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Handbook of Transurethral Resection (TUR) Technique

Editor
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Foreword
PN Dogra

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Chapter

3 Diathermy and Lasers: A Resectionist Perspective

M Anandan

INTRODUCTION

Diathermy is one of the inventions which has revolutionized surgery. Based on animal experiments, very high frequency alternating currents, with frequency more than 100–200 kHz were found to be nonexcitatory for the muscles and nerves. These did not alter the cardiac rhythm either. The reason for this being the longer repolarization time of the cells than the current frequency.

The commonly used diathermy machines have frequencies in the range of 0.2–3.3 MHz. This gives a good safety margin to avoid accidental stimulations. The diathermy machines also differ on their power, varying from 50 watts to 400 watts. Typically, surgeries requiring under water cutting need higher power. Machines with 300 watts to 400 watts power are preferred for transurethral resection of the prostate (TURP).

The three mechanisms by which diathermy units or electrosurgery units function are:

1. Cutting
2. Coagulation
3. Fulguration.

The electrical energy from the electrode is converted to thermal energy when it encounters the impedance of body. The amount of heat generated decides whether the tissue is cut, coagulated or fulgurated. If the temperature is higher than 100°C, water within the cells vaporize and the cell ruptures like a blast and membrane breaks down. This "cuts" into the tissues to create the desired effect. The frequency waveforms are typically continuous and relatively low voltage (Fig. 3.1). During TURP, cutting is the main mode used to resect the prostate chips. The current concentration is inversely proportional to the thickness of the loop. Hence, thinner loops are better for cutting.

If the temperature is between 65°C and 90°C, the proteins become denatured and form a coagulum. If the coagulum forms within the blood

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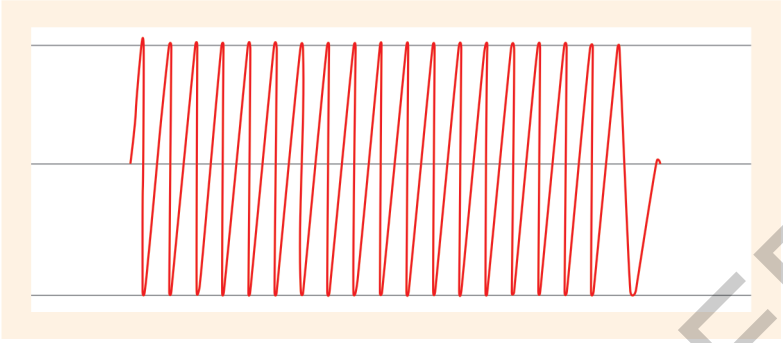


Fig. 3.1: Continuous waveforms of cutting current.



Fig. 3.2: Intermittent pulse waveforms of coagulation mode current.

vessels, the bleeding stops. The other method to stop bleeding is to compress the blood vessels and allow approximation of both the walls of the vessel with a sticky coagulum. This coagulation effect is rendered by the application of current in bursts with high voltage, rather than the continuous form with the cutting current. Coagulation mode is used for control of large arterial and venous bleeders during resection. Thicker loops (the sides of the loop) are better for coagulation (Fig. 3.2).

The third type is the fulguration, where the tissue is not in contact with the electrode. Here electric sparks are generated with very high temperatures of more than 400°C. In such situations, the layer of tissue is "burnt" due to the carbonization of the proteins, sugars and nucleic acids resulting in the formation of carbonized black layer at the surface. Fulguration is useful for diffuse oozing from the prostate surface. Ball electrode uses the fulguration and coagulation principle combined, for better hemostasis.

Any electrical circuit should be completed, for functioning. From the generator, the current circuit should return to the ground or the neural plate. Depending on the whether the current returns through the body or through

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the second lead, it is categorized as monopolar or bipolar respectively. Since the second lead is closeby, the current dissipation is minimal with bipolar diathermy. This is explained in the picture. Monopolar diathermy requires the neutral plate, which is not absolutely necessary with bipolar instruments (Figs. 3.3 and 3.4). The bipolar diathermy is relatively safer for those with pacemaker since there is transmission of current through the body. The stimulation of nerves and is also minimal with bipolar diathermy.

