CLINICAL RESEARCH

Sleep in the surgical intensive care unit: continuous polygraphic recording of sleep in nine patients receiving postoperative care

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Sleep . . . Balm of hurt minds
Great Nature's second course
Chief nourisher at life's feast.

(William Shakespeare, *Macbeth*, 1606)

Abstract

Sleep was studied in nine patients for two to four days after major non-cardiac surgery by continuous polygraphic recording of electroencephalogram, electro-oculogram, and electromyogram. Presumed optimal conditions for sleep were provided by a concerted effort by staff to offer constant pain relief and reduce environmental disturbance to a minimum.

All patients were severely deprived of sleep compared with normal. The mean cumulative sleep time (stage 1 excluded) for the first two nights, daytime sleep included, was less than two hours a night. Stages 3 and 4 and rapid eye movement sleep were severely or completely suppressed. The sustained wakefulness could be attributed to pain and environmental disturbance to only minor degree. Sleep time as estimated by nursing staff was often grossly misjudged and consistently overestimated when compared with the parallel polygraphic recording.

The grossly abnormal sleep pattern observed in these patients may suggest some fundamental disarrangement of the sleep-wake regulating mechanism.

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Introduction

Patients receiving intensive care often complain of not being left in peace long enough to get the amount of sleep that they feel they need. Frequent diagnostic, therapeutic, and nursing procedures, pain, and psychological factors may make sleep well nigh impossible.[1-5] In this busy environment light and sound levels tend to be high[6] and there may be a lack of awareness that patients have a problem sleeping. For instance, a patient who has not fallen asleep until 4 am may be wakened at 5 30 because the nurses are expected to wash him before handing over to the morning shift. Besides causing suffering to patients, the sleeplessness may be detrimental to recovery. Although much of the function of sleep remains obscure, there is evidence that deep sleep stages 3 and 4 are associated with anabolism and that rapid eye movement (REM) sleep is important for normal mental function.[7]

Studies of sleep by objective techniques—for example, polygraphic recording of electrophysiological impulses—have shown severe acute[8 9] and prolonged[9] sleep disturbance after open heart surgery. Severe sleep disturbance has also been reported after non-cardiac surgery,[9 10] but since the data were based on night recordings only, and there may have been a considerable amount of unrecorded daytime sleep, the degree of insomnia remains unknown. Studies of patients in coronary care after acute myocardial infarction show generally disturbed and disrupted sleep but suggest increased total sleep time.[11-13]

In view of the limited amount of published information we decided to study sleep during postoperative care after major non-cardiac surgery using continuous polygraphic recording. Since patients receiving intensive care may be left with little opportunity to sleep, and in order not to measure the effect on sleep of an imperfect environment, presumed optimal conditions were provided. To evaluate the accuracy of clinical observation in assessing sleep, records of apparent sleep were made by the nursing staff in parallel with the polygraphic recording.

Patients and methods

The nine subjects chosen for the study were selected from patients expected to need postoperative intensive care. Tables I and II give their details. Patients with a history or showing evidence of psychiatric illness, excessive use of neuropharmacological drugs, disease or damage to the central nervous system, or abnormal sleeping habits during the few days before the operation or previously were excluded. One patient (case 7) used opiate analgesics for abdominal pain. Another patient (case 2) was a night shift worker. The patients gave informed consent and were assured of receiving the best possible pain relief and being given maximum opportunity to sleep.

Environment—Every patient was constantly attended by trained staff in a one bed isolation room in the intensive care unit. Great effort was made to avoid or reduce disturbing factors such as noise, strong light, and nursing activities, especially at night. Activities at night entailing contact with the patient were planned to be concentrated at certain times—usually 11 pm and, if necessary, 3 am. When apparently asleep the patient was not wakened unnecessarily and nursing procedures were postponed. In addition to the usual medical staff, one of us (JA) was almost constantly present on the ward to ensure that the objective—namely, to reduce environmental disturbance and keep the patient pain free—was achieved.

