Risks Associated with Exposure to Surgical Smoke Plume: A Review of the Literature

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Surgical incision and dissection with electrosurgery, laser ablation, and ultrasonic scalpel dissection are widely used and recognized as major advances in surgical technique. These techniques, however, intentionally destroy human tissue, which creates a gaseous by-product commonly referred to as surgical smoke or plume. Although the terms *smoke* and *plume* are used interchangeably throughout the literature, the difference between them is in particle size. Lasers and ultrasonic devices produce plume, which contains larger particulate matter than smoke. Larger particulate matter is of more concern as a biological hazard. Smoke results from the use of electrosurgical tools; it contains a smaller particle mass than plume but still is considered dangerous because of its chemical composition.[1]

Concerns expressed as early as 1988 regarding the production of smoke plume[2] have led to numerous studies to determine what, if any, health risks this by-product poses to perioperative personnel. Surgeons' exposure may be transient because they do not spend 100% of their workday in the OR, but their exposure is more concentrated than for other perioperative personnel because they are closest to the tissue destruction. Regardless of the transient nature of their exposure, therefore, surgeons are at equal risk to that of their surgical counterparts (eg, circulating nurse, scrub person, anesthesia care provider) who experience continuous, long-term exposure throughout the course of a routine workday.[3]

Smoke evacuation devices have been shown to be effective in limiting exposure to the noxious odor and potential health hazards of smoke and plume.[4] These devices have not been used on a routine and consistent basis in many ORs, however, because of resistance on the part of health care organizations, surgeons, and perioperative personnel. Resistance can be attributed to expense, inconvenience, and a general lack of knowledge regarding the potential hazards associated with exposure to surgical smoke plume. Many perioperative personnel have become desensitized to the offensive odor of cauterized human tissue and consider it no more than a minor annoyance.

ABSTRACT

ELECTROSURGERY, LASER ABLATION, and ultrasonic scalpel dissection create a gaseous by-product commonly referred to as surgical smoke or plume.

SMOKE EVACUATION DEVICES have been shown to be effective in limiting exposure to the noxious odor and potential health hazards of smoke and plume; however, these devices have not been used routinely and consistently in many ORs.

THIS ARTICLE REVIEWS FIVE QUANTITATIVE research studies that explore the characteristics of smoke plume produced during surgery and presents the evidence of the need for consistent use of smoke evacuation systems. *AORN J* 86 (December 2007) 1013-1020. © AORN, Inc, 2007.

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Although no legal or regulatory mandate specific to surgical smoke evacuation currently exists, various documents have provided health care professionals with guidance for controlling the hazardous effects of surgical smoke plume. The National Institute for Occupational Safety and Health (NIOSH) has issued a warning regarding the possible health effects of surgical smoke plume exposure.[5] Although recognized as a leading authority, NIOSH has no regulatory power. AORN is specific in its recommendation that smoke evacuation systems be used whenever surgical smoke or plume is generated.[6]

The American National Standards Institute (ANSI) has developed standards related to evacuation of plume produced by laser ablation.[7] Smoke evacuation of laser plume has been widely accepted and used since the inception of laser surgery. Research findings suggest that there is little difference between smoke generated from electrosurgery versus harmonic scalpels and lasers.

The problem lies in the acceptance of all surgical smoke generated by "hot tools" as a biohazard necessitating proper evacuation. It is hypothesized that the smoke plume produced from the destruction of human tissue creates an aerosol that is mutagenic and carcinogenic and acts as a vehicle for disease transmission.[8] Furthermore, instituting mandatory regulations regarding the use of smoke evacuation devices appears to be the only safe strategy for protecting the health of personnel involved in these procedures.[8]

In one study, researchers determined that smoke particles extracted from air samples of electrosurgically destroyed breast tissue were mutagenic on the DNA of a TA98 strain of Salmonella.

