Experience of a Tertiary-Level Urology Center in the Clinical Urological Events of Rare and Very Rare Incidence. I. Surgical Never Events: 3. Urological Electrosurgical Never Events

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Key Words
Electrosurgical fires • Electrosurgical injuries • Operative burns • Surgical fires • Surgical never events

Abstract
Introduction: Surgical fires are unique topics that belong to surgical never events and deserve urological attention.

Materials and Methods: A retrospective search of our hospital records was done for the states of electrosurgical never events in the period from July 2001 to June 2016. The included events were classified according to the site of occurrence in relation to the patient’s body and possibilities of human involvement. The events were studied for the type, extent, damages, personnel involvements, complications, and management. Results: Of more than 82,000 urological interventions, 18 cases (0.022%) of electrosurgical never events were detected. Four subcategories were differentiated: electrosurgical theater fires (33.3%), electrosurgical contact skin burns (38.9%), electrosurgical internal injuries (16.7%), and electrocutions (11.1%). Electrosurgical theater fires included 3 ignition fires with fire skin burns and 3 device explosions. Fires only occurred with the use of alcoholic skin disinfectants. Contact skin burns resulted from inadvertent direct electrosurgical contacts, with 2 burns on the back, 3 burns on the lower limbs, 1 burn at the penile shaft, and 1 burn at the suprapubic region. Only 1 case of contact skin burn required plastic surgery. Electrosurgical internal injuries involved the intestine, spleen, and urethra and were followed by major complications. Electrocutions involved a doctor and a patient with multiple bone fractures in the former. Conclusion: Urological electrosurgical never events are very rare incidents and were differentiated into 4 clinical subcategories. Human involvements varied from absence to major devastating complications. Reduction of these events depends on the adjusted use of electricity-based armamentarium.

Introduction
Surgical never events comprise 3 different categories which are wrong surgeries, retained surgical items, and surgical fires. Although the real incidence of surgical fires is unknown and is believed to be the least among all...
the 3 categories in the literature [1, 2], they were reported to be comparable to them in other reports [3]. The term “surgical fires” mainly refers to fires ignited within the operative room in the presence of the surgical fire triangle: ignition source, fuel, and oxygen. However, it could be a broader subject that has different varieties of thermal and electrical injuries in the operative theater including accidents of fires, explosions, burns, and electrocutions [4]. The risks are not only directed towards the patients, but they may also extend to the medical staff and coworkers. Safety against surgical fires has been regulated according to the recommendations of The Emergency Care Research Institute and The Joint Commission. They recommended that safe and proper use of the surgical devices in the operative room, especially electricity- and laser-fired equipment, should be taken seriously [5, 6]. As a tertiary-level health care center, our hospital has 3 operative theaters, which together, consist of 12 high technology equipped operative rooms with electrical or electronic devices. Therefore, a large number of urological interventions is done either as regular elective surgeries or emergencies with common uses of these devices. So, patients’ safety is a fundamental principle and target and warrants studying in the context of this advanced technology-serviced high surgical frequency.

### Table 1. Electrosurgical never events. Classifications and human involvement possibilities

| Event subcategory       | Relation to patient’s body | Patient’s involvement | Others’ involvements* | Classes                       |
|-------------------------|----------------------------|-----------------------|-----------------------|-------------------------------|
| Electrosurgical theatre fires | external                  | variable possibilities | variable possibilities | ignition fires and explosions |
| Electrosurgical contact skin burns | on surface (skin)          | definite              | variable possibilities | fire and contact skin burns   |
| Electrosurgical internal injuries | internal                 | definite              | definitely none       | electrocautery and laser injuries |
| Electrocauteries        | total                      | variable possibilities | variable possibilities | none                          |

*Others may include humans, devices, structures, and buildings.

### Table 2. Clinical features of the electrosurgical theatre fires (ignition fires and explosions)

| No. | Site of fire ignition          | Ignition factors | Form of fire | Human damage       | Device damage | Extent          |
|-----|--------------------------------|------------------|--------------|-------------------|---------------|----------------|
| 1   | Surgical field drapes          | fire triangle    | ignition fire | first degree skin burn | none          | limited to field|
| 2   | Surgical field drapes          | fire triangle    | ignition fire | second degree skin burn | none          | limited to field|
| 3   | Surgical field drapes          | fire triangle    | ignition fire | first degree skin burn | none          | limited to field|
| 4   | Electrocautery machine         | spontaneous      | explosion    | none               | positive       | major; exchanged|
| 5   | Electrocautery machine         | electric contact | explosion    | none               | positive       | minor; fixed    |
| 6   | Electrical cable of resectoscope | electric heat    | explosion    | none               | positive       | major; exchanged|

