Anesthesiology
54:341–343, 1981

Intraoperative Awareness during High-dose Fentanyl–Oxygen Anesthesia

JOHN C. HILGENBERG, M.D.*

High-dose fentanyl–oxygen anesthesia (50–100 μg/kg) produces minimal cardiovascular effects and has been advocated for anesthesia in patients with severe valvular heart disease.[1] Furthermore, total amnesia for intraoperative events is reported to be complete following the intravenous administration of fentanyl (75 μg/kg).[1] However, this report describes intraoperative awareness following high-dose fentanyl–oxygen anesthesia for mitral valve replacement.

Report of A Case

A 41-year-old, 56-kg female with severe mitral valve insufficiency and mild congestive heart failure was scheduled for elective mitral valve replacement. Previous surgeries included an uneventful appendectomy and tubal ligation, both performed under general anesthesia and uncomplicated by intraoperative awareness or recall. Preoperative drug therapy included digoxin, hydrochlorthiazide, and hydralazine. She denied cigarette smoking and alcoholic consumption. Morphine sulfate (10 mg) and scopolamine (0.4 mg) were administered intramuscularly (im), 90 min prior to surgery. The patient appeared well sedated during placement of peripheral intravenous catheters prior to induction of anesthesia. Anesthesia was induced with intravenous (iv) fentanyl administered at a rate of 100–200 μg/min. During the fentanyl infusion, the patient was asked to open her eyes and take a deep breath every 30 s. Failure to respond to these commands three times in succession indicated loss of consciousness which occurred after fentanyl, 18 μg/kg. Pancuronium, 150 μg/kg, iv, was then administered to facilitate endotracheal intubation. Prior to surgical incision, additional fentanyl was administered until a total of 90 μg/kg had been given. During surgical skin incision and sternotomy the systemic mean arterial pressure and heart rate did not change from the values recorded prior to surgical incision. Furthermore, during this same period of surgical stimulation, no additional sign of light anesthesia (lacrimation, diaphoresis, movement) was observed.

Following initiation of extracorporeal bypass, surgical implantation of a mitral valve prosthesis was performed uneventfully. During extracorporeal bypass, body temperature was lowered to 26° C. No other medication was administered following the procedure. Following surgery, the patient was taken to the surgical intensive care unit where she regained consciousness 3–4 hours later. Her trachea was extubated 8 hours after entering the intensive care unit. No postoperative sequelae, except for mild basilar pulmonary atelectasis, occurred.

On the fourth postoperative day, she related hearing sounds and conversation during surgery. Specifically she remembered hearing a buzzing sound on her chest. At this same time she recalled hearing a male voice say, "cutting down to the abdomen," although she denied feeling the vibration of the sternal saw. Furthermore, she denied experiencing pain or anxiety at the time she heard these sounds. Postoperatively, her sleeping habits have not changed nor has she experienced any hallucinations.

The buzzing sounds the patient heard may have been produced by either the sternal saw or the electrocautery device used during skin incision and sternotomy. However, the words "cutting down to the abdomen" were indeed used by the surgeon during his description of the median sternotomy technique to the surgical residents. Nevertheless, the patient did relate hearing the buzzing sounds simultaneously with the words "cutting down to the abdomen."

Discussion

Memory formation involves registration of sensory information in the central nervous system into short-term memory.[2] This is followed by consolidation and storage of this information into long-term memory. Anesthetic drugs may produce amnesia by interfering with this memory–consolidation process.[2] The likelihood that a sensory stimulus will lead to formation of long-term memory depends on the strength of the stimulus and the sensory threshold at the time the stimulus is experienced.[3] Conditions conducive to memory consolidation exist during unsupplemented narcotic anesthesia when light levels of anesthesia occur simultaneously with intense surgical stimulation. During cardiovascular surgery, this period coincides with skin incision and sternotomy. It is, during this period of surgical stimulation when signs of inadequate anesthesia (hypertension, tachycardia, movement, diaphoresis) and awareness are likely to coexist. However, in this patient these signs were absent when intense surgical stimulation (sternotomy) coincided with inadequate amnesia (recall of sternotomy). Although pancuronium could have prevented body movement in this patient, it is unlikely it would also mask the other autonomic signs of inadequate anesthesia. This lack of correlation between signs of light anesthesia and incomplete amnesia has been corroborated by previous investigators. Abouleish *et al.*[4] found no correlation between body movement, blood pressure changes, and pupil size and the incidence of intraoperative awareness. He suggests that except for body movement, signs

* Assistant Professor.

