Editorial

Do we need to reduce surgical smoke?

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Surgical smoke has become a topic of interest recently. Nine states in the United States have considered bills to reduce surgical smoke, and three states (Rhode Island, Colorado, and Kentucky) have enacted laws regarding surgical smoke in the last 5 years (1). These laws have been advocated for by the Association of periOperative Registered Nurses (AORN) and The Joint Commission (1). The Joint Commission published, "*Alleviating the dangers of surgical smoke*" as a Quick Safety report in 2020 (2). The AORN has created the "Go Clear Award™ Program" which gives awards to facilities that have sufficient surgical smoke evacuators/accessories, and comply with use (3). Both the AORN and The Joint Commission have published the potential hazards from surgical smoke, asserting, "*research studies confirm that the surgical smoke plume can contain toxic gases and vapors…bioaerosols, dead and live cellular material (including blood fragments), and viruses*" (1).

Given that centers which provide surgical services are encouraged (and in some states mandated) to mitigate exposure of operating room staff to surgical smoke, there is a market need for this type of equipment. Medtronic, the medical device company that sponsors the AORN Go Clear Award™ Program, also sells smoke evacuator electrocautery pencils, smoke evacuator systems (4), and electrosurgical systems that function at lower temperature and reduce surgical smoke production (5). As such, Zhang *et al.* recently reported their analysis of a new surgical device called the NTS-100, which functions by pulsed radiofrequency energy at a lower temperature than traditional electrocautery (5). The authors hypothesized that the NTS-100 would produce lower quantities of surgical smoke compared to a conventional electrocautery system and another lower temperature electrocautery system. Indeed, they found that the smoke associated with diathermy from the NTS-100 had fewer particles <2.5 microns in size and produced less volatile organic chemicals (VOCs) compared to the smoke from a conventional electrocautery system (5). Of note, however, aerosolized particles were measured 5 cm from the surgical smoke source in a room with unmeasured ventilation. VOCs also were measured 5 cm from the surgical smoke source in a closed glass container. It should also be noted that respirable particulate matter and VOCs are ubiquitous in indoor environments (6), but that control values were not reported in these experiments.

In this study (5), as with many before it (7-11), the primary limitation is the failure to acknowledge that surgical staff do not directly inhale surgical smoke centimeters from the source in a closed system or poorly ventilated room. Prior studies on this topic have several other limitations as well. In the original study by Tomita *et al.*, published in 1981, the authors burned animal tongue and measured/tested smoke suctioned directly away from the burning tissue in a closed box. The authors then measured the mutagenic potential of the surgical smoke condensate. These data were compared to previously published data on cigarette smoke and their own data regarding cigarette smoke which was not shown in the manuscript (7). Further, mutagenicity was measured on *Salmonella typhimurium* strains with the Ames test (7), and did not assess mutagenicity on human airway cells. Using

this questionable data, Hill *et al.* equated staff surgical smoke exposure to cigarette smoke exposure based on the duration of electrocautery use in an operating room over a two-month period (11). In both manuscripts, the authors seem to incorrectly imply that 100% of particulate matter from surgical diathermy is inhaled as a cigarette would be inhaled directly into the lungs. These experimental designs, therefore, are not representative of the true operating room environment, which would involve measurement in a high ventilation room at a distance from the surgical smoke source that approximates the surgical staff respiratory zone. Zhang *et al.* wrote, "*the aim of this research was to compare the surgical smoke generated during electrosurgery with hazardous composition*". Actual hazard, however, can only be realized if sufficient quantities are inhaled. Like the AORN and The Joint Commission reports, Zhang *et al.* asserted, "*The results of this research reconfirm the smoke hazard of the ES* (conventional: electrocautery)". It should be noted though that no human hazard was demonstrated in this, or previous, research. As such, results of these studies should not be used to make decisions regarding behavior, equipment, or practice standards in the operating room.

The broader question that should be asked is, do we need to reduce surgical smoke in the operating room? The adverse effects of inhaling large quantities of the products of combustion and biomaterials are not subject to scientific debate. Surgical smoke only needs to be reduced though if the level of exposure to its hazardous components exceeds those outside the operating room, where there is no surgical smoke, and these values reach hazardous levels for operating room staff. In the operating room, 82% of respirable particulate matter from surgical smoke is lost in the ventilation when distance from the source is increased from 2.5 to 30 inches (12). Stewart *et al.* (12). and Brüske-Hohlfeld *et al.* (10) measured respirable particulate matter in the operating room from immediately beind the surgical drape during live operations and found high variability of particle concentration during surgery. Both studies reported that due to high ventilation in the operating room, there were only short burts of respirable particle exposure alternating with longer periods of low exposure. Stewart *et al.* also found that the quantities of paritculate matter in the surgical suite were similar to that in office spaces, and that operating room particulate caused less DNA damange when co-cultured with human small air epithelial cells (12). Additional evidence for this comes from The Nurses' Health Study, which demonstrated amongst 86,747 nurses, those who worked in the operating room were less likely to develop lung cancer (13). Studies have also reported that the majority of VOCs present in the operating room are from cleaning products, and not from surgical smoke (8,12).

With the insurgence of the COVID-19 pandemic, the potential to inhale infective biomaterials by exposure to surgical smoke has also been raised (14). Zhang *et al.* did not directly address if the NTS-100 reduced exposure to respirable infective biomaterials. In truth, these type of studies are difficult to conduct. The ability of respiratory particles containing virus to travel through air and the distance that they can travel is subject to a numerous variables, including speed, size, temperature, and ventilation, as expained by Mittal *et al.* (15). In general, the data concerning transmission of viruses through surgical smoke is weak, with the exception of human papilloma virus (14). Thus, reduction of exposure to surgical smoke has importance in higher-risk cases where fulguration of tissues infected by human papillomavirus is anticipated.

To conclude, the reported hazards of surgical smoke are generally overstated, and there are clear conflicts of interest as they relate to the medical device industry. Studies focused on surgical smoke composition and production should involve experts in air quality and consider typical operating room staff exposure in their experimental designs. In an effort to promote resource stewardship and decrease unnecessary expenditures in the healthcare sytem, future work related to surgical smoke should attempt to understand actual hazards posed, rather than hypothetical hazard from direct inhalation which does not occur in the operating room.

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