

Knowledge Assessment Among Surgeons About Energy Devices Safe Use: A Multicenter Cross-Sectional Study

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Objective: To assess the knowledge of general surgery trainees about the safe use of energy devices in 2 tertiary hospitals in Riyadh, Saudi Arabia.

Background: Electrosurgery (ES) is the use of high-frequency electrical energy to achieve cutting and coagulation. This method has become ubiquitous worldwide for the purpose of achieving rapid hemostasis and rapid dissection of tissues.

Methods: Participants completed a 35-item multiple-choice question examination, testing critical knowledge of ES. The examination was developed according to the objectives and blueprints of Society of American Gastrointestinal Endoscopic Surgeons' Fundamental Use of Surgical Energy curriculum. Sections of the examination included the following: principles of ES, ES-related adverse events, monopolar and bipolar devices, pediatric considerations, and interference with implantable devices. Scores were compared between junior and senior participants.

Results: A total of 51 general surgical trainees from 2 academic hospitals completed the assessment; 15.69% of the participants correctly answered 30 of 35 questions, 39.22% of the participants responded correctly to 20 of 35 questions, and 45.09% responded correctly to fewer than 20 questions. It was found that 52.2% of the individuals with a low level of

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understanding were junior residents; 87.5% of the participants with the highest level of understanding were senior residents, with a significant *P* value of 0.04.

Conclusions: Most general surgery residents enrolled in the Saudi Arabian Board of Surgery lack adequate knowledge about the safe and efficient use of surgical energy devices.

Key words: Energy device – Electrosurgery – Surgical education

Surgeons in different surgical specialties have used energy devices to perform surgical procedures.¹ The continued use of electrical devices has increased significantly in operating theaters. The first recorded use of an energy device to control hemorrhage in the treatment of tumors was in almost 3000 BCE, but the widespread application of these devices for different purposes only became popular within the past century.² In the United States, electrical devices were introduced into clinical practice approximately 85 years ago when an electrosurgical unit was used to achieve cutting and coagulation by altering the current that passed through the body.³

Electrosurgery (ES) is the use of high-frequency electrical energy to achieve cutting and coagulation. This method has become ubiquitous worldwide for the purpose of achieving rapid hemostasis and the rapid dissection of tissues.⁴ A large number of procedure rooms currently have facilities for endoscopy and radiofrequency ES techniques. Recently, there has been a vast array of advances in the design of surgical energy devices that has had a significant impact on the technological development and advancement of surgical procedures.³ In minimally invasive and complicated surgical procedures, ES has resulted in greater hemostasis control. This progress was made despite difficulties due to a combination of the magnitude of electrical current and heat generation. Furthermore, the interaction of these devices with other surgical tools in the operating field has resulted in more severe complications and problems. A direct consequence of the use of electrosurgical devices is potential injury to the patient's body tissue, such as the bowel, as a result of the contiguous spread of thermal heat to adjacent tissues from the primary tissue in which electrical impulses have been applied during surgery, thereby leading to an unfavorable patient outcome.⁵ The risk of surgical burns and operating room fires also constitute other possible significant adverse effects of ES in clinical practice. Electrosurgical devices

can interfere with inserted pacemakers,⁶ often with deadly consequences to the patient. According to data from the Food and Drug Administration, the use of electrosurgical devices has resulted in almost 3553 injuries, 279 operating room fires, and 178 deaths.⁷ The incidence of injuries due to energy devices in laparoscopy has been estimated by one study to be 39% in 2015, and the prevalence of injuries due to energy devices during laparoscopic surgery ranged from 1 to 2 injuries per 100,000 patients in 1994.^{8,9}

These adverse events may be attributed to the surgeons lacking knowledge and understanding of the proper and safe uses of these electrosurgical devices. Therefore, it is important for clinicians and surgical trainees alike to understand the principle of working with electrosurgical devices and the risks associated with their use to maximize the benefits of these devices, improve patient outcomes, and improve the safety of surgical procedures.⁵ Surgeons should also have an awareness of how to properly set up the devices for each procedure and how the device interfaces with other devices.¹ In view of this, the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) developed a program, Fundamental Use of Surgical Energy (FUSE), to tackle these problems¹⁰ and promote a high safety culture for the use of energy devices among surgeons. The FUSE program was developed as a form of empowerment for surgeons to receive continued education so that they can follow the guidelines set for the use of energy devices to reduce the risk of patient injury.¹¹

