

# What are You Smoking in the Operating Room?



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# Objectives

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- Describe research outcomes that demonstrate the hazards of surgical smoke.
- Describe perioperative nursing care for surgical patients to minimize the hazards of surgical smoke.
- Discuss the surgical smoke evacuation recommendations by various organizations and agencies.
- List control measures to ensure compliance with the evacuation of all surgical smoke created in the OR.
- Discuss implementation of a smoke evacuation program.



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# What are You Smoking in the OR?

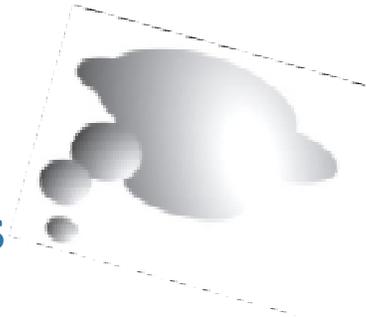
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# What is Surgical Smoke?

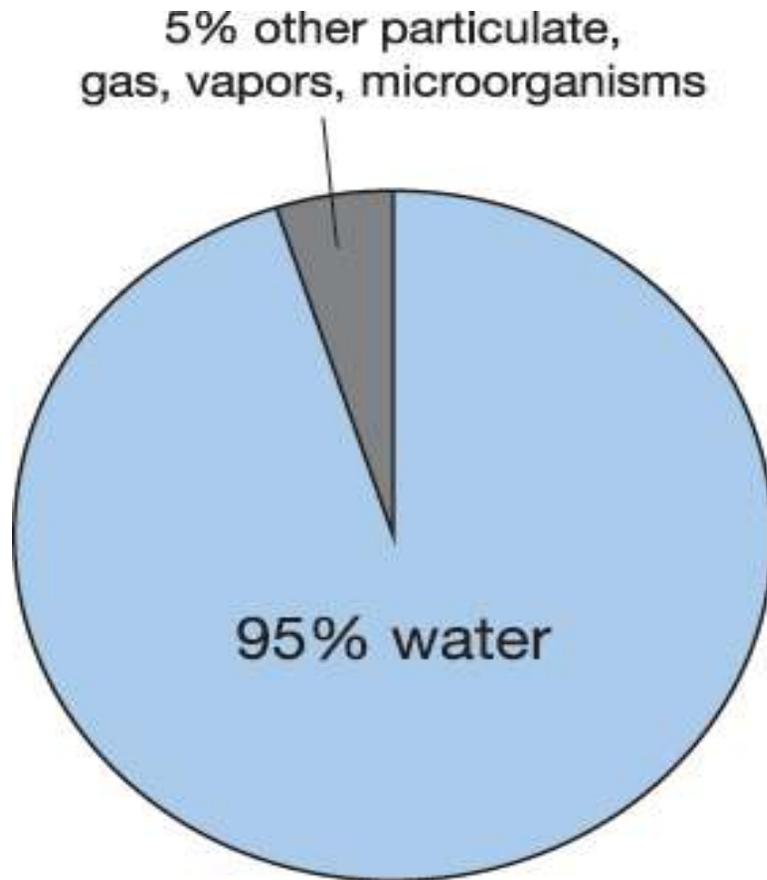
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- Surgical smoke (ie, smoke plume) is the vaporization of substances (ie, tissue, fluid, blood) into a gaseous form
  - **by-product of surgical instruments used to destroy tissue**
- Instruments
  - **Lasers – CO<sub>2</sub>, ND:YAG, KTP, and Argon**
  - **Monopolar and bipolar electrosurgery units**
  - **Powered drills & saws**
  - **Ultrasonic scalpels**
  - **Mechanical morcellators**



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# Composition of Surgical Smoke



- Plume is 95% water vapor
  - Acts as a carrier for other materials
- The remaining 5% of smoke contains...
  - Toxic chemicals (many of same found in cigarette smoke)
  - Tissue and blood particulates

