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Electrosurgery – have we forgotten it?

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SUMMARY The recent appearance of lasers has made electrosurgical methods almost obsolete. They seem to be routinely avoided by both dermatologists and their patients. In this paper, the benefits of electrosurgery are emphasized, pointing out that these are easy to master, efficient and low-cost procedures. An overview of the five types of cutaneous electrosurgery (electrodesiccation, electrofulguration, electrocoagulation/electrocutting, electrocautery, and electrolysis) is provided. Special attention is given to the use of electrosurgery in patients with electromedical implants. When performed with care, electrosurgery remains a safe, efficient and low-cost treatment option.

KEY WORDS: electrosurgery, high-frequency electrosurgery, electrodesiccation, electrofulguration, electrocoagulation/electrocutting, electrocautery, electrolysis, risks of electrosurgery

INTRODUCTION

In the new technological era a number of old methods and techniques have been unfairly pushed aside or neglected. One of such techniques is electrosurgery. The main rationale for this remainder on electrosurgical methods is that they present simple, relatively inexpensive and useful methods in daily dermatosurgical practice. The appearance of laser has made electrosurgery unexciting both for dermatologists and their patients. If both methods (laser and electrosurgery) are offered to patient, laser will be chosen more frequently. Laser is also a media sweetheart, being presented from the first day of its introduction and is an extremely attractive tool. The latest papers and reviews on electrosurgery were published in the early 1990s. One could say that everything is known, so no further research is needed. On the other hand, it could be that electrosurgery is just not in vogue.

TYPES OF ELECTROSURGERY

Electrosurgery is a general term for several techniques. It includes electrolysis, electrocoagulation, electrodesiccation, electrofulguration, and electrosection (electrocutting). The last three devices convert 220 V, 50 Hz alternating current into high frequency alternating current, which is then converted to heat energy as it passes through a high resistance medium such as skin. For this reason, some call these procedures high-frequency modalities (1). The currents applied in electrosurgery are high-voltage and high-frequency but low-amperage. The frequencies used are higher than 10,000 Hz since they do not stimulate muscles and nerves with potentially serious consequences, but affect only the local contact area. The effect on the tissue greatly depends on the characteristics of the electromagnetic energy wave applied. High frequency electrosurgical equipment produces radio frequency sine waves. The most common in dermatologic applications are damped sine waves, while cutting current in electrosurgery is undamped. Damped sine waves are characterized by diversified oscillations starting with bursts of high energy that rapidly decreases in intensity. Undamped or pure sine waves involve uniform oscillations. For the reasons that are not fully understood, pure sine waves result in tissue separation without coagulation rather than excessive heat production, and are therefore used in cutting current. As the wave becomes more damped, there is increased hemostasis as well as increased tissue damage and wound healing is prolonged. The cutting currents most commonly used are blend of pure sine wave and damped sine wave. This permits tissue cutting with hemostasis (2).

Electrocautery is usually referred to as one of the electrosurgical methods, because it can produce comparable result in hemostasis, necrosis and coagulation, although the electrical current is not entering the body in this method, but is generated to heat the metal tip of the treatment device (1). This paper describes types of electrosurgery and some common procedures. Foundation for modern high-frequency electrosurgery was laid by D'Arsonval in 1881 when he developed the circuit for generating high-frequency electrical energy. Common medical usage of this modality started in 1928, when William Bovie developed a prototype of the modern electrosurgical generator capable of coagulation and cutting (3).

Electrolysis

Electrolysis has been performed since 1875. It permanently removes hair if dermal papilla is destroyed. Hypertrichosis and hirsutism frequently pose a huge cosmetic problem that should be taken seriously. Endocrinological aspects should be considered with due care and with proper hormonal therapy cosmetic problems will be minimized. Still, a great deal of work is on dermatologists (4). Unwanted hair can be dealt with in several different ways, with either temporary (shaving, depilation, epilation) or permanent (lasers, photodynamic therapy, radiation, electrolysis) treatments. The number of clients wishing to permanently eliminate hair from different parts of the body is continuously increasing. For most of them, laser would be the first choice.

