

AANA JOURNAL COURSE

Update for Nurse Anesthetists

1

*6 CE Credits

The hazards of surgical smoke

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Inhaling surgical smoke is an ever-growing concern since the majority of all surgeries generate laser or electrosurgical smoke. Anesthesia providers must understand the dangers of surgical smoke and how to control or minimize exposure. This Journal course explores the hazards of surgical smoke (including plume odor, particulate matter size, viability of the smoke contents, and laparoscopic concerns) by citing significant research studies that support the threats and potential threats associated with surgical smoke. Effective methods to evacuate this plume are described to protect not only the healthcare professional but also the patient. Surgical smoke will continue to cause problems and concerns unless the surgical team is committed to providing a safe environment through appropriate and diligent smoke evacuation methods.

Key words: Smoke evacuation, surgical plume, surgical smoke.

OBJECTIVES

At the completion of this course, the reader should be able to:

1. Describe why surgical smoke is a hazard to healthcare professionals and patients.
2. Cite research studies that demonstrate the hazards of surgical smoke.
3. Discuss how a smoke evacuator can appropriately remove and filter surgical plume.
4. List methods to control smoke in the surgical environment.

5. Design a policy and procedure that addresses methods to minimize and eliminate surgical smoke.

The generation of surgical smoke

Each year the number of surgical procedures continues to grow as surgery is performed not only in hospital operating rooms and ambulatory surgery centers but in clinics and even physician offices. Approximately 90% of endoscopic and open surgical procedures generate some level of surgical smoke or plume.¹

During operative procedures, “hot” tools, such as lasers or electrosurgical units (ESUs), are used to excise, vaporize, coagulate, and ablate tissue. These tools char and burn the targeted cells, causing the cellular contents and combustion byproducts to be discharged into the air as surgical smoke. Approximately 350,000 healthcare workers in the United States are exposed to surgical smoke each year generated from hot surgical tools, thus creating a hazardous work environment.¹

By definition, *electrosurgery* is the application of high frequency electrical current to tissue to cause surgical cutting or coagulation. Around 1926, Harvey Cushing, MD, a neurosurgeon, and William T. Bovie, PhD, a biophysical engineer, combined their efforts to develop the electrosurgery technology for use during a neurosurgical procedure. The first commercial ESU was introduced in the early 1930s and was a 300-lb piece of equipment housed in a beautiful wooden cabinet.²

Over the years, ESU smoke has not been recognized

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as a significant inhalation hazard. The National Institute for Occupational Safety and Health (NIOSH), a governmental research organization, published and distributed the Health Hazard Evaluation Report in 1985 that stated there is a “potential hazard from exposure to smoke generated by electrocautery (electrosurgery) knives.”³ Many healthcare providers have not paid attention to this statement; therefore, many ESU procedures are performed without using a smoke evacuator to eliminate the plume.

Laser technology was introduced in the 1960s when Theodore Maiman, PhD, applied Albert Einstein’s principles on natural light and constructed the first laser.^{4(pp91-95)} Laser is an acronym for *light amplification by the stimulated emission of radiation*. Because laser energy is collimated, coherent, and monochromatic, it can be delivered to the tissue with contact or noncontact devices. When laser energy impacts tissue, cellular destruction occurs, and surgical smoke is generated.

NIOSH issued the subsequent Health Hazard Evaluation Report in 1988 that stated, “Smoke generated during laser surgery presents a potential health hazard.”⁵ Today, most healthcare professionals pay attention to this document and use a smoke evacuation method whenever laser energy is used. Classes and conferences about laser biophysics, safety, and clinical techniques stress the hazards of laser smoke, so whenever a laser was used, a smoke evacuation method is used. In comparison, when an ESU is used, smoke evacuation often is overlooked, even though the contents of the laser and ESU plume are very similar and hazardous. In 1989, Tomita and associates⁶ compared the hazards of cigarette smoke with those associated with laser and electrosurgery smoke. One gram of tissue was impacted using a carbon dioxide laser, and the plume was collected. This plume had the same hazard potential as smoking 3 unfiltered cigarettes. When the ESU was used to vaporize the same amount of tissue, the plume generated was equivalent to smoking 6 unfiltered cigarettes. Therefore, this study demonstrated that the plume produced during electrosurgical procedures had the potential to be more harmful than that produced by a laser.⁶

