

## Airway Fires during Surgery

Airway surgeries that involve ignition sources to cut or coagulate tissue (e.g., electrosurgical units, lasers) pose a significant and sometimes deadly risk of fire. Hazards exist when these ignition sources are used in the oxygen-enriched atmospheres (i.e., atmospheres containing more than 23% oxygen [O<sub>2</sub>]) that are commonly present in the airway during surgery.<sup>1</sup>

PA-PSRS received three reports, described below, of airway fires in which electrosurgery or electrocautery was used during the reported events. Often-times the term electrocautery is used incorrectly to describe electrosurgery.

*During the procedure to insert a “trach” tube, the surgeon stated “fire.” The surgeon was using electrocautery at the time. A flame was noted coming out of the incision site. The surgeon tried to extinguish the flame with a dry sponge. The surgical tech immediately doused the site with sterile saline and wet sponges. Before the tracheal tube was removed, the skin was assessed and no change in skin integrity was noted compared to the preop assessment. The tracheal tube was removed and was noted to be blackened at the distal end. The patient was transported to the intensive care unit and a bronchoscopy was performed, which was negative.*

*The doctor was opening the trachea with cautery. A flash fire occurred at the site and was immediately extinguished with the doctor’s finger, followed by saline. Anesthesia also immediately turned off the gases. The procedure continued. The patient was transferred to SICU in stable condition. The doctor did check the patient with a flexible bronchoscope; no charring or other injury was noted.*

*The patient was in the operating room (OR) for a tracheostomy and peg tube insertion. The incision was made using a scalpel. The physician instructed the anesthetist to remove the tracheal tube. At the point that the tracheal tube*

*was above the carina, “bleeders” were noted by the surgeon. The “bovie” was used to cauterize the “bleeders.” A spark was noted and the “bovie” was stopped. Smoke was noted coming out of the tracheal tube. Saline was used to douse the fire. A follow-up bronchoscopy was done. The patient was noted to have some minor redness in the airway.*

Figure 1 shows an example of a tracheal tube blackened from an airway fire during a tracheostomy and, for comparison, an exemplar tube.

### Mechanisms of Surgical Airway Fires

Ignition sources like electrosurgical units or lasers use energy to cut and coagulate tissue, which presents particular risks during airway surgeries. Airway surgeries frequently use oxygen and nitrous oxide to ventilate and anesthetize patients, respectively. Both gases support combustion and reduce the amount of energy (e.g., current, heat, friction) needed to ignite flammable substances. During airway surgery, those gases are present in the airway below a tracheal tube cuff, may leak around the cuff into the oropharynx, or may be present in high concentrations around the face of a patient receiving O<sub>2</sub> via a nasal cannula. This oxygen-enriched atmosphere creates an environment (i.e., lowers the temperature and energy at which fuels ignite) in which some fuels (e.g., tracheal tube) burn more readily and robustly than in room air (i.e., 21% O<sub>2</sub>).<sup>1</sup>

Some flammable substances present in the airway during airway surgeries include tracheal tubes, catheters, and surgical sponges. In addition, a portion of tissue heated by an ignition source may turn to gas, especially gases evolved from fatty tissue, which will burn if made hot enough or if mixed with sufficient oxygen. Still other tissue may be reduced to embers.

This article is reprinted from the *PA-PSRS Patient Safety Advisory*, Vol. 4, No. 1—March 2007. The *Advisory* is a publication of the Pennsylvania Patient Safety Authority, produced by ECRI Institute & ISMP under contract to the Authority as part of the Pennsylvania Patient Safety Reporting System (PA-PSRS).

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\* Other sources of airway fires include electrocautery pencil tip, bronchoscope lights, and fiberoptic light sources.

## Airway Fires during Surgery (Continued)

A flare of evolved gases or tissue ember can easily cause flammable substances to catch fire.<sup>1</sup>

A flame, sparking, or arcing is often observed at the surgical site prior to the fire. Usually, surgical staff believe that a malfunction occurred with the electro-surgical unit. However, the flame, sparking, or arcing is the result of accelerated burning of tissue and gases evolved from the electro-surgery. Additionally, an inactive but still hot electro-surgical active electrode or hot laser contact tip can, when in contact, ignite the tracheal tube or sponge leading to fire. In some cases, poor fiber preparation allows the laser energy to ignite the laser fiber sheath, which can then ignite other nearby fuels (e.g., tracheal tubes, bronchoscopes).

