

AWARENESS, MUSCLE RELAXANTS AND BALANCED ANAESTHESIA

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THE PROBLEM OF SURGICAL PAIN which existed before the introduction of anaesthesia may be revisited in contemporary practice when patients experience awareness during periods of inadequate depth of anaesthesia. This spectre of fully sentient patients contradicts the humane aspirations of our specialty and the purpose of this paper is to assist in the understanding and prevention of this problem.

Reviews dealing with the complication of awareness have been published¹⁻¹⁰ and attention has also been directed towards this problem by four decades of editorials.¹¹⁻²⁵ Unintentional awareness is usually related to the injudicious use of muscle relaxants, the use of anaesthetic agents which either alone or in combination are not entirely amnesic or analgesic and the use of the lightest possible levels of anaesthesia.

HISTORICAL ASPECTS

Awareness and pain due to insufficient anaesthesia were recognized as early as 1847.²⁶ Experimental work by Claude Bernard^{27,28} encompassed both the muscle relaxants and balanced anaesthesia. He identified the neuromuscular junction as the site of action of curare and he also introduced the practice of using more than one anaesthetic agent at a time. He called this technique "mixed anaesthesia" and reported that morphine decreases both the amount of chloroform need for anaesthesia and its duration.

Curare continued to be used in animal experiments and, since most scientists felt that it did not affect consciousness, its use caused considerable antivivisectionist fervour during the last half of the nineteenth century. Such sentiments were reflected in an 1880 Tennyson poem condemning the "hellish orali".²⁸

It was not until 1896, however, that William Welch²⁹ in his "50th Ether Day" anniversary

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lecture suggested that curare might be safely used with anaesthetics in man. In 1912, Arthur Lawen used curare³⁰ as an aid to anaesthesia, but it was not until 1942 that Griffith and Johnson's cautious demonstration of the benefit of curare³¹ paved the way for its wide acceptance in medicine.

Reports of the use of curare as the sole agent in anaesthesia followed,³²⁻³⁵ with only some of the patients complaining postoperatively of awareness with pain.³⁵ Thus the debate concerning the effect of curare on consciousness in man was briefly renewed until two fearless investigators, Prescott³⁶ and Smith³⁷ by experimenting upon themselves, showed that it had no such effect in clinical doses. They amplified the warning of a 1945 *Lancet* editorial¹² that, when using curare, "we must ensure unconsciousness".

Although a patient of Crile's³⁸ in 1908 experienced awareness during nitrous oxide anaesthesia, it was Winterbottom's 1950 case report³⁹ that widely publicized the possibility of awareness and pain during operations. In 1951, Mushin⁴⁰ reported another case, and he was "inclined to believe that this occurrence may be more common than we think".

In 1956 Fairley⁴¹ reported a 30 per cent incidence of recall during anaesthesia for endoscopy and in 1957 Frumin⁴² reported that of 171 patients, nine experienced awareness, three had pain, many had dreams and that on five occasions succinylcholine apnoea had outlasted the operation. Since then frequent case reports have appeared in the correspondence sections of medical journals relating episodes experienced personally.

BALANCED ANAESTHESIA

The balanced anaesthesia technique with paralysis has almost eliminated the ability to appreciate anaesthetic depth⁴³⁻⁴⁶ and even a gross change, such as awakening or over-dosage, can remain undetected, as the guidelines for drug administration may largely be derived from pre-set criteria unrelated to the particular patient being treated.

Awareness can occur when a patient drifts into the light planes of amnesia-analgesia, which

characterize stage I depth. Paradoxically, the surgeon's responses about the degree of "relaxation" may often be used to help judge the depth of "anaesthesia".

At times the agents in balanced anaesthesia counteract each other's undesired effects, as noted in the ability of curare to depress the circulatory stimulant properties of ketamine.⁴⁷ Conversely, the components may also work at cross-purposes, as the anti-analgesic activity of thiopentone and analgesic properties of the opiates and nitrous oxide.⁴⁸ The routine use of reversal agents (physostigmine, narcotic antagonists, anticholinesterases, and analeptics) in balanced techniques introduces special additional drug problems into the operative and recovery care of these patients.

