Approximately 3 minutes is required for full effect, allowing subsequent injection of local anesthetic. If sedation is inadequate, flows may be safely adjusted to provide 50% nitrous oxide and 50% oxygen. This ratio usually provides sufficient sedation for local anesthetic infiltration in hair transplantation surgery. Concentrations of nitrous oxide as high as 66% have been used without toxic effect.[3] Clearing of mentation usually occurs 10 to 20 minutes after cessation of nitrous oxide administration.

SIDE EFFECTS*

Nitrous oxide is the most commonly used inhalation agent and is considered to have the highest margin of safety of all drugs currently in use for conscious sedation. It has a minimal depressive effect on the respiratory or cardiovascular systems.[4] However, because of its poor solubility, nitrous oxide exits the bloodstream rapidly and enters the alveoli with cessation of administration. This rapid diffusion of nitrous oxide into the alveoli dilutes alveolar oxygen, so-called diffusion hypoxia, which may last from 1 to 2 minutes. This effect can be minimized by administering 100% oxygen for 3 to 5 minutes after discontinuing the nitrous oxide administration. Nausea and vomiting may occur postoperatively in up to 15% of patients. According to our own data, the incidence of nausea is less than 10% in patients undergoing hair restoration surgical procedures.[1]

*This section is taken in part from Sadick NS: Use of nitrous oxide in hair transplantation surgery, *J Dermatol Surg Oncol* 20(3):186-190, 1994.

NITROUS OXIDE

Advantages
Analgesia
Rapid uptake and elimination
Little cardiac or respiratory depression

Disadvantages
Sympathetic stimulation
Expansion of closed air spaces
Interferes with B_{12} metabolism
Limits FIO_2

Modified from Miller FM, Marshall BF: The inhaled anesthetics. In Longnecker DE, Murphy FL, editors: *Introduction to anesthesia*, ed 8, Philadelphia, 1992, WB Saunders.

CONCLUSION

Nitrous oxide is an excellent agent for the preanesthetic induction phase of hair transplantation surgery (see box). It is of great help in reducing pain from local anesthetic infiltration and has an extremely low complication profile, most commonly producing transient, minor mood alterations. It produces significant augmentation of pain threshold for local anesthetic infiltration, causes short-term dissociative effects, and produces no hypersensitivity reactions in contradistinction to other previously described preanesthetic agents.

Nitrous oxide should be added to the armamentarium of preanesthetic agents used during hair transplantation surgery. This modality has been tested in thousands of patients undergoing hair transplantation and has proved to be a useful and safe preanesthetic agent.[5]

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G. Pain Control and Management of the Postoperative Period

David J. Seager

POSTOPERATIVE PAIN

Usual Course

Pain after hair transplantation or scalp reduction is variable both in intensity and duration, between different patients, and even in the same patient between different sessions.

The most common description of pain after hair transplantation by patients in my practice is fairly consistent. Approximately 1 hour after the transplant session has finished, which is usually about 2 hours after the infiltration of local anesthetic into the recipient area, the patient reports a burning or stinging sensation over the recipient area. Patients with low pain thresholds call it pain, but most patients refer to it as mild discomfort. This sensation lasts for approximately 1 to 2 hours. During this

time the local anesthetic in the donor area seems to remain effective, and patients do not complain of pain in the donor area yet. However, 1 to 2 hours later, when the recipient area begins to feel better, the donor area begins to hurt. The pain now felt in the donor area is usually of moderate intensity and remains moderate for 3 to 12 hours, at which time it lessens in intensity and usually becomes quite mild for approximately another 24 hours. One to two days after surgery, this pain usually regresses into a "tenderness to touch" only, which lasts 1 week to 10 days. These intensities and durations can be variable; a fair number of patients (perhaps 25%) say "there was no pain at all," but a few patients (perhaps 1% to 3%) report excruciatingly severe pain in the donor area starting 1 or 2 hours after surgery; on occasion, the pain is severe enough to cause vomiting and diaphoresis. This pain stops immediately after reinfiltration with local anesthetic, first lidocaine with epinephrine for its almost immediate effect and shortly thereafter bupivacaine (Marcaine) with epinephrine for its long duration of action. This is the only instance in which I use bupivacaine in hair transplantation surgery; bupivacaine is longer lasting than lidocaine but more toxic.

