
A. Local Anesthesia in Hair Transplantation

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IMPORTANCE OF EFFECTIVE ANESTHESIA

The importance of good pain control cannot be overemphasized. A surgeon who performs painless hair transplantation will have a competitive edge over his/her colleagues. Often patients who experience a lot of pain during their first hair transplant session will not return. The result of an unfinished case with a pluggy or thin appearance will give the public a poor impression of hair transplantation in general. One's ability to perform painless hair and scalp surgery is therefore of paramount importance.

Consideration of the Patient's Emotional State

Pain control begins at the first preoperative consultation. The process of obtaining the patient's confidence begins with the patient's initial perception of the surgeon and his/her staff. A prolonged time spent in the waiting room can increase the patient's anxiety; if there is going to be any significant delay, the patient should be sent out of the office until the appointment time. One should avoid mentioning blood, pain, or needles. Before and during surgery, sharp instruments and bloodstained swabs or gloves should be kept out of the patient's sight. There should be no distracting noises, such as bursts of laughter from the staff. Soft background music should be playing. Some patients will be more at ease watching a video of their choice immediately before and during their surgery.

Role of Premedication

Although premedication is mentioned elsewhere in this textbook, it is so fundamental to effective pain control that its importance must be reemphasized. The purpose of premedication is to reduce anxiety, raise the pain threshold, and, in the case of certain benzodiazepines, provide profound amnesia and

counteract the neurological side effects of possible local anesthetic toxicity.

Nearly all of my young healthy patients receive intravenous sedation with midazolam (Versed) because of its brief duration of action and profound amnesic properties. When enough midazolam has been given to mildly impair the patient's intellect, needleless injectors, EMLA cream, 30-gauge needles, and other measures to reduce the pain of infiltration of local anesthetics are not necessary. However much these patients may wince and complain about the pain of the "needles" at the time, they all report at the end of each session that they did not feel or remember any pain at all!

In patients over the age of 60 to 65 years or those with a history of heart or respiratory disease, I avoid intravenous medication but administer intramuscularly a slightly lower dose of midazolam—1.5 to 3 mg, depending on the weight and age of the patient. For those patients reluctant to have any "injection" of a sedative, oral diazepam, 10 to 20 mg, may be administered.

LOCAL ANESTHETICS

Historical Development

Local anesthetics have been used since ancient times when the Incas chewed coca leaves and let their saliva drip into the wounds of trephination to numb pain.¹ Karl Koller was the first to use cocaine, an extract from the coca plant, in surgical practice in 1884; he initially used it as a topical agent for the eye during an operation for glaucoma.² The first regional nerve block using cocaine was performed in 1884 by Halstead.² Local anesthetics gained popularity after procaine was produced in 1904, despite the tendency of these "ester group" local anesthetics to cause local allergic reactions. Lidocaine, the first of the "amide group," was synthesized in 1943. Lidocaine is still the best known and most used local anesthetic. Local anesthetics can be classified into these two groups: the ester group and the amide group (Table 3-1). The ester anesthetics are hydrolyzed in the plasma by an enzyme called *pseudocholinesterase*. Rare individuals with abnor-

TABLE 3-1 Ester and Amide Local Anesthetics and Their Properties

				DURATION OF ACTION (MIN)		MAXIMUM DOSE (MG IN 70 KG MAN)	
GENERIC NAME	TRADE NAME	INFILTRATION DOSE (%)	ONSET OF ACTION	WITHOUT EPINEPHRINE	WITH EPINEPHRINE	WITHOUT EPINEPHRINE	WITH EPINEPHRINE
Esters							
Cocaine		Topical use only					
Procaine	Novocain	0.5-2	Fast	15-30	30-90	500	600
Tetracaine	Amethocaine (pontocaine)	0.25-1	Slow	120-240	240-480	100	—
Amides							
Lidocaine	Xylocaine	0.5-2	Fast	30-120	60-400	300	500
Bupivacaine	Marcaine	0.25-0.5	Slow (15 min)	120-240	240-480	175	225
Prilocaine	Citanest	0.5	Moderate	30-120	60-400	400	600
Etidocaine	Duranest	0.25	Slow	200	240-360	300	400

mal forms of pseudocholinesterase may experience an overdose if they are given a large dose of an ester local anesthetic. Amide anesthetics such as lidocaine are metabolized in the liver and are then excreted by the kidneys. Therefore persons with impaired liver function have reduced tolerance to amide anesthetics.

