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Diathermy awareness among surgeons-An analysis in Ireland☆

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HIGHLIGHTS

- We evaluate, among surgeons, the awareness and attitude to the appropriate use of diathermy.
- Despite 89% of surgeons regarding diathermy as safe, 56% had inadequate understanding of principles of safe use.
- 49% could recall personal experience of diathermy complications but 58% did not want any diathermy training.
- There is a concerning dearth of awareness among surgical trainees and consultants alike regarding diathermy.
- The need for a shift in attitude among surgeons to more cautious and safe use is demonstrated.

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ABSTRACT

Introduction: Diathermy is an integral part of many modern surgical procedures. While diathermy is generally accepted as 'safe', electrosurgery-induced injuries are among the more common causes for malpractice litigation. The purpose of this study was to evaluate the awareness among surgeons of the principles, risks, precautions and appropriate use of diathermy.

Methods: All surgeons employed from Senior House Officer (SHO) to Consultant grade in two teaching hospitals were surveyed. Sixty-three surgeons were asked to complete an anonymous questionnaire, which recorded level of training and addressed competence in principles, hazards, and precautions to be taken with diathermy.

Results: Eight Consultants, 5 Specialist Registrars, 19 Registrars and 13 SHO's responded (71% response). All but three subspecialties were represented. Eighty-two percent (37/45) had no formal diathermy training. Despite 89% (40/45) of surgeons regarding diathermy as a safe instrument, 56% felt they had inadequate understanding of the principles and failed to demonstrate an appropriate awareness of the potential risks. Fifty seven percent exhibited a dangerous lack of awareness in managing equipment not yielding the desired effect and 22% were unaware of any patient groups requiring special caution. Only 42% wanted formal training.

Conclusion: Our results show a dearth of awareness among surgeons regarding diathermy. Given our findings, we urge a shift in attitude towards diathermy, with surgeons adopting a more cautious and safe approach to diathermy use. We recommend that formal training be introduced as a hospital based initiative.

1. Introduction

Basic diathermy principles are now used in many permutations to offer the current surgical world vital technology in routine surgical procedures and in developing advanced surgical techniques. It allows cutting and coagulation of tissue with hemostasis. Most modern surgeons now use some form of diathermy and it is particularly invaluable in more intricate surgery, for example, in neurosurgery and ophthalmology. A varied spectrum of devices now exist in many permutations from an electrosurgical pencil or

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suction coagulators device to laparoscopic devices facilitating tissue dissection, grasping and clamping as well as vessel cutting and sealing. Procedures commonly involving the use of these instruments include breast wide local excisions, axillary dissections, Whipple procedure, colectomy, liver resections, nephrectomy, cholecystectomy and prostatectomy. While diathermy is generally accepted as 'safe', electrosurgery-induced injuries are among the more common causes for malpractice litigation [1].

It would appear that there are 2 main factors that result in unsafe or harmful use of diathermy. The first is technical error, for example bowel perforation or liver damage, which may be due to careless technique. The second is lack of awareness of the correct functioning of the equipment, for example incorrect positioning of the grounding pad causing a burn to the patient. Both of these factors appear more common in emergency surgery [1]. Modern surgery is heavily reliant on diathermy and it is incumbent on the surgeon to be fully cognizant of its safe and appropriate use. This study aims to evaluate the awareness among surgeons of the principles, risks, precautions and appropriate use of diathermy.

1.1. The general principles of diathermy

Diathermy originates from the Greek '*dia*' for passing through and '*therma*' meaning heat. It is defined as "the cutting and coagulation of body tissue with a high frequency current." [2]. It uses the basic principle that electrical current is converted to a high frequency alternating current in the range of 200 kHz–3 MHz, a frequency higher than that which causes neuromuscular stimulation. (Fig. 1). It is typically used surgically for 3 distinct purposes – cutting, fulguration (destructive coagulation with tissue charring) and coagulation. In surgical diathermy the patient forms part of the circuit, the alternating current passing through the tissue produces heat as it tries to overcome its tissue impedance. This is distinct from electrocautery which involves the direct application of heat.

In monopolar mode, the diathermy circuit is from the diathermy probe, through the patient to the grounding pad attached to the patient. Away from the active electrode the current disseminates through the body, with minimal current, therefore causing no tissue damage remote to the surgical site. In bipolar mode the current passes between the two prongs of the diathermy electrode thus with minimal flow through the patient, eliminating the need for a grounding pad and minimising tissue damage at the surgical site [3] (Fig. 2).

