Clinics in Surgery

Research Article
Published: 08 Aug, 2020

Bovie's Inferno: Understanding the Causative Agents of Intra-Operative Fire

Augustus Koch[1]*, Joseph Bowen[2] and Tamara Odom-Maryon[3]

[1]University of Washington School of Medicine, USA

[2]Kootenai Health, USA

[3]Washington State University College of Nursing, USA

Abstract

Introduction: Fire safety is a tenant of the OR but proprietary as it pertains to hospital policy. Current literature establishes guidelines for the use of electrocautery but fails to establish ubiquitous fire rating scales based on empiric risk. Our belief is that higher Bovie power output is the most causative agent of intraoperative fires given the inert status of oxygen and fuel sources together in the OR.

Methods: A porcine sample was prepped using paper drapes and a variety of antiseptic agents. Oxygen was introduced into the environment at 0 L/min, 4 L/min and 25 L/min. Electrical current was provided by the covidien force triad energy platform and bovie electrosurgical pencil. The electrical current was applied for 3 sec on cut/coag settings of 15/15, 65/50, and 150/90. The presence of fire was noted after each trial.

Results: Our study suggests the most contributive component of the fire triangle is the cut and coagulation setting. With a total of 41 fire events that could pose a threat to patients, 19 of them occurred under coagulate and 22 of them under a cut current. Some of the most dangerous combinations were the use of alcohol and ChloraPrep solutions under high energy and oxygen conditions.

Conclusion: Given the variables with the electrosurgical unit alone, we hope to provide a more in depth look at the most causative agent for intra-operative fires to help guide best practice and improve nationwide patient outcomes by reducing the incidence of these events through informed policy change.

OPEN ACCESS

****Correspondence:***

Augustus Koch, University of Washington School of Medicine, USA, Tel: 208-755-0252; E-mail: Koch4420@gmail.com

Received Date: *20 Jun 2020*

Accepted Date: *03 Aug 2020*

Published Date: *08 Aug 2020*

Citation:

Koch A, Bowen J, Odom-Maryon T. Bovie's Inferno: Understanding the Causative Agents of Intra-Operative Fire. Clin Surg. 2020; 5: 2901.

Introduction

Electrosurgery has become a staple in the operating room since its inception in the 1920's by the Doctors Bovie and Cushing [1]. It has been refined, advanced, and implemented throughout the world to help deliver safe and efficient operative care to patients in need. The fundamental laws of physics are the basis for electrosurgery. An electrical current is generated by a device, which is then passed through a patient's tissue to achieve the desired effect of cut or coagulation of bodily fluids, and then returned to the machine to complete the circuit. A generator can create a wide variety of currents and wave forms, the tactful application of which comprises the art in the safe execution of electrosurgical techniques [2]. One key component of electrosurgery use as a modality has been the development of guidelines and safety measures to ensure patients see the optimal outcomes. One of the most critical measures to ensure patient safety is the awareness of intra-operative fires [3]. Patients trust their physicians and healthcare teams to provide efficacious, data driven best practice care in a safe and thoughtful environment. One of the problems facing the modern healthcare system is determining what truly is best practice for one of the most widely used pieces of equipment in the operating room.

