Anesthesiology 2008; 108:786–801

Practice Advisory for the Prevention and Management of Operating Room Fires

*A Report by the American Society of Anesthesiologists Task Force on Operating Room Fires**

CME This article has been selected for the ANESTHESIOLOGY CME Program. After reading the article, go to http://www.asahq.org/journal-cme to take the test and apply for Category 1 credit. Complete instructions may be found in the CME section at the back of this issue.

PRACTICE advisories are systematically developed reports that are intended to assist decision making in areas of patient care. Advisories are based on a synthesis of scientific literature and analysis of expert opinion, clinical feasibility data, open forum commentary, and consensus surveys. Advisories developed by the American Society of Anesthesiologists (ASA) are not intended as standards, guidelines, or absolute requirements. They may be adopted, modified, or rejected according to clinical needs and constraints.

The use of practice advisories cannot guarantee any specific outcome. Practice advisories summarize the state of the literature and report opinions obtained from expert consultants and ASA members. Practice advisories are not supported by scientific literature to the same degree as standards or guidelines because of the lack of sufficient numbers of adequately controlled studies. Practice advisories are subject to periodic revision as warranted by the evolution of medical knowledge, technology, and practice.

Additional material related to this article can be found on the ANESTHESIOLOGY Web site. Go to http://www.anesthesiology.org, click on Enhancements Index, and then scroll down to find the appropriate article and link. Supplementary material can also be accessed on the Web by clicking on the "ArticlePlus" link either in the Table of Contents or at the top of the HTML version of the article.

The incidence of operating room (OR) fires is difficult to determine, due in part to the lack of a mandatory national reporting system for OR fires.[1–3] Some estimates suggest that between 50 and 200 OR fires occur in the United States every year, with as many as 20% of reported fires resulting in serious injury or death.[4,5]

Fire requires the presence of three components, known as the "fire triad": (1) an oxidizer, (2) an ignition source, and (3) fuel.

- *Oxidizers* used in the OR are oxygen and nitrous oxide. An oxidizer-enriched atmosphere increases the likelihood and intensity of combustion. An oxidizer-enriched atmosphere commonly exists within closed or semiclosed breathing systems, including the patient's airway. It can also be created locally when the configuration of the drapes and open oxygen sources (*e.g.*, masks, nasal cannula) promote the trapping or pooling of oxygen or a mixture of oxygen and nitrous oxide.

KEY CONCEPT: An *oxidizer-enriched atmosphere* occurs when there is any increase in oxygen concentration above room air level, and/or the presence of any concentration of nitrous oxide.

- *Ignition* sources include, but are not limited to, electrosurgical or electrocautery devices, lasers, heated probes, drills and burrs, argon beam coagulators, fiberoptic light cables, and defibrillator paddles or pads.
- *Fuel* sources include, but are not limited to, tracheal tubes; sponges; drapes; gauze; alcohol-containing solutions (*e.g.*, certain prepping solutions); solutions containing other volatile compounds, such as ether or acetone; oxygen masks; nasal cannulae; the patient's hair; dressings; ointments; gowns; gastrointestinal tract gases; blankets; suction catheters; flexible endoscopes; fiberoptic cable coverings; gloves; and packaging materials.†

Methodology

A. Definition of OR Fires, High-risk Procedures, and OR Fire Drills

For this Advisory, *operating room fires* are defined as fires that occur on or near patients who are under anesthesia care, including surgical fires, airway fires, and fires within the airway circuit. A *surgical fire* is defined as a fire that occurs on or in a patient. An *airway fire* is a specific type of surgical fire that occurs in a patient's

* Developed by the American Society of Anesthesiologists Task Force on Operating Room Fires: Robert A. Caplan, M.D. (Chair), Seattle, Washington; Steven J. Barker, Ph.D., M.D., Tucson, Arizona; Richard T. Connis, Ph.D., Woodinville, Washington; Charles Cowles, M.D., Deer Park, Texas; Albert L. de Richemond, M.S., P.E., Plymouth Meeting, Pennsylvania; Jan Ehrenwerth, M.D., Madison, Connecticut; David G. Nickinovich, Ph.D., Bellevue, Washington; Donna Pritchard, R.N., Brooklyn, New York; David Roberson, M.D., Boston, Massachusetts; Gerald L. Wolf, M.D. (Honorary), Brooklyn, New York.

Submitted for publication November 6, 2007. Accepted for publication November 6, 2007. Supported by the American Society of Anesthesiologists under the direction of James F. Arens, M.D., Chair, Committee on Standards and Practice Parameters. Approved by the House of Delegates on October 17, 2007. A complete list of references used to develop this Advisory is available by writing to the American Society of Anesthesiologists.

This Practice Advisory has been endorsed by the American Academy of Otolaryngology–Head and Neck Surgery.

Address correspondence to the American Society of Anesthesiologists: 520 N. Northwest Highway, Park Ridge, Illinois 60068-2573. This Practice Advisory, as well as all published American Society of Anesthesiologists Practice Parameters, may be obtained at no cost through the Journal Web site, www.anesthesiology.org.

† Some of these items only burn in an oxidizer-enriched atmosphere.

airway. Airway fires may or may not include fire in the attached breathing circuit.

A *high-risk procedure* is defined as one in which an ignition source (*e.g.*, electrosurgery) may come in proximity to an oxidizer-enriched atmosphere (*e.g.*, supplemental oxygen and/or nitrous oxide), thereby increasing the risk of fire. Examples of high-risk procedures include, but are not limited to, tonsillectomy, tracheostomy, removal of laryngeal papillomas, cataract or other eye surgery, burr hole surgery, or removal of lesions on the head, neck, or face.

An *OR fire drill* is defined as a formal and periodic rehearsal of the OR team's planned response to a fire. In this Advisory, the OR fire drill is characterized as a "formal and periodic rehearsal" to indicate that it takes place during dedicated education time, *not during patient care*. In other words, an OR fire drill is *not the same* as a discussion or plan about fire management that takes place during direct patient care.

B. Purpose

The purposes of this Advisory are to (1) identify situations conducive to fire, (2) prevent the occurrence of OR fires, (3) reduce adverse outcomes associated with OR fires, and (4) identify the elements of a fire response protocol. Adverse outcomes associated with OR fires may include major or minor burns, inhalation injuries, infection, disfigurement, and death. Related adverse outcomes may include psychological trauma, prolonged hospitalization, delay or cancellation of surgery, additional hospital resource utilization, and liability.

C. Focus

This Advisory focuses on a specific care setting and subset of fires. The specific care setting is any OR or procedure area where anesthesia care is provided. The specific subset is fires that occur on the patient, in the airway, or in the breathing circuit. This Advisory does not address fires away from the patient (*e.g.*, in a trash can), institutional preplanning for fire, or the responses of fire personnel.

D. Application

This Advisory is intended for use by anesthesiologists or other individuals working under the supervision of an anesthesiologist. Because prevention of OR fires requires close collaboration and prompt coordination between anesthesiologists, surgeons, and nurses, some responsibilities are shared among the disciplines. When shared responsibilities are described in this Advisory, the intent is to give the anesthesiologist a starting point for participating in the allocation and understanding of shared responsibilities. The Advisory may also serve as a resource for other physicians and healthcare professionals (*e.g.*, technicians, safety officers, hospital administrators, biomedical engineers, industry representatives).

E. Task Force Members and Consultants

The ASA appointed a Task Force of nine members. These individuals included four anesthesiologists in private and academic practice from various geographic areas of the United States, an otolaryngologist, a perioperative registered nurse, a professional engineer/fire investigator, and two consulting methodologists from the ASA Committee on Standards and Practice Parameters. Two Task Force members are former firefighters.

The Task Force developed the Advisory by means of a seven-step process. First, they reached consensus on the criteria for evidence. Second, a systematic review and evaluation was performed on original, published, peer-reviewed and other research studies related to OR fires. Third, a panel of expert consultants was asked to (1) participate in opinion surveys on the effectiveness of various strategies for fire prevention, detection, and management and (2) review and comment on a draft of the Advisory developed by the Task Force. Fourth, opinions about the Advisory were solicited from a random sample of active members of the ASA. Fifth, the Task Force held an open forum at a major national meeting‡ to solicit input on its draft recommendations. Sixth, the consultants were surveyed to assess their opinions on the feasibility of implementing this Advisory. Seventh, all available information was used to build consensus within the Task Force to formulate the advisory statements (appendix 1).

F. Availability and Strength of Evidence

Preparation of this Advisory followed a rigorous methodological process (appendix 2). Evidence was obtained from two principal sources: scientific evidence and opinion-based evidence.

Scientific Evidence. Study findings from published scientific literature were aggregated and are reported in summary form by evidence category, as described below. All literature (*e.g.*, randomized controlled trials, observational studies, case reports) relevant to each topic was considered when evaluating the findings. However, for reporting purposes in this document, only the highest level of evidence (*i.e.*, level 1, 2, or 3) within each category is included in the summary.

Category A: Supportive Literature. Randomized controlled trials report statistically significant ($P < 0.01$) differences between clinical interventions for a specified clinical outcome.

Level 1: The literature contains multiple randomized controlled trials, and the aggregated findings are supported by meta-analysis.§

‡ Society for Ambulatory Anesthesia, 22nd Annual Meeting, San Diego, California, May 5, 2007.

§ All meta-analyses are conducted by the ASA methodology group. Meta-analyses from other sources are reviewed but not included.

Level 2: The literature contains multiple randomized controlled trials, but there is an insufficient number of studies to conduct a viable meta-analysis for the purpose of this Advisory.
Level 3: The literature contains a single randomized controlled trial.

Category B: Suggestive Literature. Information from observational studies permits inference of beneficial or harmful relationships among clinical interventions and clinical outcomes.

