Anaesthetists' knowledge and awareness of diathermy use in a department of anaesthesiology

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg in partial fulfilment of the requirements for the degree of Master of Medicine in the branch of Anaesthesiology.

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Declaration

I, Harrilene Apleni declare that this research report is my own unaided work. It is being submitted for the Degree of Master of Medicine in the branch of Anaesthesiology at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

3 November 2020

Dedication

To my husband, Anele Apleni, my children and my family, who were my greatest believers; thank you for your love and support.

Abstract

Background

Anaesthetists are expected to have a basic understanding of diathermy use. The aim of the study was to evaluate anaesthetists' knowledge and awareness of diathermy use in the Department of Anaesthesiology at the University of the Witwatersrand.

Methods

A prospective, descriptive, contextual study was conducted utilising an anonymous self-administered questionnaire distributed to anaesthetists during academic meetings and convenience sampling was used. A minimum sample size of 96 anaesthetists was estimated. Using the Modified Angoff method, a score of 62% was determined for adequate knowledge.

Results

One hundred and one questionnaires met the criteria for analysis. The overall mean score obtained for knowledge was 44.7%; 47.7% for junior anaesthetists versus 42.7% for senior anaesthetists (p=0.20). The total number of anaesthetists achieving an adequate score was 13 (12.9%). Of those, 10 (76.9%) were junior anaesthetists with a mean score of 71.0% and 3 (23.1%) were senior anaesthetists with a mean score of 67.0% (p=0.72). There was no significant difference in the knowledge between anaesthetists with Fellowship of the College of Anaesthesia Part 1 exams and those without (p=0 34). In a comparison of knowledge between junior and senior anaesthetists, junior anaesthetists scored significantly better in the category of precautions and appropriate use (p=0.02).

Conclusion

The Wits anaesthetists showed poor overall knowledge of diathermy. While anaesthetists do not apply diathermy pads or use diathermy themselves, they are responsible for the safety of patients in the operating theatre and diathermy may interfere with anaesthetic equipment or patient devices.

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Abbreviations

Wits	University of the Witwatersrand
ASA	American Society of Anaesthesia
SAGES	The Society of American Gastrointestinal and Endoscopic Surgeons
FCA	Fellowship of the College of Anaesthetists

Statement

The Research Report consists of a literature review, draft article, study proposal and appendices. The study proposal is included for background reference and is not for examination.

The formatting of this Research Report complies with the University of the Witwatersrand's Style Guide for Theses, Dissertations and Research Reports. The formatting of the draft article may differ from the rest of the Research Report in order to comply with the author guidelines of the South African Journal of Anaesthesia and Analgesia, the journal to which it is intended to be submitted.

Section 1: Review of the literature

1.1 Introduction

This chapter introduces the literature of diathermy which shall be discussed under the following headings: history and background, patient safety, hazards and complications, principles of diathermy, recommendations for diathermy use, operating theatre standards for the use of diathermy, knowledge and practice of diathermy among operating theatre staff and the role of anaesthetists in diathermy use.

1.2 History and background

The word diathermy is a combination of two words “dia” and “thermal”. The word “dia” means travelling or moving through whilst the word “thermal” is related to heat, it is described as “the cutting and coagulation of body tissue with a high frequency current”. Diathermy use was first discovered in 1925, after one of Cushing’s residents suggested that an electrosurgical machine be used on the brain. Cushing later formed a collaborative partnership with Bovie at Harvard University to refine the use of diathermy during neurosurgical procedures to limit blood loss. A report published indicating their success facilitated to bring diathermy to the attention of the medical field and revolutionised surgery (1).

Over the years, the use of diathermy has increased globally; the majority of surgical procedures performed across all specialities involve the use of the diathermy (2). The number of minimally invasive surgical procedures that use diathermy have also steadily increased (1). As such, several newer electro-medical devices with comparable risks as diathermy are being developed, these include fibre-optic retractors and laparoscopic diathermy (3).

1.3 Patient safety

Human beings irrespective of their profession are prone to making errors (4). The medical profession as a whole, including the field of anaesthetics, is no exception. There is a 1 in 300 chance of a patient being harmed when receiving health care

(4). A diathermy burn constitutes a medical negligence, which has medical, legal and ethical consequences (3).

“Patient safety is the absence of preventable harm to a patient during the process of health care” (5). This is the coordinated effort to avoid harm to the patient from the administration of medical care and has been increasingly recognised as an issue of global significance (5). For anaesthetists patient safety is emphasised in the Helsinki Declaration on Patient Safety in Anaesthesiology, which is a set of principles requirement stating that any institution administering anaesthesia should have protocols for checking equipment and drugs (6).

Throughout the perioperative period, operating theatre staff from different disciplines form a multidisciplinary team with different levels of knowledge, training and skills. The multidisciplinary team has a shared responsibility, within a contained environment in close proximity to specialised equipment and potential sources of danger, to work together towards the effective and successful provision of safe anaesthesia and surgery (7).

The main aim of effective anaesthetic care is the reduction of morbidity and mortality rates, and also to prevent complications from surgery. The anaesthetist is predominantly a “physiology policeman” and good anaesthetic care aims to maximise patient well-being and safety, and prevent injury and harm from aspects other than surgery (8).

Many factors contribute to patient safety and optimal patient outcome, including the safe use of equipment, including diathermy (9). Thus it is vital for theatre staff to be knowledgeable on the principles and recognise the hazards relating to diathermy use in operating theatre and to be formally trained in its safe application and use (10).

1.4 Hazards and complications

Technical advancement has improved the safety of modern diathermy machines, but these improvements have not managed to reduce the hazards of the electric fields generated which put the patient and operating theatre staff at risk. Major complications from diathermy include smoke inhalation, burns, fires, arrhythmias and electrocution, with other minor complications that may be detected during surgery with no direct harm to the patient such as direct stimulation of the muscles causing contractions that can be interpreted incorrectly as inadequate depth of anaesthesia (3).

Iatrogenic diathermy burns during the perioperative period may be a consequence of one of four mechanisms (10):

1. Burns resulting from direct contact with active electrode placed on the patient or directly in contact with the theatre staff,
2. Burns at the site of the neutral electrode,
3. Burns from electrode heating pooled solutions such as alcohol-based skin preparations,
4. Burns from short circuits created between the positive electrode and alternative grounding sources occurring outside the operation field.

An analysis by Kressin (11) of the American Society of Anaesthesia (ASA) Closed Claims Project database of 2004 revealed that the incidence of accidental operating theatre burns was 2%. Diathermy accounted for 19% of these intraoperative burns, including both diathermy-induced fires and electric grounding pad skin burns and of these burns 64% involved the face. The occurrence of immediately identifiable burns owing to leaking currents is an estimated 0.1% (11). Some burns are only identified days after surgery and can be mislabelled as allergic reactions, pressure sores, or chemical contact reactions (12).

Accidental burns are a very traumatic experience for both the affected patient and the operating theatre staff involved (13). Intraoperative diathermy burns can range from superficial to deep thermal and full thickness burns which may require debridement, skin grafting/muscle reconstruction (12). Other consequences of burn injury are physical scars, emotional trauma and lengthy hospital visits. Doctor-patient interactions are often disturbed with the risk of medicolegal litigation (13).

Diathermy burns may affect surgeons as well. Wheble et al (14) published a case report of a surgeon who sustained a full thickness burn as a result of a crack in the insulation of a pair of monopolar diathermy which caused the diathermy current to travel along an unintended path with no or very low electrical impedance via exposed metal at the diathermy's apex.

Electrocution is another common hazard that the operating theatre staff are exposed to. It is usually due to faulty connections accompanied by electric current leaks (15). Diathermy can interfere with cardiac pacemakers and internal cardiac defibrillators by altering their electrical activities, which may result in ventricular fibrillation and other forms of arrhythmias. Furthermore, these devices may be permanently damaged with the use of diathermy (16).

The fire triangle consists of an oxidising agent, fuel and heat for theatre fire to be initiated. The three elements of the fire triangle can be identified in the operating theatre as oxygen, air, or nitrous oxide as the source of oxidising agent; body tissue or surgical drapes as the source of fuel; the diathermy unit as the source of heat (3).

The United States Fire Administration approximates that nearly 125 000 fires occur yearly in the workplace; 2260 of these fires occur in health care facilities, and results in the loss of lives and injuries (17). Diathermy is the exacerbating cause in 50 − 100 of these cases (18).

In an analysis of the ASA Closed Claims database, Metzner et al (19) found that approximately a fifth of claims during monitored anaesthesia care claims are due to operating theatre fires, but general anaesthesia and regional anaesthesia contributed to less than 1% of claims. With monitored anaesthesia care claims associated with fire, surgery to the head, face and neck, all contributed to the majority of cases reported. In all these specific cases, diathermy and supplemental oxygen were the contributing factors. Supplemental oxygen is under the anaesthetist's control and significantly adds to intensity and rapid spread of fire (19).