Klingman and Peters presented histological evidence that electrolysis destroys dermal papilla (5). Furthermore, Richards *et al.* demonstrated that destruction of follicular isthmus in electrolysis is sufficient for permanent hair removal (6). Since hair is not an electrical conductor, either direct or indirect current must be transmitted to the hair bulb in order to destroy it. Only if a needle is inserted deeply into the follicle, to carry the current to the germinative bulb, it can result in permanent hair removal. There are two main types of electrolysis, galvanic (direct current electrolysis) and thermolysis (alternating current electrolysis). In galvanic electrolysis, a direct electric current is passed down the needle inserted into the follicle. The current acts on the tissue saline to produce sodium hydroxide, a caustic that chemically destroys the hair bulb and enclosed dermal papilla (7). The chemical reaction ($2NaCl+2H_2O \rightarrow 2NaOH+H_2+Cl_2$) will occur while current is flowing and the metal tip is in contact with the follicle or skin. It is the most effective modality, but rather slow because it requires a minute or more for each hair. In thermolysis, high frequency alternating current passes down the needle and produces heat in follicular tissue by molecular vibration and destroys the hair bulb. So, destruction of the hair follicle is achieved by thermal, not chemical means (8). If thermolysis is uniterminal, it eliminates the need of grounding the electrode. If it is biterminal, it requires grounding or dispersive electrode. Unipolar thermolysis does not generate any heat in the needle or skin surface, only in the tissue that resists the current, so it is less painful than bipolar modality. It is a much faster method, which requires only a few seconds for treatment. Nowadays, dermatologists specialized in the use of electrolysis often apply the so-called bland method, which combines galvanic electrolysis and thermolysis. Needles used in electrolysis must be good electrical conductors and need to have a fine metal diameter (Φ 0.005-0.015 mm). Neither form of electrolysis is safe to apply in patients having pacemakers (9). Telogen hairs are notoriously more resistant to treatment than anagen hairs and thus may be expected to re-grow after the treatment. Major efforts are thus focused on the reduction and elimination of all anagen hairs. How can we know which hairs are in anagen phase? If you recommend a patient to shave the target area 3-5 days before the planned treatment, the hairs visible when they come for treatment are anagen hairs. Unfortunately, some patients refuse to shave because they are scared that shaving will worsen their problem. Telogen hairs are difficult to eradicate permanently due to the short telogen follicle near the surface and the related risks of scarring the surrounding skin tissue (10). In general, the side effects of electrolysis include pain, scarring (especially in patients susceptible to keloid formation), postinflammatory hypopigmentation, hyperpigmentations, and exacerbation of infection (bacterial or viral). Topical anesthetics such as lidocaine or eutectic mixture of local anesthetics (EMLA cream) may be used before treatment, as well as cooling with ice packs. Erythema and edema are common post-treatment problems, but they generally disappear over a couple of hours. Crusting or follicular nodules are usually related to repeated insertion in the same follicle and can persist for a longer period. Patients with any evident infections should be treated before starting electrolysis. Antiviral prophylaxis should be administered to patients with relapses of herpes simple infection (11-13).

Electrodesiccation

The term is derived from the Latin verb *desiccare*, which means “to dry”. Electrodesiccation is a technique which uses high-frequency alternating current of high voltage and low amperage (14). This low amperage results in less heat production, and is therefore less destructive for the tissue. Monothermal device is used in electrodessication, which produces dissipated electrical current, so an indifferent electrode is not needed. In fact, the amount of the current generated is so low that the patient’s body acts as a relative grounding (15). The most common indications are destruction of benign epidermal lesions such as verruca plana, verruca seborrheica, verruca vulgaris, condyloma acuminatum, superficial basal cell carcinoma, and skin tags. Treatments are usually performed in local anesthesia with 1% lidocaine or topical EMLA cream after occlusion for 45-60 minutes. The electrode in contact with the skin produces thermal destruction with relatively easy peripheral control. Due to the possible fire accidents it is recommended to avoid alcohol-containing substances for preparation of skin. It is also necessary to take extra caution while working in perianal region, because colonic gasses can be explosive (16). All electrosurgery techniques produce smoke that can contain intact bacterial or viral particles (like human papilloma virus, hepatitis and HIV), therefore usage of surgical mask and smoke evacuator with changeable filters are compulsory (17). Patients should be informed about the whole procedure, including all possible complications. At our Department, patients receive all information from the operating dermatologist, both in spoken and written form. Since scars usually remain after electrodessication, patients should be warned about this outcome. It is advisable that they sign an informed consent for the procedure. After the treatment, epithelialization occurs within two weeks. What remains is a pink or hypopigmented scar, which is in most cases cosmetically acceptable.

A variety of reusable electrodes are available depending on the desired effect. Sharp electrodes are used for small lesions and precise cutting, blunt type electrodes are used for large lesions, and small-ball electrodes for coagulation (18).