Level 1: The literature contains observational comparisons (*e.g.*, cohort, case–control research designs) of two or more clinical interventions or conditions and indicates statistically significant differences between clinical interventions for a specified clinical outcome.
Level 2: The literature contains noncomparative observational studies with associative (*e.g.*, relative risk, correlation) or descriptive statistics.
Level 3: The literature contains case reports.

Category C: Equivocal Literature. The literature cannot determine whether there are beneficial or harmful relationships among clinical interventions and clinical outcomes.

Level 1: Meta-analysis did not find significant differences among groups or conditions.
Level 2: There is an insufficient number of studies to conduct meta-analysis and (1) randomized controlled trials have not found significant differences among groups or conditions or (2) randomized controlled trials report inconsistent findings.
Level 3: Observational studies report inconsistent findings or do *not* permit inference of beneficial or harmful relationships.

Category D: Insufficient Evidence from Literature. The *lack of scientific evidence* in the literature is described by the following terms.

Silent: No identified studies address the specified relationships among interventions and outcomes.
Inadequate: The available literature cannot be used to assess relationships among clinical interventions and clinical outcomes. The literature either does not meet the criteria for content as defined in the "Focus" of the Advisory or it does not permit a clear interpretation of findings due to methodologic concerns (*e.g.*, confounding in study design or implementation).

Opinion-based Evidence. All opinion-based evidence relevant to each topic (*e.g.*, survey data, open-forum testimony, Web-based comments, letters, editorials) is considered in the development of this Advisory. However, only the findings obtained from formal surveys are reported.

Opinion surveys were developed by the Task Force to address each clinical intervention identified in the document. Identical surveys were distributed to two groups of respondents: expert consultants and ASA members.

Category A: Expert Opinion. Survey responses from Task Force–appointed expert consultants are reported in summary form in the text. A complete listing of consultant survey responses is reported in appendix 2.

Category B: Membership Opinion. Survey responses from a random sample of members of the ASA and, when appropriate, responses from members of other organizations with expertise in the selected topics of interest are reported in summary form in the text. A complete listing of ASA member survey responses is reported in appendix 2.

Survey responses are recorded using a five-point scale and summarized based on median values.‖

Strongly Agree: Median score of 5 (at least 50% of the responses are 5)
Agree: Median score of 4 (at least 50% of the responses are 4 or 4 and 5)
Equivocal: Median score of 3 (at least 50% of the responses are 3, or no other response category or combination of similar categories contains at least 50% of the responses)
Disagree: Median score of 2 (at least 50% of responses are 2 or 1 and 2)
Strongly Disagree: Median score of 1 (at least 50% of responses are 1)

Category C: Informal Opinion. Open-forum testimony, Web-based comments, letters, and editorials are all informally evaluated and discussed during the development of the Advisory. When warranted, the Task Force may add educational information or cautionary notes based on this information.

Advisories

I. Education

Operating room fire safety education includes, but is not limited to, knowledge of institutional fire safety protocols and participation in institutional fire safety education. Case reports indicate that lack of education can result in severe injury and death from uncontrolled OR fires.[6,7] [Category B3 evidence.]

The consultants and ASA members strongly agree that every anesthesiologist should have knowledge of institutional fire safety protocols for the OR, and should participate in OR fire safety education. The consultants and ASA members strongly agree that OR fire safety education for the anesthesiologist should emphasize the risk created by an oxidizer-enriched atmosphere.

‖ When an even number of responses are obtained, the median value is determined by a calculating the arithmetic mean of the two middle values. Ties are calculated by a predetermined formula.

Advisory Statements. All anesthesiologists should have fire safety education, specifically for OR fires, with emphasis on the risk created by an oxidizer-enriched atmosphere.

II. OR Fire Drills

A case report indicates that OR fire drills and simulation training can result in improved staff response to a fire.[8] [Category B3 evidence.]

The consultants strongly agree and ASA members agree that all anesthesiologists should periodically participate in OR fire drills with the entire OR team. The consultants and ASA members strongly agree that participation should take place during dedicated educational time, not during patient care.

Advisory Statements. Anesthesiologists should periodically participate in OR fire drills with the entire OR team. This formal rehearsal should take place during dedicated educational time, not during patient care.

III. Preparation

Preparation for OR fires includes (1) determining whether or not a high-risk situation exists and (2) a team discussion of the strategy for the prevention and management of an OR fire in a high-risk situation. The literature is silent regarding whether a preoperative determination of a high-risk situation or a team discussion of OR fire strategy reduces the incidence or severity of an OR fire. [Category D evidence.]

The consultants strongly agree and ASA members agree that anesthesiologists should participate with the entire OR team in assessing the risk of an OR fire for each case and determining whether a high-risk situation exists. The consultants strongly agree and ASA members agree that all team members should jointly agree on how a fire will be prevented and managed for each particular procedure. The consultants and ASA members strongly agree that a protocol for the prevention and management of fires should be posted in each location where a procedure is performed.

Advisory Statements. For every case, the anesthesiologist should participate with the entire OR team (*e.g.*, during the surgical pause) in determining whether a high-risk situation exists. If a high-risk situation exists, all team members—including the anesthesiologist—should take a joint and active role in agreeing on how a fire will be prevented and managed. Each team member should be assigned a specific fire management task to perform in the event of a fire (*e.g.*, removing the tracheal tube, stopping the flow of airway gases). Each team member should understand that his or her preassigned task should be performed immediately if a fire occurs, without waiting for another team member to take action. When a team member has completed a preassigned task, he or she should help other team members perform tasks that are not yet complete.

In every OR and procedure area where a fire triad can exist (*i.e.*, an oxidizer-enriched atmosphere, an ignition source, and fuel), an easily visible protocol for the prevention and management of fires should be displayed (fig. 1).

Equipment for managing a fire should be readily available in every procedural area where a fire triad may exist. Table 1 provides an example of fire management equipment that should be in or near the OR or procedural area.

IV. Prevention

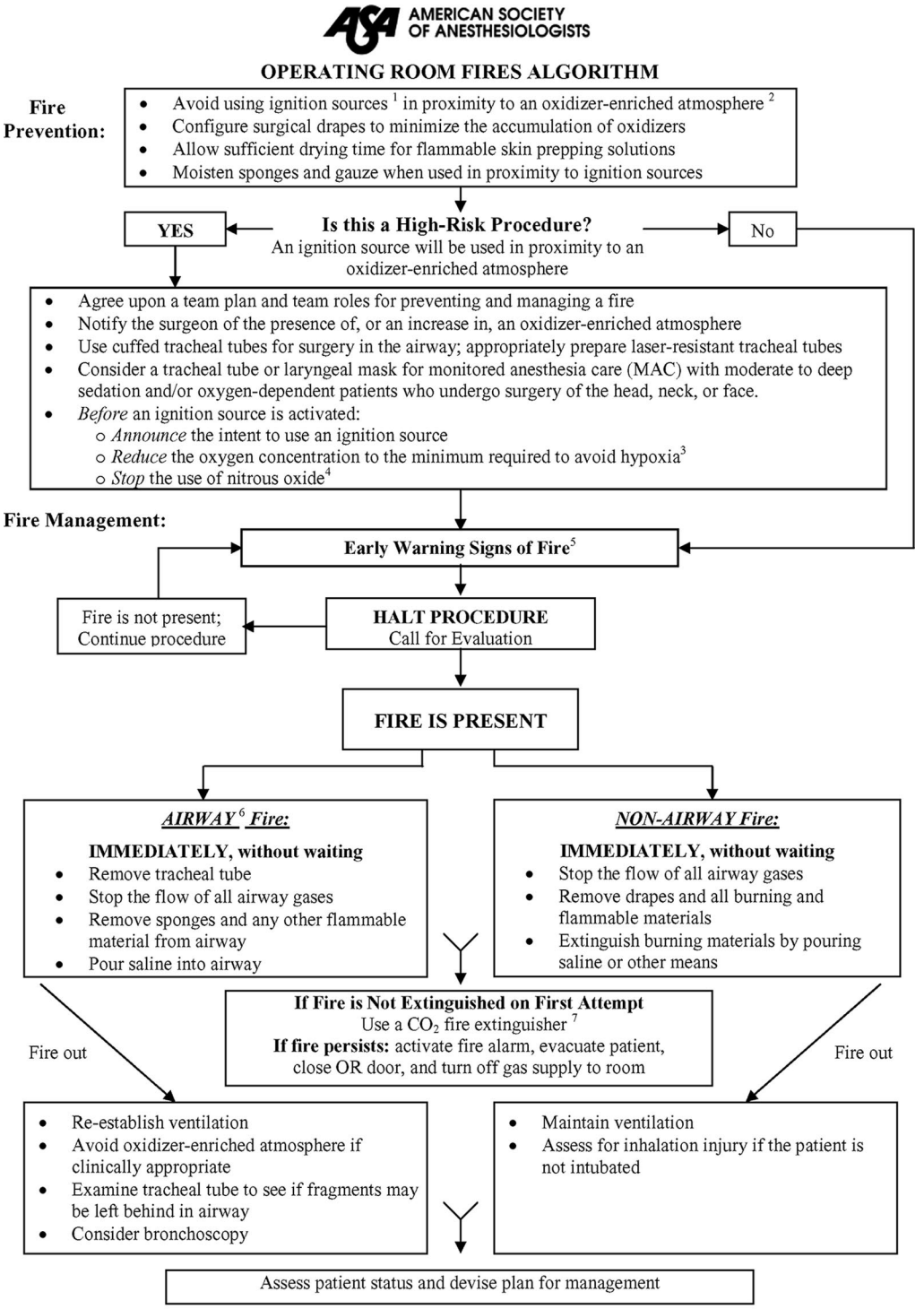
Prevention of OR fires includes (1) minimizing or avoiding an oxidizer-enriched atmosphere near the surgical site, (2) safely managing ignition sources, and (3) safely managing fuels.