### Materials and Methods

A retrospective search of the data of patients who were operated upon in Assiut Urology and Nephrology Hospital, Assiut University, Egypt in the period July 2001–June 2016 was done to study the electrosurgical never events. They are known as surgical fires and defined according to the Food and Drug Administration as fires that occur in, on, or around a patient who is undergoing a medical or surgical procedure [3, 7]. According to the National Quality Forum’s definition, they fulfill the criteria for inclusion in surgical never events [8]. Study inclusion criteria were the occurrence of a fire, explosion, burn, thermal injury, or electrocution at a certain device or human, during a surgical intervention for a urological disorder, presence of an electrical or thermal ignition or contact damage in the operative theatre, and presence of an effect on the human subjects or devices. Considering the Food and Drug Administration definition, the included electrosurgical events were subcategorized according to the relation to patient’s body as around the body (theater fires), on the body (contact skin burns), in the body (internal injuries), and total electrical involvement from external to internal (electrocauteries). Each event was studied for the cause (human error) and site of ignition, source of power, possible mechanisms, involved devices, involvement of humans, damage to the equipment, and outcome. Extra surgeries needed for correction of damages were considered for the involved cases. Final outcomes of the human damages were classified into short- and long-term damages, organ losses, and death. Also, legal disputes from the involved patients were accounted.

Board reviewing and administrative acts, in addition to the maintenance work up were searched for every state or case.
Results

Our operative urological interventions in the period July 2001–June 2016 exceeded 82,000 interventions which varied between percutaneous procedures and advanced surgeries such as kidney transplantation. Only 18 cases (0.022%) of electrosurgical never events were reported. They were differentiated into 4 subcategories (table 1); electrosurgical theater fires (6 cases, 33.3%), electrosurgical contact skin burns (7 cases, 38.9%), electrosurgical internal injuries (3 cases, 16.7%), and electrocutions (2 cases, 11.1%). Their percentages from all urological surgeries were 0.0073, 0.0085, 0.0037, and 0.0025%. There were 3 incidents of theater fires ignited by oxygen and fueled by alcoholic surgical disinfectant. Fourteen patients and 1 medical individual were involved in the whole events with an age range of 12–65 years.

Electrosurgical theater fires included 3 ignition fires and 3 device explosions (table 2). All the theater fires were limited to the involved sites or devices with 3 patients’ involvements which were mild fire skin burns. The fires were rapidly controlled within the sites of ignition and no cases of operative theater evacuation were reported with these events.

Electrosurgical contact skin burns were due to inadvertent contacts of the electrocautery and involved different parts of the body with different mechanisms (table 3). Only 1 lower limb burn in a female patient developed scars that required plastic surgery.

Electrosurgical internal injuries involved 3 internal organs through thermal burns or cutting (table 4). These events had major complications and they were discovered only when their complications clinically developed.

Two cases of electrocution were reported and were caused by an electrical leak through the walls and ground of the surgical theater. One doctor and 1 patient were involved in these events and the former had multiple bone fractures in upper and lower limbs with long-term disability.

Final outcomes in the all subcategories included no deaths. They included minor harm in the form of mild skin burns or psychological effects. Five major complications were encountered including 1 organ loss and 1 permanent disability (table 2, 3, and 4).

Only 2 legal disputes were announced against the institute for 1 skin burn and for one of the internal thermal damages.

Discussion

Electrosurgical fires, burns, and injuries represent a known category of surgical never events [1, 2]. Electrocutions or electrical shocks which are states of sustaining

| Table 3. Clinical features of electrosurgical contract skin burns |
| No. | Age (year) | Gender | Operation | Burn mechanisms | Anatomical site | Diameter (cm) | Degree | Complication |
|-----|------------|--------|-----------|-----------------|----------------|---------------|--------|--------------|
| 1   | 33         | Female | pyelolithotomy | electrocautery electrode misplaced | right leg | 4 | 3rd | scars |
| 2   | 57         | Male   | cystolitholapaxy | light source cable contact heat | suprapubic | 2 | 1st | none |
| 3   | 42         | Female | radical nephrectomy | electrocautery electrode misplaced | right leg | 3 | 1st | none |
| 4   | 24         | Female | ureterolithotomy | electrocautery electrode misplaced | left leg | 2 | 1st | none |
| 5   | 12         | Male   | hydrocelectomy | electrocautery contact on firing | penile shaft | 1 | 1st | none |
| 6   | 18         | Male   | kidney transplantation | alternate circuits via operative table | lower back | 5 | 2nd | none |
| 7   | 29         | Male   | kidney transplantation | alternate circuits via operative table | lower back | 4 | 2nd | none |

