Retinal haemorrhage as a complication of gas encephalography and gas myelography

Prospective study using oxygen gas with a discussion of pathogenetic mechanisms

J. E. SLAGSVOLD AND J. L. LARSEN

From the Department of Neurology and the Department of Radiology, Division of Neuroradiology, School of Medicine, University of Bergen, Norway

SUMMARY Seventy patients, submitted to oxygen encephalography and oxygen myelography, were examined by retinal funduscopy to establish the incidence of intraocular haemorrhages, a complication reported to be frequent by other investigators. We did not discover any retinal haemorrhages. Pathogenetic factors influencing intracranial or intraocular venous pressure or both are discussed, particularly the effect due to different technical procedures during the examination, and the type of anaesthesia used.

The early studies of the cerebral ventricles were morphological, depending upon visual observation. Leonardo da Vinci, by using wax, made casts of the ventricles (Robertson, 1967). The injection of air into the subarachnoid spaces and ventricular system as a diagnostic aid was proposed by Dandy (1918). Later, Jüngling (1922) introduced oxygen. Lack of homogeneous material due to different patient groups and techniques has made it difficult to compare the many reports of general complications (Masson, 1933; Davidoff and Dyke, 1946; Whittier, 1951; Falk, 1953; Taveras and Wood, 1964; Ruggiero *et al.*, 1969; Bergeron and Rumbaugh, 1971).

Complications in the visual system arising from pneumoencephalography are not well recognised. Masson (1933) reported a case of temporary blindness, and Hoyt and Beeston (1966) one case of retinal haemorrhage. Simon *et al.* (1973) observed intraocular haemorrhage resulting from pneumomyelography. Moseley and Pilling (1976) reported retinal haemorrhage after pneumoencephalography in 20% of their patients. These reports stimulated us to examine the retinal fundus in patients submitted to oxygen encephalography (OEG) and oxygen myelography (OMG).

Patients and methods

In the second half of 1976, 70 patients from the Department of Neurology underwent OEG and OMG examinations. The investigations were carried out under local, general, or neuroleptic anaesthesia. Fundus examination using a mydriatic was performed before and within a couple of hours after the procedure.

Filling of the temporal horns of the lateral ventricles was obtained by placing the patient's head in a slightly extended lateral decubitus for a couple of minutes while rocking it gently; one temporal horn filled at a time. In no case was the somersault manoeuvre employed.

The investigation included 21 females and 49 males aged between 12 and 69 years with a mean of 40 years. The referring diagnoses are listed in Tables 1 and 2. Four patients were examined by OMG and 66 patients were submitted to OEG. The clinical status and age of each patient determined the type of anaesthesia as follows: local anaesthesia 56 patients, ketamine anaesthesia six patients, and fentanyl (neuroleptic) anaesthesia eight patients. Atropine and droperidol were used as premedication, and pancuronium bromide for muscle relaxation. Ephedrine was given before OEG but was not used in OMG. The technique was that of fractional OEG, introducing oxygen in small fractions after lumbar puncture. At the same time cerebrospinal fluid (CSF) was removed. Oxygen myelography was undertaken with an additional needle placed suboccipitally to withdraw. In OEG the

Address for reprint requests: Dr Jon Erik Slagsvold, Department of Ophthalmology, School of Medicine, University of Bergen, Bergen, Norway.

Accepted 28 June 1977

Table 1 Diagnoses in 66 cases of oxygen encephalography

Diagnoses	Number of cases	%
Epilepsy	21	32
Intracranial haemorrhage (sequelae)	3	4.5
Cerebral ischaemic disease	1	
Cerebral and cerebellar atrophy	18	27
(Traumatic; Wernicke; aetiology unknown)		
Neurosis and psychosis	16	24
(Post-traumatic; unspecified)		
Cephalalgia	2	
Chronic alcoholic disease	1	
Intracranial tumours	6	9
Paralysis agitans	2	
Hereditary ataxias/muscular dystrophy	2	
Spasmodic torticollis	1	
Neuralgia	2	
Cerebrospinal syphilis	1	
Hydrocephalus/syringomyelia, syringobulbia	2	
Multiple sclerosis	1	
Diabetes insipidus/hypothyroidism	2	
Total	81	

Table 2 Diagnoses in four cases of oxygen myelography

Diagnoses	Number of cases
Syringomyelia	2
Cervical medullary tumour	1
Myelopathy (aetiology unknown)	1
Total	4

average amount of oxygen injected was $62(\pm 16)$ ml, while $37(\pm 11)$ ml of CSF was removed. In OMG the figures were $58(\pm 23)$ ml and $26(\pm 15)$ ml.

Results

We observed no cases of retinal haemorrhage or exudate in our patients.

Concerning general complications of the procedures, most patients complained of headache lasting for 24 to 36 hours, but no major accident, such as syncope or death, occurred.

Discussion

Hoyt and Beeston (1966) and later Simon and colleagues (1973) appear to have been the first to record retinal haemorrhages provoked by pneumoencephalography and pneumomyelography. These haemorrhages were either intra- or preretinal, and were usually asymptomatic (Moseley and Pilling, 1976). However, an affection of the vitreous body with gross visual reduction was reported by Simon *et al.* (1973).