Anaesthesia and postoperative analgesia (table II)—General anaesthesia was induced with thiopentone and suxamethonium and maintained with opiate analgesia, pancuronium relaxation, and controlled respiration with nitrous oxide and oxygen. In addition, six patients were given intraoperative epidural anaesthesia. Two patients received high dose morphine anaesthesia and postoperative ventilation. Epidural analgesia (local anaesthetics), epidural morphine, intravenous opiates, and on a few occasions coeliac ganglion and intercostal blocks were used for postoperative pain relief. The use of sedatives and hypnotics was limited but not restricted. Patients were not refused when they asked for any of these drugs.

Sleep recording—Using intradermal electrodes and an electroencephalographic mingograph (Elema Schönander) placed in an adjacent room, a three channel electrocardiogram, two channel electro-oculogram, and a submental electromyogram were recorded at a paper speed of 10 mm/s. The recordings were scored visually in 30 second epochs by an experienced interpreter according to Rechtschaffen and Kales.[14] The recording started within two hours of the operation and continued until the patient was discharged from the intensive care unit or for a maximum of 83 hours. In six patients sleep time was estimated by the nursing staff in parallel with the polygraphic recording. Sleep was considered to be present when the patient looked asleep, was breathing regularly, and was not responding to minor stimuli, if any. Every five minute period was scored as asleep—when the criteria were fulfilled for the entire period—or awake. Paired *t* test (two tailed) was used for statistical analysis of polygraphic recordings versus clinical observations.

TABLE I—*Description of patients, operations performed, and operative blood loss in each case*

Case No	Age and sex	Diagnosis	Operation	Blood loss (ml)
1	42 F	Rectal cancer	Abdominoperineal resection of rectum	1350
2	48 F	Gastric cancer	Subtotal gastric resection; thoracoabdominal approach	850
3	62 F	Angiodysplasia of colon	Left sided hemicolectomy	700
4	67 M	Retroperitoneal leiomyosarcoma	Transabdominal extirpation	2000
5	56 M	Traumatic fracture of both lower legs, hypovolaemic shock	Revision of wounds, transfixation	1700
6	52 F	Gastric cancer	Gastric resection (Billroth II), partial pancreatectomy, splenectomy	900
7	49 F	Subileus. Abdominoperineal resection of rectum 2 months earlier	Colectomy, ileostomy	8500
8	59 M	Blunt trauma, pelvic fracture, shock	Exploratory laparotomy, osteosynthesis of pelvis	7000
9	56 M	Villous adenoma of duodenum, penetrating stomach ulcer	Gastric resection (Billroth II), pancreatectomy, splenectomy, cholecystectomy, choledochojejunostomy	6500

Results

CLINICAL OUTCOME

Although all nine patients were admitted to the intensive care unit for postoperative care, three were returned to the surgical ward on the second postoperative morning, four on the third, and only two needed prolonged intensive care. One patient (case 9) who had extensive abdominal surgery under high dose morphine anaesthesia was extubated after 16 hours. The other patient (case 8) who had suffered blunt pelvic trauma was admitted in a state of traumatic shock. By the end of the operation his condition had stabilised but artificial ventilation was continued for three days. The remaining patients were extubated shortly after surgery. Delirium occurred in case 5 on the second day and persisted for a few hours. A history

TABLE II—*Details of anaesthesia and postoperative analgesia and sedation in each case*

Case No	Duration of anaesthesia	Anaesthesia	Postoperative analgesia and sedation: Day of operation	Day 1	Day 2
1	5 h 10 min	Epidural,* local; thiopentone 200 mg; fentanyl 0·9 mg	Epidural,* local	Epidural,* local; pethidine 75 mg	
2	5 h	Epidural,* local; thiopentone 300 mg; fentanyl 1·5 mg; droperidol 12·5 mg	Epidural,* local	Epidural,* local	Epidural,* local
3	3 h 35 min	Epidural,* local; thiopentone 100 mg; fentanyl 0·3 mg	Epidural,* local	Epidural,* local	Epidural,* local
4	3 h 15 min	Epidural,* local; thiopentone 100 mg; fentanyl 0·8 mg; droperidol 5 mg	Epidural,* local; epidural,* morphine 4 mg	Epidural,* local; epidural,* morphine 16 mg; intercostal block	Epidural,* morphine 18 mg
5	3 h 50 min	Thiopentone 200 mg; fentanyl 1·3 mg; droperidol 5 mg	Epidural,* local; pethidine 150 mg	Epidural,* local	Epidural,* local
6	5 h 45 min	Epidural,* local; thiopentone 250 mg	Epidural,* local; epidural,* morphine 4 mg; coeliac ganglion block; intercostal block	Epidural,* morphine 16 mg; diazepam 10 mg	Epidural,* morphine 16 mg
7	3 h 15 min	Epidural,* local; thiopentone 300 mg; fentanyl 0·5 mg	Epidural,* local; pethidine 150 mg; diazepam 15 mg	Epidural,* local; pethidine 75 mg; morphine 30 mg; diazepam 7·5 mg	Epidural,* local; morphine 40 mg; droperidol 5 mg
8	3 h 15 min	Morphine 75 mg; thiopentone 100 mg; droperidol 10 mg	Pethidine 50 mg	Morphine 14 mg	Morphine 8 mg; pentobarbitone
9	12 h 20 min	Morphine 210 mg; thiopentone 500 mg	Coeliac ganglion block	Intercostal block; pethidine 75 mg; pentobarbitone	Morphine 20 mg; pethidine 75 mg; promethazine 50 mg; diazepam 10 mg; intercostal block

