Traumatic subarachnoid haemorrhage

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The presence of subarachnoid blood following head injury is a significant risk factor for poor outcome. Treatment aims to prevent and treat secondary hypoxia, hypotension, intracranial haematoma, epilepsy and infection. There is good evidence for the benefit of nimodipine in aneurysmal subarachnoid haemorrhage. Its role in preventing cerebral ischaemia following trauma is currently under investigation.

Every year, one million people attend accident and emergency departments in the UK with head injury. Of these, 300 per 100 000 require hospital admission, and nine per 100 000, approximately 5 000 patients overall, die annually (Jennett and Macmillan, 1981). Primary injury following head trauma is considered to be complete at, or shortly after, the time of impact and irreversible. Secondary injuries, such as those resulting from hypoxia, hypotension, intracranial haematoma, epilepsy and infection, are potentially amenable to treatment. Prevention and treatment of these insults, with early resuscitation and rapid identification of extracranial injuries, has led to a gradual improvement in patient outcome over the last three decades.

Increased age, low Glasgow coma motor score (GCS) (Teasdale and Jennett, 1974), absence of pupillary reflexes, hypoxia and hypotension all have an adverse effect on prognosis following head injury (Dowling and Vollmer, 1996). Radiological features corresponding to poor prognosis include effacement of basal cisterns and midline shift (Miller et al, 1979; Von Dongen et al, 1983; Eisenberg et al, 1990). The presence of traumatic subarachnoid haemorrhage (tSAH) on the admission computed tomography (CT) scan in those with moderate (GCS 9–12) and severe (GCS 3–8) head injury has been shown to be associated with increased morbidity and mortality (Eisenberg et al, 1990; Kakarieka et al, 1994).

EPIDEMIOLOGY

Although the association of angiographic cerebral vasospasm with tSAH was recognized in the 1970s (Sunanwela and Sunanwela, 1972), determination of the incidence and significance of the condition required the introduction of CT scanning (Eisenberg et al, 1990; Kakarieka et al, 1994; Greene et al, 1996b). The true incidence of tSAH is, however, difficult to determine. It has been demonstrated in two large series that approximately 33–40% of patients suffering moderate or severe head injury have evidence of subarachnoid blood on the admission CT head scan (Eisenberg et al, 1990; Kakarieka et al, 1994).

A relationship has been shown between tSAH and outcome following severe head injury as defined by the Glasgow Outcome Scale (Jennett and Bond, 1975). There is an increased incidence of unfavourable outcome, post-traumatic epilepsy (Kakarieka et al, 1994), and a twofold increased risk of death (Eisenberg et al, 1990). Patients with tSAH have an increased incidence of hypoxia, hypotension, skull fractures, cerebral contusions and periods of intracranial pressure >20 mmHg (Greene et al, 1996a). Increased time in intensive care and total inpatient time is also associated with tSAH (Greene et al, 1996a).

PATHOPHYSIOLOGY

The large variation in pathology following head injury causes difficulty in establishing the effects of isolated tSAH. Its pathophysiology involves accumulation of blood in the subarachnoid space following rupture of bridging veins or arteries. Postmortem results indicate contused or lacerated brain or, more rarely, traumatic rupture of aneurysms as possible sources of subarachnoid blood (Dowling and Curry, 1988).

The effects of tSAH are believed to be similar to that of delayed ischaemic neurological

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deficit following aneurysmal subarachnoid haemorrhage (aSAH). Vasospasm impairs cerebrovascular autoregulation and predisposes to ischaemia, which may, in the first instance, be reversible. If ischaemia persists, the ischaemic area undergoes a process of energy failure with depletion of adenosine triphospate stores, leading to abnormalities in cellular homeostasis, subsequent cell swelling and neuronal death (Siesjo, 1992).

Vasospasm after head injury has been demonstrated using both transcranial Doppler and cerebral angiography, with a reported incidence of 2–41% (Macpherson and Graham, 1978; Weber et al, 1990). Vasospasm may occur earlier in tSAH than aSAH, but persists in both for 10–12 days. Evidence that vasospasm is responsible for ischaemia is suggested by the significant correlation between angiographic evidence of spasm and postmortem evidence of infarction following head injury (Macpherson and Graham, 1978). Half of head trauma patients with vasospasm have CT evidence of hypodense areas compatible with post-traumatic ischaemia (Harders et al, 1996).

The similarity of arterial spasm following head injury or aSAH is suggested by a statistically significant relationship between middle cerebral artery spasm and blood visualized on CT head scans following trauma (Weber et al, 1990). The risk of vasospasm in patients with non-penetrating head injuries is associated with subarachnoid haemorrhage, intraventricular haemorrhage, subdural haematoma and contusions (Martin et al, 1992). In each case, the severity of spasm correlated with a reduction of cerebral blood flow. No vasospasm was demonstrated in patients with normal scans or scans showing cerebral oedema or extradural haematoma alone. This evidence suggests that tSAH leads to vasospasm, which increases the risk and severity of cerebral ischaemia.

