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AWARENESS DURING SURGERY

A Study of its Incidence

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THERE have been sporadic reports of patients who, although apparently anaesthetized adequately, felt pain or described conversations and incidents which undoubtedly occurred during operation (Winterbottom, 1950; Mushin, 1951; Graff and Phillips, 1959; Alment, 1959). Attention has been drawn to the risk that the patient might be awake during operation, when anaesthetic techniques involving large doses of relaxants are used (Mushin, 1951; Editorial, 1959; Parkhouse, 1960). However, no attempt seems to have been made to assess the incidence of this phenomenon in an environment of expert modern anaesthesia and the purpose of this paper is to describe such a study.

METHOD

During two periods, each of about five weeks, post-operative visits were made to all patients who had received general anaesthesia in any one of four operating theatres, three of which were used for general and emergency surgery, and one for gynaecological surgery and neurosurgery. Twenty anaesthetists, ranging in status from consultant to senior house officer, gave the anaesthetics. Children under 16 years were excluded because of the uncertainty of accurate communication; excluded also were patients undergoing intracranial surgery because of the frequency of unconsciousness and semiconsciousness in the pre- and postoperative periods.

The postanaesthetic enquiry was made to seem part of the usual routine visit. Questions about the last pre-operative and first postoperative recollection led up to the main question: "Did you dream during your operation?" Great care was taken that neither patients nor nursing staff realized the purport of the investigation. For this and other obvious reasons, no patient was asked directly whether he remembered his operation, although one or two patients at once described some recollection as a reality rather than a dream. The small number of patients who had "dreamt" were all listened to with equal interest but only those "dreams" which seemed to have any possible relationship with surgical or anaesthetic procedures were recorded in detail. In these cases careful histories and details of anaesthesia, including time and dosage of premedication, and any observation made by the anaesthetist concerned were noted. The collection of these data was simplified by the routine use of anaesthetic records in this unit. The patient's dream was then compared with the events in the operating theatre to see if there was any possible connection between the two.

RESULTS

The total number of patients involved was 700, of whom 656 form the series to be described. Satisfactory answers to the enquiry were not obtained from the other 44 patients for the reasons set out in table I.

TABLE I

Minor cases (mainly cystoscopies) who were discharged from hospital on the day of operation or before the author's visit next day	30
Patients who were too ill to question, senile or imbecile	11
Patients speaking only Eastern European languages	3
Total	44

The details of the 656 remaining are listed in table II. Only 9 patients had dreams which appeared to have any possible connection with events in the theatre, and only 8 of these fall within the scope of the study as the story of the ninth patient was rejected. The details of these cases are reported below.

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TABLE II

Results of postoperative interview.

Patients who neither dreamed nor remembered part of their operation	628
Patients who had dreams unrelated to their operation	19
Patients who had a dream or experience apparently related to operation	8
Patients who had a dream related to operation, but whose story was rejected	1
Total	656

CASE REPORTS

CASE 1. An obese 36-year-old woman.

Operation. Repair of supra-umbilical hernia.

Anaesthesia. Papaveretum 20 mg, hyoscine 0.4 mg given 1 hour pre-operatively. Thiopentone 500 mg, gallamine 180 mg, pethidine 15 mg. Nitrous oxide 3 l./min, oxygen 1.5 l./min. Intermittent positive pressure respiration. Duration 1 hour. Patient began to breathe spontaneously during operation, pethidine and gallamine needed to regain control.

Patient's dream. She was struggling to remember the anaesthetist's name, she wanted to argue but could not "because there was something in my mouth, stopping me talking". "Someone was pushing something around in my stomach."

Discomfort: yes. Hearing: none. Vision: none.

Comment. The patient had an oral airway inserted for a minute or two after extubation but it was removed before she left the theatre. As she did not remember anything being put into or removed from her mouth, and as she was apparently prevented from talking by the object, it seems likely that it was the endotracheal tube. This patient was not upset by her experience.

Possible cause of anaesthetic resistance: (a) obesity; (b) occasional alcohol.

CASE 2. A 55-year-old woman with mild bronchitis.

Operation. Hemicolectomy for carcinoma of the caecum.

