IC Medical Inc. presents:

Controlling Surgical Smoke:
A Team Approach

(Informational Booklet)

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Controlling Surgical Smoke: A Team Approach

Overview

Controlling surgical smoke continues to be a major challenge to health care providers in today's surgical and endoscopy environments. The hazards associated with surgical smoke are supported by comprehensive research coupled with anecdotal statements of these hazards experienced by surgical team members. This informational booklet presents an overview of research results, organizational recommendations, and surgical team guidelines to assist in the proper evacuation of surgical smoke. Perioperative nurses and the other surgical team members must be aware of the hazards of surgical smoke so that adequate smoke evacuation methods can be employed.

Introduction

Research has shown that surgical smoke is hazardous to patients and surgical team members but yet the debate continues on the need for smoke evacuation practices. This study guide reinforces the results of research studies and anecdotal experiences that validate the need for smoke evacuation. The control of surgical smoke requires a team approach with all members of the surgical team dedicated to maintaining a smoke-free environment.

The Generation of Surgical Smoke

The number of surgical procedures continues to grow not only in hospitals but in ambulatory surgery centers, clinics, and physicians' offices. Approximately 90% of endoscopic and open surgical procedures generate some level of surgical smoke. (Ulmer B, 1998)

Lasers and electrosurgery devices that are used to cut, coagulate, vaporize, and ablate tissue are the "hot" tools that cause targeted cells to heat to the point of rupturing the cellular membrane and spewing cellular contents into the air as surgical smoke. Through continuous exposure, the inhalation of surgical smoke can become harmful to the surgical team members. Plume can also be hazardous to patients during laparoscopy or other endoscopy procedures when the contaminants of surgical smoke are absorbed into the patient's vascular system.

Research studies have repeatedly highlighted the hazards of surgical smoke during laser use so smoke evacuation has been accepted as a common practice. Unfortunately evacuation of smoke generated during electrosurgery has not been as widely accepted even though research has been definitive in proving inhalation hazards.

In comparing the hazards of electrosurgical smoke to laser plume, Dr. Tomita and his associates delivered laser energy to one gram of tissue. The plume, when inhaled, was shown to be comparable to smoking 3 unfiltered cigarettes. When Dr. Tomita used an electrosurgery device on one gram of tissue, inhaling the plume was equivalent to smoking 6 unfiltered cigarettes. This study demonstrated that plume generated during electrosurgical procedures has the potential to be twice as harmful as the smoke produced during laser surgeries. (Tomita et al.,

1989) The bottom line is that all surgical smoke should be considered as harmful if not evacuated appropriately. Unfortunately many healthcare professionals are indifferent and do not feel the need to evacuate plume since they have been breathing it for years.

Hazards of Surgical Smoke

So what are the effects of surgical smoke? Research notes that surgical smoke can cause burning, watery eyes, nausea, respiratory problems, and maybe even pathogenic contamination and regrowth. (Ball, 2004) Estimations note that approximately 350,000 health care workers are exposed to surgical smoke each year thus creating a hazardous work environment. (Ulmer, 1998) Complete evacuation of surgical smoke is necessary because of these unwanted hazards and potential complications.

Research has conclusively shown that surgical smoke is hazardous to the surgical team members who are exposed to it on a continual basis and hazardous to endoscopic patients when the plume is not evacuated. The four main areas of concern are:

- Odor
- Size of the particulate matter
- Viability of the particulate matter
- Endoscopy concerns

Research studies that support these concerns are listed in each section that follows. More research studies can be found in the "Other Readings" segment at the end of this document.

Odor

When a "hot" tool, such as a laser or electrosugery device, is used to vaporize, cut, ablate, excise, or coagulate tissue, a noxious odor is emitted within the surgical smoke. This odor is caused from toxic gases that are released when tissue pyrolysis and destruction occur when the hot tool impacts tissue. The following toxic chemical byproducts have been identified in surgical smoke resulting from tissue pyrolysis: (Hoglan, 1995 and Ott, 1993)

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

Estimates note that there are over 600 more compounds within surgical smoke that have yet to be identified. Some of these toxins, including polycyclic aromatic hydrocarbons, benzene, toluene, formaldehyde, and acrolein, have already been identified as known carcinogens. With repeated exposures these toxins can become hazardous when inhaled.