Received from the Department of Anesthesia, Indiana University School of Medicine, Indianapolis, Indiana 46223. Accepted for publication October 21, 1980.

Address reprint requests to Dr. Hilgenberg.

Key words: Surgery: cardiac. Anesthetics: intravenous, fentanyl. Anesthesia: depth. Memory.

0003-3022/81/0400/0341 $00.65

of light anesthesia are autonomic in origin and therefore, dependent on the tone of the autonomic nervous system which can be modified by prior drug administration.

In an attempt to increase the sensory threshold for memory formation, high-dose fentanyl-oxygen anesthesia (50–100 μg/kg) has been recommended as an alternative to morphine–nitrous oxide anesthesia for cardiovascular surgery.[1] This recommendation was based on the minimal cardiovascular changes and complete intraoperative amnesia following high-dose fentanyl administration when compared to morphine–oxygen anesthesia (0.5–3.0 mg/kg). This inability of morphine to consistently produce loss of consciousness necessitated the addition of nitrous oxide with its known cardiac depressing properties.[5] In contrast, Lunn *et al.*[6] reported that surgical amnesia was complete following the intravenous administration of fentanyl (75 μg/kg) without the addition of nitrous oxide. Presumably this advantage of high-dose fentanyl anesthesia is due to its larger dosage when compared to morphine–oxygen anesthesia. Assuming fentanyl is 100 times more potent than morphine 75 μg/kg fentanyl would be equivalent to 7.5 mg/kg morphine.

Despite the large dose of fentanyl administered to this patient, she was only able to recall events that occurred prior to extracorporeal bypass when plasma fentanyl concentrations must have exceeded those plasma fentanyl levels following plasma dilution by the extracorporeal priming solution. This lack of awareness following extracorporeal bypass when plasma fentanyl concentrations decrease to levels below those necessary to produce unconsciousness, has been reported. Lunn *et al.*[6] suggest that both hypothermia and/or the abnormal nonpulsatile circulation of bypass contribute to the anesthesia following extracorporeal bypass. In addition, Hess *et al.*[7] observed fentanyl concentrations in the brain to decrease much slower than plasma fentanyl concentrations following the administration of fentanyl (20 μg/kg) to rabbits.

Awareness during cardiac surgery may produce severe psychological complications. Blacher[8] described the syndrome of traumatic neurosis in several patients following cardiac surgery performed under light general anesthesia. Postoperatively, these patients complained of repetitive nightmares, anxiety, irritability, and a preoccupation with death. The content of their nightmares included descriptions of being tied down, stuck with needles, and unable to speak or move. The incidence of this complication following cardiac surgery is unknown, partly because of the patient's unwillingness to discuss these fears or to seek medical attention. However, this fear can be diminished by reassuring the patient that what they experienced (pain, paralysis, conversation) during surgery did indeed occur and was the result of incomplete anesthesia. In addition, the patient should be told that light levels of anesthesia may have been required to minimize the cardiac depressant effects associated with deeper levels of anesthesia.

The intraoperative awareness our patient experienced may seem trivial. Indeed, she could only recall events associated with intense surgical stimulation. Furthermore, she experienced no pain during this period of awareness. However, the syndrome of traumatic neurosis has been reported following cardiac surgery in several patients who denied experiencing pain intraoperatively but were aware of sounds and conversation.[8] Therefore, despite the predictable analgesia following high-dose fentanyl anesthesia, the ability to perceive threatening sounds and conversation while paralyzed still exists and conceivably could result in postoperative traumatic neurosis.

