into the suprarenal glands (two).

Clinical observations.—The condition of all these infants was unsatisfactory at birth : in eighteen there was no improvement and death occurred within forty-eight hours. The extent of improvement occurring in those living for a longer period was variable. Persistent absence of all desire for fluids was noteworthy. Irrespective of the maturity of the infant the weight showed an initial fall of normal proportion, but usually failed to show any subsequent gain. Where a gain of a few ounces did take place death was preceded by a period of arrested weight progress or actual loss of weight (figs. 11 and 12).

Evidence of intracranial trouble was liable to be obscured by physical frailty. It was detected in only 50 per cent. of cases. Convulsions occurred in one infant. Slight twitching of short duration and involving the hands and face was seen in seven cases. Failure to observe involvement of the lower limbs is

FIG. 11.—Case No. 7. Subarachnoid haemorrhage in a premature infant. Symptoms were preceded by fall in weight : pustules and stomatitis were a feature during the last ten days of life. Pneumonia was present at autopsy. The mother suffered from toxæmic symptoms.

FIG. 12.—Case No. 217. Subarachnoid haemorrhage in a premature infant. Symptoms were preceded by an arrest in weight progress. The mother was an eclamptic.

probably attributable to the fact that twitching had ceased before the legs were exposed for examination. It was not found possible to correlate the localization of the twitching and the distribution of the haemorrhage, but it was noted that convulsive movements occurred only in association with extensive bleeding. Small cortical haemorrhages were present in four cases in which peripheral twitching movements were seen and in the one case associated with convulsions : they were also present in cases showing neither twitching nor convulsions.

Restless ocular movements were seen in twelve infants. They were a constant accompaniment of twitching of the extremities : in four cases they took the form of true nystagmus. Inequality of the pupils and conjunctival haemorrhages were recorded in several cases; rapid protrusion of the tongue, spastic flexion of the limbs and retinal haemorrhages were rare findings. Examination of the fontanelle proved of little value : it was never tense and only occasionally felt abnormally 'spongy.' There was nothing characteristic about the facies.

Vomiting on isolated occasions was a feature in seven cases : in two of these it appeared to be the result of swallowing meconium, and in two the vomitus contained blood derived from congested gastric mucosa. Colour was poor throughout life and became increasingly cyanotic : improvement followed the administration of oxygen in a few cases in which pulmonary lesions were present, but in general the cyanosis was less subject to variations than in other forms of cerebral haemorrhage. Fever was noted in only five infants ; it

FIG. 13.—Case No. 208. Massive bleeding into the brain substance under the ependymal surface of the ventricle in a case of intraventricular haemorrhage. The source of the bleeding is not shown, but at autopsy haemorrhage was seen to have occurred from superficial veins in the ventricular walls and from veins in the choroid plexus.

was terminal in each case and associated with an unusually severe loss in weight. The highest recorded temperature was 103° F.

Intraventricular haemorrhage

There were twenty-two cases of intraventricular haemorrhage : in nineteen the infant was premature, in one full time, and in two post-mature at birth. Delivery was spontaneous in eighteen (including two breech presentations) and instrumental in three cases. Caesarean section was performed in one case. There were twelve first pregnancies. Six mothers gave a history of eclamptic

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fits and seven of pre-eclamptic toxæmia. Two mothers received antenatal treatment for syphilis and one for gonococcal infection. Of four other mothers with morbid conditions during the latter half of pregnancy one suffered from a profuse leucorrhoeal discharge, another was grossly anaemic, a third had repeated carbuncles and a fourth cellulitis of the leg.

Pathological findings.—Intraventricular hæmorrhage was associated with capillary oozing of limited extent into the subarachnoid space in four, and

FIG. 14.—Case No. 132. Recent thrombosis of numerous veins of the choroid plexus in a case of intraventricular hæmorrhage. Hæmorrhage has occurred in and about the plexus.

with isolated minute cortical hæmorrhages in three cases. Massive intraventricular bleeding resulted in increase in the size of the brain and marked flattening of the convolutions over the vertex. The source of the hæmorrhage was the veins of the choroid plexus in fourteen, and the superficial veins in the ventricular wall in two cases (fig. 13). Bleeding occurred from both these sites in four instances and in two its origin was not found. Hæmorrhage followed acute engorgement of the veins or occurred as a sequel to thrombosis (fig. 14). In cases included in this series thrombosis was unaccompanied by evidence of infection.

Haemorrhage was invariably gross. Blood was found throughout the entire ventricular system in several cases (fig. 15). It was usually present only in the lateral ventricles and occasionally was confined to the posterior horns, or was limited to one side. In a number of cases the ventricles were filled with blood clot without associated damage to the brain substance. Gross destruction of brain tissue was present in seven cases : in three of these the haemorrhage was visible through a thin layer of cortex ; in four it had ruptured through an occipital pole into the subdural space (fig. 16).

FIG. 15.—Case No. 111. Intraventricular haemorrhage with destruction of the brain substance. Blood is present throughout the ventricular system and both posterior horns are completely filled with blood clot.

Atelectasis was a common finding : pneumonia or intrapulmonary haemorrhage—both were present in thirteen and venous thrombosis in the kidneys in one case. Haemorrhages other than cerebral or pulmonary were a feature of six cases : they included bleeding into serous cavities (three), into the intestinal wall (three) and into suprarenal glands (two).

Clinical observations.—There was an absence of clinical evidence pointing to intracranial haemorrhage in six cases. All six infants were distressed at birth and died within twelve hours of delivery : in each instance bleeding had arisen from the choroid plexus, was severe, but had not resulted in destruction of brain substance. The remaining sixteen infants presented a striking clinical

picture (figs. 17 and 18). They were all premature. During the first week of life they showed no desire for fluids and their weight failed to increase after an initial physiological loss. Symptoms developed with dramatic suddenness : their calamitous significance was immediately apparent in the complete change in the general condition.

Onset of the condition occurred at any time during the first three weeks of life, death invariably occurring within forty-eight to sixty hours. A cry frequently coincided with the onset. The cry was unmistakable. Its piercing

FIG. 16.—Case No. 246. Intraventricular haemorrhage. View of the under-surface of the brain in a case in which massive haemorrhage into the ventricles ruptured through the left occipital pole. There was extensive destruction of brain substance. The clot shown in the figure represents only a portion of a large clot of which the remainder occupied the cavity enclosed by undamaged and partially damaged brain substance.

shrillness and agonized note were typical. The facial expression of 'torture' was equally characteristic. The eyes protruded, the pupils were dilated and the conjunctivae injected. Coarse nystagmus was present in every case. There were constant head rolling and agitated movements of the arms ; the trunk was rigid, the hands were fiercely clenched and the legs drawn up on the abdomen. The colour was ashen grey, and respirations rapid and panting. Attacks of this nature occurred at intervals until death ; between attacks the infants were left in a state of complete physical and mental exhaustion. Opisthotonos was seen once and head retraction on several occasions. A tense, bulging

fontanelle, sometimes sufficiently prominent to be seen, was characteristic. Gross twitching of the face and limbs were present in every case and generalized convulsions in the majority: abnormally brisk during attacks, tendon reflexes were diminished in the intervals between them. There was darting tongue protrusion in eight cases. Vomiting was only noted in three infants, but in each it was violent and preceded other clinical signs. Temperatures exceeding 107° F. were recorded in five cases and over 103° F. in seven others. Death

FIG. 17.—Case No. 271. Intraventricular haemorrhage occurring in a premature infant in the first week of life and characterized by the sudden onset of symptoms, a rapid course and terminal pyrexia. The mother suffered from pre-eclamptic toxæmia.