Comparative studies indicate that a wide range of material ignites more readily in an oxygen-enriched atmosphere than in room air.[9–13] [Category B1 evidence.] One comparative study with awake volunteer subjects showed that the configuration of surgical drapes can result in oxygen buildup, increasing the risk of fire.[14] [Category B1 evidence.] This study also indicated that replacing oxygen with compressed air or discontinuing supplemental oxygen for a period of time reduces oxygen buildup without significantly reducing oxygen saturation levels. Similarly, a randomized controlled trial comparing supplemental oxygen and compressed air in sedated patients undergoing cataract surgery found no differences in oxygen saturation.[15] [Category C2 evidence.]

Observational studies and case reports indicate that electrocautery or electrosurgical devices and lasers are common sources of ignition for many OR fires, particularly when used in an oxidizer-enriched atmosphere.[16–68] [Category B2–3 evidence.]

Case reports indicate that alcohol-based skin-prepping agents generate volatile vapors that ignite easily. These reports suggest that insufficient drying time after application of alcohol-based skin-prepping agents is a cause of fires on patients.[23,69–73] [Category B3 evidence.] Comparative studies show that conventional tracheal tubes, when exposed to a laser beam, are more likely to ignite or melt than laser-resistant tracheal tubes.[74–84] [Category B1 evidence.] Case reports indicate that dry sponges and gauze are common sources of fuel.[7,19,33,43,45,55,64,83–87] Comparative studies demonstrate that the flammability of sponges, cottonoids, or packing material is reduced when wet rather than dry or partially dry.[88–91] [Category B1 evidence.]

For *all procedures*, the consultants and ASA members strongly agree that flammable skin prepping solutions should be dry before draping. They strongly agree that surgical drapes should be configured to prevent oxygen from accumulating under the drapes or from flowing into the surgical site. They strongly agree that sponges



[1] Ignition sources include but are not limited to electrosurgery or electrocautery units and lasers.
[2] An oxidizer-enriched atmosphere occurs when there is any increase in oxygen concentration above room air level, and/or the presence of any concentration of nitrous oxide.
[3] After minimizing delivered oxygen, wait a period of time (*e.g.,* 1-3 min) before using an ignition source. For oxygen dependent patients, *reduce* supplemental oxygen delivery to the minimum required to avoid hypoxia. Monitor oxygenation with pulse oximetry, and if feasible, inspired, exhaled, and/or delivered oxygen concentration.
[4] After stopping the delivery of nitrous oxide, wait a period of time (*e.g.,* 1-3 min) before using an ignition source.
[5] Unexpected flash, flame, smoke or heat, unusual sounds (*e.g.,* a "pop," snap or "foomp") or odors, unexpected movement of drapes, discoloration of drapes or breathing circuit, unexpected patient movement or complaint.
[6] In this algorithm, airway fire refers to a fire in the airway or breathing circuit.
[7] A CO_2 fire extinguisher may be used on the patient if necessary.

Fig. 1. Operating room fires algorithm. CO_2 = carbon dioxide; OR = operating room.

Table 1. Operating Room Fire Equipment and Supplies That Should Be Immediately Available*

Several containers of sterile saline
A CO_2 fire extinguisher
Replacement tracheal tubes, guides, facemasks
Rigid laryngoscope blades; this may include a rigid fiberoptic laryngoscope
Replacement airway breathing circuits and lines
Replacement drapes, sponges

* Some facilities or locations may benefit from assembling a portable cart containing equipment and supplies that expedite the immediate response to an operating room fire. The contents of such a cart will vary depending on local conditions and resources. If the items needed for an immediate response to an operating room fire are already available, there may be no added benefit to assembling a portable cart.

CO_2 = carbon dioxide.

should be moistened when used near an ignition source, particularly when used in or near the airway.

For *high-risk procedures* (*i.e.*, proximity of an ignition source and an oxidizer-enriched atmosphere), the consultants and ASA members strongly agree that anesthesiologists should collaborate with the procedure team for the purpose of preventing and managing a fire. They strongly agree that the surgeon should be notified whenever an ignition source is in proximity to an oxidizer-enriched atmosphere or when the concentration of oxidizer has increased. They strongly agree that the fraction of inspired oxygen (F_{IO_2}) delivered to the patient should be kept as low as clinically feasible when an ignition source is in proximity to an oxygen-enriched atmosphere. They strongly agree that the reduction of F_{IO_2} delivered to the patient should be guided by monitoring patient oxygenation (*e.g.*, pulse oximetry). Task Force members agree that the reduction of F_{IO_2} should be monitored, if feasible, by measuring inspired, expired, and/or delivered oxygen concentration. They strongly agree that the use of nitrous oxide should be avoided in settings that are considered high risk for fire. The consultants strongly agree and ASA members agree that oxygen or nitrous oxide buildup may be minimized by either insufflating with medical air or scavenging the operating field with suction.

For *laser surgery*, consultants and ASA members strongly agree that laser resistant tracheal tubes should be used, and that the tube choice should be appropriate for the procedure and laser. They both strongly agree that the tracheal cuff of the laser tube should be filled with saline rather than air, when feasible. The consultants strongly agree and the ASA members agree that saline in tracheal tube cuff should be tinted with methylene blue to act as a marker for cuff puncture by a laser.

Surgery inside the airway can bring an ignition source into proximity with an oxidizer-enriched atmosphere, thereby creating a high-risk situation. For cases involving surgery inside the airway, consultants and ASA members both agree that a cuffed tracheal tube should be used instead of an uncuffed tracheal tube when medically appropriate. Because an elevated F_{IO_2} is often necessary during tracheostomy, the Task Force strongly agrees that surgeons should be advised not to enter the trachea with an ignition source such as an electrosurgical device. If an electrosurgical device must be used, the anesthesiologist should request that the surgeon provide adequate warning to allow the concentration of oxidizer to be minimized before the trachea is entered. Consultants and ASA members were asked to report the time that they believe is needed to reduce oxygen or nitrous oxide concentration to a safe level before using an ignition source. For patients being ventilated with a tracheal tube, consultants report a range of time of less than 1 min to 5 min (mean = 1.8 min), and ASA members report a range of time of less than 1 min to 10 min (mean = 2.9 min). For patients wearing a facemask or nasal cannula, both the consultants and ASA members report a range of time of less than 1 min to 5 min (mean = 1.7 min for consultants, and mean = 2.3 min for ASA members). The consultants and ASA members both agree that the oropharynx should be scavenged with suction during oral procedures.

Surgery around the face, head, or neck can bring an ignition source into proximity with an oxidizer-enriched atmosphere, thereby creating a high-risk situation. When monitored anesthesia care is considered for surgery around the face, head, or neck, the Task Force strongly agrees that two specific factors should be considered: (1) the *required depth of sedation* and (2) *oxygen dependence*. The Task Force agrees that a sealed gas delivery device (*e.g.*, cuffed tracheal tube or laryngeal mask) should be considered *if moderate or deep sedation is required or used, or if the patient exhibits oxygen dependence*. If neither factor is present, an open gas delivery device (*e.g.*, facemask or nasal cannula) may be considered. If an open gas delivery system is used, the Task Force agrees that before an ignition source is activated around the face, head, or neck, the surgeon should give the adequate notice that the ignition source will be activated. The anesthesiologist should (1) *stop* the delivery of supplemental oxygen or *reduce* the delivery to the minimum required to avoid hypoxia, and (2) *wait* a few minutes between decreasing the flow of supplemental oxygen and approving the activation of the ignition source. In the unlikely event of nitrous oxide delivery with an open system (*e.g.*, facemask or nasal cannula), the Task Force agrees that the anesthesiologist should (1) *stop* the delivery of nitrous oxide, and (2) *wait* a few minutes between stopping the nitrous oxide and approving the activation of the ignition source.

Advisory Statements. To the extent that is medically appropriate, the following basic principles should be applied to the management of oxidizers, ignition sources, and fuels:

- The anesthesiologist should collaborate with all members of the procedure team *throughout the procedure*

to minimize the presence of an oxidizer-enriched atmosphere in proximity to an ignition source.
- Surgical drapes should be configured to minimize the accumulation of oxidizers (oxygen and nitrous oxide) under the drapes and from flowing into the surgical site.
- Flammable skin prepping solutions should be dry before draping.
- Gauze and sponges should be moistened when used in proximity to an ignition source.

For *high-risk procedures*, the anesthesiologist should notify the surgeon whenever there is a potential for an ignition source to be in proximity to an oxidizer-enriched atmosphere or when there is an increase in oxidizer concentration at the surgical site. Any reduction in supplied oxygen to the patient should be assessed by monitoring (1) pulse oximetry and, if feasible, (2) inspired, exhaled, and/or delivered oxygen concentration.

For *laser procedures*, a laser-resistant tracheal tube should be used, and the tube should be chosen to be resistant to the laser used for the procedure (*e.g.*, carbon dioxide [CO_2], Nd:YAG, Ar, Er:YAG, KTP). The tracheal cuff of the laser tube should be filled with saline and colored with an indicator dye such as methylene blue. *Before* activating a laser, the surgeon should give the anesthesiologist adequate notice that the ignition source is about to be activated. The anesthesiologist should (1) *reduce* the delivered oxygen concentration to the minimum required to avoid hypoxia, (2) *stop* the use of nitrous oxide, and (3) *wait* a few minutes after reducing the oxidizer-enriched atmosphere before approving activation of the laser.