A fear of the risk of infectivity, mutagenicity and cytotoxicity of surgical smoke released during diathermy use has been raised. It is believed that the smoke apart from having a fetid odour, it obscures the field of vision during laparoscopic procedures and has been shown to contain harmful substances including live viruses and bacteria (18).

1.5 Principles of diathermy

Electricity is the flow of electric charges between atoms. Atoms are composed of electrons, protons and neutrons which have a negative, positive and neutral charge respectively. When a force is introduced into an atomic field, there is a movement of electrons from one atom base to another which results in a change to the charge. Electron movement is predictable; unlike charges attract and like charges repel each other (20).

Electricity is based on three basic principles, namely:

- It follows the path of least resistance.
- It always returns to a reservoir of electrons, such as ground.
- It needs a complete circuit to flow (21).

Electric current flows as electrons move from one atom to the other through an adjacent circuit (21). Ohm's law states that, "the force responsible for moving the generated electrical current through the active electrode is voltage" (22). Voltage is measured in volts (V) and is defined as "the electrical potential to move free electrons from one point to another point within a circuit" (22). The following equation below represents Ohm's law:

$$V = I \times R$$

Where V – Voltage
I – Current
R − Resistance

Current produced during diathermy use is supplied to the tip of an electrode by generators that ramp the frequency from 60 Hz to radiofrequency range of 200 kHz to 3.3 MHz range. The rate at which the radiofrequency current alternates between the positive and negative electrode is so fast that the tissue does not depolarise or respond to the changes in current. Because nerve and muscle stimulation cease at 100 kHz, diathermy can be performed safely at frequency above 100 kHz. A diathermy generator increases the frequency to over 200 kHz. At this frequency diathermy energy can pass through the patient with minimal neuromuscular stimulation and with no risk of electrocution (20). The radiofrequency spectrum is shown in Figure 1.1.

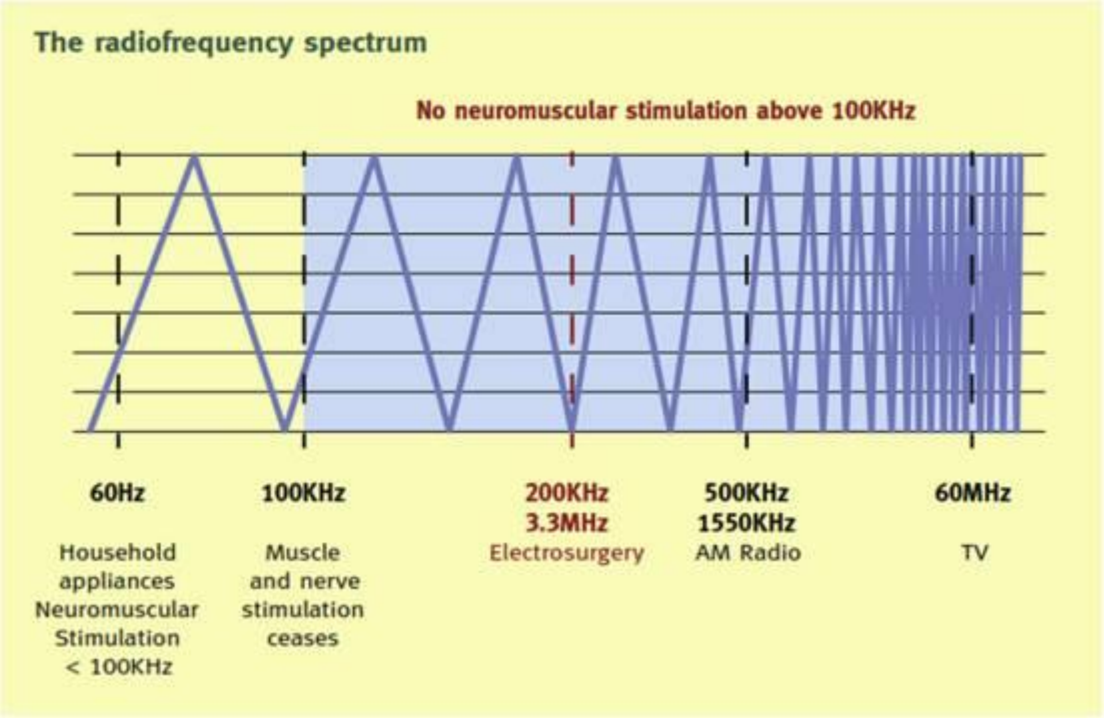

Figure 1: The radiofrequency spectrum (20)

The heat generated by diathermy is explained by Joule's law in the following equation (23):

$$\text{Heat (Q)} = \text{Current (I)}^2 \times \text{Time (t)} \times \text{Resistance (R)}$$

The heat produced is directly proportional to the square of the current, time of the current flow and resistance. The effects and complications of diathermy can be explained in terms of Joule's law (23). The heat produced by diathermy during use produces coagulation, cutting or fulguration depending on the resistance, current and contact time (8).

As the tissue resistance increases, more heat will be produced due to friction. The higher this intrinsic resistance, the higher the voltage needed to allow the flow of current through the tissue. In addition, cauterisation increases the resistance of the superficial tissues causing them to be less conductive to the electricity and thus, a high voltage will be required to be able to penetrate to deeper layers of the tissue (8).

Current density is defined as “the amount of electricity flowing through a tissue area” (24).

$$\text{Current density} = \frac{\text{Current x Time}}{\text{Area}}$$

The heat released determines the extent of the tissue effect and is inversely proportional to the surface area of the electrode (17). The small area of the diathermy tip with concentrated current increases resistance which necessitates more energy to allow current to flow through it. The higher the current passing through a smaller area creates relatively more heat and thus a greater clinical effect (1).

Current density is directly proportional to the time the tissue is exposed to current. The longer the tissue is exposed to the current, it produces a greater effect; but there is also a risk of injury to adjacent tissues due to the spread of heat (21). However, a less desirable effect may be attained if the time is too short for which the tissue is exposed to current (1).

A low current density is achieved by discharging the current through the neutral electrode; that is the patient return electrode. The current density is reduced by the neutral electrode as it has a relatively larger surface area for faster dissipation of heat , preventing temperature rising to a level that will damage the underlying tissues as it leaves the patient’s body (16).

It is recommended that the patient return electrode should be placed in close proximity to surgical site. The greater the distance the current must travel from the surgical site to the return electrode, the current will encounter more resistance which leads to more voltage being required to attain a desirable tissue effect. To minimise resistance, the patient return electrode should be positioned on a large, well vascularised muscle (1).

Power, measured in watts (W), is directly proportional to current and voltage and relates to the rate of work performed. The following equation shows how power also known as the rate of work performed is defined:

$$P = V \times I$$

Where: P – Power
V – Voltage
I – Current

In general, the lowest voltage to achieve the desired effect should be chosen and this is influenced by individual patient characteristics. The instructions detailing the use of each diathermy unit should be followed when choosing an appropriate power setting (3).

1.5.1 Monopolar diathermy

Monopolar diathermy is most frequently used as it has a variety of tissue effects and is more powerful. The current produced by the generator flows through an active electrode into the tissues of the patient, where it produces the intended tissue effect; and then flows through the patient's body to the return electrode, safely sending back the collected current to the generator (3).

1.5.2 Bipolar diathermy

In comparison to monopolar diathermy, energy flow in bipolar diathermy is divided between two special tweezers. Electrical current flow is achieved by means of two parallel poles located close together (17). No return electrode is required and less energy is necessary owing to the essentially reduced high frequency field between the two electrodes; 50 W power is used in bipolar diathermy as opposed to 400 W with monopolar diathermy (17).

Bipolar is a safe diathermy technology; burns almost never occur (25). It is also safer in patients with implanted pacemakers and defibrillators when there is a high risk of using more powerful monopolar diathermy units (17). However, bipolar diathermy may give rise to capacitive coupling with other electrical devices (18).

1.5.3 Diathermy modes

Diathermy generators are able to produce a variety of electrical waveforms with distinct tissue effects to produce variable degrees of cutting, coagulation, blend and dissection with haemostasis. The use of a specific waveform determines the clinical effect on the tissue (22).

The cutting output mode uses a low voltage setting which ensures that tissue evaporation is achieved with the least coagulation tissue effect and with the current that is continuous, non-modulated and sinusoidal waveform. This type of mode provides clean tissue separation with the least thermal spread and may also be used to cauterise bleeders by placing the active electrode in direct contact with the tissue (22).

The coagulation mode supplies a greater voltage with an intermittent duty cycle that is on 6% of the time and in a modulated waveform The energy that is delivered during this 6% timespan heats the tissues during intermittent spikes of high voltage that ranges from 9000 to 10 000V; the 94% timespan allows for the cooling down of the cells and for the formation of a coagulum (22).

The blend mode transforms the constant cut waveform into an interrupted blend waveform by modifying the duty cycle. The voltage is augmented and the current is interrupted according to the settings selected, thus changing the degree of cutting and haemostasis achieved. There are different types of blend waveforms with variations of the time on and off during the cycle. Blend 1 is 50% on and 50% off cycle; blend 2 is 40% on and 60% off cycle and blend 3 is 25% on and 75% off cycle. The intensity of the tissue haemostatic effect achieved is determined by the level of the blend setting (22).