FIG. 18.—Case No. 19. Intraventricular haemorrhage occurring in a premature infant in the second week of life. Haemorrhage was preceded by a period during which weight progress was interrupted, and resulted in the sudden onset of violent symptoms and terminal pyrexia. Extensive pneumonia was present at autopsy. The mother was a pre-eclamptic.

was usually preceded by increasing cyanosis and sometimes by coma. In the majority of cases it occurred suddenly following a recurrence of generalized convulsions.

Haemorrhage into the brain substance

Six cases are included in this group. In them, individual haemorrhages were limited in extent but numerous, and distributed throughout the brain substance. Cases described under subarachnoid and intraventricular bleeding associated with isolated cortical haemorrhages (pp. 96 and 101) are not included. The six infants were born at term after normal pregnancies, five of which were first pregnancies. Delivery was spontaneous in two and instrumental in four cases. The instrumental deliveries included one in which forceps had been applied after manual rotation of the head, and another in which rotation had been secured with the aid of forceps. Labour was prolonged in each case.

Pathological findings.—In all six cases the naked-eye appearance of the brain and the microscopic findings were the same. The brain was swollen and the convolutions over the vertex flattened; it had a uniformly red appearance

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as a result of congestion of dural and leptomeningeal vessels. The cut surface of cerebrum, cerebellum and mid-brain showed similar, severe congestion ; the cortical regions were a deep reddish-purple colour ; the medullary portions were studded and streaked by distended vessels and bleeding points.

Microscopically there was generalized congestion of veins and capillaries with related perivascular haemorrhages (fig. 19). The brain substance was

FIG. 19.—Case No. 75. Perivascular haemorrhages (marked with arrows) associated with generalized capillary and venous congestion in the cerebrum of a case of haemorrhage into the brain substance. There is slight oedema of the brain substance. At autopsy the external and cut surfaces of the brain and mid-brain were bright red in colour. Both medulla and cortex were stippled with discrete bleeding points. The brain was swollen, the convolutions flattened, the meninges congested and the brain substance soft.

slightly oedematous (fig. 20). Haemorrhages were numerous and had occurred in all parts of the brain, but were greater in number in the cerebrum than in cerebellum or mid-brain. The cord was examined in four of the cases : there were no pathological changes apart from slight congestion of the related meninges.

Extensive atelectasis was a feature of all six cases and was associated with early pneumonia in two.

Clinical observations (figs. 22, 23, and 24).—All the six children were distressed at birth, but their condition did not appear critical. They improved slowly, but remained unnaturally quiet and inactive ; did not cry for fluids but swallowed when spoon or pipette was used ; and were left undisturbed by examinations. Their colour was good, but body temperature was maintained with difficulty ; pulse and respirations were slow and tendon reflexes diminished. A striking feature of this phase was its duration : it persisted unchanged for six to ten days. It was followed by a period lasting several days of great mental

FIG. 20.—Case No. 286. Perivascular haemorrhages and generalized congestion in and oedema of the brain in a case of intracerebral haemorrhage. The macroscopic appearance of the brain resembled that described in connexion with fig. 19.

agitation and increasing physical weakness. The eyes were constantly open. They became more sunken and developed continuous, restless movements in all directions, but never true nystagmus. Later a cry was heard. At first peevish and at long intervals, it became more frequent and more typically cerebral ; it was accompanied by head rolling. There was slight fullness of the fontanelle in two cases. Twitching of all extremities and both sides of the face was seen in three infants.

In the early stages the facial expression was sullen and frowning. Simultaneously with the occurrence of a cry of pain and with restless movements of the

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eyes it became one of intense fear. Later, as general weakness increased, the expression became strangely vague and distant. In connection with two infants it prompted the remark from the sister-in-charge, 'This child is going to be mental.' The facies were striking and reminded the writer of those seen occasionally in fatal cases of acute encephalitis in young children.

The weight of infants in this group fell rapidly and without interruption from the day of birth until death. A daily loss of 8 oz. was not uncommon. Occasional vomiting occurred in all six cases. The colour became grey and Cheyne-Stokes breathing developed in three infants. Slight spasticity of the

FIG. 21.—Case No. 286. High-power magnification of perivascular haemorrhage.

limbs and inability to swallow were late features : retinal haemorrhages were detected in three cases.

Great exhaustion followed a period of mental agitation. Death came gradually and followed a state of coma lasting for a period of about two days, during which time breathing was stertorous, cyanosis increased, and the temperature rose (101° F. to 103° F.).

Discussion

Trauma to the child during birth has been described by von Reuss (1935) as inevitable even under the most favourable conditions. Trauma may be ante-natal in origin and may arise from post-natal developments. Irrespective of the time of its occurrence in relation to delivery, the extent, nature and localization of trauma in the new-born child largely determine the prospects of survival in the neo-natal period.

Bland (1934) described intracranial lesions as the most serious form of trauma to which a new-born child is subject and as the most frequent finding at autopsy.

FIG. 22.—Case No. 286. Multiple peri-vascular haemorrhages in the brain substance of a large first child. The mother was aged fifteen years and delivery was instrumental. Symptoms were present from birth and were associated with increasing restlessness of mind, extreme physical weakness and a precipitous fall in weight. At autopsy haemorrhages were found throughout the brain and mid-brain. (See also fig. 20 and 21.)

FIG. 23.—Case No. 208. Multiple peri-vascular haemorrhages in the brain substance of a large first child. The mother was aged forty-four years and delivery instrumental. Clinical and pathological findings resembled those in Case No. 286 (fig. 22). See also fig. 13.

They were present in eighteen of thirty-six cases recorded by Warwick (1919) ; in fifteen of twenty-eight cases published by Capon (1922) ; and in 130 of 290 consecutive cases of neo-natal death examined post mortem by the writer.

Haemorrhage is the most common accompaniment of intracranial injury. It may result from or contribute to damage of the brain substance and meninges, and it may be present in the absence of macroscopical evidence of injury to these structures.