The plasmakinetic resection is a special kind of bipolar resection. In this form of resection, a cloud of plasma is formed around the bipolar loop on activation. This heats up the tissues, vaporizes and cuts them. The main

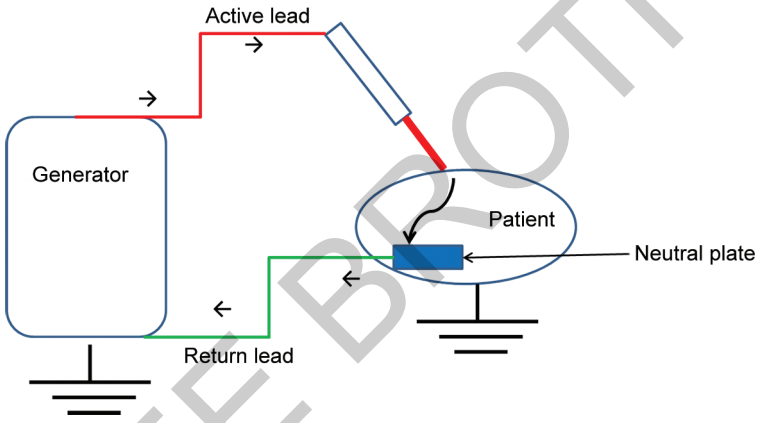


Fig. 3.3: Monopolar circuit—circuit completed through the patient body and the neutral plate.

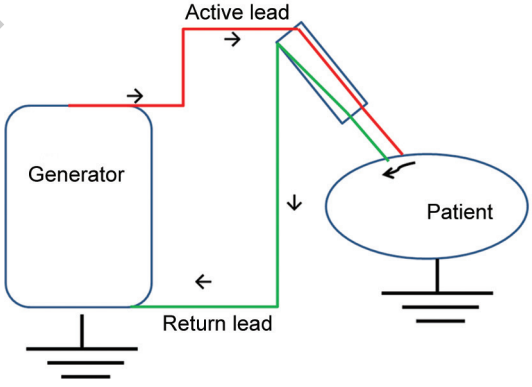


Fig. 3.4: Bipolar circuit. Note that the patient is not forming the transmission part in the circuit.

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effect is local concentrated locally. There is no gross dispersion of current and minimal collateral damage.

The most important patient safety drill in diathermy is the foolproof fixation of neutral plate. The neutral plate provides a wide area of current transfer, so that the heat generated is minimal. The few points to be noted are:

- It should close to the area of surgery—preferably in the thigh, mid-calf, or below buttocks for transurethral surgeries
- The area should be scarless, hairless
- Should not be fixed over bony prominences
- Full contact with skin necessary, partial contact can cause burns
- There should not be any metal contact with the patient's body before between the neutral plate and surgical field.

LASERS

LASER is the abbreviation of "light amplification by stimulated emission of radiation". Laser devices convert electrical energy into light energy. The laser device has three components—(1) the excitation source, (2) the medium and (3) the resonator system. The excitation source produces electrical flash which induces the electrons in the medium into activated state and release photon. This is concentrated into a coherent beam by the resonator. This produces monochromatic, coherent collimated laser beam. Depending upon the medium used, which could be solid, liquid or gas, different wavelengths of lasers are produced, with different effects.

The effect of laser on tissues depends on the reflection, scattering, or absorption of the beam. Reflection causes unintended damage to surrounding tissues and scattering diffuses the beam. The main effect is caused by absorption, which converts light energy to thermal energy. This results in either coagulation or vaporization depends on the temperature reached, similar to diathermy. The main laser energy absorbants of relevance in the prostate tissue are water and oxyhemoglobin. Depending on the variability of laser absorption by these two components, the different lasers have different effects. The more transparent tissues (with less vascularity and hemoglobin) lead to deeper penetration of laser and vice versa. This is depicted as absorption coefficient of tissue. The higher the absorption coefficient, more opaque the tissues are.