Discussion and Analysis of Studies

This article reviews five quantitative research studies that explore the characteristics of smoke plume produced during surgery and presents evidence of the need for consistent use of smoke evacuation systems (Table 1). After a thorough search of the CINAHL database, it was determined that nursing research is lacking in this area. These five studies were conducted primarily under laboratory conditions, which may account for the lack of nursing involvement. Nursing research on this subject is needed because knowledge of this problem affords nurses an opportunity to advocate for their own health and safety.

Smoke contains toxic chemicals. In a study conducted in 1992, Gatti et al[9] reported on the mutagenicity of surgical smoke. This study was one of the first of its kind to provide evidence regarding the mutagenic capacity of the chemicals extracted from surgical smoke. The surgical smoke samples were collected during actual surgical procedures. Previous mutagenicity studies had been conducted using simulated surgical conditions and animal tissue.

With the assistance of NIOSH, Gatti and colleagues generated and collected surgical smoke during two breast reduction surgeries. Multiple samples from the surgical suites in which these procedures took place were collected and analyzed.

The patients were 16 and 51 years of age, which accounted for a difference in tissue density. The heat destruction of breast tissue with electrosurgery resulted in smoke containing hydrogen cyanide, butadiene, acetylene, ammonia, and formaldehyde. The denser breast tissue from the 16-year-old patient accounted for a greater concentration of toxic chemicals and an increased mutagenic response.

For comparison, a control air sample was obtained from a side room absent of any type of electrosurgical smoke. Using an Ames test (ie, an established technique for evaluating the mutagenicity of chemicals) the smoke particles extracted from the air samples were found to be mutagenic on the DNA of a TA98 strain of *Salmonella*. The researchers also noted that the smoke particles were unstable and lost their mutagenic

potential within two hours after collection. Gatti et al, while admitting their results could not conclusively determine a serious health risk to surgical personnel who are regularly exposed to surgical smoke, proposed that attempts to minimize exposure were certainly in order.[9]

Animal behavior changes with increasing exposure time. The following year, Wenig et al[10] published a study detailing the effects of exposure to electrosurgical smoke and laser plume on the respiratory system of animal subjects. In contrast to the 1992 study by Gatti et al, Wenig and colleagues observed rats after exposure to surgical smoke plume. Their study was conducted in a laboratory setting with smoke collected from the laser ablation and cauterization of pig skin, not human tissue. The animal subjects were exposed to smoke plume captured by smoke evacuators using single and double filters in addition to nonfiltered samples. The researchers observed the animals' behavior with increasing exposure time. The researchers also examined the animal's lung parenchyma after humane euthanasia.

The exposure was conducted in three phases; the researchers extended the rats' exposure time during each phase and noted their behavioral changes. The investigators reported that the animals became sluggish during exposure to the smoke plume but resumed normal activity after periods of rest without exposure to smoke plume. Of more notable concern were the changes in lung pathology. The researchers reported the development of blood vessel hypertrophy, alveolar congestion, and emphysematous changes. These changes decreased for the samples extracted from the single- and double-filtered group and increased for those in the nonfiltered group. Control animals housed outside the test room were found to have normal lung parenchyma. Wenig and colleagues contended that the chemicals they extracted from the smoke plume, namely benzene, formaldehyde, and acrolein, might have accounted for the pulmonary changes in their subjects.

As with the previous study, these researchers advocated for the use of adequate smoke evacuation devices in the perioperative setting.[9,10] They not only noted the importance of these devices but also identified proximity parameters to aid in effective evacuation. According to the researchers, devices for smoke evacuation must be in close proximity to the source of the smoke plume to reduce or eliminate the hazardous effects on the respiratory system.

Researchers concluded that devices for smoke evacuation must be in close proximity to the source of the smoke plume to reduce or eliminate hazardous effects on the respiratory system.