FUSE is an online global educational program that includes a multimedia curriculum and validated evaluation, complemented with multiple-choice certification examinations.⁵ In addition, these examinations assess the knowledge of participants concerning the safe use of electrosurgical devices. Successful completion of the certification examination by health care professionals also leads to the award of Continuing Medical Education and Continuing Education Units to surgeons.¹² Feldman *et*

*al*¹ reported that health care providers who attended the pilot FUSE course for a half-day to learn about surgical energy devices showed an improvement in their performance after completing the course. In addition, Watanabe *et al*² conducted the first multicenter cross-sectional study among surgeons to assess their level of knowledge regarding the safe use of surgical energy devices. Watanabe *et al*² reported that surgeons and trainees with varying years of experience who completed the FUSE curriculum had a knowledge gap regarding the safe use of energy devices. Therefore, the present study aimed to assess the knowledge of surgeons about the safe use of energy devices and assess their perceptions regarding the safe use of electrosurgical devices in Saudi Arabia.²

Materials and Methods

We performed an institutional-based cross-sectional survey at 2 tertiary hospitals in the Riyadh region. The cross-sectional survey was sent electronically through a hyperlink (due to health precautions during the COVID-19 pandemic) to general surgery trainees in 2 tertiary hospitals (Prince Sultan Military Medical City and National Guard Hospital) to assess their knowledge about the safe use of energy devices. The study period was from July 2020 to January 2021. The questionnaire included multiple-choice questions developed according to the objectives and blueprints of the SAGES FUSE curriculum. A well-designed questionnaire was sent by e-mail and filled out anonymously to maintain confidentiality by all senior residents and junior residents. Participants were also given the option of opting out of the study if they wished.

Study participants

The participants completed a 35-item multiple-choice question examination that was designed for general surgery residents to test their knowledge about safety regarding ES devices. The study target was to reach all general surgeon residents during the study period, including both junior and senior residents in the Prince Sultan Military Medical City and National Guard Hospital in the capital city of the Kingdom of Saudi Arabia, Riyadh.

Data collection tool

A 35-item multiple-choice examination assessing the surgeons' fundamental knowledge of ES was previ-

ously developed based on 35 course objectives from the FUSE curriculum. Data were collected by receiving responses via a hyperlink to a structured questionnaire. Each correct answer was scored with a value of "1," and each incorrect answer had a "0" value. Each question has 4 multiple options, and participants can see their results after completing the questionnaire. The questions were developed according to the objectives and blueprints of the SAGES FUSE curriculum. Overall, 11 items pertained to the principles of ES, and 14 items concerned ES-related adverse events. Moreover, 3 items were related to monopolar devices, 2 to bipolar devices, and 2 to pediatric considerations. Three items concerned interference with implantable devices.

Results

A total of 51 general surgical trainees from 2 academic hospitals completed the assessment. Regarding the demographic characteristics of the participants, we found the mean age of the study participants to be 29 years with an SD of 1.98 years. The age variable was categorized as a binary variable based on a cutoff of 30 years; 82.4% ($n = 42.0$) of the study participants were younger than 30 years, and 17.6% were 30 years or older. With respect to place of work, 50.98% ($n = 26$) of the participants reported working in the Military hospital, and approximately half of the participants ($n = 25$) reported working in the National Guard hospital. Regarding the surgeon region, almost 100% of the participants reported working in the central region, and the same proportion (100%) reported working as general surgeons. In terms of level or hierarchy as surgeons, 33.0% ($n = 17.0$) were junior residents, and 66.7% ($n = 34.0$) were senior residents. Only 9.8% ($n = 5$) of the participants had a FUSE certification, whereas approximately 90% of the study participants were not certified, as shown in Table 1.