Anaesthesia. Promethazine 25 mg, pethidine 50 mg, atropine 0.6 mg given 1 hour pre-operatively.

Thiopentone 250 mg, gallamine 120+40 mg, nitrous oxide and oxygen. Intermittent positive pressure respiration. Duration 1½ hours. There was considerable bleeding during surgery, and intravenous plasma was started after some difficulty. The anaesthetic was purposely lightened at what was apparently the end of the operation but had to be deepened when the surgeon decided to turn the patient in order to insert a perineal drain.

Patient's story. The patient complained immediately she was back in the ward that she had felt during her operation abdominal pain "like red-hot needles". She had heard voices around her, including that of the surgeon who performed the operation. She also heard the loud noise of a machine and felt she was sliding up and down the table attached to it. She was unable to move or attract attention.

Discomfort: yes (pain). Hearing: yes. Vision: none.

Comment. The patient's story is a convincing one of mechanical artificial ventilation, about which she had no knowledge. The anaesthetist concerned felt that the experience described must have occurred at the end of the main procedure when the anaesthetic was known to be "light". As she did not remember being turned over, nor complain of the perineal incision, it seems more likely that the experience occurred earlier, possibly during skin suturing. The patient was angry and distressed.

No cause of resistance to anaesthetic drugs was apparent.

CASE 3. A wasted little old lady of 70 years.

Operation. Laparotomy and biopsy of carcinoma of head of the pancreas.

Anaesthesia. Morphine 10 mg, atropine 0.6 mg given 30 minutes before operation.

Thiopentone 150 mg, gallamine 80 mg with two increments of 20 mg, nitrous oxide 2.75 l./min and oxygen 1.25 l./min. Intermittent positive pressure respiration. Duration 1½ hours. There was no movement or loss of control of respiration during surgery. Additional gallamine was given for relaxation only.

Patient's story. She awoke in the theatre, with pain deep in the abdomen. The pain was associated with an irregular rapid clicking noise "like someone in a hurry". She thought at first that the clicking was due to cameras, but then decided she was being given "X-ray treatment". She also heard people talking about football.

Discomfort: yes (pain). Hearing: yes. Vision: none.

Comment. It was established that one particularly fast-working surgeon sewed up the posterior peritoneum and the deep layers of the anterior abdominal wall using a needle-holder with a ratchet. Another surgeon completed the closure using a different needle-holder. A forthcoming Cardiff-Springbok rugby match was discussed during the case.

This frail old lady became very distressed when an attempt was made to discover further details of her experience, and it was felt to be unjustifiable and unnecessary to continue to question her. In fact, when an attempt was made to re-open the subject a week later she denied any unpleasant experience: she had just had a bad dream.

This patient had had limited amounts of analgesic drugs before operation. Panadol (paracetamol) had been given for two weeks and in addition two doses of dihydrocodeine. There was no other obvious cause of anaesthetic resistance.

CASE 4. A rather obese 63-year-old woman who had been intermittently jaundiced.

Operation. Cholecystectomy for cholelithiasis.

Anaesthesia. Morphine 10 mg, atropine 0.6 mg given 1½ hours pre-operatively.

Thiopentone 300 mg, gallamine 100 mg with two increments of 40 mg. Nitrous oxide 4 l./min and oxygen 2 l./min. Intermittent positive pressure respiration. Duration: 1½ hours. During operation a considerable degree of hypertension was recorded 200/120 mm Hg), although the normal blood pressure was only 150/80 mm Hg.

Patient's story. She felt discomfort in the area of operation but could not move or attract attention. She knew there were people about her talking but could not remember the actual conversation.

Discomfort: yes. Hearing: yes. Vision: none.

Comment. There was no part of the patient's story

which could be checked. She was not at all upset by her experience. There was no obvious cause of anaesthetic resistance.

CASE 5. A rather excitable 48-year-old woman, with a blood pressure of 180/120 mm Hg.

Operation. Sigmoidoscopy, and cholecystectomy for cholecystitis.

Anaesthesia. Papaveretum 20 mg, hyoscine 0.4 mg given 1½ hours pre-operatively.

