POST-TRAUMATIC INTRACRANIAL SPACE-OCCUPYING LESIONS*

By LESLIE C. OLIVER, M.B., B.S. (Lond.), F.R.C.S., F.A.C.S.

Neurosurgeon, West London Hospital, Royal Northern Hospital, West End Hospital for Neurology and Neurosurgery, London; Senior Neurosurgeon, Neurosurgical Centre, Oldchurch Hospital, Romford

Extradural Haematoma (syn. middle meningeal haemorrhage)

The haemorrhage may originate from the middle meningeal vessels, the venous sinuses, or from diploic veins. It is usually, but not always, associated with a fracture of the skull or diastasis (separation of sutures). There is nearly always a visible scalp lesion overlying an extradural haematoma. The classical syndrome is as follows: After an initial improvement, and usually within 24 hours, the level of consciousness declines; the pulse rate increases; then it may fall below normal; and finally it becomes fast and weak. The classical slow pulse, although of considerable diagnostic importance, is found less often than a fast one. Occasionally in the early stages of bleeding the homolateral pupil is constricted. In the late stages of compression, whether initially constricted or not, the pupil dilates and the direct and consensual light reflexes are lost. The term *Hutchinson's pupil* is applied to these phenomena. By the time dilatation of the pupil has occurred there is an advanced degree of compression. *Therefore, the diagnosis should be made before this sign appears.* Sometimes when the patient regains consciousness after operation dilatation of the pupil is found to be accompanied by ptosis and paralysis of the external ocular muscles supplied by the oculomotor nerve. The complete oculomotor palsy is caused by pressure on the nerve by herniation of the medial border of the temporal lobe between the tentorium cerebelli and the brain stem. Bilateral dilatation of the pupils is a sign of imminent death. Unilateral or bilateral abducens palsy may result from raised intracranial pressure.

Pyramidal signs may be found on the opposite side to the haematoma or sometimes on the same side. *Homolateral* pyramidal signs are caused by displacement of the brain stem away from the

side of the haematoma and consequent indentation of the contralateral cerebral peduncle by the edge of the tentorium. (The pyramidal fibres of the indented peduncle cross below in the decussation of the pyramids to the same side as the lesion.) Thus pyramidal signs are unreliable for lateralizing a haematoma. If signs of an extradural haematoma are delayed for a few days some *papilloedema* may be found.

Only about half the patients with extradural haemorrhage develop the classical syndrome described above. Thus in many cases there is no recovery of consciousness before the onset of cerebral compression; on the other hand, in childhood, *an initial period of coma seldom occurs*, more often children are momentarily dazed and later become drowsy and finally comatose. They sometimes have convulsions. Also, wide separation of the edges of the fracture or sutures, together with the thin elastic scalp, sometimes allows much of the blood to escape under the pericranium or galea to form a large external haematoma. Thus partial spontaneous decompression may occur. *In infants*, blood lost in the formation of an extradural haematoma may cause severe anaemia and profound shock.

About a third of all extradural haematomas occur other than at the classical temporal site. The location of extradural haematomas is often revealed by bruising of the scalp, the *position of the fracture* and neurological signs.

Posterior Fossa Extradural Haematomas

These are likely to be missed because of their rarity. They are caused by lacerations of the transverse or sigmoid sinuses. In the *acute form*, occurring within 24 hours of the injury, signs of compression of the medulla oblongata (*repeated vomiting, slow pulse, rising blood pressure and slowing of respiration*) tend to occur without any previous recovery of consciousness and therefore without cerebellar signs. A fracture across the groove of the transverse or sigmoid sinus may be

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FIG. 1.—Incision for an extradural haematoma at the classical site in the temporal region. The diagnosis had first been confirmed by means of a burr-hole made through the small incision above the ear.

the only indication of a haematoma in the posterior fossa. The acute type of posterior fossa haematoma tends to be associated with severe brain damage; hence the mortality is high. The *sub-acute form* shows itself several days after injury. Manifestations of medullary failure (*vide supra*) follow a period of improvement in the state of consciousness and, in conscious patients, cerebellar signs may be found. The *chronic form* shows itself some months after injury and is usually mistaken for a posterior fossa tumour. Persistent headache, vomiting, papilloedema and cerebellar signs occur. Ventriculography shows hydrocephalus, displacement of the fourth ventricle away from the side of the lesion and forward kinking of the aqueduct.

