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Review article

"Energy devices in gynecological laparoscopy – Archaic to modern era"

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ABSTRACT

The introduction of newer vessel sealing systems has revolutionized techniques of hemostasis during laparoscopic surgery. These devices allow for rapid sequential tissue and vessel sealing, coagulation, and transection. Despite of widespread use of newer advanced bipolar and ultrasonic devices, monopolar and conventional bipolar electro-surgery still carry weightage due to wider range of tissue effect, dissection capabilities, cost effectiveness, and ease of availability. Here in we discussed different types of commonly available energy sources in terms of mechanism, efficacy and safety as thorough knowledge is utmost important for surgeon to choose appropriate instrument for surgical procedure.

Introduction

The origin of electro-surgery dates back to 1877, when P. Bozzini described the construction of a device for electro-cauterization. In 1893 the high-frequency electric current was first used for treatment purposes. Several decades later in 1928, Bovie organized a production of electrosurgical equipment and described three different effects of this energy type: desiccation, dissection, and coagulation, which led to the establishment of fundamentals in modern electro-surgery and converted diagnostic laparoscopy into operative.[1,2] In 1933 fervers, a general surgeon used laparoscopy with electro-surgery to divide intra-abdominal adhesions.[3] Later in 1941, first laparoscopic female sterilization using monopolar energy was performed. The concerns related to the considerable morbidity due to thermal injuries on using monopolar energy contributed to the evolution of bipolar devices in around 1970 by Frangenheim[4] in Germany and by Rioux and Cloutier[5] in North America. The same technique was further refined by Kleppinger,[6] then conventional bipolar devices came into use around 1970.[7]

Hemostasis is basic in all surgical procedures. Traditional methods of staples and clips have gradually been abandoned due to cost, difficulty with repeated applications, and problems of displacement. Standard energy devices monopolar and bipolar coagulation are currently widely used due to their inexpensive nature and reusability. Also the new vessel sealing technologies are so successful that they have largely made the need for laparoscopic suturing of vascular pedicles redundant. However, this involves high instrument cost, thermal spread, and sticking and charring of tissues.[8,9] Monopolar electrosurgery is most commonly used modality in laparoscopic surgeries because of its low cost, general availability, and diverse range of available tissue effects. However, potential shortcomings of monopolar electro-surgery, including the need for a dispersive electrode, the relatively high power settings, the possibility of stray current injuries, and the inability to seal vessels larger than 1–2 mm diameter, led to the development of conventional bipolar electro-surgery.[10]

Commonly used electrosurgical devices in minimally invasive gynecology surgery (Table 1)

Monopolar

Monopolar energy is the most commonly used electrosurgical modality because of its versatility and clinical effectiveness. Electrosurgical generator has "cut" and "coag" settings, cut refers to

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Table 1
Different types of available energy sources and tissue effect produce by them.[23,43]

Type		Tissue effect
Monopolar		Vaporization, fulguration, desiccation, coaptation
Conventional bipolar		Desiccation, coaptation
Advanced bipolar	Ligasure, pk gyrus, ENSEAL	Desiccation, coaptation, tissue transection
Ultrasonic technology	Ultracision harmonic scalpel, Harmonic ACE, Harmonic focus, SonoSurg, AutoSonix	Desiccation, coaptation, mechanical tissue transection
Hybrid device	Thunderbeat	
Laser energy	Nd: YAG laser, Argon laser, CO_2 laser	
Argon beam coagulator	System 7550TM ABC, Cardioblate	
Radiofrequency (RF) energy	RF 3000, starburst, cardioblate	

unmodulated continuous waveform and coagulation refers modulated interrupted waveform. During laparoscopic surgeries continuous waveform results in flow of low energy electron thus minimal smoke production with tissue cutting whereas interrupted waveform is associated with high energy electron flow and more smoke production with high temperature but better hemostasis.[11] Monopolar energy is based on the use of active and passive electrodes. In monopolar electro-surgery, the active electrode is located on the surgical site. The return electrode is located on the patient, at site away from surgical site to complete electrical circuit (cautery plate). The current passes through the patient as it completes the circuit from the active electrode to the patient return electrode.[7,10] It has the ability to use continuous and "mix/blend" current to dissect tissue while providing some hemostasis, fulguration in the interrupted mode which results in adequate hemostasis by carbonizing tissues with high capillary or small vessel density, and coagulation of grasped tissue can be achieved where desiccation occurs and proteins denature resulting in a coagulum formation. Maximum temperature reached after activation is >100 °C.[11–13] The tissue effects possible with monopolar electro-surgery include tissue vaporization and transection, fulguration, desiccation, and small vessel coaptation.

