Anesthesia Methods in Laser Resurfacing

Sergio Gaitan, B.S.¹ Ramsey Markus, M.D.¹

¹ Department of Dermatology, Baylor College of Medicine, Houston, Texas

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Address for correspondence and reprint requests Ramsey Markus, M.D., Department of Dermatology, Baylor College of Medicine, 1977 Butler Boulevard 6th Floor, Suite E6.200, Houston, Texas 77030 (e-mail: rmarkus@bcm.edu).

Abstract

Laser resurfacing technology offers the ability to treat skin changes that are the result of the aging process. One of the major drawbacks of laser resurfacing technologies is the pain associated with the procedure. The methods of anesthesia used in laser resurfacing to help minimize the pain include both noninvasive and invasive procedures. The noninvasive procedures can be divided into topical, cryoanesthesia, and a combination of both. The invasive methods of anesthesia include injected forms (infiltrative, nerve blocks, and tumescent anesthesia) and supervised anesthesia (monitored anesthesia care and general anesthesia). In this review, the authors summarize the types of anesthesia used in laser resurfacing to aid the provider in offering the most appropriate method for the patient to have as painless a procedure as possible.

Keywords

- laser
- skin
- resurfacing
- anesthesia

With an increasing aging population, in a society in which youthful appearance and beauty are highly desired, a significant amount of people are suffering from the unavoidable increase in wrinkles and scars. Laser resurfacing technology offers a much needed ally in the battle against aging with facial rejuvenation through its stimulation of collagen production in the skin, thus promoting smoother, healthier, and younger-appearing skin. Unfortunately, one of the major challenges of laser technology is the pain associated with the procedure. Carbon dioxide (CO₂) laser resurfacing involves the removal of the entire epidermis and upper portion of the dermis, providing significant stimulation to dermal nerve fibers. The pain experienced during laser procedures is of such significance that in one patient survey, it ranked third behind cosmetic outcome and communication in order of importance.¹ Hence, the use of anesthesia in laser resurfacing procedures is of great importance in the patient's treatment.

Anesthesia in laser resurfacing can be divided into noninvasive and invasive methods. The noninvasive methods include a variety of topical anesthetics, cryoanesthesia, and a combination of the former and the latter. The more invasive methods can be divided into injected anesthesia and supervised anesthesia. The injected forms can be further subdivided into infiltrative local anesthesia, specific nerve blocks,

and tumescent anesthesia. Supervised anesthesia consists of monitored anesthesia care and general anesthesia.

Here we will explore and summarize the available options of anesthesia that have been successfully tried during laser resurfacing procedures to (1) provide different options for the patient, and (2) enable the provider to offer the most effective, safe, and painless laser procedure possible.

Noninvasive Methods

The noninvasive methods of anesthesia include topical anesthesia, cryoanesthesia, or a combination of both. The noninvasive methods provide the benefit of avoiding needles, intravenous (IV) access, or need for intubation. There is a variety of effective and simple topical anesthetic products that are available as over-the-counter (OTC) and/or by prescription. Although noninvasive, topical anesthetics still carry the risk of ineffective anesthesia, systemic absorption, allergic reaction, and potential fatalities if inappropriately used.^{2–7} Cryoanesthesia is another noninvasive method that provides an analgesic effect as well as the added benefit of thermal protection. In addition, topical anesthetics can also be used in combination with cryoanesthesia or other more invasive modes of anesthesia to provide a stronger analgesic effect.