Dosage and Duration

A vasoconstrictor, usually epinephrine, is added to the local anesthetic used in hair restoration surgery. The main reason for the addition of epinephrine is to limit absorption, enabling the use of higher total dosage and prolonging the duration of action. Most local anesthetics with the exception of cocaine and prilocaine cause vasodilatation by direct relaxation of the vascular smooth muscle. Epinephrine also reduces the bleeding that would result from this increased vasodilatation. (Note that in muscle such as temporalis or occipitalis musculature epinephrine will have the reverse effect of increasing vasodilatation, thereby increasing any bleeding.)³ Other vasoconstrictors such as phenylephrine or ornithine-8-vasopressin (not currently available in North America) have been used.

Local anesthetics such as lidocaine premixed with epinephrine in various concentrations are available; 1:200,000 is the concentration most commonly used. Studies have shown that concentrations greater than 1:200,000 are probably not necessary, and concentrations greater than 1:100,000 are associated with increased side effects.⁴ The New York Heart Association believes that up to 0.2 mg of epinephrine administered subcutaneously is safe even in cardiac patients.⁵ It takes 7 to 15 minutes for the vasoconstriction

caused by epinephrine in these concentrations to achieve its maximum effects, which last for approximately 40 minutes. After 40 minutes further administration of epinephrine often fails to cause further vasoconstriction. Because epinephrine mixed with local anesthetics degrades with time, various acids are added to the premixed commercial local anesthetics to reduce the pH, which slows the degradation of epinephrine. This is important to bear in mind for two reasons. First, these acidic local anesthetics produce more pain on injection than neutral or alkaline local anesthetics. Sodium bicarbonate can be added in the amount of 1 ml of 8.4% sodium bicarbonate for every 10 ml of local anesthetic to reduce pain during infiltration; this mixture is less painful but seems to cause more post-operative edema. Second, acidity that remains after anesthetic effects have worn off may produce tolerance to further local anesthetic injected in the operative site. For both of these reasons, it may be better to mix plain local anesthetic with epinephrine freshly each operation day. A total of 0.1 ml of 1:1000 epinephrine mixed with 20 ml of lidocaine provides a solution of a 1:200,000 concentration of epinephrine.

DURATION OF ACTION

The two most commonly used local anesthetics in hair restoration surgery are lidocaine and bupivacaine. Lidocaine has a fast onset of action, within minutes, and with epinephrine it lasts 60 to 400 minutes.⁶ The shorter duration, 60 minutes, is usually applicable to the hairline area of a young patient's head, whereas the longer duration, 400 minutes, represents the longest period the effects of lidocaine with epinephrine may last in relatively in-



FIG. 3-1 Bottle containing 50 ml of 1% lidocaine (Xylocaine) with epinephrine (the maximum amount allowable for an average patient weighing 70 kg) with 30-gauge needle.

sensitive areas such as the donor area in an older patient. Bupivacaine's onset of action is slower; it often takes 12 to 20 minutes to work, and with epinephrine it may last 204 to 480 minutes (see Table 3-1). This duration of time applies to local infiltration; with peripheral nerve blocks these time intervals may be longer. My experience is that in younger patients the local anesthetic has a shorter duration of action. In general, it is more difficult to achieve adequate local anesthesia in younger patients than in older patients. It should be noted that it is more difficult if not impossible to locally anesthetize inflamed, infected tissues.

