The A.B.C.’s Of Surgical Smoke Plume

Joseph Lynch, Director of Marketing, Buffalo Filter

The use of thermal instruments for surgical applications has grown significantly over the past three decades. Unfortunately, when any type of thermal or ultrasonic surgical instrument, such as laser energy, electrosurgery, argon, ultrasonic/harmonic scalpel, or plasma is applied to human tissue an unwanted by-product is produced which is commonly known as surgical smoke plume. Through a significant number of research articles, studies, and published standards, it is well documented that surgical plume must be evacuated and filtered to protect healthcare workers and their patients from the A.B.C.’s of surgical plume namely Aerosolized blood and blood fragments, Biological particulate including intact bacteria, virus, and lung-damaging dust-like particles, and finally Chemical by-products not unlike those found within cigarette smoke. Despite the best efforts of healthcare safety officials, adoption of plume evacuation in some areas remains relatively limited. Over the past two decades, we have reached a greater comprehension as to what hazards exist within surgical smoke. These hazards have not changed; however, not unlike the learning process the international community went through relating to cigarette smoke, the hazards are better understood.

Surgical smoke plume, known under many different names such as Laser Plume, Surgical Smoke, Laser Generated Airborne Contaminants (LGAC), as well as many others, presents a danger to over 500,000 healthcare workers in the U.S. alone on an annual basis.1

Although surgical smoke plume management systems have existed in the marketplace for over 30 years, adoption of these devices and the implementation of protocols to control these dangerous by-products have been slow to develop. Not unlike the slow acceptance of the body of evidence that was accumulated with cigarette smoke, many facilities, clinicians and caregivers have been slow to accept the A.B.C. hazards of surgical smoke plume. Despite hundreds of articles that have been written on the subject, many still seek a direct cause and effect relationship between plume exposure and illness. Of course, not unlike cigarette smoke, chronic exposure leads to an increasing impact on health over time, although each exposure may have biological hazards such as blood, blood fragments, and viable virus.2

Fortunately for medical laser users, the laser community has been on the forefront of adopting standards and protocols that mandate the control of surgical smoke plume when generated by lasers, or other ablative instruments. With the advent of ANSI Z136, a prescriptive standard was adopted in which the management of surgical plume was addressed by the following wording: (ANSI Z136.3)

"Airborne contaminants shall be controlled by ventilation and respiratory protection. Ventilation techniques can include general room or local exhaust ventilation, or a combination."3

"Electrosurgical devices are often used separately and simultaneously with HCLS (Health Care Laser Systems). These devices have been found to produce the same type of airborne contaminants as produced by laser/tissue interaction, and should be evacuated from the surgical site."[3]

CDC/NIOSH also used similar wording in their HAZARD CONTROLS warning entitled ***Control of Smoke From Laser/Electric Surgical Procedures.***[4] This document makes the following statement:

"General room ventilation is not by itself sufficient to capture contaminants generated at the source. The two major LEV (local exhaust ventilation) approaches used to reduce surgical smoke levels for health care personnel are portable smoke evacuators and room suction systems."[4]

During their annual Congress in 2008, AORN (Association of periOperative Nurses) introduced a new Position Statement[5] outlining the association's stance on the management of surgical smoke plume hazards. As part of their recommendation, AORN advocates the following measures as a means of controlling the inherent hazard within this dangerous by-product:

- Use local exhaust ventilation.
- Central smoke evacuation systems.
- Portable smoke evacuation systems.
- Wall suction with inline filter.
- Laparoscopic evacuation/filtration systems.
- Develop and implement training programs.
- Comply with federal, state and local regulations and standards

As mentioned above, common practices such as the use of wall suction as a means of capturing and disposing of small amounts of laser, electrosurgical, and mechanical plume are tempered with the caution of filtering the plume prior to infusion into the central vacuum system. As these systems are not designed to capture smoke plume and aerosols, the long term effect of plume capture on the internal mechanisms of the system, as well as potential reductions in suction capability, are of concern. Additionally, personnel that maintain and care for these systems are not always outfitted with the appropriate PPE to guard against bio-hazardous exposure.