The study by Wenig et al had a larger sample size than that of Gatti et al and was performed in a more-controlled, laboratory setting. Both conclusions, however, identify the potential hazards associated with surgical smoke plume and the need for evacuation devices. Wenig and colleagues took an additional step in their study by using these devices to extract smoke plume and testing the efficacy of such evacuation devices at protecting personnel. Smoke plume extracted from evacuators with double filtration in place appeared to produce a lesser degree of histological damage.[10] Their results seem to validate further the need for consistent, mandatory use of such devices in the OR.

Smoke may seed malignant cells. Fletcher et al[11] conducted a study proposing that electrosurgical smoke was a vehicle for transplanting malignant cells to benign tissue. The observed occurrence of port site metastasis after laparoscopic resection of colon tumors led investigators to believe that the smoke might contain viable malignant cells after cauterization of the tumor. The smoke building up in the peritoneal cavity might have the capability of seeding to other sites within the abdomen. The seeding took place at sites in the abdominal wall, where trocars had been placed to allow for the introduction of electrosurgical probes. These new malignancy sites were distant from the original colon tumor.

TABLE 1
Studies Reviewed

Year published	Type of study	Research question or problem	Methodology	Sample composition and size	Study results
1992[1]	Quantitative	What is the mutagenicity of electrocautery smoke?	Airborne particles collected on glass fiber filters tested with *Salmonella* microsomal suspension test	Multiple air samples from two breast reduction surgeries as well as control air	Extracts from smoke changed the genetic makeup of *Salmonella* (ie, the histidine dependence of TA98 strain was altered)
1993[2]	Quantitative	What are the effects of laser plume and cautery smoke on the respiratory system?	Animals exposed directly to smoke plume in polymethyl methacrylate chambers, observed for behavior changes, and euthanized to examine lung parenchyma	12 male rats were studied in phases with increasing exposure time to both laser plume and electrosurgical smoke	Changes in animal behavior (eg, rats became sluggish when exposed to smoke plume), and histological changes in lung parenchyma
1999[3]	Quantitative	Can malignant cells remain viable in smoke and seed to benign sites?	Melanoma cells cauterized and examined for viability in smoke at varied wattages immediately after cauterization and for 5 to 7 days after cauterization	10 aerosol samples of cauterized melanoma with a control sample from cauterization of white paper	Viable cells from smoke present up to 1 week after collection

For purposes of investigation, melanoma cells were cauterized under aseptic conditions and tested for cell viability. The researchers conducted their experiment in two parts. Part one identified live cells in the smoke immediately after cauterization. Part two quantified the number of live cells in the smoke one week after collection. Then tumor cells were cauterized at varying wattages in short bursts to simulate actual surgical conditions. Control smoke that was not produced from tumor cauterization was used for comparison.

The researchers concluded that intact viable melanoma cells could be identified in significant quantities in the surgical smoke generated by tumor cauterization. Furthermore, the cells present immediately after collection remained viable for five to seven days under laboratory conditions.

Although the investigators admit to criticism within laboratory circles regarding the sensitivity of the culture medium in estimating cell death during part one of the study, there is widespread agreement that the assay material used in part two had a greater degree of accuracy. The higher

TABLE 1
Studies Reviewed (continued)

Year published	Type of study	Research question or problem	Methodology	Sample composition and size	Study results
2002[4]	Quantitative	Can plume be a vehicle for disease transmission?	Plume collected from lasered bovine papilloma virus (BPV) and reinoculated onto the skin of calves	9 samples from 3 calves with BPV	2 of 3 calves developed lesions with DNA identical to original lesions; therefore viral transmission is possible in plume
2007[5]	Quantitative	Identification of the organic compounds found in electrocautery smoke	Smoke obtained during abdominal laparotomy procedures analyzed with ion flow mass spectrometry	6 samples of smoke and a control air sample obtained outside of the OR	Organic compounds identified in smoke include hydrogen cyanide, butadiene, and acetylene

