SKIN

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ORIGINAL RESEARCH

Electrosurgery and Implantable Electronic Devices: A Survey of Current Practices among Cutaneous Surgeons

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ABSTRACT

Background: The use of electrosurgery within dermatology is widespread and the number of patients with an implantable electronic device (IED) is ever-increasing. Adverse effects of performing electrosurgery on patients with IEDs could pose a significant patient safety risk. There is a paucity of literature detailing guidelines for cutaneous surgeons regarding electrosurgery in IED patients.

Objective: To assess current practices and complications of cutaneous surgeons performing electrosurgery in IED patients.

Methods: An electronic survey was distributed to members of the American College of Mohs Micrographic Surgery using REDCap. Data was collected between March 2019 and May 2019.

Results: The survey was sent to 1700 ACMS members with 178 responses received. The most commonly reported routine precautions included utilization of short bursts of current, avoidance of electrosurgery around the device, and use of minimal power/lowest effective settings. In total there were nine complications with an estimated 31 patients experiencing electromagnetic interference (EMI) out of over 250,000 procedures. Complications were more common in patients with a cardioverter-defibrillator than any other device (RR:4.74, CI:1.29-17.4). The use of true heat cautery and bipolar (two-tip electrode) were associated with the lowest rate of EMI. Whereas, electrocoagulation, electrosection, and monopolar (single-tip electrode) were more likely to cause EMI (RR:3.62, 95% CI:1.82-7.19).

Conclusions: Significant EMI to IEDs during routine cutaneous electrosurgery procedures is rare, however, there is a clear lack of recommendations. The use of bipolar forceps and electrocautery may be safer when electrosurgery is required. Further investigation is required to develop guidelines for electrosurgery in IED patients.

INTRODUCTION

There is an ever-increasing number of patients with implantable electronic devices (IEDs) as indications for a multitude of cardiac and neurologic diseases continues to expand. These IEDs include implantable cardioverter-defibrillators, cardiac pacemakers, deep brain stimulators, cochlear implants, and stimulators of the spinal cord and other nerves. The use of electrosurgery within dermatology is widespread, therefore, encountering patients with an IED who present for an office-based procedure is becoming progressively common. Malfunction of IEDs has been reported during routine electrosurgical procedures due to electromagnetic interference (EMI).[1] Thus, adverse effects due to performing electrosurgery on patients with IEDs present a significant patient safety risk and prompts concern over what risks these patients are exposed to during cutaneous surgery and the precautions that need to be utilized. Minimal literature exists concerning guidelines for cutaneous surgeons regarding electrosurgery in patients with IEDs.[2,3]

METHODS

The survey was developed through a process of expert review by five dermatologic surgeons. Feedback was provided by subject matter experts and incorporated into the final version of the survey. Institutional review board exemption was obtained through Washington University School of Medicine. The electronic survey (using REDCap) was approved by the American College of Mohs Surgery (ACMS) executive committee and distributed by email to all registered ACMS members. The e-mail was sent to a total of approximately 1,700 recipients. Reponses were collected from March 2019 to May 2019. All received responses were included and analyzed.

Baseline demographic factors and routine precautions were reported as frequency distributions and percent of the total. Comparisons of complications stratified by device type were tested using Pearson Chi-Squared analysis. P-values of less than 0.05 were considered statistically significant.

Study data were collected and managed using REDCap electronic data capture tools hosted at Washington University in St. Louis.[4] All statistical analyses were conducted in SAS software.

RESULTS

An electronic survey was sent to approximately 1,700 recipients and a total of 178 responses were received with a response rate of 10.5%. The years in practice and practice setting of survey respondents are presented in table 1. Of the responses, 49% (n=87) had been in practice 1-10 years, 23% (n=40) 11-20 years, 19% (n=33) 21-30 years, and 9% (n=16) for 30+ years. Practice settings included 20% (n=35) in a University, 73% (n=128) in private practice, 4% (n=7) in a mixed practice setting, and 3% (n=6) in other. The majority of respondents had encountered the following implantable electronic devices at some point in their practice: cardioverter-defibrillator (99%), pacemaker (100%), cochlear implant (81%), deep brain stimulator (80%), spinal cord stimulator (72%), and nerve stimulator (55%) (see table 2). The estimated total number of patients treated with electrosurgery and the number of patients with an IED treated with electrosurgery over the previous five years reported by respondents is presented in

table 3. Well over 250,000 procedures involving electrosurgery were reported.