MAXIMUM DOSAGE

The maximum dosage of local anesthetic depends on many factors such as the vascularity of the site being infiltrated, concentration of the local anesthetic being infiltrated, age and general condition of the patient, and weight of the patient. For a person weighing 100 kg, the maximum recommended dose of lidocaine given as a 1% solution with 1:100,000 epinephrine is 70 ml or 700 mg (Fig. 3-1). If given as a 2% solution, the maximum dose is 35 ml or 700 mg. This maximum dose must be reduced (or increased) pro rata for patients with different weights (see Table 3-1). The maximum dose must also be reduced for older patients and especially for patients with any liver function impairment. The first signs of toxicity are all neurological, and benzodiazepines counteract all of these early side effects. Many physicians performing hair transplantation now believe that under adequate benzodiazepine cover, the total maximum recommended dose can be considerably increased. Various physicians say they regularly give patients double the pre-

viously recommended maximum dose. However, I believe that such high doses are inadvisable even under benzodiazepine cover, although there is no doubt that with generous intravenous or oral benzodiazepine sedation, doses higher than those previously recommended are quite safe; how high or how safe the dose has not yet been established. For hair transplantation I never have to exceed the traditional maximum dosage (as described in Table 3-1). In transplant sessions involving a large number of grafts in older patients or patients with lighter weights, I may anesthetize the donor area first and the recipient area later. With scalp reductions it is sometimes necessary to give patients high doses of local anesthetics; these patients should definitely receive higher doses of intravenous benzodiazepine if doses of local anesthetics around the maximal levels are going to be administered.

ADMINISTRATION TECHNIQUES

Topical Local Anesthetics

EMLA is the newest and most effective topical local anesthetic at this time. EMLA is a mixture of 2.5% lidocaine combined in a eutectic mixture with 2.5% prilocaine. Topical application under occlusion with plastic provides some superficial anesthesia to the skin but not enough for full-thickness surgery. It has been found to be useful in reducing the pain from needleless injectors. In my experience EMLA does not help unless it is applied in a thick coating covered with an occlusive plastic wrap for 2 hours (Fig. 3-2). (The manufacturer states that occlusive application for 1 hour is adequate, but I have not found this period to be long enough. Dr. Dow Stough and I have independently conducted as yet unpublished double-blind clinical trials that clearly demonstrate that 2 hours is necessary.) I would also stress that EMLA does not seem to make the sensation of either the piercing of skin by a needle or the injection of local anesthetic any less painful, but in double-blind trials it has definitely been found to reduce the discomfort caused by multiple injections of local anesthetics with a needleless injector. Use of occlusive plastic wrap over EMLA for 2 hours before surgery is not conducive to the smooth flow of patients through a busy hair-transplant clinic. I have found that patients either do not place it in the right locations for anesthetization of their hairlines or they do not like waiting at the office before surgery. Therefore I use it only with patients who refuse intravenous sedation or those with whom I am not comfortable administering intravenous sedation such as older patients or those with a history of heart disease. The dose of local anesthetic absorbed systemically from applying EMLA in this manner is negligible.



FIG. 3-2 Thick coating of EMLA cream over the hairline about to be covered by occlusive plastic.

Other methods of applying topical local anesthetics include iontophoresis, the active transport of charged ions across membranes by an electric current. This method is still in its experimental stages.

Needleless Injectors

Several kinds of needleless injectors are available (Fig. 3-3). The most widely used and in my experience the most reliable is the Dermojet (Robbins Instruments, Inc., Chatham, N.J.) (Fig. 3-3, *bottom*). Alternative needleless injectors are the Syrijet (Mizzy, Inc., Cherry Hill, N.J.) (Fig. 3-3, *top*) and the Prestyl (BMA Technologies, Billere, France) (Fig. 3-3, *middle*). Each needleless injector holds a volume of local anesthetic mixture in a reservoir or cartridge. A lever is used to cock the mechanism, and when a trigger is pressed, the needleless injector ejects a set amount of local anesthetic mixture, usually 0.1 ml, which penetrates the skin of the patient superficially. In the case of local anesthetics with added epinephrine, a circular wheal of skin blanching is produced.