Lastly, the dissection mode is a coagulation driven mode with an interrupted 25% sinusoidal waveform. This mode is different from the traditional blend mode (which is a cut-driven waveform), it allows for the combination of dissection with haemostasis using a lower energy setting to attain the required clinical effect (22).

The variable that defines whether one waveform vaporises tissue and another produces a coagulum is the rate at which heat is produced. High heat production rapidly causes vaporisation and low temperature produced creates a coagulum (22).

1.5.4 Considerations during minimally invasive surgery

The use of endoscopic diathermy presents a number of hazards due to insulation failure, direct coupling, endosurgical smoke, capacitive coupling, residual heat injury, and electromagnetic interference (26). Direct coupling, capacitative coupling and insulation failure will be discussed as these may cause adverse patient outcomes.

In order to ascertain the root causes of potential hazards the active electrode and the cannula system of diathermy are divided into four separate zones labelled 1, 2, 3 and 4 as illustrated in Figure .2 below (26):

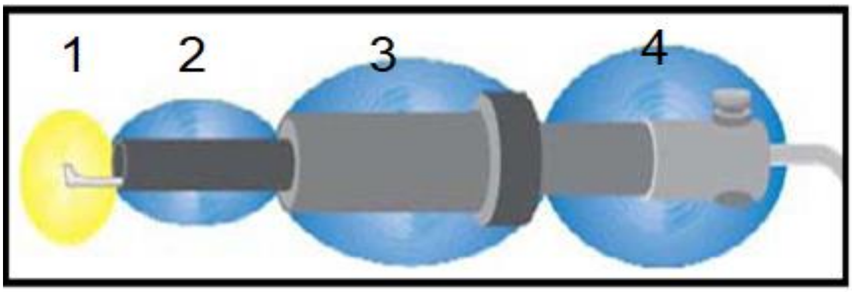

Figure 2: Four zones of injury (26)

Zone 1 represents the tip of the active electrode which is directly visible to the surgeon. Zone 2 is the section beyond the tip of the electrode to the end of the cannula. Zone 3 is part of the area of the active electrode concealed by the cannula system. Both Zone 2 and Zone 3 are not visible to the surgeon. Zone 4 is the part of the active electrode and cannula that is outside the patient’s body cavity (26).

Stray current in Zones 2 and 3 poses a potential hazard as the surgeon cannot see these zones and this current may result in direct coupling, capacitive coupling or insulation failure (26).

1.5.4.1 Direct coupling

Direct coupling occurs when the diathermy is accidentally activated in Zone 1, 2 or 3 while the active electrode is in direct contact with another metal instrument. The secondary instrument becomes energised and this energy follows the path of least resistance to complete the circuit to the patient return electrode. Direct coupling outside the surgeon's visual field has a potential for significant patient injury if the current is sufficiently concentrated The diathermy generator should not be activated while the active electrode is touching or is in close proximity to another metal object (26).

1.5.4.2 Capacitive coupling

"A capacitor consists of two conductors separated by an insulator" (27). Capacitive coupling arises when two instruments (conductors) separated by an insulator producing an electrostatic field. The current is then moved from the active electrode, via the insulator in the direction of adjacent structures without direct contact (27).

A capacitor is formed when an insulated active electrode is placed into the metal cannula during laparoscopic surgery. The energy stored in the capacitor in an all metal system is released into the patient through a relatively larger surface area of contact between the muscular abdominal wall and the cannula. In contrast, the use of a plastic cannula stops the transmission of energy and may result in damage to adjacent tissues (26).

1.5.4.3 Insulation failure

Insulation failure is considered a major cause of laparoscopic related diathermy injuries. It is caused by compromise to the insulating coating on the active electrode, this may result from instrument damage from rough handling, instrument cleaning, repeated insertions into the cannula system, or an insulation defect from the use of high voltage electrosurgical current, such as coagulation (26).

There has been some concerns raised that some of the active electrodes that are used by surgeons may not meet the recommended standards of electrosurgical devices set by the Association for the Advancement of Medical Instrumentation, posing high safety risks to the patients during surgery (26). Zones 2 or 3 are not visible to the surgeon and therefore, insulation failure cannot be easily detected by surgeon which may lead to the damage to surrounding body structures if too much concentrated current is delivered at the point of contact (26).

1.6 Recommendations for diathermy use

To ensure the safe use of diathermy, operating theatre standards pertaining to the diathermy unit, application of the return electrode, choice of diathermy mode and considerations in minimally invasive procedures must be addressed.

Alkatout et al (22) recommends the following steps to theatre staff as a way to minimise the risk of a patient being injured during the use of diathermy:

- “The insulation should be carefully inspected,
- The lowest possible power setting should be used,
- The low voltage (cut) waveform should be used,
- Brief intermittent activations should be used instead of prolonged activations of the positive electrode,
- The positive electrode should not be activated close to or in direct contact with metal or conductive objects in the abdomen,
- Bipolar diathermy should be used when possible”.

For the positive electrode of diathermy in minimally invasive procedures, an all-metal-cannula system is the best choice to disperse electrical build up along the cannula. Hybrid systems (metal and plastic components) should not be used (28).

A pad monitoring system is imperative to monitor the quality of contact between the patient's skin and the return electrode. If there is high resistance between the pad and the skin or the dislodgement of the pad, an alarm will ring to caution alert until the issue at hand is resolved. It has been reported that excessive hair between the pad and skin; air trapped between the pad and the skin or pad placement on an area that is poorly conductive such as scar tissue may increase the resistance of the diathermy unit (17).

ASA has developed a practice advisory for managing and preventing fires in operating room. The recommendations emphasise the importance of effective communication between the surgeon and the anaesthetist. It was stated that the correct timing of diathermy use is essential so as to ensure that timeous stopping of oxygen delivery before airway cauterisation and also that the surgical drapes in the theatre should be open to avoid excessive accumulation of oxygen. This can drastically reduce the risk of fires in the operating room (19).

The manufacturer's recommendations must be strictly followed including the safety features and quality contact monitoring system of the diathermy. Failure to follow these recommendations is gross negligence as the patient may be harmed or injured during the operation (28).

1.7 Operating theatre standards on the use of diathermy equipment

The following standards which act as useful guidelines were developed by the Royal Cornwall Hospitals NHS Trust to be useful during diathermy use so as to ensure that the safety of the patient is protected (29).

1. "All operating theatre staff using diathermy equipment must receive an appropriate training and have been assessed as competent. They must fully understand the safe use of equipment and the principles of diathermy.
2. Diathermy machines must be checked prior to the start of every list, in accordance with the manufacturer's recommendations.

3. Maintenance and testing of equipment must be done annually by a certified company to ensure safety; any faulty or damaged items must be removed from use immediately and reported for repair.
4. Application of diathermy grounding plates should be done by competent practitioners in accordance with the manufacturer's recommendations. For example the diathermy grounding plate should be applied to a clean, dry, hair free, muscular area, as close to the operation site as possible, away from any pre-existing metal work in the patient.
5. Diathermy return electrodes (grounding plates) must be kept clean and dry, and preventative measures taken to ensure the plate does not become soiled with preparation solutions or body fluids.
6. The scrub person must check diathermy forceps and leads prior to use, to confirm intact insulation and good connections between components.
7. The scrub person must keep the diathermy forceps or a blade within a suitable insulated receptacle during surgery, to prevent accidental burns to the patient or members of the surgical team.
8. Scratch pads may be used to clean the tips of monopolar diathermy forceps to ensure good contact with bleeding vessels is maintained, and prevent sticking and possible tissue damage from excessive charring on forceps ends.
9. Scratch pads must never be used on bipolar forceps as they remove the non-stick properties and render the instrument useless; a damp swab should be used to remove charred tissue.
10. All operating theatre staff must be aware of any patient contraindication to the use of monopolar diathermy prior to commencement of surgery.
11. Staff must be educated about the use of visor masks to prevent inhalation and eye contamination with diathermy plume.
12. The diathermy machine must be switched off or set to standby before connecting or disconnecting live electrodes, and the surgeon informed of the power settings before use.
13. Single use patient return electrodes must never be reused.
14. The patient return electrode must be in direct and complete contact with the patient throughout surgery. If the patient position is changed after the application of the plate, the site must be rechecked. Patient skin condition

must always be checked after removal of the grounding plate, and the site and skin condition recorded on the perioperative documentation.

15. The patient must be shielded from metal objects to prevent a short circuit bypass of the grounding plate" (30).

No other medical standards related to diathermy use could be identified in the literature.

1.8 Knowledge and awareness of diathermy among operating theatre staff

The technological advancement in the medical field has led to the improvement and better understanding of diathermy, and these improvements has also made it possible to avoid the hazards that were previously common (31). Despite this, literature found gaps in knowledge pertaining to the use of diathermy and the subsequent adverse effects as a result (2, 10, 31, 32).