The depth of penetration also depends on the wavelength of the lasers. Beams with shorter wavelengths travel shorter distances. The laser intensity, and not the duration of application determine the vaporization. Similar to diathermy, coagulated tissues prevent further penetration of the laser beams.

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Similar to the current waves in diathermy, lasers can be continuous or pulsed lasers. Pulsed wave has more precision and less lateral heat conduction. This minimizes damage to surrounding tissues. The commonly used lasers are Nd:YAG, Ho:YAG, KTP:YAG, Tm:YAG and diode lasers for prostate.

Nd:YAG laser: These lasers have a wavelength of 1,064 nm. It has low absorption coefficient and hence has a tissue penetration of more than 1 cm. Both water and hemoglobin do not absorb these lasers effectively. This causes more coagulative necrosis and is more effective in coagulating the tissues rather than vaporizing or cutting them. Though it was the initial laser used for prostate, it is uncommonly used now due to its inefficiencies. After the prostate surface is coagulated, a necrotic area is formed, which may take days to weeks for sloughing off. Till then patient may experience severe voiding and storage symptoms.

Ho:YAG laser: This is commonly used for prostatectomy. It is a pulsed solid-state laser with a 2,140 nm wavelength and pulse duration of 350 ms. It is well absorbed by water (and tissues with water) and hence heat is dispersed fast. Depth of penetration is 0.4 mm. It causes vaporization of tissues since prostate has high water content and large amount of energy is absorbed. The thermal damage is limited to 0.5–1.0 mm. It is a contact type laser requiring contact of the tip of the fiber with the tissue for activation. Minimal dissipating heat of 2–3 mm helps vessel coagulation.

KTP:YAG laser: This is produced by passing Nd:YAG laser beam through KTP crystal. The wavelength is 532 nm giving a greenish yellow light. It is selectively absorbed by hemoglobin and *not* by water. The penetration depth is 0.8 mm and the system is quasi continuous wave laser with pulses less than 0.25 s. Since the laser is absorbed by hemoglobin, lesser beam penetrates the tissues and blood filled prostate tissue is vaporized rapidly with a 1.0 mm rim of coagulation. Since it is more active in hemoglobin, it is better suited for hemostasis.

Tm:YAG laser: It is a continuous wave with wavelength of 2,000 nm. It is well absorbed by water. The depth of penetration is 0.25 nm. Its use is similar to that of Holmium lasers.

Diode lasers use a special diode for energy generation. Various wavelengths are available—940 nm, 980 nm or 1,470 nm. These are absorbed by both water and hemoglobin and hence have good vaporization and coagulation. Since less thermal waste is induced during diode laser induction, the cooling systems are comparatively smaller than the other lasers and hence the machine is compact.

The laser fibers are designed with different delivery methods. It could be (1) end firing with bare tip or sculptured tip, (2) side firing with metal

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or glass reflector and prismatic internal reflector, (3) interstitial with bare tip, diffuser tip or diffuser tip with temperature transducer.

Side firing is used in Nd:YAG and KTP lasers which are applied to the surface of the prostate, usually without direct contact, resulting in necrosis of the prostate layer by layer. KTP laser causes vaporization and Nd:YAG laser causes coagulation. Holmium lasers are contact lasers which are effective on direct contact with the prostate since they have less depth of penetration. Nd:YAG and KTP lasers have been tried as interstitial lasers, with the fiber inserted into the prostate and forming an area of coagulation necrosis around the tip.

Lasers are generally preferred for the patients on antiplatelets and anticoagulants, and also those with cardiac risks, who may not tolerate fluid overload caused by irrigant fluids.

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Handbook of Transurethral Resection (TUR) Technique

Salient Features

- It is a compendium of basics of uroendoscopy and transurethral resection
- Caters to the need of the beginners in transurethral surgery
- Chapters have been selected to give comprehensive knowledge on the anatomy, preparation and techniques of transurethral resection
- Includes transurethral enucleation resection and holmium laser enucleation to keep the readers up-to-date with the scientific advancements
- Beneficial for the readers with the contributions by the stalwarts of Indian Urology to this book.

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