Effects of surgical smoke

So what are the effects of surgical smoke? Surgical smoke can cause burning and watery eyes, nausea, headaches, respiratory problems, and maybe even contamination by hazardous microbes.^{4(pp91)} Nurses in surgery have sought care in employee health clinics with many of these symptoms after experiencing repeated exposures to surgical smoke. Because of these unwanted hazards and potential complications, complete evacuation of surgical smoke is the only solution to manage and control this problem. But smoke evacu-

ation still has not become a standard in many surgical settings, even though the results of numerous research studies have repeatedly demonstrated the hazards of surgical plume. The lack of appropriate smoke evacuation systems and physician and surgical team indifference are two of the main reasons that surgical smoke is an ongoing problem. While many surgical team members are passionate about using proper smoke evacuation techniques, others have the complacent attitude that inhalation hazards do not pose a problem. Until these skeptics experience surgical smoke inhalation symptoms or totally comprehend this growing concern, the battle with ignorance will continue.

Healthcare trends have fostered an increased presence and awareness of surgical smoke. Some of these trends include the following:

- More hot energy tools are being used, such as electrosurgery or laser.
- More surgeries are being performed (increased population) in a variety of diverse settings (eg, offices, clinics, free-standing surgery suites, endoscopy laboratories, emergency departments) where smoke evacuation may not be available.
- Increased cost-containment practices limit the purchase of smoke evacuation supplies and equipment.
- Indifference—some healthcare workers may not feel the need to evacuate the plume since they have been breathing it for years.

Hazards of surgical smoke

Research has shown conclusively that surgical smoke is hazardous to the surgical team members who are exposed to it on a daily basis. There are 4 issues of concern associated with the hazards of surgical smoke:

1. Odor
2. Size of the particulate matter
3. Viability of the particulate matter
4. Endoscopic issues

• *Odor.* When a hot tool is used to cut or coagulate tissue, a noxious odor is emitted with the smoke. This odor is caused by tissue pyrolysis and destruction that produces chemical byproducts and toxins. A number of toxic chemical byproducts have been identified in surgical smoke (Table 1).^{7,8}

Some of these chemical toxins, including polycyclic aromatic hydrocarbons, benzene, toluene, formaldehyde, and acrolein, are gases that are known carcinogens; therefore, repeated exposures should be avoided. The Occupational Safety and Health Administration has distributed specific statements on the hazards of acrolein, benzene, and formaldehyde. Experts have remarked that there are probably more than 600 more compounds (including gases) within surgical smoke that have yet to be identified.⁷

Table 1. Toxic chemical byproducts of laser and electro-surgical unit plume^{7,8}

Acrolein	Free radicals
Acetonitrile	Hydrogen cyanide
Acrylonitrile	Isobutene
Acetylene	Methane
Alkyl benzenes	Phenol
Benzene	Polycyclic aromatic hydrocarbons
Butadiene	Propene
Butene	Propylene
Carbon monoxide	Pyridine
Creosols	Pyrrole
Ethane	Styrene
Ethylene	Toluene
Formaldehyde	Xylene

• *Size of the particulate matter.* The various sizes of the particulate matter within surgical smoke has been demonstrated conclusively through repeated research studies. In 1975, Mihashi and associates⁹ reported the use of a carbon dioxide laser to vaporize tissue in a laboratory setting. The surgical smoke generated was 52 times greater than that allowed by the government's environmental standards, and approximately 77% of the particulate matter in the plume was smaller than 1.1 μm .⁹ A regular surgical mask filters particulate matter as small as 5 μm if worn tightly around the face. Since most of the particulate matter in the plume is so small, surgical smoke can easily pass through these masks. The contents of this plume then can be deposited in the alveoli of lungs when inhaled, potentially causing chronic irritation, bronchitis, or emphysema-like conditions.

In 1988, Baggish and associates¹⁰ conducted a study to compare the effects of unfiltered laser smoke on rat lungs. A group of rats breathed the plume created by using a carbon dioxide laser on pigskin. All of these rats developed hypoxia and pulmonary congestion with bronchial hyperplasia and hypertrophy. Another group of rats was subjected to plume that was filtered to 0.1 μm (normal filtration provided by a surgical smoke evacuator). This group developed no lesions, and their respiratory status remained identical to that of the control rats.¹⁰

Studies supporting the hazards of the small particles within surgical smoke have been replicated numerous times. Studies from 1991 and 1992, using different techniques, noted that electro-surgery produced an

aerosol with particulate matter that was smaller than 5 μm .^{11,12} Other research demonstrated that the harmful effects of the small particles found in carbon dioxide laser smoke also applied when the ESU or the Nd:YAG laser were used.^{4(p93)}

All of these studies verified the extremely small size of the particulate matter within surgical smoke. If the plume is inhaled repeatedly, then respiratory changes can occur, leading to acute and chronic respiratory conditions. Nurses and surgical technologists, along with anesthesia providers, constantly are exposed to the hazards of surgical plume; the exposure for surgeons often is much less because they may operate only a few times a week. Therefore, surgical staff members and anesthesia providers usually are the ones who request and even demand that smoke evacuation devices be purchased and used.