Routinely implemented (>90%) precautions with use of electrosurgery in a patient with an IED are presented in table 4. The most common routine precautions, independent of IED type, were utilization of only short bursts of current (< 5 secs), avoidance of electrosurgery around the IED, and use of minimal power and lowest effective settings. Intraoperative monitoring (blood pressure, heart rate), changing a pacemaker to a fixed rate mode, and pre- and post-operative EKG were the least commonly used precautions. Identification of device, including location, type, manufacturer, programming parameters, or date of manufacture/implantation, had a significant association with decreased complication rate in patients with a cardioverter-defibrillator (p-value 0.0491) and spinal cord stimulator/nerve stimulator (p-value 0.040). Deactivation of a device was associated with a decreased rate of complications in patients with a deep brain stimulator/cochlear implant (p-value 0.006). Pre- and post-operative monitoring and avoidance of electrosurgery around the IED were associated with decreased complication rate in patients with a spinal cord stimulator/nerve stimulator (p-value < 0.001 and 0.032, respectively). Having staff trained in ACLS was associated with a decreased complication rate in patients with a deep brain stimulator/cochlear implant (p-value 0.013) and spinal cord stimulator/nerve stimulator (p-value 0.001). None of the other precautions were found to have a statistically significant association with decreased rate of complications by Pearson Chi-Squared analysis.

In total there were an estimated 31 patients who experienced EMI of an IED with nine complications reported, which included firing of a cardioverter-defibrillator (n=5), arrhythmia/missed beats in a patient with a pacemaker (n=1), deactivation of a deep brain stimulator (n=1), hemi-body tetany in a patient with a deep brain stimulator (n=1), and deactivation of a spinal cord stimulator or nerve stimulator (n=1). Complications were more commonly seen in patients with a cardioverter-defibrillator than any other device (RR:4.74, CI:1.29-17.4). The mean rate of EMI due to electrosurgery in a patient with an IED was 0.96 (95% CI: 0-2.15) events per 1000 patients.

The use of true heat cautery (n=1) and bipolar (two-tip electrode) (n=1) were reported with the lowest rate of EMI. Whereas, electrocoagulation (n=10), electrosection (n=8), and monopolar (single-tip electrode) (n=9) were more commonly reported to cause EMI than any other mode of electrosurgery (RR:3.62, 95% CI:1.82-7.19).

Table 1. Years in practice and practice setting of respondents.

Years in Practice	**1-10**	**11-20**	**21-30**	**30+**
% (N)	49% (87)	23% (40)	19% (33)	9% (16)
Practice Setting	**University**	**Private**	**Mixed**	**Other**
% (N)	20% (35)	73% (128)	4% (7)	3% (6)

Table 2. Implantable electronic devices encountered by percentage of survey respondents.

Implantable electronic device	**% (n)**
Cardioverter-defibrillator	99% (171)
Pacemaker	100% (172)
Cochlear implant	81% (132)
DBS	80% (132)
SCS	72% (112)
Nerve stimulator	55% (84)

Table 3. Total estimated number of patients treated with electrosurgery over the past five years and number of patients with IEDs treated with electrosurgery.

	0-500	501-1000	1001-5000	>5,000
Estimated number of patients treated with electrosurgery within the past 5 years:	12	7	50	47
Estimated number of patients with IEDs (pacemaker, cardioverter-defibrillator, cochlear implant, deep brain/spinal/nerve stimulator) treated with electrosurgery in the past 5 years:	85	19	11	0

Table 4. Routinely (>90%) implemented precautions by cutaneous surgeons performing electrosurgery in patients with an implantable electronic device.