Litchfield and Girvan (1934) and Ehrenfest (1922) describe the occurrence of haemorrhage between two opposed dural layers without damage to the dural surfaces. Cruickshank (1930), von Reuss (1930) and others have drawn attention to the tearing of sinuses and vessels, frequently in association with injury to the dural septa as a cause of haemorrhage. Capillary oozing from the

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meninges was found to be common by Cruickshank (1930) in an investigation of neo-natal death based upon 800 autopsies. He describes it as usually occurring in association with evidences of asphyxia and as a not uncommon finding in premature infants in many of whom the intracranial contents are characterized by oedema. Described variously as leptomeningeal or sub-arachnoid, haemorrhage resulting from capillary oozing has been referred to by von Reuss (1935), Schwartz (1922), Griffiths and Mitchell (1933), Hendler (1935), Ehrenfest (1922) and others.

Haemorrhage into the cerebral ventricles has been attributed to capillary haemorrhage, asphyxial congestion, and injury and diseases of the mother and infant by Cruickshank (1930), and to rupture of vessels of the choroid plexus by Litchfield and Girvan (1934). Hemsath (1934) records the findings at autopsies on nineteen new-born infants in whom intraventricular haemorrhage was found. He was unable to determine the source of the haemorrhage in six, but considered that bleeding into the ventricles was due to sub-ependymal

FIG. 24.—Case No. 75. Multiple perivascular haemorrhages in the brain substance of the fourth child of a mother aged twenty-nine years. Delivery was instrumental. The mother showed signs of uterine inertia. Clinical and pathological findings resembled those in connexion with Cases 208 and 286 (fig. 22 and 23).

haemorrhage in seven, to haemorrhage from the choroid plexus in two and to a combination of bleeding from the choroid plexus and from sub-ependymal vessels in four cases. He describes the presence of blood in the ventricles of one case as being part of a massive intracerebral haemorrhage. Von Reuss (1920), Ylppo (1919), Browne (1922), Hendler (1935), Litchfield (1934), Cruickshank (1930) and Hemsath (1934) are agreed that the condition almost invariably occurs in premature infants.

The importance of haemorrhage into the brain substance has been emphasized by Schwartz (1922), and Hemsath and Canavan (1932) have drawn attention to the association of subpial haemorrhages with small extravasations into the brain. They found intracerebral haemorrhages at thirty-four of fifty-three autopsies and considered them to be the cause of death in twelve cases. Ford (1927) is of the opinion that multiple petechial haemorrhages in the brain and meninges are found in all forms of asphyxia. Von Haan (1934) found macroscopical evidence of haemorrhage into the brain substance in four of fifty cases examined post mortem. Couvelaire (1903) records the presence of haemorrhage in the cortex of two and in the central white matter and basal ganglia of three cases. Hendler (1935) finds haemorrhages in the

brain substance at autopsy in 65 per cent. of full-time and 95 per cent. of premature infants. He describes the haemorrhages as usually originating from the vein of Galen, states that usually they can only be recognized microscopically, and considers that they are more of a theoretical than a practical interest. Crothers (1923) is in agreement with the view of Hemsath and Canavan (1932) that significance attaches to haemorrhages in the region of the medulla as a cause of asphyxia. In contrast Warwick (1921) reports not having found any evidence of primary haemorrhage into the brain substance. Cruickshank (1930) expresses doubt as to the supposed frequency of small areas of haemorrhage in the brain substance, but allows of their occurrence in unusual circumstances.

Cruickshank (1930) divides intracranial bleeding into meningeal capillary oozing, traumatic intradural bleeding from the choroid plexus and bleeding associated with disease of the mother or of the infant. Munro (1928) discusses haemorrhages according to whether they are the result of trauma or asphyxia, or are a manifestation of haemorrhagic disease. Other workers, including Hender (1935) and von Haan (1934), adopt a classification more strictly dependent upon the anatomical location of the bleeding, and they group haemorrhages according to whether their distribution is subpial, subarachnoid, subdural, intraventricular or intracerebral. Ehrenfest (1929) differentiates subdural haemorrhages according to whether they are supratentorial or infratentorial, and haemorrhages into the brain according to whether they are diffuse or circumscribed. A similar classification is adopted by von Reuss (1920) for cases of intracerebral haemorrhage. He groups cases with symptoms simulating those of intracranial haemorrhage during life and showing only hyperamia and oedema of the brain and meninges at autopsy under the separate heading of 'contusio cerebri.' Munro and Eustis (1922) distinguished traumatic haemorrhage due to foetal distress from that arising from asphyxia.

The exact relationship between asphyxia and intracranial haemorrhage is discussed at length by Cruickshank (1930). He attaches considerable importance to asphyxia as a factor in causing capillary oozing from the meninges and from the choroid plexus in favouring a rupture of vessels related to dural tears and in accentuating the haemorrhage from traumatized areas. Discussing cranial haemorrhages von Reuss (1920) states that their severity is frequently determined by the degree and persistence of associated asphyxial stasis. Serbin (1928) and Capon (1922) are among others who have drawn attention to the importance of asphyxia in this connexion. Bland (1934), on the other hand, considers that asphyxia is a symptom rather than a cause of intracranial haemorrhage. Ford (1926) is of the opinion that asphyxia is not a common cause of cerebral birth injury and failed to produce brain lesions in animals by experimental asphyxia. The etiology of intracranial haemorrhage has been the subject of many investigations but not all recorded results deal separately with the different types of haemorrhage which may occur. Instrumental delivery; difficult, prolonged or too-rapid labour; abnormal presentation; manoeuvres in resuscitation; and prematurity of the infant are among the factors most frequently quoted as favouring intracranial haemorrhage. In this connexion special reference is made to podalic version by Burpee (1933), to the peculiar risks of a first, and particularly a male first-born child by Gland (1934) and to the obstetrical use of pituitrin by Natrass (1934). Warwick (39) and Foote (14) consider that in many cases intracranial bleeding results from a haemorrhagic diathesis. Sharpe and Maclaire (1925*a* and *b*) and Cruickshank (1930) hold the view that a haemorrhagic diathesis seldom explains intracranial bleeding. Among haematological factors suggested as favouring haemorrhage in the new-born are biochemical changes by Bland (1934), physiological delay in the coagulation time by Griffiths and Mitchell (1933) and a deficiency of prothrombin together with a qualitative defect of blood platelets by Heffernan (1932).

Subarachnoid haemorrhages are described by Ehrenfest (1922) as occurring most commonly in premature infants and as being usually associated with syphilis or haemorrhagic disease.

Bleeding into the ventricles is believed by Cruickshank (1930) to be the usual form assumed by haemorrhage attributable to disease of the infant or the mother. The occurrence of intraventricular haemorrhage in each of triplets is quoted by Hemsath (1934) in support of his view that constitutional factors are of importance in intraventricular haemorrhage.