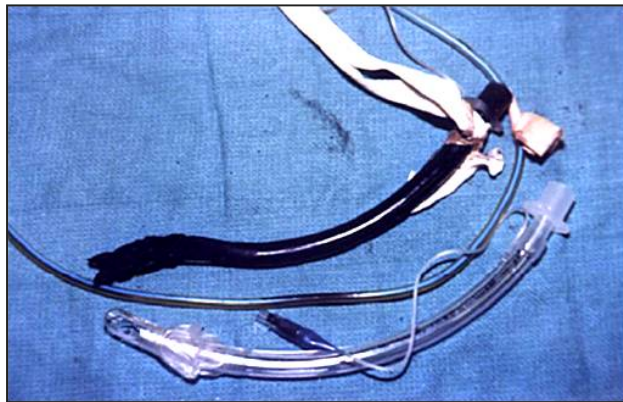


Figure 1. The top tracheal tube (blackened color) was ignited during electro-surgical use to enter the trachea during a tracheostomy. The tube damage is similar to that described in the PA-PSRS reports above, although the photo is not from the reported cases. The bottom tube is an exemplar tube for comparison. Image provided courtesy of ECRI Institute.



Figure 2. Demonstration of rocket-like flames shooting from a tracheal tube caused by laser ignition of the tube with 100% oxygen flowing. Image provided courtesy of ECRI Institute.

The ignition of a standard tracheal tube from a piece of incandescent material, nearby flaming tissue, or laser beam in an oxygen-enriched atmosphere can produce a rocket-like fire, smoke, and hot gases from the tube, which is being infused with gas continuously (see Figure 2). The result can be extensive damage to a patient's air passage and lungs.<sup>2</sup> An orange or red glow from the tracheal tube or a darkening of the breathing circuit is an indication that the tube is on fire.<sup>3</sup> ECRI Institute estimates, based on published accounts and incidents reported to it, that approximately 21% of surgical fires occur in the airway.<sup>4</sup>

### Reducing the Likelihood of Airway Surgery Fires

Ways to minimize airway fires during electro-surgery include the following:<sup>1,4</sup>

- Establish protocols for when electro-surgery will be removed from the surgical field because of risk of fire. For instance, some hospitals remove the electro-surgical unit when the tracheostomy tube is put on the surgical field.
- Do not use electro-surgical units to cut tracheal rings and enter the airway. A hot electrode tip or ember could contact the tube or tube cuff inside the trachea and ignite a fire. Instead, use a "cold" scalpel or scissors to avoid the risk of fire.
- If long, insulated electro-surgical electrode probes are needed to prevent mouth burns during procedures such as tonsillectomies, use only commercially available insulated probes. Do *not* use red rubber catheters or other materials to sheathe probes. The heat from the active electrode will ignite the rubber even in air.
- When operating in the oropharynx, scavenge around the surgical site with separate suction to catch leaking O<sub>2</sub> and nitrous oxide.
- Soak gauze or sponges used with uncuffed tracheal tubes to minimize gas leakage into the oropharynx, and keep them wet.

The delivery of laser energy may present a more serious airway fire risk than electro-surgery (see also the sidebar "Incidents of Airway Fires during Bronchoscopic Laser Surgery"). Laser energy is delivered as a collimated, coherent, monochromatic,

## Airway Fires during Surgery (Continued)

directed beam of electromagnetic radiation to cut, coagulate, and vaporize tissue. The delivered power can range from tens of watts (W) to about 120 W for some lasers; however, the power density can be in the tens of thousands of W/cm<sup>2</sup> and, depending on spot size, focal length, and pulse duration, it can create intense heat within a very small area.

Ways to minimize airway fires during laser surgery include the following:<sup>4</sup>

- Limit the laser output to the lowest clinically acceptable power density and pulse duration. Place the laser in standby mode when not in use.
- Allow the laser to be activated only by the person wielding it to minimize inadvertent activation.
- Deactivate the laser and place it in standby mode before removing the laser from the surgical site.
- During lower-airway surgery, keep the laser fiber tip in view and make sure it is clear of the end of the bronchoscope or tracheal tube before laser emission.
- Use appropriate laser-resistant tracheal tubes during upper-airway surgery. Follow the directions in the product literature and

on the labels, which typically include information regarding the tube's laser resistance, use of dyes in the cuff to indicate puncture, use of saline fill to prevent cuff ignition, and immediate replacement of the tube if the cuff becomes punctured.

### Fighting Airway Fires

Under general anesthesia, a patient is mechanically ventilated and lacks sensation; as such, hot gases can be forced deep into the lungs, causing extensive damage or death. Immediate action is required by the surgical team to reduce the extent of the damage. The guidance below can help clinicians to develop a procedure for extinguishing airway fires.<sup>4</sup> (Note, perform steps 1a and b as rapidly and simultaneously as possible.) Such a procedure should be reviewed prior to each surgical intubation.

#### 1a. Stop the gas flow.

- Disconnecting the breathing circuit is the quickest way to stop the gas flow. By removing the source of oxygen and nitrous oxide from the airway, the fire's intensity is significantly reduced and may self-extinguish.

