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Cognitive Neurobiology of Consciousness and Memory during Anesthesia Awareness—Scientific Possibilities and Clinical Implications

Berenika Maciejewicz[1,2]

[1]College of Medicine, University of Science Arts and Technology, Montserrat, BWI
[2]Department of Biomedical Engineering, Einstein Medical Institute, Florida, USA
Email: office@drberenikamaciejewicz.com

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Abstract

The condition of pharmacologically induced unconsciousness that renders a patient unresponsive to uncomfortable surgical stimuli is known as general anesthesia. When it is used for surgery, a fairly rare but traumatizing state known as anesthesia awareness might develop. What is the probability that a patient can be awake, conscious, and able to hear the surroundings and experience excruciating pain but be immobilized to communicate it during surgery? According to estimates, there are 1 to 2 cases for every 1000 patients who experience this phenomenon and retain various sensory information after general anesthesia was applied. Even with seemingly effective anesthetic care, emerging consciousness states during anesthesia are reported and often come with various degrees of memory loss mechanisms. Some researchers and the experiments covered in this paper suggest anesthesia is merely a memory loss or poorly understood neurological form of amnesia induced during the event itself and not a loss of consciousness per se during the traumatic event, as suggested by studies described in this article. In some instances, the agony may be unbearable, with long-term neuropsychiatric effects such as post-traumatic stress disorder. Although the neurobiological phenomenon of consciousness regained during anesthesia is still poorly understood, these continuously reported events carry significant medical and legal ramifications. The numerous contributing elements that may increase the risk of intraoperative raised levels of consciousness are gathered, analyzed, and discussed in this research study. Preventive methods for both preinduction and intraoperative usage, as well as corrective actions to take after such occurrences, are also discussed.

Keywords

Neuroscience of Consciousness, Memory during Anesthesia, Anesthesia Awareness, Disorders of Consciousness

1. Introduction

The aim of general anesthesia is to place a patient into a state of reversible unconsciousness, with the aim of a painless medical operation to be conducted. A patient shouldn't be able to experience any discomfort or be aware of what is happening. Even though most patients aren't awake in this scenario, some can occasionally become conscious when under general anesthesia. It may be possible for them to react and give clues during the operations in particular physical yet subtle ways. After being awakened from anesthesia, a patient shouldn't remember what happened, although there have been cases where patients recall some actual events or sentences that were said or actions done. Some patients claim to have experienced pain while being immobile. Although uncommon, this occurs in around one to two out of every 1000 procedures, which some suggest being a result of improper anesthetic distribution and dosage or unexpected side effects due to subtle medical equipment failures, among a few other factors.

2. Methodology

In this study, several cases of patients who received general anesthesia were studied, and structured interviews were conducted after anesthesia. Some of the patients interviewed claimed to have been awake, conscious, and in pain during their surgery. Perioperative characteristics, drug-related characteristics, patient psychological profiles, and individual medical histories were considered. Informed consent from the patients was requested and acquired and written assurances of anonymity were provided to adhere to the standards of research ethics and human data collection. The research was conducted on the perceived quality of episodes of consciousness, intraoperative awareness states, and consequences, with the aim of finding information that might help explain episodes of consciousness during anesthesia when it was not expected to be found.

3. Research

General anesthesia was first used in 1845 by Horace Wells and in 1846 by William TG Morton using nitrous oxide and also ether. This was a revolution being still regarded as one of the most significant advancements in medicine. Since then, millions of patients throughout the world get safe anesthesia every day thanks to the development and use of new, safer anesthetics, and quick monitoring advancements in anesthesiology. According to Fleisher, 1 in 200,000 anesthetic activities results in a fatality that is solely attributable to anesthesia [1]. Despite this, researchers continue to study the potentially harmful effects

