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Original Article

Understanding the safe application of electrosurgery: A cross sectional study of surgeons in KSA

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الملخص

أهداف البحث: هدفت هذه الدراسة إلى تحديد ما إذا كان الجراحون في مختلف المستويات والتخصصات على دراية بالاستخدام الآمن والمقبول للجراحة الكهربائية. بالإضافة إلى ذلك، تهدف الدراسة إلى توفير فهم أساسي للجراحة الكهربائية والجراحة بالإنفاذ الحراري.

طريقة البحث: تم اختيار ما مجموعه 83 طبيبا من مختلف التخصصات بشكل عشوائي من عدة مستشفيات في جميع أنحاء المملكة العربية السعودية. أجاب المشاركون على استبيان يحتوي على 16 سؤالا تتناول 10 أسئلة تتعلق بالاستخدام الآمن للجراحة الكهربائية.

النتائج: كشفت دراستنا أن المرشحين إما يفتقرون إلى المعرفة أو لم يكونوا على دراية باستخدام وسلامة الجراحة الكهربائية أحادية القطب وجراحة القطبين من حيث التطبيق. لم يتمكن بعض المرشحين من التمييز بينهم، مما قد يؤدي إلى إصابة المريض تحت إشرافهم.

الاستنتاجات: يجب تضمين الجراحة الكهربائية رسميا في برامج التدريب التخصصية في المستشفيات السعودية لزيادة خبرة الجراحة الكهربائية ويجب إعادة اختبار الجراحين بشكل دوري. يمكن استخدام النتائج الموضحة هنا لدفع التعلم. قد يحسن الجراحون مهاراتهم في الجراحة الكهربائية من خلال التقدم على طول منحنى التعلم للوصول إلى ذروتهم. أخيرا، يمكن للجراحين استخدام المحاكيات الجراحية للواقع الافتراضي لممارسة مهارات الجراحة الكهربائية الأساسية والمتطورة.

الكلمات المفتاحية: طاقة ثنائية القطب؛ حروق كهربائية؛ فتيل؛ أحادي القطب؛ مسرح العمليات؛ الضرر الحراري

Abstract

Objectives: To determine whether surgeons at different levels and in different specialties are aware of the safe and acceptable use of electrosurgery. In addition, we aimed to provide a fundamental understanding of electrosurgery and surgical diathermy.

Materials and Methods: A total of 83 doctors from different specialties were randomly selected from several hospitals across KSA. The participants answered a questionnaire featuring 16 questions that addressed 10 domain questions regarding the safe use of electrosurgery.

Results: Analysis revealed that the respondents either lacked knowledge or were unfamiliar with the use and safety of monopolar and bipolar electrosurgery in terms of application. Some respondents were unable to distinguish between the two protocols; this may have resulted in injuries being incurred by patients under their supervision.

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Conclusions: Electrosurgery should be formally included in specialty surgical Saudi hospital training programs to increase electrosurgery expertise and surgeons should be re-tested periodically. Our findings may be used to drive future learning. Surgeons may improve their electrosurgery skills by progressing along their learning curve to reach their peak. In addition, surgeons can use virtual reality surgical simulators to practice fundamental and sophisticated electrosurgery skills.

Keywords: Bipolar energy; Electrical burns; FUSE; Monopolar; Operative theatre; Thermal damage

Introduction

Electrosurgical machines have become a requirement in operating rooms. However, patient safety may be jeopardized by stray currents caused by capacitive coupling, direct coupling, insulation failure and other electrosurgical equipment malfunctions.[1] Electrosurgical complications are common, especially in minimal access surgeries in which electrosurgical instruments are not entirely visible by the surgeon during use. Non-targeted tissue injuries are not reported because they occur along with the device and go unnoticed. Patients with peritonitis, hemorrhage, organ or vascular injury, or infection, are frequently diagnosed after surgery.[2]

The use of appropriate technology, such as tissue response generators or other advanced bipolar instruments, active electrode monitoring units, and return electrode monitoring systems, can help reduce electrosurgical occurrences caused by stray currents. These precautions should prevent or reduce electrosurgical burns. However, poor technique and a lack of understanding of electrosurgical concepts are key factors in electrosurgical mishaps. As a result, surgeons require appropriate forms of electrosurgery training.[3]