Topical Anesthesia

Topical anesthetics have a long history of use and proven efficacy in decreasing pain with common dermatologic procedures such as shave biopsies, punch biopsies, curettage, and electrosurgery,^{8–11} allowing their easy introduction during laser procedures. Studies have already shown that commonly used lidocaine preparations reduce discomfort associated with the neodymium-doped yttrium aluminum garnet (Nd: YAG) laser hair removal.¹² Topical lidocaine has also been successful in reducing intense sensation during Q-switched laser tattoo removal,¹³ and the discomfort associated with the laser treatment of vascular and pigmented lesions.^{14–16} Before the use of these topical anesthetics, ablative skin resurfacing procedures using carbon dioxide (CO₂) and erbium-doped YAG lasers often required IV sedation. With the newer methods of superficial skin resurfacing like single-pass CO₂, fractional laser, and plasma skin resurfacing, topical anesthetics have shown to be effective during the procedure.^{17–21}

The active targets for topical anesthetics are the dermal nerve fibers. To reach the target, the topical anesthetic must penetrate the thickness of the stratum corneum. Several methods have been used to help facilitate penetration of the topical anesthetic and improve dermal absorption: removal of the stratum corneum with tape stripping;²² degreasing with acetone; laser ablation of the stratum corneum,²³ occlusion and heat,²⁴ and iontophoresis,²⁵ which uses an electrical current to facilitate the passage of ionized molecules through the skin barrier.²⁶ The duration of their local effect can be modified with the addition of epinephrine, which induces vasoconstriction and slows the effect of the anesthetic's withdrawal.^{25,27} Modifications can also be made to the topical anesthetic preparation to facilitate application to the skin. One example is making a eutectic mixture which allows individual compounds that would normally be solid at room temperature to be combined and be liquid at room temperature, this has been shown to permit higher concentrations to be used safely and to facilitate skin application.²⁷ Another option is liposomal encapsulation that promotes drug delivery by delivering a greater concentration of local anesthetic to sensory nerves than other formulations.^{28,29}

There are several types of topical anesthetics available both as prescription, OTC, and compounded formulas. The prescription of topical lidocaine most widely used is the eutectic mixture of local anesthetics (EMLA; Astra Pharmaceuticals, Westborough, MA). EMLA is an oil-in-water emulsion of 2.5% lidocaine and 2.5% prilocaine, which contains a polyoxyethylene fatty acid emulsifier that enhances absorption.³⁰ An analgesia depth of 3 mm is achieved after 60 minutes of application and a maximum dermal depth of 5 mm is reached after 120 minutes.^{31,32} The dermal analgesia even continues after the removal of the anesthesia. Occlusion and longer duration of application increase the penetration and efficacy of EMLA.^{33–35} EMLA cream self-applied 2 hours pretreatment is effective in many patients. When applied to the skin, EMLA produces initial vasoconstriction with blanching peaking after 90 minutes and a rebound vasodilatation with erythema,³⁶ which should not be confused for an adverse reaction. EMLA application can

have skin reactions such as contact urticaria and allergic contact dermatitis,^{37,38} where the prilocaine component is believed to play a role in the allergenicity.³⁹ The application should be avoided on damaged or inflamed skin, and on a large surface area (2,000 cm²) to avoid systemic side effects. There are also several OTC topical anesthetics which include LMX4, LMX5, Topicaine®, and Lidoderm®. LMX4 and LMX5 (Ferndale Laboratories, Ferndale, MI) are composed of 4% and 5% lidocaine, respectively; they are prilocaine free and do not require occlusion because of a lidocaine liposomal delivery cream that has several lipid bilayers, which facilitate dermal penetration and achieve the same analgesic effect as EMLA in a shorter time.⁴⁰ Topicaine® (ESBA Laboratories, Jupiter, FL) is available as a 4% and 5% water-based gel; in one study, it showed an effect equivalent to EMLA and LMX at 15 and 30 minutes of application, but not at 60 minutes of application.⁴¹ Lidoderm® (Endo Pharmaceuticals, Chadds Ford, PA) is a 5% lidocaine adhesive patch; however, no clinical studies have been conducted to examine its utility in cosmetic procedures.

