ANAESTHESIA OR CATALEPSIA FOR NEUROSURGERY?

The majority of anaesthetic drugs depress the central nervous system (c.n.s.), but some, for example ketamine and nitrous oxide, are capable of producing excitation and have been classified as cataleptoid c.n.s. stimulants (Winters, 1972). This cataleptic state is not strictly related to the condition described by clinical neurologists. Early pharmacological studies on ketamine by Corssen, Miyasaka and Domino (1968) suggested that the drug was both a stimulant and a depressant of the c.n.s., producing a state of dissociative anaesthesia. However, more recent studies of the effects of ketamine on the electroencephalogram (e.e.g.) (Kayama and Iwama, 1972; Wong and Jenkins, 1974) have shown that its overall effects are stimulant. Lack of awareness and analgesia may be secondary to cortical seizure activity in the same way that petit mal attacks are accompanied by loss of consciousness. In a study of cerebral blood flow (c.b.f.) in man, Hougaard, Hansen and Brodersen (1974) concluded that ketamine was probably not a direct cerebral vasodilator, but that the observed increase in c.b.f. was secondary to drug-induced changes in neuronal activity. Dawson, Michenfelder and Theye (1971) also demonstrated an increase in canine c.b.f. with ketamine and they were able to attenuate this response by the prior administration of thiopentone, a cerebral metabolic depressant drug (Pierce et al., 1962). Increases in intracranial pressure (i.c.p.) with ketamine have also been described in man by Shapiro, Wyte and Harris (1972).

Like ketamine, nitrous oxide is a potent cerebral vasodilator causing marked increases in i.c.p. in patients with intracranial disease (Henriksen and Jørgensen, 1973). Initially this was attributed to a direct action on cerebral vessels and this could be countered by hyperventilation, but recent observations suggest that it is secondary to neuronal stimulation (Misfeldt, Jørgensen and Rishøj, 1974; Phirman and Shapiro, 1977). An increase in i.c.p. produced by nitrous oxide in a patient was not modified when the arterial tension of carbon dioxide ($P_{CO_2}$) was reduced to 4.12 kPa, but the response was modified by the prior administration of sodium thiopentone.

Extreme hyperventilation, which may be used to prevent large increases in i.c.p. with nitrous oxide, may be harmful. Harp and Wollman (1973) described a study in man in which hyperventilation, for 1 h to $P_{CO_2}$ 2.66 kPa, with nitrous oxide and oxygen produced an increase in cerebrospinal fluid (c.s.f.) lactate and a decrease in oxygen tension in the c.s.f. (c.s.f. $P_{O_2}$). Hyperventilation to the same extent with halothane did not alter c.s.f. lactate or c.s.f. $P_{O_2}$ and it was suggested that this was a result of improved perfusion secondary to the cerebral vasodilator action of halothane. An alternative explanation is that nitrous oxide causes cerebral metabolic stimulation which is normally accompanied by an increase in c.b.f., but this response is prevented by hyperventilation resulting in anaerobic metabolism.

The possible mechanisms of cerebral vasodilatation produced by halothane are of great interest, although these have not been fully elucidated and hypotheses advocated currently are conflicting. In very light halothane anaesthesia an increase in central biochemical activity has been reported (Mori and Winters, 1975) and this may account for the initial increase in c.b.f. Most studies have concluded that cerebral vasodilatation with halothane results from a direct action on the vessel wall (Smith and Wollman, 1972). Smith (1973) has reasoned that a decrease in cerebral metabolic rate for oxygen (CMRO$_2$) and autoregulation of cerebral venous oxygen tension may be responsible for this action, but a study by Albrecht and others (1977) concluded that halothane causes cerebral vasodilatation by a mechanism unrelated to CMRO$_2$. Recently Sakabe and others (1976) have demonstrated in man that during halothane in oxygen anaesthesia the addition of nitrous oxide caused a marked increase in c.b.f.
equivalent (blood flow in relation to the oxygen demand of the brain calculated as the reciprocal of the measured arterial-internal jugular venous oxygen content difference (Smith and Wollman, 1972)). Sakabe and others (1978) later showed in the dog that nitrous oxide increases both c.b.f. and CMRO₂ during halothane anaesthesia, and that this was not a result of sympatho-adrenal stimulation. McDowall, Harper and Jacobsen (1963) showed that halothane vaporized in air reduced c.b.f. in canine brain, but subsequently it was shown (McDowall and Harper, 1965) that halothane vaporized in nitrous oxide increased flow above the control; when air was administered in place of nitrous oxide c.b.f. decreased below the control value.