The mortality of extradural haemorrhage is still 50 per cent.! This deplorable state of affairs is mostly due to lack of recognition of its rapidly lethal nature. Any decline in level of consciousness or development of new neurological signs should lead to immediate action. If a patient in traumatic coma does not rapidly improve a neurosurgeon should be consulted without delay. *Lumbar puncture* contributes nothing to the diagnosis and *may kill the patient* by causing a temporal or cerebellar pressure cone, and furthermore the lumbar cerebrospinal fluid pressure is often raised in head injuries when there is *no* space-occupying lesion, and conversely, as the result of cerebellar coning,

the pressure may be normal or even subnormal in the presence of a large haematoma.

Operation

Extradural haemorrhage is one of the most rapidly lethal conditions in surgery. Mere suspicion of it should lead to diagnostic burr-holes without delay. Opiates and barbiturates are forbidden, for the former depress the already threatened or affected vital centres, and the latter depress still more the level of consciousness. Many patients are too restless for local anaesthesia alone. Sometimes coma is so deep that no anaesthetic of any kind is required.

A burr-hole is made over the suspected site of the haematoma (the precise measurements given in some textbooks of surgery have no value). When the diagnosis is correct blood is seen as soon as the inner table of the skull is perforated. As much of the haematoma as possible is removed by suction and the extent of the dural stripping ascertained with the aid of a malleable probe. A bone flap is then planned accordingly (Fig. 1). Bleeding from the middle meningeal vessels is controlled by electrocoagulation, silk sutures, metal clips or occasionally by plugging the foramen spinosum with the pointed end cut from a sharpened match stick. When metal clips are used, a small incision is made in the dura parallel to the vessel so that the clips can be applied.

Bleeding from dural sinuses or veins is arrested by application of muscle 'stamps' or gelatin sponge together with elevation of the patient's head. Bleeding from bone is controlled with bone wax.

When an extradural haematoma is not revealed by the first burr-hole, the dura mater is opened. If an acute *subdural* haemorrhage is found a small rubber catheter is passed beneath the dura mater and the blood aspirated. Some of it may have to be washed out with normal saline injected through the catheter. If neither an extradural nor a subdural haematoma is found, but the brain is bulging, a small stab is made in an avascular part of the exposed cortex with a pointed tenotome, and a fine brain cannula passed into it. An intracerebral clot may thus be discovered. After elevation of a bone flap, the surface of the brain is incised in a relatively silent area and the clot evacuated by means of low-pressure suction.

If the first burr-hole reveals no evidence of an extradural, subdural or intracerebral haematoma, burr-holes are made at other sites on the same side. Thus if the first burr-hole was made in the temporal region, others are made in the frontal and parietal regions. Failure to find a haematoma on one side should always lead to burr-holes on the other side. When there is occipital bruising and a fracture overlying the transverse or sigmoid sinuses there is the possibility of an extradural haematoma in the posterior fossa; burr-holes should therefore be made in this region. The exposure can be extended by lengthening the burr-hole incision and removal of bone with rongeurs. In this way the site of the haemorrhage—usually a lacerated transverse or sigmoid sinus—can be exposed.

The Pseudohaematoma Syndrome

Diagnostic burr-holes are often made in cases in which there is a classical syndrome of extradural haematoma, but no haematoma is discovered. Some patients recover spontaneously, but many die. At autopsy one or more of the following lesions may be found: (a) Severe laceration and contusion of the cerebral hemispheres, (b) cerebral oedema, or (c) haemorrhage in the brain stem. The cause of the initial improvement in these patients is obscure. Cerebral oedema revealed by burr-holes should be treated by dehydration therapy.

Subdural Haematoma

There are two types of haematoma occurring between the dura and arachnoid, acute and chronic. An *acute subdural haematoma* is frequently found in severe head injuries. The collection of blood is usually small and is associated with other more serious lesions, e.g. laceration or contusion.

In these circumstances it contributes little or nothing to the clinical picture but if discovered when exploratory burr-holes are made, the blood should nevertheless be removed. Rarely a *large* subdural haematoma arises from torn meningeal vessels which have bled under the dura mater instead of over its outer surface, or a subdural haematoma of considerable size may be caused by spontaneous haemorrhage from an intracranial aneurysm. In both cases the blood is aspirated through a rubber catheter passed into the subdural space through a burr-hole, and the causal lesion appropriately treated.

A *chronic subdural haematoma* may reveal itself a few weeks, months or even years after a minor head injury, although not infrequently there is no history of injury. The cause is thought to be tearing of veins passing between the cerebral cortex and the venous sinuses. The haematoma becomes surrounded by a capsule. In adults a chronic subdural haematoma is sometimes bilateral, whereas in early childhood it is almost always bilateral. The diagnosis is made when a patient develops evidence of raised intracranial pressure, and sometimes also lateralizing signs, a few weeks after a head injury. Occasionally the course is fulminating or there may be merely a vague mental disturbance reminiscent of the dementia caused by a frontal tumour. In fact an intracranial tumour is the most likely diagnosis when there is no history of head injury. When the lesion has been overlooked the capsule tends to be thick, and indeed the haematoma may become completely organized into a fibrous mass with patches of calcification.