Pierce JS, Lacey SE, Lippert JF, Lopez R, Franke JE. Laser-generated air contaminants from medical laser applications: a state-of-the-science review of exposure characterization, health effects, and control. J Occup Environ Hyg. 2011;8(7):447-466



# Inhaling Surgical Smoke

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- Using the CO2 laser on one gram of tissue is like inhaling the smoke from **three cigarettes in 15 minutes.**
- Using ESU on one gram of tissue is like inhaling smoke from **six cigarettes in 15 minutes.**



Tomita Y, Mihashi S, Nagata K, et al. Mutagenicity of smoke condensates induced by CO2-laser irradiation and electrocauterization. *Mutat Res.* 1981;89(2):145-149



# Surgical Smoke is Toxic

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## Occupational Safety and Health Administration of US Department of Labor concludes:

- Smoke plume contains toxic gases and vapors such as
  - benzene, hydrogen cyanide, and formaldehyde
  - bioaerosols with dead and live cellular material
    - blood fragments
    - bacteria and viruses
- Smoke gases potentially mutagenic and carcinogenic

\*Occupational Safety and Health Administration, US Department of Labor. Hospital eTool. Surgical suite module. Available at:  
<http://www.osha.gov/SLTC/etools/hospital/surgical/surgical.html#LaserPlume>



# Examples of Toxic Substances found in Surgical Smoke

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Acetaldehyde\*\*\*

Acrolein

Acrylonitrile\*\*

Benzene\*\*

Butadiene\*\*\*

Carbon monoxide

Cyanide

Ethanol

Formaldehyde\*\*

Hydrogen cyanide

Methane

Phenol

Polycyclic aromatic hydrocarbons\*

Toluene

\*\*\* Carcinogen

\*\* Potential Carcinogen

\* Increased risk of certain cancers

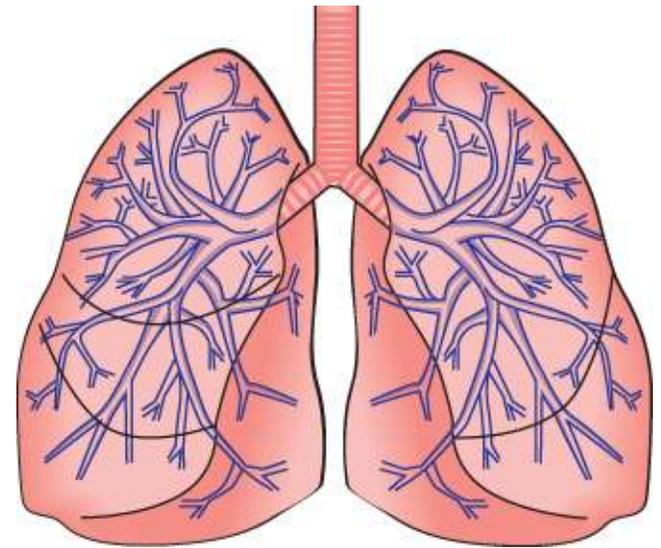
Mihashi S, Jako GJ, Incze J, Strong MS, Vaughan CW. (1976),



# Particulate Matter

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- Carbonized tissue
- Blood
- Intact virus and bacteria
  - human immunodeficiency virus (HIV)
  - human papilloma virus (HPV)
  - Hepatitis
- Particulate Matter
  - 90% is respirable (< .3 micron)
  - Increases risks for sore throats, eye irritation, respiratory infection
  - Potential contact lens absorption



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# Particle Size and Distribution