The symptomatology of intracranial haemorrhage in the new-born has been the subject of study by many workers. Von Reuss (1935) draws attention to the difficulties attached to the clinical differentiation of asphyxial from traumatic intracranial haemorrhage in the asphyxiated new-born child. Not all recorded observations take account of the underlying pathology. Few studies attempt to correlate symptoms with the type of haemorrhage present, and the majority accept a somewhat broad classification of symptoms. Thus Griffiths and Mitchell (1933) group symptoms according to whether they indicate increased intracranial pressure or increased nervous irritability. A somewhat similar classification is adopted by Levinson (1935), who groups symptoms into those which are 'irritative,' those which are 'somnolent' and those which are both irritative and somnolent. Santamarina (1934) differentiates symptoms indicative of supratentorial haemorrhage from those suggestive of infratentorial haemorrhage. Cruickshank (1930) adopts a similar classification in the case of symptoms arising from gross intracranial bleeding. Ott (1934) is of the opinion that recognizable symptoms may be classified according as they arise from cortical irritation or from haemorrhage in the region of the medulla.

Von Reuss (1920) contrasts the symptomatology of supratentorial, as opposed to infratentorial, subdural haemorrhage; stresses the resemblance of symptoms arising from simple 'contusio cerebri' and those from subdural haemorrhage; states that intraventricular simulates infratentorial haemorrhage, and remarks upon the absence of recorded clinical observations in cases of intracerebral bleeding. Discussing supratentorial haemorrhage he states that, while in a number of cases death occurs shortly after birth, in others improvement precedes symptoms of cerebral pressure. He describes convulsions as the most characteristic and most important symptom, as being frequently provoked by external stimuli, and as varying considerably in severity. He states that death usually takes place between the fifth and eighth day, is preceded by a period of paralysis characterized by an absence of reflexes and is frequently the result of aspiration pneumonia.

Infratentorial haemorrhage is described by von Reuss as differing from supratentorial bleeding in an absence of painful cries, restlessness and tension of the fontanelle in the early stages of the condition and in the presence during the later stages of marked cyanotic spasms, nuchal rigidity, opisthotonos, penile erection and spasms of the limbs.

Among clinical findings recorded by other workers it is stated by Browne (1922) that intraventricular haemorrhage is rarely indicated by clinical signs and usually occurs in weakly premature infants. Santamarina (1934) considers bradycardia to be characteristic of infratentorial haemorrhage and Griffiths and Mitchell (1933) are of the opinion that intracranial haemorrhage results in irregularity of the pulse. Convulsions are described by Griffiths and Mitchell (1933) as relatively common in the new-born and as of less value in the diagnosis of intracranial haemorrhage than paralytic symptoms. General convulsions are stated by Capon (1922) to be of particular significance when seen soon after birth and to terminate usually before the third day of life. Capon (1922) and Levinson (1935) are in agreement that external haemorrhages from the nose and pharynx are common, but disagree in that the latter records that the temperature is not elevated, whereas Capon considers that slight pyrexia

indicates progressive bleeding within the cranium. Attention has been drawn to the presence of retinal haemorrhages, but Fleming and Morton (1930) consider that they occur in a proportion of healthy new-born children and are of no value in diagnosis. The pained expression of infants with cerebral haemorrhage is remarked upon by Levinson (1935), and Shannon (1934) attached considerable importance to tetany, which he describes as part of a syndrome associated with a tendency to generalized oedema and oedema of the brain. Shannon (1934) is of the opinion that slowness of pulse and respirations, cyanotic attacks, projectile vomiting, tension without protrusion of the fontanelle and other cerebral symptoms are to be attributed to oedema of the brain and not to cerebral haemorrhage.

The present series

The different types of intracranial haemorrhage found are given in table 1. Of the 126 cases included in the investigation, subdural haemorrhage was present in forty-nine per cent., subarachnoid haemorrhage in twenty-nine, intraventricular haemorrhage in seventeen and haemorrhage into the brain substance in five per cent. While the etiology of the different forms of intracranial bleeding does not come within the scope of this paper, discussion would be incomplete without reference to certain factors which, although related primarily to causation, are of importance in diagnosis. Tables 2-9 deal with these factors. They indicate that first children predominated in the entire series and in each type of haemorrhage, but that the preponderance was most marked in cases of subdural haemorrhage (table 2); that the majority of cases with subdural bleeding associated with tentorial tears and all the cases with haemorrhage into the brain substance were born at term, and that in contrast twenty-nine of thirty-six cases of subarachnoid haemorrhage and nineteen of twenty-two cases of intraventricular haemorrhage were premature (table 3); that instrumental delivery was a feature of two-thirds of the cases with intracerebral and with subdural haemorrhage in association with tentorial tears, but of only six in a total of fifty-eight cases with subarachnoid or intraventricular haemorrhage (table 4); that a history of debility, toxæmia or infection of the mother during pregnancy was obtained in connexion with sixteen of thirty-six cases of subarachnoid haemorrhage and twenty of twenty-two cases of intraventricular haemorrhage (table 6); and that intracranial bleeding was associated with other morbid conditions and in particular with pulmonary lesions in a large number of cases (table 7).

TABLE 1

INTRACRANIAL FINDINGS AT 126 AUTOPSIES

Subdural haemorrhage arising from tentorial tears	42
Subdural haemorrhage arising from lesions other than tentorial tears ..	20
Subarachnoid haemorrhage	36
Intraventricular haemorrhage	22
Haemorrhage into brain substance	6
	<hr/>
	126

(Limited subarachnoid haemorrhage was present in addition, in six cases of subdural haemorrhage, five of intraventricular haemorrhage and in two cases of haemorrhage into the brain substance.)