Infiltration Techniques

One method of anesthetizing skin for hair transplantation consists of using a needleless injector to make wheals every $1\frac{1}{2}$ inches around the perimeter of the area to be anesthetized. The surgeon then uses a syringe filled with the local anesthetic solution attached to a 1-inch 30-gauge or larger needle. This needle is inserted to its hilt through one of these wheals in the direction of the line of the ring blockage. The plunger of the syringe is withdrawn slightly to ensure that no blood is aspirated into the syringe, indicating that the tip of the needle is not in a blood vessel. With nerve blocks one is more likely to encounter a significantly large blood vessel and the use of a 25-gauge needle is suggested be-

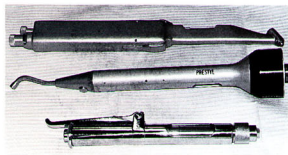


FIG. 3-3 The Syrijet (*top*) (Mizzy, Inc., Cherry Hill, N.J.) is less painful for the patient, but in my experience it is less reliable and less durable than the Dermojet. The Prestyl (*middle*) (BMA Technologies, Billere, France) is the newest and easiest to use needleless injector. It is powered by compressed air and is fired like a machine gun with foot pedal controls. The Dermojet (*bottom*) (Robbins Instruments, Inc., Chatham, N.J.) is the most reliable, commonly used needleless injector.

cause aspiration of blood as a test is more reliable with a larger bore needle. The plunger of the syringe is then pressed, injecting the anesthetic subcutaneously as the needle of the syringe is pulled backward slowly toward its insertion point in the center of the wheal created by the needleless injector (Fig. 3-4). This procedure is repeated for all adjacent wheals until local anesthetic has been infiltrated around the entire perimeter of the area to be locally anesthetized.

When the donor area is being anesthetized, it should be remembered that the nerve supply approaches from the inferior direction, and thus it is necessary to infiltrate only the lower margin of the area to be anesthetized. Similarly, if the recipient area includes hairlines and/or the vertex, most of the nerve supply to this region courses up from the face, and thus most of the local anesthetic for the ring block should be used in the hairline and less in the lateral margins of the area to be anesthetized.

Author's Technique

My own technique currently involves one of two different methods. One method is to use fairly generous intravenous sedation with midazolam and the other is to use a local anesthetic cream along with frequent use of the needleless injector. With generous intravenous sedation the patient invariably does not remember receiving the local anesthetic and one can use a longer and larger needle (such as a $1\frac{1}{2}$ -inch 25- to 27-gauge needle), which is more painful but faster to use. A ring block around the donor or recipient area is thus achieved, with the majority of the local anesthetic inserted into the proximal aspect of the fields to be anesthetized. Be-

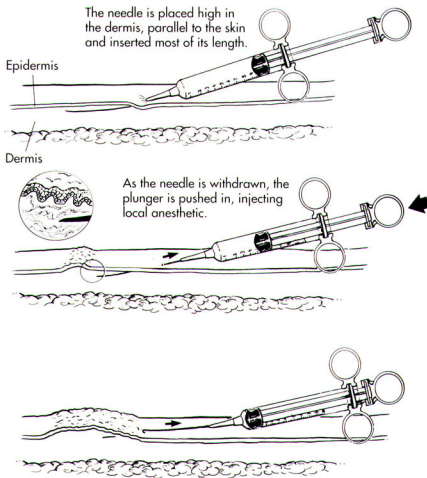


FIG. 3-4 Syringe injecting local anesthetic high in the dermis as the needle is withdrawn.

cause of the profound amnesia patients will experience, use of EMLA, a needleless injector, or a 30-gauge needle is not necessary. In my opinion this technique is the quickest, most effective, and least unpleasant method for locally anesthetizing the patient. The midazolam will counteract any early toxic neurological side effects of the local anesthetic, permitting the administration of larger doses. The disadvantage of using intravenous sedation is that close monitoring of the patient's oxygen saturation level, blood pressure, and pulse is required because intravenous benzodiazepines, especially midazolam, can depress the respiratory drive and blood pressure.

