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Understanding and Controlling the Hazards of Surgical Smoke

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More than 500,000 workers are exposed to surgical smoke every year; numerous studies have documented dangerous atmospheric agents in surgical smoke causing a range of adverse health symptoms and effects.[1,2,3] Hazardous air quality in the operating room has been an occupational concern since the mid 1970s.

Research and workplace studies conducted over long periods of time confirm that surgical smoke, also known as surgical plume, contains hazardous substances including respiratory irritants and carcinogens that have been linked to asthma and infectious agents such as human papilloma virus (HPV).[4] This article will discuss why the proper use of local exhaust ventilation (LEV) augmented by the use of properly fitted filtering facepiece respirators are the recommended and effective controls to reduce surgical smoke exposures.

Five percent contains potentially hazardous particles including blood fragments, bacteria, viruses and lung-damaging dust.[3,5]

The composition and exposure hazards associated with surgical smoke depend on a variety of factors such as the type of surgical procedure and device (i.e. laser, electrosurgical, ultrasonic); type and infectious nature of the tissue; extent of tissue ablation; the duration of surgery; and the worker's proximity to the surgical field. The hazards reported to be associated with exposure to surgical smoke are substantiated by the following research evidence.

Ninety-five percent of surgical smoke is made up of water, but the remaining 5% contains potentially hazardous particles including blood fragments, bacteria, viruses and lung-damaging dust.[3,5] Within 5 minutes of beginning an electrocautery procedure, during breast reduction surgery, the baseline measurement of particulate matter was found to

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increase from approximately 60,000 particles per cubic foot to more than 1 million particles per cubic foot. Additionally, it took approximately 20 minutes for particle concentrations to return to baseline levels once the surgical procedure was completed.[6] However, most startling is a laboratory study finding that the burning of 1 gram of tissue can release the same level of mutagenic contaminants as three to six cigarettes.[7]

In recent years, electrocautery has been commonly used for the treatment of genital warts caused by HPV and cervical neoplasia in patients infected with human immunodeficiency virus (HIV). Although electrocautery is potentially less hazardous than laser smoke as a route of disease transmission, intact virions (HIV, Hepatitis, HPV) have been shown to be present in electrocautery smoke, and their infectivity has been demonstrated.[1]

The National Institute for Occupational Safety and Health (NIOSH) recommends a combination of the specified operating room (OR) air exchanges and LEV as the *first line of protection* for controlling surgical smoke. The Association for periOperative Registered Nurses (AORN) recommends that OR air exchanges should be maintained at a minimum of 15 air exchanges per hour.[8] The ASHRAE/ASHE ventilation standard for new construction of healthcare facilities requires a minimum total air exchange rate of 20 air exchanges per hour.[9]

Burning of 1 gram of tissue can release the same level of mutagenic contaminants as three to six cigarettes.[7]

Smoke evacuators and room (wall) suction systems are the two LEV control methods recommended to reduce surgical smoke levels. Smoke evacuators should incorporate high efficiency particulate air (HEPA) or ultra low particulate air (ULPA) filters to effectively trap particulates in the air, and be highly efficient at removing airborne particles with a capture velocity of 100 to 150 ft/min at the inlet nozzle. [10,11]

In addition to OR ventilation and use of smoke evacuators, wall suction systems are another option for controlling small amounts of smoke. Room (wall) suction systems pull at a much lower rate; smoke evacuators and wall suction must be kept within 2 inches of the surgical site to efficiently capture the generated contaminants.[11] Wall unit suction devices are considered a less effective method of capturing smoke plume and only should be used with adequate room air ventilation.