For cases involving an *ignition source* and *surgery inside the airway*, cuffed tracheal tubes should be used when clinically appropriate. The anesthesiologist should advise the surgeon against entering the trachea with an ignition source (*e.g.*, electrosurgery unit). *Before* activating an ignition source inside the airway, the surgeon should give the anesthesiologist adequate notice that the ignition source is about to be activated. The anesthesiologist should (1) *reduce* the delivered oxygen concentration to the minimum required to avoid hypoxia, (2) *stop* the use of nitrous oxide, and (3) *wait* a few minutes after reducing the oxidizer-enriched atmosphere before approving the activation of the ignition source. In some cases (*e.g.*, surgery in the oropharynx), scavenging with suction may be used to reduce oxidizer enrichment in the operative field.

For cases involving *moderate or deep sedation*, *an ignition source*, and *surgery around the face, head, or neck*, the anesthesiologist and surgeon should develop a plan that accounts for the level of sedation and the patient's need for supplemental oxygen.

- If *moderate or deep sedation is required or used*, or if the patient exhibits *oxygen dependence*, the anesthesiologist and surgeon should consider a sealed gas delivery device (*e.g.*, cuffed tracheal tube or laryngeal mask).
- If *moderate or deep sedation is not required*, and the patient does *not exhibit oxygen dependence*, an open gas delivery device (*e.g.*, facemask or nasal cannula) may be considered. Before activating an ignition source around the face, head, or neck, the surgeon should give the anesthesiologist adequate notice that the ignition source is about to be activated. The anesthesiologist should (1) *stop* the delivery of supplemental oxygen or *reduce* the delivered oxygen concentration to the minimum required to avoid hypoxia, and (2) *wait* a few minutes after reducing the oxidizer-enriched atmosphere before approving the activation of the ignition source.

V. Management of OR Fires

Management of OR fires includes (1) recognizing the early signs of fire, (2) halting the procedure, (3) making appropriate attempts to extinguish the fire, (4) following an evacuation protocol when medically appropriate, and (5) delivering postfire care to the patient.

Case reports indicate that early signs of a fire may include a flame or flash, unusual sounds, odors, smoke, or heat.[22–24,41,42,46,53,62,73,92] [Category B3 evidence.] One case report indicates that removing the tracheal tube and stopping the flow of oxygen can minimize patient injury.[53] [Category B3 evidence.] One case report demonstrated that pouring saline into the patient's tracheal tube was effective in extinguishing the fire.[93] [Category B3 evidence.] One case of a patient death from an OR fire indicated that fire extinguishers were available but not used by the OR staff on the patient.[7]

When early warning signs of a fire are noted, the consultants and ASA members strongly agree that there should be an immediate halt to the procedure. When a fire is definitely present, the consultants and ASA members strongly agree that there should be an immediate announcement of fire, followed by an immediate halt to the procedure.

For a fire in the *airway or breathing circuit*, the consultants and ASA members strongly agree that, as quickly as possible, the tracheal tube should be removed and all flammable and burning materials should be removed from the airway. The consultants strongly agree and ASA members agree that the delivery of all airway gases should stop, and they both agree that saline should be poured into the patient's airway to extinguish any residual embers and cool the tissues.

For a fire *elsewhere on or in the patient*, the consultants agree and ASA members are equivocal regarding whether the delivery of all airway gases should stop. They both strongly agree that all burning and flammable materials (including all drapes) should be removed from the patient, and that all burning materials in, on, or

around the patient should be extinguished (*e.g.*, with saline, water, or a fire extinguisher).

Seventy-one percent of the consultants and 77% of the ASA members indicated that the preferred means for safely responding to an OR fire is for each team member to immediately perform a fire management task *in a predetermined sequence*. Twenty-nine percent of the consultants and 23% of the ASA members indicated that the preferred means of safely responding to an OR fire is for each team member to immediately perform a preassigned task, *without waiting* for others to act. The Task Force believes that a predetermined sequence of tasks can be attempted when a fire occurs, but that *team members should not wait for each other if there are impediments to following the predetermined sequence of tasks in a rapid manner*. The Task Force agrees that a team member who has completed a preassigned task may assist another team member whose task is not yet complete.

If the first attempt to extinguish the fire in, on, or around the patient is not successful, the consultants and ASA members both agree that a CO_2 fire extinguisher should be used. If fire persists after use of a CO_2 fire extinguisher, consultants and ASA members both strongly agree that the fire alarm should be activated and the patient should be evacuated, if feasible. The consultants and ASA members both agree that the door to the room should be closed and not reopened. The consultants strongly agree and the ASA members agree that the medical gas supply to the room should be turned off after evacuation.

The consultants and ASA members strongly agree that after a fire has been extinguished, the patient's status should be assessed and a plan should be devised for ongoing care of the patient. When an *airway or breathing circuit fire* has been extinguished, consultants and ASA members both agree that ventilation should be reestablished, avoiding supplemental oxygen and nitrous oxide, if possible. Both the consultants and ASA members strongly agree that the tracheal tube should be examined to assess whether fragments have been left behind in the airway. The consultants strongly agree and the ASA members agree that rigid bronchoscopy should be considered to assess thermal injury, look for tracheal tube fragments, and aid in the removal of residual materials. If the fire did not involve the airway and the patient was not intubated before the fire, the consultants and ASA members both strongly agree that the patient should be assessed for injury related to smoke inhalation.

Advisory Statements. When an early warning sign is noted, halt the procedure and call for an evaluation of fire. Early signs of a fire may include unusual sounds (*e.g.*, a "pop," "snap," or "foomp"), unusual odors, unexpected smoke, unexpected heat, unexpected movement of drapes, discoloration of drapes or breathing circuit, unexpected patient movement or complaint, and unexpected flash or flame.

When a fire is definitely present, immediately announce the fire, halt the procedure, and initiate fire management tasks.

Team members should perform their preassigned fire management tasks as quickly as possible. Before the procedure, the team may identify a predetermined order for performing the tasks. If a team member cannot rapidly perform his or her task in the predetermined order, other team members should perform their tasks *without waiting*. When a team member has completed a preassigned task, he or she should help other members perform tasks that are not yet complete.

The following lists are shown in an order that the team may wish to consider in its discussion of a predetermined sequence.

For a fire in the *airway or breathing circuit*, as fast as possible:#

- Remove the tracheal tube.
- Stop the flow of all airway gases.
- Remove all flammable and burning materials from the airway.
- Pour saline or water into the patient's airway.

For a fire *elsewhere on or in the patient*, as fast as possible:

- Stop the flow of all airway gases.
- Remove all drapes, flammable, and burning materials from the patient.
- Extinguish all burning materials in, on and around the patient (*e.g.*, with saline, water, or smothering).

If the airway or breathing circuit fire is extinguished:

- Reestablish ventilation by mask, avoiding supplemental oxygen and nitrous oxide, if possible.
- Extinguish and examine the tracheal tube to assess whether fragments were left in the airway. Consider bronchoscopy (preferably rigid) to look for tracheal tube fragments, assess injury, and remove residual debris.
- Assess the patient's status and devise a plan for ongoing care.

If the fire elsewhere on or in the patient is extinguished:

Some experts and educators recommend an initial step that involves two simultaneous actions: *removal* of the tracheal tube and *stopping* the flow of medical gases (*e.g.*, by disconnecting the breathing circuit at the Y-piece or the inspiratory gas limb). The intent is to prevent a "blowtorch" effect caused by continued gas flow through a burning tracheal tube. This "blowtorch" effect can spread fire to other locations on or near the patient, and may cause additional burns on the patient or other members of the OR team. The Task Force has carefully considered this concern and agrees that these simultaneous actions represent an ideal response. However, the Task Force is concerned that, in actual practice, the simultaneous actions may be difficult to accomplish or may result in delay when one team member waits for another. Therefore, the Task Force recommends that the actions take place *as fast as possible*.

- Assess the patient's status and devise a plan for ongoing care of the patient.
- Assess for smoke inhalation injury if the patient was not intubated.

If the fire is *not* extinguished after the first attempt (*e.g.*, after performing the preassigned tasks):

- Use a CO_2 fire extinguisher in, on, or around the patient.
- If the fire persists after use of the CO_2 fire extinguisher:
  - Activate the fire alarm.
  - Evacuate the patient if feasible, following institutional protocols.
  - Close the door to the room to contain the fire, and do not reopen it or attempt to reenter the room.
  - Turn off the medical gas supply to the room.

Follow local regulatory reporting requirements (*e.g.*, report fires to your local fire department and state department of health). Treat every fire as an adverse event, following your institutional protocol.

