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Managing Surgical Smoke Risk While Improving Visualization and Minimizing Patient CO_2 Exposure Using the Ultravision™ System During Laparoscopy

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Introduction

Surgical smoke, along with other particulate matter generated in the operating room (OR) poses a health problem for staff, as well as reduces visualization for the surgeon and acts as a potential impediment to OR efficiency in laparoscopic surgery due to increased wait times for smoke clearance or camera cleaning.[1,2] At high concentrations during a procedure, surgical smoke also may cause eye and upper respiratory tract irritation among staff.[3] In the United States, to combat the risk for health effects from surgical smoke, 5 states have implemented laws to require smoke management for laparoscopic procedures[4] and 6 additional states have legislation pending for such requirements, according to the Association of periOperative Registered Nurses (AORN).[5,6]

Understanding smoke management technology and available options is growing in importance for the surgical community.[7,8] In contrast to traditional technologies that clear smoke by evacuating smoke particulates and carbon dioxide (CO_2) from the abdomen, the Ultravision system uses electrostatic precipitation to clear smoke and increase visualization in laparoscopy.[9] Additionally, it offers the advantages of reducing aerosolized biomatter and minimizing patient CO_2 exposure with a stable pneumo and increasing procedural efficiency.[2]

Need for Smoke Management Systems

Surgical smoke, produced by a variety of heat-generating energy sources such as electrosurgical devices, laser tissue ablation, and drills or saws, is associated with health hazards to OR staff.[1,10] In addition to the symptoms of exposure—including cough, headache, nausea, and throat irritation[11]—surgical smoke can contain mutagens and carcinogens.[12] Evidence that surgical smoke also carries live bacteria and viruses has intensified interest in strategies for surgical smoke abatement, particularly in the COVID-19 era.[13,14]

Various smoke management options, all evacuating smoke using different mechanisms for capturing and filtering smoke and particulates, have been used to clear the surgical field.[15] Most utilize the pressure of the pneumoperitoneum in combination with a passive filter or a type of suction action with a capture velocity in the range of 100 to 150 feet per minute within the surgical site and include a filter to clear the evacuated CO_2 from smoke particulates. This affects the pressure of the pneumoperitoneum and creates the need for continuous insufflation.[16]

Smoke management is of particular importance in laparoscopic surgery because unlike open procedures, smoke concentrates within the abdominal cavity, impairs visibility, and may be released into the OR by opening a valve of the trocar. Once open, smoke can be emitted into the OR at a high velocity, thereby exposing surgical staff to high concentrations of surgical smoke at once. Even without opening the valve, smoke can still leak from functional trocars during instrument changes.[17] When using a filtration-based smoke management device, only the smoke that is being captured by the filter is being contained. In other words, while the smoke evacuator may have a ULPA filter capable of more than 99% filtration efficiency, not all smoke reaches the filter. For example, a recent paper reported that the use of a smoke evacuator only reduced detectable OR particulates by 32% during laparoscopic surgery.[17] Over a sustained period of time with regular OR smoke exposure, this can become hazardous to the health of OR staff and surgeons.[18]

Ultravision™ System

Unlike other devices, only one commercially available system uses electrostatic precipitation: the Ultravision™ System

(Alesi Surgical; distributed by Olympus in the United States). It has been shown to eliminate the release of smoke into the OR[2] with near-complete smoke and particle clearing after 1 minute of use.[9,19] Electrostatic precipitation functions based on the creation of low-energy gas ions in the abdominal cavity. When these ions are released by the generator into the abdomen during a laparoscopic procedure, they transiently associate with the smoke and aerosolized particulate, including biomatter, and thus accelerate their sedimentation, preventing them from exiting the body and circulating in the OR environment.[2,9] Ultravision™ is indicated for the clearance of smoke and other particulate matter that is created during laparoscopic surgery.[9]

"When Ultravision™ was first demonstrated to me, the smoke seemed to magically disappear. However, there is a science to the device technology, which has several advantages. On the other hand, one might initially wonder about the smoke particles left in the patient's body, but in my experience, there is no significant risk about this one-time exposure to the patient. On the contrary, I believe it actually enhances patient outcomes," said Jin S. Yoo, MD, an assistant professor of surgery with the Duke University Health System, in Durham, North Carolina, who specializes in minimally invasive surgery with clinical expertise in hernia, foregut, and bariatric surgeries. "In a demonstration of the Ultravision™ system, I learned that it rapidly eliminated smoke, but also permitted low-pressure surgery as it allowed procedures to be performed with less CO_2, due to its working principle of not evacuating smoke from the pneumoperitoneum."

In the demonstration, Dr Yoo noted that he was intrigued about the potential for Ultravision™ to maintain pneumoperitoneum without requiring continuous CO_2 insufflation as it is required by the common technique. Continuous and high CO_2 inflow insufflation for creating a pneumoperitoneum presents its own potential health hazards for clinicians when released into the OR due to higher CO_2 concentrations.[20,21] It can also be associated with surgical complications, including the risk for postoperative pain.[22]

"Intraabdominal insufflation with CO_2 has several disadvantages, including increased pressure on the abdominal wall and vital organs in the abdomen. I already had developed an interest in low-pressure surgery when AORN began to lobby for smoke evacuators," Dr Yoo said. However, Dr Yoo had struggled with the fact that these 2 surgical goals, smoke evacuation and low-pressure surgery, could not be combined due to the continuous insufflation and high flow need, which strengthened his interest in using Ultravision™ for smoke management.