Surgeons are legally responsible for determining the age and type of the electrosurgical machine used, the safety systems involved, the environment of the operation, and the type of tissue cauterized. To avoid flash fires, oxygen-enriched environments in otolaryngology, for example, require low-power settings with sparing-use-of-supplemental-oxygen. Non-hazardous operating settings are critical for open surgery. The heat generated by electrosurgical equipment has been reported to ignite a skin cleansing solution, thus setting a patient who was being treated for appendicitis on fire. The vast majority of surgical procedures involve the use of energy to generate heat effects on the tissue for cutting, coagulation, desiccation or fulguration. Various energy sources are available, including electricity, ultrasound, laser, argon gas, microwaves or radiofrequency (RF) waves.

It is evident that most electrosurgical complications are preventable. However, it is also evident that many surgeons have knowledge gaps regarding the safe use of the energy-based devices that are commonly used in surgery.[4]

Materials and Methods

This study was conducted at the Ministry of National Guard Hospital in Riyadh, King Faisal Specialist Hospital and Research Centre in Riyadh and Damam, Makkah Maternity and Children's Hospital, Al-Ahsa Ministry of National Guard Hospital, and Abha Maternity and Children's Hospital. A total of 83 doctors were recruited from different specialties, including general gynecology or obstetric gynecology (OB-GYN), general surgery, colorectal surgery, urogynecology, pediatric urology, and maternal–fetal medicine (MFM). The doctors featured middle-grade students and consultants (Figure 1).

Study questions were sent to the administration offices of the above-mentioned hospitals with a Google survey link, where they were distributed to many targeted surgical departments *via* email. The survey reached hundreds of surgeons with different specialties and levels of experience. We did not control for who was going to respond to the survey. The questionnaire included several areas of basic technical and safety knowledge regarding electrosurgery. Data were gathered and collected on various topics related to electrosurgery, including basic knowledge of high-frequency electrosurgery and its possible risks. The type of electrosurgery used (bipolar or monopolar) and the rationale for its use were discussed. Personal encounters with any electrosurgical use complications were also sought. Participants in this study were also questioned if they thought that further electrosurgery education was needed. The resulting responses were analyzed in detail.

The candidates had more than four years of practice in the use of electrosurgery units. The frequency of electrosurgery performed at the time of testing was between one and three times per week. The candidates were aged between 30 and 60 years. This study addressed ten domain questions. These questions were validated by three senior consultants from three surgical specialties.

Results and discussion

Electrosurgery units were first designed in 1928 to facilitate hemostasis and tumor removal. The types and functions of these machines have become highly complex. In this study, we aimed to evaluate the knowledge and understanding of local doctors with respect to the safe use of electrosurgery by asking several questions pertaining electrosurgery.[5] A total of 83 candidates responded and completed the questionnaire. One participant responded but did not agree to participate in the study. The median time required to complete the survey was approximately 480 s.

Our assessment model participants were classified into three major categories: 64% were OBGYN doctors, 16% were surgeons and 20% were urologists. Moreover, we examined the level of training practice received and found that 34% were board-certified (including registrars, assistant consultants, associate consultants and fellows), 24% were

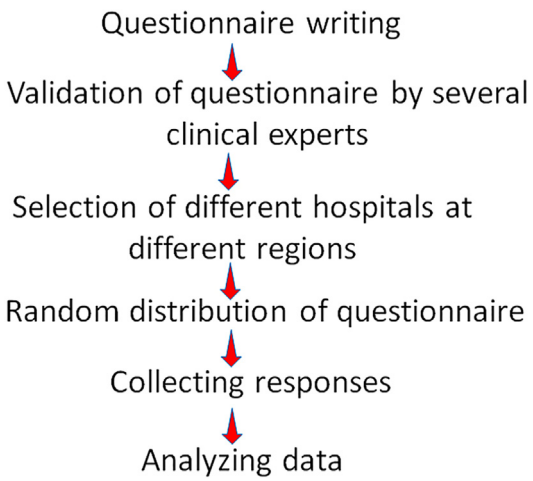

Figure 1: Study design process.

consultants, 28% were senior residents, 13% were junior residents, and 1% were staff physicians.