References

1. Barnes AM, Frantz RA: Do oxygen-enriched atmospheres exist beneath surgical drapes and contribute to fire hazard potential in the operating room? AANA J 2000; 68:153–61
2. McCranie J: Fire safety in the operating room. Todays OR Nurse 1994; 16:33–7
3. Milliken RA, Bizzarri A: Flammable surgical drapes. Anesth Analg 1985; 64:54–7
4. Wolf GL: Danger from OR fires still a serious problem: ASA Panel reports risks. J Clin Monit Comput 2000; 16:237–8
5. Surgical fire safety. Health Devices 2006; 35:45–66
6. Use of wrong gas in laparoscopic insufflator causes fire. Health Devices 1994; 23:456–7
7. Stouffer DJ: Fires during surgery: Two fatal incidents in Los Angeles. J Burn Care Rehabil 1992; 13:114–7
8. Halstead MA: Fire drill in the operating room: Role playing as a learning tool. AORN J 1993; 58:697–706
9. Laser ignition of surgical drapes. Health Devices 1992; 21:15–6
10. Surgical drapes. Health Devices 1986; 15:111–36
11. Epstein RH, Brummett RR Jr, Lask GP: Incendiary potential of the flashlamp pumped 585-nm tunable dye laser. Anesth Analg 1990; 71:171–5
12. Wolf GL, Sidebotham GW, Lazard JLP, Charchaflieh JG: Laser ignition of surgical drape materials in air, 50% oxygen, and 95% oxygen. ANESTHESIOLOGY 2004; 100:1167–71
13. Treyve E, Yarington CT Jr, Thompson GE: Incendiary characteristics of endotracheal tubes with the CO2 laser. Ann Otol Rhinol Laryngol 1981; 90: 328–30
14. Greco RJ, Gonzalez R, Johnson P, Scolieri M, Rekhopf PG, Heckler F: Potential dangers of oxygen supplementation during facial surgery. Plast Reconstr Surg 1995; 95:978–84
15. Neatrour GP, Lederman IR: Reducing fire hazard during ophthalmic surgery by using compressed air. Ophthalmic Surg 1989; 20:430–2
16. Aly A, McIlwain M, Duncavage JA: Electrosurgery-induced endotracheal tube ignition during tracheotomy. Ann Otol Rhinol Laryngol 1991; 100:31–3
17. Airway fires during surgery. PA-PSRS Patient Safety Advisory 2007; 4:1–4
18. Case history number 82: "Nonflammable" fires in the operating room. Anesth Analg 1975; 54:152–4
19. Surgical fire case summaries. Health Devices 1992; 21:31–4
20. Ashcraft KE, Golladay ES, Guinee WS: A surgical field flash fire during the separation of dicephalus dipus conjoined twins. ANESTHESIOLOGY 1981; 55:457–8
21. Awan MS, Ahmed I: Endotracheal tube fire during tracheostomy: A case report. Ear Nose Throat J 2002; 81:90–2
22. Bailey MK, Bromley HR, Allison JG, Conroy JM, Krzyzaniak W: Electrocautery-induced airway fire during tracheostomy. Anesth Analg 1990; 71:702–4
23. Barker SJ, Polson JS: Fire in the operating room: A case report and laboratory study. Anesth Analg 2001; 93:960–5
24. Baur DA, Butler RC: Electrocautery-ignited endotracheal tube fire: Case report. Br J Oral Maxillofac Surg 1999; 37:142–3
25. Bennett JA, Agree M: Fire in the chest. Anesth Analg 1994; 78:406
26. Boyd CH: A fire in the mouth: A hazard of the use of antistatic endotracheal tubes. Anaesthesia 1969; 24:441–6
27. Burgess GE III, LeJeune FE Jr: Endotracheal tube ignition during laser surgery of the larynx. Arch Otolaryngol 1979; 105:561–2
28. Casey KR, Fairfax WR, Smith SJ, Dixon JA: Intratracheal fire ignited by the Nd-YAG laser during treatment of tracheal stenosis. Chest 1983; 84:295–6
29. Chang BW, Petty P, Manson PN: Patient fire safety in the operating room. Plast Reconstr Surg 1994; 93:519–21
30. Cozine K, Rosenbaum LM, Askanazi J, Rosenbaum SH: Laser-induced endotracheal tube fire. ANESTHESIOLOGY 1981; 55:583–5
31. Datta TD: Flash fire hazard with eye ointment. Anesth Analg 1984; 63: 700–1
32. Dini GM, Casagrande W: Misfortune during a blepharoplasty. Plast Reconstr Surg 2006; 117:325–6
33. Eade GG: Hazard of nasal oxygen during aesthetic facial operations. Plast Reconstr Surg 1986; 78:539
34. Galapo S, Wolf GL, Sidebotham GW, Cohen D: Laser ignition of surgical drapes in an oxygen enriched atmosphere (abstract). ANESTHESIOLOGY 1998; 89: A580
35. Gunatilake DE: Case report: Fatal intraperitoneal explosion during electrocoagulation *via* laparoscopy. Int J Gynaecol Obstet 1978; 15:353–7
36. Handa KK, Bhalla AP, Arora A: Fire during the use of Nd-Yag laser. Int J Pediatr Otorhinolaryngol 2001; 60:239–42
37. Hirshman CA, Smith J: Indirect ignition of the endotracheal tube during carbon dioxide laser surgery. Arch Otolaryngol 1980; 106:639–41
38. Howard BK, Leach JL: Prevention of flash fires during facial surgery performed under local anesthesia. Ann Otol Rhinol Laryngol 1997; 106:248–51
39. Katz JA, Campbell L: Fire during thoracotomy: A need to control the inspired oxygen concentration. Anesth Analg 2005; 101:612
40. Keller C, Elliott W, Hubbell RN: Endotracheal tube safety during electrodissection tonsillectomy. Arch Otolaryngol Head Neck Surg 1992; 118:643–5
41. Krawtz S, Mehta AC, Wiedemann HP, DeBoer G, Schoepf KD, Tomaszewski MZ: Nd-YAG laser-induced endobronchial burn: Management and long-term follow-up. Chest 1989; 95:916–8
42. Lach E: The hazards of using supplemental oxygen. Plast Reconstr Surg 1996; 98:566–7
43. Lai A, Ng KP: Fire during thoracic surgery. Anaesth Intensive Care 2001; 29:301–3
44. Le Clair J, Gartner S, Halma G: Endotracheal tube cuff ignited by electrocautery during tracheostomy. AANA J 1990; 58:259–61
45. Lederman IR: Fire hazard during ophthalmic surgery. Ophthalmic Surg 1985; 16:577–8
46. Lew EO, Mittleman RE, Murray D: Endotracheal tube ignition by electrocautery during tracheostomy: Case report with autopsy findings. J Forensic Sci 1991; 36:1586–91
47. Lypson ML, Stephens S, Colletti L: Preventing surgical fires: Who needs to be educated? Jt Comm J Qual Patient Saf 2005; 31:522–7
48. Magruder GB, Guber D: Fire prevention during surgery. Arch Ophthalmol 1970; 84:237
49. Mandych A, Mickelson S, Amis R: Operating room fire. Arch Otolaryngol Head Neck Surg 1990; 116:1452
50. Marsh B, Riley RH: Double-lumen tube fire during tracheostomy. ANESTHESIOLOGY 1992; 76:480–1
51. Martin L, Dolman P: Fire! Can J Anaesth 1999; 46:909
52. Meyers A: Complications of CO_2 laser surgery of the larynx. Ann Otol Rhinol Laryngol 1981; 90:132–4
53. Michels AM, Stott S: Explosion of tracheal tube during tracheostomy. Anaesthesia 1994; 49:1104
54. Ng JM, Hartigan PM: Airway fire during tracheostomy: Should we extubate? ANESTHESIOLOGY 2003; 98:1303
55. Ortega RA: A rare cause of fire in the operating room. ANESTHESIOLOGY 1998; 89:1608
56. Pashayan AG, Gravenstein JS: Airway fires during surgery with the carbon dioxide laser. ANESTHESIOLOGY 1989; 71:478
57. Paugh DH, White KW: Fire in the operating room during tracheotomy: A case report. AANA J 2005; 73:97–100
58. Reyes RJ, Smith AA, Mascaro JR, Windle BH: Supplemental oxygen: Ensuring its safe delivery during facial surgery. Plast Reconstr Surg 1995; 95:924–8
59. Robinson JS, Thompson JM, Wood AW: Fire and explosion hazards in operating theatres: A reply and new evidence. Br J Anaesth 1979; 51:908
60. Rogers ML, Nickalls RW, Brackenbury ET, Salama FD, Beattie MG, Perks AG: Airway fire during tracheostomy: Prevention strategies for surgeons and anaesthetists. Ann R Coll Surg Engl 2001; 83:376–80
61. Santos P, Ayuso A, Luis M, Martinez G, Sala X: Airway ignition during CO_2 laser laryngeal surgery and high frequency jet ventilation. Eur J Anaesth 2000; 17:204–7
62. Schettler WH: Operating room flash fire. Anesth Analg 1974; 53:288–9
63. Simpson JI, Wolf GL: Endotracheal tube fire ignited by pharyngeal electrocautery. ANESTHESIOLOGY 1986; 65:76–7
64. Singla AK, Campagna JA, Wright CD, Sandberg WS: Surgical field fire during a repair of bronchoesophageal fistula. Anesth Analg 2005; 100:1062–4
65. Thompson JW, Colin W, Snowden T, Hengesteg A, Stocks RM, Watson SP: Fire in the operating room during tracheostomy. South Med J 1998; 91:243–7