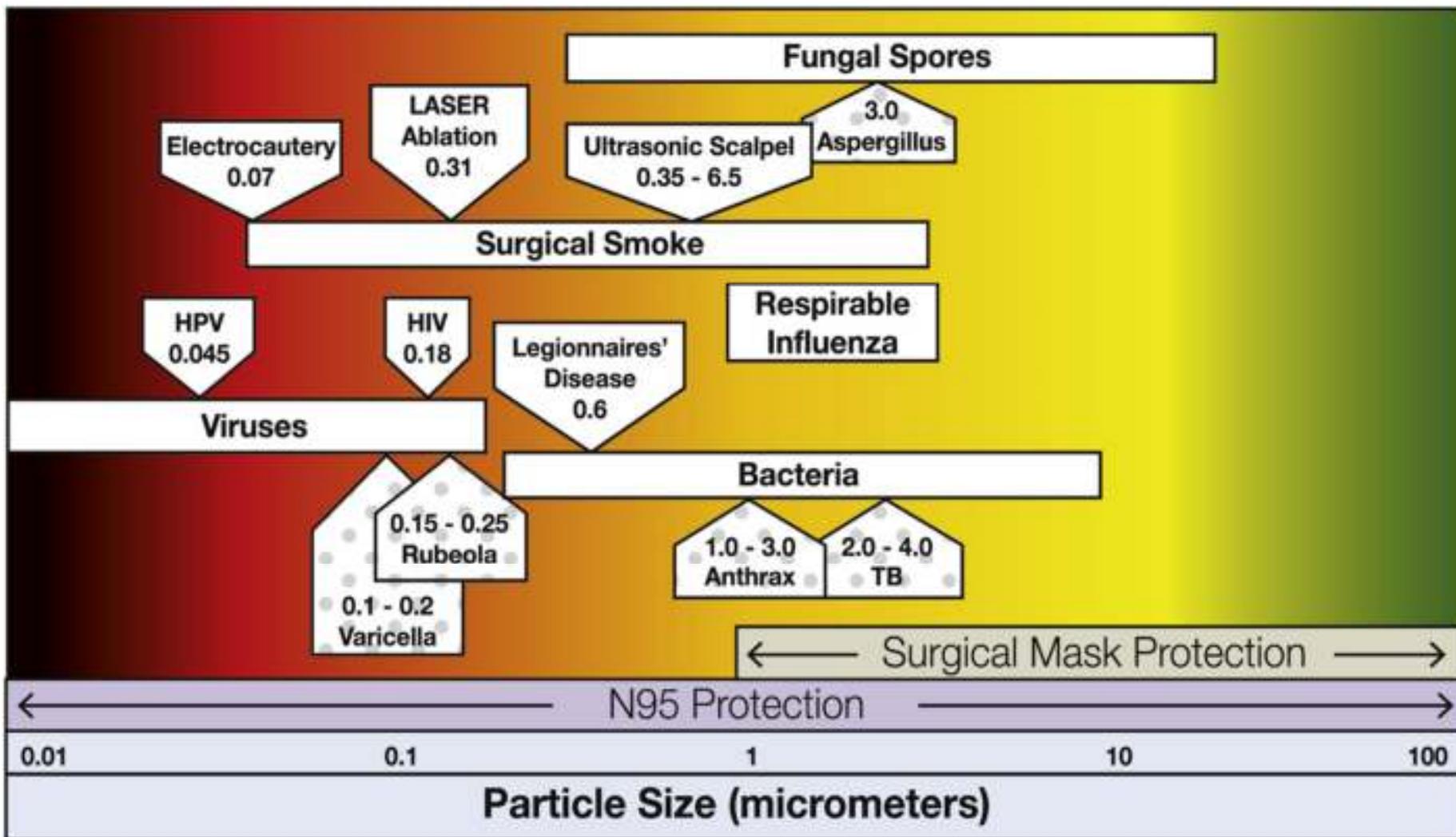
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- Particle size varies
  - ESU particles – smallest
  - Laser particles – largest
  - Ultrasonics release cool aerosols – carry live particles
- Smoke is evenly distributed throughout the OR
- Smoke particles can travel about 40 mph
- When ESU is activated, the concentration of the particles can rise from 60,000 particles/cubic feet to over 1 million particles/cubic feet
  - It takes 20 min after the activation of the ESU for the concentrations to return to baseline level

Nicola JH, Nicola EM, Vieira R, Braile DM, Tanabe MM, Baldin DH. Speed of particles ejected from animal skin by CO2 laser pulses, measured by laser Doppler velocimetry. *Phys Med Biol.* 2002;47(5):847-856.



