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Sleep and delirium after open heart surgery

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SUMMARY

The quantity and quality of sleep have been measured objectively in 4 patients before and after open heart surgery; 2 of these became delirious on the third postoperative day. A fifth patient was studied in relation to major abdominal surgery. The degree of sleep disturbance in the early postoperative period was greater after cardiac than abdominal surgery but was not consistently related to the ensuing delirium. Although patients were woken frequently by the necessity for nursing and other care, they were unable to remain asleep when left undisturbed during the period of delirium, which lasted for several days. Rapid eye movement (REM) sleep was absent and delta wave sleep markedly reduced after cardiac surgery and with delirium although the patients described frequent 'dream-like' experiences in their drowsy state. Delirium after cardiac surgery differs from that which sometimes occurs after withdrawal of addictive drugs, when a high proportion of REM sleep is observed.

ADULT patients who undergo cardiac surgery frequently exhibit postoperative delirium (Fox et al., 1954; Egerton and Kay, 1964; Abram, 1965; Kornfeld et al., 1965). Typically there is an initial postoperative period of from 3–5 days when the patient is mentally lucid, followed by several days when he is confused, irritable and disorientated in time, place and sometimes in person. There may be visual and auditory perceptual distortions, delusions and perhaps hallucinations. Some degree of this 'psychosis' has been reported by different investigators to occur in proportions which have varied from a few per cent to more than 50 per cent of all adults who undergo open heart surgery (Kornfeld, 1967).

Many factors present in cardiac surgical patients could contribute to brain dysfunction. Two obvious ones are hypotension causing cerebral ischaemia (Tufo et al., 1970) and microemboli—either gas bubbles or platelet aggregates (Brennan et al., 1971). Microemboli have been seen in large numbers in the retinal arterioles during open heart surgery (Williams, 1971) and have been demonstrated by retinal angiography to cause infarcts. The use of 20 μm filters does not seem greatly to have affected this situation (Williams, 1973). However, the common lucid interval of 3–5 days is difficult to explain either on hypoxic or embolic grounds. Several investigators have suggested that the postoperative environment might produce a psychological condition which would favour mental disturbance (Kornfeld et al., 1965; Hazan, 1966; Blachly, 1967; Dudley, 1968; Morse and Litin, 1971). Sleep deprivation and reduction of meaningful sensory stimuli in the face of a monotonous sensory barrage are obvious concomitants of intensive care. In other but similar circumstances such as 'brainwashing' and experimental sleep deprivation the evidence is conflicting. Prolonged deprivation of sleep produces psychomotor deterioration only during brief snatches of 'micro-sleep' (Pasnau et al., 1968), and the original fear that selective deprivation of rapid eye movement sleep (REM—dreaming sleep) would produce a reversible psychotic state has proved to be unfounded (Dement, 1969). In addition the sleep disturbance seen in the delirium of drug withdrawal involves an unusually high proportion of REM sleep (Gross et al., 1966). Feinberg (1969) has suggested that an increased pressure for REM sleep occurs in delirium when REM-sleep-depressant drugs are withdrawn. Therefore, we wondered if the delirious behaviour of the patient after cardiac surgery could be attributed to a sleep disturbance of this kind rather than to a lack of sleep. Subjective observations of sleep and wakefulness in a cardiac intensive care ward suggested that patients are unlikely to be left alone and undisturbed for more than half an hour at a time during the first 2 days and nights after open heart surgery. A typical activity record from such a patient is shown in *Fig.* 1. The amount of sleep obtained by this patient may have been less than recorded because sleep was measured only by seeing the eyes closed.