66. Varcoe RL, MacGowan KM, Cass AJ: Airway fire during tracheostomy. ANZ J Surg 2004; 74:507–8
67. Waldorf HA, Kauvar NB, Geronemus RG, Leffel DJ: Remote fire with the pulsed dye laser: Risk and prevention. J Am Acad Dermatol 1996; 34:503–6
68. Wegrzynowicz ES, Jensen NF, Pearson KS, Wachtel RE, Scamman FL: Airway fire during jet ventilation for laser excision of vocal cord papillomata. ANESTHESIOLOGY 1992; 76:468–9
69. Fire hazard created by the misuse of DuraPrep solution. Health Devices 1998;27:400–2
70. Hurt TL, Schweich PJ: Do not get burned: Preventing iatrogenic fires and burns in the emergency department. Pediatr Emerg Care 2003; 19:255–9
71. Prasad R, Quezado Z, St. Andre A: Fires in the operating room and intensive care unit: Awareness is the key to prevention. Anesth Analg 2006; 102:172–4
72. Shah SC: Operating room flash fire. Anesth Analg 1974; 53:288
73. Tooher R, Maddern GJ, Simpson J: Surgical fires and alcohol-based skin preparations. ANZ J Surg 2004; 74:382–5
74. Laser contact tips and tracheal tubes. Health Devices 1992; 21:18
75. Ossoff RH, Duncavage JA, Eisenman TS, Duncavage JA, Karlan MS: Comparison of tracheal damage from laser-ignited endotracheal tube fires. Ann Otol Rhinol Laryngol 1983; 92:333–6
76. Patel KF, Hicks JN: Prevention of fire hazards associated with use of carbon dioxide lasers. Anesth Analg 1981; 60:885–8
77. Simpson JI, Schiff GA, Wolf GL: The effect of helium on endotracheal tube flammability. ANESTHESIOLOGY 1990; 73:538–40
78. Sosis MB, Braverman B: Evaluation of foil coverings for protecting plastic endotracheal tubes from the potassium-titanyl-phosphate laser. Anesth Analg 1993; 77:589–91
79. Sosis MB, Braverman B: Prevention of cautery-induced airway fires with special endotracheal tubes. Anesth Analg 1993; 77:846–7
80. Sosis MB, Braverman B, Caldarelli DD: Evaluation of a new laser-resistant fabric and copper foil-wrapped endotracheal tube. Laryngoscope 1996; 106: 842–4
81. Sosis MB, Caldarelli D: Evaluation of a new ceramic endotracheal tube for laser airway surgery. Otolaryngol Head Neck Surg 1992; 107:601–2
82. Sosis MB, Dillon FX: A comparison of CO_2 laser ignition of the Xomed, plastic, and rubber endotracheal tubes. Anesth Analg 1993; 76:391–3
83. Sosis MB, Heller S: Evaluation of five metallic tapes for protection of endotracheal tubes during CO_2 laser surgery. Anesth Analg 1989; 68:392–3
84. Sosis MB: Which is the safest endotracheal tube for use with the CO_2 laser? A comparative study. J Clin Anesth 1992; 4:217–9
85. Gupte SR: Gauze fire in the oral cavity: A case report. Anesth Analg 1972; 51:645–6
86. Healy GB, Strong MS, Shapshay S, Vaughan C, Jako G: Complications of CO_2 laser surgery of the aerodigestive tract: Experience of 4416 cases. Otolaryngol Head Neck Surg 1984; 92:13–8
87. Tysinger JW Jr: Weck-Cel sponges and Steri-Drapes burn. Ophthalmic Surg 1986; 17:174.
88. Do pledgets protect the tracheal tube cuff from lasers? Health Devices 1992;21:17
89. Axelrod EH, Kusnetz AB, Rosenberg MK: Operating room fires initiated by hot wire cautery. ANESTHESIOLOGY 1993; 79:1123–6
90. Macdonald MR, Wong A, Walker P, Crysdale WS: Electrocautery-induced ignition of tonsillar packing. J Otolaryngol 1994; 23:426–9
91. Rohrich RJ, Gyimesi IM, Clark P, Burns AJ: CO_2 laser safety considerations in facial skin resurfacing. Plast Reconstr Surg 1997; 100:1285–90
92. Anderson EF: A potential ignition source in the operating room. Anesth Analg 1976; 55:217–8
93. Chee WK, Benumof JL: Airway fire during tracheostomy: Extubation may be contraindicated. ANESTHESIOLOGY 1998; 89:1576–8

Appendix 1: Primary Findings of the Advisory Task Force

I. Education

- All anesthesiologists should have fire safety education, specifically for OR fires, with emphasis on the risk created by an oxidizer-enriched atmosphere.

II. OR Fire Drills

- Anesthesiologists should periodically participate in OR fire drills, with the entire OR team. This formal rehearsal should take place during dedicated educational time, not during patient care.

III. Preparation

- For every case, the anesthesiologist should participate with the entire OR team (*e.g.*, during the surgical pause) in assessing and determining whether a high-risk situation exists.
- If a high-risk situation exists, all team members—including the anesthesiologist—should take a joint and active role in agreeing on how a fire will be prevented and managed.
- Each team member should be assigned a specific fire management task to perform in the event of a fire (*e.g.*, removing the tracheal tube, turning off the airway gases).
- Each team member should understand that his or her preassigned task should be performed immediately if a fire occurs, without waiting for another team member to take action.
- When a team member has completed a preassigned task, he or she should help other team members perform tasks that are not yet complete.
- In every OR and procedure area where a fire triad can exist (*i.e.*, an oxidizer-enriched atmosphere, an ignition source, and fuel), an easily visible protocol for the prevention and management of fires should be displayed.
- Equipment for managing a fire should be readily available in every procedural location where a fire triad may exist.

IV. Prevention

- The anesthesiologist should collaborate with all members of the procedure team *throughout the procedure* to minimize the presence of an oxidizer-enriched atmosphere in proximity to an ignition source.
- For *all* procedures:
  - Surgical drapes should be configured to minimize the accumulation of oxidizers (oxygen and nitrous oxide) under the drapes and from flowing into the surgical site.
  - Flammable skin prepping solutions should be dry before draping.
  - Gauze and sponges should be moistened before use in proximity to an ignition source.
- For *high-risk* procedures:
  - The anesthesiologist should notify the surgeon whenever there is a potential for an ignition source to be in proximity to an oxidizer-enriched atmosphere or when there is an increase in oxidizer concentration at the surgical site.
  - Any reduction in supplied oxygen to the patient should be assessed by monitoring (1) pulse oximetry and, if feasible, (2) inspired, exhaled, and/or delivered oxygen concentration.
- For laser procedures:
  - A laser-resistant tracheal tube should be used.
    - The laser-resistant tracheal tube used should be chosen to be resistant to the laser used for the procedure (*e.g.*, CO_2, Nd:YAG, Ar, Er:YAG, KTP).
  - The tracheal cuff of the laser tube should be filled with saline and colored with an indicator dye such as methylene blue.
  - Before activating a laser:
    - The surgeon should give the anesthesiologist adequate notice that the laser is about to be activated.
    - The anesthesiologist should:
      - *Reduce* the delivered oxygen concentration to the minimum required to avoid hypoxia.
      - *Stop* the use of nitrous oxide.
      - *Wait* a few minutes after reducing the oxidizer-enriched atmosphere before approving activation of the laser.
- For cases involving an *ignition source* and *surgery inside the airway*:
  - Cuffed tracheal tubes should be used when clinically appropriate.
  - The anesthesiologist should advise the surgeon against entering the trachea with an ignition source (*e.g.*, electrosurgery unit).
  - *Before* activating an ignition source inside the airway:

  - The surgeon should give the anesthesiologist adequate notice that the ignition source is about to be activated.
  - The anesthesiologist should:
    - *Reduce* the delivered oxygen concentration to the minimum required to avoid hypoxia.
    - *Stop* the use of nitrous oxide.
    - *Wait* a few minutes after reducing the oxidizer-enriched atmosphere before approving the activation of the ignition source.
- In some cases (*e.g.*, surgery in the oropharynx), scavenging with suction may be used to reduce oxidizer enrichment in the operative field.

- For cases involving *moderate or deep sedation, an ignition source, and surgery around the face, head, or neck:*
  - The anesthesiologist and surgeon should develop a plan that accounts for the level of sedation and the patient's need for supplemental oxygen.
    - If moderate or deep sedation is required or used, or if the patient exhibits oxygen dependence, the anesthesiologist and surgeon should consider a sealed gas delivery device (*e.g.*, cuffed tracheal tube or laryngeal mask).
    - If moderate or deep sedation is not required, and the patient does not exhibit oxygen dependence, an open gas delivery device (*e.g.*, facemask or nasal cannula) may be considered.
  - *Before* activating an ignition source around the face, head, or neck:
    - The surgeon should give the anesthesiologist adequate notice that the ignition source is about to be activated.
    - The anesthesiologist should:
      - *Stop* the delivery of supplemental oxygen or *reduce* the delivered oxygen concentration to the minimum required to avoid hypoxia.
      - *Wait* a few minutes after reducing the oxidizer-enriched atmosphere before approving the activation of the ignition source.

V. Management of OR Fires

- When an early warning sign is noted, halt the procedure and call for an evaluation of fire.
- When a fire is definitely present, immediately announce the fire, halt the procedure, and initiate fire management tasks.
- Team members should perform their preassigned fire management tasks as quickly as possible.
  - Before the procedure, the team may identify a predetermined order for performing the tasks.
  - If a team member cannot rapidly perform his or her task in the predetermined order, other team members should perform their tasks without waiting.
  - When a team member has completed a preassigned task, he or she should help other members perform tasks that are not yet complete.

- For a fire in the *airway or breathing circuit*, as fast as possible:
  - Remove the tracheal tube.
  - Stop the flow of all airway gases.
  - Remove all flammable and burning materials from the airway.
  - Pour saline or water into the patient's airway.

- For a fire *elsewhere on or in the patient*, as fast as possible:
  - Stop the flow of all airway gases.
  - Remove all drapes, flammable, and burning materials from the patient.
  - Extinguish all burning materials in, on, and around the patient (*e.g.*, with saline, water, or smothering).

- If the airway or breathing circuit fire is extinguished:
  - Reestablish ventilation by mask, avoiding supplemental oxygen and nitrous oxide, if possible.
  - Extinguish and examine the tracheal tube to assess whether fragments were left in the airway.
    - Consider bronchoscopy (preferably rigid) to look for tracheal tube fragments, assess injury, and remove residual debris.
  - Assess the patient's status and devise a plan for ongoing care.

- If the fire elsewhere on or in the patient is extinguished:
  - Assess the patient's status and devise a plan for ongoing care of the patient.
  - Assess for smoke inhalation injury if the patient was not intubated.

- If the fire is *not* extinguished after the first attempt (*e.g.*, after performing the preassigned tasks):
  - Use a CO_2 fire extinguisher in, on, or around the patient.
  - If the fire persists after use of the CO_2 fire extinguisher:
    - Activate the fire alarm.
    - Evacuate the patient if feasible, following institutional protocols.
    - Close the door to the room to contain the fire and do not reopen it or attempt to reenter the room.
    - Turn off the medical gas supply to the room.