A study by Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) which involved general surgeons, cardiothoracic surgeons and neurosurgeons as participants discovered gaps in the basic safety principles of diathermy; it found gaps in knowledge relating to basic safety among its leaders and indirect feedback from those who did not choose to participate in the study indicated that most of them felt that they lacked understanding on the basic principles of diathermy (10). It was also revealed that there were some safety concerns with some of the practices that were used. Among these are the following:

- If the size of the plate required to perform a procedure is not an appropriate size, some of the participants indicated that they would cut the bigger plate to the required size for a paediatric patient.
- In case of a fire in theatre, some of the participants indicated that they would not remove the patient from the breathing circuit.
- Some of the participants indicated that if there is burning material on the patient they would not remove it immediately.

All the aforementioned demonstrated the knowledge gap amongst some of the surgeons. All these actions could result in significant patient injury. Subsequently, SAGES developed an education programme called Fundamental Use of Surgical Energy to improve knowledge about the safe use of diathermy among surgeons at all levels (10).

In a study conducted on the awareness and attitude to the appropriate use of diathermy in Ireland by Mcquil et al (18) in 2016 amongst surgical employees, revealed that the majority of surgical employees did not follow these:

- Place diathermy pad on the patients themselves,
- Check the diathermy equipment before using the equipment,
- Check the diathermy pad site after the surgical procedure, and
- Did not know the reason for placing the diathermy pad when using monopolar diathermy.

A survey by Pandey et al (31) conducted in 2007 to assess the knowledge of diathermy of Obstetrics and Gynaecology trainees in the Yorkshire Deanery revealed that the knowledge of diathermy was lacking amongst the trainees. Furthermore, there is poor overall knowledge of diathermy amongst surgeons and the most common causes of diathermy injuries were identified as:

- Inadvertent touching of the tissue during current application,
- Direct coupling between a portion of bowel and a metal instrument in contact with the activated probe;
- Insulation breaks in the electrodes;
- Direct sparking to the intestine from the diathermy probe; and
- Current flowing through the intestine from recently coagulated, electrically isolated tissue (33).

No literature could be identified regarding knowledge and awareness of diathermy use among anaesthetists.

1.9 The role of anaesthetists in diathermy use

While anaesthetists do not apply diathermy pads or use diathermy themselves, they are responsible for the well-being of patients in theatre. In this regard, effective anaesthetic care must help in the reduction of morbidity, mortality and complication rates during surgery (34).

Anaesthetists are expected to have a basic understanding of diathermy and principles of diathermy use, operating theatre fires and explosions, basic electricity, and electrical safety, which are all included in the Fellowship of College of Anaesthetists Part 1 curriculum (35).

Anaesthetists' daily practice involves the use of equipment that could pose potential hazards in the presence of diathermy, such as pacemakers and defibrillators. Ensuring patient and operating theatre staff safety by minimising risk is crucial, and knowledge is key to patient safety (27).

1.10 Summary

Diathermy is a potentially hazardous piece of equipment used routinely in most surgical procedures. The operating theatre staff including nursing staff, surgeons and anaesthetists share the responsibility for safe operating theatre practice and patient safety. While the anaesthetist is not directly responsible for the placement of diathermy pads or use of the machine, knowledge of its use and potential complications are essential.

Due to a lack of research and guidelines on diathermy use, especially in the South African literature, studies to determine the knowledge of diathermy among anaesthetists, who act as the patients advocate during the perioperative period, could influence patient care.

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Acknowledgements

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The following are sample references:

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Figure numbers: Arabic, table numbers: Roman

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Section 3: Draft article

Anaesthetists' knowledge and awareness of diathermy use in a department of anaesthesiology

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Key words: knowledge, diathermy, anaesthetists

Abstract

Background

Anaesthetists are expected to have a basic understanding of diathermy use. The aim of the study was to evaluate anaesthetists' knowledge and awareness of diathermy use in the Department of Anaesthesiology at the University of the Witwatersrand.

Methods

A prospective, descriptive, contextual study was conducted utilising an anonymous self-administered questionnaire distributed to anaesthetists during academic meetings and convenience sampling was used. A minimum sample size of 96 anaesthetists was estimated. Using the Modified Angoff method, a score of 62% was determined for adequate knowledge.

Results

One hundred and one questionnaires met the criteria for analysis. The overall mean score obtained for knowledge was 44.7%; 47.7% for junior anaesthetists versus 42.7% for senior anaesthetists (p=0.20). The total number of anaesthetists achieving an adequate score was 13 (12.9%). Of those, 10 (76.9%) were junior anaesthetists with a mean score of 71.0% and 3 (23.1%) were senior anaesthetists with a mean score of 67.0% (p=0.72). There was no significant difference in the knowledge between anaesthetists with Fellowship of the College of Anaesthesia Part 1 exams and those without (p=0 34). In a comparison of knowledge between junior and senior anaesthetists, junior anaesthetists scored significantly better in the category of precautions and appropriate use (p=0.02).

Conclusion

The Wits anaesthetists showed poor overall knowledge of diathermy. While anaesthetists do not apply diathermy pads or use diathermy themselves, they are responsible for the safety of patients in the operating theatre and diathermy may interfere with anaesthetic equipment or patient devices.

Number of words: 246

Introduction

Electricity is a phenomenon that has been used for many years in the operating theatre and its current use is an intrinsic characteristic of modern surgery. Diathermy utilises the principles of electricity and is defined as “the cutting and coagulation of body tissue with a high frequency current” (1). Historically, diathermy use in medicine dates back to 1925 when Cushing first contemplated the use of diathermy during a medical conference when one of his residents suggested that an electrosurgical machine be used on the brain (2). Cushing later discussed this concept with Bovie at Harvard University and this partnership turned into a collaborative effort in refining electrocautery and its use during neurosurgical procedures to limit blood loss. A report published indicating their success helped to bring diathermy to the attention of the medical field and it therefore revolutionised surgery (2).

Although most modern diathermy machines are safe, the electric fields they create may pose hazards to the patient and operating theatre staff. They can cause burn injuries, electrocution, operating theatre fires, arrhythmias and smoke inhalation (3). The incidence of diathermy induced injuries reported is 1 – 5 cases per 1000 operations. Between 50 – 100 cases of surgical fires occur every year in the United States of America, with diathermy being the primary cause of such fires (1).

An analysis by Kressin (4) of the American Society of Anaesthesia Closed Claims Project Database of 2004 revealed that the incidence of inadvertent operating theatre burns occurrence was 2%. Electrocautery accounted for 19% of intraoperative burns, including both diathermy-induced fires and electric grounding pad skin burns. Sixty-four percent of burns caused by diathermy were facial burns, and these represented 21% of all burns claims (4).

Inadvertent burning of a patient is traumatic and often catastrophic, not only for the affected patient but equally for the operating theatre team. Physical scars, emotional trauma and prolonged hospital stay are inevitable, depending on the extent of the burn. Doctor-patient relationships often become disrupted with legal consequences to the relevant practitioners following a diathermy injury (5).

While anaesthetists do not apply diathermy pads or use diathermy themselves, they are responsible for the well-being of patients in theatre. Anaesthetists practice involves the use of patient devices that could pose potential hazards in the presence of diathermy, such as cardiac pacemakers and internal cardiac defibrillators. Ensuring patient and staff safety by minimising risk is crucial and knowledge is key to patient safety (6). Anaesthetists are expected to have a basic understanding of diathermy and the principles of diathermy use, operating theatre fires and electrical safety which are all included in the Fellowship of the College of Anaesthetists (FCA) Part 1 curriculum (7). The aim of this study was to evaluate anaesthetists' knowledge and awareness of diathermy use in the Department of Anaesthesiology at the University of the Witwatersrand (Wits).

Methods

Approval to conduct this study was obtained from the Human Research Ethics Committee (Medical) and other relevant authorities. This was a prospective, contextual, descriptive study using an anonymous self-administered questionnaire.

The study population consisted of all anaesthetists working in the Department of Anaesthesiology at Wits. In consultation with a bio-statistician, a minimum sample of 96 anaesthetists was calculated. This was based on the assumption that 65% of anaesthetists in the Wits Department of Anaesthesiology would have adequate knowledge of diathermy use to within an accuracy of 10%, with 95% confidence (8). In this study a junior anaesthetist was defined as a medical officer or registrar in the first, second or third year of training and a senior anaesthetist was a registrar with 4^{th} or more years of training, a consultant or a career medical officer.

No questionnaires pertaining to the appropriate use of diathermy were identified in the literature. A draft questionnaire was compiled based on a review of the literature to ensure content validity. The draft questionnaire was reviewed by three specialist anaesthetists to ensure face and content validity and their changes were incorporated into the questionnaire. The final questionnaire consisted of two sections: Section 1 included the demographic data of anaesthetists and Section 2 consisted of 15 questions regarding the knowledge and awareness of diathermy. The questions in Section 2 were divided into different knowledge categories; firstly the principles of diathermy consisting of three questions, followed by hazards and complications with six questions, and lastly a category on precautions and appropriate use of diathermy with six questions.