2. Materials and methods

We conducted a survey of surgeons employed at two teaching hospitals. All surgical employees from Senior House Officer (SHO) to Consultant grade inclusive were issued with a questionnaire which was filled out by face-to-face interview between March and June 2014.

Questions posed included surgeon grade, years of surgical experience, sub-specialty and whether any formal diathermy training was ever received. Surgeons were also asked about their understanding of the principles of and differences between different diathermy modes and settings. Surgeon's clinical practice, i.e. whether they put on the diathermy pad or inspect the site at the end of a procedure was also investigated. Lastly, the surgeon's hazard awareness and experience of complications arising from electro-surgery was examined.

Initial interviewing revealed a flaw in the survey design in that it became apparent that participants were answering 'yes' to questions specific to diathermy principles (Questions-11,13,14,16,18,22,27). 6 questionnaires were completed with 'yes' answers that were not qualified with explanation. To rectify this and improve face validity the answers were defaulted to 'no' if examples were not provided and the original 6 questionnaires were discounted.

Construct validity was examined by means of an intervention study. Twenty medical students were surveyed and 13% were able to answer correctly the 'principles of diathermy' questions from the questionnaire. A tutorial was given by a surgical trainee on the principles of safe and appropriate diathermy use. Post tutorial increase in awareness was reflected in the re-survey with 96% of students providing correct answers for the same 'principles of diathermy' questions.

A copy of the questionnaire can be seen in Appendix 1.

3. Results

Eight Consultants, 5 Specialist Registrars, 19 Registrars and 13 SHO's responded. The mean time of surgical experience acquired

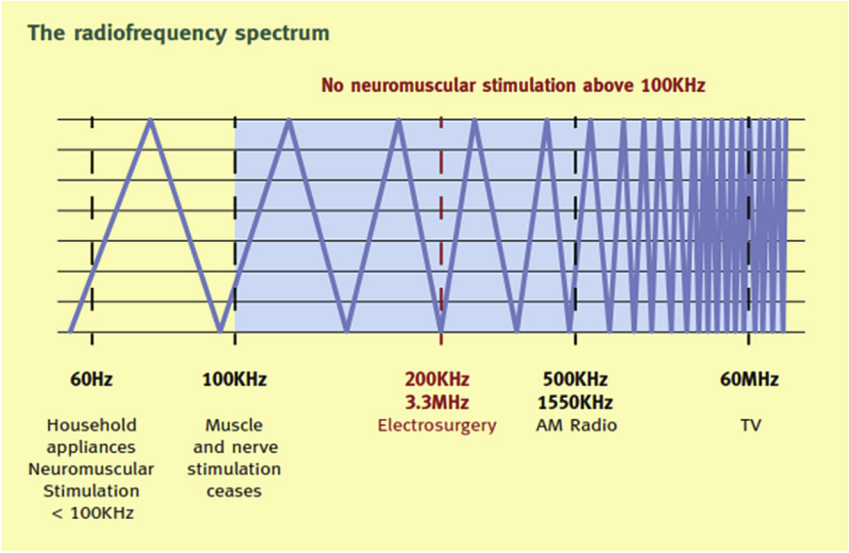

Fig. 1. Electrosurgery current on the radio frequency spectrum.

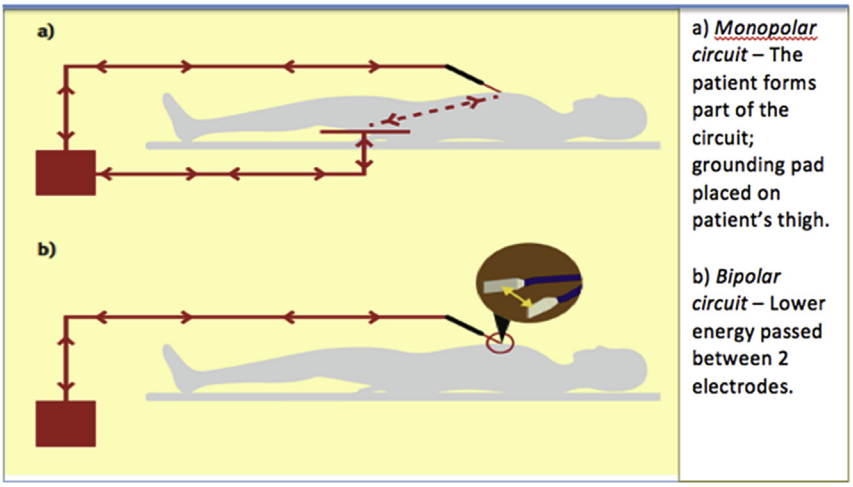

Fig. 2. The mechanism of monopolar and bipolar diathermy.

was 6–10 years. General Surgery and its subspecialties were the predominant sub-speciality represented, followed by Orthopaedics (Table 1).