Thiopentone 300 mg, gallamine 200 mg. Nitrous oxide 3 l./min and oxygen 1½ l./min with 0.5 per cent halothane (Fluotec) V.O.C.* Intermittent positive pressure respiration. Duration: 1½ hours. The halothane was discontinued and washed out before the end of the operation. The patient moved a leg during closure of the abdomen and was told to lie still. Anaesthesia was deepened.

Patient's story. She was conscious of a "gnawing" sensation under the right ribs. She wanted to move, but felt compelled to be still. After a time she felt able to move a little "because the pain was getting rather much" and moved her left foot. She heard a "voice from above" telling her to lie still.

Discomfort: yes (pain). Hearing: yes. Vision: none.

Comment. This patient seemed excited by her experience. She later spontaneously wrote as follows: "Increasingly I believe that there is a level during anaesthesia where one feels and knows everything that is going on but there is no distress. . . . The memory I have is one of exultation and complete confidence. This has occurred each time I have had an anaesthetic."

No cause was found for any resistance to anaesthetic agents.

CASE 6. A healthy 38-year-old female.

Operation. Hysterectomy for fibromyomata.

Anaesthesia. Morphine 10 mg, hyoscine 0.4 mg.

Thiopentone 350 mg, gallamine 140 mg, Pethilorfan 100 mg, nitrous oxide and oxygen. Intermittent positive pressure respiration. Duration 1½ hours. During the early part of the case the ventilator appeared to be leaking. Even with high flow rates it would only give a positive pressure of 10 cm H_2O and manual intermittent positive pressure respiration was started because it was felt that the patient was being hypoventilated.

Patient's dream. The patient dreamt that the pages of a heavy book were being slowly turned over at regular intervals. There was a continuous noise which reached a crescendo during the effort of getting the page upright. The page then flopped over. She felt that she must struggle to wake up but could not.

Discomfort: none. Hearing: yes. Vision: none.

Comment. The possible relationship between this dream and a mechanical ventilator is mere conjecture. But, as the story was told, the time intervals and description of the background noise were very suggestive. The dream was not at all unpleasant to the patient.

No known cause of anaesthetic resistance was discovered.

CASE 7. A healthy 52-year-old woman.

Operation. Radical mastectomy for carcinoma of breast.

Anaesthesia. Morphine 10 mg, atropine 0.6 mg given 1 hour pre-operatively.

Thiopentone (dose not recorded), relaxant, nitrous oxide, oxygen and halothane. Intubation was "uneventful".

Patient's story. The worst part of the operation was the extremely unpleasant choking sensation when the "tube was put down my throat" after the injection. This happened before she became unconscious, she thought.

Comment. This patient had no knowledge of anaesthetic procedures.

CASE 8. A healthy 55-year-old woman.

Operation. Shea's operation for deafness.

Anaesthesia. Morphine 10 mg, atropine 0.6 mg.

Thiopentone (dose not recorded), suxamethonium 50 mg, nitrous oxide and oxygen with halothane.

Patient's dream. Elijah came and breathed into her mouth.

Comment. Possibly pre-intubation oxygenation.

REJECTED CASE.

The patient whose story was rejected was a girl of 26, who had had a partial thyroidectomy for a mildly toxic goitre. She claimed to have dreamt of her whole operation, describing the procedure in detail and at length, but often in the form of a question and always watchful to see the effect of her remarks upon the observer. There was no mention of pain, tracheal intubation, or of the noise of conversation or of surgical instruments. There were so many inconsistencies with what actually took place that this case was not felt to fall within the scope of the present study.

DISCUSSION

The purpose of this study was to discover whether any of a series of apparently adequately anaesthetized patients had experienced recovery of awareness during surgery. That this condition does occur has been demonstrated. As an assessment of its incidence, however, the study is obviously open to some criticisms, four of which will be considered.

There is very little proof that the experiences described by the patients really occurred during operation. Only case 3, who reported conversation and a noise similar to that of a needle-holder actually used, and case 5, who moved and overheard a remark subsequently made, tell of experiences which can be corroborated.