- Follow local regulatory reporting requirements (*e.g.*, report fires to your local fire department and state department of health).
- Treat every fire as an adverse event, following your institutional protocol.

Appendix 2: Methods and Analyses

A. State of the Literature

For this Advisory, a literature review was used in combination with opinions obtained from experts and other sources (*e.g.*, professional society members, open forums, Web-based postings) to provide guidance to practitioners regarding OR fire prevention and management. Both the literature review and opinion data were based on *evidence linkages*, or statements regarding potential relationships between fire prevention and management interventions and OR fire outcomes.** The evidence linkage *interventions* are listed below.

I. Education

1. Fire safety education, with an emphasis on an oxidizer-enriched atmosphere

II. OR Fire Drills

2. Periodic participation in OR fire drills

III. Preparation

3. Display of an easily visible protocol for the prevention and management of fires
4. Preoperative determination of a high-risk situation
5. OR team discussion of OR fire strategy

IV. Prevention

6. Surgical drape configuration to minimize the accumulation of oxidizers
7. Drying of flammable skin prepping solutions
8. Moistening of sponges and gauze when used in proximity to an ignition source
9. Reducing the concentration of supplied oxygen for high-risk procedures
10. Avoidance of nitrous oxide for high-risk procedures

** Unless otherwise specified, outcomes for the listed interventions refer to the occurrence of fire or adverse sequela.

11. Cuffed *versus* uncuffed tracheal tubes for cases in or around the airway
12. Insufflating with medical air during cases in or around the airway
13. Scavenging with suction during cases in or around the airway
14. Laser-resistant *versus* non–laser-resistant tracheal tubes during laser surgery
15. Filling the tracheal cuff of the laser tube with saline colored with an indicator dye

V. Management

16. Early signs of a fire include a flame or flash, unusual sounds, odors, smoke, or heat (observational)
17. Removing the tracheal tube and stopping the flow of oxygen to minimize patient injury after an airway or breathing circuit fire
18. Pouring saline into the patient's tracheal tube to extinguish an airway fire

For the literature review, potentially relevant studies were identified *via* electronic and manual searches of the literature. The literature search covered a 56-yr period from 1952 through 2007. More than 400 citations were initially identified, yielding a total of 340 articles that addressed topics related to the evidence linkages and met our criteria for inclusion. After review of the articles, 240 studies did not provide direct evidence and were subsequently eliminated. A total of 100 articles contained direct linkage-related evidence.†† No evidence linkage contained enough studies with well-defined experimental designs and statistical information to conduct a quantitative analysis (*i.e.*, meta-analysis).

Interobserver agreement among Task Force members and two methodologists was established by interrater reliability testing. Agreement levels using a κ statistic for two-rater agreement pairs were as follows: (1) type of study design, κ = 0.63–0.82; (2) type of analysis, κ = 0.40–0.87; (3) evidence linkage assignment, κ = 0.84–1.00; and (4) literature inclusion for database, κ = 0.69–1.00. Three-rater chance-corrected agreement values were (1) study design, Sav = 0.69, Var (Sav) = 0.013; (2) type of analysis, Sav = 0.57, Var (Sav) = 0.031; (3) linkage assignment, Sav = 0.89, Var (Sav) = 0.004; and (4) literature database inclusion, Sav = 0.79, Var (Sav) = 0.025. These values represent moderate to high levels of agreement.

†† A complete list of references used to develop this Advisory is available on the ANESTHESIOLOGY Web site, www.anesthesiology.org, or by writing to the American Society of Anesthesiologists.

B. Consensus-based Evidence

Consensus was obtained from multiple sources, including (1) survey opinion from consultants who were selected based on their knowledge or expertise in OR fire prevention and management, (2) survey opinions solicited from active members of the ASA, (3) testimony from attendees of a publicly held open forum at a national anesthesia meeting, (4) Internet commentary, and (5) Task Force opinion and interpretation. The survey rate of return was 52% (n = 38 of 73) for the consultants, and 64 surveys were received from active ASA members. Results of the surveys are reported in tables 2 and 3 and in the text of the Advisory.

The consultants were asked to indicate which, if any, of the evidence linkages would change their clinical practices if the Advisory was instituted. The rate of return was 18% (n = 13 of 73). The percent of responding consultants expecting a change in their practice associated with each linkage topic was as follows: (1) education, 77%; (2) OR fire drills, 69%; (3) team discussion of fire strategy, 69%; (4) minimizing or avoiding an oxidizer-enriched atmosphere near the surgical site, 38%; (5) managing ignition sources, 38%; (6) managing fuels, 31%; (7) identification of a high-risk procedure, 85%; (8) management of a high-risk procedure, 31%; and (9) OR fire management, 77%. Eighty-five percent of the respondents indicated that the Advisory would have *no effect* on the amount of time spent on a typical case, and 15% indicated that there would be an increase of 1–5 min in the amount of time spent on a typical case with the implementation of this Advisory.

Table 2. Consultant Survey Responses

	n‡	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
Education						
1a. Every anesthesiologist should have knowledge of institutional fire safety protocols for the OR	38	92.1*	7.9	0.0	0.0	0.0
1b. Every anesthesiologist should participate in OR fire safety education	38	81.6*	15.8	2.6	0.0	0.0
1c. OR fire safety education for the anesthesiologist should emphasize the risk of an oxidizer-enriched atmosphere	38	81.6*	18.4	0.0	0.0	0.0
OR fire drills						
2a. All anesthesiologists should periodically participate in OR fire drills with the entire OR team	38	60.5*	31.6	5.3	2.6	0.0
2b. Participation in an OR fire drill should take place during dedicated educational time, not during patient care	38	50.0*	34.2	5.3	10.5	0.0
Preparation						
3. Anesthesiologists should participate with the entire OR team in assessing the risk of an OR fire for each case, and determining whether a high-risk situation exists	38	57.9*	29.0	2.6	10.5	0.0
4. All team members should agree on how an OR fire will be prevented and managed for each particular procedure	38	60.5*	29.0	7.9	2.6	0.0
5. Hospitals and procedure units should post a protocol for the prevention and management of fires in each location where a procedure is performed	38	50.0*	26.3	18.4	5.3	0.0
Prevention for all procedures						
6. Flammable skin prepping solutions should be dry before draping	38	86.8*	13.2	0.0	0.0	0.0
7. Surgical drapes should be configured to prevent oxygen from accumulating under the drapes or from flowing into the surgical site	38	76.3*	18.4	2.6	2.6	0.0
8. Sponges should be moistened, particularly when used in or near the airway	38	63.2*	15.8	21.0	0.0	0.0
Prevention for high-risk† procedures						
9. Anesthesiologists should collaborate with the procedure team for the purpose of preventing and managing a fire	38	84.2*	15.8	0.0	0.0	0.0
10. The surgeon should be notified of an increase in or the presence of an oxidizer-enriched atmosphere in which an ignition source will be used	38	84.2*	15.8	0.0	0.0	0.0
11a. Oxygen levels should be kept as low as clinically feasible while the ignition source is in proximity to the oxygen-enriched atmosphere	38	81.6*	13.2	2.6	0.0	2.6
11b. The reduction of F_{IO_2} should be guided by monitoring patient oxygenation	38	86.8*	7.9	5.3	0.0	0.0
12. The use of nitrous oxide should be avoided in settings that are considered high risk for OR fire	38	52.6*	26.3	15.8	5.3	0.0
13. Oxygen or nitrous oxide buildup may be minimized by either insufflating with room air or scavenging the operating field with suction	38	50.0*	36.8	10.5	2.6	0.0
Prevention during cases in or around the airway						
14. Cuffed tracheal tubes should be used instead of uncuffed tracheal tubes	38	39.5	31.6*	23.7	5.2	0.0
15. The oropharynx should be scavenged with suction during oral procedures	38	42.1	23.7*	28.9	5.3	0.0
16. The sufficient amount of time needed to reduce oxygen or nitrous oxide concentrations to a safe level before using an ignition source *in the airway*:	Mean = 1.76 min, Range = 0.25–5 min					
17. The sufficient amount of time needed to reduce oxygen or nitrous oxide concentrations to a safe level before using an ignition source for patients wearing *a facemask or nasal cannula*:	Mean = 1.67 min, Range = 0.15–5 min					
Prevention during laser surgery						
18. Laser-resistant tracheal tubes appropriate to the procedure and laser should be used	38	68.4*	29.0	2.6	0.0	0.0
19a. Tracheal tube cuffs should be filled with saline rather than air, when feasible	38	71.1*	26.3	2.6	0.0	0.0

(*continued*)

