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Review

Review of advanced energy devices for the minimal access gynaecologist

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Key content
- Contemporary energy devices utilise advanced bipolar, ultrasound, hybrid technology, plasma beam and laser energy.
- Each energy modality has specific characteristics influencing its particular benefits and disadvantages.
- Gynaecologists must be aware of the available energy modalities to select the optimum device.
- Minimal access surgeons must demonstrate a comprehensive understanding of their instruments to ensure surgical success and safety.

Learning objectives
- To understand the biophysics of advanced energy devices and their practical applications.
- To review advantages, disadvantages and safety issues associated with each modality and offer practical tips and problem-solving for commonly available devices.
- To enable surgeons to select the optimal device for their surgical tasks.

Ethical issues
- Trainee minimal access surgeons should have solid theoretical knowledge of energy devices before performing hands-on surgery.
- Consideration of the safety aspects of energy devices will enable surgeons to minimise harm to their patients.
- Potentially high investment costs necessitate consideration of the anticipated benefits of energy devices to ensure value for money.

Keywords: bipolar / energy devices / laser / ultrasound

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Introduction

The progression of energy technology has brought to the market various devices delivering safe and efficient haemostasis and dissection. Consequently, minimal access surgeons have many devices at their fingertips. The choice is no longer simply between conventional monopolar or bipolar; a surgeon can choose from advanced bipolar, ultrasound, hybrid, plasma beam and laser energy. This poses an exciting challenge for trainees in gynaecology, who can expect to encounter various devices within their training. The article published in *The Obstetrician & Gynaecologist* by El-Sayed et al.[1] presents a thorough review of safety issues associated with electrosurgery, specifically in relation to conventional devices (CD). This article presents a second chapter in the review of laparoscopic energy devices with emphasis on advanced modalities.

Our aim is to equip gynaecologists with the essential theoretical and practical knowledge required to safely and confidently utilise advanced energy devices. This includes the biophysics underpinning each energy modality, their safety considerations, the advantages and disadvantages of each device, and tips to facilitate usage. It may require several visits to the operating theatre before this familiarity can be achieved. Presenting the information in a summarised form will arm trainees with the theoretical background they require to correctly and appropriately select an instrument and enable them to excel in their minimal access surgery (MAS) experience.

Drive to develop new devices

The evolution of laparoscopic surgery has driven the development of advanced energy devices. Minimal access surgeons are expanding the boundaries of laparoscopic surgery and, correspondingly, manufacturers are striving to deliver safer and more efficient instruments. Advanced devices convey benefits to surgeons throughout the spectrum of technical proficiency. For those embarking upon their MAS training, advanced devices dramatically reduce operating times for laparoscopic hysterectomies.[2] The same reduction in operating times is not seen for surgeons with advanced laparoscopic skills performing standard procedures.[3] However, advanced devices enable experienced surgeons to complete technically complex surgery; for example, radical hysterectomy with pelvic lymphadenectomy, in less time, with the same perioperative outcomes.[4]

Economics of energy devices

The use of advanced energy devices requires consideration of the financial implications. On face value, the purchasing price of advanced energy devices is significantly greater than for CDs and varies between modalities and manufacturers. However, as outlined by Munro,[5] the issue of cost in health care is far more complex. The net increase in cost of using a particular device is equal to the additional capital cost per procedure, compared with the alternative, minus the cost savings. The additional capital cost includes purchasing of energy generators, staff training, device maintenance and cost of single-use components. Examples of cost savings include reduction in operating time, lower complication rates and shorter hospital stays. Evidently, these costs will vary from hospital to hospital, with considerable regional and international variations. Given the complex economics, we have chosen to include a price range for the single-use component of each device for interest only; see Table 1.