The incidence of awareness during general anesthesia for noncardiac surgery is approximately 1 per cent.[9] This complication is more likely to occur during narcotic–oxygen anesthesia than during the same anesthesia supplemented with inhalation anesthetic drugs.[10] When 50 per cent nitrous oxide was added to fentanyl–oxygen anesthesia, no postoperative recall was observed.[10] In addition to nitrous oxide supplementing narcotic–oxygen anesthesia, several adjuvant anesthetic drugs have also been recommended to minimize intraoperative awareness. These include the administration of a benzodiazepine (diazepam, lorazepam) and scopolamine as premedicant drugs,[11,12] and halothane (0.3–0.5 per cent inspired).[13] However, these supplemental inhalation anesthetic drugs may alter the stable cardiovascular dynamics associated with high-dose fentanyl oxygen anesthesia. For example, 60 per cent nitrous oxide administered after fentanyl (75 μg/kg) produced a significant decrease in cardiac output and increase in heart rate prior to surgical incision in patients scheduled for cardiac surgery. Because the adverse cardiovascular changes following the use of these supplemental anesthetic drugs may outweigh their advantage of suppressing intraoperative awareness, caution should be used when administering these drugs to patients with severe cardiac dysfunction.

In summary, we report intraoperative awareness (sounds and conversation associated with surgical sternotomy) in a patient who had previously received intravenous fentanyl (90 μg/kg) for mitral valve replacement. Based on this observation, it may be prudent to consider supplementing high-dose fentanyl anesthesia with nitrous oxide (50 per cent), or halothane (0.3–0.5 per cent) at those times corresponding to intense surgical stimulation.

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Anesthesiology
54:343–345, 1981

Ulnar Artery Occlusion Simulating Reflex Sympathetic Dystrophy

Fred J. Spielman, M.D.,* Jawahar N. Ghia, M.D.,† Edward Teeple, M.D.,‡ Valerie S. Mandell, M.D.§

Diagnosis of intense burning pain in an extremity following trauma resulting from a high velocity impact of an object is caused by reflex sympathetic dystrophy (RSD).[1] It differs from true causalgia in that no demonstrable peripheral nerve injury has occurred. Most commonly, this type of pain follows fractures, sprains, or sharp and blunt trauma to soft tissues. In this report, we describe a case of ulnar artery occlusion simulating RSD. Systematic evaluation during a series of stellate ganglion nerve blocks helped establish the diagnosis which saved the patient from undergoing an unnecessary surgical sympathectomy.

* Anesthesiology Resident, Department of Anesthesiology.

† Associate Professor of Anesthesiology, Department of Anesthesiology.

‡ Anesthesiology Fellow, Department of Anesthesiology.

† Assistant Professor of Radiology, Department of Radiology.

Received from the Departments of Anesthesiology and Radiology, the University of North Carolina at Chapel Hill, North Carolina Memorial Hospital, Chapel Hill, North Carolina 27514. Accepted for publication October 21, 1980.

Address reprint requests to Dr. Spielman.

Key words: Anesthesia: diagnostic. Anesthetic techniques, regional: stellate; sympathetic block. Sympathetic nervous system: dystrophy. Arteries: ulnar.

Report of a Case

A 53-year-old man who worked as a textile machine operator sought treatment at the University of North Carolina Multidisciplinary Pain Clinic because of a two-month history of pain, paresthesias, and intermittent cyanosis in the fourth finger of his right hand. A throbbing and burning pain began a few seconds after he sustained an injury to the involved finger in a spinning frame (a high-velocity, low-weight object) at the mill where he worked. The pain worsened over the next several days, and was accompanied by swelling and cold sensations in the finger tip, with intermittent periods of paresthesias. One week after the injury, he noticed the right hand to be cold and cyanotic. The burning pain had spread to his right hand, and the entire right upper extremity experienced associated weakness. Treatments prior to arrival at the Multidisciplinary Pain Clinic consisted of acetylsalicyclic acid and codeine for pain, and oral reserpine.

A summary of positive findings reported by the referring physician consisted of a history of smoking for sixty pack years. Roentgenogram of the right ring finger obtained after the initial injury showed no evidence of a fracture or foreign body. The patient's right hand was cool and showed a slow capillary refill. Doppler examination of the right radial and ulnar arteries were within normal limits. Plethysmographic flow studies of the right ring finger were consistent with sympathetic based arteriospasm. Intra-arterial reserpine was tried in an effort to improve circulation in the affected finger.[2] Following the injection of 1 mg reserpine in the right brachial artery, an immediate warming of the right hand was observed. Shortly after the injection, the patient de-

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