1. Gatti JE, Bryant CJ, Noone RB, Murphy JB. The mutagenicity of electrocautery smoke. Plast Reconstr Surg. *1992;89(5):781-784.*
2. Wenig BL, Stenson KM, Wenig BM, Tracey D. Effects of plume produced by the Nd:YAG laser and electrocautery on the respiratory system. Lasers Surg Med. *1993;13(2):242-245.*
3. Fletcher JN, Mew D, DesCoteaux JG. Dissemination of melanoma cells within electrocautery plume. Am J Surg. *1999;178(1):57-59.*
4. Garden JM, O'Banion MK, Bakus AD, Olson C. Viral disease transmitted by laser-generated plume (aerosol). Arch Dermatol. *2002;138(10):1303-1307.*
5. Moot AR, Ledingham KM, Wilson PF, et al. Composition of volatile organic compounds in diathermy plume as detected by selected ion flow tube mass spectrometry. ANZ J Surg. *2007;77(1-2):20-23.*

electrosurgical wattage selections resulted in greater destruction of cells; however, despite high heat concentrations, viable tumor cells were identified in all samples.[11]

Finding viable tumor cells in surgical smoke lends support to the researchers' hypothesis that the incidence of port site metastasis may be a result of implantation from cells contained in the smoke.[11] Although Fletcher and colleagues focused primarily on the clinical problem that occurred in laparoscopic colon resection, the study's findings could be used to support the contention that surgical smoke plume contains harmful waste in the form of malignant cellular debris. Surgical smoke plume, therefore, should be treated as a biohazard with proper disposal of smoke evacuation materials (eg, suction unit with sufficient vacuum pressure to adequately capture the smoke plume, filter, and tubing withing close proximity to the source).

The risk of perioperative personnel inhaling viable tumor debris via surgical smoke plume cannot be discounted. Although a case could be

made that the tumor cells contained within the smoke had been grown in a culture medium and not a human respiratory tract, the findings support that viable cells are present in the aerosol of surgical smoke plume, and as such, surgical smoke plume should be treated as a contaminated by-product of surgery. It would appear that smoke evacuation is the only reliable solution for eliminating the possibility of inspiring biohazardous material in the OR.

Surgical smoke plume and disease transmission. The scientific work of Fletcher et al would seem to support the dramatic findings of Garden et al[12] in proving the ability of surgical plume to be a vehicle for transmitting infectious disease. Garden and colleagues described their study as the first of its kind to prove that surgical plume can transmit disease. The researchers made a strong case for adhering strictly to the use of personal protective equipment, including gowns, gloves, eye protection, and masks, and the use of smoke evacuation systems with high flow volume and good filtration capabilities for those in contact with surgical plume.

Viable cells are present in the aerosol of surgical smoke plume, and smoke evacuation appears to be the only reliable solution for dealing with this contaminated by-product of surgery.

Although the study is lacking in detail regarding sample size compared with the previous studies, Garden et al collected viable papillomavirus in plume. Bovine papillomavirus (BPV) was used in this study; however, the researchers noted that previous studies have recovered human papillomavirus (HPV) in plume produced by laser vaporization of these types of lesions. Much like the Fletcher study, Garden's study employed three wattage settings when extracting bovine viral DNA from the plume. Two of three calves inoculated with the viral DNA collected from laser plume developed bovine fibropapilomas identical to the original lesions.[12]

The investigators admitted that the injection of BPV to produce transmission of the disease does not equal routine clinical exposure to plume in the OR. They referred to a previous study, however, that reported on the development of laryngeal papillomatosis containing HPV in a surgeon who had been routinely treating these types of lesions with a laser. Garden and colleagues strongly advised that safety precautions including smoke evacuation during laser surgery be strictly maintained. They asserted, however, that limited use of aerosol-producing lasers in favor of other treatment modalities for patients with viral lesions is appropriate in some situations.