The most commonly stated type of diathermy used was monopolar, used by 67% of surgeons. The most commonly stated mode of diathermy used was cutting and coagulation together. However, only 44% accurately defined the difference between monopolar and bipolar diathermy with only 4% able to define the differences in modes. Thirty-six percent of surgeons did not know the reason for pad placement when using monopolar diathermy.

Eighty seven percent of surgeons do not personally supervise the diathermy pad application and only 13% supervise its removal and the pad site. The diathermy pad is reportedly applied by the nursing staff in 96% of cases. Fifty one percent of surgeons reacted to inadequate diathermy effect by increasing the current. Twenty six percent would check the circuit with 4% reporting that they would ask the nurses to deal with the issue and 2% were unsure of what to do.

Eighty percent of surgeons felt the primary surgeon was responsible for complications arising from diathermy. Notably 49% of surgeons could recall personal experience of diathermy complications.

Fifty four percent of these listed burns to the patient's skin as an experienced complication. Others included burns to the surgeon (36%), burns at the pad site (14%), bowel perforation (9%), fires (4.5%), liver damage (4.5%) and allergy to the gel at the pad site (4.5%). Eighty-nine percent of surgeons felt that diathermy was a safe instrument.

Seventy eight percent of surgeons correctly identified patients with cardiac devices as a patient group requiring special consideration when using diathermy. Other identified sub-groups were patients with 'metal implants' (11%), neuro-stimulators (4%), skin piercings and joint replacements (2%). Twenty two percent could not identify any sub-group of patients requiring special precaution with diathermy usage.

Despite such deficits in knowledge and awareness, only 42% reported that they would like to receive up to date formal diathermy training. Eighty two percent of those surveyed never had formal diathermy training.

Table 1
Population of subjects by professional description.

	Number of surgeons
General surgery	21
Orthopaedics	14
Plastic surgery	3
Urology	3
Vascular surgery	2
Gynaecological surgery	2

4. Discussion

Despite the revolutionary usefulness of diathermy in surgical practice, it can pose significant hazards. It is therefore essential that operators understand the technology in their hands in order to avoid adverse side effects and complications. This study analyses such awareness among surgeons and is the first to do so in Ireland.

Briefly, some of the answers to key questions are exampled as follows. Replies to the question 'If the diathermy effect was not adequate what do you/would you routinely do?' included, 'stop, check equipment (i.e. connections, diathermy plate connected), check settings, if still no resolution change instrument.' However there were several others who would 'increase the frequency', some commented 'change the mode and effect', 'increase the coagulation setting' and 'ask the nurse'.

Responses to questions asking for an explanation of the principles of and differences between monopolar and bipolar diathermy included ' monopolar - the current is passed directly from pad to one instrument, bipolar = stick-patient-pad-machine', 'monopolar is less safe', 'monopolar current generally dispersed'. Some surgeons gave somewhat more accurate answers including 'in bipolar the current moves between the two active poles of the device.'

4.1. Surgical burns and fires

An alarming 22% of surgeons failed to identify any risks associated with diathermy usage. Surgical burns and fires are common and are listed in the emergency care research Institute's (ECRI) Top 10 health technology hazards for 2013 [4]. Burns arise as a result of one of the following mechanisms; burns at the site of the grounding electrode, burns resulting from the electrode heating pooled sterilizing solutions and burns outside the operating field resulting from aberrant circuits generated between the active electrode and an alternate grounding source. Additionally it is estimated that 50–100 cases of surgical fires occurring in the USA every year can be attributed to diathermy as the inciting factor,

resulting in severe disfigurement and even death [5]. Fires due to pooling of flammable skin prep and oropharyngeal/facial fires due to oxygen use, have been reported widely in the literature and in 2013 the American Society of Anesthesiologists released an advisory on surgical fires [6–8].