*Epidural agents given through catheter.

of heavy drinking was reported but recent alcohol abuse was denied by the relatives. No other complication of note occurred in any patient during the study. Two patients exhibited anxiety (cases 4 and 7), but the rest appeared to be calm. Complaints from the patients were few and mostly related to occasional pain. Six patients virtually never had pain.

SLEEP RECORDING

A total of 536 hours, including 26 nights, were recorded. The total sleep time was greatly reduced in all patients compared with normal. From the start of recording until the next morning at 8 am (sleep period I) five patients did not sleep at all, and during the following 24 hours (sleep period II) two patients still got virtually no sleep. The mean cumulative sleep time during periods I and II was 3 hours 42 minutes (range 0-7 hours), giving an average of 1 hour 51 minutes a night. During the next 24 hours (sleep period III),

TABLE III—*Mean values of sleep time in various sleep stages (minutes per sleep period)*

	Sleep period				Values in healthy volunteers
	I	II	III	IV	(n = 46)
Stage 1	24*	69	119	66	37
Stage 2	82	123	197†	50	224
Stages 3-4	0	9	11†	0	84
Rapid eye movement sleep	1	7	19	8	94
Total sleep time (excluding stage 1)	83	139	228†	58	402

Sleep period I denotes period from start of recording until 8 am next morning (8-16 hours of recording). Sleep periods II, III, and IV denote following 24 hour periods from 8 am to 8 am including second, third, and fourth postoperative nights respectively.
*Excludes one patient (case 9) who had 373 minutes of ambiguous stage 1 activity.
†Excludes one patient (case 4) who showed rebound sleep phenomenon: stage 2, 585 minutes; stages 3 and 4, 113 minutes; total sleep time 711 minutes.

ending on the third postoperative morning, one patient (case 4) showed a rebound phenomenon by sleeping nearly 12 hours out of 16. When the recording was discontinued on the fourth postoperative morning (after sleep period IV) the two remaining patients (cases 8 and 9) had accumulated 7 hours 10 minutes and 1 hour 43 minutes of sleep, respectively, giving averages of 1 hour 48 minutes and 26 minutes of sleep a night. Table III gives the mean values of sleep time and figure 1 shows how sleep was composed in each case. Some 40% of total sleep time was recorded during the day (8 am to 12 pm).

The proportion of stage 1 sleep was greatly increased, amounting to 40% of all other sleep stages (table III). By comparison a value of 5% was obtained in a series of normal healthy volunteers who had their sleep recorded in a sleep laboratory and recordings scored by the same person as in this study.[15] Stage 1 is a transition stage between sleep and wakefulness and there is controversy whether it should be regarded as real sleep or not. In this study we have omitted stage 1 when calculating sleep time. One patient (case 9) who was given high dose morphine anaesthesia showed ambiguous electroencephalographic activity during his first postoperative night; this was scored as stage 1 (abnormal). The duration of this (6 hours 13 minutes) was excluded when calculating the proportion of stage 1. The bulk of sleep recorded was stage 2 (table III). Sleep stages 3 and 4 were greatly reduced (table III). With the exclusion of case 4 during sleep period III, stages 3 and 4 accounted for less than 5% of total sleep time (stage 1 excluded; reference value 21%[15]). REM sleep was