We assessed the knowledge of the surgeons regarding various aspects of surgery by developing multiple-choice questions regarding various domains of surgery. Figure 1 shows the proportion of participants who answered correctly to different numbers of questions. The graph shows that approximately half of the participants (47%) provided 11 to 15 correct answers. Moreover, 31% responded correctly to 16 to 20 questions, whereas only 10% responded correctly to more than 25 questions, as shown in Figure 1. Furthermore, 6%

Table 1 Demographic and other characteristics of study participants regarding training and their skills (n=51)

Demographic and other variables	n	%
Age		
Mean	29 years	NA
SD	1.98	NA
Age categories		
<30 y	42.0	82.4
≥30 y	9.0	17.6
Surgeon's hospital		
Military hospital	26.00	50.98
National guard hospital	25.00	49.02
Surgeon region		
Central region	51.0	100.0
Surgeon specialty		
General surgeons	51.0	100.0
Surgeon level		
Junior resident	17.0	33.3
Senior resident	34.0	66.7
Certification for FUSE course		
No	46.0	90.2
Yes	5.0	9.8

FUSE, Fundamental Use of Surgical Energy

responded correctly to fewer than 10 questions, and another 6% responded correctly to 21 to 25 questions.

Figure 2 is a pie chart showing the proportion of participants with different levels of understanding based on a cutoff score for correct answers. It was found that 15.69% of the participants correctly answered 30 of 35 questions, meaning that 15.69% of the study participants had the highest level of understanding. Approximately 39.22% of the study participants responded correctly to 20 of 35 questions, meaning they had a moderate level of understanding about the safe use of ES or energy devices. The largest proportion of the participants responded correctly to fewer than 20 questions, and were judged to have a low level of understanding, as shown in Fig. 2.

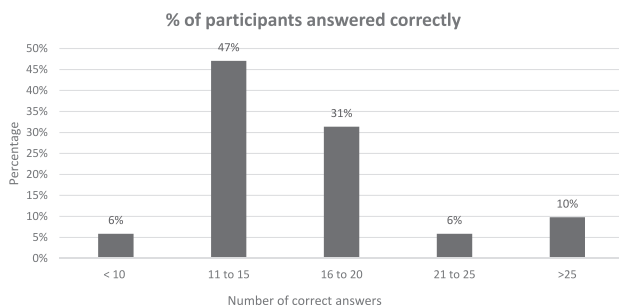


Fig. 1 Proportion of participants who correctly answered the questions of the survey.

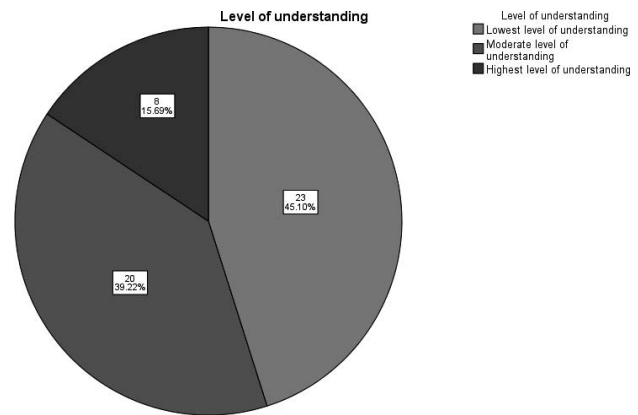


Fig. 2 Proportion of participants demonstrating the expertise regarding the safe use of ES.

Table 2 shows the differences in the level of understanding regarding the safe use of ES by demographic characteristics and clinical experience. It was found that 9.1% of participants with a low level of understanding were 30 years old, whereas 37.5% of the older individuals with the highest level of understanding were older than 30 years. However, the difference in the level of understanding was not statistically significant between age groups (P value: 0.166). It was found that 52.2% of the individuals with a low level of understanding were junior residents, whereas 87.5% of the participants with the highest level of understanding were senior residents, which was a significant difference with a P value of 0.04. We did not find any differences between the level of understanding based on FUSE certification (P value: 0.074) or type of hospital (0.275), as shown in Table 2.