The questionnaires were distributed at departmental academic meetings. A convenience sampling method was used. The questionnaires were numbered in order to calculate a response rate. One author (HA) was present during the completion of questionnaires to assist with queries and to prevent data contamination. To further prevent data contamination, questionnaires were distributed at non-consecutive departmental meetings. Anonymity was maintained as no personal information was requested on the questionnaire. All the completed questionnaires were folded and placed in a sealed box at the door of the meeting room. Return of completed questionnaires implied consent. Unanswered questions were considered incorrect.

Adequate knowledge was determined as 62% using the Modified Angoff method (9). Blank questionnaires were excluded from the study. Using Microsoft Excel 2010, data were captured onto spread sheets. The statistical program, STATA version 15 (StataCorp, USA) was used to analyse data. Categorical variables were described using frequencies and percentages and compared using Chi-squared tests. Continuous variables were described using means and standard deviations and compared using independent t-tests. A p-value of <0.05 was considered statistically significant.

Results

A total of 110 questionnaires were distributed at departmental academic meetings, of which 101 (91.8%) were returned. There were 59 (58.4%) junior and 42 (41.6%) senior anaesthetists who participated. The demographics of anaesthetists are shown in Table I.

Table I: Demographics of anaesthetists

Demographics	Anaesthetists	
	Number	Percentage
Professional designation		
Consultants	31	30.7
Registrars	58	57.4
Medical officers	12	11.9
Years of experience in anaesthesia		
0 − 5 years	64	63.3
6 − 10 years	25	24.8
>10 years	12	11.9
Registrar time		
First year	15	25.9
Second year	14	24.1
Third year	18	31.0
Fourth year or more	11	19.0
FCA Part 1 exams		
Yes	80	79.2
No	21	20.8
When FCA Part 1 exams were passed		
Not applicable	21	20.8
<1 year ago	17	16.8
1 − 5 years ago	48	47.5
>5 years ago	15	14.9

For the questionnaire as a whole, the overall mean score obtained for knowledge was 44.7% (SD 16). There were 13 (12.9%) anaesthetists who achieved an adequate knowledge score. Of those, 10 (76.9%) were junior anaesthetists with a mean score of 71.0% and 3 (23.1%) were senior anaesthetists with a mean score of 67.0%; the difference was not statistically significant (p=0.72). Of those who achieved an adequate knowledge score, 10 (76.9%) had passed the FCA Part 1 exams ≤5 years ago. The number of correct responses to the questions is presented in Table II.

Table II: The number of correct responses to the questions

Question description	Anaesthetists with correct responses		
	Total n=101 n (%)	**Junior n=59 n (%)**	**Senior n=42 n (%)**
Principles of diathermy			
Range of alternating frequency	16 (15.8)	10 (9.9)	6 (5.9)
Type of diathermy	64 (63.4)	36 (35.7)	28 (27.7)
Amount of heat generated	65 (64.4)	41 (40.6)	24 (23.8)
Hazards and complications			
Fire triangle	95 (94.1)	56 (55.5)	39 (38.6)
Minimally invasive surgery complications	58 (57.4)	33 (32.7)	25 (24.7)
Diathermy waveform	29 (28.7)	17 (16.8)	12 (11.9)
Operating room fire with oxygen use	57 (56.4)	33 (32.7)	24 (23.7)
Airway fire with 100% oxygen	43 (42.6)	25 (24.8)	18 (17.8)
Peripheral skin burns	36 (35.6)	22 (21.8)	14 (13.8)
Precautions and appropriate use			
Ground plate contact areas and wires	16 (15.8)	10 (9.9)	6 (5.9)
Advantage of bipolar diathermy	51 (50.5)	30 (29.7)	21 (20.8)
Diathermy and cardiac pacemaker	39 (38.6)	29 (28.7)	10 (9.9)
Patient safety from electrocution	10 (10.0)	8 (8.0)	2 (2.0)
Patient safety from electrical shock	59 (58.4)	39 (38.6)	20 (19.8)
Placement of return electrode	40 (39.6)	22 (21.8)	18 (17.8)

The knowledge scores of the anaesthetists and the comparison of knowledge between the junior and senior anaesthetists for the questionnaire as a whole and per knowledge category are presented in Table III. The only category where there was a statistically significant difference between junior and senior anaesthetists was precautions and appropriate use (p=0.02). There was no difference in knowledge for the questionnaire as a whole between anaesthetists with Part 1 exams and those without (p=0.34).

Table III: Comparison of knowledge in different categories between the junior and senior anaesthetists

Knowledge	Mean (SD)		p value
	Score	Percentage	
Overall score (15 points)			
All anaesthetists	6.7 (2.4)	44.7 (16.0)	
Juniors	7.0 (2.5)	46.7 (16.7)	0.20
Seniors	6.4 (2.1)	42.7 (14.0)	
Principles (3 points)			
All anaesthetists	1.4 (0.8)	46.7 (26.7)	
Juniors	1.5 (0.8)	50.0 (26.7)	0.55
Seniors	1.4 (0.7)	46.7 (23.3)	
Hazards and complications (6 points)			
All anaesthetists	3.2 (1.4)	53.3 (23.3)	
Juniors	3.2 (1.5)	53.3 (25.0)	0.87
Seniors	3.1 (1.2)	51.7 (20.0)	
Precautions and appropriate use (6 points)			
All anaesthetists	2.1 (1.1)	35.0 (18.3)	
Juniors	2.4 (1.1)	40.0 (18.3)	**0.02**
Seniors	1.8 (1.1)	30.0 (18.3)	

Regarding awareness, more than 60% of the procedures that the anaesthetists were involved with required diathermy. The majority of anaesthetists, 88 (87.1%), responded that they thought diathermy was a safe instrument; however, 48 (47.8%) anaesthetists had witnessed complications. Figure 1 shows the complications witnessed during diathermy use. The complications under “other” in Figure 1 were sparks and shock and burns to the surgeon’s hand.

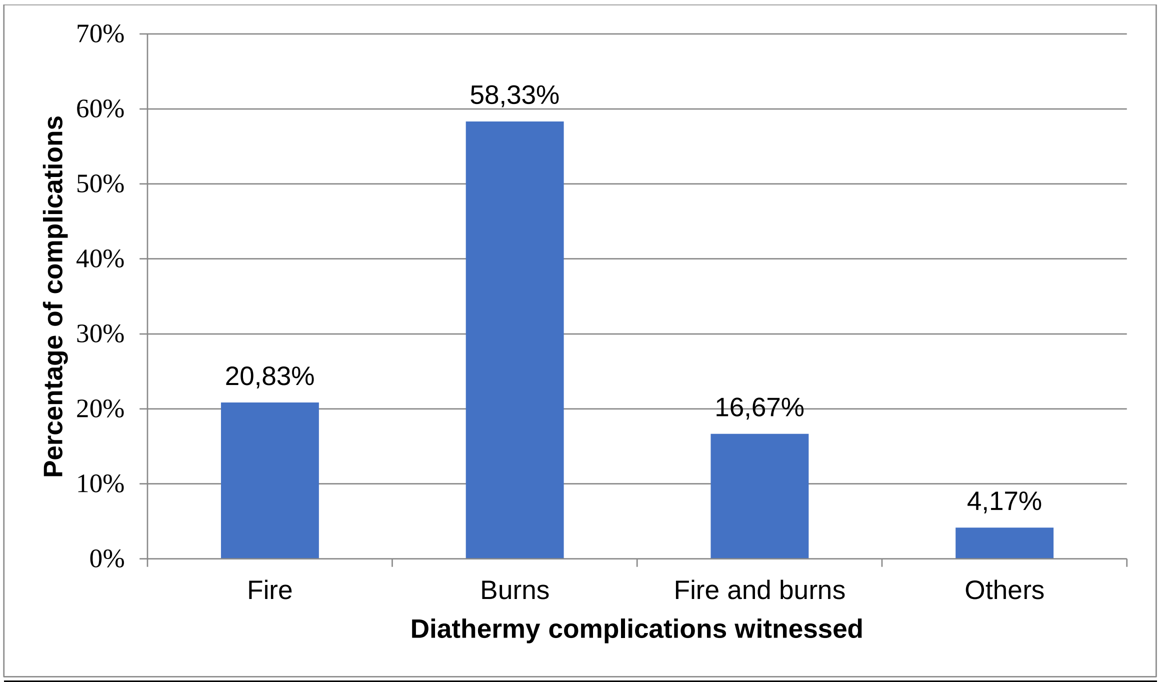

Figure 1: Complications witnessed during diathermy use

Discussion

The results of this study indicate that the knowledge amongst anaesthetists in the categories: principles of diathermy, hazards and complications and precautions and appropriate use of diathermy was poor, with an overall mean score of 44.7%. Using a cut-off score of 62% for adequate knowledge, there were only 13 (12.9%) anaesthetists who achieved adequate knowledge. The poor scores were unexpected as diathermy use and principles form part of the FCA Part 1 curriculum (7) and 65 (64.3%) anaesthetists indicated that they had passed these examination within the last five years.

There was no difference between the overall knowledge of senior and junior anaesthetists. The senior anaesthetists are role models for junior anaesthetists and oversee the teaching, and it would have been expected that they would be more knowledgeable regarding diathermy use due to their experience, despite having written their FCA Part 1 exam many years ago.