The second method is reserved for those who refuse intravenous sedation or those for whom I do not feel comfortable giving intravenous sedation, as mentioned previously. A thick coating of EMLA is applied to the area requiring infiltration of local anesthesia (see Fig. 3-2), occlusive plastic wrap (such as that used in any kitchen) is placed over it, and the patient is sent away for 1½ hours. When

the patient returns, he is taken to the surgery room and the EMLA and plastic wrap are removed from the donor area, the hair is taped up, and the area is shaved and cleaned in the usual manner. A needleless injector is then used to create series of wheals immediately adjacent to each other along the inferior margin of the selected donor site and up both sides, as shown in Fig. 3-5. With the 30-gauge needle, 1% lidocaine with 1:200,000 epinephrine is injected into each of these wheals very superficially, as is done for a tuberculin test. This injection pattern will create a peau d'orange appearance of the skin. In this manner the ring block is created around the inferior and lateral borders of the donor site. A 30-gauge needle is better than a 27-gauge needle because it is easier to inject smaller doses more precisely and superficially. Injecting more slowly and using local anesthesia warmed to room temperature and buffered with sodium bicarbonate as described all help to reduce the pain of infiltration. The rest of the donor site is then infiltrated with 0.5% lidocaine with 1:200,000 epinephrine. To prepare an



FIG. 3-5 Wheals produced by a needleless injector immediately adjacent to one another, initiating a ring block.

area 1 cm wide by 12 cm long, it generally takes approximately 5 ml of 1% lidocaine and epinephrine and approximately 7 ml of 0.5% lidocaine and epinephrine. This is the way I currently locally anesthetize a typical donor site. This method of very superficial infiltration into the dermis results in a more rapid onset of anesthesia that lasts longer than that achieved with deeper injections. Deeper subcutaneous injection is faster to give, but the effect is slower in onset with shorter duration and is less effective. I should stress that the key to successful and lasting local anesthesia is very superficial injection into the upper dermis (Fig. 3-4). However, should the local anesthesia begin to wear off before the procedure is finished (never the case in the donor area), additional local anesthetic may be infiltrated with a 30-gauge needle to create a *peau d'orange* effect. This reinfiltration should be timed to take place just as the patient is beginning to feel sensation in the anesthetized area, so that the discomfort of this "reanesthetizing" is easily bearable. It is remarkable how little local anesthetic is necessary to reanesthetize; often 1 to 2 ml of 2% lidocaine will reanesthetize an entire hairline. One should *not* wait until the local anesthesia has completely worn off, or the patient will complain bitterly. If necessary, additional intravenous sedation can be given, which will make the second injection better tolerated with regard to pain and total dosage of local anesthetic.

I then finish harvesting the donor grafts and suture the area closed. A pressure dressing is applied, and I then turn my attention to the recipient area. The occlusive plastic wrap is removed and the EMLA is thoroughly cleaned off (this is an important step; severe scarring erythematous reactions have occurred as a result of the needleless injector

"tattooing" EMLA into the skin). The site of application of the EMLA will be apparent either by blanching of the skin or by noting the erythema created by the EMLA. With the needleless injector I then repeatedly inject this "EMLA line," typically just below the hairline, with wheals immediately adjacent to each other with 2% lidocaine with 1:200,000 epinephrine. I then inject more 2% lidocaine with epinephrine with a 30-gauge needle into each wheal very superficially into the dermis, again creating a *peau d'orange* effect. I use 2% lidocaine only in the hairline and 1% lidocaine for the ring block in the lateral margins of the recipient areas. I then infiltrate 0.5% lidocaine with epinephrine over the entire recipient area using a 30-gauge needle. I try to ensure that 5 ml of 2% lidocaine with epinephrine is injected into the anterior hairline in the manner described. I believe this approach is the most effective way of securing complete and lasting local anesthesia to the sensitive hairline area.