• *Viability of the particulate matter.* The viability of the particulate matter (eg, cellular debris, tissue, deoxyribonucleic acid [DNA]) in the surgical smoke that may be transmitted through inhalation has yet to be demonstrated conclusively, but the potential for transmission of viable contamination remains a concern. Various research studies have examined the viability of the smoke particulate and the potential for transmission.

When a carbon dioxide laser was used on pigskin contaminated with bacteria, viable bacteria were found in the plume.¹³ Another study noted that cellular clumps and erythrocytes can be found in laser smoke, illustrating that viable cells probably could survive if a laser were operated at low-power settings.¹⁴ Other research demonstrated that bacteria could be cultured successfully from the laser plume and that plume cell viability can be determined by the power density of the laser beam on the tissue.¹⁵

In 1988, Garden and associates¹⁶ used the carbon dioxide laser to vaporize bovine fibropapillomavirus and then extracted intact viral DNA from the plume that was emitted. The viral DNA material was injected back into the host (cow), and the same papillomavirus grew at another site. This significant study demonstrated that viral DNA can cause viral growth in the host if the transmission mode is through injection.¹⁶ Transmission by injection is accomplished through direct inoculation of the infectious matter into the body, while transmission by inhalation is relatively indirect as it requires the breathing in of the infectious matter through the respiratory system. Further studies are needed to determine whether viral transmission and regrowth are possible through the inhalation of surgical smoke that contains viral DNA.

Other studies have supported the presence of viral DNA in surgical smoke generated by laser and electro-

surgery applications.¹⁷ Human immunodeficiency virus DNA also was found in the laser plume. There was no sustained viability of the human immunodeficiency virus in the smoke, but there were positive results from the tissue culture in the tubing connected to the evacuator.¹⁸ Multiple air samples taken during reduction mammoplasties were shown to contain mutagenic cells in the surgical smoke.¹⁹ These and other studies continue to support the need for proper smoke evacuation.

A retrospective survey noted a substantial number of healthcare providers contracting verrucous lesions (benign, viral, warty skin lesions) from infected patients who were treated surgically. Investigators concluded that wearing gloves and masks is vital, and controlling the plume through adequate smoke evacuation methods is absolutely mandatory.²⁰

In 1991, a case report was published about a 44-year-old surgeon in Norway who developed laryngeal papillomatosis, which was probably workplace related; he used the laser to vaporize condyloma. The surgeon's own laryngeal biopsy report revealed human papillomavirus DNA types consistent with the anogenital condyloma that he was treating by laser.²¹ This report gives further credence to inhalation transmission of viable particulate matter in surgical smoke.

Many research studies have shown the presence of viable and potentially pathogenic particulate matter in surgical smoke, but the question of whether this particulate matter can transmit disease through inhalation has yet to be shown conclusively. Since the potential for pathogenic transmission is plausible, healthcare professionals and workers must be continually alert to ensure proper smoke evacuation.

• *Endoscopic issues.* In 1993, Ott⁸ reported that when the surgical plume was not evacuated during a laparoscopic procedure, some patients experienced increased methemoglobin and carboxyhemoglobin levels. The affected patients then had nausea and vomiting in response to this problem. This research demonstrated that absorption of surgical smoke may contribute to the genesis of nausea and vomiting in patients undergoing hot tool laparoscopic surgery.⁸ Current research efforts are being directed at the effect of unevacuated smoke on wound healing.

The presence of surgical smoke during flexible endoscopic biopsy or surgical excision with a laser or ESU causes visibility problems. Research has not been conducted that would show whether absorption of this plume occurs during the flexible endoscopic procedure.

Solutions to minimize surgical smoke

• *Smoke evacuation methods.* One of the most critical challenges in providing adequate smoke evacuation is determining the type of smoke evacuation needed. A

variety of choices are available depending on the amount of plume produced: in-line filters, individual smoke evacuators, and centralized smoke evacuation systems.