Individual chronic tolerance to barbiturates, narcotics and ketamine is well known and Sia⁴⁹ felt that previous exposure to anaesthetics induces a tolerance which was responsible for a higher incidence of awareness in re-anaesthetized patients. Cross tolerance between chronic alcohol exposure and anaesthetics has also been demonstrated⁵⁰ necessitating a need for more anaesthetic in such patients. Though increased drug tolerance may weaken the expected potency of an anaesthetic, no similar evidence of habituation or tolerance to pain exists⁵¹ to counterbalance such diminished drug effectiveness and help prevent awareness in these cases.

STUDIES OF AWARENESS

Frumin⁴² reported five per cent incidence of awareness, and Hutchison³ established the incidence at one per cent in her series. A recent editorial stated that the range varied between none to 25 per cent.²³

Bergstrom and Bernstein's⁵² experience in caesarean section patients was even more varied with a 100 per cent incidence of nightmares during anaesthesia in six patients with their "method A", and no reactions in 11 patients with "method B". Crawford in his caesarean section series⁵³ reported an incidence of awareness of three per cent. Both Ng⁵⁴ and Crawford⁵³ reported that some caesarean patients have had more than one episode of awareness during anaesthesia.

In general surgery, Wilson⁵⁵ found a one per cent incidence of awareness and reported no correlation to either the type of operation, duration of anaesthesia or patient age. In a larger series of 4,000 patients, Lett⁵⁶ also reported a one per cent overall incidence with a higher frequency in

patients undergoing endoscopy, caesarean section and biliary surgery. Fairley,⁴¹ Barr⁵⁷ and McKenna⁵⁸ similarly reported a higher incidence of awareness during endoscopy and tracheal intubation.

Mendelsohn⁵⁹ had "several" cardiac surgery patients in a series of 58 patient report awareness, but a lack of fear or discomfort. Lowenstein²⁴ found that despite total analgesia, consciousness during anaesthesia was a problem and Maunuk-sela⁶⁰ in his cardiac patients noted awareness was more common in those who were younger, in better physical condition, and who had received balanced or neurolept anaesthesia rather than halothane.

In a prospective study of awareness Authier⁶¹ showed that amnesia during surgery was greater in subjects uninformed of the study than in those informed beforehand. Many prospective studies have found that awareness did not occur.^{7,62-66} This may be due to more meticulous attention to the depth of anaesthesia during the study.

Cobb¹¹, Frumin⁴² and Smith³⁴ all expressed concern about untoward psychological consequences of awareness during paralysis, but were unable to provide definitive follow-up data. Meyer and Blacher⁶⁸ and Blacher⁶⁹ in studies of eleven patients, described a traumatic neurosis (catastrophe reaction) in response to awakening while paralyzed during surgery although they did not necessarily feel pain. They felt that relief of symptoms could be obtained in these patients by sympathetically explaining exactly what had happened during the operation, and they recommended this as therapy for such patients, taking care to discuss any mitigating factors, such as an arrhythmia or shock. In a follow-up correspondence to Blacher's⁶⁹ report, Larson⁷⁰ disputed some of his broad and theoretical interpretations. The many reports of personal awareness experienced by physicians,^{19,36,37} suggest that professional knowledge does not mitigate the discomfort of awareness while paralyzed.

Studies using hypnosis have suggested that recall is not only possible but likely under even deep general anaesthesia^{71,72}. Other reports deny this,^{62-66,73} and the problem of auditory perception during general anaesthesia has been reviewed,⁷⁴ with the recommendation for better designed and controlled studies.

Although the illegal use of anaesthetics, and especially relaxants, in awake victims⁷⁵, has been well publicized in the popular media, the legal status of awareness during surgery is uncertain. It would seem to be one of the risks of the safe

practice of medicine and, as one editor²⁰ concludes, "assessing the state of consciousness of the paralyzed patient is something on which even the most experienced may occasionally be deceived".

CLASSIFICATION OF PERIODS OF AWARENESS DURING PARALYSIS

I. Preoperative period

The use of non-depolarizing relaxants to diminish undesirable effects of succinylcholine is widely practiced and reported to be "harmless and comfortable"⁷⁶. Similar low dosage has been advocated as an aid to operations under local anaesthesia,⁷⁷ but this is condemned by others⁷⁸ as unsafe and uncomfortable.