Despite these statistics, our research illustrates gross inattention regarding this matter. Simple precautions such as monitoring the application and removal of the diathermy pad are not performed by the operating surgeon. Furthermore, most surgeons increase the frequency of the diathermy current if there is an inappropriate effect rather than check the pad placement. In the event that the desired effect is not achieved on normal settings, all equipment should be checked prior to increasing the power to minimise the risk of accidental burns to the patient or surgeon.

As was highlighted by Massarweh et al., the common assumption by surgeons that surgical gloves provide complete immunity from a diathermy burn is false [9]. Breakdown or hydration of the glove and capacitative coupling may lead to burns of the operating staff-as was documented by 8 surgeons (22%) in our study. Additionally, of the surgeons experiencing diathermy complications, 54% listed burns to the patient and 4.5% listed surgical fire. It is clear surgical fires and particularly diathermy burns are a common risk to patients and surgeons alike.

4.2. Special precautions

Special precautions must be taken in certain subgroups of patients due to capacitative coupling and selective conductance of the current through metal implants. An awareness that precaution was required in those with pacemakers and cardiac implants was present among 78% of surgeons. However, surgeons were largely unaware that precaution was necessary in patients with cochlear implants, those undergoing laparoscopic, arthroscopic surgery or ENT surgery. Oxygen-enriched atmospheres in otolaryngology, for instance, require minimal power settings and sparing use of supplemental oxygen in an effort to prevent flash fires [10]. If diathermy is necessary in these subgroups, bipolar diathermy is advisable where possible.

4.3. Surgical smoke

Our results demonstrate an unawareness and ambivalence to surgical smoke and its risks. An analysis of surgical smoke, using an animal model, found that the mutagenic potency of condensates from 1 g of tissue destroyed through electrocautery ablation was equivalent to smoking six unfiltered cigarettes [11]. Concerns have been raised regarding the infectivity, mutagenicity, and cytotoxicity of surgical smoke with the smoke plume having been shown to contain hazardous chemicals, live malignant viruses, and bacteria [12–14]. Additionally, surgical smoke is odorous and obscures the view of the operative field, especially during laparoscopic procedures [15].

Based on this literature, many health organizations have recommended the routine use of evacuation devices to avoid potential problems [16,17]. Despite this, the use of local exhaust ventilation has changed very little in recent years [18]. It would be prudent for surgeons to be cogniscent of the postulated risks and documented evidence. Furthermore, it is advisable to employ and advocate for surgical plume evacuation devices and surgical masks to prevent morbidity.

4.4. Future implications

As Farrugia et al. clearly state, a lack of knowledge of basic electrophysiology principles and the inappropriate use of electrosurgery can cause serious iatrogenic complications [19]. This has been substantiated by the experience of our study cohort. It is concerning that the majority of surgeons (58%) did not wish to receive any formal education or training despite the lack of knowledge. We hope the findings presented of the cohort as a whole will change the predominant sentiment among surgeons towards diathermy. We believe a significant improvement could be achieved by means of a short diathermy course for surgical staff. This could be run as a manufacturer sponsored hospital-based initiative. Trainees may also benefit from highlighting of the subject in membership exams. The success or otherwise of these changes could be assessed by a follow up study.

4.5. Limitations

Construct validity of the questionnaire was examined by means of the response of students to a diathermy tutorial, however, was not proven, as the tutorial itself was not validated. A larger sample size across more institutions would have provided further insight.

5. Conclusion

This article has unfortunately corroborated in 2 large teaching hospitals in Ireland, previous findings in the literature elsewhere, that there is a concerning dearth of awareness among surgical trainees and consultants alike regarding diathermy. It is reasonable to infer that increased awareness of the significant number of technical errors as experienced by this cohort may yield a more cautious approach to its use and that an increased awareness of the principles of safe use would translate into safer practice. As such, we urge a shift in attitude among surgeons towards more cautious approach and safer use and recommend that formal diathermy training be introduced as a hospital based initiative.

Ethical approval

Not applicable.

External funding

none.

Conflict of interest

none.

Unique identifying number (UIN)

Not applicable.

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Appendix 1

Diathermy awareness survey

Please complete all questions. Please use block capitals and write clearly.