Types of advanced energy devices

Advanced bipolar

Advanced bipolar devices (ABDs) combine bipolar electrocoagulation with an integral blade to deliver haemostasis and cutting in one device. Commonly encountered models

Table 1. Comparison of advanced energy devices

	Advantages	Disadvantages	Cost**	Examples
ABD	Consistent vessel seal Haemostasis feedback Seals vessels up to 7 mm in diameter Cut with blade only Independent coagulation	Two-step cut and coagulation Less suitable for fine dissection Greater LTS	£££ £££	Ligasure Enseal PK Cutting Forceps Caiman 5
UD	Fine dissection Haemostasis feedback No radiofrequency energy Avoids neuromuscular activation Reduced surgical plume Reduced LTS vs ABD	Less reliable seal for vessels >5 mm in diameter* Residual heat	££££ £££	Harmonic Sonicision Sonicbeat Lotus
HD	Consistent vessel seal Seals vessels up to 7 mm in diameter Fine dissection Reduced instrument traffic Improved efficiency Haemostasis feedback	Residual heat	££££	Thunderbeat
PD	Precise tissue effect Minimal LTS No residual heat No smoke production	Small vessels only Raised intra-abdominal pressure Potential for gas emboli	£ ££££	Helica TC PlasmaJet SS ABC
LD	Extremely precise tissue effects Minimal LTS Minimal tissue penetrance	Small vessels only Inefficient dissection Staff training Optical damage Implementation cost Maintenance Fire hazard Surgical plume	£££££	Lumenis AcuPulse

Abbreviations: ABD = advanced bipolar device; HD = hybrid device; LD = laser device; LTS = lateral thermal spread; PD = plasma device; UD = ulstrasonic device.
*Harmonic Ace +7 Shears can seal vessels up to 7 mm in diameter
**Cost of single-use component excluding VAT. £ = £0–150, ££ = £150–300, £££ = £300–450, ££££ = £450–600, £££££ = £600+. All prices £GBP. CO_2 laser price includes fibre.

include Ligasure (Covidien), Enseal (Ethicon), PK Cutting Forceps (Olympus) and Caiman 5 (B. Braun) (Figure 1). All ABDs require a specialist energy generator. Most handpieces are single use, except for the reusable Marseal device (KLS Martin). ABDs are licensed to seal vessels up to 7 mm in diameter.

Biophysics

ABDs exert their haemostatic effect by combining high current, low voltage electrocoagulation with mechanical force to denature collagen and elastin in the vessel walls and generate a haemostatic seal (Figure 2).[6]

A key feature of ABDs is the incorporation of technology capable of detecting tissue impendence. Impedance is the opposition to flow of electrical current. The impedance of tissues is a complex concept and depends upon multiple variables. Usually, tissues with higher water content have decreased resistance to electrical current; for example, skin and adipose demonstrate high resistance, whereas muscle, tendon and blood have a relatively lower resistance. Additionally, tissue damage, such as scarring, oedema and eschar, results in higher impedance. The integrated feedback system within the device monitors the tissue impedance to determine when the seal is complete. Subsequently, the generator terminates delivery of energy to the device or signals the surgeon with an audible tone. Computer-controlled feedback systems enable ABDs to deliver consistent and reliable vessel sealing.

How to use

Tissue is grasped between the jaws. Activation of the device results in generation of heat and mechanical compression of the tissue held in the jaw. The device control unit alerts the surgeon, through an audible tone change, when haemostasis has been achieved. Within the handheld unit is an integral blade that can be advanced to cut tissue held in the device. In this way, the device can be used for haemostasis and dissection.

Evidence demonstrates little or no difference between the leading ABDs in terms of surgical outcomes and measurable variables.[7] The choice of ABD will depend upon the surgeon's preference, availability of equipment and cost.

Figure 1. A) Enseal (Ethicon) and B) PK Forceps (Olympus) advanced bipolar devices.

Advantages of advanced bipolar devices

ABDs provide reliable vessel sealing at supraphysiological burst pressures. Burst pressure is defined as the maximal pressure required to overcome the vessel seal. It is important to note that despite producing very high burst pressures, not all devices can consistently provide this seal.[7,8] ABDs can provide coagulation without cutting, such as that required in spot haemostasis. Furthermore, ABDs allow the surgeon to cut tissue without radiofrequency energy; this conveys the advantage of allowing dissection in areas where thermal energy may result in injury. Compared with ultrasound devices (UD), ABDs are less expensive.

Disadvantages of advanced bipolar devices

The jaw design and energy delivery of ABDs leads some surgeons to select alternative devices for finer dissection. Additionally, there is evidence to suggest that ABDs can result in greater lateral thermal spread (LTS) than other advanced energy modalities.[8,9] Haemostatic transection is a two-step process requiring activation of energy followed by deployment of the blade. This can make dissection more cumbersome.