The cases are to a small extent selected. Some overnight-stay cases and some very ill patients were not questioned. Also, only certain types of surgical procedures were carried out in the few theatres concerned. Neither operative obstetrics nor chest surgery are included.

*V.O.C.=vaporizer out of circuit (Mushin and Galloon, 1960).

Although about twenty anaesthetists were concerned there were not wide differences in anaesthetic techniques. In fact in the majority of patients anaesthesia was induced with thiopentone and maintained either with nitrous oxide, oxygen and halothane if respiration was spontaneous, or with nitrous oxide and oxygen, muscle relaxant and intermittent positive pressure techniques when respiration was controlled.

The experiences described are not all clear cut, and might be described as a graded series. It could be argued that cases 6 and 8 at one end of the scale had no real "awareness", whereas case 3 gave an account that could hardly be doubted. Also, perhaps, cases 7 and 8 should be excluded because the events described probably occurred before consciousness was ever lost.

Incidence.

Although realizing the inadequacies of the study in calculating the incidence statistically, it was felt worth while to do so. As it seems self-evident that this condition is likely to be associated with the use of muscle relaxant drugs, the anaesthetic records of the whole series were collected and grouped according to the usage of these drugs (table III).

STATISTICAL ANALYSIS

(Dr. E. Lewis Faning)

Problem 1. What confidence can be placed in the percentages shown in table III?

For all groups combined, out of a sample of 656 patients, 8 had the characteristic of awareness during operation. This is 1.22 per cent, from which it can be calculated that one can say with 95 per cent degree of confidence (95 per cent confidence interval) that for a general population of anaesthetized patients, from which this sample is presumably drawn, the percentage would be between 0.4 and 2 per cent.

For group 2—2 cases out of a sample of 201 (1.0 per cent)—the confidence interval is from 0 to 2.3 per cent.

For group 4—6 cases out of a sample of 216 (2.78 per cent)—the confidence interval is from 0.6 to 5 per cent. In other words, 2.78 per cent of this group were aware, but because of sampling variation, we would be unwise to quote this as more accurate than somewhere between 0.6 and 5 per cent. But this range of accuracy has a 95 to 5 chance (95 per cent) of being correct. (Similar for the two previous paragraphs.)

Problem 2. Are the differences between the proportions who were aware in the four groups significant, i.e. are these differences greater than would be expected to arise just by chance?

Clearly since no cases arose either in group 1 or group 3, no test of significance can be applied. So I have combined these groups and get:

Group		Percentage "aware"
1 and 3	No relaxant, or small doses over a long period	0
2	Relaxants for short time (early in operation)	1.0
4	Relaxants in large doses	2.78
	All groups	1.22

Statistical tests suggest that the differences between the three sub-divisions is significant, but due to smallness of numbers, some technical difficulties prevent one from being dogmatic.

But if we compare group 4 against the rest (i.e. 2.78 per cent against 0.46 per cent) this difference is unlikely to be due merely to chance ($\chi^2=4.7$; $n'=1$; $0.05>P>0.02$).

TABLE III

Occurrence of awareness during surgery according to the usage of muscle relaxants.

	Total	Patients subsequently found to have been "aware"	
		No.	Per cent
Patients given no muscle relaxants	181	Nil	Nil
Patients given short-acting relaxant for intubation only (rarely repeated)	201	2 (Cases 7 and 8)	1.0
Patients given small doses of long-acting relaxants. Respiration spontaneous	58	Nil	Nil
Patients given large doses of long-acting relaxants. Respiration controlled	216	6	2.78
Totals	656	8	1.22
*Excluding cases 7 and 8	656	6	0.91

*These cases were possibly describing events occurring before loss of consciousness.

If we compare group 2 with group 4 (1.0 per cent with 2.78 per cent) the difference is not significant. Nor is the difference between group 2 and groups 1 and 3 combined (1 per cent and 0 per cent).

But group 4 is significantly different from groups 1 and 3 combined ($\chi^2=4.76$; $P<0.05$).

To sum up, it seems that group 4 with large doses of relaxants gives somewhere between 0.6 and 5 per cent who were aware. This sample percentage (2.78 per cent) is significantly higher than that given either by groups 1 and 3 together, or groups 1, 2 and 3 together.