#### 1b. Remove the tracheal tube, and maintain airway patency.

- To minimize thermal and chemical damage to the airway, quickly remove the tracheal tube from the patient. The

### Incidents of Airway Fires during Bronchoscopic Laser Surgery

Since mid 2006, ECRI Institute received six reports of airway fire during bronchoscopic laser surgery.<sup>1</sup> In each case, the fiber optic laser probe tip ignited in an oxygen-enriched atmosphere, and the resulting fire caused extensive airway injury.

A laser fiber is typically a slender glass fiber coated with a reinforcing plastic sheath. During use, the fiber tip may need to be refurbished because of damage or because of its initial condition. This refurbishment is called cleaving and stripping, and it involves several steps to insure a good fiber tip. The glass fiber must be scored and carefully broken at the score to produce a flat, circular fiber tip. The plastic sheath must be stripped from the fiber to expose several millimeters of the glass fiber and remove flammable material near the tip. The tip must be checked for proper transmission by either fiber calibration or aiming beam circularity; a round aiming beam spot without rays, commas, or halos indicates a good tip.

An improperly refurbished tip can cause the glass fiber to heat at the tip during laser emission. If the plastic sheath is close to the hot tip, the plastic will melt, ignite, and burn, especially in oxygen-enriched atmospheres. Should this occur, the burning plastic sheath can ignite the nearby bronchoscope components and tracheal tube. Rapid removal of all the burning materials can minimize the patient injury; delay or stepwise removal of the instruments can lead to severe patient injury or death.

Preventing such fires requires a properly prepared fiber tip and the lowest O<sub>2</sub> concentration possible at the point of laser use. This can be achieved by delivering air only for a short time before (e.g., 60 seconds) and during laser use. Elevated O<sub>2</sub> levels to maintain the patient can be delivered at other times when the laser will not be used.

#### Note

1. PA-PSRS. Conversation with: ECRI Institute. 2007 Feb 5.

## Airway Fires during Surgery (Continued)

- intense heat from the O<sub>2</sub>-fed fire will remain in the mass of the tube and can still harm the patient even if the fire is out; the fire can reignite if oxygen flow is restored. Additionally, remove cuff-protective devices or any segments of burned tube that may remain smoldering in the airway.
2. Extinguish the fire.
    - A smoldering or glowing tube can ignite surgical drapes or gowns. OR personnel other than the anesthesiologist should extinguish the tube with water or saline in a basin or sink, or with a wet towel. Be wary of using any flammable liquids (e.g., alcohol) that may be near or in the surgical field to extinguish the fire. Liquids in the OR should be clearly labeled to avoid mix-ups. (For more information on labeling liquids see the article “Danger Associated with Unlabeled Basins, Bowls, and Cups” in the March 2005 *PA-PSRS Patient Safety Advisory*.) Save the tube and other relevant materials for later examination.
  3. Care for the patient.
    - Reestablish the airway and resume ventilation with air until absolutely nothing is burning in the throat; then switch to 100% O<sub>2</sub>. Some smoke and gases from the tracheal tube fire can cause chemical burns or toxic reactions. Examine the airway for the extent of damage and treat the patient accordingly. A rigid bronchoscope and forceps should be readily available during all tracheal surgery. Procedures such as lavage and suction to remove soot and particles in the airway, excision of burned tissue and melted material, or a tracheostomy may be necessary.

### Notes

1. ECRI Institute. Electrosurgical airway fires still a hot topic. *Health Devices* 1996 Jul;25(7):260-2.
2. ECRI Institute. Airway fires: reducing the risk during laser surgery. *Health Devices* 1990 Apr;19(4):109-10.
3. ECRI Institute. Fighting airway fires. *Healthcare Risk Control* 1996 Jan;4:Surgery and anesthesia 10:1-2.
4. ECRI Institute. Surgical fire safety. *Health Devices* 2006 Feb;35(2):45-66.

### Self-Assessment Questions

The following questions about this article may be useful for internal education and assessment. You may use the following examples or come up with your own.

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1. Oxygen and nitrous oxide support combustion and
  - A. increase the amount of energy needed to ignite flammable substances.
  - B. decrease the amount of energy needed to ignite flammable substances.
  - C. increase the temperature and energy at which fuels ignite.
2. Ways to minimize airway fires during electrosurgery include all EXCEPT which one of the following?
  - A. Scavenge around the surgical site with separate suction to catch leaking oxygen and nitrous oxide.
  - B. Use red rubber catheters to sheathe the electrosurgical probe to insulate the patient's mouth from sparks during activation of the electrosurgical unit.
  - C. Use a “cold” scissors or a scalpel instead of an electrosurgical unit to cut tracheal rings to enter the airway.
  - D. Establish protocols for when electrosurgery will be removed from the surgical field.
3. The first step in stopping the flow of gas during an airway fire is to
  - A. disconnect the breathing circuit.
  - B. turn off the gas flow by shutting off the gas regulator(s).
  - C. remove the tracheal tube from the airway.

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