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TABLE 2
THE NUMBER OF PREGNANCY IN RELATION TO THE TYPE OF HAEMORRHAGE

TYPE OF INTRACRANIAL HAEMORRHAGE	NUMBER OF PREGNANCY											TOTAL NO. INFANTS
	1	2	3	4	5	6	7	8	9	10	11	
Subdural (tentorial tears)	31	2	6	2	—	—	—	—	1	—	—	42
Subdural (not associated with tentorial tears) ..	13	5	—	1	—	—	—	—	—	1	—	20
Subarachnoid	18	5	7	2	3	1	—	—	—	—	—	36
Intraventricular ..	12	2	3	1	1	—	—	—	—	1	2	22
Into brain substance ..	5	—	—	1	—	—	—	—	—	—	—	6
All cases	79	14	16	7	4	1	—	—	1	2	2	126

TABLE 3
MATURITY IN RELATION TO THE TYPE OF HAEMORRHAGE

TYPE OF INTRACRANIAL HAEMORRHAGE	MATURITY			TOTAL
	PREMATURE	FULL-TIME	POSTMATURE	
Subdural (tentorial tears) ..	9	27	6	42
Subdural (not associated with tentorial tears)	10	7	3	20
Subarachnoid	29	7	—	36
Intraventricular	19	1	2	22
Into brain substance	—	6	—	6
All cases	67	48	11	126

TABLE 4
NATURE OF THE DELIVERY IN RELATION TO THE TYPE OF HAEMORRHAGE

TYPE OF INTRACRANIAL HAEMORRHAGE	DELIVERY						TOTAL
	SPONTANEOUS		INSTRUMENTAL			CAES. SECT.	
	VERTEX	BREECH	VERTEX	*VERTEX PRE- CEDED BY ROTATION OF HEAD	BREECH		
Subdural (tentorial tears)	11	2	12	14	2	1	42
Subdural (not associated with tentorial tears) ..	6	6	6	2	—	—	20
Subarachnoid	25	5	3	—	—	3	36
Intraventricular	16	2	3	—	—	1	22
Into brain substance ..	2	—	4	—	—	—	6
All cases	60	15	28	16	2	5	126

* Manual or instrumental rotation.

TABLE 5

AGE OF MOTHER IN RELATION TO THE TYPE OF HAEMORRHAGE

INFANT	MOTHER'S AGE—YEARS						TOTAL NO. INFANTS
	UNDER 20	— 20–25	— 25–30	— 30–35	— 35–40	OVER 40	
Subdural (tentorial tears)	—	12	11	15	4	—	42
Subdural (not associated with tentorial tears) ..	—	9	9	1	1	—	20
Subarachnoid ..	—	10	9	13	4	—	36
Intraventricular ..	—	10	5	1	6	—	22
Into brain substance ..	1	—	1	—	2	2	6
All cases	1	41	35	30	17	2	126

TABLE 6

ILLNESS OF THE MOTHER DURING PREGNANCY IN RELATION TO INTRACRANIAL HAEMORRHAGE OF THE NEW-BORN

INFANT			MOTHER														
INTRACRANIAL HAEMORRHAGE			NUMBER SUFFERING DURING PREGNANCY FROM														TOTAL NO. WITH HISTORY OF ILLNESS IN PREGNANCY
TYPE	NO. OF CASES	ECLAMPSIA PRE-ECLAMPTIC SYMPTOMS THREATENED ABORTION ANTE-PARTUM HAEMORRHAGE HYPEREMESIS HYDRAMNIOS SYPHILIS GONOCOCCAL INFECTION LEUCORRHOEA CELLULITIS FURNUNCULOSIS PYELITIS GASTRIC ULCER ANAEMIA CARDIAC CONDITION															
Subdural (tentorial tears) ..	62	2	4	—	1	2	—	—	1	1	—	—	—	—	—	—	11
Subdural (not associated with tentorial tears) ..		—	5	2	—	1	3	—	—	—	—	—	—	—	—	—	
Subarachnoid ..	36	—	5	2	—	1	3	—	—	—	—	1	1	—	3	16	
Intraventricular ..	22	6	7	—	—	—	2	—	1	1	1	1	—	1	—	20	
Into brain substance ..	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	
All cases ..	126	8	16	2	1	3	3	2	2	2	1	1	1	1	3	47	

It is evident that intracranial haemorrhage was contributed to by a variety of factors of which some were ante-natal, others natal and a number post-natal. The interdependence of these factors requires that their relative importance should be judged only in relation to the individual case. In general, however, bleeding into the subarachnoid space and into the ventricular system was associated with prematurity and with illness of the mother during pregnancy ;

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and haemorrhage into the brain substance and into the subdural space with instrumental delivery and with delivery at or after term. Intracranial bleeding occurred as a manifestation of a haemorrhagic diathesis in only four cases, all of which were premature, and in two of which it was intraventricular, in one subarachnoid and in a fourth subdural. In cases of intraventricular haemorrhage, illness of the mother during pregnancy was an almost constant finding and was probably a factor of primary etiological importance.

Among cases of subdural haemorrhage, a history of manual or instrumental rotation of the head was a feature of a large proportion of the forceps deliveries (table 4). It was found to be characteristic also of those cases in which subdural bleeding was most extensive at autopsy. The findings suggest that the risks of intracranial haemorrhage associated with instrumental delivery are increased when delivery involves instrumental or manual rotation of the head, a view which has been confirmed in the writer's experience by an analysis of cases surviving intracranial trauma at birth.

The five infants delivered by Caesarian section are of interest in that they included examples of three types of haemorrhage (table 4). In no case was bleeding directly related to the nature of the delivery. Of the three infants with subarachnoid haemorrhage one was premature and the mothers of the remaining two were pre-eclamptics. Subdural haemorrhage occurred in one and intraventricular haemorrhage in the other of two cases in which intraventricular bleeding was a manifestation of a haemorrhagic diathesis. The bleeding in the first-named case came from minute tentorial tears and would probably not have occurred in the absence of a haemorrhagic tendency.

TABLE 7
MORBID CONDITIONS ASSOCIATED WITH DIFFERENT TYPES OF INTRACRANIAL HAEMORRHAGE

TYPE OF INTRACRANIAL HAEMORRHAGE	TOTAL NO. OF INFANTS	NUMBER OF CASES ASSOCIATED WITH						
		PNEUMONIA AND/OR PULMONARY HAEMOR- RHAGE	HAEMOR- RHAGE INTO			HAEMATURIA AND/OR PYURIA DURING LIFE ; AND/OR RENAL IN- FARCTION POST MORTEM	EVIDENCES OF A HAEMOR- RHAGIC DIATHESIS	INFECTION OF SKIN, MUCOUS MEMBRANES OR SUB- CUTANEOUS TISSUES
			SUPRARENAL GLAND(S)	INTESTINAL WALL	SEROUS SAC(S)			
Subdural (tentorial tears)	42	17	4	—	—	5	1	9
Subdural (not asso- ciated with tentorial tears)	20	6	1	—	—	2	—	6
Subarachnoid	36	17	2	3	2	1	2	12
Intraventricular	22	13	2	3	3	2	1	8
Into brain substance	6	2	—	—	—	—	—	1
All cases	126	55	9	6	5	10	4	36