Because of higher capture velocity, smoke evacuators should be used in high plume situations. To ensure optimal function, LEV and room ventilation systems must be properly maintained, cleaned, and monitored according to manufacturer's recommendations. Healthcare personnel should consider used filters, tubing and wands as biohazards and handle them properly.[11]

Every facility should establish guidelines for dealing with surgical smoke. *Figure 1* provides a sample of a facility's OR procedures for smoke evacuation and includes examples of low and high plume generating surgical procedures. In addition to NIOSH, the Occupational Safety and Health Administration (OSHA), AORN, Laser Institute of America (LIA), ANSI, and The Joint Commission (TJC) recommend that surgical smoke be filtered and evacuated through the use of room ventilation and LEV methods. [12] Despite these recommendations, a 2007 survey of 623 AORN members indicated weak compliance by healthcare facilities.[13]

FIGURE 1.
Example Surgical Plume Evacuation Procedures*

For surgical procedures that generate small amounts of plume:

1. 0.1 µm in-line filter will be positioned between the wall suction and the suction canister.
2. In-line filters will be changed weekly in every area that generates plume.
3. A suction tubing no longer than 12 feet in length will be used with a suction tip or attached to the ESU.
4. Contaminated filters and plume evacuation supplies will be disposed of by personnel using personal protective equipment.

A. Examples of procedures that generate small amounts plume:

- Temporal Artery Biopsy
- Hand Procedures
- Vocal Cord polyps
- Tonsillectomies
- Laparoscopies
- Ear Procedures
- Dermatological procedures
- Nasal Procedures
- Thorascopy
- Back Procedures
- Craniotomies
- Breast Biopsies

Surgical Procedures that generate greater amounts of smoke, a smoke evacuation system with an evacuation hose will be used:

1. Corrugated smoke evacuation tubing with a smooth inner lumen will be connected directly to the smoke evacuator and used when evacuating large amounts of plume.
2. The standard suction tubing will be used to evacuate fluid and the corrugated tubing will be used to evacuate surgical plume.
3. The plume capture devices will be positioned in close proximity to the generation of the surgical plume.

A. Examples of procedures which require a smoke evacuator with an evacuation hose:

- Abdominal Surgical Procedures
- Breast Reduction Procedures
- Large Extremity Procedures
- Vaporization of Condyloma
- Thoracic Procedures
- Excisional Neck Procedures
- Spinal Fusions

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Due to the inconsistent use of smoke mitigation systems and the variability in smoke production during a surgical procedure, one may need additional sources of protection. A secondary form of protection is the appropriate respiratory protection used in conjunction with properly functioning OR ventilation and LEVs.

While the type of respirators used in the OR has been a controversial issue, the proper selection and use of personal protective equipment (PPE) can also reduce or prevent exposure to smoke plume. Various degrees of protection are associated with different types of PPE.

Surgical and laser (high filtration) masks create a barrier that protects the wearer's face from large droplets and splashes of blood and other body fluids during medical procedures. They also function to some extent to limit the spread of contamination from the wearer to the patient, although this is a subject of debate. Surgical and laser masks do not protect wearers from airborne particles small enough to be inhaled through the larynx and into the lungs. Additionally, surgical and laser masks are designed with a wide range of filter media. Research findings reveal that the performance of surgical masks for capturing particles varies widely.[14,15]

A study conducted with particles the size of viruses and bacteria (0.04 – 1.3μm) found that of the nine surgical masks tested, none provided the minimum level of protection recommended by OSHA.[16] Correspondingly, small particles, less than 1.1μm in diameter, constitute 77% of the particulate matter generated in surgical smoke.[17] Most significant and perhaps easily misunderstood is the fact that surgical and laser masks do not seal to the face and thereby allow contaminants to enter the worker's breathing zone through gaps between the wearer's face and the mask.[14]

Surgical and laser masks do not seal to the face and thereby allow contaminants to enter the worker's breathing zone.

For these reasons, NIOSH recommends the use of properly fitted, filtering facepiece respirators rather than surgical and laser masks. Filtering facepiece respirators with an N95 filter class designation prevent all sizes of particles from passing through the filter media and entering the wearer's breathing zone. Even taking some facepiece seal leakage around the respirator into account, a properly fitted N95 reduces the wearer's exposure against a range of very small particles (less than 1μm) to large droplet sized particles (> 60μm) by at least 10-fold. Thus, healthcare personnel should wear respiratory protection at least as protective as a fit-tested N95 filtering facepiece respirator when working with known disease transmissible cases (ie, HPV) and/or during aerosol-generating procedures or with aerosol transmissible diseases (ie, TB, varicella, rubeola). Furthermore as a precautionary measure, it is recommended that respiratory equipment as protective as a fit-tested N95 be worn in the absence of properly functioning smoke control measures (ie, OR exchanges, LEV).

