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Patient Safety Tip of the Week

January 12, 2021 Surgical Smoke

One safety topic we've been largely remiss in discussing is **surgical smoke**. Though a number of states have adopted specific legislation regarding the dangers of surgical smoke, most regulatory bodies and professional societies have been slow to adopt and enforce guidelines on the issue. Perhaps one of the few positive aspects arising from the COVID-19 pandemic has been increased attention to the dangers of aerosols produced by a variety of surgical procedures, and that should include surgical smoke.

In our July 28, 2020 Patient Safety Tip of the Week "Electrosurgical Safety" we did note that surgical smoke is a concern any time electrosurgery is used. The smoke generated during electrosurgical procedures can potentially contain viruses (such as HPV), bacteria, cancer cells, hazardous chemicals, and other fine, particulate matter. In the COVID-19 pandemic era, we'd also be concerned that coronavirus might also be aerosolized in surgical smoke, though it had not yet been known whether that happens (AORN 2020a). It's recommended you use smoke evacuation systems and fit-tested surgical N95 masks during procedures in which electrosurgery is used. The AORN Go Clear Award Program (AORN 2020b) has numerous resources and recommendations about surgical smoke generated by electrosurgery devices and any other type of device.

A review of the surgical smoke issue (Limchantra 2019) just prior to the COVID-19 pandemic acknowledged that surgical smoke is dangerous, but the severity of the risk has yet to be determined and that no safe level is known at this point. It recommended efforts be made to reduce and possibly eliminate smoke from the operating room and that research into cost-effective forms of smoke evacuation is necessary. It also noted the need for studies of respiratory and cancer sequelae of exposure to operating room smoke in personnel who have had long-term exposure to surgical smoke.

Surgical smoke consists of chemical compounds in the gaseous phase along with particles of cells, bacteria, and viruses. Viable bacteriophage has been found in surgical smoke, and transmission of human papillomavirus from the patient to operating personnel has occurred, even leading to laryngeal papillomatosis in an operating room nurse. Volatile organic compounds (VOC's) may also be found in surgical smoke and may be impacted by medications the patient had been receiving. There is even concern about the possibility of viable cancer cells in surgical smoke.

The review goes on to note that the type of device creating the surgical smoke may also be relevant. Smoke produced by laser irradiation or harmonic scalpel is relatively cold

compared with electrocautery smoke. That may present a biological hazard, because lower temperature plumes are expected to contain more infectious material than high-temperature plumes. Laser plume has been found to contain several potentially infectious components, such as viable bacteriophages, viable cells, and virus particles, and is believed to have a higher infectious potential than electrocautery smoke.

The Limchantra review discusses the various methods of surgical smoke evacuation that are in use currently, noting that they are all probably underused, and also discusses methods that might be used in the future.

Though the hazards of surgical smoke began to be described in the 1970's, it wasn't until the late 1990's that awareness of concerns became more widespread. An excellent review by Ulmer in 2008 (Ulmer 2008) highlighted smoke production by electrosurgical units, lasers, ultrasonic devices, and high-speed electrical devices like bone saws, drills, and other high-speed electrical devices used to dissect and resect tissue. The review included a discussion of components of surgical smoke, including issues of particle size, chemical contents, and presence of blood particles, viruses, and bacteria in the smoke particulate matter. It also discussed how the surgical smoke is dispersed throughout the OR. It discussed the potential health risks to OR personnel and patients. It went on to discuss risk mitigation issues, including general OR ventilation, use of high filtration surgical masks, wall suction to remove smoke, portable smoke evacuation systems, and central smoke evacuation systems. It also discussed surgical smoke evacuation and filtration during laparoscopic procedures.

Two recent reviews in the nursing literature (Vortman 2020, Vortman 2021) also point out that surgical smoke exposure has been equated to smoking 27 to 30 unfiltered tobacco cigarettes, and that perioperative teams have reported twice as many respiratory health issues (headache, watery eyes, cough, rhinitis, sore throat, sneezing, etc.) as the general public. These two excellent articles discuss the economic, political, practical, ethical and legal factors bearing on the issue of management of surgical smoke.