The number of participants who responded correctly or incorrectly to different numbers of questions related to the secure use of energy devices is shown in Fig. 3 and Fig. 4. For example, while assessing knowledge regarding “the infant’s back is an appropriate place for the dispersive electrode,” it was found that 31 participants provided correct answers. Likewise, regarding “using a bipolar instrument in neonate less than 1lb,” 36 respondents provided correct answers. Regarding “decreased current flow through the tissue between the jaws of the instrument when the tissue is completely desiccated,” 14 individuals answered correctly, as shown in Fig. 3. Similarly, regarding “uses of radiofrequency energy to induce intracellular tissue effects,” only 15 study participants responded to the question. When assessing their knowledge on “uses

Table 2 Level of understanding regarding the safe use of electrosurgery by demographic characteristics and clinical experience (n = 51)

Variables	The lowest level (n = 23)	Moderate level (n = 20)	The highest level (n = 8)	P value
Age, y				
< 30	21 (91.3)	16 (80.0)	5 (62.5)	0.166
≥ 30	2 (8.7)	4 (20.0)	3 (37.5)	
Surgeon level				
Junior resident	12 (52.2)	4 (20.2)	1 (12.5)	0.04
Senior resident	11 (47.8)	16 (80.0)	7 (87.5)	
FUSE certified				
No	23 (100)	16 (80.0)	7 (87.5)	0.074
Yes	0	4 (20.2)	1 (12.5)	
Type of hospital				
Military Hospital	12 (52.2)	8 (40.0)	6 (75.0)	0.275
National Guard Hospital	11 (47.8)	12 (60.0)	2 (25.0)	

FUSE, Fundamental Use of Surgical Energy

Bold text indicates a significant finding.

a continuous low voltage waveform,” 24 answered correctly, as shown in Figure 4 and Table 3.

Discussion

The use of electrosurgical devices in clinical practice has continued to gather more momentum globally. Such devices can either aid in performing complex, safe, and expeditious surgeries or result in severe problems. To this end, our aim was to ascertain the level of knowledge among surgeons about the safe use of energy devices in Saudi Arabia. Surprisingly, we found an appreciable deficiency in knowledge regarding the use of energy devices among surgeons. Surgeons who participated in the study lacked knowledge and understanding of energy devices and ES. Based on the questionnaire that was administered to assess this knowledge, only 10% of the study participants provided correct answers to more than 25 of 35 questions, and most participants responded correctly to only 11 to 15 questions. For example, while assessing knowledge regarding the “coagulation” mode of the electrosurgical unit, we found that 39.2% of the participants provided answers correctly; however, for knowledge regarding fire safety in the operating room, approximately 68% of the respondents provided correct answers. We also found that 16% of the participants answered correctly in the assessment of electrosurgical burns to the surgeons. Nonetheless, 71% of the respondents provided correct answers regarding knowledge about avoiding areas while placing the dispersive electrode. This indicates that most surgeons at both the senior and junior levels need to update their knowledge about different components

regarding the usage of energy devices. Such gaps in knowledge permeated almost all aspects of ES, such as the fundamental tenets, adverse events, monopolar and bipolar devices, pediatric considerations, and interference with implantable devices. We also assessed the level of understanding by demographic and clinical characteristics and found that junior residents had a lower level of understanding than senior residents; however, we did not find differences by age, type of hospital, or FUSE certification.

These findings are consistent with other similar studies conducted across the world. For example, a study conducted in Japan found similar results with huge gaps in the knowledge of surgeons at all levels.² Furthermore, the same study also highlighted the gaps in knowledge across different aspects of ES.² Likewise, another study conducted in North America also confirms the findings of our study, with similar gaps in knowledge.¹ Similarly, a study conducted by Ally Ha *et al*¹³ found that surgeons in all specialties, such as general surgery, orthopedics, gynecology, and neurosurgery, have the same issue of knowledge gaps regarding the usage of ES. Another study was conducted in 2 large hospitals in Pakistan, where researchers also reported substantial unawareness about the surgical technique and indications for using a simple electrosurgical apparatus, which warrants increased understanding and further training.¹⁴ In addition, there has been a plethora of research in the past couple of years pointing out the deficiencies of surgeons regarding the use of electrosurgical devices.¹⁵

These findings regarding gaps in knowledge reveal that this issue of inadequate knowledge is a common problem, irrespective of geographic set-