TABLE 8

DURATION OF LIFE IN RELATION TO THE TYPE OF HAEMORRHAGE

TYPE OF INTRACRANIAL HAEMORRHAGE	DAY OF DEATH																					TOTAL NO. INFANTS
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Subdural (tentorial tears)	13	9	2	2	2	6	—	—	1	1	—	—	1	—	3	—	—	—	1	—	—	42
Subdural (not associated with tentorial tears) ..	3	1	3	4	5	1	—	—	1	—	2	—	—	—	—	1	—	—	—	—	—	20
Subarachnoid ..	12	6	1	4	5	—	1	—	1	—	—	2	—	—	1	—	1	—	—	—	2	36
Intraventricular ..	5	3	1	1	1	—	3	1	—	—	3	2	—	—	—	—	—	2	—	—	—	22
Into brain substance ..	—	—	—	—	—	1	—	—	—	—	—	1	1	1	—	1	—	1	—	—	—	6
All cases	33	19	7	11	13	8	4	1	3	1	5	5	2	1	4	2	1	3	1	—	2	126

TABLE 9

DURATION OF LIFE IN RELATION TO THE TYPE OF HAEMORRHAGE AFTER
ELIMINATION OF CASES WITH PULMONARY INFLAMMATION OR
HAEMORRHAGE

TYPE OF INTRACRANIAL HAEMORRHAGE	DAY OF DEATH																					INFANTS	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	NO. WITH PUL- MONARY COMPLI- CATIONS	TOTAL
Subdural (tentorial tears)	8	6	2	1	2	3	—	—	1	—	—	—	1	—	1	—	—	—	—	—	—	17	42
Subdural (not asso- ciated with ten- torial tears) ..	3	1	2	4	3	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	20
Subarachnoid ..	10	4	1	3	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	17	36
Intraventricular ..	4	1	1	—	1	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	13	22
Into brain sub- stance ..	—	—	—	—	—	1	—	—	—	—	—	1	1	—	—	—	—	1	—	—	—	2	6
All cases	25	12	6	8	7	5	—	1	1	—	—	2	2	—	1	—	—	1	—	—	—	55	126

The six infants with haemorrhage into the brain substance were noteworthy for the similarity of the clinical pictures they presented (p. 104) and for distinctive features common to their antenatal and natal histories. Delivery at term of a large, first child by a mother at the extremes of the reproductive period was a feature of the birth of five of the infants (tables 4 and 5). The remaining infant was a fourth child given birth to by a mother aged twenty-nine who on admission to hospital showed evidence of uterine inertia. In the absence of evidence of a contracted pelvis, and of a history of illness during pregnancy in connexion with all six mothers, haemorrhage in these cases would appear to have resulted from an unusual combination of factors making for prolonged and difficult labour.

The cases are too few in number to allow of definite conclusions being arrived at, but they are of especial interest in that they represent a clinical entity.

Equal importance attaches to the group consisting of three infants in whom there was pathological evidence of recurrence following earlier arrest of intracranial bleeding. Death of one infant took place on the sixth, of another on the ninth and of the third on the fifteenth day of life. In each case death was sudden and followed a period during which clinical evidence of post-natal intracranial haemorrhage had gradually disappeared. One infant was removed from hospital contrary to advice only to return within the space of a few hours, having in the interval gone into coma following a succession of violent convulsions. The second infant threw fits after having been lifted from its cot without permission. The remaining infant suffered a relapse on the eighth day within a few minutes of fixing at the breast for the first time. Initial attempts at suckling were followed by twitching movements of the extremities which rapidly developed into convulsions and culminated in death within six hours. These three cases illustrate the risks already referred to (p. 95) of ill-considered handling during convalescence from intracranial haemorrhage. For these risks to be avoided it is necessary that nursing management should be subject to strict medical supervision and that all movements of patients should be reduced to a minimum. Cases of intracranial haemorrhage in the present series include a number of infants sent to hospital on account of their critical condition following delivery at home. In several instances removal to hospital had involved a road journey of ten miles or more. It is doubtful if the worst of home conditions justified such removal or if the best of hospital provisions could compensate for the risks of transport. The need in such cases is for domiciliary treatment and is one which, should the necessity arise, can be met by utilizing available public health services.

Diagnosis

Appropriateness of treatment is largely dependent upon the accuracy of diagnosis. Diagnosis in the new-born infant is associated with difficulties peculiar to the age of the patient, and in no condition are these difficulties more in evidence than in intracranial haemorrhage. A moribund state associated with gross asphyxia and rapidly terminating in death, or prematurity associated throughout life with extreme frailty were features of the picture presented by those infants of the series who showed no clinical signs distinctive of intracranial bleeding. Of cases in which a diagnosis of intracranial haemorrhage was not made during life the bleeding was subarachnoid in twenty-two, subdural in twenty and intraventricular in six. Of fourteen cases in which only a tentative diagnosis was made haemorrhage was subarachnoid in four and subdural in ten. A diagnosis was made during life in the case of all the infants with haemorrhage into the brain substance. The observations made in connexion with each type of case indicate that while certain clinical features were associated with all forms of intracranial haemorrhage, others were characterized by their occurrence in association with only one or more particular types. Recognition of

the fact allowed of a differential diagnosis being made in an appreciable proportion of cases.

In many instances the clinical picture presented by the infants was in itself sufficient to suggest a diagnosis of intracranial haemorrhage. Consideration of the mother's ante-natal history and of the details of the labour was essential for diagnosis in some cases, and in others allowed of a diagnosis being made at an earlier stage than would have been possible had reliance been placed solely on clinical findings. Account was taken of the preponderance of first children and of premature infants, the risks associated with forceps delivery and particularly when such delivery followed instrumental or manual rotation of the head, the factors which may combine to make delivery of a mother at the extremes of the reproductive period of a first child difficult, the frequent association of illness of the mother during pregnancy and haemorrhage in the infant, and the possible existence of intracranial haemorrhage in cases showing evidences of a tendency to bleed.

Considerable importance was attached to severe or prolonged asphyxia as evidence of existing haemorrhage or of possible future bleeding. Improvement during the first thirty-six hours of life in a child suspected of suffering from intracranial haemorrhage was only rarely found to warrant revision of the original diagnosis, confirmation of which was usually forthcoming in the gradual appearance of symptoms of cerebral pressure and motor irritation. Characteristic clinical signs included a persistent disinclination for fluids, agitated movements of the eyes, inequality of the pupils and an anxious expression which suggested that the restlessness which later accompanied it was one of mind more than of body. The facial expression was in itself distinctive, was characteristic of a great majority of cases and had a particular value in that it was recognizable at an early stage. Darting protrusion of the tongue was an inconstant but characteristic sign of intracranial haemorrhage. It was not seen in any one of 200 control infants suffering from other diseases of the new-born. Convulsive twitching movements of the extremities occurred frequently in other neonatal conditions and were considered to be indicative of an intracranial condition only in the presence of other suggestive signs and symptoms. The significance of convulsions in cases of cerebral haemorrhage was frequently confirmed by a cerebral cry or by changes in the tension of the fontanelle in infants at rest. Bulging of the fontanelle served to confirm the diagnosis in a limited number of cases, but fullness or 'sponginess' as distinct from bulging was of greater value as an early indication of haemorrhage. Taken in conjunction with other symptoms, vomiting when only occasional and when not attributable to swallowed mucus was of some significance. General failure to progress, variability in reflex responses and spastic flexion of the limbs and extremities were among other features which when present completed the clinical picture. In no case was the clinical picture typical of tetany.