Certain details should be noted:

1. The total amount of local anesthetic used should be continuously monitored. One can assume that only approximately one third of what was used with the needleless injector actually penetrates the skin; the remainder splatters off the surface of the skin without being injected.
2. The maximum response of the vasculature from the epinephrine takes 3 to 15 minutes. When a large number of grafts are to be transplanted, I would not delay making recipient sites at all but would apply digital pressure to any bleeding incisions in the recipient area immediately. This vasoconstricting effect is fairly short-lived and will be needed more when the transplanting is actually begun; it often wears off all too soon.
3. The 30-gauge needle is particularly useful because it is easier to be more precise while injecting the local anesthetic superficially into the dermis. In this manner less local anesthetic can be used more effectively.
4. It is more difficult to achieve adequate local anesthesia in younger patients than older patients and the anesthetic wears off sooner. This observation has been an invariable finding of mine. It is well known that most medications are dose for dose more potent in older patients. In my experience younger patients, in general, also have higher anxiety levels.

Tumescent Method

Another method of administering local anesthesia is the tumescent method in which large quantities of very dilute solutions of local anesthetic solutions

with epinephrine are injected into the scalp to make it balloon out. I, and most other hair transplant surgeons I have spoken to who have tried this method, find it more time consuming and difficult than traditional anesthetic techniques because the grafts tend to sink below the surface of the skin, and we find it offers no real advantage in hair transplantation. However, the tumescent method does have its proponents.

Nerve Blocks

Nerve blocks are rarely used for hair transplantation. For scalp reductions and other major hair restoration procedures I use supraorbital, supratrochlear, and occipital nerve blocks. The details of these nerve blocks are beyond the scope of this discussion.

ADVERSE REACTIONS AND THEIR TREATMENT

Toxicity

Toxicity from anesthesia can be divided into neurological and cardiac side effects. Early neurological side effects occurred frequently before the use of significant premedication with benzodiazepines. Early side effects are a chilled sensation, shivering, muscle twitching, and visual disturbances. Perioral paresthesia and numbness are said to be pathognomonic, as is a bitter taste in the mouth. Other subjective CNS symptoms involve sensations of light-headedness and dizziness, visual and auditory disturbances, disorientation, and drowsiness. The rate of injection and rapidity with which a particular blood level is achieved will alter the toxicity of that particular blood level of the local anesthetic drug; that is, the more rapidly absorbed the local anesthetic, the lower the level at which CNS toxicity occurs. More serious signs of CNS overdose include muscle twitching and tremors involving the facial muscles and distal parts of the extremities and then generalized tonic-clonic convulsions. Ultimately these signs of CNS excitation are followed by a generalized state of CNS depression. Respiratory depression and then respiratory arrest may occur. Cardiac side effects occur much later and with a much more serious local anesthetic overdose. (To cause cardiac side effects, the blood level has to be at least double the dosage required to cause neurological side effects.) Initially a decrease in cardiac output occurs; later, profound myocardial depression followed by cardiac collapse occurs. Experimental evidence with animals and humans implies that three to seven times the dose of local anesthetic is necessary to cause cardiac collapse as compared to convulsions.⁷ Bupivacaine is notorious for a more potent effect on the heart, and toxicity can cause severe cardiac arrhythmias.

Drug Interactions

Monoamine oxidase inhibitors and phenothiazines are both contraindicated with local anesthetic agents, and these drugs should be discontinued 2 weeks before surgery. Amiodarone has also been reported to interact adversely with lidocaine.

Epinephrine/ β -Blocker Reaction

Interaction with β -blockers has been well documented. A syndrome of severe hypertension with bradycardia has occurred when lidocaine with epinephrine has been administered to patients currently taking β -blockers. This drug interaction must be extremely rare because these drugs have frequently been given together for years, often deliberately to counter anxiety and epinephrine side effects. However, this syndrome does occur and it is dangerous. My opinion is that lidocaine and epinephrine may be given with β -blockers if the patient cannot discontinue the β -blocker but that the anesthetic must be administered with great caution and in stages, with monitoring equipment and full resuscitative facilities available. Prilocaine, with its lack of vasodilatory effect and its long duration of action, may be a good alternative in cardiac patients, although its tendency to produce methemoglobinemia should be considered in cyanotic heart or pulmonary disease.