As part of their on-going efforts to educate the clinical community as to the risks associated with surgical smoke exposure, AORN has developed an educational toolbox that caregivers can use to promote safety within their institutions. For more information visit: www.aorn.org [1].

Bewildering to some, many facilities are still waiting for more specific mandates on a federal level, for example from organizations such as OSHA before taking action to manage surgical smoke plume. With reimbursement revenues decreasing and increased costs, healthcare facilities are having to make tough decisions when

trying to address both staff and patient safety. Fortunately for the clinical and patient communities, those mandates are beginning to fall into place. The Joint Commission released in January 2009 an updated Environment of Care standard, EC.02.02.01- entitled: ***The [organization] manages its risk related to hazardous materials and waste***[6]. Part of the new verbiage includes more dogmatic language relating to surgical smoke. The standard makes the following statements:

- The hospital minimizes risks associated with selecting, handling, storing, transporting, using, and disposing hazardous gases and vapors.
- Note: Hazardous gases and vapors include, but are not limited to, glutaraldehyde, ethylene oxide, vapors generated while using cauterizing equipment and lasers, and gases such as nitrous oxide.
- A measure of success is required.

The international community in many ways has been light years ahead of the United States in terms of adoption of clear standards relating to smoke plume hazards. Nations such as Denmark and Australia have laws in place mandating the use of some form of engineering control, such as smoke evacuation systems, to manage the surgical smoke plume within their operating theatres. Recently the Canadian Standards Association (CSA) released a new standard that specifically addresses surgical plume. The standard is entitled "*Plume Scavenging in surgical, diagnostic, therapeutic, and aesthetic settings*"[7] and contains the most direct and comprehensive standard language to date.

It has been proven that surgical masks do not provide adequate protection against the biological, chemical, or physical (particulate) hazards associated with surgical smoke plume, regardless of what instrument is used to create the plume.[8] Most regulatory and professional organizations recognize the inherent fit issues with surgical masks as gaps in which particles (averaging in size of 1.1 micron) can easily pass through. Airborne particulate demonstrating this aerodynamic size will seek the path of least resistance as inhalation acts to draw these particles to the mask. Very often this path may be around the mask itself. Additionally, most surgical masks can only trap particles 5 microns or larger. The common analogy often referenced is "trying to stop a 1.1 micron particle with a surgical mask is like trying to stop a flying BB with a chain link fence"- very ineffective.

With regards to biological particulate, one study conducted by Garden, et al. entitled Viral Disease Transmitted by Laser Generated Plume (Aerosol)[9] demonstrated that when bovine papillomavirus was exposed to a carbon dioxide laser, the virus could be harvested from the collection of laser generated airborne contaminants and reinoculated into foreign tissue, in this case calf tissue, and tumor growth was observed in the post inoculation site. These tumors presented the same virus as harvested from the laser plume. Surgical smoke plume consists primarily of water, which generates vessels that can host viable organisms into the air stream. Additionally, over 40 different chemical substances have been isolated within surgical smoke plume including several known carcinogens such as: [7,9]

1. Benzene- known carcinogen
2. Toluene- suspected carcinogen
3. Formaldehyde- known carcinogen
4. Ethylbenzene- suspected carcinogen
5. Percloroethylene- suspected neurotoxin and carcinogen

Outside of the well-documented evidence relating to the biological and chemical elements within the plume, there remains a physical hazard from what has been coined as "lung-damaging dust". Particles less than 2.5 microns may not be trapped by the primary and secondary bronchia within your respiratory system.[10] Therefore they can reach the deepest regions of your lungs, the alveoli, settling into these tiny air sacs and potentially transferring biological materials, or causing infection, congestion, or aggravation of conditions such as chronic obstructive pulmonary disease (COPD) and asthma.