# Particle Sizes



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# So... is Surgical Smoke Harmful?

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## Past Misconceptions:

*“Surgical Smoke is not Hazardous”*

*“Surgical Smoke is Sterile”*

**Surgical Smoke is  
Hazardous to Your Health!**



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# Inhalation and Exposure

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## Potentially Harmful

- Patients
- Perioperative Team Members
- Others (anyone in the procedure room)



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# Patient Safety: Exposures to Surgical Smoke

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Laparoscopic procedures present unique exposures to smoke to the patient.



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# Laparoscopic Surgical Procedures

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- Levels of carboxyhemoglobin of patients who underwent laparoscopic procedures using laser were significantly elevated
- Pulse oximeter readings may be falsely elevated and could result in unrecognized patient hypoxia
- Carbon monoxide levels increase in the peritoneal cavity and exceed recommended exposure limits

1. Beebe DS, Swica H, Carlson N, Palahniuk RJ, Goodale RL. High levels of carbon monoxide are produced by electro-cautery of tissue during laparoscopic cholecystectomy. *Anesth Analg*. 1993;77(2):338-341.

2. Ott DE. Carboxyhemoglobinemia due to peritoneal smoke absorption from laser tissue combustion at laparoscopy. *J Clin Laser Med Surg*.1998;16(6):309-315.

3. Ott, D. E. (1997). Smoke and particulate hazards during laparoscopy procedures. *Surgical Services Management*, 3(3): 11-13.



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# Exposure to Surgical Smoke during MIS: Risks to Patients

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- Exposure to carbon monoxide
- Increased levels of carboxyhemoglobin
- Occurrence of methemoglobin
- Loss of visibility in the surgical field or potential delay of the procedure
- Port-site metastasis

1. Fletcher JN., Mew D, DesCoteaux JG. Dissemination of melanoma cells with electrocautery plume. The American Journal of Surgery. 1999; 178: 57-59.

2. In SM, Park DY, Sohn IK, et al. Experimental study of the potential hazards of surgical smoke from powered instruments. Br J Surg. 2015;102(12):1581-1586.



# Worker Safety: Exposures to Smoke/Plume

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“Each year, an estimated 500,000 workers, including surgeons, nurses, anesthesiologists, and surgical technologists, are exposed to laser or electrosurgical smoke.”

Laser/Electrosurgery Plume. Occupational Safety and Health Administration (OSHA) Quick Takes. United States Department of Labor

<https://www.osha.gov/SLTC/laserelectrosurgeryplume/index.html> (accessed July 22, 2015)



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# Health Effects Reported by Healthcare Workers

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- Eye, nose, throat irritation
- Headaches
- Nausea, dizziness
- Runny nose
- Coughing
- Respiratory irritants
- Fatigue
- Skin irritation
- Allergies

\*Tomita Y, Mihashi S, Nagata K, et al. Mutagenicity of smoke condensates induced by CO<sub>2</sub>-laser irradiation and electrocauterization. *Mutat Res.* 1981;89:145–149.



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# Case Report

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44-year old laser surgery developed laryngeal papillomatosis with biopsy identified the same virus type as anogenital condyloma

- Rarely evacuated surgical smoke when using laser to vaporize condyloma
- Demonstrates transmission of viable organisms in surgical smoke

Hallmo P, Naess O. Laryngeal papillomatosis with human papillomavirus DNA contracted by a laser surgeon.  
*Eur Arch Otorhinolaryngol.* 1991;248(7):425-427



# Exposure to Surgical Smoke during MIS: Perioperative Team Members

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- Health effects to the perioperative team
  - **Release of pneumoperitoneum into the OR without filtration**
- Important to use a filtering device or a closed evacuation system



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# American National Standards Institute (ANSI) (Safe Use of Lasers in Healthcare)

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## **Airborne Contaminants:**

Shall be controlled by the use of ventilation (ie, smoke evacuator) and respiratory protection for any residual plume escaping capture.