Treatment for the epinephrine-propranolol reaction includes intravenous administration of chlorpromazine in 1 mg increments with careful monitoring. No more than 5 mg is usually necessary. A hydralazine drip, 20 mg in 250 ml saline solution, also administered with monitoring, is equally effective. If bradycardia persists after control of hypertension, the patient can be given atropine.⁵

Allergic Reactions

Allergic reactions to local anesthetics are rare and are mainly associated with the ester anesthetics. These allergic reactions may be anaphylactic, delayed and urticarial, contact dermatitis, or a mixture of all three types. Because the ester and amide classes of local anesthetic are antigenically distinct, a patient may react to one group but not the other. Usually the history is somewhat vague and more typical of an anxiety or vasovagal attack or an epinephrine reaction. True allergies to the more commonly used amide anesthetics are extremely rare and are more often caused by the paraben preservatives included in commercial preparations. Preservative-free lidocaine is obtainable, but considering that patch and intradermal testing are not reliable in these cases, it is preferable to use an anesthetic from a different group or even general anesthesia in patients who seem to have had a true allergic reaction to lidocaine. If an anaphylactic reaction occurs

during local anesthesia, it should be treated in the usual manner with intravenous epinephrine, intravenous hydrocortisone, and a tourniquet placed around the skull; the patient should be placed in the Trendelenburg position, given oxygen, and immediately transported via ambulance to a suitable emergency department.

Epinephrine Reactions

Epinephrine reactions are more likely to occur if the epinephrine solution is inadvertently administered intravenously, but they also occur with usual field infiltration. Epinephrine reactions are characterized by anxiety and apprehension, tachycardia, palpitations, and perspiration. These epinephrine reactions are nearly always short and self-limited. The following scenario represents a more serious epinephrine reaction: If the heart rate remains above 140 beats per minute, ventricular tachycardia, premature ventricular complexes (with a frequency of more than six per minute, or closely coupled [R on T phenomenon], multiform, or occurring together in short bursts), the administration of a 100 mg bolus of intravenous lidocaine or intravenous propranolol should be considered.

TREATMENT OF ADVERSE REACTIONS

Syncope

The first step required when an adverse reaction occurs is accurate diagnosis. Distinguishing syncope from other, more serious forms of collapse may be difficult. Syncope is common in the patients of novice, inexperienced surgeons; the patients seem to be able to sense the lack of experience and/or confidence of the surgeon and staff. Syncope is common in physically fit patients who often have high vagal tone. In my experience it is particularly more likely in a patient who has already verbalized anxiety, such as a patient who has said that he hates the smell of hospitals, cannot stand the sight of blood, has a history of syncope, or has been in the waiting room an excessively long length of time. I try to ensure that these patients take 5 to 10 mg of diazepam (Valium) by mouth before leaving home for my clinic, and when they arrive I give them atropine, 0.4 mg intramuscularly (provided they have no tachycardia or hypertension). Syncope is characterized by the patient feeling faint or having nausea and by the appearance of pallor, hypotension, and bradycardia; in fully blown cases the patient loses consciousness. Occasionally a syncopal seizure may occur with simple syncope as a result of cerebral anoxia; however, with any seizure activity one should carefully consider the possibility of local anesthetic toxicity. Usually with syncope the total dosage of local anesthetic (which should continu-

ously be monitored during the course of the procedure) will be well below the traditional maximum amounts; thus, especially if benzodiazepines have also been given, anesthetic toxicity is extremely unlikely. Treatment consists of putting the patient into Trendelenburg position with the legs raised.