There is a fire triangle that exists in the operating room. This triangle consists of fuel, an ignition source, and an oxidizer or oxidizing environment [4]. In operating rooms around the world there is paper draping, high flow oxygen, and at least one electrosurgical unit being used in very close proximity. The current literature agrees that fires are rare "never events" that are primed to happen, but little is known about the most contributive factors [5]. Even following current best practice guidelines with draping and surgical prepping, fires can happen in, on, or around a patient leading to not only horribly disfiguring catastrophes for patients but very expensive lawsuits for health systems [6]. Current estimates put the incidence of operative fires between 20 and 650 cases per year in this country, comprising 17% or all anesthesia related malpractice lawsuits [3]. Understanding and preventing operative fires is not only important for patient safety but also the bottom line of our current health infrastructure. The most up-to-date guidelines on Bovie use focus more on how the device operates rather than how it should be implemented in conjunction with other fire risk parameters. The basic principle relies on passing an electrical current through tissue to achieve a cutting or coagulative effect. Variables in this outcome include the current density, application time, electrosurgical unit type, tissue conductivity, wave form, and electrode size [7]. Proper application and utilization of electrosurgical techniques relies on the judgment and assessment of the surgeon and generally results in a safe operation. With so many variables regarding a single facet of the fire triangle and its widespread use, there is a required effort from all members of the surgical team to ensure positive outcomes. The most effective way to prevent intra-operative fires currently is the communication and recognition of high-risk situations by all members of the team along with proper fire safety precautions [3]. Because of the electrical current, heat production, and common use associated with these instruments, compounded by the complex environments in which they are deployed, potential contributive factors must be considered and are likely underreported in literature. Our inquiry seeks to help guide best practice application of electrosurgical techniques and provide a constructive framework for guiding patient safety that extends beyond identifying the dangerous nature of fires in the operating room. By observing which singular component of the fire triangle poses the greatest risk to patient safety, we hope to provide structure to the current proprietary system of fire safety guidelines. Our foundational belief is that higher Bovie power output is the most dangerous and causative agent of intraoperative fires due to the relatively inert status of oxygen and fuel sources together in the operative setting.

Methods

To best assess causes of intra-operative fires we had to create a realistic environment in which to adjust each arm of the fire triangle. A fire resistant, one cubic meter chamber was constructed. The chamber was not made air-tight to help replicate air circulation in a larger room as well as prevent any unrepresentative oxygen pooling.

A porcine tissue sample was used to ensure patient safety and real-world applicability. The tissue sample was then prepped and draped in standard surgical fashion using paper drapes and a variety of antiseptic agents such as chloraprep, betadine, alcohol-based skin prep, and hibiclens, with appropriate drying times per product instructions. Oxygen was introduced into the environment in three levels, 0 L/min, 4 L/min to indicate standard use, and 25 L/min to indicate high flow [8]. This was preformed *via* nasal cannula from a portable E-tank. Electrical current was provided by the covidien force triad energy platform and Bovie electrosurgical pencil unit. The Bovie was placed in an insulating brace to allow for removal from the system and to limit interfering electrical arcing. The electrical current was applied to the tissue for 3 sec to adequately cover average use ranges [9]. Cut and Coag settings were placed at 15/15 to indicate low power, 65/50 for medium power, and 150 to 95 for high power as indicated by the Covidien electrosurgical manual guidelines [10]. The presence or absence of fire was noted after each trial.

Trials were organized by surgical prep conditions. Once the sample had been prepped and draped and low power settings had

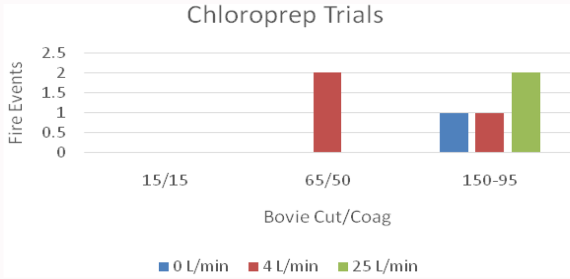

Figure 1: Fire event outcomes for preparation with chloraprep across a variety of cut/coag settings and oxygen flow.

been inputted, oxygen conditions were applied, and three seconds of cut were applied followed by three seconds of coag. This was repeated three times at each oxygen concentration. After nine trials of low power were completed, medium power was applied in similar fashion across all oxygen concentrations followed by high power trials for a total of 27 trials for a particular surgical prep type and a total of 216 trials spanning four standard preparatory solutions. Fire safety precautions were taken to ensure safety for all participants.

Results

Our study suggests the most contributive component of the fire triangle to operative room danger is cut and coagulation setting of the Bovie electrosurgical unit (Figures 1 to 4). With a total of 41 fire events that could pose a threat to patient safety (i.e. generation of an open flame, mobile sparks, or heavy singing or charring of the surgical drapes), 19 of them occurred under coagulate current administration and 22 of them under the administration of a cut current. Fire events were notably more numerous at the medium and high-power conditions compared to the lower energy setting across all levels of oxygen administration and antiseptic varieties. Some of the most dangerous combinations were the use of alcohol and chloraprep solutions under high energy and oxygen conditions. Betadine was found to be the safest prep solution across all levels of energy and oxygen administration having only two fire events (Figure 2).