When to use

ABDs are useful when reliable vessel sealing is required, particularly of larger vessels. These devices are an excellent choice when complex dissection is not anticipated, such as basic adnexal surgery or routine hysterectomy.

Tips and tricks

The jaws of ABDs are coated in nonstick material to prevent tissue and eschar from adhering to the device. If tissue does become stuck, it can affect the delivery of energy to the tissue, with a subsequent haemostatic effect. Furthermore, tissue sticking may dislodge a haemostatic seal. Therefore, it is important to keep the instrument tip clean to maximise the function of the device.

Placing the grasped tissue under tension during device activation will reduce the coagulation effect. Therefore, maximum coagulation is best achieved by relaxing the tension on the tissue. Subsequently, the tissue is then placed under tension to optimise the cutting effect of the blade.

Safety issues specific to advanced bipolar devices

All ABDs generate heat with potential dissipation to nearby tissues. Tissue damage occurs at temperatures above 42°C (see Table 2). Heat can spread deep and lateral to the intended target, known as LTS.[1] ABDs can result in LTS up to 7 mm from the intended target.[10] Surgeons should endeavour to maintain a safe margin of 0.5–1.0 cm from vital tissue and use the minimum power setting and activation time required to avoid unintended thermal damage.[7]

Ultrasound

Ultrasonic devices (UDs) were first used for haemostasis in 1988. These instruments utilise ultrasound to seal vessels and cut tissue without the need for an integral blade. These are single-use instruments; examples include Harmonic (Ethicon), Sonicision (Covidien) and Lotus (BOWA Medical) (Figure 3). UDs are licensed to seal vessels up to 5 mm in diameter, except for the Harmonic Ace+ 7 Shears, which can seal vessels with a diameter of 7 mm.

Biophysics

Ultrasonic waves are high frequency sound waves inaudible to the human ear. Piezoelectric materials generate ultrasonic energy when they are placed under mechanical stress. The handpiece of an ultrasound device contains a piezoelectric transducer, which converts electrical energy to ultrasonic energy. This mechanical energy, in the form of ultrasonic waves, is transferred to the active blade of the device causing it to vibrate or oscillate. Depending on the UD, oscillations are torsional, angular or longitudinal at rates from 36 000 to 55 500 Hz. At low energy settings, the mechanical vibrations result in breakage of hydrogen bonds and subsequent denaturation of proteins. The proteins are converted to a coagulum that 'welds' vessels together to form a haemostatic seal. This is known as coaptive coagulation (Figure 2).

Table 2. Biothermal effects

Temperature (°C)	Tissue effect
37	Normal temperature
45–50	Hyperthermia Reduced enzyme activity Necrosis
60–80	Denaturation of proteins and collagen Coagulation and desiccation
100	Vaporisation Ablation
>100	Carbonisation
>300	Melting

The ultrasound scalpel effect is a consequence of cavitation. At higher energy settings the mechanical energy causes the production of small vapour cavities, which collapse to cause cell destruction and tissue dissection. The energy generator is controlled by a microprocessor capable of sensing changes in the acoustic system and subsequently altering energy delivery.

How to use

Tissue is grasped between the jaws of the device. The lower blade is active and generates the mechanical energy. The upper, inactive blade is immobile and holds the tissue in apposition. The surgeon utilises higher energy to cut tissue for the purpose of dissection and lower energy settings to simultaneously coagulate and dissect tissue.

Advantages of ultrasonic devices

A considerable benefit of UDs over bipolar devices is the avoidance of the inherent complications of electrosurgery, such as coupling effects.[1] Furthermore, ultrasound energy does not result in neuromuscular stimulation. Surgeons recognise that UDs demonstrate precise dissection with a small thermal footprint,[8] thus potentially minimising the risk of damage to adjacent structures. In contrast to ABDs, cutting and haemostasis is achieved in one step, resulting in improved ergonomics. UDs tend to generate less smoke plume than ABDs,[9] conveying the benefit of improved visibility and reduced risks of exposure for the surgical team.[11] Sonicision is cordless, with a reusable handheld generator and rechargeable battery. Some surgeons find the absence of a power cable improves freedom of movement, although this comes at the cost of an approximate additional 150 g of weight compared with the Harmonic Ace.