Table 3 The knowledge regarding electrosurgery and safety in the operating room

Main question to assess knowledge and its responses	Frequency	Percent
Q11: Electrosurgery		
a. Uses radiofrequency energy to induce intracellular tissue effects	15.0	29.4
b. Uses the thermal energy of a metal electrode to cauterize tissue	18.0	35.3
c. Uses direct current electrical energy to induce tissue effects	15.0	29.4
d. Uses the kinetic energy of a metal electrode to cauterize tissue	3.0	5.9
Q12: The "coagulation" mode on the electrosurgical unit		
a. Uses an interrupted high voltage waveform	20.0	39.2
b. Uses a continuous low voltage waveform	15.0	29.4
c. Uses an interrupted low voltage waveform	10.0	19.6
d. Uses a continuous high voltage waveform	6.0	11.8
Q13: The "cut" mode on the electrosurgical unit:		
a. Uses an interrupted high voltage waveform	11.0	21.6
b. Uses a continuous low voltage waveform	24.0	47.1
c. Uses an interrupted low voltage waveform	6.0	11.8
d. Uses a continuous high voltage waveform	10.0	19.6
Q14: Which of the following is NOT a characteristic of modulated high voltage output		
a. Caramelization of tissue	9.0	17.6
b. Homogeneous vessel seal	11.0	21.6
c. Poor vessel seal	18.0	35.3
d. Superficial zone of desiccation	13.0	25.5
Q15: When using a monopolar device, the dispersive electrode:		
a. Acts as a grounding pad and transfers the current to the ground	10.0	19.6
b. Conducts the same amount of current as the tip of the active electrode but at a higher current density	6.0	11.8
c. Completes the circuit	25.0	49.0
d. Diverts the current away from other organs to prevent electrocution	10.0	19.6
Q16: As a laparoscopic nephrectomy is beginning, the surgical drapes catch fire from the fiberoptic light cable that was turned on. The immediate next step is:		
a. Pull the fire alarm and activate a code red	14.0	27.5
b. Stop flow of all airway gases and remove the endotracheal tube	9.0	17.6
c. Extinguish the fire with the fire extinguisher	5.0	9.8
d. Remove burning and burned materials from the patient	23.0	45.1
Q17: Regarding fire safety in the operating room		
a. If possible, 100% oxygen should be avoided during head and neck procedures	31.0	60.8
b. During an open tracheostomy, electrosurgery should be used when entering the airway to minimize bleeding	6.0	11.8
c. The light source should be turned on before the fiberoptic cable is connected to the laparoscope	9.0	17.6
d. The surgical drapes should be applied before the skin prep has dried	5.0	9.8
Q18: Regarding safety measures during electrosurgical procedures		
a. It is OK to leave jewelry on the patient, as long as it is far from the surgical field	11.0	21.6
b. The patient should be grounded by being placed on a metal table	8.0	15.7
c. Wrapping wires around a metal clamp fixed to the surgical drapes could result in capacitive coupling	12.0	23.5
d. At the same power setting, using a waveform with a higher duty cycle increases the risk of thermal injury	20.0	39.2
Q19: In the image below, what is the mechanism of injury that may lead to thermal injury where the retractor is touching the skin?		
a. Alternate site injury	5.0	9.8
b. Direct coupling	19.0	37.3
c. Direct thermal injury	15.0	29.4
d. Capacitive coupling	12.0	23.5
Q20: During a hip arthroplasty, you grab a bleeding vessel with your forceps and activate the monopolar device while its metal tip is touching the forceps. This process is best done:		
a. Using the "cut" mode	16.0	31.4
b. By grabbing as much tissue as possible to ensure good vessel seal	29.0	56.9
c. While the forceps makes contact with the skin	2.0	3.9
d. In a wet environment to increase conduction of electricity	4.0	7.8

Bold text indicates the correct answer.