Our results report only notable events that pose a risk to patient safety, not depicted graphically are the destructive consequences of high-powered electrosurgical settings. Our chosen energy levels came from the middle of what the covidien product manual describes as low, medium, and high-power use but the devastating effects on the tissue were anything but standard. Low and medium powered cut and coagulation settings produced acceptable tissue modification while high power caused focal tissue obliteration with a substantial area of effect. Sparks were often ejected from the field and hazardous

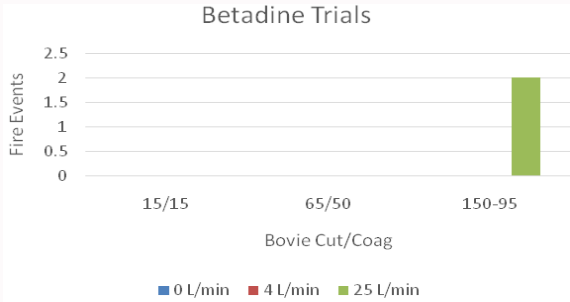

Figure 2: Fire event outcomes for preparation with Betadine across a variety of cut/coag settings and oxygen flow.

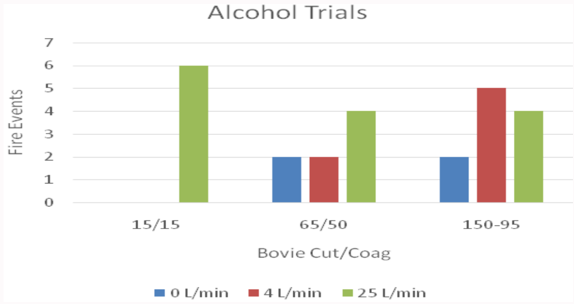

Figure 3: Fire event outcomes for preparation with Alcohol across a variety of cut/coag settings and oxygen flow.

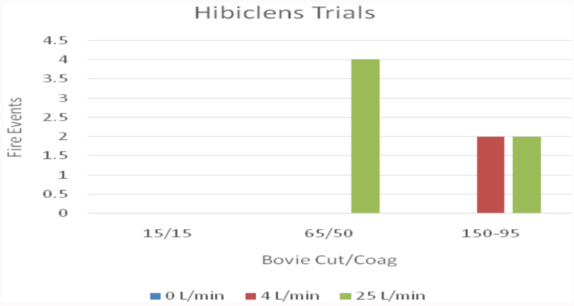

Figure 4: Fire event outcomes for preparation with Hibiclens across a variety of cut/coag settings and oxygen flow.

amounts of smoke were rapidly generated in only three seconds. This condition not only creates a hazardous environment for the creation of operating room fires but also puts all operative staff at a greater risk of injury. Based on our trials we do not believe that high powered electrosurgical techniques have a place in traditional "bread and butter" medicine and should be reserved for only the limited and absolutely most necessary situations and only after more conservative settings have been applied.

Discussion

At our institution, a rural referral level II trauma center, and many others across the country, the fire safety guidelines are remarkably proprietary. Our institution's policy covers a wide range of possible outcomes given the current environment the patient is in to assess their fire risk. The organization provides guidelines and training for staff should a fire break out, as well as, guidelines on how to score patients in terms of fire risk. The fire risk assessment questions include use of an alcohol-based skin antiseptic, operation being performed above the xiphoid process, administration of open oxygen or nitrous oxide, use of an electrosurgical unit or fiber optic light, and other contributive factors, such as, defibrillators, drills and saws [11]. Given the myriad of variables with the electrosurgical unit alone our study hopes to provide a more in depth look at the most causative agent for intra-operative fires to help guide best practice and improve nationwide patient outcomes by reducing the incidence of these rare but catastrophic events [12].