Electrofulguration

The term electrofulguration is derived from the Latin word *fulgur*, meaning lightning. While in lightning there is discharge of atmospheric electricity from cloud to cloud or ground, in electrofulguration the flash occurs as a discharge between the electrode and the patient. This is a technique that also uses high-frequency alternating current of high voltage and low amperage, but the electrode is not in contact with the skin during the procedure. The effect is achieved by the spark that jumps from the electrode to the skin (19). In comparison to electrodessication, this procedure results in even more superficial thermal destruction. Therefore, when treating thicker lesions repeated treatments are needed. The lesions are cleaned with non-alcohol containing preparations and administered in local anesthesia (1% lidocaine or EMLA cream). The treatment is fairly simple. When the device is activated the electrode is moved in side to side fashion to produce a superficial crust of the whole lesion. Moistened gauze or a curette is used to remove crust, and if necessary the treatment can be repeated for thicker lesions. When inspected, the treated area shows satisfactory results, and moist wound care is required until re-epithelialization occurs (16).

Special care is needed for patients with a history of hypertrophic or keloid scars. Also, a conservative approach is needed when treatment is performed on regions at a high risk of scar formation such as anterior chest, presternum, proximal lateral arm, ear lobes, and mandibular angle of the jaw. Indications for electrofulguration are the same as for electrodessication (15). Electrosurgery of small, superficial basal cell carcinoma can result in high cure rates when used selectively. Lesions that are recurrent, larger than 1 cm in diameter, lesions with an infiltrative or morpheaform pattern or those that are located in a high-risk area require surgical approach. The best choices for this therapy are low-risk anatomical sites, trunk and extremities. After cleaning, well-selected basal cell carcinomas can be removed in local anesthesia by electrodessication or electrofulguration with curettage. The first curettage removes friable tumor and provides good visualization of its lateral spread, while the second curettage results in elimination of the tumor. A 3- to 5-mm margin around the curetted defect should be subsequently electrofulgurated or electrodesiccated. It is recommended that this curetting-electrofulguration cycle is repeated two or even three times to improve the cure rate. A standard moist occlusive dressing and wound care are needed and wound healing results in several weeks (20-24).

Electrocoagulation

Electrocoagulation/electrocutting is also produced by a high-frequency alternating current but of high amperage and low voltage (25). Electrocoagulation and electrocutting can be performed by monopolar or bipolar electrode (Fig. 1). Due to its higher amperage, electrocoagulation causes greater heat production in surrounding tissue and deeper penetration. In fact, the heat generated in the tissue tends to cook the tissue in its own fluid. Therefore it produces greater coagulation effect.

Figure 1. Electrocoagulation/electrocutting device – monopolar and bipolar modalities.

The depth of penetration is approximately equivalent to the radius of the lateral blanching. It is important to use a minimal exposure time and the lowest possible setting, because deeper penetration may be enhanced along the neurovascular bundle producing unwanted damage. Operating field should be dry because blood allows diffusion of the electrical current, resulting in less effective coagulation (26,27). Absorption of blood with cotton pads and direct pressure over the bleeding site should be applied to achieve better coagulation. Monopolar electrocoagulation can be performed with either blade or needle tip electrode. Monopolar electrodes produce the current from a pinpoint source and complete the electrical circuit via a large dispersive electrode or plate attached to a distant body site, usually a limb. The technique used with monopolar electrode is to clamp bleeding vessel with a hemostat and then touch the forceps with the electrode. The forceps conducts the current to the vessel where heat is produced. The forceps should be held perpendicularly to the operating field to prevent contact with adjacent tissue and avoid possible unwanted damage. In contrast, a bipolar electrode provides a direct, pinpoint hemostasis. It produces and collects the current via a pair of forceps. During working mode, each tip of the bipolar electrode functions at different time as the active and indifferent electrode so that tissue damage is limited to the tissue between the electrodes. The tissue should be gently touched bilaterally with the forceps tips spread 2 to 3 mm apart and then coagulated. Grasping of the tissue should be avoided. The voltage necessary for tissue coagulation with bipolar electrode is significantly lower than the one required for monopolar electrocoagulation. Coagulation with bipolar electrode thus minimizes adjacent tissue damage (15,16).

The standard device used in electrocoagulation can also be used for electrocutting. Using a knife-like electrode, the device enables fast and precise incisions. Electrocutting procedure requires considerable skill and practice.