1. In which institution are you currently employed?
   - Connolly Hospital Blanchardstown ☐
   - St. Vincents University Hospital ☐
   - Mater Misericordiae University Hospital ☐
   - Beaumont Hospital ☐

2. What grade of hospital doctor are you currently employed as?
   - Consultant ☐
   - Specialist Registrar ☐
   - Registrar ☐
   - Senior House Officer ☐

3. How many years of surgical experience do you have?
   - 1 year ☐
   - 2-5 years ☐
   - 6-10 years ☐
   - 10-15 years ☐
   - >15 years ☐

4. What surgical subspecialty are you currently working in?
   - Orthopaedics ☐
   - General Surgery/General Subspecialty ☐
   - Plastic Surgery ☐
   - Neurosurgery ☐
   - Otolaryngology/E.N.T. ☐
   - Urological Surgery ☐
   - Gynaecological Surgery ☐
   - Maxillo-facial Surgery ☐
   - Cardio-thoracic Surgery ☐
   - Paediatric Surgery ☐

5. Have you ever received formal diathermy training?
   - Yes ☐
   - No ☐

6. How long ago did you receive diathermy training?
   - Not applicable ☐
   - < 1 year ago ☐
   - 1-5 years ago ☐
   - 5-10 years ago ☐
   - >10 years ago ☐

7. Would you like to receive up to date formal diathermy training?
   - Yes ☐
   - No ☐

8. Have you ever used diathermy in your operative experience?
   - Yes ☐
   - No ☐

9. What percentage of procedures, that you are involved in, require diathermy?
   - 0% ☐
   - 1-20% ☐
   - 21-40% ☐
   - 41-60% ☐
   - 61-80% ☐
   - 81-100% ☐

10. What *TYPE* of diathermy do you predominantly use?
   - Monopolar ☐
   - Bipolar ☐
   - Unsure ☐

11. Do you feel that you adequately understand the principles of and differences between monoplar and bipolar diathermy? If yes, please explain them.
(**If you fail to attempt to explain your response will be defaulted to the "No" option)
   - Yes ☐
   - No ☐
   - Comment

12. What *MODE* of diathermy do you predominantly use?
   - Coagulation only ☐
   - Coagulation and cutting ☐
   - Blended cutting ☐
   - Unsure ☐
   - Other, please specify

13. Do you feel that you adequately understand the principles and differences between diathermy modes? If yes, please explain them.
(**If you fail to attempt to explain your response will be defaulted to the "No" option)
   - Yes ☐
   - No ☐
   - Comment

14. Are you aware of any risks/complications of diathermy? If yes please list.
(**If you fail to list, your response will be defaulted to the "No" option)
   - Yes ☐
   - No ☐

15. Have you any experience of complications arising from diathermy? If yes, please specify.
   - Yes ☐
   - No ☐

16. If the diathermy effect was not adequate what do you/would you routinely do?

17. Who do you think is responsible for complications arising from diathermy?
   - Scrub nurse ☐
   - Circulating nurse ☐
   - Assisting surgeon ☐
   - Primary Surgeon ☐
   - Manufacturer ☐
   - Other, please specify

18. Are you aware of the reason for diathermy pad placement prior to beginning the operation? If yes please give reason.
*(**If you fail to provide a reason, your response will be defaulted to the "No" option)*
   - Yes ☐
   - No ☐

19. Who routinely puts the diathermy pad on the patient in your practice?
- Primary surgeon ☐
- Assisting surgeon ☐
- Scrub Nurse ☐
- Circulating nurse ☐
- Porter ☐

20. Do you routinely supervise the diathermy pad placement on the patient in theatre?
- Yes ☐
- No ☐
- Not applicable ☐

21. Do you routinely inspect the diathermy pad site at the end of the procedure?
- Yes ☐
- No ☐
- Not applicable ☐

22. Are you aware of any risks of the diathermy smoke plume? If yes, please specify.
*(**If you fail to attempt to specify, your response will be defaulted to the "No" option)*

- Yes ☐
- No ☐

23. What method of diathermy smoke extraction do you use?
- None ☐
- Not applicable ☐
- Standard suction ☐
- Laparoscopic smoke extractors ☐
- Open the laparoscopic ports ☐
- Other, please specify..... ☐

24. Do you employ any additional precautions to avoid the smoke plume? If yes, please specify.
- Yes ☐
- No ☐

25. Do you think there are currently adequate precautions against diathermy smoke at your disposal in your institution?

26. Do you feel that diathermy is a generally safe instrument?
- Yes ☐
- No ☐
- Unsure ☐
- Comment

27. Are you aware of any sub-groups of patients that require special precautions regarding diathermy usage? If yes, please specify.
*(**If you fail to attempt to explain your response will be defaulted to the "No" option)*

- Yes ☐
- No ☐

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