Our results report only notable events that pose a risk to patient safety, not depicted graphically are the destructive consequences of high-powered electrosurgical settings. Our chosen energy levels came from the middle of what the covidien product manual describes as low, medium, and high-power use but the devastating effects on the tissue were anything but standard. Low and medium powered cut and coagulation settings produced acceptable tissue modification while high power caused focal tissue obliteration with a substantial area of effect. Sparks were often ejected from the field and notable amounts of smoke were rapidly generated in only three seconds. This condition not only creates a hazardous environment for the creation of operating room fires but also puts all operative staff at a greater risk of injury. Based on our trials we support the notion that high powered electrosurgical techniques do not have a place in traditional "bread and butter" medicine and should be reserved for only the limited and absolutely most necessary situations and only after more conservative settings have been applied. Building upon the foundation of established electrocautery guidelines, our aim was to provide a frame work that demonstrates the elements of the fire triangle with the greatest empiric risk. By providing this knowledge, we hope to help drive hospital fire safety guidelines and policy decisions around assessing fire risk in an effort to improve patient safety with the Bovie energy setting at the forefront of thought when assessing fire risk.

Strengths and Limitations

Our investigation builds upon a robust foundation of fires safety research and reinforces the "less is more" paradigm of electrocautery. A simple design and qualitative results lend the study to easy replicability and transparency. The implementation of modern equipment also ensures the timeliness and modernity of our methods. We did not implement a statistical analysis as we felt this was an observational study but an analysis driven model could have strengthened our observations and provided insight not previously thought of.

Conclusion

The ubiquity of electrocautery in the operative setting proves a necessary danger in the execution of safe surgical procedures. To develop more universal and evidence-based guidelines for assessing fire risk it is important to understand the most causative agents of operating room fires. This study suggests that the use of high energy electrocautery puts patients in the greatest danger in comparison to other potentially hazardous but necessary exposures. While we recognize that the use of high energy output is rare and not the current best practice Bovie, we hope to demonstrate that when assessing patient risk it is efficacious to center the discussion around the energy level as opposed to a surgical field above the xiphoid process as is the case at our institution. Developing guidelines around this particular piece of equipment and its implementation will be the best step we can take to improve patient safety in the operative setting and providing universal best practice guidelines in assessing fire risk and patient safety in the operating room.

References

1. O'Connor BSJL, Bloom MD. William T. Bovie and electrosurgery. Surgery. 1996;119(4):390-6.

2. Alkatout I, Schollmeyer T, Hawaldar NA, Sharma N, Mettler L. Principles and safety measures of electrosurgery in laparoscopy. J Society of Laparoendoscopic Surgeons. 2012;16(1):130-9.

3. Yardley IE, Donaldson LJ. Surgical fires, a clear and present danger. The Surgeon. 2010;8(2):87-92.

4. Barker SJ, Polson JS. Fire in the operating room: A case report and laboratory study. Anesth Analg. 2001;93(4):960-5.

5. Vogel L. Surgical fires: Nightmarish "never events" persist. CMAJ. 2018;190(4):E120.

6. Choudhry AJ, Haddad NN, Khasawneh MA, Cullinane DC, Zielinski MD. Surgical fires and operative burns: lessons learned from a 33-year review of medical litigation. Am J Surg. 2017;213(3):558-64.
7. Rinder C. Fire safety in the operating room. Curr Opin Anesthesiol. 2008;21(6):790-5.
8. Riccio CA, Sarmiento S, Minhajuddin A, Nadir D, Fox AA. High-flow *vs.* standard nasal cannula in morbidly obese patients during colonoscopy: A prospective, randomized clinical trial. J Clin Anesth. 2019;54:19-24.
9. Meeuwsen FC, Guédon AC, Arkenbout EA, Elst MVD, Dankelman J, Dobbelsteen JJ. The art of electrosurgery: Trainees and experts. Surgical Education: Training for the Future. 2017;24(4):373-8.
10. Covidien. Force FX Electrosurgical Generator C. Retrieved from Medtronic. 2011.
11. Kootenai Health. Perioperative Services: Fire Safety. Retrieved from Kootenai Health. 2018;6:20.
12. Wang K, Advincula AP. "Current thoughts" in electrosurgery. Int J Gynecol Obstetr. 2007;97(3):245-50.