Chronicity of exposure. Finally, a study published in 2007 examined the chemical compounds extracted from surgical smoke and evaluated the possible health risk as a result of exposure to those chemicals. Moot et al[13] reported that the discovery of volatile organic compounds in surgical smoke had been facilitated by the recent development of an ion flow mass spectrometer that has the capacity to detect the most minute amounts of hazardous chemicals. These investigators collected surgical smoke produced during an actual surgical procedure (ie, abdominal laparotomy), much like Gatti et al.

The researchers analyzed nine samples of electrosurgical smoke and three control samples. They collected the nine study samples at a distance from the surgical site that replicated the concentrations of smoke that typically would be inspired. Compounds consistently identified in all the electrosurgical smoke samples were hydrogen cyanide, acetylene, and butadiene. The researchers noted that their results did, in fact, detect low concentrations of volatile organic compounds in the smoke, a finding that probably represented a chronic low exposure risk to personnel.[13] They suggested that the level of hydrogen cyanide present in their samples was 30

times less than that of directly inhaled cigarette smoke. They also recognized, however, that chronic exposure to such volatile organic compounds could be a health hazard similar to that of exposure to second-hand cigarette smoke.

For perioperative personnel, the chronicity of exposure may be a factor that thus far has not been determined. Although hydrogen cyanide has been associated with cardiotoxicity, the compound butadiene is a known carcinogen. Because there is a lack of evidence that surgical smoke is safe to breathe, the researchers recommended using smoke evacuation, which, in their opinion, significantly reduces exposure.[13]

Because there is a lack of evidence that surgical smoke is safe to breathe, researchers recommend using smoke evacuation to significantly reduce exposure.

Advocating for the Health and Safety of Perioperative Personnel

Available research seems to indicate that there are several inherent dangers and health risks associated with exposure to surgical smoke plume. As early as 1988, researchers published studies that revealed the presence of mutagens, carcinogens, and viable disease-causing cells in the smoke plume produced by heat destruction of human tissue.[2] Perioperative personnel continue to inspire this obvious health hazard, often without the benefit of any type of smoke evacuation system. Standard surgical masks offer little protection. Without regulatory mandates, many administrative personnel at health care organizations continue to allow surgical personnel to be the victims of this malodorous contaminant.

Surgical smoke plume quickly dissipates; therefore, it fails to garner the attention afforded to material soiled with blood or other body fluids. In view of the research, however, it would appear that the designation of surgical smoke plume as a biohazard should be equal to that of other harmful waste products. As such, it would be reasonable to expect that the same type of safeguards be implemented (eg, mandatory use of smoke evacuation for all types of surgical smoke plume) to avoid exposure.

Further research using authentic surgical conditions rather than laboratory simulations may produce more convincing findings to assist regulatory agencies such as the OSHA. The studies by Gatti et al[9] in 1992 and Moot et al[13] in 2007 probably are the most convincing thus far. In addition, a longitudinal study comparing the respiratory tracts of new versus senior perioperative personnel may be in order. Comparing the pulmonary capacity of personnel who routinely use evacuation devices compared to those who do not also could be a topic of study.

Although the exposure to surgical smoke plume may, at the very least, pose a minimal risk, any risk to the health and safety of perioperative team members requires serious attention. The studies in this review overwhelmingly agree that some type of smoke evacuation system could effectively eliminate and/or reduce exposure to surgical smoke plume.

Furthermore, four of five studies in this review recommended the use of smoke evacuation devices, which supports the hypothesis that mandatory compliance with smoke evacuation must be ensured in all ORs to maintain a healthy environment for perioperative personnel. Expense, convenience, and apathy are unacceptable impediments when the health and safety of perioperative personnel may be compromised without these devices. Although recommendations from professional organizations to decrease exposure to surgical smoke plume are beneficial, available evidence indicates that it is time to mandate the use of smoke evacuation systems in every OR.