An in-line smoke evacuation filter is an appropriate smoke evacuation method when small amounts of plume are generated, such as during a microlaryngoscopy vaporization of vocal cord polyps. The in-line filter is connected to the existing 1/4-inch wall suction line and is positioned between the wall connection and the suction canister. The suction canister collects the fluids while the air is purified by the filter. Care must be taken not to suction fluids through the in-line filter because effectiveness is decreased if the filtering media become wet. If a procedure does not produce fluids that need to be suctioned, the in-line filter can be used without the suction canister.^{4(p99)}

If an in-line filter is not present, the particulate matter from the surgical smoke can occlude and corrode the suction pipes and contaminate the building. The suction flow may not be forceful enough to adequately capture the plume as well. A suction line usually generates 2 cubic feet per minute (cfm) of air movement, while an individual smoke evacuator may move air at 35 to 50 cfm.^{4(p99)} Using an in-line suction filter is appropriate only for small amounts of plume. Manufacturers usually recommend changing in-line filters before every procedure.

An individual smoke evacuator is used if larger amounts of plume are generated. A variety of smoke evacuators are available that are small, portable, quiet, and cost-effective. Smoke evacuators usually have a triple filtration system that includes a prefilter, a charcoal filter, and an ultra-low-penetration air (ULPA) filter.

The prefilter is designed to capture the large particles within the plume as it is directed through the filtration system. Most manufacturers recommend that prefilters be changed with every procedure.

The purpose of the charcoal filter is to remove the toxic gases and odor within the surgical smoke. Charcoal is rated by the weight of the material it can capture or absorb. Charcoal from activated virgin coconut shell is the most effective for absorbing and deactivating the odor associated with the laser plume.²² *Activated* means that the charcoal has been treated using a heating process to expose the active absorption sites. *Virgin* means that the charcoal has not been reprocessed. Coconut shell-based charcoal is more effective for absorbing particulate matter than the wood-based charcoal because it has a greater internal pore area.^{4(p98)}

The filtration rating of the smoke evacuator filter describes the capture of the particulate matter of a certain size at a particular efficiency. Older technology filters use a HEPA (high-efficiency particulate air) system

that captures 0.3- μm matter at 99.97% efficiency. The type of filtration found in most smoke evacuators is the newer ULPA filter, which provides filtration of 0.01- μm matter at 99.9999% efficiency.^{4(p96)}

ULPA filtration is achieved as the particulate matter is forced through a depth filter that is similar to a maze. Filtration is accomplished using 3 modes depending on the particulate matter size.^{4(p96)}

1. Direct interception captures particles that are larger than 1 μm because they are too large to pass between the fibers of the filter media.

2. Inertial impaction filters matter that is 0.5 to 1.0 μm as the particles collide with the fibers and remain there.

3. Diffusional interception captures particles smaller than 0.5 μm because of the effects of brownian motion as the particles "search out" fibers and adhere to them.

A particle size of 0.12 μm is called the "most penetrating particle" and is the most difficult size to capture. This mid-range particle size can pass through some of the 0.1 to 0.5 μm openings in the filter media, but it is not small enough to have significant random thermal motion to be captured through diffusional interception.^{4(p98)} Particles of larger and smaller sizes are more easily captured through the methods previously described.

Maintenance of a smoke evacuator involves changing the filter according to the manufacturer's written instructions. The filter must be changed as often as needed to prevent odor and contamination. Usually when a lingering odor is noticed in the air and the suction pressure has decreased, the filter needs to be changed. Most smoke evacuation units have an indicator light that signals when the filter needs to be replaced. This signal may be activated when the suction starts to decrease, signifying that the filter is becoming less effective, or the signal may be activated through a timing device.

A contaminated filter should never be left in a smoke evacuator for changing at a later date. The odor from the used filter can travel into the smoke evacuation system and be absorbed by foam padding, hoses, and other internal parts. Attention to the filter alert light helps ensure that the filter will be changed as often as necessary.