Size of the particulate matter

Lasers, electrosurgical tools, ultrasonic generators, and other particle-generating devices all have been shown to create small particulate matter that can be dangerous if inhaled. The small size and hazards of this particulate matter have been demonstrated repeatedly through research studies.

In 1975 Mihashi and his associates used a carbon dioxide laser to vaporize tissue. They found that the particulate matter within the surgical smoke was 52 times greater than that allowed by the government's environmental standards. Further results noted that approximately 77% of the particulate matter in the plume was less than 1.1 microns in size. (Mihashi et al., 1975) Many standard surgical masks only filter particulate matter down to 5 microns in size. Most of the plume can easily pass through this mask and be deposited in the alveoli of lungs when inhaled thus causing chronic irritation, bronchitis, or emphysema-like conditions.

In 1988, Dr. Baggish and his partners conducted a study to compare the effects of laser smoke on the lungs of laboratory rats. One group of rats breathed in large amounts of plume that was created by impacting pigskin with a CO_2 laser beam for different time durations. 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 down to 0.1 micron in size with a smoke evacuator. This group developed no lesions and remained identical to the control rats. (Baggish et al., 1988) The results of this study demonstrated that smoke evacuation can be performed effectively to remove surgical smoke.

Another study that supported the effects of particulate matter was one conducted by Dr. Barry Wenig who found that the results regarding the harmful effects of CO_2 laser smoke also applied to the use of the electrosurgery unit and the Nd:YAG laser. (Wenig et al., 1993)

Two studies using different techniques from 1991(Helnsohn et al.) and 1992 (Smith et al.) noted that electrosurgery produced an aerosol with particulate matter that was less than 5 microns in size.

All of these studies demonstrated that the size of the particulate matter in surgical smoke is extremely small and could be harmful to the respiratory system. If inhaled repeatedly, then respiratory changes can occur leading to acute and chronic respiratory conditions. Nurses and technologists, along with anesthesia providers constantly are exposed to the hazards of surgical plume as compared to surgeons who may only operate maybe two days per week. Therefore, surgical staff members and anesthesia providers are usually the ones who demand smoke evacuation devices be purchased and used regularly.

Viability of the particulate matter

Whether surgical smoke can transmit particulate matter that is viable is still being debated but the potential for transmission has become a growing concern. Research studies listed below support the potential for transmission and plume particulate matter viability.

1985: Mullarky and his colleagues discovered that when bacteria was placed on pigskin and then impacted by the CO_2 laser, viable bacteria could be found in the plume. (Mullarky et al., 1985)

1986: Walker and associates conducted a study that noted cellular clumps and erythrocytes (red blood cells) can be found in laser plume. Also the study proved that viable cells could probably survive if the laser were operated at lower power settings. (Walker et al, 1986)

1987: Byrne and associates found that bacteria could be successfully cultured from laser plume. This study indicated that plume cell viability is determined by the power density of the laser beam on the tissue. (Byrne et al., 1987)

1988: Dr. Jerome Garden and his associates were able to extract intact viral DNA from the smoke emitted when a CO_2 laser was used to vaporize bovine fibropapillomavirus. The material was then injected back into the host (cattle) and the same papilloma viral lesions grew. This study noted that viral DNA can cause viral growth in the host if injected. (Garden et al., 1988) Further studies need to be conducted to note if viral transmission and regrowth are possible through inhalation.

1988: Dr. Lobraico and his partners conducted a retrospective survey that noted 26 incidences of transmitted verrucous lesions to health care providers (4 being proven by biopsy) from infected patients being treated surgically. Conclusions made from the survey indicated that the surgical team needs to strictly adhere to wearing gloves and masks. Also adequate smoke evacuation must be mandatory to control surgical smoke. (Lobraico et al., 1988)

1989: Dr. Sawchuk and his team used a CO_2 laser and an electrosurgery unit to vaporize infectious papillomavirus in warts. Results from this study noted that viral DNA was present in the plume generated from treatment with a laser or electrosurgery but did not determine whether the papillomavirus material in the plume was infectious. (Sawchuk et al., 1989)

1991: Dr. Baggish and his associates detected the presence of the human immunodeficiency virus DNA in laser plume. There was no sustained viability but there was positive tissue culture in the tubing of the smoke evacuator. (Baggish et al., 1991)

1991: Hallmo and others reported that a 44 year old surgeon in Norway developed laryngeal papillomatosis when using a laser to ablate condyloma on his patients. The surgeon's laryngeal lesions tested positive for human papillomavirus DNA types that were consistent with his patients' anogenital condyloma. (Hallmo et al., 1991) These startling results highlighted the possibility for inhalation spread of viable particulate matter in surgical smoke.