of anesthetics, particularly on elderly individuals and people with serious medical conditions. The condition of pharmacologically induced unconsciousness that renders a patient unresponsive to uncomfortable surgical stimuli is known as general anesthesia. Although anesthesia could be thought of as synonymous with loss of consciousness, there are many instances where individuals remember specific events that happened during the procedure. This discovery raises concerns about how surgical anesthesia affects memory and consciousness systems and the potential effects of intra-anesthetic awareness on the patient's life following the procedure. Another crucial concern is the capability of monitoring anesthetic depth in order to detect and avoid intraoperative consciousness, as well as the steps that a surgeon and an anesthesiologist must take if awareness does emerge. According to Morton, his surgical patients who were under anesthesia were "half asleep" and experiencing agony [2]. The first case that was reported on this phenomenon was written by Winterbottom in 1950, and Meyer and Blatcher noted in 1961 that patients who were recovering from cardiac operations showed signs of neurosis and also severe psychological disorders post surgery. These symptoms were later referred to as the "invisible scars of the surgery". The risk of consciousness during surgery has grown as a result of the usage of neuromuscular blocking medications and the rise in one-day surgeries. Significant multicenter research conducted in the USA in 2004 found that there are around 2000 cases of intra-anesthetic consciousness annually, or 0.13 percent of all cases. Despite the relatively low frequency, the issue is severe when we take into account that 50% to 54% of patients are concerned about waking up during surgery, and statistics show that 2% of legal claims and proceedings against anesthesiologists are the ones that involve awareness cases [3].

Different degrees of consciousness have been reported by people who have gone under anesthesia and become conscious. Some only remember fleeting and blurry details. Others recall a certain stage of the procedure or their surroundings. Additionally, patients are more likely to be conscious during non-general anesthetic operations. For instance, if one underwent one of these forms of anesthesia, they could remember all or part of their procedure: intravenous sedation, sometimes known as "twilight" sedation, which is frequently used for quick operations like colonoscopies, specific kinds of biopsies, also, any local or regional anesthetic, which temporarily numbs the area being treated during surgery, such as an epidural, spinal block, or nerve block. Anesthesia awareness may be unsettling or even distressing, depending on the person and the circumstances. If this were to occur, it's advised to tell your doctor or anesthesiologist about it after your procedure. Following surgery, some patients find that therapy helps them deal with their emotions of worry and general post-surgery distress [4].

Although neuroscience is constantly researching the processes behind sophisticated brain functions like awareness and memory, these mechanisms are still not fully understood. The outcomes of the continuing research have been greatly influenced by studies coming from anesthesia patients. Various studies explore how anesthetic medicines affect the central nervous system. The primary me-

chanism involves interfering with neurotransmission systems, specifically with ion gates influencing the release of neurotransmitters which stimulate or inhibit the central nervous system, including nicotinic receptors, NMDA receptors, and GAAA (Gamma-Amino-Butiric-Acid) receptors (nACh). In addition to ion gates, anesthetic medicines also affect G protein receptors (also known as GPCRs), which are connected to the actions of acetylcholine, norepinephrine, dopamine, adenosine, and opioid receptors [5]. The numerous negative effects of these medications are caused by this activity. Recent research has also explored how anesthetic medications interact with potassium receptors, controlling the excitability of neurons by supplying auxiliary electrical currents [6]. Through those gates also known as 2p gates, anesthetics change how sensitive nerve cells are to electrical impulses.

A person may analyze and interpret the information they get from their surroundings when they are conscious. Anesthesia induces the disappearance of consciousness, mainly through thalamocortical neurons. The short-term and long-term memories are the two groups affected by the process. Keeping and processing information related to learning, making decisions, and recalling experiences that are kept in long-term memory may all become impaired. Information is kept visually or phonetically (when one's "inner voice" says the information again to oneself) as opposed to storing it in a visual form. According to certain research, it is feasible to learn, absorb information, and store it in long-term memory even while under a strong anesthetic. In some experiments, names of colors or fruits were played to subjects through headsets while they were under deep anesthesia, and upon awakening, even though the subjects could not remember hearing anything, they guessed correctly (compared to the statistical group) the colors and fruit names when asked and surveyed after the procedure [7]. The patients were fully unconscious, so how could this result be explained? In a similar research, patients were asked to complete unfinished sentences, and the findings showed that they were filling in the blanks with words they had heard intraoperatively rather than ones they could recollect hearing. The fact that researchers were able to significantly reduce the length of postsurgical hospital stays and the requirement for opioid analgesics by sending encouraging messages to patients while they were being operated on while under general anesthesia (such as "you will get up early" or "you will not feel pain after surgery") is even more impressive. Some patients who were instructed to cease smoking while under general anesthesia have even been seen to stop their addiction, which was interpreted to come from suggestions made while under anesthesia [8]. Finally, it has been shown that auditory and somatosensory inputs can generate cerebral electrical activity in individuals who are under deep anesthesia. On the other hand, several researchers found different outcomes from comparable studies, so the results overall were deemed inconclusive. Intraoperative information storage and postoperative recollection are still debatable topics. It's been suggested that intra-anesthetic awareness is more likely as a result of particular specific risk factors but overall remains as one of unsolved mysteries of the science of the mind and conscious-

ness [9].