Is this cerebral vasodilator action of halothane related to cerebral metabolic stimulation? Most workers have held the view that nitrous oxide has minimal effects on CMRO₂ but Theye and Michenfelder (1968), like Sakabe and others (1978), demonstrated an increase in dogs. However, the e.e.g. during nitrous oxide administration may be synchronized at a fast frequency which may be indistinguishable from that of a conscious subject, relaxed with his eyes closed (McDowall, 1976). In addition, power spectrum analysis of the e.e.g. has shown that in patients anaesthetized with nitrous oxide supplemented with light halothane, methoxyflurane or narcotic analgesics, arousal patterns may appear, and these are frequently associated with cardiac arrhythmia, hypertensive responses or alterations in respiratory patterns when spontaneous ventilation has been retained (Stockard and Bickford, 1975; Bimar and Bellville, 1977). These responses were not necessarily linked to any surgical manoeuvre.

There has been some concern about the use of enflurane in neuroanaesthesia because of its propensity to induce seizures which are associated with marked increases in c.b.f. and CMRO₂ (Michenfelder and Cucchiara, 1974). It has been demonstrated recently that seizure activity with enflurane is augmented by nitrous oxide (Smith et al., 1978).

Some recent studies on the effects of nitrous oxide on brain are difficult to interpret, but this may be related to species differences. One may speculate that its actions are biphasic, causing stimulation at light levels of "anaesthesia", but potentiating any existing cerebral metabolic depression. Carlsson and his colleagues (1976) showed that the administration of nitrous oxide to rats which were sedated or anaesthetized with diazepam resulted in decreases in both c.b.f. and CMRO₂. However, these workers could not demonstrate a decrease in CMRO₂ with diazepam alone, although Maekawa, Sakabe and Takeshita (1974) found that it reduced canine c.b.f. in parallel with CMRO₂. Similar reductions in response to diazepam have been described also in man following head injury (Cotev and Shalit, 1975). The work of Sakabe and colleagues (1978) is also difficult to interpret in that the e.e.g. was slowed while both c.b.f. and CMRO₂ increased following the administration of nitrous oxide during background halothane anaesthesia.

Most of the observations which have been discussed emphasize the need to avoid ketamine and to provide adequate supplementation of a nitrous oxide in oxygen technique in neuroanaesthesia. This may be particularly important when cerebral ischaemic hypoxia is present or induced, for example by the application of a temporary clamp on a main vessel feeding an intracranial aneurysm. Lightfoote, Molinari and Chase (1977) have shown that the type of anaesthetic (stimulant or depressant) can affect the size of an infarct in various animal stroke models. They found that cerebral infarction during ketamine anaesthesia substantially exceeded that occurring with barbiturates and they suggested that these studies should assist in the development of new pharmacological approaches to limiting ischaemic brain injury in man. Narcotic analgesics or light halothane supplementation of nitrous oxide may not be sufficient for this purpose but drugs such as barbiturates or Althesin can improve perfusion of ischaemic areas by reducing total c.b.f. and i.c.p. and their use has been recommended when there is a possibility of cerebral infarction (Hoff et al., 1974). There may also be a place for the use of halothane or enfurane vaporized with oxygen-enriched air and with a continuous Althesin i.v. infusion, a combination known to reduce cerebral activity (Dubois et al., 1978). Total i.v. anaesthesia with Althesin and fentanyl may be useful also for avoiding anaesthetic gas pollution and preventing nitrous oxide amplification of air during air encephalography. Finally, it should be emphasized that neurosurgery is performed most easily on a resting brain, particularly during cerebral vascular surgery or when brain compression is present.

John Barker

REFERENCES


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THE EDITOR wishes to apologize for two errors which appeared in our February Editorial (Br. J. Anaesth., 1979, 51, 79).

The reference to Thorburn and Moir relates to a report in preparation (this was not published in 1978 as indicated). The editorial staff is well aware of the difference in spelling between the name of Dr Mendelson and that of the celebrated composer. We are grateful to the large number of readers who took the trouble to point out our shortcomings in this respect and hope that they will accept in mitigation the fact that the correct spelling appeared on the second last line of the Editorial.