1992: Gatti and his partners took multiple air samples during reduction mammoplasties to determine the mutagenicity of the smoke produced when an electrosurgery device was used. Results noted that the surgical smoke particles were found to be mutagenic. The researchers concluded that the surgical team should attempt to minimize exposure to surgical smoke. (Gatti et al., 1992) In 2001, Dr. Bray in Toronto, Canada, measured the particles in the plume during reduction mammoplasties and noted that proper smoke evacuation can remove particulate matter to baseline levels. (Bray, poster session)

Endoscopic concerns

The fourth concern involves the surgical smoke that is produced during endoscopic procedures (i.e., laparoscopy) and is not appropriately evacuated.

In 1993 Dr. Doug Ott and his team noted that when surgical plume is not evacuated during a laparoscopic procedure, there was an increase in the formation of methemoglobin and carboxyhemoglobin, which are modified forms of hemoglobin that cannot carry oxygen to the tissue. Therefore, tissue oxygenation suffers. Patients in this study presented with nausea, vomiting, and/or headaches in response to this problem. (Ott et al., 1993) For years when a patient exhibited these symptoms in the PACU, the anesthesia agents were blamed. This research showed that other conditions may be causing this problem. Dr. Ott also questions whether the presence of surgical smoke left during laparoscopy can cause a delay in tissue healing.

Recommendations & Guidelines

The hazards of surgical smoke continue to be debated but as research results conclusively demonstrate these hazards, stricter guidelines and recommendations are being introduced. For example, some guidelines now state that "surgical smoke SHALL be evacuated" (mandatory) instead of saying that "surgical smoke SHOULD be evacuated" (advisory). This verbiage change makes the statement much more powerful so many facilities are now mandating that all surgical smoke be evacuated.

Professional organizations, agencies, and research groups have developed guidelines and statements that address the hazards of surgical smoke. These recommendations should be followed closely by health care professionals since they are based on definitive research. Some recommendation and guideline examples about surgical smoke hazards are listed below:

American National Standards Institute (ANSI) Z136.3

"The Safe Use of Lasers in Healthcare Facilities," 2005:

"In operations that produce vaporized target tissue through the disruption of cells, LGAC (laser generated airborne contaminants) is a resulting hazard, requiring appropriate management. Analysis of the LGAC produced during laser surgical procedures has shown the presence of gaseous toxic compounds, bio-aerosols, dead and live cellular material, and viruses...At certain concentrations some of the LGAC can cause ocular and upper respiratory tract irritation, have unpleasant odors, create visual problems for the user, and have been shown to have mutagenic and carcinogenic potential."

"NOTE: Electrosurgical devices and instrumentation are often used both separately and simultaneously with health care laser systems. These devices have been found to produce the same type of airborne contaminants as produced by laser-tissue interactions, and these contaminants should be evacuated from the surgical site."

National Institute of Occupational Safety and Health (NIOSH) and the Centers for Disease Control and Prevention (CDC)

"Control of Smoke from Laser/Electric Surgical Procedures," 1998:

"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, 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…NIOSH research has shown airborne contaminants generated by these surgical devices can be effectively controlled…The two major …approaches to reduce surgical smoke levels for health care personnel are portable smoke evacuators and room suction systems."

Association of periOperative Registered Nurses (AORN)

AORN Recommended Practice for Electrosurgery

RP XIV: "Exposure to smoke plume generated during electrosurgery should be minimized."