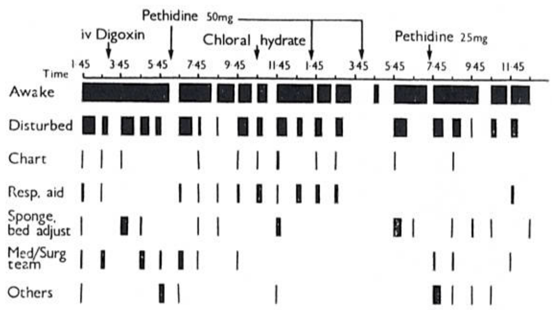

Fig. 1. A 24-hour activity record of a patient for the first day after mitral valve replacement. The broken sleep obtained amounted to no more than 5 hours and was probably less.

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To investigate our hypothesis of sleep disturbance we have now studied by objective techniques 5 patients; 4 after open heart surgery and 1 after major abdominal surgery. Two of the cardiac patients showed typical delirium.

Materials and methods

Sleep and wakefulness were assessed by continuous parietotemporal electroencephalogram (EEG), electro-oculogram (EOG) and palmar skin resistance (Johns, 1971). Data were accumulated on a multichannel FM tape recorder housed beneath the patient's bed. The EEG signal was replayed through an analogue electronic unit which counted the number of delta waves whose amplitude exceeded 40 μV (peak to peak) during each 20-second epoch. Combination of this information with that from the EOG and skin resistance allows any epoch to be assigned to a sleep stage and obviates the necessity of writing out the EEG and EOG on miles of paper with subsequent visual scoring.

Details of the patients are given in *Table I*. All were between 45 and 64 years, and their freedom from overt psychiatric disorder was determined by routine psychiatric interview and psychometric testing using the Minnesota Multiphasic Personality Inventory. Their informed consent was a deciding factor in determining their participation in this work and thus they cannot be regarded as necessarily representative of all the patients undergoing surgery at our hospital. Only the general surgical patient was abnormal in respect of alcohol consumption: he was described as a heavy drinker, consuming at least 2 litres of beer daily.

Table I: DETAILS OF THE PRESENT SERIES

Age	Sex	Procedure	Clinical course	Retinal microemboli
64	M	Aortic valve replacement	Uneventful	−
51	M	Aortic valve replacement	Uneventful	−
45	M	Aortic valve replacement	Delirium	+
46	F	Mitral valve replacement	Respiratory insufficiency Delirium	−
49	M	Left colectomy	Uneventful	−

General anaesthesia was induced by intravenous thiopentone and maintained by nitrous oxide/oxygen. Patients who underwent cardiac surgery were connected to a pump-oxygenator to maintain cardiopulmonary bypass for 1–2 hours. Hypoxia or hypotension (systolic blood pressure < 60 mm Hg) did not occur for a total of more than a few minutes in any patient. During the postoperative period the patients' physical and mental status were assessed daily by specific questioning, both of them and of their attending staff.

Response to a sleep questionnaire indicated that when at home the patients woke occasionally during the night but, with the exception of the female patient, had little difficulty in initially falling asleep. The usual duration and subjective quality of their sleep were similar to those of other middle-aged patients (Johns et al., 1970). When first admitted to hospital the patients slept in general surgical wards. After cardiac surgery they were isolated in an intensive care ward for periods which varied from 4 to 10 days before returning to a general ward. The man who underwent abdominal surgery was cared for in a general ward throughout his hospital stay. Each patient's sleep was measured objectively for 2 or 3 nights during the week before surgery but not on the last preoperative night. Continuous recordings were made during the first few postoperative days and nights and then intermittently at night for another 1–3 weeks, depending on the speed of the patient's recovery. Opiates were administered with decreasing frequency during the first 2–3 days postoperatively. Parenteral diazepam, and later oral nitrazepam, was given to most patients, particularly at night.

Results

In hospital most patients slept well before their operation. Four who were given nitrazepam (5–10 mg) at night obtained an average of between 6 and 7½ hours of sleep, with few interruptions. One exception who voluntarily did not take his hypnotic showed considerable variation of sleep from night to night. The average proportion of REM sleep during this preoperative period varied between 15 and 29 per cent in different subjects while that of delta wave sleep (stages 3 and 4) varied from 7 to 20 per cent, both proportions which are within the normal range for middle-aged subjects (Webb and Agnew, 1968).