Filling Unmet Needs in Surgery: Ultravision™ Use

Dr Yoo began using the Ultravision™ system in 2019 (Figure). Since then, he has performed more than 600 cases with this device in a wide variety of laparoscopic and some robotic procedures, such as cholecystectomy; inguinal and ventral hernia repairs; and bariatric procedures such as sleeve gastrectomy, gastric bypass, and duodenal switch.

According to Dr Yoo, the use of Ultravision™ has been easily and seamlessly adopted in the OR. Ultravision™ requires a compact low-power generator that delivers the voltage that creates the gas ions and one of 2 options for a single-use, sterile consumable, both containing an active Ionwand™ electrode. The Ionwand™, which delivers the ions to the pneumoperitoneum, is placed into the operative field either through a dual-function 5-mm trocar or a dedicated 2.5-mm catheter.[9] The 5-mm trocar option replaces an existing 5-mm trocar and is placed in that trocar's standard location.[9] The 2.5-mm catheter is placed according to clinician preference, typically between the laparoscope trocar and an adjacent working trocar.[9]

Dr Yoo noted that while the Ionwand™ should be in reasonable proximity to the surgical site where smoke is being generated and biomatter is likely to be aerosolized, it also needs adequate space to produce negative ions. "Positioning of the wand is important," Dr Yoo said, "but the learning curve for the optimal positioning is short. I became comfortable using the device within a few cases."

Ultravision™ has been shown to silently clear 99.9% of surgical smoke and mist within 1 minute in the abdomen.[19] Additionally, the unintentional release of smoke in the OR through leaks in trocars or as a result of instrument exchanges is 23 times less when using Ultravision™ than when using a smoke evacuator.[23]

Low-Pressure Surgery and CO_2 Reduction

Ultravision™ is a smoke management system that offers the user the advantage of controlling smoke and other aerosolized matter from the surgical procedure at the surgical site. It further clears the field of view, supports a more efficient workflow, promotes a smoke-free OR, and improves air quality for surgical staff without influencing intraabdominal pressure. It combines multiple advantages

Figure. Dr Yoo using the Ultravision™ system during surgery.

Image courtesy of Jin S. Yoo, MD.

in one system and overcomes the pitfalls of standard smoke evacuation in laparoscopy. In addition to these indications and main advantages of using Ultravision™, Dr Yoo remains enthusiastic about and additionally emphasizes its role in low-pressure, low-flow surgery and in enhancing reduced patient exposure to, and consumption of, cold, dry CO_2.

"In procedures performed with Ultravision™, I can turn off the CO_2 valves once pneumoperitoneum is achieved. This allows me to use 20 to 25 L of CO_2 overall rather than the typical 300 to 500 L for a 1-hour laparoscopic case when using a high-flow insufflator and maintain a stable pneumo," Dr Yoo said. Lower intraoperative pressure on the abdominal wall is associated with reduced postoperative pain.[24] Dr Yoo explained that most laparoscopic and robotic procedures are performed with a CO_2 pneumoperitoneum pressure of 15 mm Hg, a level that has long been associated with potential adverse consequences in selected patient populations.[25]

Due to potential risks, Dr Yoo said lower pressures often are needed in high-risk individuals, such as patients who have heart and/or lung disease that cannot tolerate standard pneumoperitoneal pressure of 15 mm Hg well, or patients who are morbidly obese and/or elderly. But he thinks the approach should be used more broadly. "Why limit low-pressure surgery only to high-risk cases? I currently lower the intra-abdominal pressure down as much as possible on all my minimally invasive surgery cases without sacrificing the surgical view and exposure I need to safely perform the operation. For some patients that may be 6 mm Hg and for some it may be 12 mm Hg," he said.

Improving OR Efficiency

The first clinical trial on the use of Ultravision™ for laparoscopic surgery was performed by Ansell et al and they concluded that improved visibility using the system led to reduced operating times, as clinicians did not need to pause procedures to wait for smoke clearance or to clean the laparoscope.[2]

Dr Yoo also said the lower consumption of CO_2 during cases translates to less changing of CO_2 gas tanks during the procedure or the OR day, which increases efficiency and can lead to cost savings in the OR. Additionally, Dr Yoo noted that the setup of the device is fast and easy to understand. Ultravision™ also operates silently —a notable benefit as evacuator noise often is a cited issue when using other technology.[7]

Conclusion

The effort to reduce staff exposure to surgical smoke has been led by OR nurses (through initiatives like the AORN Go Clear Award Program), but the issue is relevant to all members of the OR team.[5] Even in states that do not pass legislation mandating smoke management during surgical procedures, the growing interest in this issue has the potential to establish the use of smoke management devices as a standard of care. Of the methods for surgical smoke management, electrostatic precipitation utilized by Ultravision™ has been shown to be uniquely effective in preventing smoke and toxins from circulating in the OR environment, while offering further meaningful benefits and improvements in visualization, OR efficiency, and patient exposure to CO_2.[2,23] The simultaneous enhancement of a stable pneumoperitoneum is an independent but meaningful additional benefit over traditional smoke evacuation.

"Ultravision™ is the only technology that will allow the surgeon to perform laparoscopy with low-pressure, low-flow, and low-volume CO_2," Dr Yoo said. "This is one way we can take minimally invasive surgery to the next level in an effort to reduce physiological stress and postoperative pain while providing enhanced visualization for the surgeon and protecting OR staff from smoke and particulate generated by the procedure."

For more information about the Ultravision™ system, please visit: https://medical.olympusamerica.com/products/ultravision.

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