This RP states that surgical smoke generated by electrosurgery should be evacuated with the use of smoke evacuation systems or in-line filters used with wall suction devices. The plume created from electrosurgery is just as hazardous as the smoke generated during laser surgery. Both can contain toxic gases and vapors, chemical byproducts, blood fragments, and viruses. In high concentrations, surgical smoke can cause ocular and upper respiratory tract irritation. NIOSH recommends that appropriate smoke evacuation systems be used to prevent acute and chronic health problems to patients and personnel. OSHA addresses the need to evacuate surgical smoke through the General Duty Clause that states a safe work environment must be provided. The RP further states that smoke evacuation systems and accessories should be used according to the manufacturer's instructions and that the suction wand should be positioned as close to the tissue impact site as possible to maximize smoke capture and enhance visibility at the surgical site. (AORN Recommended Practices, p.490-1)

AORN Recommended Practice for Laser Safety in Practice Settings

RP VI: "Personnel working in the laser environment should avoid exposure to smoke plume generated during laser surgery."

This RP stresses that surgical smoke should be reduced by using local exhaust ventilation controls such as wall suction units with in-line filters or smoke evacuation units. The collection device should be held as close to the point where the plume is generated. The RP continues to state that high-filtration masks should be worn during laser procedures to filter particulate matter and reduce noxious odors but should not be viewed as the absolute protection from chemical contaminants. An in-line filter connected to a wall suction line can be used to evacuate when very small amounts of surgical smoke are generated. When large amounts of plume are created, then a mechanical smoke evacuation system with a high-efficiency filter should be used. Standards precautions should be used during laser procedures since surgical smoke has been shown to contain toxic gaseous compounds, bioaerosols, and dead and living cell material. The potential for bacterial and/or viral contaminations from the surgical smoke remains controversial. (AORN Recommended Practices, p.567-8)

American Society for Laser Medicine and Surgery (ASLMS)

Recommendation, 1999: (Even though this document is from 1999, it is reviewed annually.)

"All medical personnel should consider the vaporized tissue plume to be potentially hazardous both in terms of the particulate matter and infectivity…Evacuator suction systems should be used at all times to collect the plume."

Occupational Safety and Health Administration (OSHA)

OSHA developed a monograph on the hazards of surgical smoke in 1999 but was never distributed. This monograph was based on conclusive research that demonstrated the problems experienced with exposure to surgical smoke. Instead OSHA states that facilities must provide a safe work environment under the General Duty Clause and therefore, if workers report a facility is not promoting or providing smoke evacuation devices, then OSHA can inspect and penalize a facility if an unsafe work environment is discovered.

Solutions to minimize surgical smoke

Appropriate smoke evacuation method

One of the most critical practices in surgery today is to use the appropriate smoke evacuation method for the amount of plume generated. A variety of choices are available depending upon the amount of plume produced.

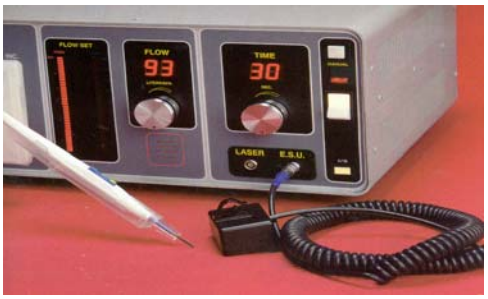
An **in-line filter** placed within the wall suction system can be used for small amounts of plume (i.e., plume produced during a microlaryngoscopy vaporization of vocal cord polyps). The in-line filter is connected to the existing 1/4-inch wall suction line and is positioned between the wall connection and the suction canister. The suction canister is used to collect any fluids, and the air is purified by the filter. Fluids must not be suctioned through the in-line filter because the effectiveness of the filter will be altered if the filtering media gets wet. If a surgical procedure does not produce or require fluids that will be suctioned, the in-line filter can be used without the suction canister. (Ball, 2004)

If surgical smoke is evacuated directly into the wall suction without the use of an in-line filter, the surgical smoke can corrode the suction pipes and contaminate the building.

Usually the flow from the wall suction is not high enough to adequately capture larger amounts of plume. The suction in-line filter must only be used for small amounts of plume. A suction line may only generate 2 cubic feet per minute (cfm) of air movement while an individual smoke evacuator may move air at 35 to 50 cfm.

The manufacturer's written instructions must be followed when determining how often the in-line filter must be changed. Some manufacturers recommend that in-line filters be changed after every procedure.