Table 2. Continued

	n‡	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
19b. Saline in tracheal tube cuffs should be tinted with methylene blue to act as a marker for cuff puncture by a laser	38	50.0*	39.5	10.5	0.0	0.0
Management of OR fires						
20. When early warning signs of a fire are noted, the procedure should be halted immediately	38	78.9*	15.8	5.3	0.0	0.0
21. When a fire is definitely present, the fire should be immediately announced and the procedure should halt	38	92.1*	7.9	0.0	0.0	0.0
22. For a fire in the *airway or breathing circuit*:						
a. The tracheal tube should be removed as quickly as possible	38	78.9*	13.2	7.9	0.0	0.0
b. All flammable and burning materials should be removed from the airway as quickly as possible	38	94.7*	5.3	0.0	0.0	0.0
c. The delivery of all airway gases should stop	38	73.7*	18.4	5.3	2.6	0.0
d. Saline should be poured into the patient's airway to extinguish any residual embers and cool the tissues	38	47.4	21.0*	21.0	7.9	2.6
23. For a fire *elsewhere on or in the patient*:						
a. The delivery of all airway gases should stop	38	47.4	13.1*	23.7	15.8	0.0
b. All burning and flammable materials (including all drapes) should be removed from the patient	38	89.5*	10.5	0.0	0.0	0.0
c. All burning materials in, on and around the patient should be extinguished (*e.g.*, with saline, water, or a fire extinguisher)	38	86.8*	13.2	0.0	0.0	0.0
24. The preferred means of safely responding to an OR fire is:						
a. For each team member to immediately respond without waiting for others to act	Agree = 29%					
b. To immediately initiate a predetermined sequence of responses	Agree = 71%					
25. If the first attempt to extinguish the fire is not successful, a CO_2 fire extinguisher should be used	38	39.5	39.5*	13.1	7.9	0.0
26. If the fire persists after use of a CO_2 fire extinguisher:						
a. The fire alarm should be activated	38	79.0*	10.5	10.5	0.0	0.0
b. The patient should be evacuated, if feasible	38	60.5*	34.2	5.3	0.0	0.0
c. The door to the room should be closed and not reopened	38	47.4	23.7*	26.3	2.6	0.0
d. The medical gas supply to the room should be turned off	38	60.5*	18.4	21.1	0.0	0.0
27. After a fire has been extinguished, the patient's status should be assessed and a plan devised for ongoing care of the patient	38	84.2*	10.5	2.6	0.0	2.6
28. When the *airway or breathing circuit fire* has been extinguished:						
a. Ventilation should be reestablished, avoiding supplemental oxygen and nitrous oxide, if possible	38	47.4	31.6*	10.5	10.5	0.0
b. The tracheal tube should be examined to assess whether fragments may be left behind in the airway	38	81.6*	18.4	0.0	0.0	0.0
c. Rigid bronchoscopy should be considered to assess thermal injury and look for tracheal tube fragments and other residual materials	38	68.4*	23.7	5.3	0.0	2.6
29. If the fire did not involve the airway and the patient was not intubated before the fire, the patient should be assessed for injury related to smoke inhalation	38	60.5*	36.8	2.7	0.0	0.0

* Median response falls within this designated response category. † A high-risk procedure is defined as one in which an ignition source may be in proximity to an oxidizer-enriched atmosphere. ‡ n is the number of consultants who responded to each item. All other numbers in the table represent the percentage of consultants who selected the designated response category.

CO_2 = carbon dioxide; F_{IO_2} = fraction of inspired oxygen; OR = operating room.

Table 3. ASA Member Survey Responses

	n‡	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
Education						
1a. Every anesthesiologist should have knowledge of institutional fire safety protocols for the OR	142	74.6*	24.7	0.7	0.0	0.0
1b. Every anesthesiologist should participate in OR fire safety education	142	55.6*	38.7	5.6	0.0	0.0
1c. OR fire safety education for the anesthesiologist should emphasize the risk of an oxidizer-enriched atmosphere	142	73.9*	22.5	3.5	0.0	0.0
OR fire drills						
2a. All anesthesiologists should periodically participate in OR fire drills with the entire OR team	142	42.3	40.1*	12.0	5.6	0.0
2b. Participation in an OR fire drill should take place during dedicated educational time, not during patient care	142	54.9*	31.0	10.6	2.1	1.4
Preparation						
3. Anesthesiologists should participate with the entire OR team in assessing the risk of an OR fire for each case, and determining whether a high-risk situation exists	142	38.7	45.8*	8.5	3.5	3.5
4. All team members should agree on how an OR fire will be prevented and managed for each particular procedure	142	39.4	38.0*	13.4	7.8	1.4
5. Hospitals and procedure units should post a protocol for the prevention and management of fires in each location where a procedure is performed	142	51.4*	36.6	8.5	2.8	0.7
Prevention for all procedures						
6. Flammable skin prepping solutions should be dry before draping	142	68.3*	21.8	9.2	0.7	0.0
7. Surgical drapes should be configured to prevent oxygen from accumulating under the drapes or from flowing into the surgical site	142	64.8*	28.2	6.3	0.7	0.0
8. Sponges should be moistened, particularly when used in or near the airway	142	63.4*	30.3	5.6	0.7	0.0
Prevention for high-risk† procedures						
9. Anesthesiologists should collaborate with the procedure team for the purpose of preventing and managing a fire	142	67.6*	31.0	1.4	0.0	0.0
10. The surgeon should be notified of an increase in or the presence of an oxidizer-enriched atmosphere in which an ignition source will be used	142	66.2*	29.6	3.5	0.7	0.0
11a. Oxygen levels should be kept as low as clinically feasible while the ignition source is in proximity to the oxygen-enriched atmosphere	142	70.4*	26.1	2.1	1.4	0.0
11b. The reduction of F_{IO_2} should be guided by monitoring patient oxygenation	142	71.8*	24.7	2.8	0.7	0.0
12. The use of nitrous oxide should be avoided in settings that are considered high risk for OR fire	142	50.0*	36.6	9.2	3.5	0.7
13. Oxygen or nitrous oxide buildup may be minimized by either insufflating with room air or scavenging the operating field with suction	142	32.4	43.0*	21.8	2.8	0.0
Prevention during cases in or around the airway						
14. Cuffed tracheal tubes should be used instead of uncuffed tracheal tubes	142	35.9	43.0*	16.2	4.9	0.0
15. The oropharynx should be scavenged with suction during oral procedures	142	22.5	27.5*	44.4	5.6	0.0
16. The sufficient amount of time needed to reduce oxygen or nitrous oxide concentrations to a safe level before using an ignition source *in the airway*:	Mean = 3.3 min, Range = 0.08–10 min					
17. The sufficient amount of time needed to reduce oxygen or nitrous oxide concentrations to a safe level before using an ignition source for patients wearing *a facemask or nasal cannula*:	Mean = 2.8 min, Range = 0.0–10 min					
Prevention during laser surgery						
18. Laser-resistant tracheal tubes appropriate to the procedure and laser should be used	142	61.3*	35.9	2.8	0.0	0.0
19a. Tracheal tube cuffs should be filled with saline rather than air, when feasible	142	61.3*	33.1	4.9	0.7	0.0

(*continued*)

Table 3. Continued

	n‡	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
19b. Saline in tracheal tube cuffs should be tinted with methylene blue to act as a marker for cuff puncture by a laser	142	44.4	37.3*	14.1	3.5	0.7
Management of OR fires						
20. When early warning signs of a fire are noted, the procedure should be halted immediately	142	78.2*	19.0	2.8	0.0	0.0
21. When a fire is definitely present, the fire should be immediately announced and the procedure should halt	142	85.9*	12.7	1.4	0.0	0.0
22. For a fire in the *airway or breathing circuit*:						
a. The tracheal tube should be removed as quickly as possible	142	59.2*	26.1	8.4	4.2	2.1
b. All flammable and burning materials should be removed from the airway as quickly as possible	142	73.9*	22.5	2.8	0.0	0.7
c. The delivery of all airway gases should stop	142	46.5	20.4*	16.9	14.1	2.1
d. Saline should be poured into the patient's airway to extinguish any residual embers and cool the tissues	142	33.1	29.6*	28.9	7.0	1.4
23. For a fire *elsewhere on or in the patient*:						
a. The delivery of all airway gases should stop	142	14.8	14.8	26.8*	39.4	4.2
b. All burning and flammable materials (including all drapes) should be removed from the patient	142	74.7*	22.5	2.8	0.0	0.0
c. All burning materials in, on and around the patient should be extinguished (*e.g.*, with saline, water, or a fire extinguisher)	142	73.2*	26.1	0.7	0.0	0.0
24. The preferred means of safely responding to an OR fire is:						
a. For each team member to immediately respond without waiting for others to act	Agree = 20%					
b. To immediately initiate a predetermined sequence of responses	Agree = 80%					
25. If the first attempt to extinguish the fire is not successful, a CO_2 fire extinguisher should be used	142	19.7	43.7*	36.6	0.0	0.0
26. If the fire persists after use of a CO_2 fire extinguisher:						
a. The fire alarm should be activated	142	58.5*	37.3	4.2	0.0	0.0
b. The patient should be evacuated, if feasible	142	52.1*	36.6	9.9	1.4	0.0
c. The door to the room should be closed and not reopened	142	30.0	28.2*	26.1	6.3	1.4
d. The medical gas supply to the room should be turned off	142	39.4	30.3*	20.4	7.0	2.8
27. After a fire has been extinguished, the patient's status should be assessed and a plan devised for ongoing care of the patient	142	78.2*	20.4	0.7	0.0	0.7
28. When the *airway or breathing circuit fire* has been extinguished:						
a. Ventilation should be reestablished, avoiding supplemental oxygen and nitrous oxide, if possible	142	23.9	38.7*	11.3	21.8	4.2
b. The tracheal tube should be examined to assess whether fragments may be left behind in the airway	142	60.6*	38.0	1.4	0.0	0.0
c. Rigid bronchoscopy should be considered to assess thermal injury and look for tracheal tube fragments and other residual materials	142	43.7	39.4*	14.8	2.1	0.0
29. If the fire did not involve the airway and the patient was not intubated before the fire, the patient should be assessed for injury related to smoke inhalation	142	52.1*	42.3	4.2	1.4	0.0

* Median response falls within this designated response category. † A high-risk procedure is defined as one in which an ignition source may be in proximity to an oxidizer-enriched atmosphere. ‡ n is the number of ASA members who responded to each item. All other numbers in the table represent the percentage of ASA members who selected the designated response category.

CO_2 = carbon dioxide; F_{IO_2} = fraction of inspired oxygen; OR = operating room.