Subdural haemorrhage was the most common type of intracranial bleeding. It was associated more frequently with maturity than prematurity, and with instrumental than spontaneous delivery; and was the type of haemorrhage found in the majority of postmature infants. Some degree of asphyxia at

birth followed by a period of limited improvement in the general condition was characteristic of cases surviving more than a few hours. An unnatural alertness and anxiety of expression was the earliest, most constant and most reliable clinical sign. It resembled the facies of intraventricular and of intracerebral haemorrhage in the mental restlessness it betrayed, but lacked the impression of agonized suffering in the face of the infant with bleeding into the ventricles, and of fear in the expression of infants with intracerebral bleeding. Customarily the anxious expression was apparent within thirty-six to forty-eight hours of birth and served to distinguish cases of subdural haemorrhage from those in which the condition was one of intense asphyxial congestion. It was characteristic alike of depressed and irritative clinical phases. In general the symptoms of subdural haemorrhage were more conspicuous than those of subarachnoid or intracerebral haemorrhage. Convulsive movements of the limbs, incoordinated movements of the eyes and reflex irritability were more pronounced and, generalized increase of muscle tone was more common and more sustained. Subdural haemorrhage below the tentorium resembled intraventricular bleeding in giving rise in some cases to nuchal rigidity and to some degree of head retraction, but differed in that it was associated with a cyanosis, which was typically deep and persistent. In a limited number of cases it was associated with athetoid movements and tremors of the extremities not seen in any other form of intracranial haemorrhage.

Subarachnoid haemorrhage was the most difficult form of intracranial bleeding to recognize. Clinical signs were absent or indefinite more frequently in cases of subarachnoid haemorrhage than in other types of intracranial bleeding. In some cases diagnosis was one largely of elimination and presumption based upon the presence of such predisposing factors as prematurity and antenatal debility of the mother, and upon the absence of signs suggestive of other types of cerebral haemorrhage. Subarachnoid haemorrhage resembled intraventricular haemorrhage in that the first appearance of symptoms was sometimes delayed until after the first week of life and always followed a period during which weight had failed to progress. It differed from intraventricular haemorrhage in that the onset of symptoms was gradual and that severe symptoms were absent. It was associated with frailty which was consistent with the prematurity of the majority of the cases and which was readily distinguishable from the combination of physical weakness and exhaustion characteristic of cases of intracerebral haemorrhage. Of the different types of intracranial bleeding, subarachnoid haemorrhage was the only one in which a study of the facies was of little diagnostic value. Slight twitching of the extremities and rapid, incoordinated movements of the eyes were findings which when they occurred in a frail, premature infant showing no signs of progress, were of some value in suggesting the possible presence of subarachnoid haemorrhage.

Intraventricular haemorrhage differed from other forms of intracranial bleeding in the absence of an initial stage of depression, the dramatic suddenness of its onset, the severity of the symptoms to which it gave rise, and the rapidity with which death followed on the first appearance of symptoms. It was the form of haemorrhage most frequently found in infants in whom evidence of

intracranial disturbance did not appear until after the first week, and resembled infratentorial haemorrhage into the subdural space in mature infants in occasionally giving rise to nuchal rigidity and head retraction. It occurred only in premature infants, invariably followed a period during which the weight had remained stationary, and was remarkable for an almost constant association with illness of the mother during pregnancy. Symptoms were characterized by a severity which was the more striking occurring as they did in premature infants. Bulging of the fontanelle was appreciable to the naked eye. The cry and expression betrayed agonizing pain in a manner not typical of any other intracranial condition. Painful crises were suggested by a characteristic occurrence of periods of great violence followed by complete physical exhaustion. Lumbar puncture afforded considerable but only temporary relief and invariably resulted in undiluted blood being obtained under great pressure. A terminal rise of temperature was typical. Meningitis may simulate intraventricular haemorrhage, but, as indicated elsewhere (Craig, 1936), is characterized by a purulent cerebro-spinal fluid, a less abrupt onset, symptoms of less severity and by pyrexia for some days prior to death.

Haemorrhage into the brain substance occurred only in large children delivered at term after a prolonged labour. It was characterized by a vague indefinite onset, a prolonged course and a slow death, a progressive, uninterrupted and at times precipitous decline in weight from the day of birth, a low body temperature and an abnormally, flaccid inactivity, and by extreme physical weakness. The facies were typical. Sullen and frowning at first, the expression became one of fear as distinct from that of pain described in connexion with intraventricular haemorrhage. The association of continuous mental restlessness with extreme physical weakness distinguished these cases from all other forms of intracranial haemorrhage. The absence of other findings commonly met with in cases of cerebral haemorrhage was an important point of diagnosis. Difficulty in diagnosis arose from the essential insidiousness of these cases. The difficulty was one of diagnosis as distinct from differential diagnosis. A diagnosis of intracranial bleeding in these cases implied recognition of the type of haemorrhage.

Associated conditions

The difficulties of diagnosis were sometimes added to by the association of intracranial haemorrhage with other morbid conditions. Pathological processes were present elsewhere than within the cranium in a large number of cases and occurred in association with intracranial haemorrhage of all types (table 7). Pulmonary lesions predominated. They were detected during life in the majority of cases, but differentiation of pneumonia from intrapulmonary haemorrhage was not possible. Improvement in colour following the administration of oxygen has been described (Craig, 1935a) as characteristic of pulmonary consolidation in the new-born. It proved of value in the present series as an indication of complicating pneumonia or intrapulmonary haemorrhage. In cases of cerebral haemorrhage in which the lungs were healthy or

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only atelectatic the degree of cyanosis was not influenced by oxygen therapy. In a number of cases the pulmonary lesions were sufficiently extensive to have accounted for death had other pathological conditions not been present. In a few cases, consisting mainly of those with subarachnoid haemorrhage, it could be said with some confidence that as a contributory cause of death the pulmonary lesion had been of greater importance than the cerebral condition. In others it was apparent that pneumonia was a terminal event, but in a considerable number it was impossible to judge of the relative importance of intracranial haemorrhage and pulmonary consolidation as the primary cause of death.

A comparison of tables 8 and 9 is of interest in this connexion. It shows that pulmonary lesions were present at death in twenty-three (74 per cent.) of thirty-one infants surviving the first week of life and in thirty-two (33 per cent.) of ninety-five infants dying within seven days of birth, and that of uncomplicated cases of cerebral haemorrhage the great majority died during the first week of life. The figures are sufficiently striking to suggest that of infants in the series a number would have survived had pulmonary complications not supervened.