An **individual smoke evacuator** should be used if larger amounts of plume are generated. A variety of smoke evacuators are available today that are very small, portable, quiet, and cost effective.



Smoke evacuators today have a sophisticated filtration system that includes:

*Charcoal filter

*ULPA filter

The purpose of the charcoal filter is to remove the toxic gases and odor generated by the surgical smoke. Charcoal is rated by the weight of the material captured. Charcoal from activated virgin coconut shell is effective in absorbing and deactivating the odor associated with the laser plume. "Activated" means that the charcoal was treated by a heating process to expose the active absorption sites, while "virgin" means that the charcoal has not been reprocessed. The coconut shell is more effective in absorbing particulate matter than wood-based charcoal because it has greater internal pore areas. (Ball, 2004)

Filtration within a smoke evacuator is achieved by capturing the particulate matter of a certain size at a particular efficiency. Older technology filters that used a HEPA (high efficiency particulate air) system captured 0.3 micron sized matter at 99.97% efficiency. The type of filtration found in most smoke evacuators today is the ULPA (ultra low penetration air) filter which provides filtration of 0.1 micron sized matter at 99.9999% efficiency. (Ball, 2004)

ULPA filtration is achieved through a depth filter that is similar to a maze. The particulate matter is filtered using three different methods depending on the particulate matter size:

* Direct interception: Captures particles that are over 1 micron in size because they are too large to pass between the fibers of the filter media.

*Inertial impaction: Filters matter that is 0.5 to 1.0 micron in size as the particles collide with the fibers and then remain there.

*Diffusional interception: Particles less than 0.5 micron are captured because of the effects of Brownian motion as the particles "search out" fibers and adhere to them.

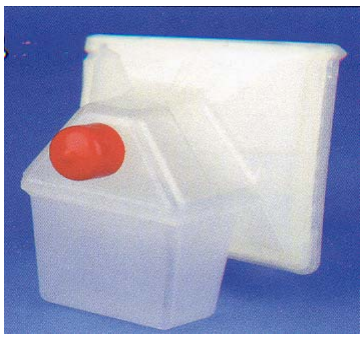
The most difficult particle to capture (most penetrating particle – MPP) is the mid-range particle of 0.12 micron. It is difficult to capture because it can pass through some of the 0.1 to 0.5 micron openings in the filter media. A particle of this size is not small enough to have significant random thermal motion to be captured by diffusional interception. Particles of larger and smaller sizes are more easily captured through the methods previously described.

Centralized smoke evacuation systems have been designed to accommodate several surgical rooms. In a centralized unit, the smoke tube is attached to the connecting port located in the surgical or treatment room. The plume is then suctioned through the tubing to a central area where filtration takes place. The advantage of this system is easy accessibility to smoke evacuation. A limitation of this type of system is that the internal tubings need to be flushed regularly to prevent debris build-up and pathogen growth. Another disadvantage is that if the central system malfunctions or breaks down, then smoke evacuation is not available to multiple surgical areas.

Smoke evacuator system maintenance

The manufacturer's written instructions should be followed regarding the changing of a contaminated smoke evacuator filter. The proper timing of changing filters in the smoke evacuation unit is of critical importance. 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 or some sort of alarm system that notes when the filter needs to be changed. This signal is usually activated when the suction starts to decrease, signifying that the filter is becoming less effective. (Ball, 2004)

When the smoke evacuation filter needs changing, the contaminated filter should never be left in the unit for changing at a later time. The odor from the used filter can travel into the system and cause the foam padding, hoses, and other internal components to absorb this offensive smell. Monitoring of the filter and changing the filter when indicated is vital to proper smoke evacuator maintenance. The health care worker should use gloves (standard precautions) and clean technique when changing the contaminated filter as this practice is considered to be an occupational hazard. The filter can be placed in a plastic bag and discarded in a general waste receptacle or a contaminated filter may also be treated as infectious or regulated medical waste depending on the facility's policies and protocols. Debates continue as to whether a contaminated smoke evacuator filter should be treated as an environmental hazard since transmission of infection in the environment has never been documented.