In the (Yes, No) questions, we found that 57% of the participants received formal training on the safe use of electrosurgery. Similarly, we found that 65% never encountered complications caused by electrosurgery. To further evaluate their understanding, we moved to a section featuring ten domain questions regarding general knowledge on the safe use of electrosurgery. We asked the participants: "Which of the following statements is correct regarding the placement of the dispersive electrode." Approximately 52% answered "should always be placed on the patient's legs for proper monitoring," 30% answered "should be as close as possible to the surgical site," (correct answer) and 17% did not know the correct answer.

Given that bipolar electrosurgery employs a low voltage, it requires minimal energy. However, as this technique uses low power to coagulate and cut bleeding areas, it is best utilized for procedures in which the forceps electrode can readily grip tissues on both sides. The electrosurgical current experienced by the patient is limited to the tissue between the arms of the forceps electrodes. This provides more control over the targeted area and protects other sensitive tissues. The likelihood of patient burns is considerably reduced by bipolar electrosurgery.[6]

Surgeons use forceps attached to an electrosurgical generator; the current passes through the tissue held in place using forceps. This can be used in patients with implanted devices to prevent electrical current from traveling through the device. Creating a misfire or short-circuit is why the path of the electrical current is constrained to the tissue between the two electrodes. To avoid these difficulties, the user handbook should be consulted for the implanted equipment before performing any electrosurgical procedure. The aim of these questions was to determine how much our candidates knew about bipolar electrosurgery. When asked about the requirements of laparoscopic bipolar electrosurgery, 59% answered "two active electrodes in close proximity to allow electricity to flow between them," (correct answer), 23% answered "a grounding pad to collect extra electrons that flow into the patient" and 18% did not know the correct answer. When asked about the following effects that can be achieved by conventional bipolar electrosurgery, 29% answered they did not know the correct answer, 29% said fulguration, 22% said tissue transection, and only 20% answered desiccation (correct answer).

Electrosurgical units are the most abundant type of electrical equipment used in operating theaters. To use an electrosurgical unit correctly, a basic understanding of the electrical fundamentals is crucial; one key concept is monopolar function. The monopolar approach is the most prevalent electrosurgical modality because of its clinical effectiveness and adaptability. The active electrode in monopolar electrosurgery is located on the surgical site. The patient's return electrode is located elsewhere on their body. As the current completes the circuit from the active electrode to the patient's return electrode, it flows through the patient.[7]

Mechanical trauma and electrothermal injury are possible complications associated with electrosurgery during laparoscopy. Unrecognized-energy-transfer-in-the-operative field or, less commonly, unnoticed stray current outside of the laparoscopic field of view, can cause the latter.[8]

When asking about the risks carried by the use of monopolar electrosurgery during laparoscopic surgery, 39% of candidates answered "the risk of insulation failure" (correct answer), 34% answered "do not know the correct answer," 19% answered "tissue damage from having to use undersized surgical equipment," and 8% answered "longer instruments