*Note:* ESU produces the same type of airborne contaminants as lasers



# National Institute of Occupational Safety and Health/Centers for Disease Control NIOSH/CDC: *Ventilation*

**Ventilation** combination of general room and local exhaust ventilation (LEV)

- portable smoke evacuators
- room suction systems



HC11

### Control of Smoke From Laser/Electric Surgical Procedures

**HAZARD**

During surgical procedures using a laser or electrosurgical unit, the thermal destruction of tissue creates a smoke byproduct. Research studies have confirmed that this smoke plume can contain toxic gases and vapors such as benzene, hydrogen cyanide, and formaldehyde, bioaerosols, dead and live cellular material (including blood fragments), and viruses. At high concentrations the smoke causes ocular and upper respiratory tract irritation in health care personnel, and creates visual problems for the surgeon. The smoke has unpleasant odors and has been shown to have mutagenic potential.

**CONTROLS**

NIOSH research has shown airborne contaminants generated by these surgical devices can be effectively controlled. Two methods of control are recommended: Ventilation and Work Practices.

■ **VENTILATION**

Recommended ventilation techniques include a combination of general room and local exhaust ventilation (LEV). General room ventilation is not by itself sufficient to capture contaminants generated at the source. The two major LEV approaches used to reduce surgical smoke levels for health care personnel are portable smoke evacuators and room suction systems.

Smoke evacuators contain a suction unit (vacuum pump), filter, hose, and an inlet nozzle. The smoke evacuator should have high efficiency in airborne particle reduction and should be used in accordance with the manufacturer's recommendations to achieve maximum efficiency. A capture velocity of about 100 to 150 feet per minute at the inlet nozzle is generally recommended. It is also important to choose a filter that is effective in collecting the contaminants. A High Efficiency Particulate Air (HEPA) filter or equivalent is recommended for trapping particulates. Various filtering and cleaning processes also exist which remove or inactivate airborne gases and vapors. The various filters and absorbers used in smoke evacuators require monitoring and replacement on a regular basis and are considered a possible biohazard requiring proper disposal.

Room suction systems can pull at a much lower rate and were designed primarily to capture liquids rather than particulate or gases. If these systems are used to capture generated smoke, users must install appropriate filters in the line, insure that the line is cleaned, and that filters are disposed properly. Generally speaking, the use of smoke evacuators are more effective than room suction systems to control the generated smoke from non-endoscopic laser/electric surgical procedures.



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES  
Public Health Service  
Centers for Disease Control and Prevention  
National Institute for Occupational Safety and Health



September 1986

# NIOSH/CDC: *Work Practices*

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- The smoke evacuator or room suction hose nozzle inlet must be kept within 2 inches of the surgical site
- The smoke evacuator should be ON (activated) at all times when airborne particles are produced
- Health care workers should follow standard precautions



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# Follow Standard Precautions at the Completion of the Procedure

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- All smoke evacuator tubing, filters, and absorbers
  - considered infectious waste
  - disposed of appropriately
- New tubing should be installed on the smoke evacuator for each procedure
- Change filters according to manufacturer's directions
- Local exhaust ventilation (LEV) equipment
  - regularly inspected and maintained



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# Occupational Safety and Health Administration (OSHA)

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## General Duty Clause:

Employers **MUST** provide a safe workplace environment!



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# OSHA Respiratory Protection

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## Recognizes:

Lasers and electrosurgical plume contains toxic, mutagenic, and carcinogenic elements

## Mandates and identifies:

Removal of atmospheric contaminants with acceptable engineering controls and local ventilation, including smoke evacuation systems.

Occupational Safety and Health Standards. 29 CFR 1910.134. Personal protective equipment: respiratory protection. June 8, 2011. Occupational Safety & Health Administration.