AETIOLOGY

The possible causes for this condition will be considered, with reference to the cases described where this is possible.

Reduction in percentage of nitrous oxide in the inspired mixture.

The percentage of nitrous oxide which is considered optimal in the inspired gas mixture varies with the anaesthetist but is usually between 60 and 80 per cent. Where known in the cases described it was about 70 to 75 per cent. Experience with outpatient nitrous oxide anaesthesia, confirmed by Bourne's experiments (Bourne, 1960), suggests that even 80 per cent nitrous oxide in oxygen is inadequate alone to produce loss of awareness in all individuals. But using the technique under discussion, even if there is no premedication or other pharmacological supplementation, the use of muscle relaxants and hyperventilation is an integral part of the technique. The percentage of nitrous oxide necessary in these circumstances is virtually unknown. Unfortunately Rosen's interesting study (Rosen, 1959) of 58 patients' recollections of auditory stimuli was carried out on postoperative cases, an unknown number of whom were still being artificially ventilated. One patient, however, is described who recollected noises played to her from a tape recorder during the operation of cholecystectomy, while nitrous oxide 71 to 73 per cent was being given.

However, while realizing that the generally accepted nitrous oxide percentage in the inspired gas mixture may not always be adequate, there are occasions when this percentage is purposely or inadvertently reduced. For example, many anaesthetists give a rather higher percentage of oxygen to cardiac and very ill patients. The obvious and commonest cause of inadvertent reduction in nitrous oxide percentage is a nitrous oxide cylinder which runs out unnoticed. Although there is no evidence of this having happened in any of the cases described here, it is a sufficiently common occurrence that an anaesthetist is likely to forget during which of the cases on an operating list the nitrous oxide cylinders were changed, and whether or not the bobbin on the flowmeter was noticed to be falling before it reached zero. It is pertinent to add here that in the four theatres used during this study there was not a piped nitrous oxide supply, cylinders being used. Also, mechanical ventilation was commonly employed, so that the feel of a reservoir bag which was failing to fill as rapidly as before would not be appreciated.

Another possible cause of inadvertent reduction of nitrous oxide percentage is the dilution of the inspired mixture with air or oxygen. For example, with some mechanical ventilators air may be drawn in if the fresh gas flowrate is insufficient, or through leaks in the system, especially if there is a negative pressure phase (Cole, 1955). Oxygen bypass taps can be left on unwittingly. Waters has measured a leak of 1.5 l./min on a Boyle's apparatus with a faulty oxygen bypass tap (Waters, 1960, personal communication).

Resistance to nitrous oxide anaesthesia.

Bourne (1960), in a study of the potency of nitrous oxide used as a sole anaesthetic, asked his patients about their consumption of alcohol and other central nervous system depressants. He concluded that the influence of acquired tolerance to central nervous system depressants was of paramount importance. "Acquired tolerance appeared to be not simply the main but the only factor influencing a patient's response to nitrous oxide after the induction period." In this study, therefore, the eight patients were asked about their alcohol intake and drug habits. None admitted more than an occasional drink except case 1, who had a "bitter or cider when playing skittles", apparently a few nights a week. However, patient 3 had been taking the mild analgesic paracetamol for 2 to 4 weeks and also dihydrocodeine for 2 days.

Inadequate supplementation of nitrous oxide anaesthesia.

It is difficult to discuss this factor as it has not

been established that any supplementation is needed for techniques using nitrous oxide and oxygen and controlled respiration. For example, many anaesthetists use no hypnotic or narcotic drugs in premedication or thiopentone for induction of anaesthesia in their cardiac cases. All the patients in this study had both narcotic premedication and induction of anaesthesia with thiopentone. Cases 1 and 6 received intravenous pethidine during surgery and case 5 received halothane 0.5 per cent although the incident recollected by the patient occurred after the halothane had been washed out. Unfortunately, the indications for supplementation of nitrous oxide are not defined but it may be—as pointed out by Siker (1956)—that there is a great need for a means by which gas can be potentiated safely.

Hypoventilation.

