Advanced Smoke Removal Technology for Enhanced Productivity in Minimally Invasive Surgery

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Background

Conventional smoke removal methods in minimally invasive surgery can result in tradeoffs between pneumoperitoneum stability, in-field visibility, and safety. Filtered gas is often vented into either a central facility vacuum line or the OR. Passive smoke removal methods that rely on pneumoperitoneum pressure to generate leakage flow may not provide complete pathogen protection to OR staff.[1] Some active smoke removal devices offer heavier filtration capacities and higher flow rates, but constant siphoning increases CO_2 consumption and pneumoperitoneum instability during a procedure. Though such methods attempt to increase visibility to surgeon, they compromise workflow and outcomes.

[1] Barrett, William L., and Shawn M. Garber. "Surgical smoke: a review of the literature." Surgical endoscopy 17.6 (2003).

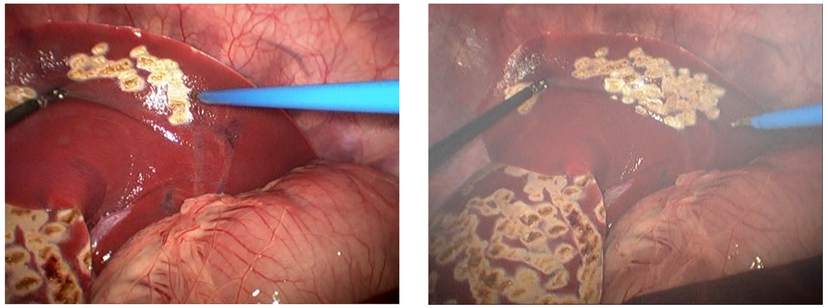


Figure 1: Endoscopic images illustrating the degraded visual clarity that results from accumulation of surgical smoke [taken during during simulated monopolar cautery in an animal model].

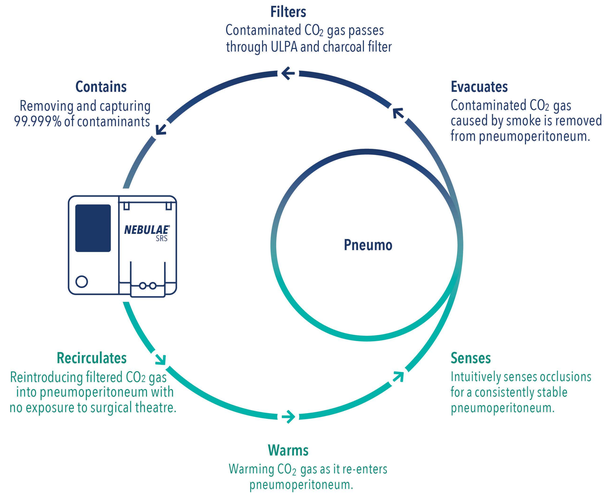
Technology

The present technology aims to overcome these limitations through an advanced, closed-loop filtration design to maintain visual clarity in the surgical field. It features a disposable tubing set that connects to two standard trocar luers and is powered by a pump system. At one end, contaminated gas is removed at 10LPM and then passes through ULPA & Charcoal filters. Filtered gas is then optionally warmed before recirculating to the pneumo. In doing so, an extension of the pneumoperitoneum is created, with virtually no CO_2 entering the OR room, and insufflation pressure is unaffected.

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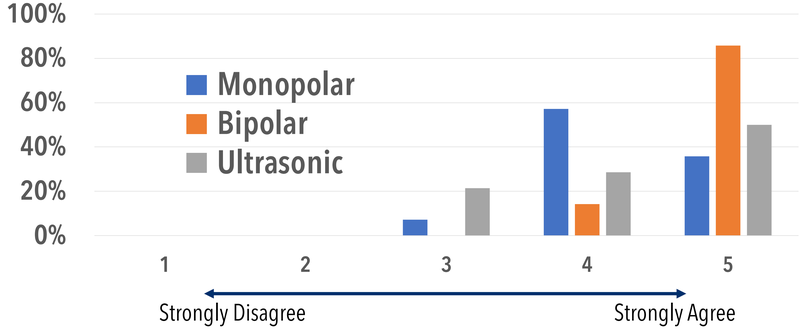


Figure 2 (above): NEBULAE® SRS in surgery
Figure 3 (below): A schematic illustrating the closed-loop flow path utilized by the NEBULAE® SRS.



Study

Initial evaluation of the device was conducted in a simulated laparoscopic environment by 14 surgeons using monopolar & bipolar electrocautery and ultrasonic dissection. User surveys were taken to gauge device performance with three different energy devices, rating the statement, "The [device] helped maintain visual clarity by removing smoke and particulates during [cautery/dissection] from the field of vision," on a scale of 1-5 (strongly disagree to strongly agree).



Results and Conclusion

When using the device with a monopolar instrument, users recorded an average response of 4.3 out of 5 (36% strongly agreed, 57% agreed, 7% neutral); with the bipolar, 4.9 out of 5 (86% strongly agreed, 14% agreed); and with the ultrasonic, 4.3 out of 5 (50% strongly agreed, 29% agreed, 21% neutral). This indicates that the proposed technology effectively maintains visual clarity and stable pneumoperitoneum under conditions of a typical laparoscopic procedure, regardless of instrument used. Future directions of study include assessing the device in procedures which challenge conventional insufflators, such as low-pressure (e.g., <=10mmHg), low-volume, and single-port surgeries. Additionally, studies may be conducted to quantify efficiency gains offered by continuous, recirculating smoke evacuation.