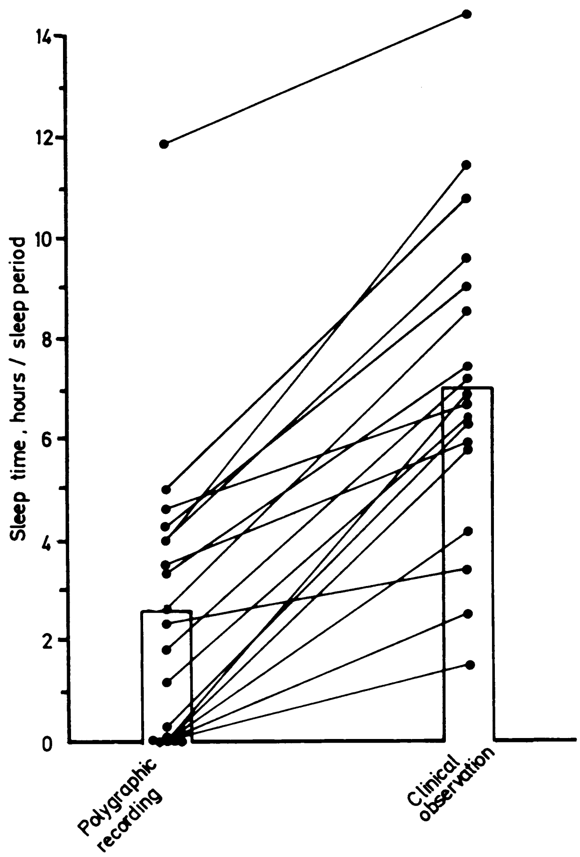

FIG 2—Comparison of sleep time per sleep period in six patients in whom sleep time was assessed by clinical observation in parallel with polygraphic recording (stage 1 excluded). ($p<0.001$.)

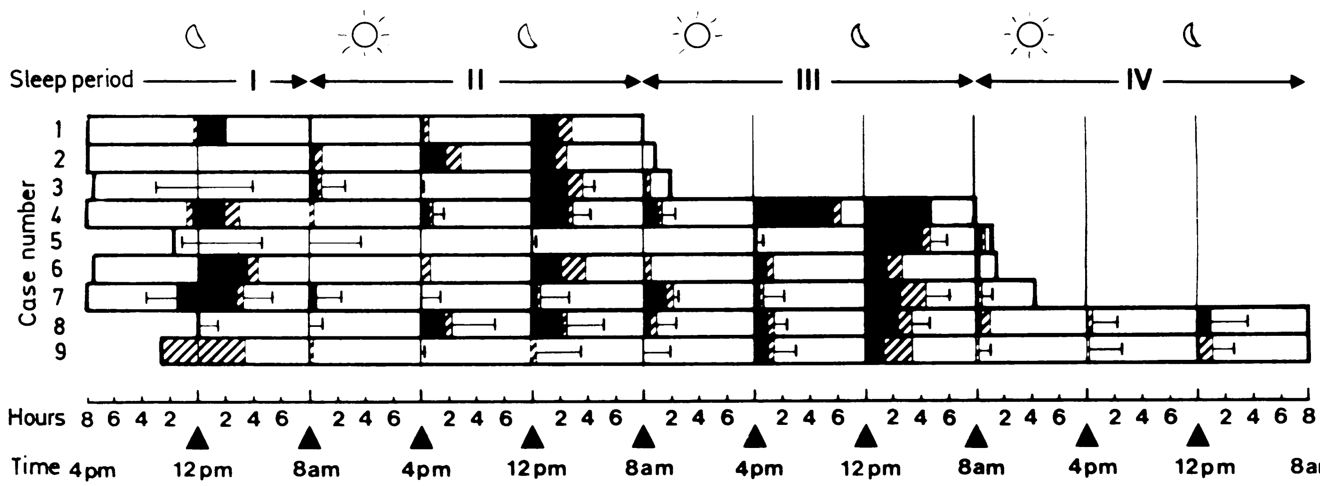

FIG 1—Accumulated sleep time during each eight hour period. Black areas represent sleep stages 2, 3, and 4, and rapid eye movement sleep combined. Hatched areas represent stage 1 sleep. Bars represent sleep time as estimated by nursing staff when in excess of total sleep time (cases 3, 4, 5, 7, 8, and 9 only).

greatly suppressed (table III), the proportion being 5% (reference value 20%[15]). It was often noted that even when sleep was uninterrupted long enough to allow a full sleep cycle (90 minutes) REM sleep did not appear.