Gray and his colleagues pointed out the importance of hyperventilation in techniques employing nitrous oxide and oxygen, intermittent positive pressure respiration and muscle relaxants (Gray and Rees, 1952; Geddes and Gray, 1959). The hypnotic effect of low Pco_2 levels has been established (Clutton-Brock, 1957). Failure to hyperventilate seems a likely explanation in case 6, where trouble occurred with the ventilator. Cases 2 and 5 both remembered events occurring towards the end of the operation at a time when the effects of relaxants are often wearing off, and when the Pco_2 level is being allowed to return to normal prior to the re-establishment of spontaneous respiration.

Inadvertent hypoventilation can occur quite easily. Particularly when a respirator is used, there may be a considerable discrepancy between the volume recorded by the machine and that actually reaching the patient's lungs—a fact not always appreciated.

The anti-analgesic action of thiopentone.

All the patients in this series received this drug, It cannot be excluded that, particularly in the early operative period, the pain-relieving effect of analgesic drugs was reduced by the simultaneous action of small amounts of thiopentone in the blood (Clutton-Brock, 1960; Dundee, 1960), although the hypnotic effect of the latter was no longer effective.

CONCLUSION

There seems little doubt that it is possible for patients to be in a state of awareness during operations performed under techniques employing nitrous oxide and oxygen with muscle relaxants. Fortunately it appears that the incidence is low. In this series of 656 patients, only 6 of 216 anaesthetized using this technique reported any experience which could possibly be related to anaesthesia. Of these, only one or two remembered events which clearly did occur. Thus the statement that 0.6 to 5 per cent of patients anaesthetized in this way are likely to be "aware" is more likely to be an exaggeration than an understatement because all these 6 cases were included in the statistical evaluation. Also although in this series about 1 per cent of all anaesthetized patients were found to be "aware" this figure is not of much importance because it has been shown to depend principally on the proportion of cases anaesthetized by one particular technique, which obviously varies in different practices.

The difficulty of recognizing this occurrence has not been mentioned. All that can be said from this small series is that the patients were all women and that more often than not the events recalled took place at the end of operation. Hearing seems to be the first sense to return and vision the last. There may be no obvious physical signs. Prophylaxis must depend on the use of adequate nitrous oxide concentrations, possibly with supplementation and hyperventilation.

Is the possibility of awareness during surgery important? In this series of 656 patients only one (case 2) complained immediately after return to the ward, but there seems no doubt of the pain experienced by case 3. The other patients, particularly case 5, did not seem distressed. Parkhouse (1960) commented on the dispassionate manner in which the experience of awareness during surgery is often recalled, and felt that this is not due to repression of a terrifying experience into the subconscious, as this would be expected to produce a high incidence of anxiety states and fear of subsequent operations which is not apparent in clinical practice. There is evidence from this study that this is not always the case. It is possible that case 3 changed her story because the experience had been repressed. Also there were two patients in this series who claimed to have felt

part of a previous surgical procedure. They made their justifiable anxiety quite obvious. It is unfortunate that this anxiety is very easily communicated to other patients in the ward, possibly more so than to the medical staff.

It can be concluded, therefore, that every possible effort must be made to ensure complete and continuous unconsciousness during general anaesthesia, not only because of the moral obligation of the anaesthetist to provide freedom from physical and mental suffering which might otherwise occur in a very small percentage of cases, but also because of the disproportionate anxiety which knowledge of such a case may induce in other patients.

SUMMARY

A follow-up study of 656 general surgical, gynaecological and neurosurgical patients is reported in which enquiry was made into the patient's recollection of the operative period and dreams during anaesthesia. Eight patients either remembered some part of the procedure or had a dream suggestive of a partial return to consciousness. Case histories are tabulated. Excluding two cases, because they might have been describing events occurring prior to the onset of unconsciousness, all the remaining six were in the group of patients whose anaesthesia was maintained with nitrous oxide and oxygen, relaxants, and intermittent positive pressure respiration.

The aetiology of the condition is considered with reference to these cases. It is felt that inadequate nitrous oxide percentage and lack of hyperventilation are the most likely causes. A brief assessment of the importance of this condition is made.

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