Disadvantages of ultrasonic devices

UDs may be less reliable for haemostasis of larger vessels than CDs and ABDs.[7-9] UDs usually have more expensive operating costs than ABDs.

When to use

UDs are versatile instruments suitable for a variety of procedures, including total laparoscopic hysterectomy and adnexal surgery. However, UDs are particularly favourable for cases requiring complex dissection, such as excision of deeply infiltrating endometriosis, ureterolysis and laparoscopic myomectomy.[12]

Tips and tricks

Like ABDs, placing tissue under tension during activation will result in quicker cutting with less coagulation; relaxing tissue tension has the opposite effect. The force of the surgeon's grip will also affect the balance between cutting and coagulation of tissue. With lighter pressure on the trigger, the surgeon can achieve better coagulation with slower cutting. Conversely, a firmer grip will deliver higher energy and subsequent efficient cutting with less haemostatic effect. Subtle use of instrument rotation can create tension, enhance cutting while improving exposure, and allows fine movement in a tight space. Applying tension to the active blade by twisting will also lift the hot blade away from underlying vulnerable structures.

Energy can be delivered without the need to grasp tissue between the jaws of the device. This is known as 'back-scoring'; a unique feature of UDs. With jaws open, the surgeon places the back of the lower blade in contact with tissue while activating and moving the device.

Safety issues specific to ultrasonic devices

All energy devices generate heat when activated, so have the potential to cause inadvertent tissue damage as a result of residual heat. Residual heat is the temperature of the tip of the device postactivation. It varies with length of activation, the type of device and the device's settings. Ex vivo evidence demonstrates that UDs have significantly higher tip temperatures postactivation and demonstrate residual heat for longer than monopolar, bipolar and argon beam devices.[13]

The following steps are recommended to avoid tissue damage:

- Minimise activation time
- Use the minimal energy setting required
- Use irrigation to cool the tip
- Keep the device in view or remove it from the port and store safely in a surgical quiver when not in use
- Wait before manipulating tissue

Hybrid energy device

Thunderbeat (Olympus) is a hybrid device (HD) combining ultrasound and bipolar energy (see Figure 4). It is currently the only device with this capability. The manufacturers aim to provide a device that combines the optimum vessel sealing of bipolar energy with the efficiency of dissection of ultrasonic energy. The Thunderbeat is licensed for use on vessels up to 7 mm in diameter.[14]

Biophysics

The lateral edge of the upper and lower jaw conducts bipolar energy and a central band on the active blade generates ultrasound. The biophysics of each modality is explained in the ABD and UD sections above. As with other advanced energy devices, Thunderbeat contains an integral feedback mechanism for detecting tissue impedance and moderating energy delivery.

How to use

Tissue is grasped between the toothed jaws. The device has two modes: 'seal and cut' and 'seal'. In 'seal and cut' mode, both ultrasound and bipolar energy are active; this setting is used for dissection and coagulation of vessels up to 7 mm in diameter. In 'seal' mode, only bipolar energy is active; this setting is used for coagulation only and will not cut tissue. It is not possible to activate ultrasound energy independently. The device microprocessor detects when tissue has been sealed or transected and automatically terminates energy delivery.

Advantages of Thunderbeat

Thunderbeat is a versatile instrument with the capacity for effective dissection and reliable haemostasis. Incorporation of multiple functions in a single device results in reduced instrument traffic and consequent improved surgical efficiency. This is demonstrated by the significant reduction in operating times for complex laparoscopic procedures.[4]

Disadvantages of Thunderbeat

Thunderbeat results in high residual tip heat,[15] as demonstrated by all devices exploiting ultrasound energy. Thunderbeat costs more per single-use instrument and requires a specialist generator.

When to use

Its inherent versatility means Thunderbeat can be used for a variety of surgical procedures. However, it conveys greatest advantage when applied in advanced laparoscopic surgery, such as that encountered in gynaeoncology, performing excision of severe endometriosis or laparoscopic myomectomy.[12]

Tips and tricks

Thunderbeat provides dual energies in one platform, which offers the surgeon superior versatility.[15] With tissue grasped between the jaws, it is not possible to activate the ultrasonic energy independently of bipolar energy. However, the surgeon can 'back-score' in the same way as with a UD, thus delivering ultrasound energy independently. To perform fine dissection and minimise tissue sticking caused by coagulum formation, it is important to move the device through the tissues during activation via the 'seal and cut' button. Like ABDs and UDs, applying the correct tissue tension during activation is key to operating the device skilfully.