TREATMENT

Treatment of head injury aims to prevent and treat secondary insults. The major objectives are to maintain adequate oxygenation and blood pressure, keeping intracranial pressure below 25 mmHg and cerebral perfusion pressure (the difference between mean arterial blood pressure and intracranial pressure) above 70 mmHg (Kirkpatrick, 1997). Therapy to achieve these objectives is employed in all cases of moderate and severe head injury, irrespective of the presence of tSAH.

Raised intracranial pressure and reduced cerebral perfusion pressure are treated with fluid replacement, inotropes, mannitol, high-dose propofol or barbiturates, hypothermia, ventricular drainage and surgery. Hyperventilation may also be employed to reduce raised intracranial pressure by inducing vasoconstriction with consequent reduction in intracranial volume, but there is a risk of inducing cerebral ischaemia, which may be particularly deleterious in patients with tSAH and vasospasm (Menon et al, 1997).

NIMODIPINE

Several drugs have been used to attempt to reduce secondary injury following head trauma. Calcium antagonists reduce cerebral damage in experimental models of cerebral ischaemia and haemorrhage (Uematsu et al, 1989), possibly by preventing calcium influx into cells after ischaemic damage. They do not, however, reduce the incidence of vasospasm. Nimodipine has been shown to be beneficial in preventing delayed ischaemia following aSAH (Pickard et al, 1989). A dose of 60 mg, 4-hourly for 21 days reduced the incidence of cerebral ischaemia by 34% over those receiving placebo. The number of poor outcomes was also reduced in those receiving nimodipine.

Compared with the evidence in aSAH, with its many substantial trials and a robust meta-analysis (Barker and Ogilvy, 1996), there is no clear evidence as yet that nimodipine is beneficial in tSAH. To date, there have been three trials of nimodipine in severe head injury — HIT I (Teasdale et al, 1992), HIT II (European Study Group on Nimodipine in Severe Head Injury, 1994), and the German tSAH study (Harders et al, 1996).

Once it was suspected that nimodipine might be beneficial in tSAH, retrospective analysis of the CT scans in HIT I was performed. The quality of resolution from that generation of scanners was not optimal and there was no evidence of treatment benefit with nimodipine in the tSAH group. Benefit was shown, however, in Head Injury Trial (HIT) II and the German study. The latter was a prospectively randomized trial that suggested that nimodipine achieves reduction in mortality, persistent vegetative state and severe disability.

Altogether, 460 patients with tSAH were included in HIT I, HIT II, and the German study, 245 receiving placebo and 215 nimodipine. Regardless of the comparability of patients in these studies, with different treatment schedules, entry criteria and protocol compliance, a pooled analysis of outcome after 6 months was performed on the basis of inten-

tion to treat. This analysis shows a statistically significant decrease in unfavourable outcome in patients treated with nimodipine, with a relative reduction in unfavourable outcome as high as 20%. Furthermore, nimodipine was given for only 7 days in HIT I and HIT II, whereas vasospasm persists for 10–12 days, so therapeutic benefit may have been underestimated.

However, the role of nimodipine in tSAH is as yet undefined. The CT scan diagnosis of tSAH is not always straightforward in the emergency setting, particularly if the scan is not of the highest quality. With its calcium channel-blocking action, nimodipine has the potential to cause hypotension and a detrimental reduction in cerebral perfusion. It is essential to balance the risk of adversely affecting cerebral perfusion against the as yet unproven benefits of nimodipine.

Therefore although benefit in outcome has been shown in studies to date, until larger studies are reported caution should be exercised in using nimodipine. We have used nimodipine in selected patients but would not currently recommend commencing it before neurosurgical unit admission.

CONCLUSION

tSAH following severe head injury is associated with increased morbidity and mortality. There is preliminary evidence of benefit from using nimodipine in tSAH, but this must be balanced against the risk of lowering blood pressure and jeopardizing cerebral perfusion. The results of a new, larger trial are awaited. **HM**

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KEY POINTS

- Traumatic subarachnoid haemorrhage occurs in up to 40% of patients with moderate or severe head injury and is a significant risk factor for poor outcome.
- The initial priority in treating traumatic subarachnoid haemorrhage is prevention and treatment of secondary insults, particularly hypoxia and hypotension.
- Nimodipine is effective in preventing ischaemia in aneurysmal subarachnoid haemorrhage and may also have a role in traumatic subarachnoid haemorrhage. A large prospective randomized controlled trial is currently in progress.
- Although nimodipine is registered for use in traumatic subarachnoid haemorrhage, we do not advocate therapy until after neurosurgical consultation to avoid the risk of hypotension.