Other options for topical anesthetic include the S-Cain Patch® (Zars, Inc., Salt Lake City, UT), which contains a eutectic mixture of 70 mg of lidocaine and 70 mg of tetracaine. Along with the anesthetic is a patented heating element that raises the temperature to 40°C for over 14 hours enhancing the delivery of the anesthetic. The product insert states erythema, blanching, and edema are the most common local reactions. The S-Caine Peel® (Galderma Laboratories, Fort Worth, TX), which was a novel eutectic mixture of 7% lidocaine and 7% tetracaine in a cream base, was discontinued in September 2008 because of an inability to maintain consistent product viscosity.⁴²

Then there are the use of compounded formulas as topical anesthetics, which are not regulated by the Food and Drug Administration (FDA). Examples include lidocaine ointment 30%, BLT (20% benzocaine, 6% lidocaine, and 4% tetracaine), TAC (0.5% tetracaine, 1:200 epinephrine, 11.8% cocaine), and many more. One major problem with compounds is that standardization of products is difficult because individual pharmacies use different protocols to mix various ingredients in their topical anesthetics.²⁶ In fact in 2006 the FDA advised five pharmacies to discontinue compounding a standardized version of topical anesthetic creams that were available for general distribution.⁴³

In full-face laser resurfacing, topical anesthesia has also been combined with other methods to try to reduce the need for more invasive methods. One method that has been described in CO₂ laser resurfacing is the use of EMLA cream with oral analgesics, oral diazepam (5–10 mg), and intramuscular ketorolac (30–60 mg). In that study, 95% of the 200 patients did not require more invasive methods of anesthesia such as regional nerve blocks and/or local infiltration.⁴⁴ The authors caution against the usage of lidocaine and diazepam concurrently due to diazepam's inhibition of cytochrome-P450 (CYP3A4), leading to a slower elimination of lidocaine and increased risk of lidocaine toxicity. An alternative benzodiazepine to be considered is lorazepam as it is not metabolized by CYP3A4.⁴⁵

Although there are many options for topical anesthetics in laser resurfacing, unfortunately, there is no standard guideline that exists for optimal safety and use. Several factors should be taken into consideration when deciding which one to use: the anatomic area involved, the amount of anesthetic to be applied, the duration necessary for desired anesthesia depth, and the safety profile of the individual topical anesthetic and how it interacts with the patient's comorbidities. The side effects of systemic lidocaine toxicity occur in phases.⁴⁶ The first phase presents as tinnitus, metallic taste, and circumoral numbness. The patient can exhibit drowsiness or light headedness, and become apprehensive, agitated, and talkative due to central nervous system toxicity. At this point, all topical medications should be washed off; cardiopulmonary resuscitation and advanced cardiovascular life support (ACLS) should be applied if the effects of the toxicity worsen. The second phase of toxicity presents as generalized tonic-clonic seizures; the third phase exhibits as a respiratory and cardiovascular depression that can lead to coma. The prilocaine portion of EMLA can induce methemoglobinemia because of its ability to oxidize iron in red blood cells from the ferrous to ferric state.⁴² The patient's initial presentation can be cyanosis, later leading to dyspnea, tachycardia, and headache. At high enough levels (> 50%), lethargy and coma can occur. Therefore, one must be very careful to read the manufacturer's instructions in the packet insert of the medication and use it as indicated.

Cryoanesthesia

Cryoanesthesia is the use of chilling to provide local anesthesia. It has begun to gain importance in various dermatologic procedures including laser therapy.⁴⁷⁻⁵² Cryoanesthesia produces an analgesic effect by cooling the epidermis and provides an additional advantage in laser therapy of thermal protection.⁵²⁻⁵⁷ This protective effect allows the use of higher levels of therapeutic energy without the risk of damage to the epidermis.⁴⁷⁻⁵² In addition, cryoanesthesia has the benefit of decreased postlaser side effects (erythema, purpura, and crusting).⁴⁷⁻⁵²