Purchasing a smoke evacuator

When purchasing a smoke evacuation unit, the following considerations usually are explored in evaluating smoke evacuation systems:

*Efficiency in filtering capability – A charcoal filter and ULPA filter provide the most effective filtration.

*Efficiency in suction power – The air movement or suction-ability of a smoke evacuator is usually between 30 and 50 cubic feet per minute of air movement. The suction power is determined by the type of pump within the smoke evacuator. A turbine pump (10 amps) usually moves air at 60 liters/minute after a 3 second delay or 90 liters/minute after a 6 second delay. Usually a turbine pump smoke evacuator has no occlusion feature if the evacuation tubing were to get clogged. The newer rotary vein pump (2 amps) is more efficient in air movement as an

instant negative pressure is achieved with this small powerful pump. The static suction is five times greater than the turbine pump. Usually the rotary vein pump has an occlusion feature that will shut off the unit if the suction line becomes occluded.

*Noise level - The amount and condition of the foam padding inside the smoke evacuator determines the amount of noise that will be produced.

*Mobility of unit

*Maintenance

*Cost (smoke evacuator and disposable supplies)

*Accessories and supplies

Individual smoke evacuation units have been installed in ceiling mounted systems to ensure availability and access. Ideally there should be a smoke evacuator in every surgical suite where plume may be generated.

Smoke evacuation during laparoscopy

The research conducted by Dr. Doug Ott has resulted in concerns about the hazards of surgical smoke during laparoscopic procedures. The presence of surgical smoke in the abdomen not only obscures visibility but the toxic gases can be absorbed by the patient causing other problems. Hand control suction devices and purge systems have been designed to provide a gentle movement of the plume during a laparoscopic procedure without destroying the pneumoperitoneum. A high flow insufflator is recommended so that any gas evacuated can be replaced rapidly.

Smoke evacuation tube positioning

If smoke evacuation is not available or used, then the plume will contaminate the surgical room and become hazardous if inhaled. Every effort should be made to properly evacuate surgical smoke and to prevent its spread throughout the surgical suite.

One critical practice in controlling the spread of surgical smoke is to capture as much plume as possible at the tissue impact site. The smoke evacuation wand or tubing must be positioned close to the tissue site where the plume is being generated. Studies have shown that the further a smoke tube is from the site of plume generation, the amount of smoke evacuated will decrease significantly, thus allowing residual plume to escape into the air.

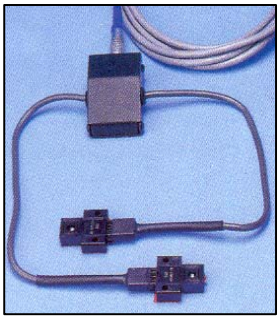
Since the electrosurgery device is used so frequently during procedures, ESU pencils have been designed that incorporate the smoke tube within the pencil for thorough smoke evacuation. This design allows the plume to be evacuated at the tissue impact site through a vortex motion which promotes greater plume capture.

The surgical assistant or scrub person has the responsibility to make sure that the smoke evacuation tubing is positioned closely to the site of plume generation. Devices have been designed that are positioned closely to the surgical site to provide a continual evacuation of plume. Care must be taken to not evacuate specimens, surgical sponges, or tissue as the wand is held closely to the tissue impact site. Mesh covers for suction tubes are available to prevent this from happening. Also some smoke evacuators have occlusion features that turn the system off if the suction tubing becomes clogged.

Appropriate supplies

Appropriate supplies must be readily accessible for smoke evacuation to be effective. Filters should be available so that filter changes can be done as often as needed.

Foot pedals can be used to turn the smoke evacuation unit on only when it's needed. Automatic activation devices also can be installed that mechanically sense when the ESU or laser is being used so that the smoke evacuator is turned on and off accordingly. This decreases the actual operating time of the motor and ensures smoke evacuation is available whenever needed.



Smoke evacuation tubes should have a smooth inner lumen to decrease the whistling noise that a corrugated tubing produces. Sometimes people try to control costs by using the anesthesia circuitry that does not have a smooth inner lumen to substitute for smoke tubing. The whistling noise produced by this circuitry during plume evacuation can be very annoying.

If a surgical procedure does not require a sterile set-up, then clean smoke evacuation tubing may be purchased in bulk to save money.