Protective gloves and clean technique should be used when discarding a contaminated filter. The used filter can be placed in a plastic disposal bag and discarded in the general waste receptacle. A contaminated filter need not be treated as biohazardous waste as it is not considered an environmental hazard. There are no reports of transmission of infectious material to humans by disposal of a contaminated smoke evacuation filter in the environment. Waste that creates an environmental hazard needs to be treated as biohazardous waste (ie, placing it in a "red bag," then making

it unrecognizable through mechanical methods, such as compacting or shredding the device and disinfecting it). Changing a contaminated filter is an occupational hazard, so gloves should be worn when handling it, but the filter itself is not designated as an environmental hazard, so it does not need to be treated as biohazardous medical waste.^{4(p99)}

The following factors should be considered when comparing smoke evacuation systems for possible purchase:

1. Filtering capability (ULPA filtration is the most effective.)

2. Air movement (or suction ability; usually between 30 and 50 cu ft/min of air movement is desired.)

3. Noise level (The amount and condition of the foam padding inside the smoke evacuator determines the amount of noise that is produced. Foot pedals can be used to turn the smoke evacuation unit on when needed to decrease the duration of the noise and the operating time of the motor.)

4. Mobility of unit

5. Maintenance

6. Accessories and supplies (costs and availability)

7. Cost (smoke evacuator and disposable supplies)

Centralized smoke evacuation systems have been designed to provide smoke evacuation for several surgical rooms at the same time. The smoke tube is attached to the connecting port located in the surgical or treatment room, and the plume is conducted through the tubing to a central area for filtration. The advantage of this system is quick and easy accessibility to smoke evacuation. A limitation is that the internal tubings need to be flushed regularly to prevent debris buildup and pathogen growth. Another disadvantage is that if the central system malfunctions or breaks down, smoke evacuation is not available to multiple surgical areas.

- *Smoke evacuation during laparoscopy.* Smoke evacuation concerns during laparoscopic procedures have resulted in the study conducted by Ott.⁸ The presence of surgical smoke in the abdomen obscures visibility, and the toxic gases can be absorbed by the patient, causing many other problems. Hand-controlled suction devices have been designed to provide a gentle movement of the plume during a laparoscopic procedure without destroying the pneumoperitoneum. A high-flow insufflator also is recommended for continual replacement of the carbon dioxide gas. A low-pressure suction device also can be used during flexible endoscopy to evacuate the plume so visibility can be maintained.

- *Smoke evacuation tube positioning.* A valuable recommendation to control surgical smoke is to position the smoke tube near the tissue site where the plume is generated. When a smoke tube is moved away from the

smoke generation site, the amount of smoke evacuated decreases substantially. The smoke then escapes into the air and can be inhaled by anyone in the area.

The surgical assistant or scrub personnel have the responsibility to make sure that the smoke evacuation tubing is positioned as near as possible to the site of plume generation. Besides the smoke tubings for evacuation, unique devices have been designed for positioning around the surgical site to provide continual evacuation of the plume. If smoke evacuation is not available or is not used, the plume will contaminate the surgical room. Since the ESU is used so frequently during procedures, ESU pencils have been designed to incorporate the smoke tube within the pencil for immediate and thorough smoke evacuation.

- *Appropriate supplies.* Appropriate supplies must be readily accessible so that smoke evacuation can be performed effectively. As the hazards of surgical smoke

have become more evident, smoke evacuation methods are used more frequently; therefore, a consistent inventory of supplies must be maintained.

Filters should be available so that filters can be changed as often as needed. Manufacturers of the smoke evacuator sell filters for their systems, but other companies may also sell filters that fit certain models of smoke evacuators. If these other filters are purchased, the buyer should make sure that the filtering materials are made of quality products and that the filter fits appropriately into the smoke evacuator.

Smoke evacuation tubes should have a smooth inner lumen to decrease the whistling noise produced by corrugated tubing. Surgical team members have tried to control costs by using anesthesia breathing circuit tubing that usually has a corrugated lumen. The loud whistling noise produced by this tubing as the plume is evacuated can be annoying.

Table 2. Sample policy and procedure: Surgical smoke evacuation^{4(p69), 23}

Purpose: To provide effective smoke evacuation of surgical plume.

General statement: According to numerous research studies, surgical smoke is potentially hazardous and must be evacuated adequately and appropriately. Continuing education will help describe the hazards of surgical smoke and encourage the use of appropriate methods for evacuation.