| Table 4. Clinical features of electrosurgical internal injuries |
| No. | Age (year) | Gender | Operation | Injury cause | Anatomical site | Extent/effect | Complication/outcome | Extra surgery |
|-----|------------|--------|-----------|--------------|----------------|---------------|----------------------|--------------|
| 1   | 65         | Male   | TURP | electrical leak | urethra | whole length/charring | urethral stricture | twice |
| 2   | 36         | Female | ureteroscopy | laser cut depth | intestine | full-thickness/perforation | fecal peritonitis | twice |
| 3   | 44         | Male   | radical nephrectomy | electrocautery cut | spleen | deep cut/hemorrhage | splenectomy | none |

TURP = Transurethral resection of the prostate.
large volumes of electrical current due to improper wiring of devices during operations represent the most hazardous form [9]. Any form of these events could happen at any time and involve any individual in the operative theater, even with fully-taken safety measures. The involved personnel could suffer serious injuries depending on the extent and type of the committed error [5, 10].

Initially in this discussion, two suggestions should be formulated in the context of results of the current study and the reviewed literature. First, the term “electrosurgical never events” is suggested as a title for this category of never events instead of the old term “surgical fires”. The suggested term is broader, more inclusive, and can include the whole events resulting from heat, electricity, and electronic misuse effects during surgeries. This term has the advantages of including these clinically-ambiguous but electrotechnically-similar never events at the same time that it enables their smooth differentiation as an indicative term in such a matter of classification representing the second suggestion.

Classification of the electrosurgical never events may facilitate their study and prevention. Four subcategories of the electrosurgical never events were clinically differentiated. In the first subcategory of theater fires, the event occurs outside the patient’s body and the fire damage has the potentials to extend to all other entities in the area including humans, devices, and structures up to involvement of the whole building. So it could be further classified into theater ignition fires and device explosions. The second subcategory starts on and involves the outer surface of the patient as limited contact skin burns. The third subcategory starts within and is limited to the patient’s internal environment. The fourth subcategory is electrocution and combines all the previous events. It starts around the patient (or any individual in the theater), contacts the patient skin, and passes through and involves the whole body up to causing cardiac arrest. In the first category, the patient and other beings have variable involvement possibilities (table 2), although the patient’s possibilities could be higher than those of the others in the theater. This could be attributed to that the patient is the target of the surgical work with the components of the fire triangle available in the patient’s vicinity. In the second subcategory, however, the patient is definitely involved with or without others. Patient skin burns have 2 possibilities of occurring, either from theater fire flames or from direct electrocautery contacts. In the third subcategory, the patient is definitely involved by the error event with no possibilities of involvement of the surrounding personnel and structures by the same event.

Other authors have separately discussed these events, but without sufficient classifications [4, 11].

Although the electrosurgical never events are usually described under the term “surgical fires” as rare or very rare surgical never events, their real global incidences are unknown due to the limited reporting in the literature. However, variable rates were sporadically stated. According to an analysis done by the Pennsylvania Patient Safety Authority, the estimated rate was variable from 0.32 to 0.63 per 100,000 operations [6]. Also, from similar reports, more than 100 surgical fires occur yearly in operating rooms. The most common causes include electrical factors (68%), electrocautery (19%), and lasers (13%). The burn involvement areas commonly include the respiratory tract during anesthesia, face, head, neck, and chest due to higher oxygen concentrations leaking from endotracheal tubes [10–12]. In the current study, the incidents of electrosurgical never events accounted for few events in a large series of urological surgeries. The burns were distributed on the legs and trunk due to etiologic mechanisms that were contact skin burns rather than fire flame skin burns. Electrosurgical fires were limited to the site of ignition that was caused by technical manipulation faults in the electrical contacts. However, the faulty placement of the electrocautery returning electrode was the main factor.

Electrosurgical units including electrocautery and laser devices are the most common ignition sources for electrosurgical fires in operative theatres. According to European Commission against Racism and Intolerance reports, more than 80% of electrosurgical fires involve electrosurgical equipment and lasers [12, 13]. Our results showed that electrocautery was the main cause of patient’s involvement in damages.