Routinely (>90%) implemented precautions	ICD; % respondents (n)	Pacemaker; % respondents (n)	Deep brain stimulator/Cochlear implant; % respondents (n)	Spinal cord/nerve stimulator; % respondents (n)
Utilize only short bursts of current (<5 sec)	63% (101)	70% (98)	60% (72)	62% (62)
Avoid use around device	63% (100)	67% (95)	56% (67)	58% (59)
Use of minimal power/lowest effective settings	54% (86)	67% (94)	57% (68)	54% (55)
Code/crash cart available	47% (75)	50% (70)	45% (54)	42% (41)
Have staff available trained in ACLS	44% (69)	42% (60)	42% (50)	36% (36)
Pre- and postoperative monitoring (BP, HR)	42% (68)	42% (59)	32% (39)	32% (33)
Use of bipolar forceps (coag/pinch forceps)	30% (48)	25% (36)	29% (35)	24% (24)
Use only true heat cautery devices	28% (46)	16% (23)	24% (29)	19% (20)
Placement of dispersive (grounding) plate to avoid pathway of IED	24% (38)	23% (32)	23% (28)	18% (18)
Identify device (location, type, manufacturer, programming parameters, date of manufacture/implantation)	17% (27)	22% (31)	19% (24)	15% (16)
Establish level of pacemaker dependence	NA	18% (26)	NA	NA
Neurology/neurosurgery/ENT consultation	NA	NA	10% (12)	7% (7)
Deactivate device	8% (12)	2% (3)	4% (5)	8% (8)
Cardiology consultation	5% (8)	5% (7)	NA	NA
Intraoperative monitoring (BP, HR)	4% (7)	6% (8)	2% (2)	1% (1)
Change pacemaker to fixed rate mode	NA	3% (4)	NA	NA
Pre- and postoperative EKG	1% (1)	1% (1)	NA	NA

DISCUSSION

Historically, the presence of an implantable electronic device was considered a contraindication to the use of electrosurgery.[5] IEDs are at risk of sensing extrinsic electromagnetic potentials, which is referred to as electromagnetic interference (EMI). A few examples of external medical sources of electromagnetic potentials include electrosurgery, magnetic resonance imaging, lithotripsy, radiation therapy, radiofrequency catheter ablation, and transcutaneous electrical nerve stimulation. Numerous nonmedical potential sources of EMI also exist, including cellular phones, electronic article surveillance antitheft equipment, and radiofrequency energy used for communications and radar equipment.[6]

Potential risks of EMI on cardiac IEDs (pacemakers, cardioverter-defibrillators) include inhibition or triggering of the cardiac pacing system, reversion to asynchronous pacing, and faulty ICD tachyarrhythmia detection.[6-10] Potential risks of EMI on cochlear implants include device failure or permanent damage to cochlear tissues.[11] Nerve stimulators are at risk of damage to the device as well as changes in output and reprogramming due to electrosurgery.[10] The manufacturer of deep brain stimulators warn that external electromagnetic fields may adversely affect the device and recommend against use of diathermy, therapeutic ultrasound, electrolysis, and radiation directly over the implanted site.[10,12,13] Recent advancements in engineering of the intrinsic design of IEDs has significantly increased resistance to EMI, therefore, decreasing theoretical risk of complications secondary to external electromagnetic potentials.

The first dermatologic perioperative recommendations for use of electrosurgery in patients with a pacemaker were published in 1975.[14] More recent guidelines were published within the dermatologic literature in 1998, however, they did not differ significantly from the original recommendations.[3] The guidelines included preoperative cardiology consultation, preoperative surgical evaluation, utilizing electrocautery or bipolar forceps, deactivating ICDs, changing pacemakers to fixed-rate mode, use of continuous cardiac monitoring (ECG or pulse oximeter), contingency plan for arrhythmias, utilizing bursts less than 5 seconds, utilizing a minimal electrosurgical current setting, and having a cardiologist evaluation postoperatively. These recommendations were very conservative, based on complications experienced within non-dermatologic electrosurgery, and did not represent consensus statements.[2,3,14,15]

A survey of Mohs surgeons in 2001 reported a very wide variation in the precautions taken prior to electrosurgery in patients with pacemakers or implanted cardioverter-defibrillators. Within this survey, 8% of Mohs surgeons reported taking no unique precautions prior to electrosurgery within this population.[1] Similar to our survey the most commonly reported precautions were related to advanced cardiac life support (ACLS) training and conservative electrosurgical technique. This was also the first report of electrosurgical interference to a pacemaker or ICD within a dermatologic setting.[1]

Weaver et al. published recommendations for the use of electrosurgery in a patient with a deep brain stimulator after performing multiple electrosurgical procedures on a patient with a deep brain stimulator. The recommendations included: deactivation of the device if the tremor does not interfere with surgery; use of bipolar electrosurgical

devices to reduce potential of EMI; use of a dispersive plate positioned so that neither the pulse generator nor the lead wire are located between the plate and surgical site if a monopolar device must be used; use of handheld battery-operated heat cautery for hemostasis of small lesions.[16]