Safety issues specific to Thunderbeat

Thunderbeat generates higher tip temperatures and takes longer to cool than CDs and ABDs owing to the effect of ultrasound energy.[15] Therefore, it is recommended that surgeons exert the same level of caution as when operating UDs to avoid inadvertent tissue damage as a consequence of residual heat.

Plasma devices

Plasma devices (PDs) utilise radiofrequency energy to create a plasma jet capable of causing superficial haemostasis and cutting. Examples include the PlasmaJet SS (Plasma Surgical), the Helica TC (Helica Instruments) and the ABC (ConMed). These systems include a console with surgeon-controlled settings and a single-use hand-piece (Figure 5). The devices can be used for shallow, unified haemostasis, tissue ablation and superficial tissue cutting.

Biophysics

Plasma is a gas containing free ions and electrons. It can be generated by applying high voltage energy to an inert gas. The handheld component of PDs contains electrodes that ionise a stream of gas as it passes over them (Figure 6).[16] This generates a plasma beam that can be directed to the surgical site.

The highly conductive plasma beam can generate light, kinetic and thermal energy. The light energy illuminates the surgical site and enables the surgeon to visualise the point of application. Kinetic energy from the flow of gas clears fluid or debris from the surface of tissue, creates tissue planes and opens adhered areas. Transmission of highly focused thermal energy predominantly results in tissue ablation and can generate haemostasis through coagulation or desiccation. Additionally, the plasma beam can conduct radiofrequency energy to tissue. The electrical energy principally causes coagulation and desiccation. As desiccated tissue forms, energy is diverted to areas of lower resistance, such as superficial exposed vessels. A superficial layer of coagulation therefore forms.

Surgeons must appreciate how different PDs operate to ensure optimum and safe usage; not all PDs exert their tissue effect through generation of thermal energy, and some devices do not conduct radiofrequency energy. More recently developed PDs, such as the PlasmaJet SS, generate an electrically neutral, thermal plasma beam at very low argon gas flow. Thermal plasma is generated through multiple collisions between electrons in the plasma generating extremely high temperatures (10 000–20 000°C).[18] The

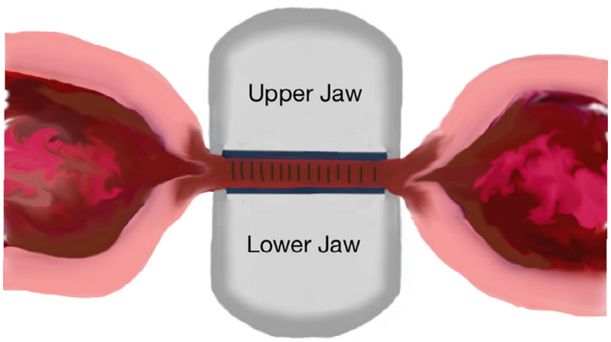

Figure 2. Coaptive coagulation: collagen and elastin fibres crosslink to seal vessel wall.

Figure 3. A) Harmonic (Ethicon) and B) Lotus (BOWA) ultrasonic devices.

Figure 4. Thunderbeat (Olympus) hybrid device.

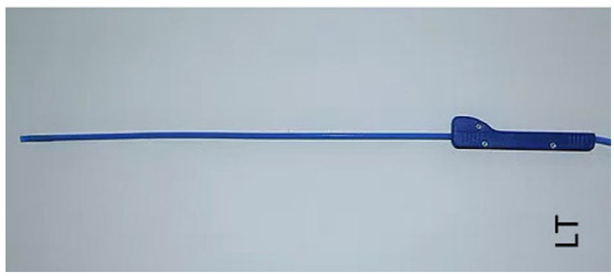

Figure 5. Helica TC (Helica Instruments) plasma device.

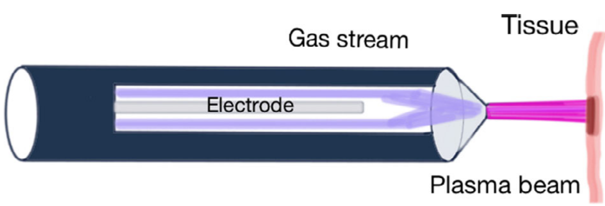

Figure 6. Plasma beam generation.

plasma jet discharges the thermal energy directly to the tissue without conducting electrical energy.