Fortunately, electrosurgical never events seem to be very rare in urological practice where they are hardly detectable in the operative urological literature [14]. However, advances in the electrical and electronic equipment in the urological field provide higher possibilities for these events to occur as direct contact burns or cuttings by inadvertent appliances of electrocautery and laser probes [10]. The common form of electrosurgical never events that is usually reported is surgical fires [11] which corresponds to theater ignition fires in the current classification with availability of what is known as the fire triangle including the source of ignition, fuel, and flammable gas. An illustrative example is the ignition of flammable solutions used for superficial skin disinfection before operations such as alcohol-based solutions [6, 10, 11, 15]. In the current study, electrosurgical theater fires...
were ignited on the patient surfaces by alcoholic disinfectant or in the devices themselves. They were very few events, while contact skin burns were the most common.

Contact skin burns result from the misuse of electrocautery and have different degrees that may require plastic surgery. They involve 4 mechanisms: direct contact from the fired active electrode contacting the patient’s skin or the operating staff, burns at the site of the misplaced returning electrode, burns resulting from circuits generated between the active electrode and an alternate returning source, and burns due to the heat effect of pooled solutions such as spirits by an electrode [16, 17].

The current study cases exemplified the 4 mechanisms. Prolonged contact of the light source heat effect resulted in the same effect as a fired electrocautery electrode in contact with the patient’s skin. Other causes of skin burns included the direct flame heat in the first subcategory and the site of the electrical current input in the fourth subcategory.

Internal electrosurgical injuries involve the internal body organs and structures due to inadvertent energy-induced cuttings by electrocautery and lasers. Non-adjusted thermal or electrical depths of cutting may reach beyond the surgically-targeted depth and result in concealed organ injuries. These injuries are more dangerous to patients than skin burns. Major and life-threatening complications including organ perforations and luminal obliterations may follow these injuries [18]. In the current study, a single laser injury resulted in a major complication. In different patients, complications of internal injuries resulted in life-threatening short-term complications, permanent damage of the urethra, and loss of the spleen.

Electrocution is a known problem in the operative theater since the time of introduction of electricity into surgical armamentariums. It may just take the form of electric shock or a major event of death and it attracted attention many decades ago [9, 19]. Involvement of the medical staffs by electrocutions has been reported [20]. Electrical stimulation of muscles is a known principle that has been used in some medical therapeutics such as electroconvulsive therapy. However, inadvertently applied large electric current to a patient or a person in the operative room is life-threatening due to massive muscle contractions and even cardiac arrest [20, 21].

Electricity was the common factor among the all electrosurgical never events, either directly or indirectly. Safety rules of electrosurgical units and devices were recommended by many agencies concerned with these subjects [5–7, 11–13]. In the current study, operative rules and safety were reviewed after each electrosurgical never event. Two back burns occurred in 2 consecutive operations which warranted consultation of the medical engineering and maintenance units and they were attributed to accidental pooling of fluid between the table and the patient body representing an alternative circuit via the table-fluid-patient contact. The faults were corrected and no similar events were thereafter encountered. Discussion of the legal and administrative considerations or punishments of the involved personnel are beyond the scope of this article. The low incidence of legal claims for electrosurgical events could be attributed to the low incidence of the events themselves, the final outcomes were mostly short-term minor harms, and the free treatment policies.

The current study targeted a large series of urological interventions in a high technological well-equipped tertiary-level urology center for the occurrences of the electrosurgical never events. Although these subjects are very rare, they are very important from the perspective of human safety. Accordingly, exposing our experiences in dealing with these events and their prevention may motivate other hospitals to discard reluctance, and to develop and follow solid safety programs for protection of the patients and medical personnel. However, the results of the current retrospective study represent the situation in our tertiary-level urology center. They may not be fairly generalizable to the national and international levels until other larger studies can optimally consider the problem.

**Conclusion**

Electrosurgical never events are very rare incidents during urological surgical practice. They can be differentiated into theater fires, contact skin burns, internal injuries, and electrocutions. Improper use or application of electricity in the operative theaters is the common factor among most of the electrosurgical never events through human errors such as misuses of electrosurgical units, inaccuracy in application of safety rules, and faulty contacts and manipulations. Although these never events usually result in mild damages to humans, they potentially represent major harm and life-threatening probabilities, especially when they involve internal organs. Application of the safety rules against the electrosurgical never events is a must in urological operative rooms that contain variable electrosurgical units and lasers.
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