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Original Research Paper

Surgery

PRINCIPLES AND PATIENT SAFETY MEASURES OF ELECTROSURGERY IN LAPAROSCOPY

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ABSTRACT **Background:** Electrosurgery is one of the most commonly used energy systems in laparoscopic surgery.complications related to electrosurgery in laparoscopy are electrothermal injury, can result from unrecognized energy transfer in the operational field or, less commonly, to unnoticed stray current outside the laparoscopic field of view. Stray current can result from insulation failure, direct coupling, or capacitive coupling.he increase in laparoscopic surgery has resulted in an increased need for a safe and reliable method of obtaining minimally invasive operative hemostasis. Because the traditional "open" methods of controlling bleeding (pressure, tying, and suture (ligating) are not as easily applied in the laparoscopic arena, a heavy reliance on forms of tissue and vessel coagulation is necessary. To better assess these forms, we compare monopolar, bipolar, and ultrasound energy,laser energy,plasmakinetic energy used in a novel application.

AIM: The aim of this study was to compare the effectiveness and safety of various electrosurgical modalities.

MATERIAL & METHODS: A literature search was performed using springer link, PubMed, search engine google, various types of the electrosurgical generator, such as the monopolar,bipolar,ultrasound

KEYWORDS : Electrosurgery,laparoscopy,bipolar,Monopolar,harmonic, safety

INTRODUCTION

Electrosurgery is the most commonly used energy systems in laparoscopic surgery.The surgical team should possess a good understanding of the principles of electrosurgery and tissue effects to stop complications. The risk of complications is linked to the surgeon's fundamental knowledge of instruments, surgical technique, biophysics, relevant anatomy, and safe technical equipment. The risk of complications is linked to fundamental surgical knowledge of instruments, surgical technique, biophysics, and relevant anatomy. Appropriately applied, electrosurgery is safe and effective. Electrothermal injury may result from direct application, insulation failure, direct coupling, and capacitive coupling.[1,2]

Principles of Electrosurgery

The behaviour of electricity in living tissue is generally governed by Ohm's law:

Voltage (V) = current (I) x resistance (R)

Electrical current flows via continuous circuit. Voltage is the necessary electromotive force that mediates or drives this electron movement through the circuit. Heat is produced when electrons encounter resistance. The electricity has the following characteristics, which how it works and how it associates complications: i.e. (i) electricity takes the path of least resistance, (ii) seeks ground, and (iii) must have a complete circuit to do work.[3]

For current to flow, a continuous circuit is required. In the operating room, the circuit is made up of the patient, the electrosurgical generator, the active electrode and the return electrodes. The electrosurgical unit is the source of the voltage.[4–6]

Electrical energy is transformed in to heat in tissue as the tissue resists the flow of current from the electrode. Three tissue effects are possible with today's electrosurgical units—cutting, desiccation, and fulguration.electrosurgical injury depends on the following factors: current density, time, electrode size, tissue conductivity, current waveform.

1. Current density

As expected, the greater the current that passes through an area, the greater the effect will be on the tissue.[4]

2. Time

The length of time a surgeon uses an active electrode determines the tissue effect. Too long time an activation will produce wider and deeper tissue damage. Too short an activation will result in lack of the desired tissue effect.[9]

3. Electrode Size

When it comes to electrode size, smaller electrodes provide a higher current density and creat a concentrated heating effect at the site of tissue contact. Following the similar principle, the patient return electrode used in monopolar electrosurgery is large in relation to the active electrode in order to disperse the current returning to the electrosurgical unit and minimize heat production at this return electrode site.[6–8]

4. Tissue Conductivity

Different tissuehave a different electrical resistance, which affects the rate of heating. Adipose tissue and bone have high resistance and are poor conductors of electricity, while muscle and skin are good conductors of electricity and have low resistance.[7,10]

5. Current Waveforms

- **CUTTING CURRENT.**

Cutting current uses a pure, nonmodulated sinusoidal waveform (Figure 1). This waveform achieves a higher average power when compared with any other alternating waveform of equal peak voltage, allowing the voltage to be limited when compared with coagulation current. The high average power creates a higher current density than is allowed by other waveforms, encouraging a smooth cutting action without extensive thermal damage.