Controls to manage the hazards of surgical plume within healthcare have advanced over the past two decades. Most of these systems are based on creating a vacuum or laminar flow of air stream that captures the hazardous by-products contained within the smoke plume and then pulls it through filter media where it is trapped for disposal. One common approach is central and portable smoke evacuation systems. Although coined as "smoke evacuators", these systems are designed to capture all of the elements of the plume, aerosols, bio-hazardous materials, chemical agents, and physical particles. The spectrum of smoke evacuation equipment ranges from very simplistic equipment to highly advanced centrally located systems for multiple operating rooms. An examination of plume capture devices needs to take into account the following key characteristics:

- The rating and efficiency of the filter system
  - What size particles will it capture
  - To what level of effectiveness
- Presence and methodology for trapping hazardous gases
- Method for capturing gross particulate (to prolong effectiveness of high efficiency filter)
- Physical size and location of the system
- Sound level
- Ease of maintaining the system and working with accessories

It is important to understand the rating of your system to insure appropriate capture for your desired goals. Manufacturers provide a myriad of surgical smoke evacuation solutions to facilitate a safe operating environment.

Joseph Lynch is Director of Marketing for Buffalo Filter. Joseph is active in the educational conference circuit and manages solution development for the organization. He may be reached at joseph.lynch@buffalofilter.com *[2].*

References: *1: U.S. Department of Labor, Occupational Safety and Health Administration: "**Safety and Health Topics: Laser/Electrosurgery Plume"** ,* http://www.osha.gov/SLTC/laserelectrosurgeryplume/index.html *[3] 2: U.S. Center*

*for Disease Control (CDC [4]) and the National Institute for Occupational Safety & Health (NIOSH [5]): Hazard Controls: **"Control of Smoke from Lasers/Electric Surgical Procedures"**, http://www.cdc.gov/niosh/hc11.html [6] 3: American national Standards Institute (ANSI): "**American National Standard for Safe Use of lasers in Health Care Facilities, Z136.3-2005"**, www.ansi.org [7] 4: Association of periOperative Registered Nurses: **"AORN Position Statement on Surgical Smoke and Bio-Aerosols- 2008"**, http://www.aorn.org/PracticeResources/AORNPositionStatements/SurgicalSmokeAndBioAerosols [8] 5: The Joint Commission: **Hospital Accreditation Program, 2009 Chapter: Environment of Care**, **Standard EC.02.02.01**, www.jointcommission.org [9] 6: Canadian Standards Association (CSA): **Plume Scavenging in Surgical, Diagnostic, Therapeutic, and Aesthetic Settings- Number Z305.13-09**, www.csa-intl.org [10] 7: Barrett W.L., Garber S.M.: "**Surgical Smoke: A Review of the Literature"**, Surg Endosc 2003, 17:979-987 8: Garden J.M., O'Banion M.K., Bakus A.D.: Olson C.,: "**Viral Disease Transmitted by Laser-Generated Plume**", Archives of Dermatology [11] 2002, October Vol. 138/ No. 10 9: Al Sahaf O.S., Vega-Carrascal I, Cunningham F. O., McGrath J. P., Bloomfield F. J. : "**Chemical Composition of Smoke Produced by High-Frequency Electrosurgery"**, Irish Journal of Medical Science [12], 2007 10; Bruske-Hohlfeld I., Preissler G., Jauch, K.W., Pitz M., Nowak D., Peters A., Wichmann H.E.: **"Surgical Smoke and Ultrafine Particles"** , Journal of Occupational Medicine and Toxicology, December 2008 11: Ott D.E.: **"Carboxyhemoglobin Changes Due to Laser Smoke at Laparoscopy"**, American Society for Laser Medicine & Surgery 12: Ott D.E.: **"Laser Smoke/ Plume Absorption via the Peritoneum at Laparoscopy"**, American Society for Laser Medicine & Surgery- Abstracts 1994 13: Brandon H.J., Young V.L.: "**Characterization and Removal of Electrosurgical Smoke"**, Surgical Services Management, March 1997, Vol. 3/ No. 3 14: Tomita T., Mihashi S., Nagata K., Ueda S., Fujiki M., Hirano M., and Hirohata T.: **"Mutagenicity of Smoke Condensates Induced by CO2 - Laser Irradiation and Electrocauterization"**, Mutation Research [13], 1981*

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Links:
[1] http://www.aorn.org/
[2] mailto:joseph.lynch@buffalofilter.com
[3] http://www.osha.gov/SLTC/laserelectrosurgeryplume/index.html
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