Treatment

Treatment of postoperative pain varies tremendously from physician to physician. Shiell rarely if ever prescribes anything stronger than plain acetaminophen (Shiell R: Personal communication, 1992). He says that preparations containing codeine are rarely necessary and do more harm by upsetting stomachs than good by relieving pain. On the other hand, Unger[1] gives patients acetaminophen with 30 mg codeine and usually gives packets of six Percocet (oxycodone and acetaminophen) and six meperidine (Demerol) tablets in case they are needed.

My own routine is to provide every patient who undergoes hair transplantation with a prescription for 20 tablets of Tylenol No. 3 (acetaminophen, 325 mg, and codeine, 30 mg). Extremely rarely, when patients have described severe pain in the donor area before leaving the clinic, I have injected the donor area incision with lidocaine and bupivacaine with dramatic relief of pain. Thankfully, postoperative pain rarely warrants this step, and thus most patients are offered one or two Tylenol No. 3 tablets before leaving the clinic. Approximately 60% of my patients accept them. Some say that they only require plain Tylenol, and a few say they do not require any analgesics. Patients who have particularly severe pain on leaving the clinic, those with a history of severe postoperative pain, or those with a tolerance to codeine are given a prescription for 12 tablets of Percocet with instructions to take one to two every 4 hours as required.

NEURALGIA

Usual Course

Another type of pain sometimes experienced is neuralgia, which usually if not always is felt only in the donor area. Neuralgia generally takes a few days to develop and occurs after a nerve has been either severed or otherwise damaged (e.g., injury by cautery, suture material wrapped around a small branch of a nerve). Neuralgia varies from being fairly mild and lasting only a few days to being extremely severe and lasting for weeks, then lingering for months with milder intensity. Neuralgia is characterized by continuous and/or shooting pains ("like electric shocks") and tingling and hypersensitivity distal to the nerve injury. Patients say that water from the shower falling on the area, combing their hair, or even the blowing of wind causes pain in the hypersensitive area. I perform an average of approximately 20 hair transplant procedures per week in my practice, and about one patient per month complains bitterly about neuralgia, which usually lasts a couple of weeks. However, if every patient is carefully questioned about his postoperative pain, milder forms of neuralgia are found to occur much more commonly but are usually insufficiently severe for the patient to mention. Dr. Pierre Porteaux of France has commented that neuralgia may be more common with the scalpel technique than with the traditional hand engine technique.[2] Stough has had one extremely severe case of neuralgia after transplantation combined with scalp reduction. The neuralgia was described as severe, excruciating, shooting pains across the occiput. The symptoms persisted for 4 months. During this time, local anesthetics led to complete, albeit temporary, relief. The patient was treated with nonsteroidal antiinflammatory agents with limited benefit. Complete resolution occurred after 6 months (Stough DB: Personal communication, April 1994). One patient of mine had severe neuralgia for 6 months that responded partially to amitriptyline (Elavil); hyperesthesia distal to the nerve injury was the principal symptom. Eventually the pain completely resolved.

Neuralgia is definitely a patient-specific phenomenon. When the main neurovascular bundle of the greater occipital nerve is severed completely and then cauterized, many patients feel no pain whatsoever afterward, whereas others report neuralgia after almost any significant incision into skin anywhere on their bodies.

Treatment

Neuralgia can be very difficult to treat. I try to convince patients that after they use all of their original prescription of Tylenol No. 3, they should try to make do with plain Tylenol only because the codeine in the Tylenol No. 3 can become very addictive. When the prescription is renewed once, it is more difficult to say no the third time, and it is easy to fall into the trap of creating an addict.