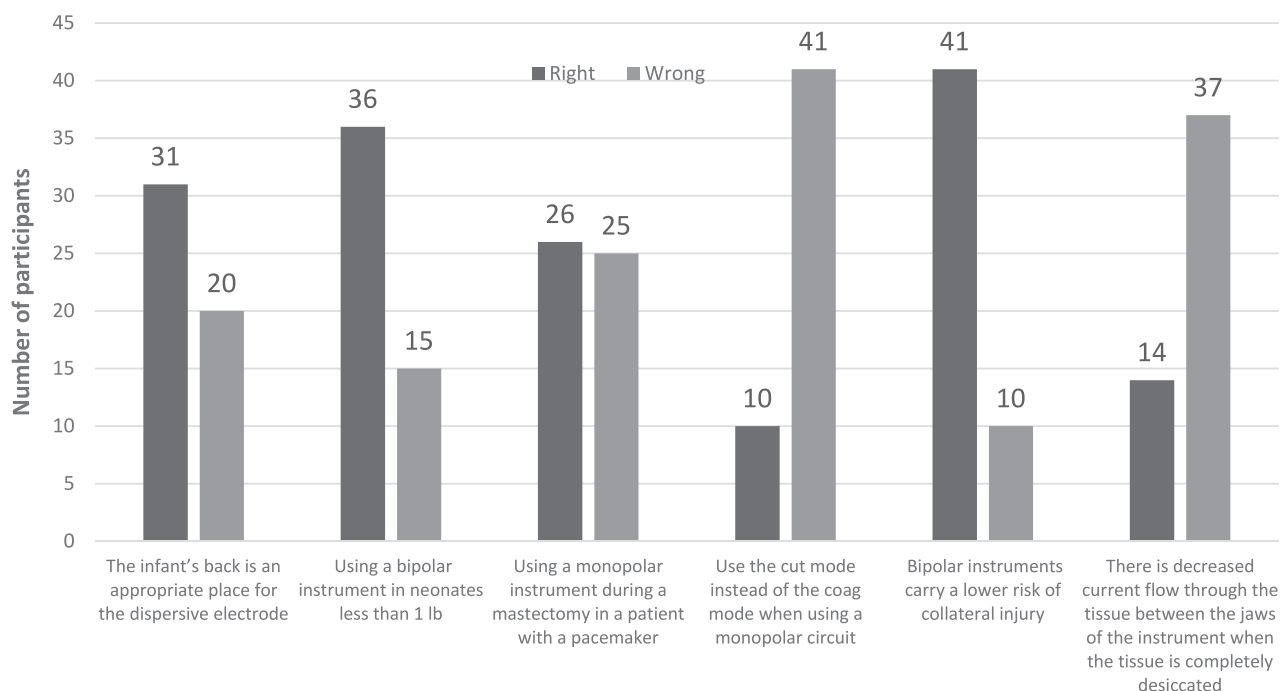


Fig. 3 Number of participants who responded correctly to questions regarding safe use of energy devices.

ting. This concordance across different studies highlights the need for formal training regarding the use of ES in Saudi Arabia. The findings can be explained by inadequate training in the FUSE program, as reflected by the small proportion (9.8%) of surgeons who were certified for this course. This also implies that surgeons and junior surgeons obtain training informally either by obser-

vations in the operating rooms or via sponsorship by pharmaceutical companies. However, we did not explore the reasons for the low certification rate for FUSE in our study and did not explore the reasons for the low level of knowledge, as this was not the objective of the current cross-sectional study. The findings regarding differences in the level of understanding by type of resident can be explained