The types of cryoanesthesia can be subdivided into contact cooling and noncontact cooling. In contact cooling, the medium makes direct contact with the skin on application. Moistening of the skin with cold water and the application of ice or ice packs are some examples. Contact cooling specifically associated with lasers include the sapphire cooling tip hand piece for the long-pulsed Nd:YAG laser,^{51,53} the metal "cooling finger" for the ruby laser, and the sapphire lens for the diode laser.⁵²⁻⁵⁷ In noncontact cooling, the cold is transferred to the skin by a gaseous medium. Examples include the use of cold sprays, as well as cold air anesthesia. In dermatologic laser therapy, contact cooling has been the primary method of cryoanesthesia in the past.^{48,50,51,53} Today cold-air cooling provides the same benefit with less chance of frostbite because higher minimum temperatures are achieved.⁴⁷⁻⁵⁷ Forced cold-air cryoanesthesia has been reported to decrease the discomfort associated with laser therapies including nonablative fractionated erbium laser,⁵⁸ CO₂ laser,⁵⁹ and pulsed dye laser (585 nm) resurfacing.⁶⁰ It also has been

shown that with single-pass ablative CO₂ laser resurfacing there was no impact on long-term results in laser efficacy with the use of cold-air anesthesia.^{59,61} In cold-air cooling, there are several air transport systems; one example is the Zimmer Cooler[®] device (LaserMed, Shelton, CT). There are also several ways to apply the cooling; according to one study the best approach is to hold the air-cooling nozzle ~3 to 4 inches from the skin as the laser head passes over the skin, with the cold air beam directed at a ~90-degree angle to the laser. This method provides simultaneous prechilling of untreated skin and cooling of the treated skin.⁶¹

Cryoanesthesia can also be used in conjunction with topical anesthesia to amplify the analgesic effect. In one study, cold-air anesthesia was used in combination with topical anesthesia as opposed to just topical anesthesia; the group with the combination had a lower patient reported mean pain score.⁶¹ Studies using an ablative fractionated CO₂ dermal optical thermolysis laser (DOT therapy; DEKA, Calenzano, Italy) with a combination of topical anesthesia and forced air cooling have shown that patients experience sufficient comfort in treatments for photoaging, poikiloderma of Civatte, neck laxity, and eyelid laxity.⁶²⁻⁶⁴

Cryoanesthesia is easy to use, has a high level of patient acceptance, and an excellent safety profile. It also can be added in combination with topical anesthesia to decrease pain and to avoid more invasive methods. One of the main limiting factors with cryoanesthesia is the patient's comfort level with cold temperature; therefore, it is not very effective in patients with cold sensitivity. Most important, the cryoanesthesia method used, whether contact or non-contact cooling, should minimally influence the intensity and direction of the laser beam; more studies are needed to ensure that it does not alter the effectiveness of the laser therapy.

Invasive Methods

If a stronger analgesic effect than can be provided by noninvasive methods is desired for the laser resurfacing procedure such as in the case of deep resurfacing, invasive methods that include injected anesthesia and supervised anesthesia may be applied.

Injected Anesthesia

The injected forms of anesthesia include infiltrative local anesthesia, specific nerve blocks, and tumescent anesthesia. One of the major drawbacks of this method of anesthesia is that it requires needles, which can cause anxiety in patients.⁶⁵

Local anesthesia with infiltration is the injection of an anesthetic solution into the tissue. This provides anesthetic effect, but can cause significant tissue distortion. Types of infiltrative local anesthesia include lidocaine, lidocaine buffered with bicarbonate, or lidocaine with epinephrine. However, because of the volume required a local injection of lidocaine with epinephrine from stock solutions could easily make the patient lidocaine toxic.⁶⁶