Smoke tubing comes in a variety of sizes depending on the amount of plume to be evacuated. Reducer fittings are also available to adapt a large smoke evacuation tube to a smaller suction tubing that may be attached to surgical instrumentation.

Surgical masks

High filtration surgical masks can be worn to protect against any residual plume that may have escaped capture by the smoke evacuation system. Since most surgical masks only protect against 5 microns in size particulate matter, high filtration masks have been designed that offer protection down to 0.1 micron in size particulate matter. Since most of the particulate matter in surgical smoke is less than 1.1 microns in size (Mihashi et al., 1975), high filtration masks will adequately help to protect the health care professional from any residual plume that may be left in the air. High filtration surgical masks have become so popular that some mask manufacturers are now only selling the high filtration type. Surgical masks must fit snugly around the face to provide adequate protection. Wearing a high filtration mask must not replace the need to use a smoke evacuation system to remove the surgical smoke from the environment.

Continuing education

The final solution to control surgical smoke is to provide continuing education for the entire surgical team on the hazards and methods to minimize and eliminate plume. The results of definitive research need to be promoted so that practices and attitudes can be changed regarding surgical smoke. Many smoke evacuation manufacturers and distributors have smoke evacuation education tools such as videotape or DVD programs, inservice materials, booklets, and other educational tools. The entire surgical team must be involved in continuing education so everyone understands the hazards of surgical smoke.

Sample smoke evacuation policy

The following is a sample policy and procedure that can be used as a model when addressing smoke evacuation practices.

Surgical Smoke Evacuation
Sample Policy

Purpose:

To provide adequate smoke evacuation of surgical plume.

General Statement:

According to research studies, surgical smoke is potentially hazardous and must be evacuated effectively.

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 may be used (e.g., during microlaryngoscopic vaporization of vocal cord polyps).
   b. For large amounts of plume, an individual smoke evacuator unit or centralized system must be used (e.g., for mastectomies).

2. An in-line suction smoke evacuation filter should be used to prevent particulate matter from contaminating and coating the internal suction lines.
   a. An in-line suction smoke evacuation filter is used only for small amounts of plume as it can become blocked by the particulate matter found in large amounts of plume.
   b. An in-line filter is placed between the suction canister and the wall or ceiling connection so that fluids are not pulled through the filter, which would make it ineffective.
   c. An in-line filter should be replaced according to the manufacturer's recommendations.

3. The smoke evacuation suction tube must be held close (i.e., less than 1 inch away) to the tissue interaction site to remove as much plume as possible. Surgical smoke contains extremely small particulate matter and may contain viable cells.

4. When a purge gas flow is used with the CO_2 laser or a fiber delivery device, the smoke evacuation tube must be held close to the laser-tissue interaction site because the gas flow will tend to spread the plume.

5. If a smoke evacuation foot pedal is available, the scrub person or first assistant can operate it. A system that automatically activates the smoke evacuator can be connected to the laser or electrosurgery unit system.

6. Smoke evacuation tubing should have a smooth inner lumen to eliminate any whistling noise.

7. A reducer fitting can be used to adapt a large smoke evacuation tube to a small suction

tubing.

8. Smoke evacuator filters should be changed as recommended by the manufacturer.
   a. The contaminated filter should be bagged for disposal. The filter should be discarded according to the facility's recommendations.
   b. Standard precautions (e.g., wearing gloves) should be practiced when changing smoke evacuation filters.

9. Special efforts should be made to remove smoke during any endoscopic or laparoscopic procedure.
   a. Endoscopic smoke evacuation instruments, such as suction tubes, help decrease the presence and retention of plume inside a body cavity or organ.
   b. A low-pressure suction valve can be used to gently remove plume during a laparoscopic procedure without destroying the pneumoperitoneum.
   c. A smoke evacuator attachment may be used that automatically activates the smoke evacuator when plume is created, thus providing a gentle movement of the abdominal air without destroying the pneumoperitoneum.
   d. A high flow insufflator should be used when surgical smoke is generated to allow for the rapid replacement of the insufflation gas when the smoke is evacuated.
   e. A special smoke evacuator may be used that will de-insufflate the abdomen when the procedure is finished by using a closed system to eliminate inhalation hazards of the insufflation gas and contaminants.