The choice is yours to advocate for workplace safety practices (ie, OR ventilation, LEV and respiratory protective equipment) that best protect you from the known hazardous exposures of smoke plume. For more information on this topic see *Figure 2* for a list of selected web-based references. Let's protect ourselves by clearing the air we breathe in the OR!

**Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.*

FIGURE 2. Selected Resources

Resource	Access
AORN Surgical Smoke Tool Kit (available to AORN members)	http://www.aorn.org/PracticeResources/ToolKits/SurgicalSmokeEvacuationToolKit
LINA-Making Things Clear about Surgical Smoke	http://www.lina-medical.com/files/34/penetration_brochure.pdf
OSHA Hospital eTool Surgical Suite Module: Smoke Plume	http://www.osha.gov/SLTC/etools/hospital/surgical/surgical.html#LaserPlume
OSHA Videos: Respirator Safety	http://www.youtube.com/watch?v=Tzpz5fko-fg
The Difference Between a Respirator and a Surgical Mask	www.youtube.com/watch?v=ovSLAuY8ib8

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Editor's Corner

Welcome to the winter edition of *Preventing Infection in Ambulatory Care,* APIC's quarterly e-newsletter providing ambulatory care infection prevention professionals with valuable, up-to-date information aimed at keeping them apprised of important items of interest impacting their field.

More than 500,000 workers are exposed to surgical smoke every year, and numerous studies have documented dangerous atmospheric agents in surgical smoke causing a range of adverse health symptoms and effects, writes Debra A. Novak, DSN, RN, and Stacey M. Benson, MS. In the article titled, "Understanding and Controlling the Hazards of Surgical Smoke," these authors address why the proper use of local exhaust ventilation (LEV) augmented by the use of properly fitted filtering facepiece respirators are the recommended and effective controls to reduce surgical smoke exposures.

Gwenda Felizardo, RN, BSN, CIC, and Janie Garris, MN, of Group Health Cooperative in Seattle, Washington explain how to minimize influenza transmission in the ambulatory care setting. In the article, "Overcoming the Challenges of the Influenza Prevention Program," Felizardo and Garris provide case studies from their own organization and focus on key strategies to ensure that ambulatory influenza prevention program efforts are effective, efficient and fun.

Also in this issue, Elizabeth Garman, APIC senior director of communications, profiles David Daniel, FACHE, FAAMA, CEO of the Lakeland Surgical & Diagnostic Center (LSDC) in Lakeland, Florida who is the 2010 recipient of the Healthcare Administrator Award. The award calls attention to the importance of executive involvement and recognizes healthcare administrators who support infection prevention efforts throughout their facilities.

Additionally, Nancy Hailpern, APIC's associate director of Government Affairs, provides a year-end summary of the status of 2010 legislative bills that apply to infection prevention practices within ambulatory settings, as well as hospitals and healthcare facilities.

The U.S. Department of Health and Human Services (HHS) released draft Tier 2 modules for the *Action Plan to Prevent Healthcare-Associated Infections* intended to reduce HAIs in ambulatory surgery centers (ASCs) and end-stage renal disease facilities. Lisa Tomlinson, APIC senior director of Government Affairs, provides a brief update on what ambulatory professionals might expect of the revised modules, scheduled to be released in early 2011.

We hope you'll find these articles, along with those to come in upcoming issues of *Preventing Infection in Ambulatory Care,* informative and useful for your practice.

As always, we welcome your comments and encourage you to write to **editor@apic.org** telling us what you want to read and need to know.

Regards,

***Preventing Infection in Ambulatory Care* Editors**

Preventing Infection in AmbulatoryCare

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