The least number of correct responses was for the question regarding patient safety from electrocution. Only 10% of anaesthetists answered this question correctly. Electrocution may results in cardiac arrhythmias, burns, nerve injury and minor complications such as stimulation of excitable tissues, lower limb movement during urological surgery or direct stimulation of the muscles causing contractions (10). Several measures can prevent or reduce the risk of electrocution, such as adequate maintenance and regular testing of diathermy, and ensuring the patient is not in contact with earthed objects which is a role of anaesthetists in the operating theatre (11).

Similarly, both junior and senior anaesthetists answered poorly on how to use diathermy in a patient with a cardiac pacemaker and identifying diathermy waveforms. Diathermy interferes with cardiac pacemakers and internal cardiac defibrillators by altering their electrical activity, which may result in ventricular fibrillation and other forms of arrhythmias (12). Furthermore, these devices may be permanently damaged by the use of diathermy (13). Failure to understand the effects of diathermy use pose a risk to patient safety and adverse outcomes may result from incorrect use.

Diathermy is a commonly used instrument in the operating theatre as the anaesthetists indicated that more than 60% of the procedures they were involved in required diathermy. Most of the diathermy related adverse events are considered preventable by ensuring an understanding of the technology and the application and by being aware of the potential risks (14). Many complications are based on the faulty use of diathermy and its settings; knowledge and basic skills in operating these devices are of great importance (15).

Studies looking at the knowledge and awareness of diathermy among anaesthetists could not be identified. A number of studies conducted amongst surgeons indicated poor knowledge regarding diathermy use irrespective of speciality, seniority or training (1, 14, 16-19). Mayooran et al (18) found that retention of knowledge after training was poor as the respondents demonstrated inadequate knowledge of diathermy a year later. Similarly, Pandey et al (19) surveyed obstetrics and gynaecology trainees regarding knowledge of diathermy and found that trainees had poor knowledge and that those who had attended a surgical skills course were not more knowledgeable. Assiotis et al (16) assessed diathermy training of surgical trainees and concluded that most of them had received no training on the basic principles and appropriate use of diathermy. Similar to our study, seniority played no role in better knowledge regarding diathermy use (16).

The contextual nature of this study is a potential limitation as the study was done in the Department of Anaesthesiology at Wits and may not be generalisable to other departments in South Africa or other countries.

The authors recommend that the use of diathermy receive greater attention in the training program of anaesthetic registrars and that it be part of continuous learning initiatives for anaesthetists.

Conclusion

The Wits anaesthetists showed poor overall knowledge regarding the principles, hazards and complications and precautions and appropriate use of diathermy. While anaesthetists do not apply diathermy pads or use diathermy themselves, they are responsible for the safety of patients in the operating theatre and diathermy may interfere with anaesthetic equipment or patient devices.

Conflict of interest

The authors declare that we have no financial disclosures.

Acknowledgement

This study was done in partial fulfilment of the requirements for the degree of Master in Medicine in Anaesthesiology. The authors would like to thank Professor EE Oosthuizen and Dr B Gardner for their contribution in formulating the questionnaire.

Number of words: 2301

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Section 4: Annexures

Ethics approval

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R14/49 Dr H Apleni

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M190107

NAME: (Principal Investigator)	Dr H Apleni
DEPARTMENT:	School of Clinical Medicine Department of Anaesthsia Charlotte Maxeke Johannesburg Academic Hospital
PROJECT TITLE:	Anaesthetists' knowledge and awareness of diathermy use in a department of anaesthesiology
DATE CONSIDERED:	25/01/2019
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Ms H Perrie
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	18/03/2019

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on 3rd floor, Phillip V Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.
I/We fully understand the conditions under which I am/we are authorised to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to resubmit to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date of the meeting when the study was initially reviewed. In this case, the study was initially reviewed in **January** and will therefore reports and re-certification will be due early in the month of **January** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical)

Principal Investigator Signature ____________ Date ____________

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Postgraduate approval

UNIVERSITY OF THE
WITWATERSRAND,
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06 February 2019
Person No: 0210775D
PAG

Dr H Apleni
769 Skukuza Street
0002
South Africa

Dear Dr Harrilene Apleni

Master of Medicine: Approval of Title

We have pleasure in advising that your proposal entitled *Anaesthetist's knowledge and awareness o diathermy use in department of anaesthesiology* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty'shigher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

Turnitin report

Section 5: Proposal

Anaesthetists' knowledge and awareness of diathermy use in a department of anaesthesiology

Harrilene Apleni

0210775D

Supervisor	Helen Perrie Department of Anaesthesiology
Co-supervisor	Juan Scribante Department of Anaesthesiology
Co-supervisor	Zainub Jooma Department of Anaesthesiology

5.1 Introduction and problem statement

Diathermy utilises the principles of electricity, and it is defined as “the cutting and coagulation of body tissue with a high frequency current” (1). Historically, diathermy use in medicine dates back to 1925, when Cushing first contemplated the use of diathermy during a medical conference when one of his residents suggested that the electrosurgical machine be used on the brain and later he formed a collaborative partnership with Bovie at Harvard University to refine the use of diathermy during neurosurgical procedures to limit blood loss. A publication reported on their success, which helped to bring diathermy to the forefront of surgical procedures and revolutionised surgery (2).

A diathermy machine changes electricity from the main supply (240 volts; 50 hertz) into a high frequency current (0,2 − 3 megahertz) to minimise the danger of electrical shocks (3). In monopolar mode, the current from the diathermy enters the patient through the active electrode and attached to the patient is a patient plate that completes the circuit back to the diathermy machine. The area of the patient plate is large so that the current density is small and there is no tissue damage. In bipolar mode, there is no patient plate as the current is conducted between the two prongs of the diathermy forceps (4). Bipolar diathermy is relatively low power and is therefore used for delicate work only.

Although most modern diathermy machines are safe, the electric fields they generate are still inherently hazardous to the patient and theatre staff. Complications from diathermy include burns, electrocution, operating room fires, arrhythmias and smoke inhalation (3).

The incidence of diathermy induced injuries reported is 1 ─ 5 cases per 1000 operations. Between 50 ─ 100 cases of surgical fires occur every year in the United States of America, with diathermy being the primary cause of such fires (1). If such an injury occurs, it can be tragic when vital structures are involved and they may lead to unsightly scars, even if it’s only superficial burns (4).

An analysis of the American Society of Anaesthesia Closed Claims Project Database of 2004 by Kressin (5) revealed inadvertent operating theatre burns occurrence was 2%. Electrocautery was responsible for 19% of intraoperative burns, including both diathermy-induced fires and electric grounding pad skin burns. Sixty-four percent of burns caused by diathermy are facial burns, and these represented 21% of all burns claims (5).

Most of the diathermy related adverse events are considered to be preventable by ensuring an understanding of the technologies and their applications and an awareness of potential risks (6). Many complications are based on the faulty use of diathermy and its settings; knowledge and basic skills in operating these devices are of great importance (4).

Technological advances and improvements in understanding diathermy have made most potential hazards avoidable. Despite this, the literature found gaps in knowledge pertaining to the use of diathermy and the subsequent adverse effects (6-9). The Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) assessed knowledge of the basic principles of diathermy, and found gaps in knowledge of basic safety principles among SAGES leaders. Subsequently, SAGES developed an education programme called Fundamental Use of Surgical Energy to improve knowledge about the safe use of diathermy among surgeons of all levels (6).

Modern surgery is reliant on diathermy, thus the need for health care workers to be knowledgeable regarding diathermy use to prevent injuries to self and patients. Although anaesthetists may not be directly involved with diathermy, they are responsible for wellbeing of patients in theatre (10). The knowledge and practice regarding diathermy use of anaesthetists working in the Department of Anaesthesiology at the University of the Witwatersrand (Wits) is not known.

The aim of this study is to evaluate anaesthetists’ knowledge and awareness of diathermy use in the Department of Anaesthesiology at Wits.

5.2 Objectives

The primary objectives of this study are to**:**

- evaluate the knowledge of the principles, risks, precautions and appropriate use of diathermy
- describe the awareness of diathermy use.

The secondary objective of the study is to compare the knowledge between junior and senior anaesthetists.

5.3 Aim

The aim of this study is to evaluate anaesthetists' knowledge and awareness of diathermy use in the Department of Anaesthesiology at Wits.

5.4 Research assumptions

The following definitions will be used in this study.

Anaesthetist: is any qualified doctor working in the Department of Anaesthesiology including interns, medical officers, registrars and consultants

Medical officer: is a qualified doctor practising in the Department of Anaesthesiology under specialist supervision**.** Medical officers with more than 10 years of experience are career medical officers and are regarded as consultants.

Registrar: is a qualified doctor who is registered with the Health Professions Council of South Africa as a trainee anaesthetist.

Consultant: is a specialist anaesthetist or career medical officer.

Specialist anaesthetist: is an anaesthetist who is registered with the Health Professions Council of South Africa as a specialist.