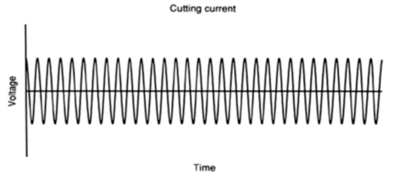

Figure 1

- **COAGULATION CURRENT.**

Coagulation current is portrayed by extensive wave modulation, which produces intermittent bursts of damped sine waves of high peak voltages (Fig. 2). These peak voltages result in high tissue temperatures, and hence significant thermal destruction, making this type of current particularly suited for the coagulation of bleeding vessels.

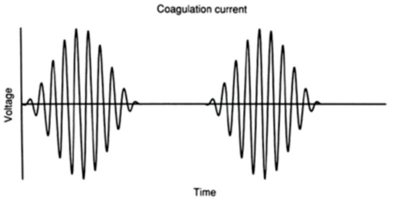

Figure 2

- **BLENDED CURRENTS**

Blended currents allow the surgeon to neatly divide tissue while maintaining a variable degree of hemostasis, depending on the amount of coagulating current utilized. Blended currents are created by modulating a second, lower frequency, higher amplitude sine wave with the sine wave from the cutting generator, producing a higher peak-to-peak voltage. The new waveform is then conveyed in intermittent bursts at a rate determined by the settings of the electrosurgical generator (Fig. 3). This burst effect, although delivered at higher peak-to-peak voltage, contains a lower average power than a pure sinusoidal waveform because of the duty cycle.

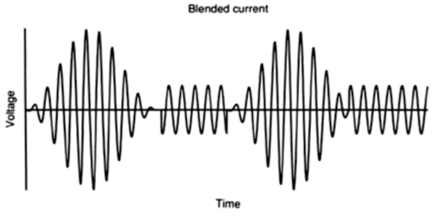

Figure 3

THE ELECTRICAL CIRCUIT

MONOPOLAR, radiofrequency current flows from the generator through the active electrode, into the target tissue, through the patient, the dispersive electrode and then returns to the generator.[11] The most widely injury site is at the patient return electrode. The return electrode must be of low resistance with a large sufficiently surface area to disperse the electrical current without generating heat. If the patient's return electrode is not large enough or is not completely in contact with the patient's skin, then the current exiting the body can have enough density to produce unintended burns. Excessive hair, adipose tissue, bony prominences, and the vicinity of fluid and scar tissue compromise the quality of contact. To keep away this type of injury, contact quality monitoring systems were introduced in 1981. This system inactivates the generator if a condition develops at the patient return electrode site that could result in a burn (Figure 4).

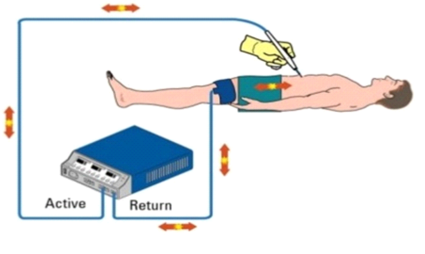

Figure 4

Monopolar circuit

In **BIPOLAR CIRCUIT** the active and return electrodes are located at the site of surgery, typically within the instrument tip. The classical example is the 2 tines of forceps that are the active and return electrode and represent the entire circuit.[9] Most bipolar units use a lower voltage waveform to achieve hemostasis and avoid collateral tissue damage.[4] Bipolar electrosurgery has a more constrained area of thermal spread compared with that of monopolar electrosurgery.[12,13] The maximal lateral thermal spread is within 5mm and the depth restricted to the serosal layer (Figure 5).[13]

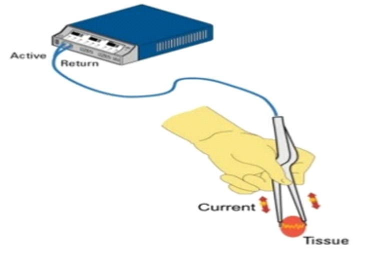

Figure 5

Disadvantages of bipolar electrosurgery include the increased time needed for coagulation due to a low power setting, charring, and tissue adherence with incidental tearing of adjacent blood vessels.