Toxicity

With local anesthetic toxicity, one usually knows that a large amount of local anesthetic has been given. Initial subjective symptoms of early toxicity may be present, such as a feeling of being chilled, a bitter taste in the mouth, paresthesia, circumoral and lingual numbness, difficulty hearing, visual disturbance, and drowsiness and confusion. (Drowsiness from benzodiazepines may mask these symptoms.) The next objective signs of toxicity are shivering, muscle twitching, tremors, and loss of consciousness, followed by convulsions.

Treatment of a local anesthetic overdose consists of immediate administration of intravenous benzodiazepine—perhaps midazolam, 5 mg, lorazepam, 3 mg, or diazepam, 15 mg—whichever one the surgeon is most familiar with. This medication should be given by slow intravenous injection over 1 to 5 minutes depending on the urgency. I always leave an intravenous “butterfly needle” in place and keep it flushed with saline solution to keep it patent precisely in case of this sort of eventuality; once a patient has become hypotensive or is convulsing, inserting an intravenous line can be next to impossible.

Administration of oxygen and hyperventilation is the next step. An open airway must be secured and the patient, if conscious, should be asked to hyperventilate. If the patient is unconscious and/or the airway is obstructed, the patient should be intubated and hyperventilated with an Ambu-bag or its equivalent. This is necessary because higher levels of arterial carbon dioxide increase blood flow to the brain, bringing higher amounts of local anesthetic there sooner. In addition, diffusion of carbon dioxide into the nerve cells of the brain lowers their intracellular pH, which results in increased local anesthetic CNS toxicity.⁷ In cats, increasing the PaCO_2 from an average of 32.5 mm Hg to 73 mm Hg decreased the convulsive threshold of prilocaine, lidocaine, and bupivacaine by 50%.⁶ While these first two steps are being effected, one's staff should call for an ambulance. The patient should by now be placed in the Trendelenburg position. Should cardiovascular collapse take place, cardiopulmonary resuscitation must be performed. The staff of any office using intravenous sedation or large amounts of local anesthesia should be trained in basic and advanced cardiac life support and necessary equipment must be on hand.

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B. Nerve Block Anesthesia of the Scalp

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The fear of pain is one of the chief concerns of potential hair transplant patients. Minimizing the discomfort of the anesthetic process is an important aspect of the refinement of the surgical approach. Standard scalp anesthesia in the past has consisted of establishing a ring block with lidocaine and epi-

nephrine, chosen for rapid onset and hemostasis, followed by bupivacaine for more prolonged anesthesia.^{1,2} In our experience the most painful area of the ring block occurs along the frontal hairline. Nerve blocks are useful in this regard because they can substitute a single injection for a larger number of injections and anesthetize a large area with a small amount of anesthetic.¹⁻⁴ Nerve blocks can also be used in conjunction with tumescent anesthesia. The performance of nerve blocks is rarely taught in residency programs, and for this reason many physicians are uncomfortable with the procedure, believing that it requires a high degree of skill and training. Although a detailed knowledge of regional anatomy is required, this procedure is readily learned.

A nerve block involves the infiltration of a small volume of anesthetic around the trunk of a nerve that has a specific and defined anatomical distribution to provide anesthesia to that entire region.^{3,5} Its advantages include the production of a large area of anesthesia with a minimum of discomfort to the patient, as well as a reduction of the total volume of anesthetic required.

ANATOMY

Although scalp anatomy was addressed in Chapter 1, Part D, this section reviews scalp sensory innervation as related to nerve blockade. Sensory innervation of the forehead and frontal scalp is supplied by branches of the frontal nerve, itself a branch of

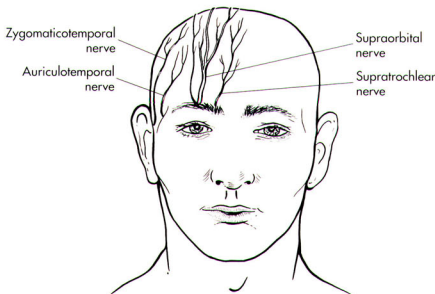


FIG. 3-6 Sensory nerve supply to the forehead and frontal scalp.