In the early postoperative period all the patients were mentally lucid and were free from signs of neurological disorder on clinical examination. The 3 men who underwent aortic valve replacement all had mechanical assistance to their respiration from the time surgery ended. This was not given after abdominal surgery and not until several days after mitral valve replacement in the woman.

All the patients obtained no more than a few brief periods of sleep, the total duration of which varied from 1 to 4 hours, during the first 24 hours postoperatively and thereafter no more than 2–6½ hours of sleep on the second day. Most complained to some extent about being woken up repeatedly when they felt like sleeping. There were prolonged periods when they lay quietly with eyes closed, apparently asleep but the EEG showed only alpha waves, initially with superimposed high frequency waves which were thought to be the consequence of the preceding barbiturate anaesthesia.

During the first 2 postoperative days the only patient to obtain any REM sleep was the man who underwent abdominal surgery; his REM sleep amounted to 9 per cent of the 4 hours' sleep which he obtained on the first postoperative night and 15 per cent of 5 hours' sleep on the second night. Delta wave sleep was markedly reduced and regular sleep cycles were absent in all the patients. Thereafter, the pattern of sleep and wakefulness gradually returned to normal in the 3 patients whose postoperative course was uneventful. For example, a 64-year-old man who underwent aortic valve replacement and who recovered rapidly obtained a total of 9 hours' sleep with 9 per cent of REM sleep and with sleep cycles present on the seventh postoperative day. The return to the preoperative pattern of sleep and wakefulness was almost complete by the fourth postoperative night in the general surgical patient.

By contrast, 2 patients became agitated late on the second postoperative day and progressed to clinical delirium which persisted, particularly at night, for 4 days in a man who underwent aortic valve replacement and for 12 days in the woman after mitral valve replacement. In both of these patients the onset of delirium was associated with postoperative complications (haemothorax and pulmonary infection in the first; pulmonary infection which necessitated tracheostomy on the fourth day in the second). Throughout this period of delirium the man obtained a total of at least 6 hours' sleep in each 24 hours although this was highly fragmented by periods of drowsiness and wakefulness. Reduced amounts of delta wave sleep were obtained, but REM sleep and regular sleep cycles were absent. Thus, sleep was mainly in stage 1 and stage 2. Nevertheless, he reported frequent brief 'dream-like' experiences which at the time he was unable to distinguish from reality. For example, he thought he was in another city or at home talking with friends. His ability to maintain alert wakefulness was reduced as much as his capacity to sustain uninterrupted sleep, even when he was left undisturbed. His mental and physical condition improved gradually over the next few days. On the thirteenth postoperative night he obtained a total of 7½ hours' sleep, with REM sleep comprising a proportion similar to that measured preoperatively. At no time was an increased proportion of REM sleep observed during his 3 weeks of convalescence.

A more prolonged but otherwise similar postoperative course was followed by the woman. She obtained only brief periods of stage 1 and stage 2 sleep (totalling 2–3 hours/24 hours) during the first week after surgery. Most of the time her EEG comprised high amplitude waves (100 μV), the frequency of which slowed progressively to about 7 Hz. Although she also reported frequent 'dreaming' during the day and night, REM sleep was absent until the tenth day when her delirium was beginning to clear. Later she remembered very little of what had happened during the period of delirium. On the twenty-fifth postoperative night (when feeling reasonably well) she obtained 9½ hours of almost uninterrupted sleep, with a similar proportion of REM sleep to that measured preoperatively but with an increased proportion of delta wave sleep.

Repeated intra- and postoperative retinoscopy revealed microemboli and subsequent small infarcts only in the male patient who became delirious.