To avoid significant distortion, specific nerve blocks can be used; they also provide the advantage of less total volume of anesthetic required and less patient discomfort, but they have

the drawback of increased difficulty of administration. Nerve blocks are the injection of local anesthetic near the nerve; they have been used successfully in laser procedures. One retrospective study of nerve blocks in 135 patients with 816 nerve blocks in people undergoing laser procedure showed that complete nerve block was achieved in 96% of cases with complications occurring in only 1.1%.⁶⁷ The complications included transient neurapraxia, vasovagal syncope, and swelling, which cumulatively occurred in less than 1% of the cases. Prolonged neurapraxia, which lasted over 18 hours, was reported in 0.1% of the patients and was believed to be the result of direct intranerve anesthetic injection or nerve trauma from the needle.⁶⁸ The lesions most appropriate for nerve blocks are those contained within a particular skin dermatome that corresponds to a branch of the trigeminal nerve.⁶⁷ There are a number of nerve blocks, e.g., the supra-orbital, infraorbital, supratrochlear, mental, zygomatic-facial, zygomatic-temporal, and nasal. The supraorbital nerve can be blocked below the frontalis muscle just above the periosteum. The supratrochlear nerve can be blocked on the supraorbital ridge ~1 cm medial to the supraorbital notch. The preferred method for the infraorbital and mental nerve blocks are the intraoral route into the mucobuccal fold to block the nerve close to the exit of the foramen.^{69–71} The zygomatic-facial nerve may be blocked as it emerges from one or two foramina on the facial aspect of the zygomatic bone. The zygomatic-temporal nerve may be blocked as it emerges from the temporal surface of the zygomatic bone posterior to the zygomaticofrontal suture. The nasal block is a combination of three nerve blocks the external nasal, infratrochlear, and the external branches of the infraorbital nerve.

Tumescent anesthesia (TA) is a specialized form of injected anesthesia that involves a large volume of dilute anesthetic solutions with lidocaine into the subcutaneous fat compartment resulting in the bulging of targeted areas. Epinephrine and bicarbonate are often added to the solution of lidocaine with normal saline. The epinephrine causes vasoconstriction slowing the absorption rate of lidocaine and producing profound hemostasis. Bicarbonate helps neutralize the acidic nature of the solution, reduces pain during administration, and speeds up the onset of action of lidocaine. The injection into the subcutaneous fat produces less pain and a slower rate of absorption when compared with injection into the dermis, because, compared to the dermis, fat has fewer nerve fibers and is relatively avascular.

TA has been used successfully in facial resurfacing procedures;^{72,73} it was first used in dermabrasion.⁷² The tumescent fluid was slowly infiltrated into the subcutaneous plane of the face after application of a topical anesthetic. The TA produced adequate anesthesia while promoting tissue firmness and a decrease in blood splatter. However, one of the disadvantages during dermabrasion was that the character and feel of the skin was different, not allowing proper determination of the depth of the dermis based on the fine pinpoint and course bleeding landmarks.⁷³

In laser resurfacing, one technique is a combination of nerve blocks and TA, or just TA in which a “horseshoe” tumescent block is performed on each side of the face

beginning at the temporal hair line and extending sequentially to the preauricular area, jaw, and chin with a mixture of 0.2% lidocaine and 1:1,000,000 epinephrine. Local nerve blocks are then applied to the supraorbital, supratrochlear, infratrochlear, and mental nerves with 1% lidocaine and 1:100,000 epinephrine or one can alternate those nerve blocks with a subcutaneous block just above the eyebrow using the same TA (0.2% lidocaine, 1:1,000,000 epinephrine). Then the upper and lower eyelids are injected with TA from the lateral canthus to the inner canthus. This injection is kept within the dermis (above the orbicularis oculi) to minimize ecchymosis. The nose is then injected with TA first in the nasofacial sulcus below the medial canthus, inferiorly at the columella, and then a small amount of TA in the area of the external nasal branch of the anterior ethmoidal nerve. The face is then tested for sensation using a sharp needle and the remaining anesthetized areas (usually the cheek, lateral to the oral commissure) are then infiltrated with TA.⁷⁴ The advantages of this method for laser resurfacing are no infusion pumps are necessary, the tumescent firmness required for dermabrasion is not necessary,⁷² and postanesthesia recovery is immediate with the anesthetic effect lasting for many hours postoperatively. The use of nerve blocks in the central face and TA for the lateral face and cheeks with a TA solution including 0.2% lidocaine and 1:1,000,000 epinephrine is another method used in laser resurfacing.⁷⁵ The main disadvantage in both these techniques is the extra time required and the multiple needlesticks.