Junior anaesthetist: is a medical officer or registrar in the first, second or third year of training.

Senior anaesthetist: is a registrar with four or more years of training or a consultant.

Adequate knowledge/pass mark: in this study will be determined by using the modified Angoff method (11).

5.5 Demarcation of study field

The study will be conducted in the Department of Anaesthesiology, affiliated to the Faculty of Health Sciences of the University of the Witwatersrand. The staff complement of the department is 74 consultants, 112 registrars and 22 medical officers. The following core hospitals are affiliated to the department's training platform.

The following hospitals form part of the Wits clinical platform:

- Chris Hani Baragwanath Academic Hospital, a central hospital with 2888 beds and 23 theatres;
- Charlotte Maxeke Johannesburg Academic Hospital, a central hospital with 1200 beds and 25 theatres;
- Helen Joseph Hospital, a regional hospital with 500 beds and seven theatres;
- Rahima Moosa Mother and Child Hospital, a regional hospital with 338 beds and five theatres;
- Wits Donald Gordon Medical Centre, a public private hospital with 190 beds and seven theatres.

5.6 Ethical considerations

Approval to conduct the study was obtained from the Human Research Ethics Committee (Medical) and the Graduate Studies Committee of the University of the Witwatersrand. The Head of Department (Appendix 1) will be approached for consent to conduct the study in the Department of Anaesthesiology at Wits.

This study is knowledge and practice based using an anonymous self-administered questionnaire. Anaesthetists will be approached at academic departmental meetings; the researcher will explain the study and invite participation. If they agree, they will receive an information letter (Appendix 2) and the questionnaire (Appendix 3). Participation is voluntary and consent will be implied on completion of a questionnaire.

Anonymity will be maintained as no personal information will be required to complete a questionnaire. A study number will be allocated to each questionnaire in order to calculate the response rate. The completed questionnaire will be folded and placed in a sealed box at the door of the meeting room. It will take approximately 10 minutes to complete the questionnaire. Confidentiality will be ensured by allowing only the researcher and supervisors access to the raw data. The raw data will be stored in a locked cupboard for six years following the completion of the study.

If the results of the study show inadequate knowledge, the Head of Department will be informed and departmental teaching will be organised.

The study will be conducted in accordance with the Declaration of Helsinki (12) and the South African Good Clinical Practice Guidelines (13).

5.7 Research methodology

5.7.1 Research design

Burns and Grove (14) describe a research design as the blueprint for a study. According to Brink et al (15), a research design determines the methods by which the researcher obtains subjects, collects data and interprets results. A prospective, contextual and descriptive research design will be followed in this study.
A prospective study is one in which a specific population is followed over time to observe an outcome (15). This will be a prospective study as data will be collected at departmental academic meetings at the time the study takes place.

A contextual study is one which refers to a specific group or population, defined by De Vos et al (16) as a “small-scale world” which can for example be a ward, an intensive care unit or a clinic. This study will be contextual because the research will be conducted in the Department of Anaesthesiology at Wits.

According to Brink et al (15), a descriptive study is one in which a populations characteristics are described to answer a specific question about the population, without attempting to establish a causal link. The knowledge and awareness of anaesthetists regarding diathermy will be described in this study.

5.7.2 Study population

The study population will consist of all anaesthetists working in the Department of Anaesthesiology at Wits.

5.7.3 Study sample

Sample size

In consultation with a bio-statistician, a minimum sample of 96 anaesthetists was estimated. This was based on the assumption that 65% of anaesthetists in the Wits Department of Anaesthesiology would have adequate knowledge of diathermy use to within an accuracy of 10%, with 95% confidence.

Sampling method

Sampling is intended to predict outcomes or trends that can be extrapolated to a larger population (14). This study will use a convenience sampling method. Convenience sampling is described as non-random sampling of the most easily accessible individuals in the sample population (15).

Inclusion and exclusion criteria

The inclusion criteria for this study are:

- anaesthetists attending the departmental academic meetings and who are willing to participate
- incomplete questionnaires.

The exclusion criterion of the study will be questionnaires that are returned blank.

5.7.4 Data collection

Questionnaire development

Self-report techniques are used when the objective of the researcher is to determine what a population believes, thinks or knows and an easy method to collect this data is by means of questionnaires (14).

No questionnaires pertaining to the appropriate use of diathermy were identified in the literature. A draft questionnaire based on a review of the literature was developed to ensure content validity. The questionnaire was reviewed by three specialist anaesthetists to ensure face and content validity. Their suggestions were incorporated into the final questionnaire.

The self-administered questionnaire (Appendix 3) consists of two sections:

- **Section 1** includes the demographic data
- **Section 2** consists of questions regarding the knowledge and awareness of anaesthetists of the principles, risks, precautions and practice of diathermy.

Determination of adequate knowledge

In this study, adequate knowledge will be determined by using the modified Angoff method (11). The modified Angoff method is a form of standard setting which is criterion referenced. Using a predetermined test, certification of competence of the examinee is tested using a cut-off or pass score. A minimum of five subject matter expert raters (specialist anaesthetists), will establish the adequate knowledge level or pass rate. Validation of this method lies in the judgement of expert judges (specialist anaesthetists) who must agree on the minimum mark required to determine competence (11).

Each question is assessed separately and any item with a standard deviation that exceeds 10 needs to be discussed. After this some of the raters may decide to re-evaluate a question. The raters will periodically review the concept of a minimally qualified performer to ensure estimates are as accurate as possible.

Once test items have been re-evaluated, the estimates will be entered into the experts rating spreadsheet. The cut-off score will be calculated by adding the numbers in the “average percentage correct” column and dividing by the number of test items.

Data collection

At the beginning of the meeting, the researcher will address the audience giving anaesthetists a brief introduction to the study and inviting them to participate. Information letters (Appendix 2) and questionnaires (appendix 3) will be distributed to those who agree to participate.

The questionnaires will be numbered before distribution in order to calculate a response rate. The researcher will be present during the completion of questionnaires to assist with queries and to prevent data contamination. To further prevent data contamination, the researcher will collect the data at non-consecutive departmental meetings. The questionnaire will take approximately 10 minutes to complete. Questionnaires will request no identifying data. All the completed questionnaires will be folded and placed in a sealed box at the door of the meeting room. This will ensure anonymity and confidentiality of the anaesthetists participating in the study.

5.7.5 Data analysis

Using Microsoft Excel spreadsheet 2010, data will be captured onto spread sheets. Data will be analysed in consultation with a biostatistician using the statistical program STATA (StataCorp, USA). Categorical variables will be described using frequencies and percentages. Continuous variables will be described using means and standard deviations or median and interquartile ranges depending on the distribution of the data. Comparisons between knowledge of junior and senior anaesthetist will be done using either independent t-tests or Mann-Whitney tests. A Chi-squared test will be done between juniors and seniors. A p-value of <0.05 will be considered statistically significant.

5.8 Significance of the study

Inadvertent burning of a patient is traumatic and often catastrophic, not only to the affected patient but equally to the theatre team. Physical scars, emotional trauma and prolonged hospital stay are inevitable, depending on the extent of the burn. Doctor-patient relationships often become disrupted with legal consequences to the relevant practitioners (17).

While anaesthetists do not apply diathermy pads or use diathermy themselves, they are responsible for the well-being of patients in theatre. Effective anaesthetic care aims to reduce the morbidity, mortality and complication rates from surgery (10). The results from this study will provide insight into knowledge and awareness of diathermy use of anaesthetists working in the Department of Anaesthesiology at Wits, and may influence patient safety.

5.9 Validity and reliability of the study

According to Botma et al (13), "validity indicates whether the conclusions of the study are justified based on the design and interpretation" and reliability refers to how consistent the measurements have been.

The validity and reliability of this study will be maintained by:

- using an appropriate study design
- using a questionnaire with face and content validity
- the sample size being calculated in consultation with a biostatistician
- the researcher will be present during the completion of the questionnaires to answer any queries and to prevent data contamination
- questionnaires will be completed at non-consecutive academic meetings to further prevent data contamination
- completed questionnaires being folded and placed in a sealed box, thereby facilitating a non-threatening environment
- data being analysed with the assistance of a biostatistician.

5.10 Potential limitations

Burns and Grove (14) define study limitations as problems with the study, either theoretical or methodological, that may limit the conclusions that can be made from the results.

The contextual nature of the study is a limitation. The study is limited to a single university and, therefore, the results of this study may not be generalisable to other populations. Usually contextual design and convenience sampling, but you might have more.

5.11 Project outline

5.11.1 Time frame

	Sept-Nov 2018	Jan 2019	Feb-March 2019	April - June 2019	July 2019	Aug 2019	Sept 2019
Protocol							
Ethics and postgrad submission							
Ethics and postgrad approval							
Data collection							
Data analysis							
Draft article							
Submission							

5.11.2 Budget

The Department of Anaesthesiology will bear the cost of printing and paper for the study.