The depth of tissue effect depends upon the penetration of energy. This will vary depending upon the mode of action of the PD, tissue impedance, generator and gas settings and the distance from the tissue.[19]

How to use

The handheld devices can be used in open and laparoscopic procedures. The device is activated in a non-touch method. The beam is emitted from the tip of the device upon activation by a hand switch (PlasmaJet), foot pedal (Helica) or both (ABC). To achieve haemostasis or tissue ablation, the device is held approximately 5 mm from the intended target. To achieve superficial cutting, for example of the peritoneum, the device is held in closer proximity to the tissue. The radiofrequency energy is delivered in a monopolar circuit and requires a dispersive pad (this is not necessary for PlasmaJet).

Advantages of plasma devices

PDs can deliver energy with minimal penetration depths, resulting in superficial thermal effects (up to 2 mm) and minimal LTS (less than 8 mm).[17,20] Altering the power setting and gas flow allows the surgeon to accurately control the depth of penetration. The degree of LTS does not depend upon duration of activation or power settings.[20] Furthermore, the tip of the device will always remain cool, negating any complications caused by residual heat. PDs produce little or no smoke, improving visibility and minimising the surgical team's smoke exposure. Gas is expelled from the device at pressure, pushing debris and blood away from the intended target, resulting in improved visibility and coagulation effects.

Disadvantages of plasma devices

PDs are limited to superficial tissue effects. They cannot coagulate large vessels or efficiently cut dense tissue. PDs with high gas flows can elevate intra-abdominal pressures and necessitate frequent evacuation of pneumoperitoneum.[21]

When to use

The commonest use of PDs is to treat superficial endometriosis, either through ablation or excision of peritoneal endometriotic deposits. PDs may result in better preservation of ovarian function when used to treat ovarian endometrioma compared with cystectomy.[22] PDs are used for devitalisation and shrinkage of tumours and treating tissue overgrowth.

Tips and tricks

This modality performs surgical tasks in a precise 'no touch' manner. Adjusting the 'tip-to-tissue' distance alters the subsequent effect on the tissue. The spectrum of results ranges from superficial surface coagulation through dispersed surface vaporisation, and ultimately focused tissue vaporisation and cutting as the distance is closed.

Safety issues specific to plasma devices

PDs with high gas flows can significantly elevate intra-abdominal pressures during laparoscopy. High intra-abdominal pressures can result in harmful physiological effects; in particular, reduced ventilatory capacity and cardiac output. Surgeons must maintain safe pressure limits. In addition, high flow gases have the potential to result in gas emboli. Case reports have cited incidences of pressurised argon gas entering large open vessels during laparoscopic procedures.[23] As argon and helium gas are not readily soluble, they can potentially pass into the systemic circulation, resulting in fatal gas emboli. To minimise the risk of gas emboli and excessive intra-abdominal pressures, manufacturers recommend the following:

- Use the lowest flow rate required to achieve haemostasis
- Remove the instrument when not in use
- Use gas insufflators with non-defeatable pressure alarms
- Never touch the tissue while the device is active
- Follow the manufacturer's recommendations for use and staff training

Laser devices

'LASER' is an acronym for Light Amplification by Stimulated Emission of Radiation. The gynaecologist is probably most familiar with laser for treatment of cervical intraepithelial neoplasia, emerging vaginal therapies and for treatment of condyloma accuminata. Laser devices (LDs) for use in MAS are less popular than other advanced energy devices because of their high costs and considerable operational requirements. However, some surgeons favour their use when operating close to vital structures, such as the ureter, because of the highly accurate application of energy. Most gynaecologists probably have limited exposure to this modality; therefore, we focus on the commonest encountered CO_2 LDs, such as the Lumenis AcuPulse.

Biophysics

A laser is an instrument that projects a highly concentrated beam of light through the stimulated emission of photons. These photons have the same wavelength, travel in synchrony, and move in the same direction. This results in monochromatic, highly focused and very bright light. The wavelength of the photon, and therefore the colour of light emitted, depends upon the laser medium.