The haemorrhages seemed to be of venous origin (Hoyt and Beeston, 1966). Several factors may con-

tribute to such bleedings, especially those causing raised intracranial or intraocular venous pressure or both, possibly as a result of special examination procedures. The technique of having the patient's legs higher than the head results in a stasis of cephalic venous vessels (Simon *et al.*, 1973, Moseley and Pilling, 1976). This Trendelenburg position is particularly unfavourable if long-lasting. The somersault manoeuvre to fill the temporal horns with gas is another way of causing increased venous pressure (Moseley and Pilling, 1976) due to compression of the thorax and abdomen by the necessary support (Pearce, 1957). This mechanism is further illustrated by the haemorrhagic retinopathy caused by the Valsalva manoeuvre (Duane, 1973) and by the retinal angiopathy after heavy compression trauma to the chest, in Purtscher's disease (1910). In the present study none of these manoeuvres were undertaken, and this may be why there were no ocular complications.

Transient rise in intracranial pressure may be caused by the injection of air into the ventricular system (Cronquist *et al.*, 1963). This rise may also be observed when using carbon dioxide, nitrous oxide, or ethylene. The use of these gases, however, leads to poorer radiographs, although the residual symptoms are considerably reduced compared with injection of air. Oxygen occupies an intermediate position between these gases and air.

In the present study the method was that of 'fractional pneumoencephalography'—that is, repeated injections of small quantities of oxygen and subtractions of cerebrospinal fluid. In OEG the volume difference between injected oxygen gas and withdrawn CSF was on average 26 (range 14–38) ml. Larger volumes of oxygen were thus used than in comparable investigations by Ruggiero *et al.* (1969) using air. The amount of oxygen injected into the 54 patients under local anaesthesia was 24 (range 15–33) ml and in the 12 patients under general anaesthesia 33 (range 15–31) ml. More oxygen was injected into the patients under general anaesthesia, probably because, unlike the conscious patients, they did not present adverse reactions such as headache, profuse sweating, nausea, and general discomfort.

Our investigation included only four patients submitted to OMG, and this is too small a number for analysis. The amount of air injected and CSF withdrawn does not influence the incidence of retinal haemorrhages (Simon *et al.*, 1973) or general complications (Ruggiero *et al.*, 1969).

Local anaesthesia does not increase intracranial pressure. Using ophthalmodynamometry, the intraocular pressure has been shown to be affected by

lumbar spinal puncture in some patients (Finke and Jaenicke, 1970). All inhalation anaesthetics increase the intracranial pressure (McDowall *et al.*, 1966), and mechanical obstacles constitute one of the main causes for this. The effect of compression of the thorax and abdomen has already been discussed. A report by Jeppson and Järpe (1960) revealed an increase in intracranial pressure caused by intubation which necessitated the use of muscle relaxation. The vasodilatation arising from general anaesthesia leads to a rise in cerebral blood volume and a consequent increase of intracranial pressure, for example with fluothane as used by Simon *et al.* (1973). However, in these respects the anaesthetic agents behave differently. Nitrous dioxide does not change the cerebral blood volume when hypoxia is avoided and there is no free air trapped inside the skull. Saidmann and Eger (1965), however, reported a substantial increase in CSF pressure using nitrous dioxide during pneumoencephalography. This gas, more soluble than nitrogen, is carried to the air-containing ventricles in a greater quantity than the amount of nitrogen removed from the ventricles. Nitrous dioxide is best avoided, unless used both as contrast gas for gas encephalography and as inhalation drug for general anaesthesia in the same patient (Ruggiero, 1974; Elwyn *et al.*, 1976). Moseley and Pilling (1976) hyperventilated their patients to minimise rise in intracranial pressure. Hypocapnia counteracts the effect of vasodilatation while hypercapnia adds to it. In their discussion, they do not mention nitrous dioxide as a cause of intraocular haemorrhage among their patients.

The use of ketamine for general anaesthesia, as suggested by Corrsen (1967), offers two advantages—quick recovery from anaesthesia without respiratory depression, and preservation of pharyngeal reflexes. In our study patients given ketamine were young, since this drug is preferably not given to adults. However, it causes a moderate increase in intracranial pressure by raising the arterial blood pressure and cerebral blood volume (Gardener *et al.*, 1971). Diazepam seems to counteract this effect when given in combination with ketamine (Gran, 1976, personal communication), and this tranquilizer was added in our study.

Analgesic and neuroleptic drugs were combined for general anaesthesia in our third group. The CSF pressure decreases, and the patients are awake and cooperative. Neuroleptic anaesthesia, which is easy to administer even by the radiologist, is now in common use.

Ruggiero *et al.* (1969) summed up the relevant

factors influencing the complication rate for gas encephalography. They were more frequent if (a) examination was carried out under general anaesthesia, (b) patients were in poor general condition, and (c) diagnosis was that of cerebral tumour.