On several occasions during the study patients asleep according to the polygraphic recording were seen to wake up without any obvious cause.

Sleep time as estimated by the nursing staff was often grossly misjudged and consistently overestimated when compared with the parallel polygraphic recording (fig 2). Even with stage 1 sleep included the correlation was very poor (fig 1). The mean value of sleep time as estimated by nursing staff was close to normal.

Discussion

This study was performed to gain information about sleep after major non-cardiac surgery when presumed optimal conditions for sleep were provided. While the number of patients may seem small and the study covered the first few postoperative days only, we emphasise that the results are based on continuous polygraphic recording with the subsequent visual interpretation of some 64 000 half minute epochs. The results were consistent: all patients were severely deprived of sleep when compared with normal. In the limited amount of sleep thus recorded, sleep stages 3 and 4 and REM sleep were severely or completely suppressed.

Our results are in good general agreement with those of other studies[8-10] and so are further evidence that severe sleep disturbance is common after major surgery. That sleep time as estimated by clinical observation was often grossly misjudged and consistently overestimated when compared with the parallel polygraphic recording suggests that sleep disturbance after major surgery is more common and more severe than is usually realised in clinical practice.

The objective to provide presumed optimal conditions for sleep by offering virtually constant pain relief and by reducing environmental disturbance to a minimum was achieved by a concerted and dedicated staff effort. Under these conditions an inability to sleep even when given a fair opportunity to do so became obvious, because the presence of arousing stimuli from pain, light, noise, and nursing activities could account for only a small fraction of the sustained wakefulness.

Interviews with the patients disclosed only moderate sleep disturbance before operation. Data on "hospital sleep"[16] and preoperative sleep[9] also record only moderate sleep disturbance. It is therefore most unlikely that the severe sleep disturbance detected in our patients was of preoperative origin. In duration and severity the inability to sleep seemed to be roughly related to the clinical course.

We do not believe that general discomfort, inability to lie comfortably,[4] the strange bed or environment, or anxiety played a determinant part. Complaints from the patients were few, and any that were made were dealt with immediately. Preoperatively all patients (except the two admitted for trauma) adapted to the hospital environment and slept reasonably well, according to the interviews. The two anxious patients did not sleep less than the rest of the patients.

Of the drugs and doses used, to our knowledge only morphine has been shown to have such profound effects on sleep as possibly to explain the severe sleep disturbance recorded in our patients.[17] The ambiguous stage 1 activity recorded in case 9 during the first postoperative night may well have been induced by the high dose morphine anaesthesia. In most of the patients the use of opiate analgesics, sedatives, and hypnotics was low or moderate and is not likely to have caused the sleep disturbance. Possibly higher doses of hypnotics might have counteracted the inability to sleep.

That all our patients had severe or complete suppression of stages 3 and 4 and REM sleep and lacked the normal inherent rhythmicity of sleep is consistent with previous reports.[8-10] The gross abnormality of the sleep pattern suggests that the inability to sleep may be the result of some fundamental disorder of the sleep-wake regulating mechanism. This hypothesis is supported by the observation that even when sleep was uninterrupted long enough to allow a full sleep cycle REM sleep often did not appear. A direct effect on the brain by the general anaesthetic or the systemic reaction to the surgical or accidental trauma may be the crucial factor for the sleep disturbance.

In conclusion, our findings are further evidence that severe sleep disturbance is common after major surgery and probably more so than is realised even by close clinical observation. In bringing about the severe sleep disturbance recorded in this study, pain and environmental factors such as light, noise, and nursing activities were secondary to an endogenous inability to sleep. The cause of this remains unknown, but the grossly abnormal and characteristic pattern of sleep disturbance may suggest that the inability to sleep is the result of some fundamental disarrangement of the sleep-wake regulating system. For the patient with an inability to sleep, consideration of pain relief and peace and quiet is nevertheless of greatest importance, since he is the victim of an environment from which he cannot escape—by falling asleep.

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