[https://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=STANDARDS&p\\_id=12716](https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=12716)



# Emergency Care Research Institute (ECRI)

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- Independent, nonprofit organization
- Researches the best approaches to improving the safety, quality, and cost-effectiveness of patient care
- Electrosurgical smoke is overlooked
- The spectral content of laser and ESU smoke is very similar



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# Canadian Standards Association (CSA)

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- CSA Z305.13: Plume scavenging in surgical, diagnostic, therapeutic, and aesthetic settings, 2013 publication
- Supersedes the previous edition published in 2009
- Provides detailed standards on surgical smoke evacuation



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# International Federation of Perioperative Nurses (IFPN)

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## IFPN Guideline on Risks, Hazards, and Management of Surgical Plume 2015

- Smoke particles may contain bloodborne pathogens and potential for viral transmission
- Identification of smoke as a workplace safety hazard
- Respiratory protection
- Use of standard precautions
- Use of local exhaust ventilation with ULPA filter
- Smoke evacuation methods

International Federation of Perioperative Nurses <http://www.ifpn.org.uk/>



# AORN Guidelines

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- Electrosurgery
- Laser Safety
- Minimally Invasive Surgery (MIS)



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# AORN Guidelines

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“Recommendation X - Potential hazards associated with surgical smoke generated in the practice setting should be identified and safe practices established.” pg. 128-129

“Recommendation V - Potential hazards associated with surgical smoke generated in the laser practice setting should be identified and safe practices established.” pg. 141-142

“Recommendation IV - Personnel should take additional precautions when using electrosurgery units (ESUs) during MIS and computed assisted procedures.” pg. 597-600



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# Guideline Interventions

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- Evacuate smoke with a smoke evacuation system during open and laparoscopic procedures
- Used smoke evacuator filters, tubing, and wands should be disposed of as potentially infectious waste following standard precautions
- Personnel should wear respiratory protection during procedures that produce surgical smoke



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# Methods to Reduce Exposure

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- Surgical Masks
- Wall Suction
- Smoke Evacuation Units
  - Central Systems
  - Portable Systems
  - Ceiling Mounted Systems
  - Laparoscopic Systems



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# Surgical Masks

- Standard masks filter  $>0.5$  micron
- High Efficiency Masks filter  $>0.1$  micron
- No mask provides absolute protection
  - **Perimeter leakage**
  - **Diminished effectiveness with wear**



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# Wall Suction

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- Works for procedures that **do not** produce large volumes of smoke
- Must use in-line filtration with this method

When there is no in-line filter:

- **Damage to health care facility air exchange system**



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# Wall Suction: Use an In-Line Filter