Guidelines for use of electrosurgery in patients with cochlear implants were published within the dermatologic literature by Behan et al. in 2017. These recommendations included: use of monoterminal and biterminal electrosurgical instruments below the clavicles with utilization of a grounding pad when possible; complete avoidance of monoterminal instruments above the clavicles; use of biterminal instrumentation with two tines above the clavicles and at least two centimeters away from the CI or any component parts.[11]

As demonstrated by the results of our survey and supported by El-Gamal there is no clear current consensus among dermatologic surgeons regarding routine precautions in patients with an implantable electronic device. Furthermore, the precautions recommended in the literature including pre-operative specialty consult, changing pacemakers to a fixed rate and intraoperative monitoring[2,3,14,15] are routinely implemented less than 10%, 3%, and 6% of the time, respectively. The most commonly reported precautions in our survey were related to use of conservative electrosurgical technique with avoidance of electrosurgery in close proximity to the IED and utilization of minimal power settings and short bursts (<5 seconds). Having a crash cart available and staff trained in ACLS were also more commonly reported. Precautions that were less commonly executed included a pre-operative device-specific specialty consultation (i.e., cardiology, ENT, neurology, neurosurgery), deactivation of device, switching pacemaker to fixed rate mode, intraoperative monitoring of heart rate and blood pressure, and monitoring of EKG prior to and following the surgery.

A total of 31 patients were estimated to have experienced EMI during electrosurgery with nine reported complications. Firing of a cardioverter-defibrillator was the most common complication (n=5). Other reported complications included: arrhythmia/missed beats in a patient with a pacemaker (n=1), deactivation of a deep brain stimulator (n=1), and deactivation of a spinal cord stimulator or nerve stimulator (n=1). One physician reported hemi-body tetany in a patient with a deep brain stimulator after use of electrocoagulation due to failure to identify the device prior to surgery. This resulted in an urgent neurosurgery consultation.

Theoretical risk of EMI exists for all modes of high-frequency electrosurgery. However, EMI is more likely to occur when monopolar cautery is used in long (>5 seconds) or frequent bursts.[6,7,17,18] Bipolar electrosurgery and heat electrocautery are the preferred method of treatment in patients with an IED due to their high safety profile.[1,19] As indicated in our survey, the use of true heat cautery (n=1) and bipolar (two-tip electrode) (n=1) were associated with the lowest rate of EMI. Electrocoagulation and electrosection are biterminal circuits which pose a greater potential risk of EMI due to higher currents generated that travel throughout the patient. Electrocoagulation (n=10), electrosection (n=8), and monopolar (single-tip electrode) (n=9) were more commonly reported to cause EMI than any other mode of electrosurgery (RR:3.62, 95% CI:1.82-7.19).

Overall, the rate of complications secondary to EMI in a patient with an IED treated with electrosurgery is relatively low.[1,6,15] The incidence of EMI within the dermatologic literature may even be over-reported as it is thought that some reports of EMI may actually be the result of interference with the electrocardiographic monitor.[7,20] The rate of EMI encountered in our survey 0.96 (95% CI: 0-2.15) per 1000 patients. We hypothesize that the lack of a significant association between precautions implemented and complications encountered by cutaneous surgeons performing electrosurgery in patients with an IED may be secondary to one of two theories. Either the rate of complications in patients with IEDs secondary to electrosurgery is so low that the precautions taken prior to the procedure are irrelevant or the precautions that are commonly implemented are effective and therefore, very few complications are encountered.

Limitations to this study in include recall bias, administration to ACMS members only resulting in small sample size, low survey response rate (10.5%), and inability to know or track the number of electrosurgery procedures performed on patients with IEDs.

CONCLUSION

As the population ages and technology and medicine continue to advance the use of implantable electronic devices increases. This same population with IEDs is often at high risk for development of skin cancer and therefore commonly encountered by the dermatologic surgeon. Adverse effects of electrosurgery in patients with an IED could pose a meaningful patient safety risk. While significant electromagnetic interference to implantable electronic devices during routine electrosurgery procedures is rare, the complications are potentially severe and costly. Ideally, electrosurgery is avoided or limited in patients with an implantable electronic device. However, when necessary there is a clear lack of guidelines or current consensus among cutaneous surgeons regarding the use of electrosurgery in patients with implantable electronic devices. Device-specific recommendations are necessary to ensure safety when performing electrosurgery in patients with IEDs. It is imperative that dermatologic surgeons are familiar with implantable electronic devices and have a firm understanding of electrosurgery to minimize risk within this patient population. Further investigation is required to formulate consensus statement recommendations for the use of electrosurgery in a patient with an implantable electronic device. This may be possible going forward with the participation in and collection of detailed data for the ACMS National Registry of Outcomes, or similar registry and outcomes work by other groups.