MECHANISMS OF INJURY

- **Direct Application**

This can be as aresult of unintended activation of the electrosurgical probe.

- **Direct Coupling**

One on one coupling happens if your electrosurgical model is usually inadvertently initialized as the lively electrode is usually near yet another metallic instrument. Current from the lively electrode streams over the surrounding instrument over the pathway associated with least amount of resistance, as well as perhaps problems surrounding houses or even internal organs not really in the visual discipline which have been inside immediate contact with the secondary instrument. It might be prevented using creation of the electrode in touch with the target muscle as well as steering clear of contact with any conductive devices before initiating the electrode.[4]Direct coupling happens when an active electrode makes an unintended contact with another electrode or conductive instrument.

- **Insulation Failure**

This is presently thought to be a main cause of laparoscopic electrosurgical injuries. It is defined as a break or defect in the insulation that coats the instrument. Insulation failure is caused by excessive use of reusable instruments, particularly with repetitive passage through trocars and frequent mechanized sterilization.[17] By bringing down the concentration of the current used, coagulation with cutting current and use of an active electrode monitoring system, the risk of accidental burns can be reduced.[6]Disposable instruments have a lower incidence of insulation failure compared to reusable instruments. The distal third of laparoscopic instruments is the most common site of insulation failure.[18]

- **Capacitive Coupling**

Capacitive coupling is electrical current that is established in tissue or in metal instruments running parallel to—but not directly in contact with—the activated electrode. The electromagnetic field around the active electrode created by the alternating current induces electrical energy in any adjacent parallel conductor.

- **Surgical techniques** include hand-eye coordination, speed of procedure, proximity between the electrode and the tissue, and dwell time. During the learning curve, hand-eye coordination difficulties may be encountered involve working in a two-dimension environment with their hands generally disassociated from their eyes, esp. in radically new operative skills[24]. The speed of procedure will result in either less or more coagulation and thermal spread.

ELECTROTHERMAL INJURIES

Injury from inadvertent energy transfer has a reported incidence of 1 to 5 recognized injuries per 1,000 cases.[16]

Most of electrothermal injuries to the bowel (approximately 75%) are unrecognized at the time of occurrence.[16] The result of an unrecognized bowel injury is usually serious, often leading to long-term complications. The small bowel, especially the ileum, is most frequently involved, and the injury may not cause clear-cut or rapid symptoms and abnormal laboratory values.[19] Generally speaking, symptoms of bowel perforation following electrothermal injury are usually seen 4 to 10 days after the procedure. With direct traumatic perforation, symptoms usually occur within 12 hours to 36 hours, although their occurrence up to 11 days later has been reported. The time delay from burn to perforation would appear to be related to the severity of the coagulation necrosis. Features of electrical injuries are distinguished by an area of coagulative necrosis, absence of capillary ingrowth of fibroblastic muscle coat reconstruction, and absence of white cell infiltration, except in focal areas at the viable borders of injury.[20,21]

SAFETY MEASURES FOR PREVENTION OF ELECTRO SURGICAL COMPLICATIONS:

- Use a low-voltage waveform (cut)
- Inspect insulation carefully
- Do not activate in open circuit
- Use the lowest possible power setting
- Use brief intermittent activation
- Do not activate in close proximity or direct contact with another instrument
- Use bipolar electrosurgery when appropriate
- Select an all metal cannula system as the safest choice
- Utilize available technology (tissue response generator, active electrode monitoring) to eliminate concerns about insulation failure and capacitive coupling.
- Use electrode geometry to attain precise coagulation or cutting. Choose a smaller contact patch to achieve cutting and a larger contact patch to to achieve coagulation.
- The tissue needs to be positioned on tension to attain cutting.
- Use the thin wire electrodes to cut. Thick wire electrodes perform poorly simply because they tend to cause coagulation, and cutting and coagulation can't be properly achieved. Thinner wire electrodes may be used for precise bloodless dissection.