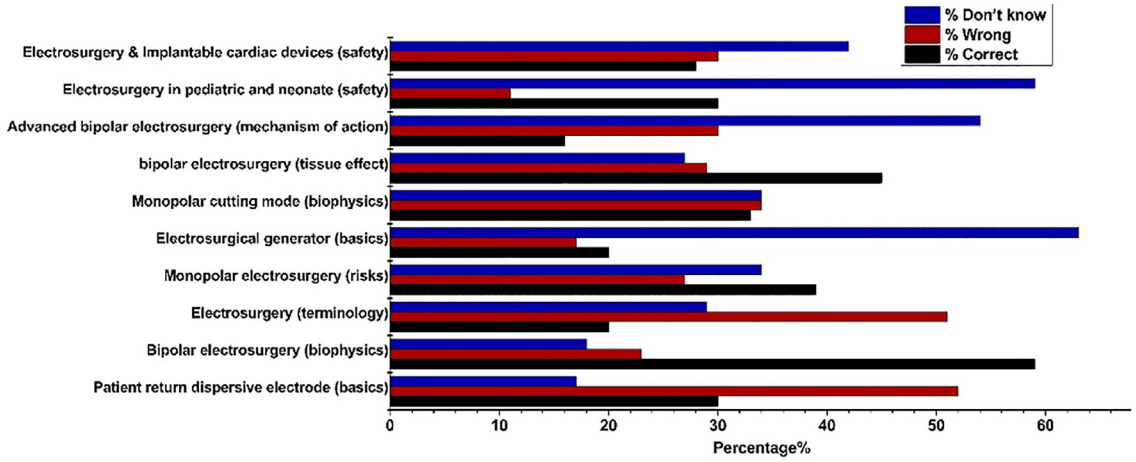

Figure 2: Distribution of answers provided by the study participants.

have greater resistance, which can cause burning of the surgeon's hand."

We also asked which of the following statements was correct for the modern electrosurgical generator unit. About 63% did not know the correct answer, 20% said "produces alternating currents in the frequency range of 0.3–5 MHz" (correct answer), 11% said "produces an alternating current of 50–60 Hz (household current) to be used in electrosurgery" and 6% chose "converts the household electricity into direct current."

When asked to identify the reason underlying the effects of the monopolar cutting mode, 34% did not know the correct answer, 33% replied "rapid increase in tissue temperature above 100c leading to rupture of cell wall" (correct answer), 22% answered "using intermittent alternating current with low voltage" and 12% answered "cutting cannot be achieved with tissues of high-water content."

The answers provided by the respondents in this section indicated that they were unable to distinguish, may have a different opinion, or were unsure about the monopolar risk or the amount of tissue damage that could occur. It was also unclear which procedure was quicker, easier or safer. Moreover, the respondents did not know the correct relationship between the cutting mode and tissue temperature, or between low voltage and tissues with high water content. Some candidates were also unaware of frequency range differences.[9]

A basic understanding of electricity is required for the appropriate use of electrosurgical equipment for patient care. Electrosurgery is one of the most commonly employed energy systems in laparoscopic surgery. To avoid these difficulties, the surgical team should thoroughly understand the principles of electrosurgery and tissue effects. A surgeon's lack of fundamental knowledge of instruments, surgical techniques, pertinent anatomy, biophysics, and safe technical equipment is associated with the likelihood of problems. When used correctly, electrosurgery is both safe and effective. However, direct application, direct coupling, insulation breakdown and capacitive coupling can cause electrothermal damage. Thus, we asked our candidates two related questions.[10]

First, we asked the respondents to choose from a series of statements regarding the use of bipolar electrosurgery; 45% said "tissue desiccation and then coagulation occurs by progressive tissue heating" (correct answer), 27% said they did not know the correct answer, 27% said "dispersive electrode is used to complete the electrical cycle" and 2% said "thermal damage can never occur with the use of bipolar electrosurgery."

Second, when asked to choose from statements regarding advanced bipolar devices, 54% said they did not know the correct answer, 18% replied "ligature works by converting electrical energy into vibrations at more than 20,000 cycles per second," 16% chose "Enseal device has a temperature-sensitive material, which maintains the sealing temperature at around 100 °C" (correct answer), and 12% said "ultrasonic device works by measurements of tissue impedance."

Pediatric surgeons require accurate and modern energy sources to perform surgeries in neonates. Technology has progressed and the industry is always upgrading to provide solutions that execute precise and effective actions while remaining safe and trustworthy for both patients and workers. Electrosurgery and its variations, lasers, ultrasonic dissectors and cryotherapy are the most commonly used energy sources in neonatal surgery. Ultrasonic energy and electrosurgery are the two most commonly used methods. For optimal and safe use, neonatal surgeons must have a fundamental understanding of the instruments. This question helped us understand and measure how much our participants knew about the safety for both newborns and surgeons. When asked a general question that requires no specialty knowledge about electrosurgical energy use in pediatric and neonate patients; 59% said "do not know the correct answer," 30% said "in a neonate, the best site to place a dispersive electrode is on the back between the scapula and the sacrum" (correct answer), 7% said "dispersive electrode should be trimmed to fit when used in children," and 4% said "dispersive electrodes are only available in adult size."