Electrocautery

Electrocautery machine works in a completely different manner, but provides good coagulation and hemostasis (Fig. 2). In this technique, electrical current does not enter the patient's body, but is generated to heat the metal tip of the device (27,28). When in direct contact with the tissue, this heated metal tip produces desiccation, necrosis or coagulation, with no current being passed to the

Figure 2. Electrocautery device and different types of metal tips.

patient (29). The most common indications are hemostasis after curettage and shave biopsy, but the method can also be used to destroy ragged edges or remaining fragments, reduce tumor prior to radiotherapy and cut skin tags. The treatment can be performed with or without local anesthesia. Due to the fact that no electrical current is passed to the patient, it is useful in patients with pacemakers, as well as for periorbital surgery. Another advantage is that the tip is simply sterilized by increasing the power. The tip glows red hot burning off any residual debris. When in use, the power level should be set in a way that the tip is not glowing but is hot enough to char a cotton swab easily. If the cautery tip drags on the tissue, the tip is either not hot enough or is being moved too fast across the skin (15,16).

HAZARDS OF ELECTROSURGERY

An accidental burn is one of the most obvious hazards of electrosurgery. Most often this occurs due to unwanted contact of the electrode with the patient's skin, improper technique or a defect in the grounding electrode in a bithermal electrosurgery device. In the presence of flammable materials like alcohol, gauze, paper, oxygen etc., accidental fires occur in electrosurgery units (16).

Patients with cardiac pacemakers face the potential risk of interference with high-frequency electric current. Namely, electrosurgery produces electromagnetic forces that can interfere with functioning of a cardiac pacemaker or defibrillator. Today, most modern pacemakers are the demand type, triggered or inhibited by intrinsic heart beat. Although they are well-shielded and insulated from external electric current, high frequency electrosurgery should be avoided. All types of electrosurgical equipment, except for electrocautery, can cause the problem of inhibition by interference or true interference. Electromagnetic interference can produce profound bradycardia or asystole, pacemaker reprogramming, and even inhibition or damage to the pulse generator. Bradycardia or asystole can occur when the pacemaker detects current produced by high-frequency electrosurgery and recognizes it, by mistake, as the patient's heart pulse, resulting in inhibition by interference. If the pacemaker's programming circuit interprets electrical signal as a command and permanently alters the device, even when electromagnetic interference has ended, the result will be true interference. Two main complications, oversensing and undersensing, are associated with cardiac defibrillators. Oversensing happens when the device mistakenly interprets electromagnetic interference as a malignant pulse, delivering a shock. This can turn heart rhythm into ventricular tachycardia or fibrillation. Undersensing occurs when defibrillator is inadvertently deactivated by electromagnetic interference, leaving the patient unprotected from potential arrhythmia. If electrosurgery is necessary, consultation with the patient's cardiologist is needed. The indifferent electrode should be placed as far from the heart but as close to the operating field as possible. Patients with any type of electromedical implants should avoid electrosurgery, despite the lack of well-documented side effects associated with cutaneous surgical procedures. With the exception of heat conductance when treatment is attempted above the implant, electrocautery provides minimal risk to cardiac devices. It is the least hazardous procedure and should be used whenever possible. If high-frequency methods (such as electrofulguration) need to be used in patients with electromedical implants, the treatment should last less than five seconds. The patient's heart rate should be closely monitored and resuscitation equipment should be readily available. Thorough understanding of electrosurgical procedures and potential cardiac device complications is essential (28,30-32).

Once again, the importance of using smoke evacuator and surgical masks should be emphasized. The smoke generated by electrosurgery has been proven to be carcinogenic and to contain bacterial and viral particles that are hazardous for medical personnel (33).

CONCLUSION

This article has attempted to review the existing electrosurgical methods used in everyday dermatological practice. With the appearance of lasers, some of these procedures have lost in popularity and are rarely used. In our view, these simple to use, efficient and low-cost methods should not be left to oblivion. They can be used for effective treatment of a variety of cutaneous lesions, ablation of superficial parts of tumor (prior to radiotherapy), epilation, and to achieve hemostasis during surgical procedures. Skills required for the use of electrosurgery have been taken for granted by many physicians. Those who use electrosurgery should be familiar with the proper techniques and should have thorough understanding of the basic principles of electrophysics. In addition, safety guidelines must be strictly followed to prevent uncommon complications such as contamination, electrical shock and thermal burns.

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