In early childhood, birth trauma is held to be a major factor in the aetiology. A history of other types of head injury is more often lacking in children than in adults and there is no characteristic clinical picture in the majority of cases. Thus *infants* may show nothing more than restlessness and bad temper, or there may be generalized convulsions (*the commonest symptom of the lesion in early life*), and vomiting. There is pyrexia in more than half the cases and bulging of the fontanelle in somewhat less than half. The circumference of the head may be two or three inches more than average. Retinal haemorrhages are quite common, but papilloedema is rare. The tendon reflexes may be exaggerated, but paresis of limbs is found in only a small proportion of cases. The manifestations in early life are thus vague and therefore subdural haematoma should be one of the conditions considered when a child is not thriving.

Investigations

Plain radiography usually gives no evidence of

a chronic subdural haematoma, although in long-standing haematomas in children there may be enlargement of the calvarium on the affected side in unilateral cases, and also elevation of the lesser wing of the sphenoid (as seen through the orbit in an antero-posterior view of the skull). There may also be separation of the cranial sutures (diastasis). Occasionally calcification of the haematoma is shown radiologically. Electroencephalography shows electrical 'silence' or low potentials over the haematoma. When the diagnosis of subdural haematoma is made the appropriate investigation is exploration by means of burr-holes. In doubtful cases carotid *angiography* is sometimes carried out. In the presence of a haematoma the vascular tree is seen to be displaced to the opposite side. A frontal haematoma causes displacement of the corresponding anterior cerebral artery towards the opposite side, and downward deflection of the middle cerebral artery and its branches. In some cases angiography reveals no abnormality. Ventriculography is not performed deliberately when a subdural haematoma has been diagnosed, but it may reveal the presence of one when the investigation is carried out for a suspected intracranial tumour.

Treatment

A chronic subdural haematoma is usually drained through burr-holes. The dura mater is opened and the outer membrane of the haematoma is punctured (the surgeon is careful not to mistake a large cortical vein for a haematoma). A rubber catheter is passed into the haematoma. If the altered blood is in the fluid state much of it will flow out. The remainder is evacuated by saline irrigation through the catheter. Burr-holes are then made on the opposite side, for subdural haematomas are frequently bilateral. Further irrigation of the cavity may be required in a few days if the patient's condition does not improve, or deteriorates. If the haematoma is composed of clotted blood it is necessary to elevate a bone flap to remove it.

In *children*, especially during *infancy*, the management is different, for *sudden evacuation of large subdural haematomas has a high mortality*. Treatment begins with aspiration of not more than 10 ml. of blood daily on alternate sides. (*N.B.*—Subdural haematomas are bilateral in children in the majority of cases.) Aspirations are carried out through the coronal sutures at a different point each day and well away from the midline. After about a week when the patient's condition is sufficiently improved, *burr-holes* are made to see whether or not a membrane has formed. It is particularly important in children to remove all the membrane of subdural haema-

FIG. 2.—A giant left subdural hydroma, in a child of 7 years, demonstrated by partial replacement of the fluid with air. Note also enlargement of the skull on the side of the hydroma. Despite this change, symptoms had been present for only ten weeks; they were pain on the left side of the head, attacks of vomiting, drowsiness and double vision.

tomas to prevent cortical atrophy. Removal is carried out after elevation of a large osteoplastic flap. It is of the utmost importance immediately to replace all blood lost during operation. After operation, repeated aspiration of the subdural space is often necessary. During the early years of life, when the brain is growing rapidly, it is vitally important to avoid missing a subdural haematoma which, if untreated, causes marked dementia.

Subdural Hygroma (syn. subdural hydroma)

Subdural collections of clear or yellow fluid of high protein content may occur, with or without a history of head injury (Fig. 2). They cause increased intracranial pressure. Some cases follow meningitis, especially that caused by *H. influenzae*. The traumatic hydromas are assumed to follow tears in the arachnoid. Hygromas, whether traumatic or inflammatory, are frequently bilateral. Treatment is the same as for subdural haematomas, including removal of any capsule which may have formed.

FIG. 3.—This boy, aged 18 months, had had the pointed end of a pencil driven through the medial end of the right upper lid and the roof of the orbit. In three weeks a right frontal abscess developed. It was successfully treated by the aspiration method.