Other medications are commonly used for treating neuralgia. First-line medications after simple analgesics are tricyclic antidepressants such as amitriptyline followed by anticonvulsants such as carbamazepine (Tegretol) or phenytoin (Dilantin), and lastly by membrane stabilizers such as mexiletine (Mexitil). After all these agents have been tried (and in my extensive experience while pain control physician at a large general hospital, none of these more complex drugs are very effective) and have failed, local anesthetics and long-lasting cortisone agents (such as methylprednisolone acetate [Depo-Medrol], triamcinolone diacetate [Aristocort], or triamcinolone acetonide [Kenalog]) can be injected into the affected nerve. These treatments usually provide only temporary relief. In my experience of treating occipital neuralgia (the usual type of neuralgia encountered in patients who have undergone hair transplantation), firm reassurance regarding the subjective and self-limiting nature of the condition and temporizing is my usual approach. In most cases this suffices.

POSTOPERATIVE EDEMA

Usual Course

After hair transplantation to the front one third of the scalp there is usually some edema of the forehead and periorbital areas. This edema usually does not appear the day after surgery but begins the second day after surgery. It varies tremendously in its extent and duration, but nearly everyone who has even a fairly minimal number of grafts inserted into the front of the scalp will have at least enough edema to eliminate the wrinkles in the forehead. At the other extreme end of the spectrum are those who, after a fairly minor session of hair transplantation, experience massive, disfiguring facial edema that closes one or both eyes. As stated, this process begins on the second postoperative day, usually reaches a peak on the fourth postoperative day, and has usually resolved completely by the sixth or seventh postoperative day. In about 1 in 50 patients, especially after the first transplant session, one or two "black eyes" will develop. This edema starts at the hairline and then drifts inferiorly, affecting next the forehead and the bridge of the nose, then the eyelids, and by the fifth or sixth day it usually resolves through the cheeks. Unfortunately, there is no way of predicting which patients will experience edema or the degree of edema and therefore there is no way to determine exactly who will need prophylactic corticosteroids. Some of my patients have had almost no significant edema after the first and second sessions, yet with a smaller third session, huge periorbital edema developed. In my experience, once edema has begun, ice packs and sleeping while sitting in an upright position have little effect. Because of the lag time it takes for corticosteroids to work, the late institution of cortisone has hardly any effect on shortening the natural course that the edema would have taken to resolve without it.

Prevention

Most experienced hair transplant surgeons routinely administer some type of corticosteroid preparation to most patients without contraindications who are undergoing hair transplant surgery. Perioperative and postoperative steroids have been found to reduce the incidence and degree of postoperative edema (and to a lesser extent, discomfort) after head and neck surgery.[3,4] These steroids are usually given immediately before or after the surgery. The three most common methods of administering steroids are as follows:

1. *Celestone Soluspan (a commercially available preparation of a mixture of betamethasone sodium phosphate and betamethasone acetate), 1 to 2 ml administered intravenously or intramuscularly, often with a sedative at the start of a procedure.* This regimen provides effective blood levels of betamethasone for 5 to 7 days. The downside of this method of administration in my opinion is that once given, it cannot be stopped. Should a serious side effect develop, such as cortisone psychosis, or worse still, a bleeding ulcer, one cannot prevent further worsening effects of the cortisone from continuing. However, this method is an extremely convenient way of administering a corticosteroid, and is probably slightly easier on the gastrointestinal tract than oral preparations, although cortisone by any route can cause a silent ulcer to bleed.
2. *Oral cortisone preparations.* The most common method of using oral cortisone preparations is to prescribe prednisone (physicians usually prescribe doses between 15 to 60 mg) in a single daily dose to be taken as early as possible in the morning with food. This dose is repeated daily for 3 to 5 days, often on a sliding scale. The advantage of the oral route is that

at the first hint of any side effect the prednisone can be stopped. Because of the short half-life of prednisone, side effects and complications usually then cease immediately.