Pulmonary lesions were found in association with all types of intracranial haemorrhage. Intraventricular haemorrhage differed from other forms of intracranial bleeding in that the interval separating the onset of symptoms and death never exceeded and was frequently less than two days. It is probable that the massive haemorrhage present in the lungs of some of these cases occurred simultaneously with that into the ventricles. In contrast, pneumonia in cases of intraventricular bleeding almost certainly preceded the onset of haemorrhage of which it must be regarded as having been a potentially, predisposing factor. It is not improbable that pneumonia may be of equal importance in the etiology of other forms of intracranial haemorrhage and that it is incorrect to assume that in them it occurs only as a late sequela. Similar significance may attach to other forms of infection noted in connexion with a number of infants included in the investigation (table 7).

The abnormal findings in the kidneys of ten infants with cerebral haemorrhage (table 7) are of interest in this connexion. Discussing urinary disorders in the neonatal period Craig (1935*b*) described one infant in whom pyelitis preceded fatal intraventricular haemorrhage, and nine infants in whom urinary infection occurred as a late complication of intracranial haemorrhage, of whom one died and was found at autopsy to have an extensive tentorial tear and a massive subdural haematoma. The two fatal cases are included in the present series. The incidence of urinary infection in cases of cerebral haemorrhage is sufficient to merit attention, but does not warrant dogmatic conclusions. The fact that haemorrhage was intraventricular in the one case in which symptoms referable to it were preceded by urinary infection is at least of interest in view of the frequent association of intraventricular haemorrhage with pneumonia. It is possible that in this case urinary infection favoured intraventricular haemorrhage in a way similar to that postulated in connexion with pulmonary infection. In the other cases the late occurrence of urinary complications may be attributed

to an aggravation of physiological factors. Passive hyperaemia of the kidneys, limited excretion and a concentrated urine are normal features favouring infection of the urinary tract during the early days of life. In cases of cerebral haemorrhage, asphyxia and an impaired circulation intensify renal congestion, concentration of the urine is increased as a result of a limited fluid intake, flushing of the kidney tubules and pelvis is reduced to a minimum and favourable conditions are created for bacterial growth and multiplication. There is evidence in support of the theory in the frequency with which a negligible urinary output was noted in connexion with cases of the present series. Uncomplicated neonatal pyelitis is not a dangerous condition when promptly treated and recovery of the cases already referred to suggests that it is only rarely fatal when a sequela of cerebral haemorrhage. Nevertheless, the condition is one of sufficient severity to require that every endeavour should be made to prevent its occurrence in infants recovering from intracranial conditions. The clinical problem presented is a difficult one and consists in determining the maximum amount of fluid which can be given consistent with the requirements of the cerebral condition.

The management of cases of intracranial haemorrhage must take account of the dangers and possible consequences of complications. It requires the most skilled of nursing attention. I hold no brief for the view sometimes expressed that recovery is not always desirable. From a follow-up from birth of a large number of recovered cases I am satisfied that the severity of symptoms during the early days of life does not afford a reliable indication either as to the possibility or otherwise of subsequent physical or mental impairment, or of the probable extent of such disability should it eventually develop. It is due to every new-born infant, the victim of cerebral haemorrhage or in virtue of predisposing factors in danger of cerebral haemorrhage, that he should receive skilled nursing comparable with that ordinarily available to an adult case of pneumonia or typhoid. In order that skilled treatment may be more readily and more universally available it is desirable that increasing attention be paid in the training of medical students and of pupil midwives to the care and treatment of the new-born infant in health and disease.

Greater familiarity of those responsible for the care of new-born infants with conditions as they are found in the early days of life would minimize the risks of intracranial haemorrhage attendant upon post-natal factors. It would in all probability contribute to a reduction in the neonatal mortality rate which represents one of the outstanding problems requiring investigation.

Summary

1. A series of 126 infants in whom intracranial haemorrhage was found post mortem is described. Clinical observations made from the time of birth and the pathological findings at autopsy are given.
2. The cases are grouped and clinical and pathological observations in connexion with them recorded, according to the distribution of the intracranial bleeding. Subdural haemorrhage was present in sixty-two, subarachnoid

haemorrhage in thirty-six, intraventricular haemorrhage in twenty-two, and haemorrhage into the brain substance in six infants.

3. In general subdural haemorrhage was associated with tearing of the tentorium, maturity and instrumental delivery ; subarachnoid and intraventricular haemorrhage with prematurity and with illness of the mother during pregnancy ; and haemorrhage into the brain substance with prolonged labour and with delivery of a mother at the extremes of the reproductive period of a large first-born child. Intracranial haemorrhage occurred as a manifestation of a haemorrhagic diathesis in only four cases.

4. It is suggested that toxæmia or infection (or both) of the mother during pregnancy is a factor of primary etiological importance in cases of intraventricular haemorrhage ; and that the risks of cerebral haemorrhage associated with forceps delivery are increased when delivery is preceded by manual or instrumental rotation of the head.

5. Diagnosis is discussed and the value of physiognomical diagnosis emphasized. Importance is attached to an anxious expression ; to restlessness of mind rather than of body ; and to 'sponginess' rather than tension or bulging of the fontanelle as early and reliable diagnostic signs. It is considered that although not always present, 'adder-like' protrusion of the tongue occurs only in cases of intracranial haemorrhage.

6. The clinical pictures associated with the different types of intracranial haemorrhage are compared. Attention is drawn to the indefiniteness and frequent absence of clinical signs in cases of subarachnoid haemorrhage ; to the successive periods of improvement, irritation and depression in cases of subdural haemorrhage ; to the sudden onset, violent symptoms, short course and terminal hyperpyrexia in cases of intraventricular haemorrhage ; and to the prolonged course, the uninterrupted, progressive fall in weight, the association of mental restlessness with extreme physical weakness, the low body temperature and the insidious decline characteristic of infants with haemorrhage into the brain substance.

7. The frequency with which intracranial bleeding is associated with other pathological conditions is emphasized. Pneumonia, intrapulmonary haemorrhage and superficial infections together or separately are described as common and urinary infection as occasional complications. It is considered that in some cases infection is related to the etiology of intracranial haemorrhage ; and that the scanty urinary output associated with cerebral haemorrhage favours infection of the urine.

8. The view is held that among infants showing symptoms of cerebral haemorrhage death of a number is attributable to the development of complications. The dangers of ill-considered handling ; the risks of removal to hospital and the desirability of domiciliary treatment of infants born at home and showing symptoms of intracranial trauma ; and the necessity for skilled nursing are emphasized.

9. A plea is submitted for the improved instruction of medical students and pupil midwives in the health and diseases of the new-born infant as necessary for a reduction in the neonatal mortality rate.

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