The injected methods of anesthesia provide a stronger level of anesthesia than the noninvasive methods without the need for supervised anesthesia. Drawbacks include needle usage, high volumes and tissue distortion in infiltrative anesthesia, the complexity of nerve blocks and potential complications, and for the combined TA and nerve block methods possible increased procedure time when compared with supervised anesthesia, but this drawback is offset by the decreased postanesthesia recovery time.⁷⁴ An advantage of all the injected forms of the anesthesia is that they do not have the associated risk and personnel required for supervised anesthesia.

Supervised Anesthesia

Finally, the most invasive option for anesthesia used in laser resurfacing is supervised anesthesia. This form of anesthesia carries the most risk; therefore, it requires the patient be chosen appropriately, the staff have appropriate training, and the proper methods of monitoring be used. This type of anesthesia is most effective in cases where the patient is reluctant to undergo the procedure with just local or regional anesthesia for fear of pain or awareness of the procedure. This category can be divided into monitored anesthesia care (MAC) and general anesthesia (GA). GA and unconscious sedation are usually appropriate in the hospital or ambulatory surgery center whereas conscious sedation can be appropriate in an office setting if certain parameters are followed.⁷⁶

One form of MAC is conscious sedation (CS): a medically controlled state of depressed consciousness in which protective reflexes are maintained, a patent airway is maintained continuously by the patient, and appropriate responses can

be elicited to physical stimulation or verbal command.^{77,78} A way of measuring the level of sedation is the Ramsey Sedation Scale, which is broken down into six levels. Levels 2 and 3 are appropriate for an office procedure, as the patient is cooperative (level 2), or drowsy and able to respond to commands (level 3). Levels 5 and 6 are considered GA, where the patient is asleep and has a sluggish (level 5) or no (level 6) response to stimuli.⁷⁹

CS is increasingly being utilized for dermatologic and cosmetic surgery.⁸⁰ The site in which CS is administered should meet certain standards to account for patient safety and ease of anesthetic administration. Examples of these standards are outlined in guidelines published by the Committee on Guidelines of Care of the American Academy of Dermatology, the Accreditation Association for Ambulatory Health Care, and many other sources.⁸¹⁻⁸³ In addition to following the standards outlined, anyone administering this level of anesthesia should have crisis planning customized to the individual office staff. This should be done with written algorithms for prospective problems; e.g., the ACLS algorithms. The facility floor plan and design must also allow for the administration of life-saving care, and monitoring in the operating room or recovery room if necessary be made as easy as possible. The office should be equipped with oxygen, suction sources, emergency cardiac medications, nasal oxygen cannulas, resuscitator bag and assorted masks, oral and nasal airways, endotracheal tubes and stylet, laryngoscope (at least two), continuous pulse oximeter, continuous electrocardiograph, blood pressure monitor, temperature monitor, IV access, and antagonist medications (naloxone and flumazenil), and methods to summon for additional help if necessary.^{77,84} The individual administering the medications for anesthesia should have appropriate clinical pharmacologic training and be legally authorized to administer anesthesia.^{85,86} They should also be designated to monitor the patient while under CS, typically an anesthesiologist or certified registered nurse anesthetist (CRNA).⁷⁶

The candidates for conscious sedation should be selected based on the American Society of Anesthesiologist classification system. The patients should undergo a preliminary medical evaluation and an evaluation by an anesthesiologist prior to the procedure. The candidates usually suitable for office surgery are healthy patients undergoing routine procedures (class 1) and those with mild to moderate systemic disease (class 2); higher classes and those patients with significant cardiopulmonary and/or compromised neurologic status must be considered for the hospital setting.^{87,88} The patient should be informed of the benefits, risk, and limitations associated with the procedure and anesthesia, and an informed consent should be clearly documented. In the case of laser resurfacing one should be extremely cautious with the use of oxygen in close proximity to the laser procedure to avoid the danger of ignition.