II. Intubation period

Awake intubation for emergency operations is an accepted technique,⁷⁹ but awareness during intubation in elective operations is also often reported, especially when difficulty is encountered, so that the relaxant outlasts the induction agent.⁵⁸ Beyond the problem of recall, light anaesthesia at this time can expose the patient to serious vascular complications from the pressor response to intubation.⁸⁰

III. Intraoperative period

Recall at this time may^{35,39,67,81} or may not^{40,49,59,82} be accompanied by pain. It can also be associated with pleasant or unpleasant dreams and may occur as a dissociative "out of body" phenomenon.⁵ Recall may also be due to the very light anaesthesia deliberately maintained because of concern for cardiovascular stability or for the unborn child of an unpremedicated mother undergoing caesarean section. Brief awakening from anaesthesia during Harrington rod instrumentation seems to be painless, as the patients are advised of the plan preoperatively and also as a result of the precaution that no manipulations or new incisions are carried out during this period of awareness.⁸³ Neuro-surgical experience¹⁶ has been similarly reported as comfortable where consciousness was a requirement of the surgical technique.

IV. Postoperative period

Awareness may occur if the relaxant outlasts the operation and anaesthesia is discontinued. Maintenance of nitrous oxide is often recommended therefore until reversal has occurred. Potential postoperative awareness may be antici-

pated before completion of the operation as in suspected cholinesterase deficiencies or in the myasthenic syndrome. Reassurance together with appropriate sedation can be given, while ventilation is being supported.

V. Periods of extra-surgical recall

Use of relaxants, alone or with inadequate sedation, in coronary and intensive care units often results in unpleasant and frightening recall of cardioversion, tracheal intubation, or induced paralysis to prevent "fighting the ventilator".¹⁹

CASE REPORTS

All cases except the last occurred at an altitude of approximately 5,000 feet at an ambient pressure of 83.79 kPa (630 mm Hg). A study of nitrous oxide anaesthesia at this altitude described recall in one of 14 patients.⁸²

I. Preoperative period

Uncomfortable experiences after pretreatment with low doses of curare were seen chiefly in our caesarean section patients who usually complained of shortness of breath despite inhalation of oxygen. Agitation was seen in a teenage spastic child who was to undergo eye surgery and who found the motor impairment disagreeable.

II. Intubation period

Two cases of awareness and discomfort during intubation were seen in young women aged 19 and 24. In one the intravenous line was lost just after induction, delaying supplementation. Both communicated their complaints directly to the anaesthetist after discharge from hospital.

III. During operation

Recall with pain was seen in the following cases:

1. A 37-year-old woman had meperidine 100 mg with hyoscine 0.3 mg for premedication. This was followed by thiopentone 300 mg, alphaprodine 36 mg and pancuronium 6 mg, with 50 per cent nitrous oxide and oxygen for a 90-minute cholecystectomy. Recovery was uneventful. Three years later on admission for further surgery, she complained bitterly of awakening twice during the earlier operation in great pain and unable to move or talk. After the second anaesthetic, identical to the first except for the addition of enflurane up to two per cent, no recall could be elicited.

2. A 53-year-old man, a reformed alcoholic taking chlordiazepoxide 100 mg daily received

300 mg thiopentone followed by diazepam 10 mg, morphine 15 mg, fentanyl 0.2 mg and curare 87 mg with 67 per cent nitrous oxide for a 200-minute gastric operation. He complained of painful awareness and his postoperative narcotic requirements were high. His wife, on a surgical admission later, refused to have his anaesthetist for her operation.

3. A 41-year-old woman received meperidine 75 mg for premedication, thiopentone 200 mg for induction, and meperidine 60 mg, pancuronium 7 mg, with 67 per cent nitrous oxide in oxygen for maintenance during a two-hour pelvic operation. Anaesthesia was unremarkable, with cardiovascular stability. Three weeks after the operation her husband contacted the anaesthetists about her recall of excruciating pain and total "helpless" paralysis during the operation, together with recurrent nightmares postoperatively. He declined to allow her to be interviewed, but the surgeon later related that the night terrors had slowly disappeared.