For laser light to exert a tissue effect, cells must first absorb the light. Light energy not absorbed by cells will be transmitted and penetrate deeper tissue. The wavelength of the laser determines which tissue will absorb the light energy.

Additionally, surgeons can vary the amount of energy transmitted to tissue by changing the output wattage, beam focus (the narrower the beam the higher the energy density) and duration of application.[24] The light energy absorbed by the tissue is converted to thermal energy. Subsequent thermal effects on the tissue will depend upon the temperature generated (see Table 2).

CO_2 LDs operate in the infrared spectrum (10 600 nm). They are paired with a low-energy aiming laser to enable surgeons to visualise the beam position. Modern CO_2 LDs use a flexible fibre optic cable to transmit the laser. At long wavelengths (>10 000 nm) light is absorbed by water. This means CO_2 laser energy is readily absorbed by cells. Accordingly, CO_2 LDs demonstrate limited thermal penetrance (0.1–0.5 mm) with minimal LTS (0.5 mm).[25]

How to use

A focusing beam is emitted from the probe, which must be aligned before use. The laser is emitted by activating a foot pedal. As with PDs, this is a no-touch technique, with the probe held at a distance to tissues. To vary the laser action, the surgeon can alter the beam focus to result in vaporisation (narrow beam) or desiccation (wide beam). The power of the laser can be varied with a typical setting of around 30 watts. Finally, the laser can be delivered continuously or in a pulsed mode.

Advantages of laser devices

CO_2 lasers generate minimal thermal penetrance and LTS enabling highly accurate tissue effects.

Disadvantages of laser devices

Equipment, theatre modifications and set-up, device maintenance and staff training are very expensive. There are also important safety issues that must be considered to prevent harm to theatre staff (see below). LDs are less versatile than ABDs and UDs, offering only superficial dissection and haemostasis of vessels up to 1 mm in diameter. CO_2 LDs produce large amounts of surgical plume.

When to use

CO_2 LDs are capable of precise cutting and haemostasis, with limited adjacent tissue damage. Consequently, they are particularly useful for excision of lesions; for example, endometriosis or malignancy close to ureters, bladder and bowel serosa. The superficial haemostatic effect is useful for ablation of endometrioma cyst walls.

Tips and tricks

Varying the speed of movement alters the tissue effect; slow strokes cause cutting, whereas quicker strokes result in ablation. The suction-irrigation instrument can be used to protect distant structures in the line of the laser beam. Additionally, suction-irrigation is required for intermittent evacuation of surgical plume and removal of carbon debris. Pulsed modes are typically used to allow more controlled application of energy when close to vital structures.

Safety issues specific to laser devices

All LDs, including aiming beams, can cause optical damage, ranging from mild corneal burns to irreversible retinal damage. High-power LDs pose a considerable fire hazard through their potential to ignite flammable materials in the operating room. In addition, LDs, especially CO_2 lasers, generate large amounts of surgical plume, posing a further health risk to theatre staff.[11] Departments utilising LDs must adhere to strict safety protocols, including appointing a laser safety officer to supervise all aspects of risk management.[26]

Conclusion

Advanced devices can reduce the learning curve for novice surgeons.[2] For the expert surgeon, advanced devices can improve surgical efficiency.[4] These advances can deliver the benefits of MAS to a greater number of patients.

The surgeon's instrument of choice will depend upon various factors, including the suitability of a device for the intended operation and the surgeon's experience.[7] An awareness of all available energy modalities allows operators to select the optimum device. Additionally, gynaecologists have an obligation to their patients to demonstrate a comprehensive understanding of their instruments to ensure surgical success and safety.

Trainee minimal access surgeons require solid theoretical foundations to optimise their hands-on surgical training. The next step for trainees is to undertake simulator-based laparoscopic training to reinforce this knowledge and embed the practical elements.[27] A curriculum that delivers theoretical and practical components is required to cultivate surgeons capable of safe and successful MAS.[1]

Disclosure of interests

JP is a member of faculty for the BSGE/Olympus Blended Learning Laparoscopic Gynaecology Skills Development Programme 2021.

Contribution to authorship

GB conceived, researched and co-wrote the article. JP researched, co-wrote and critically revised the article. Both authors read and approved the final version.

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