In dermatologic surgery, some of the agents used in conscious sedation include midazolam, fentanyl, propofol, and ketamine.⁸⁰ Midazolam is used at a dose of 0.05 to 0.075 $\mu\text{g}/\text{kg}$. It is a water-soluble benzodiazepine (BZD) that has rapid onset and induces sedation, amnesia, and is anxiolytic.

It is the shortest acting of the BZDs with an elimination half-life of 2 hours. Side effects are related to dosage, speed of infusion, patient's age, and the synergistic effect of other analgesics. They include nausea, vomiting, and respiratory arrest which are rare, and can be reversed with IV flumazenil. Another BZD that has been used is diazepam, which is an older agent and often used with the narcotic meperidine even though midazolam is superior in its amnesic potential. Fentanyl is another agent used at a dose of 1 to 2 $\mu\text{g}/\text{kg}$; it is a synergistic opiate that is 100 times more potent than morphine. Fentanyl is highly lipophilic resulting in rapid uptake by the lipid-rich brain; it has a peak analgesic effect after 2 to 3 minutes of IV injection. Side effects are usually seen at high doses ($>8-10 \mu\text{g}/\text{kg}$) and with rapid injection. They include rigidity of the chest wall and bradycardia. These effects are reversible with naloxone. Meperidine is another narcotic used as described above; it has a slower onset of action and a higher incidence of nausea and vomiting. Propofol is also used at a rate of 25 to 50 $\mu\text{g}/\text{kg}/\text{min}$. It is a sedative hypnotic. It is fast acting and has a short initial distribution half-life of 2 to 8 minutes. It has a low incidence of nausea and vomiting, with the benefit of a clear head postoperative state. Side effects include pain on injection, apnea, and hypoxemia. Propofol has no preservatives and contains soybean oil, glycerol, and egg lecithin. Strict sterile technique is required to avoid sepsis, and administration should be within 6 hours of opening an ampoule. Prior to propofol, methohexital was used but caused more nausea and vomiting. Ketamine is also a good agent for analgesia in small doses $< 1 \text{ mg}/\text{kg}$. It is often used with diazepam, and/or propofol. Side effects include dysphoria and hallucinations. A sample regimen of conscious sedation in dermatologic surgery includes establishing an IV line, starting midazolam and fentanyl at the doses given above until the desired level of conscious sedation is achieved based on the Ramsey scale, then beginning propofol administration as described above.⁸⁰

Another option in full-face laser resurfacing is the propofol-ketamine technique with room air and spontaneous ventilation, a type of dissociative MAC.⁸⁹ This method avoids the use of opioids which requires the use of oxygen to maintain the pulse oximeter at $>90\%$.⁹⁰ This method is of great advantage because oxygen is a fire hazard in the presence of lasers, and this technique has a very low incidence (0.6%) of postoperative nausea and vomiting.⁹¹ This method simulates general anesthesia because you have a relaxed surgical field, and a quiet and immobile patient. This method also makes use of glycopyrrolate, a muscarinic anticholinergic with a side effect of dry mouth. To initiate the propofol-ketamine technique 0.2 mg of IV glycopyrrolate was given. Some patients received 2 to 4 mg of midazolam prior to induction to reduce propofol requirements, although a prospective, double-blind, randomized control study has shown there was no significant reduction in the amount of propofol required for either induction or maintenance of anesthesia with midazolam premedication.⁹² The propofol was administered in a dilute (5 mg/ml) solution and titrated until a loss of lid reflex, and a loss of verbal response. Once this was achieved 50 mg IV bolus of ketamine was administered. Then the main branches