Bipolar

In bipolar energy sources current passes between two active electrodes which are in close proximity to each other unlike the monopolar in which it travels through patient body. As current passes between tips of instrument, it only affects tissue grasped between electrodes. These are relatively safe and more useful as compared to monopolar as it causes minimum collateral spread, reduce risk of interference with other devices and better coagulation.[1] The disadvantage of using conventional electrosurgery are it cannot cut tissue and requires more time to coagulate causing more tissue charring and adherence of tissue which may lead tearing of adjacent vessel causing more bleed.[7] These shortcomings were overcome by advanced new generation bipolar and ultrasonic devices. Conventional electrosurgical devices (monopolar and bipolar) use are associated with stray current injuries like capacitive coupling, insulation coupling, and direct coupling.[13]

Ligasure

The Ligasure™ (Valleylab Inc., Boulder, CO, USA) (LS) vessel sealing instruments use a high-current, low-voltage continuous bipolar radiofrequency energy in combination with a feedback controlled response system that automatically delivers and disrupts the power according to the composition and impedance of the tissue between the jaws of the instruments. It fuses collagen and elastin within the vessel walls, resulting in a permanent seal that can withstand three times the normal systolic pressure, and seals vessels up to 7 mm. Maximum temperature during activation is below 100 °C,[14–17] thus reduces thermal spread to 1 mm with LS Precise and to 1.5 mm with LS V.

Plasma kinetic gyrus

The Plasma Kinetic Gyrus™ (PK) (Gyrus ACMI, Southborough, MA) is a bipolar electrosurgical device that uses plasma kinetic technology to deliver a high current at a very low voltage to the tissue. It has two tier jaw design with serrated surfaces for secure grasping.
A series of rapid pulses allows a cooling phase during coagulation, thereby decreasing lateral thermal spread. It can seal vessel up to 7 mm by denaturing the protein within the vessel walls, forming a coagulum that occludes the lumen. It yields maximum temperature which is below 100 °C.[16] This technology does not have a feedback mechanism like LS and Enseal; however, it allows the physician to choose how long energy is applied with the aid of audible tone change, indicating tissue desiccation to the user. This system has two different modes (vapor pulse coagulation and plasma kinetic tissue cutting) delivering predetermined levels of energy matched to special surgical instruments.[10]

Enseal

ENSEAL™ (Ethicon Endo-surgery, US, LLC) this tissue-sealing and hemostasis system is a bipolar instrument that combines a high-compression jaw with a tissue dynamic energy delivery mechanism. Because of the configuration and the temperature sensitive matrix (Nanopolar thermostats) embedded within the jaws of the instrument, each tissue type within the jaws receives a different energy dose that is constantly changing as the tissue is being sealed and its impedance changes.[10,18] It is the first and only system that controls energy deposition at the electrode-tissue interface.[19] The instrument has a blade that simultaneously cuts the sealed tissue. It can seal vessels ranging in diameter from 1 mm to 7 mm, also sealed vessel walls are capable of withstanding greater than seven times normal systolic pressure.[1]

Ultrasonic devices

In 1993, Amaral first described the ultrasonic scalpel for laparoscopy as having the ability to provide both vessel sealing and tissue transection. However, it gained practical popularity only from 2010 onwards. It produces tissue effects by converting electrical energy into vibrations at more than 20,000 cycles per second which is above the audible range.[15,20] Instrument consist of transducer, hand grip, long shaft and blades. The upper blade, called tissue pad is an inactive one which helps in grasping the tissues and also prevents the vibrational energy from spreading further while lower active jaw vibrates and denatures protein in the tissue to

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