NEWER TECHNOLOGIES

- **Active Electrode Monitoring Systems**

In an effort to minimize the risks of insulation failure and capacitive coupling, active electrode monitoring systems now exist. When interfaced with electrosurgical units, these systems continuously monitor and shield against the occurrence of stray electrosurgical currents. Critical to the success of these systems are the integrated laparoscopic instruments that have a secondary conductor within the shaft that provides coaxial shielding.[9]

- **Tissue Response Generator**

Tissue response generators are the next step in the evolution of electrosurgical generators. By using a computer-controlled tissue feedback system that senses tissue impedance or resistance, a consistent electrosurgical clinical effect is obtained through all tissue types.[6]

Vessel Sealing Technology

this technology is the use of bipolar electrosurgery that relies on tissue response generators. This advanced electrical current is combined with optimal mechanical pressure delivery by the instruments to fuse vessel walls and create a seal. Specifically, high current and low voltage are delivered to the targeted tissue and denature the collagen and elastin in the vessel wall while the mechanical pressure from the instrument allows the denatured protein to form a coagulum.22 Vessels up to 7mm in diameter and large tissue bundles can now be surgically ligated. Additionally, thermal spread appears to be reduced compared to traditional bipolar electrosurgical systems. Unlike traditional electrosurgical instruments, these devices require a tension-free application to tissue bundles to successfully obtain the desired tissue effect

- **The LigaSure**

system produces supraphysiological seals with significantly higher bursting pressures than the plasma kinetics sealer (PK, Gyrus Medical, Maple Grove, MN) in vessels ranging from 4mm to 7mm. The plasma kinetics (PK) seal becomes progressively weaker while the LigaSure seal increases in strength as the vessel size increases.[23]

- **PlasmaKinetics**

The word PlasmaKinetics (PK) was made by Gyrus Medical to describe formation of vapor pockets within tissue using bipolar energy. Their PlasmaKinetic (PK) Tissue Management System, which is based on bipolar technology, includes a proprietary PlasmaKinetic generator and particular instruments, designed as a system. The PK system uses high-powered pulsed energy and can supply across medical specialties. It offers vapor pulse coagulation, vessel ligation, in addition to minimal thermal spread and adherence to tissue.

- **The EnSeal instrument**

is Bipolar device feature a unique offset electrode design, which helps contain energy flow within the jaws, reducing lateral thermal spread to approximately 2mm. A polymer compound within the jaw uses Positive Temperature Coefficient (PTC) technology to modulate energy flow. It maintains a tissue temperature of approximately 100°C, minimizing tissue sticking, charring and smoke.

- **Ultrasonic Technology**

The Harmonic scalpel is an ultrasonic surgical instrument for cutting and coagulating tissue, operating at a frequency of 55.5 kHz/second or 55,500 cycles per second.There is no electrosurgical current generated. The combination of mechanical energy and the heat that is generated causes protein denaturation and formation of a coagulum that seals small blood vessels up to 5mm in diameter with less heat, charring, and thermal injury to surrounding tissues.

CONCLUSION

Principles of electrosurgery must be thoroughly understood by all operating room personnel. This forms the basis for patient safety and helps in early recognition of possible complications.Newer technologies with more efficient hemostatic properties must be used whenever appropriate. Safe application of electrosurgical devices lies in the hand of the surgeon. Adherence to standards for careful surgical dissection, appropriate exposure of the surgical field, and a thorough knowledge of anatomy are still necessary regardless of all of the advances in modern technology. Bipolar electrosurgery was much slower than the other modalities, while monopolar electrosurgery caused significantly more tissue damage,the ultrasound technology and other vessel sealing technologies appears to be the safest and most efficacious commercially available device for obtaining hemostasis.

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