They discuss 3 policy options for dealing with the surgical smoke issue:

1. Health Care Facilities Develop and Institute Surgical Smoke Evacuation Policies and Procedures That Promote a Safe Perioperative Environment
2. Individual States Enact Smoke Evacuation Laws
3. "Do Nothing" Approach

Ultimately, they recommend adoption of Option 2: individual states enact smoke evacuation laws requiring facilities to adopt policies and procedures to evacuate surgical smoke.

Vortman and Thorlton (Vortman 2020) discuss the costs of surgical smoke evacuation devices that may dissuade particularly smaller hospitals from implementation but note that the costs related to adverse health effects on staff may outweigh such costs. They also note that some surgeons have complained of practical difficulties (noise, distraction, limited space) when using smoke evacuation devices. They note other reasons reported

for lack of use include a misconception among surgeons that surgical smoke is harmless and that past surgical smoke evacuation devices were loud and designed with bulky tubing.

AORN (Association of periOperative Registered Nurses) for several years now has recommended organizations provide a surgical smoke–free environment by using smoke evacuator systems (AORN 2017). But other regulatory bodies and professional societies have been slow to make firm recommendations on surgical smoke.

The American College of Surgeons, in response to the COVID-19 pandemic, issued a statement "Covid-19: Considerations for Optimum Surgeon Protection Before, During, and After Operation" (ACS 2020) that states "Use **smoke evacuator** when electrocautery is used."

Somewhat surprisingly, OSHA (The Occupational Safety and Health Administration), which requires employers to provide a work environment free of recognized hazards that may cause serious physical harm or death, does not have a specific standard addressing inhalation hazards of surgical smoke exposure.

NIOSH (National Institute for Occupational Safety and Health) supports and recommends local exhaust ventilation (LEV) to control perioperative team exposure to surgical smoke (NIOSH 2015) but, in a survey, found that only half of respondents reported that LEV was always used during laser surgery and only 15% reported LEV was always used during electrosurgery. The study also indicated that control of surgical smoke in workplaces may not be a priority, with nearly half of respondents reporting that they had never received training on the hazards of surgical smoke and one-third said that LEV use was not part of their workplace's protocol. NIOSH also recommends general room ventilation in addition to LEV to control healthcare workers' exposure to surgical smoke.

Finally, just this past December, The Joint Commission issued a Quick Safety Issue "Alleviating the dangers of surgical smoke." (TJC 2020) that has the following recommendations:

- Health care organizations that conduct surgery and other procedures using lasers and other devices that produce surgical smoke should take the following actions to help protect patients and especially staff from the dangers of surgical smoke.
- Implement standard procedures for the removal of surgical smoke and plume through the use of engineering controls, such as smoke evacuators and high filtration masks. Use specific insufflators for patients undergoing laparoscopic procedures that lessen the accumulation of methemoglobin buildup in the intra-abdominal cavity. (Surgical smoke is cytotoxic if absorbed into the blood and can cause elevated methemoglobin.) For example, a lapro-shield smoke evacuation device — a filter that attaches to a trocar — helps clear the field inside the abdomen.
- During laser procedures, use standard precautions, such as those promulgated by the Blood-Borne Pathogen Standard (29CFR1910.1030) and the CDC's Core

Infection Prevention and Control Practices for Safe Healthcare Delivery in All Settings, to prevent exposure to the aerosolized blood, blood by-products and pathogens contained in surgical smoke plumes.
- Establish and periodically review policies and procedures for surgical smoke safety and control. Make these policies and procedures available to staff in all areas where surgical smoke is generated.
- Provide surgical team members with initial and ongoing education and competency verification on surgical smoke safety, including the organization's policies and procedures.
- Conduct periodic training exercises to assess surgical smoke precautions and consistent evacuation for the surgical suite or procedural area.

The COVID-19 pandemic has raised concerns about any aerosol-generating procedure (AGP) , not just those producing traditional "surgical smoke". A number of recent studies have tried to identify those AGP's presenting a risk of respiratory transmission that merits use of a higher grade of PPE (personal protective equipment).