The electrosurgical unit is obsolete in most modern surgeries with regards to the facilitation of hemostasis. When this modality is used in patients with implanted electronic cardiac devices (IECDs), such as defibrillators and pacemakers, caution is advised because electromagnetic interference from the tool may cause these devices to malfunction. Determining the type of implanted device and the patient's level of reliance is critical before using electrosurgery in patients with IECDs. The position of the lesion to be treated relative to the device should also be considered. Interference resistance is high in bipolar pacemakers. Therefore, the use of bipolar forceps and appropriate monitoring is recommended. We asked our respondents what they recommended when using electrosurgical energy in patients with implantable cardiac devices (ICDs). Approximately 42% said "do not know the correct answer," 28% said "the device should always be checked after the operation" (correct answer), 16% said "there is no effect on ICD when using modern electrosurgical generators" and 14% said "bipolar electrocautery system and ultrasonic (harmonic) devices should be avoided."

Our study showed that the respondents either lacked knowledge or were unfamiliar with the use and safety of monopolar and bipolar electrosurgeries. The candidates could not distinguish the difference between these techniques, which may have resulted in injuries to being incurred by patients under their supervision. A summary of responses to the ten domain objectives of the study is shown in Figure 2.

This study revealed considerable ignorance regarding a potentially dangerous yet commonly used piece of operating equipment, regardless of seniority or specialty. In these days of clinical governance, clinical effectiveness and increased medicolegal awareness, the authors believe that surgical diathermy refresher courses should be offered regularly as part of continuing medical education and should be aimed at all levels of health care providers.

As these questions measure knowledge in written form, practical skills must be evaluated to ensure that no gap exists between these two scenarios. Doctors employed in a certain hospital should be regularly evaluated and continually trained for continuous improvement in the hospital environment.

The strengths of our study include practical and theoretical knowledge to ensure that the test was comprehensive and consistent. A practical diathermy station should disclose aspects of the electrosurgical technique that cannot be tested in a textual manner. These include selecting adequate power settings, determining the optimum tissue volume and applying brief intermittent stimulation. Repeating the same

questions in the future through repeated studies can provide a useful evaluation for research progress.

Electrosurgical tests can be improved by adding case studies (e.g., ectopic pregnancies, appendicitis and ovarian cysts) and simulation. Given that electrosurgical injuries are difficult to diagnose or are diagnosed postoperatively, our research revealed that the root of the problem was a lack of basic electrosurgery expertise among surgeons as well as an effective program to improve this clinical ability. The Society of American Gastrointestinal and Endoscopic Surgeons launched the Fundamental Use of Surgical Energy program which developed a curriculum designed to cover both educational and hands-on approaches to the use of energy in interventional procedures in the operating room and endoscopic procedure areas. The objectives are to avoid unfavorable outcomes such as operating room fires, patient injuries, and surgeon/staff injuries and to promote optimal utilization.[11]

Electrosurgery should be formally included in specialty surgical Saudi hospital training programs to increase electrosurgery expertise and surgeons should be retested periodically.

Conclusions

The results outlined here may be used to drive learning. Surgeons may improve their electrosurgery skills by progressing along their learning curve to reach their peak. Finally, surgeons can use virtual reality surgical simulators to practice fundamental and sophisticated electrosurgery skills.

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Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

This study was approved by the Institutional Review Board of the King Abdullah International Medical Research Center (KAIMRC), Ministry of National Guard, study number: NRC21R/421/08, IRB approval date: November 09, 2021.

Authors contribution

MA: Conceptualization, Methodology, Software, Writing- Reviewing and Editing, Analysis and Interpretation of data. **SA:** Conceptualization, Writing- Original draft preparation, Analysis and Interpretation of data. **MB:** Interpretation of data, Visualization, Investigation. **YA:** Interpretation of data, Supervision. **SB:** Software, Analysis, Supervision, and Validation. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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