Discussion

Objective sleep studies of the kind described are complex and difficult to make on seriously ill surgical patients and the small number that we have been able to study permit only tentative conclusions. We are largely ignorant of the sleep and wakefulness pattern of patients undergoing major non-cardiac surgery but subjective records based upon sleep questionnaires suggest that many patients sleep adequately in the general wards before surgery, particularly with the aid of a hypnotic such as nitrazepam (Johns et al., 1972). After surgery sleep is fragmented and may amount to a total of 1–4 hours per 24 hours for 2–3 days. The patient in intensive care after cardiac surgery may obtain even less sleep, but in the absence of complications this pattern of sleep and wakefulness seems to return to normality within a week.

The absence of REM sleep soon after cardiac surgery, even in patients who did obtain some other sleep and who recovered rapidly, stands in contrast to the findings after less major surgery. Both types of operation involve prolonged general anaesthesia and the administration of opiates several times postoperatively. Barbiturates, opiates and diazepam could all reduce the proportion of REM sleep but would be unlikely to abolish it (Oswald, 1968; Kay et al., 1969). Thus, some special feature of cardiac surgery or cardiopulmonary bypass seems to be implicated in the specific inhibition of REM sleep during the early postoperative period. Minor degrees of cerebral dysfunction caused by microemboli and mild cerebral hypoxia could produce this inhibition.

The severity of sleep deprivation during the first 2 postoperative days did not distinguish patients who later became delirious from those who recovered uneventfully. This conclusion, which is based on objective measurements of sleep, is consistent with the only other published material derived from subjective observations by nursing staff (Heller et al., 1970). Indeed, the total amount of sleep obtained by the male patient during the period of his delirium was such that sleep deprivation probably played little part in producing the disorder. However, this may not be true for the female.

The absence of REM sleep with this type of delirium is markedly different from the excess observed after drug withdrawal, for example in alcoholics (Dement, 1969). Thus, whatever the role of REM sleep may be in drug-withdrawal states, it does not appear to play an important part in producing the delirium which we have observed after cardiac surgery. The intense 'dream-like' experiences, confusion and misperceptions experienced by the delirious patients may have occurred during the frequent prolonged periods of drowsiness and stage 1 sleep (without REMs) when the ability to distinguish reality from fantasy is known to be reduced even in normal people (Vogel et al., 1972).

The delirium which we observed probably resulted from the additive effects of several factors including cerebral hypoxia and perhaps bacterial toxaemia associated with pulmonary infection. Although retinal microembolism was seen in only 1 patient, cerebral microencephalopathy caused by multiple cerebral infarcts could have been sustained during cardiopulmonary bypass. In addition, prolonged drowsiness with only brief periods of sleep may have exacerbated the symptoms and signs of cerebral dysfunction, especially at night, without being a primary cause of the disturbance.

Although we did not keep formal records to identify the periods of wakefulness which were caused by environmental stimuli, unintentional waking of the patients was undoubtedly common during the first few postoperative days and nights, mainly because of the need for intensive nursing care, physiotherapy and observation of patients' vital functions. It is a matter of common observation that, in general, the longer people go without sleep under any circumstances the harder it is to keep them awake. However, on many occasions the patients who underwent cardiac surgery were observed to wake up without obvious environmental stimulation and after dozing for only a few minutes. Thus, there was an inability to sleep when given the opportunity to do so, in addition to the factor of being woken frequently from what might otherwise have been restful sleep. Psychological distress engendered by the nature and severity of the illness may well have been a major cause of this insomnia. However, in delirium the inability to remain asleep was accompanied by an equal inability to remain fully alert. Under these circumstances, both disorders were probably the result rather than the cause of cerebral dysfunction.

We can conclude that our original hypothesis was too simplistic. Both sleep deprivation and sleep disturbance exist after bypass surgery; however, the delirium that may ensue is typical of neither. Much work is required to dissect the disordered neurophysiology of this situation. In the meantime, our data provide additional evidence that we should seek means of providing the opportunities for normal sleep in seriously ill patients.

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