Cerebral Abscess

When fractures of the skull are open to the exterior or into the nasal air sinuses or middle ear, and when the membranes of the brain are penetrated, there is a strong tendency to intracranial infection. A brain abscess is almost certain to form if fragments of bone, hair, or other foreign material remains in the brain; the presence of a missile is much less likely to cause an abscess. Therefore only the most easily accessible missiles should be removed. There is no justification for inflicting further damage on the brain in order to remove a missile which may never cause suppuration. Small penetrating wounds produced by other means are dangerous, for they are apt to be ignored as a possible source of intracranial complications (Fig. 3).

An abscess of the brain behaves like a tumour, giving rise to increased intracranial pressure and sometimes localizing signs. Thus there are drowsiness, headache, vomiting and often, though not always, a mild or moderate degree of papilloedema.

Any abnormal neurological signs are dependent on the site of the abscess.

Investigations

Lumbar puncture is avoided for the reasons given under 'Extradural Haematoma,' but if done inadvertently the c.s.f. obtained is usually clear although there is a moderate increase in the white cells. There should be no organisms in the fluid either on direct examination or after culture. When there is doubt about the presence or location of an abscess, *ventriculography* and/or *carotid angiography* should be done.

Electroencephalography is likely to show slow waves of marked amplitude and phase-reversal in the region of a supratentorial abscess. When a brain abscess has been localized its extent can be demonstrated by positive contrast radiography. Diodone (Pyelosil), 2-3 ml., is injected into the abscess cavity after some of the pus has been aspirated. The skull is then X-rayed. Some neurosurgeons use Thorotrast (thorium dioxide) for it has the advantage of remaining *in situ* and thus the progress of the abscess can be followed by radiography. But there is experimental evidence to show that Thorotrast, acting as a foreign body, stimulates gliosis. Therefore if resolution of an abscess is desired after aspiration, the rapidly absorbable contrast medium, diodone, should be employed. Furthermore, it is a violation of surgical principles to leave an unabsorbable foreign body in a septic place.

Methods of Treatment

Aspiration. A burr-hole is made over the site of the abscess. A small incision, a few millimetres long, is made in the dura mater with a round-ended tenotome. An avascular point on the surface of the brain is punctured with a pointed tenotome, and a blunt-ended brain needle is passed into the abscess cavity. The pus is aspirated and replaced by 2-3 ml. penicillin solution (100,000 units per ml.); only a small volume of fluid is injected to avoid rupture of the capsule which may be extremely thin. Sometimes an abscess heals after one penicillin replacement, but the procedure may have to be repeated several times. The cannula (brain needle) is then passed through the original burr-hole between the sutures. Considerable judgment is needed in spacing aspirations. Needling should be repeated if the patient's general and neurological state do not improve; it should not be delayed until deterioration occurs. At first, aspiration and penicillin replacement may be needed at intervals of 24-48 hours, but when progress is satisfactory, the intervals become longer and longer until no more pus can be aspirated. The majority of abscesses

FIG. 4.—An aerocele and spontaneous ventriculogram produced by a fracture involving the frontal sinuses. After repair of the torn dura mater the patient made an uneventful recovery.

can be completely cured by this technique. The aspiration technique is particularly applicable to abscesses which involve the motor cortex, the speech zones or the optic radiations when other methods would cause severe neurological deficits. Furthermore, aspiration may be life-saving for patients who are too ill to undergo a major operation.

Primary Excision. This is the most recent method of treatment, and is made possible by the use of antibiotics. The advantage is that the anxious period of observation required by the aspiration technique is eliminated. Primary excision of the abscess is particularly indicated when it is situated in a relatively silent part of the brain, e.g. the frontal or cerebellar lobes where a neurological deficit is unlikely to be caused by excision. It is also the best method of treating an abscess following an open head injury, for any indriven fragments of bone or foreign bodies are automatically removed and the infection is thus brought to an end.

Secondary Excision. Excision of the abscess capsule is carried out when aspiration alone fails.

Some neurosurgeons, however, excise the abscess capsule as a routine as soon as aspiration is unproductive. Before enucleation, penicillin (20,000 units in 5 ml. of normal saline) is injected into the ventricles, and it is also given systemically, to 'cover' the operation and the post-operative period. After excision of the abscess capsule, the wound is closed without drainage.

If the responsible organism can be discovered, an antibiotic to which it is sensitive is given in all methods of surgical attack.

Aerocele

An aerocele is a collection of air in the brain arising from a fracture which opens into the air sinuses. Sometimes air penetrates into the corresponding lateral ventricle producing a ventriculogram (Fig. 4). The condition is usually discovered on routine radiography before a build-up of intracranial pressure can occur. The patient should be warned not to blow his nose. Sometimes there is an associated c.s.f. rhinorrhoea, but with or without it, aerocele calls for immediate craniotomy and repair of the dural defect with fascia lata.