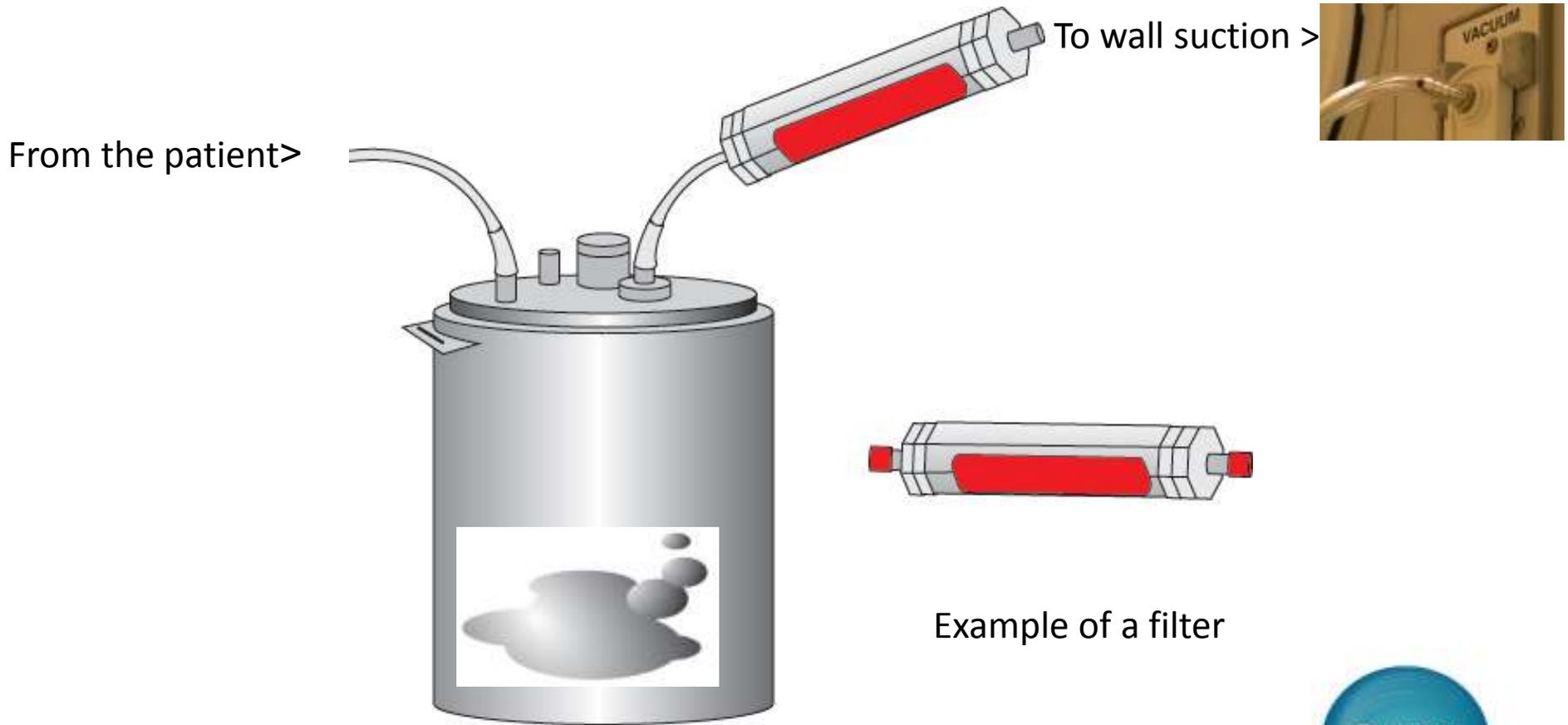
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- Simple
- Use an in-line filter:
  - Use and change as recommended by the manufacturer's instructions
  - Use standard precautions when changing and disposing of in-line filters



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# Wall Suction: In-Line Filters



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# Central Systems

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- Central unit that connects to several ORs
- Quiet operation, easy to maintain
- More effective than wall suction



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# Portable Systems

- Highest recommended method by CDC & NIOSH
- Available in many different sizes and configurations
- Easy to use, maintain, & move around
- Lowest capital equipment cost



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# Ceiling Mounted systems

Many manufacturers have conveniently integrated portable smoke evacuation technology into their ceiling mounted systems



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# Specialty Tubing

Specialty tubing can eliminate the need for an extra set of hands to manage tubing



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# Laparoscopic Systems

Specialty tubing for laparoscopic cases can....

- **Dramatically improve visibility**
- **Minimize operating time**
- **Minimize patient absorption of toxic gases into their tissues**



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# Choosing a Smoke Evacuation System

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Important Factors to consider...

- **Noise Levels**
- **Filtration Efficacy**
- **Suction Capability**
- **Portability**
- **Maintenance**
- **System Warranties**
- **Disposable Costs**
- **Ease of use**
- **Quiet**
- **Foot pedal activation and/or automatic on-off**
- **Indicators for filter changes**
- **Efficiency**
- **Cost**



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# Smoke Evacuation Units

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- Generally the most effective method
- Look for...
  - HEPA Filtration 99.97% efficient @ .3 micron
  - **ULPA Filtration 99.9995% efficient @ .1 micron** (100 times more effective than HEPA)