4. A 48-year-old man received morphine 10 mg and hydroxyzine 50 mg for premedication, thiopentone 500 mg for induction and meperidine 120 mg, curare 54 mg with 67 per cent nitrous oxide in oxygen for maintenance in the course of a two-hour cholecystectomy. Several days postoperatively he told his surgeon he had experienced pain and awareness.

5. A 65-year-old woman received unsupplemented thiopentone, curare, with 67 per cent nitrous oxide in oxygen during which she experienced surgical awareness and pain.

6. A 51-year-old woman had a shoulder repair under balanced technique and experienced excruciating pain and exact conversational recall. She refused to return to that same hospital for two later operations.

7. A 58-year-old man who weighed 90 kg had diazepam 20 mg, curare 27 mg, gallamine 120 mg, morphine 275 mg and 50 per cent nitrous oxide in oxygen for a five-hour repair of atrial septal defect using the bypass pump oxygenator. He experienced operative awareness and pain. Postoperatively he required additional sedation because of "tenseness" and he refused to lie down, preferring only to sit up in bed during convalescence.

Three patients experienced awareness during operation under general anaesthesia without feeling pain.

8. A 47-year-old man who had multiple vascu-

lar operations for advanced athero-arteriosclerosis was aware of the operation but free of pain during a period of hypotension when the anaesthetic was briefly stopped.

9. A 41-year-old woman experienced awareness twice without pain during an abdominal operation under balanced technique. Over-hearing the conversation she recalled wondering if tying of the requested retention sutures would hurt, but she fell asleep again.

10. After a laminectomy a 50-year-old woman recalled explicit surgical directions which she could otherwise not have known, such as "Put the pieces of the disc into the medicine glass". She had no pain or discomfort and said she seemed to be out of her body and present only peripherally as an uninvolved observer.

Recall during periods of inadvertent administration of muscle relaxants without anaesthesia⁶⁷

11. A surgeon as was his routine for extensive procedures using local anaesthesia, started an intravenous infusion on a 26-year-old woman. He used a bottle left hanging on the intravenous standard. Twitching and convulsive agitation of the patient became "unresponsive" respiratory depression, which was quickly treated by an immediately available anaesthetist. The bottle contained 0.2 per cent succinylcholine and was so labelled in small writing.

12. A 31-year-old woman who was waiting for anaesthesia to be started, received 40 mg of succinylcholine slowly intravenously when the intravenous "piggyback" line, inserted as a relaxant drip for later use, had been incompletely clamped shut. Immediate diagnosis and treatment was successful, but on returning for another operation one year later, she requested no more "funny anaesthesia".

13. In a case similar to the two above, a patient was thought to have been given alphaprodine 12 mg intravenously before induction, but in fact received succinylcholine 20 mg.

14. A 26-year-old female had a negative surgical exploration at midnight for a penetrating stab wound of the abdomen. The primary anaesthetic was cyclopropane with a drip infusion of succinylcholine. She awoke very quickly, was coherent, had stable vital signs and was discharged to the ward. Three hours postoperatively her condition was satisfactory. Some time thereafter she received the 300 ml of fluid left in a bottle attached as a "piggyback" intravenous. She was found dead two hours later, and the "piggyback" bot-

tle, labelled succinylcholine, was empty. Awareness was presumed to have occurred.

PREVENTION

Since no adequate sign or test of awareness during anaesthesia exists, both diagnosis and prevention are difficult. Most suggestions for prevention or correction relate to deepening of the anaesthetic,^{11,12,21-23,40} unless the patient's condition is so precarious as to exclude supplementation.

Crawford,⁴³ in extensive studies of awareness in caesarean section patients, recommends the addition of low concentrations of volatile agents after delivery, while others^{84,85} recommend them as a preventative from the time of induction. Premedication is similarly regarded⁸⁶ and narcotics⁸⁴ or thiopentone²² after delivery are also recommended.

Muscle relaxants should be used cautiously and only when necessary. If paralysis is partial the patient may be able to respond effectively if awareness occurs. Dundee⁸⁷ has shown that narcotic supplementation allows for reduction in the dosage of relaxant.