3. *Cortisone preparations added to the local anesthetic to be used to infiltrate into the recipient area.* Norwood[5] advocates adding triamcinolone acetonide to the lidocaine to achieve a concentration of 1 mg/ml of lidocaine solution. This preparation is used in addition to injected and oral steroids. Whether the reduction in postoperative swelling that results from this method is caused by the local effect of the triamcinolone acetonide being injected directly into the dermis or by the systemic effect of the (usually) extra 50 mg of triamcinolone acetonide thus administered is unknown. I suspect that the reduction of postoperative swelling is simply a function of the total dose of steroid received by whichever route. The more cortisone that is administered, the lesser the swelling but with a greater potential for serious side effects. Arnold has reported the occurrence of a folliculitis-like reaction that occurred at injection sites after the addition of triamcinolone acetonide to lidocaine (Arnold J: Personal communication, Jan. 1994).

There are more complex and esoteric protocols for administering cortisone. For instance, some advocate administering 100 mg of hydrocortisone intravenously 1 hour before surgery in addition to oral prednisone because this combination will be effective in preventing damage to the microcirculation as surgery takes place; these drugs are given in addition to large doses of prednisone afterward.

The previously described three methods are frequently used and, with large enough doses, work well. However, even with the use of cortisone doses at the upper limits mentioned, there is often some minor swelling and rarely considerable swelling.

My policy is to discuss with the patient the possible need for the reduction or elimination of probable edema by the use of cortisone and the potential side effects and complications of steroids. Each patient who elects to take cortisone is given a packet that contains four tablets of 50 mg prednisone with instructions to take one whole tablet with his next meal, three fourths of a tablet the next morning with food, one half of a tablet the next morning with food, and a one quarter of a tablet the next morning with food.

CRUSTING

The day after surgery, crusts will form over every graft. These crusts vary in color; they are usually straw-colored but may possibly be white or blood-stained dark red or brown. The duration of time they remain on the scalp depends on the size of the graft. Micrograft crusts usually remain adherent for 5 to 7 days and minigraft crusts usually remain 10 to 14 days, whereas 4 mm graft crusts are usually firmly adherent for at least 2 to 3 weeks. If shortly after surgery these grafts are coated with some moisturizing agent such as an antibiotic ointment or Vaseline or vitamin E oil, they will look a lot messier, but the crusts will come off slightly sooner. These moisturizing agents both decrease the amount of crusting (especially if applied within hours of the end of the procedure) and make the crusts softer and less adherent to the grafts, allowing them to be removed earlier and more easily.

ADVICE TO PATIENTS WHO WEAR HAIRPIECES

Patients who habitually wear a hairpiece before hair transplantation are usually extremely reluctant to abandon wearing the hairpiece. Traditional advice has been that, provided the base of the hairpiece is made of open mesh rather than solid plastic, it may be worn a few days after surgery (provided, of course, no tape is placed over the grafts; clips to existing fringe hair are generally recommended to attach hairpieces after hair transplantation). However, I have spoken to a hair transplant surgeon who performed hair transplantation on a set of identical twins who were identically bald and gave each man the same number of grafts in the same pattern. One wore a hairpiece daily after surgery and the other did not. The twin who wore the hairpiece had noticeably poorer growth than the other (Bedard P: Personal communication, 1992). It was after hearing about this anecdotal evidence that after my own hair transplant, I abandoned the use of the hairpiece I had previously worn daily. I therefore feel dutybound to advise patients in general that they may have better hair growth if they minimize the use of the hairpiece after surgery. Since Dr. Bedard communicated this observation to me, I have more closely inspected the hair growth of many of my patients who continued to wear hairpieces soon after hair transplantation, and it is my opinion that these patients as a whole experience a slightly higher incidence of poor growth than the rest of my patients who have not worn hairpieces. Nonetheless, conventional teaching is that mesh hairpieces do not affect growth.