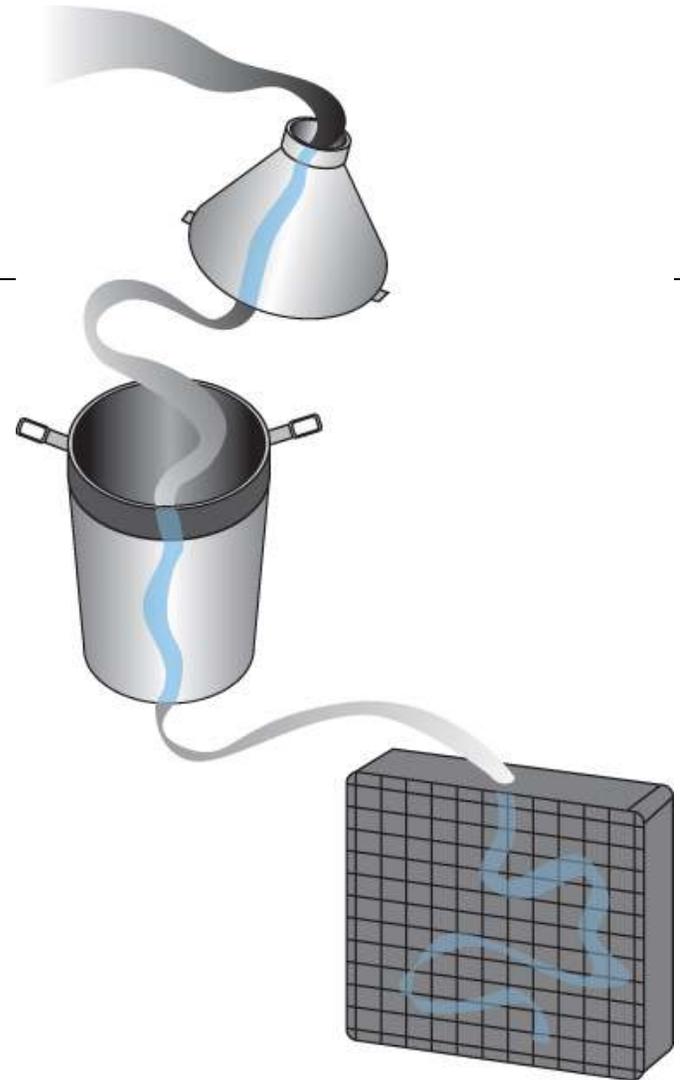


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# Triple Filter System

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- Pre filter
  - captures large particles
- ULPA filter
  - captures small particles
- Charcoal filter
  - captures toxic gases and odors



Ball, K. (2004). Lasers: The Perioperative Challenge, 3rd ed. Denver, CO: AORN.



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# Disposal and Changing Smoke Evacuation Filters

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- Used filters are an occupational hazard
- Wear PPE when handling
- Dispose of used smoke evacuation filters per manufacturer's instructions and your facility's procedures



# Smoke Evacuation Program

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- Increase awareness of the hazards of surgical smoke
- Promote and implement safe practices
- Interdisciplinary Team
  - **Include staff RNs, anesthesia professionals, surgeons, scrub persons, and personnel from administration, infection prevention, employee health, safety, and risk management**



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# Implementing Smoke Evacuation Practices

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- Provide data and evidence to support best practices
  - **Scientific research data**
  - **Financial analysis**
  - **AORN guidelines for perioperative practice**
- Work collaboratively:
  - **Administrative Safety Committee**
  - **Infection Prevention**
  - **Risk Management**



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# Barriers to Compliance for Smoke Evacuation Practices

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<ul style="list-style-type: none"><li>•Equipment not available</li><li>•Physician</li><li>•Noisy Equipment</li><li>•Complacent staff</li></ul> <p>-- Ball, 2010</p>	<ul style="list-style-type: none"><li>•Surgeons' resistance or refusal</li><li>•Cost</li><li>•Bulkiness</li><li>•Excessive noise</li></ul> <p>--Edwards &amp; Reiman, 2012</p>	<ul style="list-style-type: none"><li>•Noise</li><li>•Distraction</li><li>•Ergonomic difficulty of equipment</li></ul> <p>--Watson, 2010</p>
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# Conclusions

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- Surgical smoke plume and aerosols are hazardous to healthcare workers and patients
- Hazards can be removed with proper engineering controls
- Surgical smoke from MIS procedures can dramatically impair visibility, increase surgical time, and put the patient at risk
- Proper equipment selection and filter construction are important for implementing an efficient smoke evacuation program



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# Questions?



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