Why might a patient wake up during surgery (known as anesthesia awareness)? There are several causes suggested for this. Medication's ineffective distribution is one, a human error in which the incorrect drug dose is administered, or technical or equipment failures that result in inadequate medication administration. One could also face the chance of experiencing anesthetic awareness if they have several medical issues or are being sedated in challenging circumstances. The most frequent instances of this occur with cesarean births, some heart operations, and other sensitive procedures when it would not be safe to utilize the standard dosage of sedation [10]. Many different actions have been suggested to lessen intraoperative consciousness. Prescription of amnesic medications, such as benzo-diazepines was one. It has been suggested to provide benzodiazepines as a premedicant on a regular basis, especially when mild anesthesia is expected. A preventive midazolam injection as an adjuvant during complete intravenous anesthesia has been investigated in numerous double-blind, randomized clinical studies for effectiveness. It was shown to lessen intraoperative consciousness problems compared to the placebo groups, but it's not standardized or recommended as such yet as the delayed post-operative emergence of consciousness was also noticed, which causes a risk on its own. The main part of the current protocol to minimize occurrences of disturbances is that before induction, the anesthesia administration system must be thoroughly inspected. Errors in the administration of anesthetic concentration have been linked to cases of intraoperative consciousness [11]. Clinical methods and standard monitoring involve checking for movement, responding to orders, eyelash reaction, pupillary responses, breathing pattern, sweating, and weeping are a few of the clinical approaches used to gauge intraoperative awareness. There haven't been any clinical trials or research that particularly looks at how sensitive various monitoring techniques are to identifying intraoperative consciousness. Some research found a strong correlation between memory and reaction to commands and suggestions when propofol was administered continuously as the induction anesthetic but other studies are not conclusive about this anesthetic medication. To determine intraoperative consciousness, standard protocols are still in use, like keeping an eye on the patient's breathing even when there is no neuromuscular paralysis presents [12]. To establish optimal anesthetic depth, the Guedel's Stage 3 plane III degree of anesthesia should preferably be attained before the operation to establish a sufficient level of anesthesia. Additionally, current scan monitors measuring results do not seem to have consistent sensitivity across various anesthetics and patient/brain injury types. Thus, even when they show low values for brain awareness activity, patients may still be conscious. The type of operation, the anesthetics used, the timing and method of monitoring awareness all affect the risk of the occurrence of intraoperative consciousness. Many patients' anesthesia records revealed human variables in this regard that may have been avoided. Subjective auditory experiences as well as attempts to move or speak, as well as touch or pain perception, were the dominant ones [13].

A little known but terrifying informal study was conducted by Ian Russell (1993), a little-known anesthesiologist from Hull Royal Infirmary, England, who released shocking announcements that year. He measured the states of consciousness of 32 women who went under a somewhat routine gynecological surgery he performed being known as a relatively simple procedure. A low-dose anesthetic medication that had lately been praised for offering a reliable defense against intraoperative consciousness was used to put the women to sleep. To successfully immobilize her throughout the procedure, the key components were the (at the time) relatively new medicine midazolam, combined with a painkiller and muscle relaxant. Russell then did a small addition to the procedure by wrapping each woman's arm in what was essentially functioning as a blood-pressure. Then he put his patients under general anesthesia. Next, the cuff on their forearms was tightened to essentially apply pressure to prevent otherwise relaxing of the muscles—this way the women could essentially use their right hand if the anesthesia was not in full effect. This was the surgeon's creative way to design a channel of communication, in a small chance that someone would be awake and aware to hear him during the operation and answer this way. It was creatively referred to as a priority emergency phone line [14].