of the trigeminal nerve (supraorbital, supratrochlear, infraorbital, and mental) and the zygomatic-temporal and zygomatic-facial branches were blocked with 2% lidocaine with 1:100,000 epinephrine. Afterwards, a field block of 1% lidocaine with 1:100,000 epinephrine was injected along the facial perimeter.⁹⁰ In this retrospective study, 95 patients were all satisfied with the anesthetic in laser resurfacing and were willing to have it again. There was also no postoperative nausea and vomiting, hallucinations, recall, or clinical signs of lidocaine toxicity; no patient stayed longer than 60 minutes before being discharged with only 12% requiring postoperative analgesia.⁹⁰ An important part of this technique is achieving appropriate analgesia on the facial nerve blocks. In another study with a variation of this technique on 20 patients with full facial laser resurfacing, there was inadequate analgesia as evidenced by the requirement of postoperative anesthesia in 70% of the patients.⁹³ A possible explanation is that in this study the facial nerve blocks were done with 0.5% lidocaine with 1:400,000 epinephrine. Fentanyl was also used and there was a 35% incidence of postoperative nausea and vomiting, and the patients were allowed to have the pulse oximeter drop as low as 85% on room air.⁹³

Finally, the most invasive form of anesthesia that can be used in laser resurfacing is general anesthesia. GA with endotracheal intubation for full-face laser resurfacing has been an acceptable technique that provides the benefit of airway control that is quickly administered, and allows the administration of adequate narcotic analgesia without concern for respiratory depression.⁹⁴ The main drawbacks are that GA has increased equipment requirement (anesthesia machine, scavenging, endotracheal tube, laryngeal masks airways, and dantrolene) and an increased level of care that all facilities may not have available. The patient is also at risk for malignant hyperthermia if he or she has never been exposed to inhaled halogenated anesthetics before. All the previous requirements discussed for MAC and proper patient selection need to be implemented for GA.

The supervised methods of anesthesia (MAC and GA) in laser resurfacing if used appropriately can produce rapid sedation, allow patient safety, comfort, and enhance physician efficacy. The main disadvantage is the risk associated with the anesthesia and the increased personnel, equipment, and monitoring required.

Conclusion

There are several methods of effective anesthesia available for laser resurfacing procedures. The type of laser resurfacing procedures plays a role in which type to use. The deeper the resurfacing procedure goes, the more pain sensation the patient feels. Noninvasive topical forms have proven to be effective in superficial resurfacing procedures. Cryoanesthesia has also proven to be effective and adds the benefit of a good safety profile and a thermal protective effect. Cryoanesthesia can also be used in conjunction with topical anesthesia to amplify the analgesic effect of either one alone. If more analgesic effect is required, there are more invasive methods of anesthesia. The injected forms of anesthesia include local

infiltrative which is simple, but has the disadvantage of tissue distortion and requiring a significant volume of anesthetic that puts the patient at risk for toxicity. Specific nerve blocks are more difficult to perform, but have the advantage of less anesthetic required and less patient discomfort. Tumescence anesthesia adds the benefit of reduced blood splatter and an immediate postanesthesia recovery effect that lasts for hours. Finally, supervised anesthesia provides the benefit of rapid onset of anesthesia. In monitored anesthesia care, the patient is able to protect his or her own airway; in general anesthesia, the airway is maintained by the person administering the anesthetic. The main disadvantages of supervised anesthesia are that an expert needs to administer it and the increased equipment required limits the locations in which it can be provided. The decision on which type of anesthetic used during a laser resurfacing procedure will ultimately depend on both the patient and the provider. Important considerations are the patient preferences, comorbidities, individual pain tolerance, available methods of anesthesia at the facility, and the provider's comfort level with various methods.

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