The routine electroencephalogram has not lived up to expectation as a reliable guide to the assessment of anaesthetic depth during operation.⁴³ A different recording technique has recently allowed for the study of circulatory and respiratory effects of the electroencephalographically detected arousal response and it was felt that this could be of value in detecting awareness.⁸⁸ In a similar way, the electroencephalograph cerebral function monitor has had success in detecting both light and deep anaesthesia and hypoxia.⁸⁹ Monitoring of galvanic skin response is also suggested as a guide to arousal and awakening.⁹⁰

A digital pulse volume plethysmograph can demonstrate vasoconstriction indicating inadequate anaesthesia. Vasodilatation is regarded as a sign of unconsciousness in patients lightly anaesthetized with halothane.⁹¹ This correlates with findings that 0.65 per cent halothane added to nitrous oxide and oxygen in caesarean section patients prevents awareness⁸⁵ and that pallor and clinical vasoconstriction are indications for narcotic supplementation.⁸⁷

Tunstall⁹² devised a simple technique for detecting awareness during anaesthesia. A blood pressure cuff inflated above the systolic pressure isolates one arm from the general circulation before induction. The patient can then move that

arm in response to pain and questioning after induction, if he is conscious, as the arm has had no exposure to relaxants. The usual time-limits for maintenance of an ischaemic limb must be adhered to.

"Minimum blood concentration" has been proposed as a guide to anaesthetic depth and potency.⁹³ However, studies of the awakening level of thiobarbiturates show wide variations.⁹⁴ Continuous or intermittent determinations of anaesthetic concentrations moreover are not widely available for either exhaled air or blood.

Although clinical signs of impending consciousness are neither consistent nor reliable, some of the following may be seen: decreased compliance, bronchospasm, tracheal tug, swallowing, sweating, lacrimation, changes in blood pressure, pulse or pupil size and facial, eye or other movements. A relationship was shown between dreaming and movement during surgery.⁷³ However, the most purposeful movements often are associated with the least awareness.^{40,41} Fairley⁴¹ reported little relationship between suspected and actual awareness in any particular case.

The possibility of auditory perception⁷⁴ during anaesthesia requires that all operating-room conversation receive our most thoughtful consideration.^{5,7,57,71,72} Ear plugs for patients and distracting music have been recommended. However, if not directly for patient reassurance during awareness, then for the sake of the attitude of the surgical team, all conversation about the patient should be both optimistic and supportive.

Finally, in the prevention of awareness, the importance of meticulous attention to the details of the technique must be re-emphasized⁴⁵ so that the patient may be assured of safety and comfort.

SUMMARY

The incidence of awareness during insufficient anaesthesia is reported to be one per cent. It is usually due to the use of muscle relaxants, a balanced technique and the lightest possible depth of anaesthesia. Increased incidences were noted in open-heart surgery, during intubation-endoscopy procedures and in caesarean delivery patients.

Experiences of awareness are disturbing to patients, who are usually benefited by a sympathetic and forthright explanation of the event. Fourteen representative cases of the problem are reported.

Since no adequate sign or test exists for detec-

tion of awareness during very light anaesthesia or with associated paralysis, more meticulous attention is required in using relaxants or the balanced technique. Greater anaesthetic supplementation and reduction in the use of relaxants are recommended to halt the recurrence of this most serious anaesthetic problem.

RÉSUMÉ

Le maintien de la conscience au cours d'anesthésies de profondeur insuffisante est de l'ordre d'un pourcent. Cette complication survient le plus souvent avec les techniques d'anesthésie balancée alors que l'on utilise des curarisants tout en maintenant le niveau d'anesthésie le plus léger possible. Les situations où l'on est le plus susceptible de rencontrer le phénomène sont le moment de l'intubation endotrachéale et les procédures endoscopiques en général, ainsi que la chirurgie cardiaque et les accouchements par césarienne.

C'est une expérience traumatique pour les malades. Il est généralement préférable de leur fournir une explication franche du phénomène tout en adoptant une attitude sympathique.

Comme il n'existe pas de signes permettant de détecter que l'état de conscience persiste au cours d'anesthésie légère avec curarisation, il faut être très conscient de ce danger, et utiliser les curares et l'anesthésie balancée avec grande attention. Il est recommandable d'utiliser une anesthésie plus profonde et moins de relaxants musculaires afin d'éliminer ce problème sérieux.

Les auteurs rapportent quatorze cas du genre pour illustrer leur présentation.

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