A recent viewpoint on aerosol-generating procedures (Klompas 2020) does not discuss surgical smoke per se but does outline the 4 key factors in respiratory transmission:

1. forced air
2. symptoms and disease severity
3. distance
4. duration

Certainly, in the OR where surgical smoke is generated, the latter two factors (distance and duration) place OR personnel at risk for respiratory transmission of pathogens and, undoubtedly, also the other untoward elements present in surgical smoke.

In the many studies on aerosol-generating procedures that have appeared since the COVID-19 pandemic began, it is surprising that there is little or no mention of the traditional surgical smoke generating procedures we've discussed above. A systematic review (Jackson 2020) categorized aerosol-generating procedures into 39 procedure groups, with comments on the strength of the evidence. Another review of aerosol-generating procedures with respect to infective risk to healthcare workers from SARS-CoV-2 does not even mention surgical smoke producing procedures like electrocautery or procedures using laser or ultrasonic devices (Harding 2020).

One excellent review (Howard 2020) does include laser procedures and electrocautery in its discussion of aerosol-generating procedures. This review has a nice discussion of the more advanced forms of PPE that must be used in the higher risk aerosol-generating procedures. This includes elastomeric respirators with various filters. Howard recommends that, for high-risk AGP's, respiratory protection above N95 should be considered. Options for this include N-P 99 respirators, N-P 100 respirators, elastomeric respirators with filters type N-P 99-100 level, PAPR, or CAPR. Additionally, fitted goggles should be worn for eye protection; face shields are not adequate eye protection during high-risk AGP's.

Thamboo et al. (Thamboo 2020) reviewed aerosol generating medical procedures in otolaryngology and head and neck surgery. They specifically note that HPV DNA can be present in the surgical smoke generated by CO2 lasers for the treatment of (laryngeal) papillomatosis and warts. They also note studies demonstrating the potential of virus transmission by surgical smoke produced by electrocautery, though they note the evidence for actual viral transmission following electrocautery is not strong. In addition to use of appropriate PPE, they recommend that aerosol-generating procedures (AGP's) be performed in negative pressure rooms to minimize the risk of spread of contaminated aerosols. They do not specifically comment on use of LEV (local exhaust ventilation).

Orthopedic procedures are especially likely to generate not only what is technically "surgical smoke" but also generate a variety of aerosols. Sobti et al. (Sobti 2020) reviewed the literature and concluded that most orthopedic procedures are high-risk aerosol-generating procedures (AGP's) and that, in the current era of COVID-19 pandemic, there is a significant risk to the transmission of infection to the OR staff. They note that conventional surgical masks do not offer protection against high-risk AGP's. For protection against airborne transmission, appropriate masks should be used. These need proper fitting and sizing to ensure full protection when used. But they do not discuss what measures should be used to evacuate the aerosols from the OR environment. A recent article (Geevarughese 2020) on aerosol-generating procedures (AGP's) in orthopedics does include surgical smoke that may accompany electrocauterization, laser procedures, and use of ultrasonically activated devices like the harmonic scalpel, but also notes that blood and irrigation fluid coming in close contact with high-speed instruments get aerosolized. The authors categorize high-, moderate- and low-risk procedures and provide recommendations for PPE (personal protective equipment) for each category. Though the article does not mention LEV (local exhaust ventilation), it does state that "high- and moderate-risk AGP's should preferably be performed in a negative pressure room with a minimum of 12 air changes per hour, as it prevents dissemination outside the room. The exhaust air is filtered through HEPA filters, which are capable of filtering essentially all particles, including nanoparticles (<0.01 μm). The number of team members exposed should be minimized, movement in and out of the OR limited, only equipment and supplies required for the procedure should be retained in the theatre, and a runner should be stationed outside the OR to attend to additional supplies required."

And, while most of the literature on surgical smoke is aimed at ensuring the safety of OR personnel, don't forget that patients undergoing the procedures can also be potentially exposed to many of the untoward elements contained in surgical smoke.

The time has come for all hospitals, ambulatory surgery centers, and any venue performing procedures that generate surgical smoke to recognize this as a legitimate issue and follow the recommendations in that recent Joint Commission communication (TJC 2020).

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