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References:

1. El-Gamal HM, Dufresne RG, Saddler K. Electrosurgery, pacemakers and ICDs: a survey of precautions and complications experienced by cutaneous surgeons. *Dermatol Surg.* 2001;27(4):385-390.
2. Sebben JE. Electrosurgery and cardiac pacemakers. *J Am Acad Dermatol.* 1983;9(3):457-463.
3. LeVasseur JG, Kennard CD, Finley EM, Muse RK. Dermatologic electrosurgery in patients with implantable cardioverter-defibrillators and

pacemakers. *Dermatol Surg.* 1998;24(2):233-240.
4. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)--a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009;42(2):377-381.
5. Levine PA, Balady GJ, Lazar HL, Belott PH, Roberts AJ. Electrocautery and pacemakers: management of the paced patient subject to electrocautery. *Ann Thorac Surg.* 1986;41(3):313-317.
6. Howe N, Cherpelis B. Obtaining rapid and effective hemostasis: Part II. Electrosurgery in patients with implantable cardiac devices. *J Am Acad Dermatol.* 2013;69(5):677 e671-677 e679.
7. Yu SS, Tope WD, Grekin RC. Cardiac devices and electromagnetic interference revisited: new radiofrequency technologies and implications for dermatologic surgery. *Dermatol Surg.* 2005;31(8 Pt 1):932-940.
8. Matzke TJ, Christenson LJ, Christenson SD, Atanashova N, Otley CC. Pacemakers and implantable cardiac defibrillators in dermatologic surgery. *Dermatol Surg.* 2006;32(9):1155-1162; discussion 1162.
9. Dawes JC, Mahabir RC, Hillier K, Cassidy M, de Haas W, Gillis AM. Electrosurgery in patients with pacemakers/implanted cardioverter defibrillators. *Ann Plast Surg.* 2006;57(1):33-36.
10. Tripathi S HE. Pacemakers, Deep Brain Stimulators, Cochlear Implants, and Nerve Stimulators: A review of common devices in the encountered in the patient undergoing dermatologic surgery. *Dermatologic Surgery.* 2019;In press.
11. Behan J, Higgins S, Wysong A. Safety of Cochlear Implants in Electrosurgery: A Systematic Review of the Literature. *Dermatol Surg.* 2017;43(6):775-783.
12. Martinelli PT, Schulze KE, Nelson BR. Mohs micrographic surgery in a patient with a deep brain stimulator: a review of the literature on implantable electrical devices. *Dermatol Surg.* 2004;30(7):1021-1030.
13. Questions and Answers about Activa Parkinson's Disease Therapy. Medtronic. http://www.medtronic.com/neuro/parkinsons/activa_qa.html. Accessed.
14. Krull EA, Pickard SD, Hall JC. Effects of electrosurgery on cardiac pacemakers. *J Dermatol Surg.* 1975;1(3):43-45.
15. Riordan AT, Gamache C, Fosko SW. Electrosurgery and cardiac devices. *J Am Acad Dermatol.* 1997;37(2 Pt 1):250-255.
16. Weaver J, Kim SJ, Lee MH, Torres A. Cutaneous electrosurgery in a patient with a deep brain stimulator. *Dermatol Surg.* 1999;25(5):415-417.
17. Healey JS, Merchant R, Simpson C, et al. Canadian Cardiovascular Society/Canadian Anesthesiologists' Society/Canadian Heart Rhythm Society joint position statement on the perioperative management of patients with implanted pacemakers, defibrillators, and neurostimulating devices. *Can J Cardiol.* 2012;28(2):141-151.
18. Pinski SL. Emergencies related to implantable cardioverter-defibrillators. *Crit Care Med.* 2000;28(10 Suppl):N174-180.
19. Boughton RS, Spencer SK. Electrosurgical fundamentals. *J Am Acad Dermatol.* 1987;16(4):862-867.
20. Fader DJ, Johnson TM. Medical issues and emergencies in the dermatology office. *J Am Acad Dermatol.* 1997;36(1):1-16; quiz 16-18.