HAIR GROWTH

Most of the transplanted hair in the grafts will fall out from 1 to 6 weeks after surgery. Much of the transplanted hair that comes out is attached to the

crusts; most of the rest looks as if it is continuing to grow, but it eventually falls out also. Usually only a very small proportion of hairs (especially micrografts in the hairline) will continue to grow continuously from the day of transplantation without shedding. The rest of the transplanted hair in the scalp will begin to regrow anywhere from 7 weeks with minigrafts (especially anteriorly) to 10 to 14 weeks for larger grafts (especially further back from the hairline). With some patients I observed that 20 weeks passed before any hair at all grew after any of the transplant sessions, and yet ultimately they experienced good growth. Some hair transplant surgeons have said that in their experience an occasional graft has not grown until 1 year after hair transplantation (Shiell R: Personal communication, 1993). Not all hairs in the same graft begin to grow at the same time, and a five-hair graft that has only three hairs growing from it 12 weeks after transplantation may well have all five growing by 20 weeks after transplantation. I have observed that hair transplanted at third and fourth sessions may take slightly longer to begin growing than hair transplanted at the first or second sessions, probably because of slightly impaired vascularity. It has also been my observation that these subsequent sessions of slit incisional grafting may actually accelerate the onset and rate of hair growth from previous sessions. This accelerated growth is probably because of the increased blood flow resulting from the inflammation caused by the most recent hair transplant.

MINOXIDIL USE

Many hair transplant surgeons, including myself, believe that hair growth after hair transplantation starts sooner and is more rapid with the topical use of minoxidil. It is also believed that a greater proportion of hairs will not initially shed with minoxidil use. I know of no evidence that hair growth will be any better eventually with or without the use of minoxidil. Because of the expense and some of the fears regarding the potential side effects of minoxidil, I do not offer it routinely to all patients. However, I prescribe it postoperatively to certain selected patients in cases in which I believe I may have crowded the grafts excessively closely together or when I am otherwise concerned about the impaired vascularity of the recipient area. Those patients who are in a hurry for their hair to grow (e.g., grooms-to-be who wish to look good in their wedding photographs) or anyone who requests it because they have heard about it elsewhere will receive a prescription for 2% minoxidil solution (after a discussion about potential side effects) to be applied twice daily until new growth occurs. Some physicians recommend its use the first day after transplantation. However, at this point the scalp is inflamed, and therefore systemic absorption is greatly increased. When I routinely prescribed minoxidil starting the day after surgery, several patients reported palpitations. I now advise patients to wait 1 week before they cautiously begin to use it.

BANDAGING

Bandaging is another subject about which different experienced and successful hair transplant surgeons hold rigid and opposing opinions. For approximately the first two decades of hair transplantation, virtually all hair transplant patients were fully bandaged postoperatively in turbanlike dressings, and even today following most hair transplants the patient's head is bandaged. Either Vaseline gauze covered with antibiotic ointment or sofra-tulle is applied directly to the recipient area (although some surgeons prefer a dry nonstick dressing such as a Telfa pad). These dressings are then adhered to the patient's head by bandaging them into place with a slightly elastic gauze bandage, such as Kling. Many surgeons generally apply some tension around the donor area when applying the bandage so that the bandage acts as a pressure dressing, lessening the risk of hematoma formation. There are a variety of different bandaging techniques (Figs. 3-22 and 3-23) (see Chapter 8, Part B). Those that are wrapped un-