10. A high filtration mask (0.1micron filtration) should be worn to protect against any residual smoke particulate matter that has not been evacuated. Wearing a high filtration mask must 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.

11. Continuing education will help describe the hazards of surgical smoke and encourage the use of methods to evacuate it appropriately.

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Summary

The sign on the front of a hospital or ambulatory surgery center reads “no smoking” but yet smoking (in another form) is allowed in the surgical environment, thus causing hazards to the surgical team and even the patient. Research has conclusively shown that surgical smoke must be appropriately evacuated to minimize its hazards. Controlling surgical smoke requires a team approach with everyone demanding clean air in the operating room. Research validates the need for smoke evacuation and industry has provided efficient and cost effective smoke evacuation systems. Smoke evacuation technology is available, smoke evacuation practices are easy, smoke evacuation is effective – so why not use the proper smoke evacuation method for every surgical procedure that produces plume?

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Smoke Evacuation in a Healthcare Setting:

A Position Statement

March 2, 2001

Smoke Evacuation in the Healthcare setting is not only for a clear view of the surgical site, but for added protection from infection. Healthcare institutions that have a Standard Precaution policy in place should be looking at the studies done about infectious materials found in particles generated by ESU ("BOVIE"), Lasers, Ultrasonic generators, or any other surgical smoke or particle generating device. Since live viral material has been found in these particles, it is our position that any procedure that generates either smoke or particles needs to be actively evacuated. This would range from procedures that are only a few minutes long to those lasting several hours. This would include not only In-Patient and Out-Patient Surgeries, but Emergency Departments, Women's Care Centers, Radiological Departments, Cath Labs, and any other department in which a Healthcare facility would be using this type of equipment.

For laparoscopic procedures one must be careful, for not only does smoke evacuation help with visibility, but also helps in the prevention of absorption of the smoke into the peritoneum and the creation of methemoglobin, a modified form of hemoglobin that cannot carry oxygen to tissues. Please see Dr. Ott's article in the Dec. 1993 issue of OB.GYN News. After a laparoscopic procedure the smoke absorbed by the patient is equivalent to smoking 60 cigarettes.

It is our opinion that evacuation of smoke during open or laparoscopic procedures is very important. We include the Dr. Ott article for laparoscopic and AORN article about OSHA action to this position statement. There are numerous other articles of the effects of surgical smoke that should be reviewed by those with the potential of being exposed to any type of particles that have organic components.

I.C. Medical, Inc. is in no way attempting to dictate Healthcare policies or attempting to enforce current policies.

Mr. Ioan Cosmescu,
President

I.C. Medical, Inc.

Review Questions

1. An ULPA filter will capture particulate matter at 0.1 microns at 99.99999% efficiency.
   A. True
   B. False

2. A high filtration surgical mask will filter particulate matter that is _____ microns in size.
   A. 5
   B. 0.1
   C. 0.3
   D. 0.003

3. Concerns about surgical smoke are:

   A. Odor, inhalation, absorption
   B. Odor, particulate matter size, viability of the plume, and endoscopic concerns.
   C. Particulate matter size, endoscopic concerns
   D. Viability and mutations

4. Charcoal filters are used to remove
   A. Odor and toxic gases
   B. Particulate matter
   C. Viability
   D. All of the above

5. An in-line suction filter must be placed between the wall outlet and the suction canister.
   A. True
   B. False

6. Most of the particulate matter in surgical smoke is less than 1.1 microns in size and can be easily inhaled.
   A. True
   B. False

7. When surgical smoke is not evacuated during a laparoscopic procedure, the patient exhibit signs of decreased methemoglobin and carboxyhemoglobin.
   A. True
   B. False

8. The surgical team members must position the smoke evacuation wand or tube as close as possible to the tissue impact site to evacuate as much plume as possible.

A. True
B. False

9. The plume produced during electrosurgical procedures is as hazardous as the plume produced during laser surgery.

A. True
B. False

10. The noxious odor from surgical smoke is not hazardous if inhaled.

A. True
B. False

Answers:

1. A
2. B
3. B
4. A
5. A
6. A
7. B
8. A
9. A
10. B