Perioperative nurses routinely advocate for the welfare and safety of their patients. The time has come for them to be advocates for their own health and safety as well. Perioperative nurses working at health care organizations that have smoke evacuators should insist on using them. The devices themselves should be considered contaminated materials and

treated as a biohazard necessitating proper disposal.[4] If the facility does not evacuate surgical smoke plume, perioperative nurses should make those in charge of safety aware of the research and campaign for the purchase of these devices. – AORN –

References

1. Buffalo Filter Resource Center. What is it? Buffalo Filter. http://www.buffalofilter.com/Resources.aspx. Accessed October 16, 2007.
2. Baggish MS, Baltoyannis P, Sze E. Protection of the rat lung from the harmful effects of laser smoke. *Lasers Surg Med.* 1988;8(3):248-253.
3. Thomas L. No smoking in the OR. *Outpt Surg Mag*. November 2004:37-40.
4. Andersen E. Surgical smoke—is there a fire? *AAOHN J*. 2005;53(3):103-104.
5. Laser/electrosurgery plume. United States Department of Labor. Occupational Safety & Health Administration. http://www.osha.gov/SLTC/laserelectrosurgeryplume/index.html. Accessed October 16, 2007.
6. Recommended practices for electrosurgery. In: *Standards, Recommended Practices, and Guidelines.* Denver, CO: AORN, Inc; 2007:524-525.
7. *ANSI Z135.3. The Safe Use of Lasers in Health Care Facilities.* Washington, DC: American National Standards Institute; 1996:7.
8. Roark J. Dangers of surgical smoke still persist despite awareness campaign. *Infection Control Today*. July 2003. http://www.infectioncontroltoday.com/articles/406/406_371topics.html. Accessed October 16, 2007.
9. Gatti JE, Bryant CJ, Noone RB, Murphy JB. The mutagenicity of electrocautery smoke. *Plast Reconstr Surg.* 1992;89(5):781-784.
10. Wenig BL, Stenson KM, Wenig BM, Tracey D. Effects of plume produced by the Nd:YAG laser and electrocautery on the respiratory system. *Lasers Surg Med.* 1993;13(2):242-245.
11. Fletcher JN, Mew D, DesCoteaux JG. Dissemination of melanoma cells within electrocautery plume. *Am J Surg.* 1999;178(1):57-59.
12. Garden JM, O'Banion MK, Bakus AD, Olson C. Viral disease transmitted by laser-generated plume (aerosol). *Arch Dermatol.* 2002;138(10):1303-1307.
13. Moot AR, Ledingham KM, Wilson PF, et al. Composition of volatile organic compounds in diathermy plume as detected by selected ion flow tube mass spectrometry. *ANZ J Surg.* 2007;77(1-2):20-23.

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Purchasing Medications Over the Internet Is Risky

Consumers who purchase prescription medications from foreign Internet sites may put their health at risk and may not be saving money, according to a July 2, 2007, news release by the US Food and Drug Administration (FDA). Purchasing medications over the Internet without a prescription is a particularly unsafe practice.

The FDA warns that purchasing medications from unregulated Internet sellers raises numerous safety concerns. Some of these medications may

- require careful dosing and monitoring,
- not have adequate labeling for safe and effective use,
- have product integrity issues because of inappropriate packaging,
- have been withdrawn from the US market for safety or efficacy reasons,
- carry risks that require initial screening or periodic patient monitoring,
- cause harm unless their use is supervised by a health care professional because of the potential for abuse of the medication,
- not have been manufactured under proper conditions to ensure sterility and may be susceptible to contamination, and
- have clinically significant interactions with other medications a patient is taking.

New data also reveal that imported medications may actually cost more than generic versions of domestic medications. An examination of foreign mail shipments found that approximately 45% of the imported medications are available in the United States as FDA-approved generic medications. About half of these generic medications are available through national pharmacy chain programs that offer generic prescriptions at $4 each, a cost that usually is significantly less than the cost for medications purchased through Internet sites.

