CHAPTER 4
ELECTROSURGICAL SYSTEM

Azli Yahya, Ali Adham,
Fauzan Khairi Che Harun, and Mohd Riduan Mohamad

4.1 INTRODUCTION

Electrosurgery (ES) has been a widely employed technique in various surgical procedures for over a century. However, it is interesting to note that, despite its long history, electrosurgery has only been formally recognised as a surgical medium for the past 50 years. Surgery has experienced a significant surge in the last 30 years, and it is widely recognised as a remarkable medical intervention. Microvascular surgery, in particular, frequently makes use of radio frequency instruments. These instruments enable precise control over the amount of radiofrequency electrical current delivered to the delicate tissue being operated on. Researchers are constantly exploring new applications for this innovative technique that utilises a composed electrode. High-frequency energy and mechanical forces are routinely utilised in surgery, where they are transformed into heat to achieve thermal tissue destruction through rapid vaporisation, haemostasis, coagulation, or a combination of these methods. Study by Kanhere (2024), they referenced Cushing and Bovie (1920) research, which introduced the first type of electrosurgical device used on cows. They emphasise the importance of precisely controlling tissue heating to prevent unintended current paths or heat transfer to neighbouring tissues. Similarly, Bashetty et al. (2009) mentioned that improper control could lead to cellular necrosis and injury. Figure 4.1 illustrates an arc created by an electrosurgical generator at the scalpel tip.

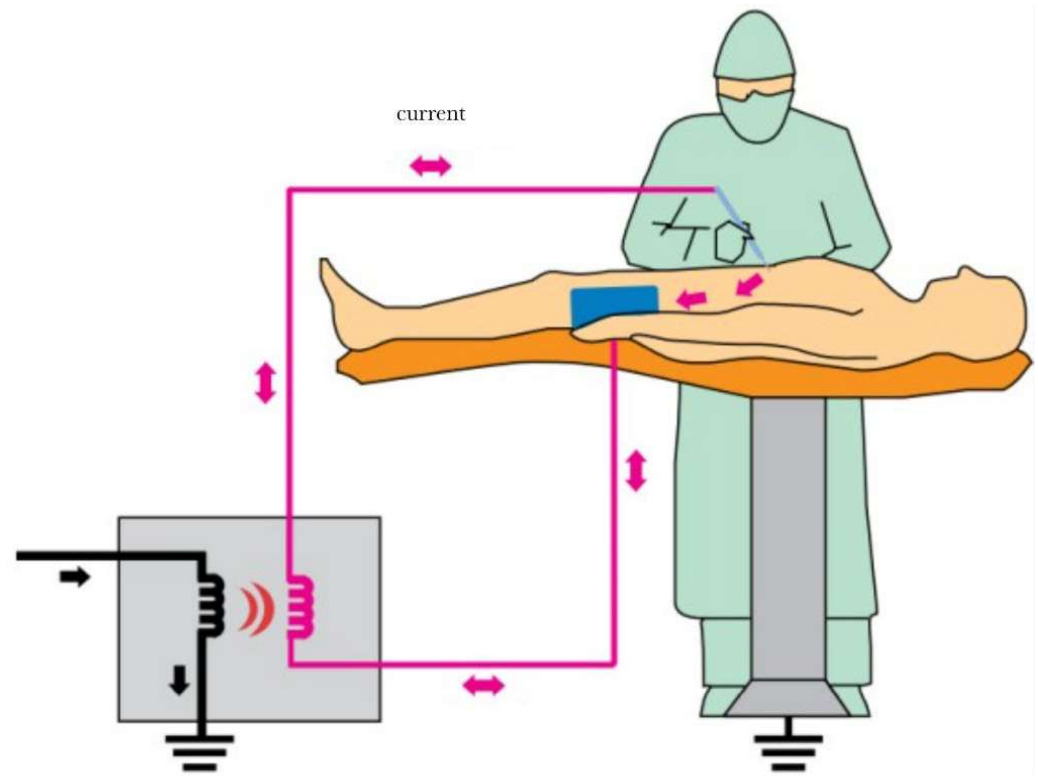

Figure 4.1 An electrosurgery process

The arc creates a high current density pathway in the immediate surrounding tissue. The current density then drops rapidly on its way back to the return pad which is usually situated on the patient thigh. Thus, the current needs to be dispersed to avoid alternate burn injuries on the patient as well as to complete the circuit.

Various types of surgical procedures can be performed using high-frequency instruments, including bipolar and monopolar devices, as well as a diverse array of high-frequency surgical tools. The distinction between bipolar and monopolar techniques lies in the way electric currents are conducted, with the latter heating a metallic probe (hot iron cautery) that is subsequently applied to the tissue. In bipolar electrosurgery, both the active and return electrodes are situated at the surgical site, whereas in monopolar electrosurgery, only the active electrode is present at the site of surgery. During the surgical procedure, the heat produced by the electrodes penetrates the tissue, with the electrode functioning as a conductor. The electrode transmits a specific amount of current, while the temperature remains lower than that of the tissue being treated.

The electrosurgical generator (ESG) comprises several components, including input power voltage, the RF frequency generator, and the active electrode. The power generator converts electricity into high-frequency electrical energy. As noted by Ikechebelu and Ezeama (2022), the energy delivered from the electrosurgical electrode is contingent upon the type of electrosurgical unit used, which can be classified as either monopolar or bipolar.

4.1.1 Safety Considerations and Current Dispersion in Monopolar Electrosurgical Systems

In the case of monopolar ES devices, the electrical current is transmitted from the patient back to the ESG through the return pad. Previously, electrosurgical units operated on ground-referenced systems (Bandral et al., 2018). The electrical current can traverse the ground through any object that encounters the patient, including stirrups or electrocardiogram electrodes. Furthermore, the current can also flow through the return pad positioned on the patient body. The heightened likelihood and risk of burns can result in the propagation of thermal injury and burns at alternative sites, in addition to affecting the electrodes being utilised. Consequently, these conditions could lead to a major problem if there is inadequate dispersion for the current. However, note that monopolar electrosurgery is the only procedure where this situation arises. Additionally, the risk of electrocution is significantly lower at higher frequencies because the skin directs the current flow towards the outer part of the conduction path. This control of the current path reduces the risk of the current crossing the heart, leading to electrocution. Electrosurgical generators must operate at an adequate frequency to prevent neuromuscular stimulation and to reduce the risk of electrocution (El-Sayed & Saridogan, 2021).