We did not observe retinal haemorrhages or general complications among our patients. Bearing in mind the results from Ruggiero's study, the fact that most of our patients were submitted to local anaesthesia may be significant; tumours were diagnosed in only 10%. Epilepsy, cerebral and cerebellar atrophy, and mental disturbances were the most frequent diagnoses. The use of ketamine/diazepam or neuroleptic anaesthesia avoids any great rise in intracranial pressure. Oxygen minimises residual symptoms and can be used in larger volumes than air due to its rapid absorption. Retinal haemorrhages are infrequent complications of gas encephalography and gas myelography, and, if they occur, are, as a rule, hardly noticed by the patients (Moseley and Pilling, 1976). However, they are a potential threat to vision (Simon *et al.*, 1973), and can be kept to a minimum by considering the factors known to increase the intracranial or intraocular venous pressure or both.

References

- Bergeron, R. T., and Rumbaugh, C. L. (1971). Problems incident to pneumographic and other nonangiographic radiologic contrast studies of the brain. *Bulletin of the Los Angeles Neurological Society*, **36**, 1–10.
- Corrsen, G. (1967). National Burn Seminar. Recent developments in the anesthetic management of burned patients. *Journal of Trauma*, **7**, 152–156.
- Cronquist, S., Lundberg, N., and Pontin, U. (1963). Cerebral pneumography with continuous control of ventricular fluid pressure. *Acta Radiologica*, **1**, 558–564.
- Dandy, W. E. (1918). Ventriculography following the injection of air into the cerebral ventricles. *Annals of Surgery (Philadelphia)*, **68**, 5–11.
- Davidoff, L. M., and Dyke, C. G. (1946). *The Normal Encephalogram*. Second edition. Lea and Febiger: Philadelphia.
- Duane, T. D. (1973). Valsalva hemorrhagic retinopathy. *American Journal of Ophthalmology*, **75**, 637–642.
- Elwyn, R. A., Ring, W. H., Loeser, E., and Myers, C. G. (1976). Nitrous oxide encephalography: 5 years experience with 475 pediatric patients. *Anesthesia and Analgesia*, **55**, 402–407.
- Falk, B. (1953). Encephalography in cases of intracranial tumour. *Acta Radiologica*, **40**, 220–233.
- Finke, V., and Jaenicke, H. (1970). Kreislaufänderungen während lumbalpunktion und pneumoencephalographie (am hand ophthalmodynamographi-

- scher befunde). *Deutsche Zeitschrift für Nervenheilkunde*, **197**, 171–180.
- Gardener, A. E., Barry, E. O., and Lichtinger, M. (1971). Cerebrospinal fluid pressure during dissociative anesthesia with ketamine. *Anesthesiology*, **35**, 226–228.
- Hoyt, W. F., and Beeston, D. (1966). *The Ocular Fundus in Neurologic Disease*. C. V. Mosby: St Louis.
- Jeppson, S., and Järpe, S. (1960). Intravenous urea as an aid in intracranial surgery. *Acta Chirurgica Scandinavica*, **120**, 137–141.
- Jüngling, O. (1922). Zur Technik der Sauerstoffüllung der Hirnventrikel zum Zwecke der Roentgendiagnostik. *Zentralblatt für Chirurgie, Leipzig*, **49**, 833–836.
- McDowall, D. G., Barker, J., and Jennett, W. B. (1966). Cerebrospinal fluid-pressure measurements during anaesthesia. *Anaesthesia*, **21**, 189–201.
- Masson, G. B. (1933). The disturbances in vision and visual fields after ventriculography. *Bulletin of Neurology (New York)*, **3**, 190–209.
- Moseley, I. F., and Pilling, J. B. (1976). Intraocular haemorrhage as a complication of pneumoencephalography. *Journal of Neurology, Neurosurgery, and Psychiatry*, **39**, 375–380.
- Pearce, D. J. (1957). The role of posture in laminectomy. *Proceedings of the Royal Society of Medicine*, **57**, 109–112.
- Purtscher, D. (1910). Noch unbekannte befund nach schaedeltrauma. *Bericht Versamtlche Ophthalmologische Gesellschaft*, **36**, 294–301.
- Robertson, E. Graeme (1967). *Pneumoencephalography*. Second edition. Charles C. Thomas: Springfield, Illinois.
- Ruggiero, G., Cristi, G., and Trevisan, C. (1969). Clinical aspects of encephalography. *Acta Radiologica, Supplement* 292.
- Ruggiero, G. (1974). *Radiological Exploration of the Ventricles and Subarachnoid Space*. Springer Verlag: Berlin, Heidelberg, New York.
- Saidmann, L. J., and Eger, E. I. (1965). Change in cerebrospinal fluid pressure during pneumoencephalography under nitrous oxide anesthesia. *Anesthesiology*, **26**, 67–72.
- Simon, J., Garrec, A., and Guegan, Y. (1973). Les complications hemorragiques oculaires de la myelographie gazeuse. *Journal de Radiologie*, **54**, 675–679.
- Taveras, J. M., and Wood, E. H. (1964). *Diagnostic Neuroradiology*. Williams and Williams: Baltimore.
- Whittier, J. R. (1951). Death related to pneumoencephalography during a six year period. *Archives of Neurology and Psychiatry (Chicago)*, **65**, 463–471.