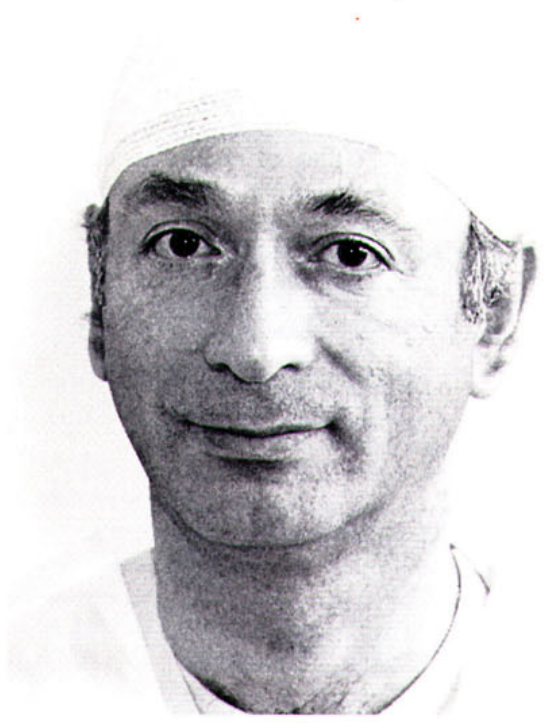

FIG. 3-22 Typical postoperative bandaging.

FIG. 3-23 Bandaging continued under patient's chin is more secure but less tolerated by patients.

der the chin are the most secure but are slightly less accepted by the patients. In fact, being sent home with a turban-type bandage is generally not very well accepted by a lot of patients. A growing number of hair transplant surgeons are sending patients home from surgery without any bandaging at all.

The advantages of bandaging are the following:

1. Any spotting of blood, which is quite common, is concealed. This spotting of blood is worrisome to patients and makes them look all the more unsightly.
2. A great deal of evidence indicates that certain types of bandaging encourage earlier epithelialization and more rapid healing.
3. Should the patient bump his head or let it roll on a pillow, a graft is less likely to be lost.
4. These bandages can be applied immediately after surgery and the patient can be released from the office without delay.
5. A pressure dressing around the donor area helps to lessen the risk of hematoma formation.

Usually the patient is asked to return to the office the next day for the removal of the bandage, at which time the nursing staff washes the patient's hair and cleans off any spotting of blood that may have stained the scalp. The patient is then sent home looking relatively clean.

On the other hand, if the patient is kept in the office for 1 or 2 hours after the completion of surgery, any beading or spotting of blood is meticulously cleansed from around the grafts as it occurs, and pressure is applied to any bleeding points, in most cases the patient's scalp eventually stays clean and spotless. The patient is then sent home and does not need to return the next day or have the psychologically traumatic task of removing a dressing at home. I find that patients prefer to go home wearing a baseball cap rather than a conspicuous turbanlike dressing. The extra work and inconvenience of having the patient wait at the office afterward is more than made up for by not having to tend to him the next day. If the patient sleeps sitting upright, as he should to help prevent swelling, a graft is almost never lost. I have not found any practical difference in the rate of healing or epithelialization by sending patients home without a dressing on the recipient area. However, I apply a dry dressing over the donor area by means of a moderately tight pressure dressing that looks like a headband. I believe this helps to prevent hematoma formation and allows one to be somewhat less meticulous in achieving hemostasis in the donor region (i.e., less cautery and/or use of hemostats). The patient is instructed to remove the pressure dressing 24 hours later. I find that this method of bandaging is more acceptable to patients. However, several patients refuse to wear even the pressure dressing around the donor area, and these patients have the pressure dressing removed before leaving the office. Chapter 8, Part B discusses in detail the specific steps in bandaging.

GENERAL POSTOPERATIVE ADVICE

My advice to patients after hair transplantation is presented in my postoperative handout instruction pamphlet (see Appendix H). Again, much of this advice regarding when to first wash the hair or touch the grafts or perform various types of exercise is determined by each surgeon partly by tradition and partly empirically. My aftercare instructions have been modified from those of several other hair transplant surgeons including Dr. Richard Schiell. I have found they work well in practice and have faced no complications as a result of these instructions.

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