FDA finds consumers continue to buy potentially risky drugs over the Internet [news release]. Rockville, MD: US Food and Drug Administration; July 2, 2007. http://www.fda.gov/bbs/topics/NEWS/2007/NEW01663.html. Accessed August 31, 2007.

Risks Associated with Exposure to Surgical Smoke Plume: A Review of the Literature

Purpose/Goal

To educate perioperative nurses about the risks associated with surgical smoke plume.

Behavioral Objectives

After reading and studying the article on surgical smoke plume, nurses will be able to

1. explain why surgical smoke plume presents a risk for perioperative personnel,
2. identify reasons why smoke evacuators may not be used in some ORs,
3. describe the results of the studies on smoke plume presented in this article, and
4. discuss recommendations for further research studies on surgical smoke plume.

Questions

1. Resistance to the use of smoke evacuators can be attributed to
   1. desensitization to the offensive odors.
   2. expense.
   3. inconvenience.
   4. lack of knowledge.
   5. lack of evidence that these devices are effective.

   a. 1 and 2
   b. 3, 4, and 5
   c. 1, 2, 3, and 4
   d. 1, 2, 3, 4, and 5

2. No legal and regulatory mandates specific to smoke evacuation currently exist.
   a. true
   b. false

3. In a study conducted by Gatti et al, heat destruction of breast tissue with electrosurgery resulted in smoke containing
   1. acetylene.
   2. ammonia.
   3. butadiene.
   4. formaldehyde.
   5. hydrogen cyanide.
   6. strychnine.

   a. 1, 3, and 5
   b. 2, 4, and 6
   c. 1, 2, 3, 4, and 5
   d. 1, 2, 3, 4, 5, and 6

4. Wenig et al noted in their study that rats exposed to electrosurgical smoke and laser plume
   1. became sluggish during exposure.
   2. developed pulmonary blood vessel hypertrophy, alveolar congestion, and emphysematous changes.
   3. became aggressive and frenzied during exposure.

   a. 1
   b. 1 and 2
   c. 2 and 3

5. The results of a study by Fletcher et al supported the researchers' hypothesis that port site metastasis may be a result of implantation from tumor cells contained in surgical smoke.
   a. true
   b. false

6. In a study conducted by Garden et al, two of three calves inoculated with the viral DNA collected from laser plume developed

a. bovine fibropapilomas.
b. cutaneous papillomatosis.
c. human papillomavirus.

7. Moot et al suggested that chronic exposure to volatile organic compounds found in electrosurgical smoke could be a health hazard similar to that of exposure to
a. asbestos.
b. carbon monoxide.
c. gasoline fumes.
d. second-hand cigarette smoke.

8. Standard surgical masks offer adequate protection from the heath hazards of surgical smoke plume.
a. true
b. false

9. Recommendations for further research on surgical smoke plume include
1. using authentic surgical conditions rather than laboratory simulations.
2. conducting longitudinal studies comparing the respiratory tracts of new versus senior perioperative personnel.
3. comparing the pulmonary capacity of personnel who routinely use evacuation devices with those who do not.

a. 1 and 2
b. 2 and 3
c. 1, 2, and 3

10. _____ of the five studies evaluated in the literature review recommended the use of smoke evacuation devices in ORs.
a. One
b. Two
c. Three
d. Four

The behavioral objectives and examination for this program were prepared by Rebecca Holm, RN, MSN, CNOR, clinical editor, with consultation from Susan Bakewell, RN, MS, BC, director, Center for Perioperative Education. Ms Holm and Ms Bakewell have no declared affiliations that could be perceived as a potential conflicts of interest in publishing this article.

This program meets criteria for CNOR and CRNFA recertification, as well as other continuing education requirements.