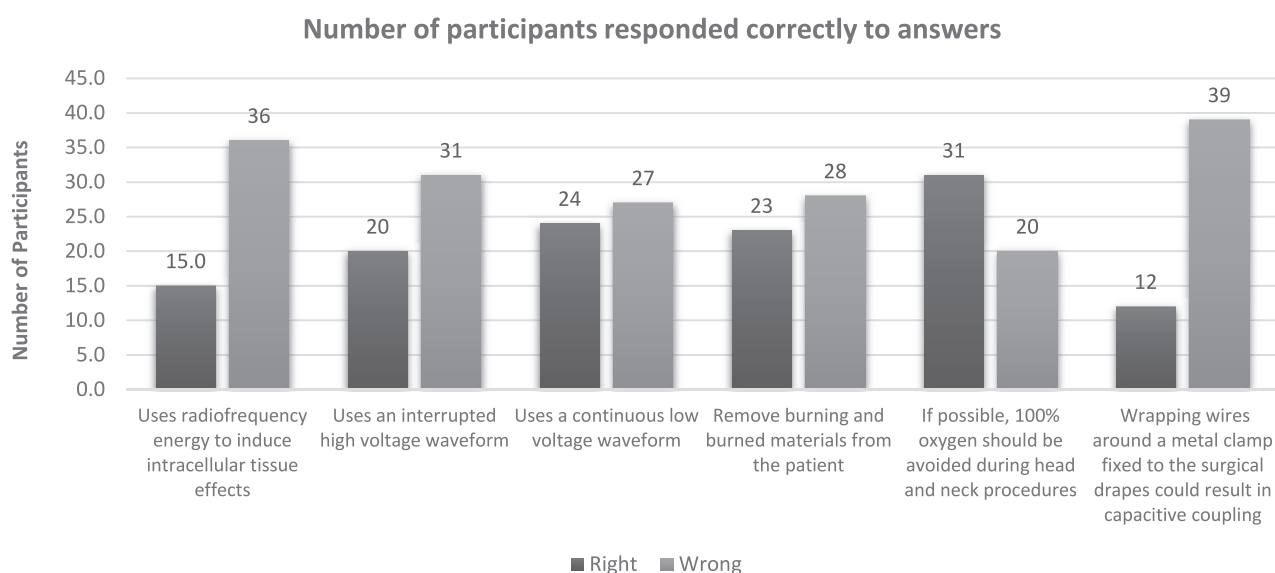


Fig. 4 Number of participants who responded correctly to questions regarding safe use of energy devices.

by the fact that senior residents have more exposure to knowledge, and they might be more skillful than junior residents.

The findings of the study inform various interventions to be designed in Saudi Arabia. Because gaps in knowledge or inadequate knowledge regarding the safe usage of energy devices may increase the risk of problems, mainly for patients, it is important and urgent that hospital administrations take actions to provide the required training to surgeons through different methods. One possible technique to tackle this issue of inadequate knowledge is to develop educational curricula to enable surgeons to understand and embrace best practices that can reduce the possibility of injury while using energy devices. This can be done by integrating FUSE training in the existing curricula because the literature illustrates that the FUSE program can fill this gap effectively through either online training or workshops.^{16,17} For example, the findings of a randomized controlled trial revealed that the FUSE-integrated training curriculum resulted in an improvement in the knowledge of junior surgeons regarding the safe use of electrosurgical devices.¹⁷ Currently, the Federation of Visceral and Digestive Surgery has demonstrated that surgeons are satisfied with the program after taking the FUSE course.¹⁸ Furthermore, according to the Society of Laparoendoscopic Surgeons, there is a need to improve the knowledge and awareness of principles related to ES, and improved credentialing was needed approximately 10 years ago.¹⁹ Nevertheless, no standardized guidelines exist on training surgeons and other related staff about the use of ES and other energy devices. In addition, there is no well-defined requirement to reveal proficiency after training.

Strengths and limitations

This study is the first of its kind to assess the knowledge of surgeons regarding the safe use of energy devices in Saudi Arabia. We collected information from a reasonable number of surgeons and assessed their knowledge by using multiple-choice questions that have been used by other researchers in different settings. However, we did not study the reasons for the knowledge gap, and our sample size was not large enough to further study such an area of research. In addition, this was a cross-sectional survey; therefore, we cannot establish a temporal relationship between factors

and knowledge regarding the use of energy devices.

Conclusion

Most general surgery residents enrolled in the Saudi Arabian Board of Surgery lack adequate knowledge about the safe and efficient use of surgical energy devices. The level of understanding is lower among junior residents than senior residents. The gaps in knowledge might not improve even after gaining experience. There is a need to implement formal education or awareness programs in the existing curriculum with refreshers by conducting online courses or workshops for surgeons. Such a program should become a requirement for surgeons. The gap in knowledge and a pervasive absence of proper training indicates the necessity for a regulated and more proper program, such as FUSE, to tackle the lack of knowledge among surgeons about the safe use of energy-based devices in surgical procedures.

Acknowledgment

The Research Ethics Committee in Health and Science Disciplines (REC-HSD) in the College of Medicine, Prince Sattam Bin Abdulaziz University, with the institutional review board approved the current study after the aim of the study was explained. Moreover, proper consent was obtained from each participant who was included in the research. To maintain ethics, the identities of the participants was kept confidential throughout the study. We gratefully acknowledge the great effort of the surgical residents, as they were spending some time of their busy schedule in answering the multiple-choice questionnaire. All authors have seen and approved the final version of the manuscript being submitted.

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