Paper and printing	R1/page
Proposal and appendices	23 pages x 10 copies = R 230.00
Ethics application form	10 pages x 25 copies = R250.00
Postgrad application form	1 page x 6 copies = R6.00
Completed research report	100 pages x 4 copies = R 400.00

Total cost: **R 886.00**

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5.13 Appendices

Appendix 1: Head of department letter

GAUTENG PROVINCE
HEALTH
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Department of Anaesthesia
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Tel: 011 488-4344
14th March 2019

Subject: **Permission to collect data from Department of Anaesthesia**

To whom it may concern,

This letter stands to affirm that I, Dr PMV Motshabi, grant permission to Dr Harrilene Apleni, HPCSA number MP 0740543, to collect data in Department of Anaesthesiology at University of Witwatersrand for her study "Anaesthetists' knowledge and awareness of diathermy use in a department of anaesthesiology".

The approximate time frame will be, but not limited to, the months of April to July 2019, until her sample size is obtained. The information obtained from the data will be used for Dr Apleni research study for her Masters in Medicine only, and will include information and data relevant to her study.

Yours sincerely,

Dr Palesa Motshabi
Academic Head: Department of Anaesthesia
Head of Clinical Unit: Cardiac Anaesthesia

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WITS UNIVERSITY | WITS SCHOOL OF CLINICAL MEDICINE | FACULTY OF HEALTH SCIENCES

Charlotte Maxeke Johannesburg Academic Hospital, 6th Floor, Area 361/16, Jubilee Road, Parktown, Johannesburg

Appendix 2: Information letter

Study title: Anaesthetists' knowledge and awareness of diathermy use in a department of anaesthesiology.

Dear Colleague,
Hello, my name is Harrilene Apleni. I am a registrar in the Wits Department of Anaesthesiology, and I am currently busy with my M Med degree. I would like to invite you to participate in my research study titled: **Anaesthetists' knowledge and awareness of diathermy use in a department of anaesthesiology**. Identifying the current knowledge and practice of diathermy within the department will assist in the continued professional development in the department and reduce unintended injuries and the consequences thereof for both patient and staff.

Participation is completely voluntary and consent will be implied on completion of the self-administered, multiple choice questionnaire. The questionnaire is anonymous. Numbering of questionnaires is to enable calculation of the response rate. Confidentiality will be maintained as only the researcher and supervisor will have access to the raw data. Should you wish not to participate you can withdraw from study at any time prior to submission of the questionnaire. No incentives will be provided for the completion of the questionnaire.

The questionnaire should not take longer than 10 minutes to complete and participants are encouraged not to share the information provided. All questionnaires, whether complete or not, should be folded and placed in the sealed box at the door of the meeting room.
Before completion of this questionnaire, please ensure that you understand the above information.
If you have any questions regarding this study you can contact the following:
Harrilene Apleni - 079 519 6716 or my supervisor Helen Perrie at Helen.Perrie@wits.ac.za and her telephone number is 011488 4397.

The final report can be assessed at the Wits Institutional Repository environment on DSpace (WIReDSpace) at www.wiredspace.wits.ac.za.

Permission to conduct the study will be obtained from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg. If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariats on 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Thank you for taking time to read this letter.
Harrilene Apleni

Appendix 3: Questionnaire

Anaesthetists' knowledge and awareness of diathermy use in a department of anaesthesiology

All questionnaires, whether complete or not should be folded and placed in the sealed box at the door of the meeting room.

Please indicate your answer by using an X.

Section 1

1. Please indicate your professional designation:

Consultant	
Career Medical Officer	
Registrar	
Medical Officer	

2. Please indicate your years of experience in anaesthesia:

<1 year	
1 − 5 years	
6 − 10 years	
11 − 15 years	
16 − 20 years	
>20 years	

3. If you are a registrar, please indicate your years of training:

First year	
Second year	
Third year	
≥ Four years	

4. Have you completed FCA part 1 exams?

Yes	
No	

5. How long did you pass the FCA part 1 exams?

Not applicable	
<1 year ago	
1 − 5 years ago	
6 − 10 years ago	
>10 years	

6. What percentage of procedures that you are involved in require diathermy?

0 – 20%	
21 – 40%	
41 – 60%	
61 – 80%	
81 – 100%	

7. Do you feel that, in general, diathermy is a safe instrument?

Yes	
No	
Not sure	

8. Have you ever witnessed any complications arising from diathermy? If yes, please specify:

Yes	
No	

Specify:……………………………………………………………………………………

Section 2

2.1 Principles of diathermy

Choose the most accurate answer. Please indicate your answer by using an X.

9. Diathermy uses the basic principle that electrical current is converted to a high frequency alternating current in the range of:

50 kHz – 100 kHz	
3 kHz – 200 MHz	
3 MHz – 200 MHz	
200 kHz – 3 MHz	

10. Identify the type of diathermy where the current enters the patient through the small area from an active electrode and exits safely through a much larger, neutral electrode?

Monopolar cauterisation	
Bipolar diathermy	
Radiofrequency ablation	
Plasma coblation	

11. Which statement is most correct regarding the amount of heat generated by diathermy? Choose the most correct answer.

Heat generation is inversely related to the current frequency	
Heat generation is directly related to the current density	
Heat generation is directly related to the electrode surface area	
Heat generation is inversely related to current amplitude	

2.2 Hazards and complications

12. The fire triangle consists of three elements necessary for initiation of an operating room fire, i.e. a heat source, fuel, and an oxidizer. Diathermy acts as:

Heat source	
Fuel	
Oxidiser	

13. How can electrosurgical patient complications be avoided when using diathermy during minimally invasive surgery? Choose the most correct answer.

Direct coupling can be avoided by the use of electro-conductive surgical instruments	
Use the cutting current while holding the diathermy in direct contact with the tissue	
Metal anchors isolate the current, increasing the likelihood for current to accumulate	
High frequency usage can blow holes in compromised diathermy probe insulation	

14. Diathermy generators are able to produce a variety of electrical waveforms with the resulting clinical effect on the tissue being determined by the application of the specific waveform. What is the correct clinical application when using a pure continuous low voltage sine wave that rapidly produces high temperatures, vaporising tissue fluid, causing cells to explode and forming a gap in the tissues?

Cutting	
Coagulation	
Fulguration	
Ablation	
Desiccation	
Coblation	

15. A patient with severe COPD is receiving oxygen via face mask during the excision of a submandibular tumour under local anaesthesia. What is the best way to prevent a fire caused by diathermy in this operating room?

Using adhesive tape to limit oxygen leakage from the face mask	
Using chlorhexidine instead of iodine as the surgical skin prep	
Using face mask oxygen holds no fire risk in this scenario	
Using a bipolar instead of monopolar cautery	
Using nitrous oxide to reduce the oxygen concentration	

16. During surgery for tracheostomy insertion surgical diathermy is being used at the tracheal incision. You are ventilating with 100% oxygen. As the trachea is opened you notice a blue flame shooting up from the incision. What should your first action be?

Disconnect breathing circuit from tube	
Douse the wound with saline	
Insert a tracheostomy tube	
Turn off oxygen and ventilate with air	

17. How can surgical diathermy cause peripheral skin burns?

Burns occur outside the operative field by direct coupling	
Peripheral burns are more likely to occur with monopolar diathermy	
Burns result from poor contact between the active electrode and the patient	

2.3 Patient safety

18. Why does the patient ground plate of some diathermy units have two separate contact areas and two wires?

To allow a back-up if one contact area fails	
For using bipolar cautery	
To allow capacitive coupling to the patient	
For simultaneous coagulation and cutting currents	
To allow monitoring of the return electrode current	

19. An advantage of the use of bipolar diathermy over monopolar is that bipolar:

Lacks pacemaker interference and ground plate burns	
Uses the patient as part of the electrical circuit	
Is based on a direct electrical current density principle	
Current density at the neutral plate is relatively low	

20. Select the most correct statement regarding the use of diathermy in a patient with a cardiac pacemaker.

The return electrode should be placed more than 50 cm from the pacemaker	
Electromagnetic interference can cause the pacemaker to decrease its firing rate	
The lowest possible amplitude in short bursts should be used	
Monopolar diathermy can be used in the asynchronous mode	
It is preferable not to use a monopolar diathermy in the presence of a pacemaker	

21. Why is a patient, in general, safe from electrocution when using diathermy?

The current is too low to initiate cardiac fibrillation	
Current travels on the surface of the body	
The frequency is too high to electrocute	
The return electrode is not placed between the heart and operating site	
The voltage is too low to cause electrocution	

22. What safety feature protects the patient against electrical shock when using diathermy?

The larger the tip of a diathermy instrument, the greater the current density	
The metal casing of the diathermy unit is earthed as a safety measure	
Cutting uses a higher voltage than coagulation	
Coagulation is achieved by a continuous sine wave pattern	

2.4 Appropriate use of diathermy

23. Where is the ideal site for placement of patient return electrode?

The patient return electrode should be placed on the calf	
The patient return electrode should be placed close to the surgical site	
The patient return electrode should be placed as far from the surgical site as possible	
The patient return electrode should be placed over poorly conductive tissue (scar tissue).	

Thank you for taking the time to complete this questionnaire.