Present and Future Application of Energy Devices in Thoracic Surgery

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KEYWORDS

• Electrosurgery • Minimally invasive surgery • Vascular sealing • Endoscopic procedures • Radiofrequency ablation

KEY POINTS

- There is growing evidence that ultrasonic shears are effective and safe for pulmonary artery branch ligation of 7 mm diameter or less.
- Palliation of esophageal cancer with brachytherapy has been largely replaced by endoluminal stenting.
- Radiofrequency ablation is an interesting treatment option for inoperable patients, although it has been replaced by stereotactic body radiation therapy otherwise known as stereotactic ablative radiotherapy.
- Argon plasma coagulation is useful in the treatment of endobronchial lesions and for hemostasis; its tissue penetration of 2 to 3 mm makes it a relatively safe energy device.
- Cryoablation does not destroy tissue instantaneously; it can control malignant airway lesions in non–life-threatening situations and is contraindicated in life-threatening airway obstruction.

INTRODUCTION

In 1920, Dr William T. Bovie, a physicist at Harvard in collaboration with the neurosurgeon Dr Harvey W. Cushing, created the first electrosurgical unit.[1] Since the creation of this first unit, there have been important developments in the field of energy devices with the emergence of new technologies including ultrasonic devices. Today, the vast majority of surgical procedures performed involve energy devices for tissue cutting, dissection, and vessel sealing.[2] Although most surgeons use these devices in their daily practice, a majority of them are not familiar with the technology behind them, or their applications.[3]

In the last decade, there has been an incremental use of video assisted thoracoscopic surgery (VATS) for the treatment of lung disease owing to the multiple benefits of the procedure, such as decreased pain, decreased morbidity, and shorter

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duration of hospital stay.[4] However, there remains a minority of anatomic pulmonary resections that are being performed by VATS.[5] For example, in VATS lobectomy, the technical difficulty is primarily related to pulmonary artery (PA) branch manipulation and the perceived and actual danger of potentially injuring the PA while using an endostapler. This is owing to the size, rigidity, and footprint of the endostaplers devices. Energy devices have the potential to overcome these limitations, hence making these procedures safer and less stressful for the surgeon, and therefore more prevalent for anatomic pulmonary resections. They have a smaller footprint and are easier to manipulate around short and small PA branches.

In this article, we review the present and future applications of energy devices in thoracic surgery.

ELECTROCAUTERY: MONOPOLAR AND BIPOLAR DEVICES

The concept of electrosurgery refers to the use of a high-frequency electric current to cut tissue and coagulate vessels.[6] In electrosurgery, the flow of electricity requires a complete pathway that includes the electrosurgical generator (high-frequency oscillator and an amplifier) with the patient plates (inactive dispersive electrodes), the connecting cables and the active electrode.[7] The generator is the source of electron flow and voltage, it takes 60 cycles current and increase it to more than 200,000 cycles per second. At this frequency, electrosurgical energy can pass through the patient with minimal neuromuscular stimulation and no risk of electrocution. The patient tissue represents the impedance, producing heat as the electrons overcome the impedance.[8] There are 2 main types of electrocautery devices that are used in electrosurgery: monopolar and bipolar devices.

With monopolar electrosurgery, energy flows from the generator to the active electrode, and then the energy passes through the patient to the dispersive cautery pad, thus completing the electrical circuit.[9] There are 3 main monopolar modes used to produce the different tissue effect: (1) cut, (2) coag, and (3) blend.[10] Cut uses a constant waveform to vaporize (cut) the tissue. Using the coag waveform, the duty cycle is reduced. Coag waveform produces less heat and, instead of vaporization, a tissue coagulum is produced. The blend current is a modification in the duty cycle of these 2 forms.

In bipolar electrosurgery, 2 electrodes serve as the equivalent of the active and dispersive leads in the monopolar mode. The electrical current is confined to the tissue between the tines of the bipolar forceps. The LigaSure (LS) device (Medtronic, Covidien, Boulder, CO) is a bipolar device that delivers high current at a low voltage along with the pressure from the jaw to tissue. However, this system differs from classical bipolar devices, with an incorporated technology that monitors the energy expended while denaturing the collagen and elastin within the vessel walls. During the cooling phase of the cycle, cross-linking re-occurs, creating a new seal.

A study by Lacin and associates[11] in 2007 evaluated the capacity of LigaSure in sealing of PAs. They used the LigaSure device to seal and divide the main lobar PAs and veins in 12 sheep. The sheep were divided into 2 groups. The first group underwent right lower lobectomy and were humanely killed immediately. The second group underwent right upper lobectomy in a 7-day survival model. The vascular dehiscence rate was very high in the first group (2 of 6 PAs and 3 of 6 pulmonary veins >9 mm). There was no vascular dehiscence in the second group that contained pulmonary vessels smaller than 7 mm.

Tsunezuka and colleagues[12] evaluated the bursting pressure of PAs sealed with the LigaSure device in a human model during VATS lung resection. LigaSure was used to seal segmental and subsegmental PAs less than 5 mm in diameter. PAs larger than 5 mm and smaller than 10 mm were secured with proximal ligation with a 1-0 unidentified suture followed by LigaSure sealing. PAs greater than 10 mm were divided using endostaplers. PAs sealed with LigaSure in this study achieved high bursting pressures with higher bursting pressures in PAs smaller than 5 mm compared with PAs larger than 5 mm (607 vs 447 mm Hg). Another group from Japan described the use of LigaSure in the division of intersegmental PA branches in 2 VATS segmentectomies in 2011.[13] However, once again, vessels sealed with LigaSure were secured with proximal ligation. There were no bleeding episodes.

Albanese[14] reported on 14 total energy VATS lobectomies in 3- to 15-month old children. LigaSure was used to transect the main pulmonary vessels and complete the fissure. There were no intraoperative or postoperative complications. Another series of 6 total energy VATS lobectomies in children was published in 2006. The LigaSure device was used to seal the pulmonary lobar vessels, while the bronchi were sealed with interrupted sutures. There were no intraoperative complications. Two patients had postoperative hemothorax, which resolved without a second intervention.[15]

PA ligation and sealing is a critical step in anatomic lung resection. During VATS lobectomy,