Policy and procedure:

1. The smoke evacuation system must be adequate to handle the amount of plume produced during surgical procedures.
 - A. For very small amounts of plume, in-line suction filters shall be used (for example, during microlaryngoscopic vaporization of vocal cord polyps).
 - B. For large amounts of plume, an individual smoke evacuator unit or centralized system shall be used.
2. If an in-line suction filter is used for large amounts of plume, it will become blocked by the abundance of particulate matter found in surgical smoke. This plume will then clog the wall suction lines.
3. If surgical smoke is directly suctioned into the wall outlet without a filter, the particulate matter in the plume will eventually clog the wall suction line.
4. An in-line suction filter is placed between the suction canister and the wall connection. Fluids must not be drawn through the filter, as its effectiveness will be destroyed.
5. Surgical smoke contains an offensive odor, extremely small particulates, and potentially viable cells. The smoke evacuation suction tube must be held close (less than 1 inch away) to the tissue interaction site to remove as much plume (odor and particulate matter) as possible.
6. Smoke evacuation tubing should have a smooth inner lumen to eliminate whistling noise.
7. A reducer fitting can be used to adapt a large smoke evacuation tube to a smaller suction or evacuation tubing.
8. The scrub person or first assistant can operate the smoke evacuation foot pedal (if available) to minimize the wear and tear on the smoke evacuator motor and to decrease noise.
9. Filters should be changed as recommended by the manufacturer.
10. Special efforts should be made to remove smoke during any endoscopic or laparoscopic procedure. Endoscopic smoke evacuation instruments, such as suction tubes, help decrease the presence and retention of plume inside a body cavity or organ. A low-pressure suction valve can be used to gently remove plume during a laparoscopic procedure without destroying the pneumoperitoneum. A high-flow insufflator also is recommended.
11. A high-filtration mask can be worn to protect against residual smoke particulate matter. Wearing a high-filtration mask does not replace the need to use a smoke evacuation system to remove the surgical smoke from the environment. The high-filtration mask must fit snugly around the face.

If a surgical procedure does not require a sterile setup, clean smoke evacuation tubing may be purchased in bulk to save money. Sometimes the tubing can be purchased in a roll so a specific length can be cut when a clean smoke evacuation tube is desired. Many other cost-effective practices can be used while still ensuring adequate smoke evacuation.

Smoke tubing comes in a variety of lumen diameter sizes depending on the amount of plume to be evacuated. For example, smaller diameter tubing can be used to evacuate minute amounts of plume (eg, microlaryngoscopy to vaporize vocal cord polyps), while the wider diameter tubing will be needed for larger amounts of plume (eg, mastectomy). Reducer fittings are also available to adapt a large smoke evacuation tube to a smaller suction tubing that can be attached to surgical instrumentation.

- **Surgical masks.** High-filtration surgical masks can be worn to filter any residual plume that has not been evacuated. Since regular surgical masks filter 5- μm particulate matter, high-filtration masks have been designed to filter particulate matter to 0.1 μm . Since most of the particulate matter in surgical smoke is smaller than 1.1 μm , high-filtration masks will adequately protect healthcare professionals from residual plume.

A number of surgical masks are available that provide a high level of filtration. High-filtration masks must fit snugly around the face and must be changed as the manufacturer suggests to provide adequate filtration and protection. Wearing a high-filtration mask does not replace the need to use a smoke evacuation system, but the mask can be worn to offer further protection against residual airborne particulates.

Recommendations and guidelines

Surgical smoke continues to gain recognition as a hazardous substance as the results of more research are published. Professional organizations, along with agencies and research groups, have developed guidelines and statements about these hazards and how to minimize them. Recommendations should be referenced, and healthcare professionals should follow them closely when developing policies and procedures to address the evacuation of surgical smoke (Table 2). Some of the recommendations and statements that are based on conclusive research are as follows.²³

- American National Standards Institute (ANSI): Z136.3 The Safe Use of Lasers in Healthcare Facilities, 1988.
- NIOSH and the Centers for Disease Control and Prevention (CDC): Control of Smoke from Laser/Electric Surgical Procedures, 1996.
- Association of periOperative Registered Nurses

(AORN): Recommended Practices for Laser Safety in Practice Settings, 2000.²⁴

- Occupational Safety and Health Administration (OSHA): Statement to be available in the near future.

Summary

All surgical smoke must be appropriately evacuated to protect surgical team members from continual exposure. Most hospitals post "No Smoking" signs at the entrance, but smoking (even though it is in another form) is permitted in the surgical environment. Appropriate smoke evacuation is vital to protect healthcare professionals from inhalation hazards. Smoke evacuation technology is readily available to offer substantial protection from plume hazards, so let's use it.

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