Russell then gave each woman a set of headphones for their ears when they were already asleep and played them a pre-recorded one minute loop playing over and over again, where he called their name twice at the very beginning and then delivered this message: "Dr. Russell is on the line. If you can hear me, please open and shut the fingers on your right hand". If any of the women were to respond to this, according to his pre-designed operation protocol, Russell was then to remove part of their headset, take their hand and say the following line: "If you can hear me, squeeze my fingers". Following that, Russell was to then ask about the level of pain and hurt the woman was feeling by squeezing his hand further on following cues and commands. In response to that Russell was to apply more medication to attempt to put them deeper to sleep, within safety protocols.

The shocking and terrifying result of the study was that out of 32 women that were operated on, 23 squeezed Russell's hand, giving him the signal for being partially aware. Out of those 23, 20 gave further signals of experiencing pain and suffering during the procedure. He halted the study at this time. Very interestingly, none of the subjects who were questioned in the recovery room indicated that they could recollect anything, but three days later, some of them displayed some memory-related behaviors. 2 of them specifically recolled opening and closing and squeezing their right hands but were unable to remember why they did that. At the same time, none of the classical measurements like changes and variables in heart rate during operation or fluctuations of blood pressure were of any indicator of the group who showed signs of consciousness by squeezing the hand of the surgeon vs the group that didn't [15]. Other physiological predictors to this intraoperative emergence of awareness like perspirations, tears, and temperature were also noted as not indicative of the level of anesthesia seen within

that group.

As a result, while patients may not recall the operation itself and even describe the perioperative period as a mild and not unpleasant experience, the conclusion was that the regimen itself may meet that needs and standards. However, the concept of general anesthesia would often involve being unconscious and pain-free *during* surgery, which are aspects that the current methods don't seem to seamlessly provide. Russell himself stated, "The state of mind created by the anesthetic could not be considered as general anesthesia for the majority of the ladies in his research. Instead, it should be treated as widespread amnesia" [16]. Numerous patients still awaken on the operating table each year, as anesthesia is still a perplexing and imprecise form of practiced science that routinely results in tragic and traumatic cases [17].

4. Conclusion

The most disturbing aspect of the emergence of consciousness during surgery is unbearable pain reported, but additional symptoms include the capacity to hear conversations, emotions of fear, powerlessness, lock-in immobility, and senses of approaching death. Some individuals have postoperative psychological and physiological complications such as nightmares, daytime anxiety, and sleep difficulties. Posttraumatic stress disorder, characterized by recurrent nightmares, agitation, and anxiety, is reported to emerge in a small percentage of these groups. It is unclear why this phenomenon only manifests in certain patients and not in others. The subject's personality, genetic susceptibility to cognitive disturbances, and underlying illnesses like general cardiovascular instability are among the factors considered. It's estimated that intraoperative consciousness may affect 2% of cases and these are only the ones resulting in claims that were reported. Among cases when the nitrous oxide-opioid relaxant method was utilized, claims were more prevalent in females [8]. Reporting the case to medical personnel is crucial to gather the needed data for the procedures and protocols to be able to be improved. Support from a psychologist or psychiatrist should also be given to the patient. The surgeon, the patient's nurse, the hospital lawyer, and the doctor's insurance company should all be informed as well. The information from the interview should also be entered into the patient's medical history charts. Daily visits should be made while the patient is in the hospital to check for any psychiatric side effects, such as daytime worry, disturbed sleep, etc. Telephone contact should then continue after release from the hospital until the patient is fully recovered. To lower the prevalence of posttraumatic stress disorder, prompt referral to a psychiatrist or psychologist should always be made. For the purpose of quality management, an occurrence report regarding the incident should be finished. Although it is uncommon, the patient may experience extreme emotional suffering as a result, and the anesthesiologist may face professional, financial, and legal repercussions. Although it could result from faults in equipment or improper dosage, these causes are not always present. While a few straightfor-

ward preventive steps to minimize the risk of human error might significantly lower the incidence rate, more investigation is required to find a solution to the problem of anesthesia awareness. Finally, the trauma that the patient experiences as a result of such dramatic occurrences might be lessened with structured psychological post-operative support offered.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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