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Answer Sheet

1.8 CE

Risks Associated with Exposure to Surgical Smoke Plume: A Review of the Literature

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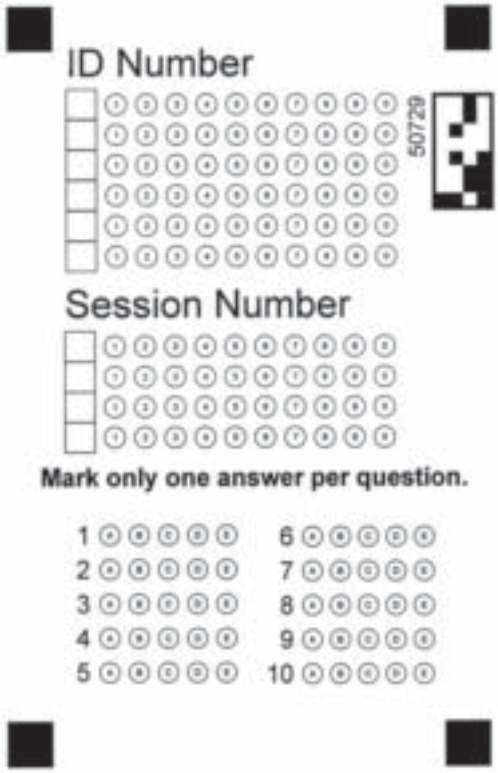

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1.8 Learner Evaluation

Risks Associated with Exposure to Surgical Smoke Plume: A Review of the Literature

THIS EVALUATION is used to determine the extent to which this continuing education program met your learning needs. Rate these items on a scale of 1 to 5.

PURPOSE/GOAL

To educate perioperative nurses about the risks associated with surgical smoke plume.

OBJECTIVES

To what extent were the following objectives of this continuing education program achieved?

1. Explain why surgical smoke plume presents a risk for perioperative personnel.
2. Identify reasons why smoke evacuators may not be used in some ORs.
3. Describe the results of the studies on smoke plume presented in this article.
4. Discuss recommendations for further research studies on surgical smoke plume.

CONTENT

To what extent

5. did this article increase your knowledge of the subject matter?
6. was the content clear and organized?
7. did this article facilitate learning?
8. were your individual objectives met?
9. did the objectives relate to the overall purpose/goal?

TEST QUESTIONS/ANSWERS

To what extent

10. were they reflective of the content?
11. were they easy to understand?
12. did they address important points?

LEARNER INPUT

13. Will you be able to use the information from this article in your work setting?
    1. yes
    2. no
14. I learned of this article via
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    2. a *Journal* I obtained elsewhere.
    3. the *AORN Journal* web site.
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    3. subject matter relevant to current position
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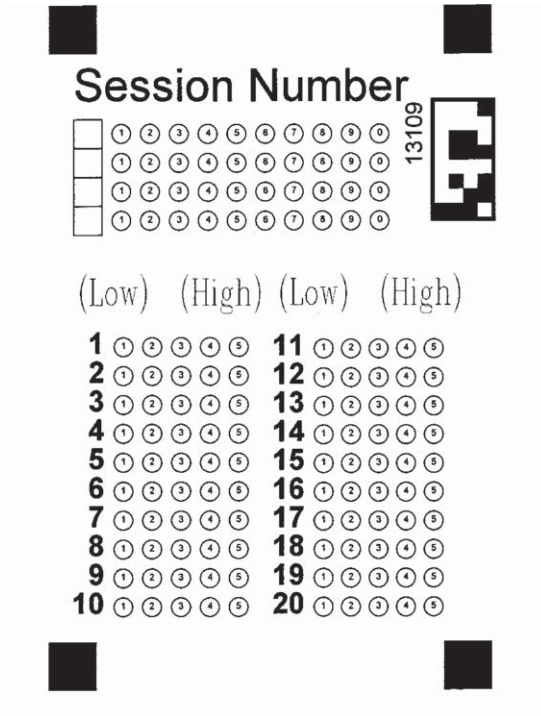

What other topics would you like to see addressed in a future continuing education article? Would you or someone you know be interested in writing an article on this topic?

Topic(s): _____

_____

_____

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