Does the Use of a Smoke Evacuation Device Reduce Smoke Exposure in the Operating Room? A Prospective Study

James Hall, Joshua Eisenberg, Ashley J Bell, Christopher N Carender[1], Christopher P Lindsay[2], Natalie Ann Glass, Catherine Renee Olinger[3], Cassim M Igram[4], Andrew James Pugely[5]
[1]University of Iowa Hospitals and Clinics, [2]University of Iowa, [3]University of Iowa Hospitals and Clinics/ Departme, [4]University of Iowa Hosp & Clinics, [5]University of Iowa Hospital

INTRODUCTION:
It is widely accepted that the inhalation of smoke, specifically the particulate matter contained therein, can cause adverse health effects. The contents of surgical smoke have been closely studied, establishing the average particle size, and the presence of dangerous compounds including known carcinogens. Few, however, have investigated the utility of smoke evacuation systems in the surgical theater. In June 2018, Rhode Island was the first state to enact a law mandating the use of a smoke evacuation system in the operating room. This was followed by nine more states with similar legislation in 2020. With increased scrutiny on surgical smoke levels, these devices should be further studied. Our primary aim was to investigate the efficacy of smoke evacuation during orthopaedic spine surgery in reducing smoke levels. Secondary aims were to investigate patient, equipment, and facility factors that may impact smoke levels.
METHODS:
Consecutive patients undergoing orthopaedic spine surgery at a single institution had surgical smoke levels measured during the first hour of the procedure utilizing one manufacturers particle counter instrument. Room set-up was standardized such that the particle counter was positioned on an IV pole supporting the surgical drape nearest the anesthesiologist. Patients were grouped by the type of evacuation device used. A control group was included and no evacuation device was used in this cohort. Evacuation devices used included a cautery evacuator pencil (CEP) and a para incisional vacuum (PIV). The CEP has suction inline with the cautery tip while the PIV uses a large suction tube at the proximal aspect of the incision. Both evacuation systems are activated by the same cautery device. Average and peak smoke particle counts were measured in size range 0.3 - 10 µm. Patient characteristics collected included age, BMI, and number of operative levels. Facility data collected included room size, and OR air turnover rate. Equipment data collected included cautery power settings. Evacuators were compared to one another and to the control. Bivariate and multivariate statistical analyses were completed with smoke levels as the dependent variable. Smoke evacuation group, patient and room characteristics were independent variables. Significance was defined as $p < 0.05$.
RESULTS:
The study included 117 patients. The CEP was employed in 36, PIV in 43, while the control group included 38 patients. Average and peak smoke particle levels were collected. Across all particle sizes, the CEP and PIV demonstrated significant smoke reduction compared to the control group. There was no significant difference between the two devices when comparing average smoke level, while the PIV significantly reduced peak smoke levels when compared to the CEP. Spearman's rank test showed a moderate correlation between smaller room size and higher peak and average particle counts. Furthermore, increased number of operative levels correlated with higher average smoke levels. Patient demographics and cautery power settings did not significantly impact surgical smoke levels.
DISCUSSION AND CONCLUSION:
Surgical smoke is generated by the heating of tissue to its boiling point by electrocautery causing membrane rupture and release of cellular contents as fine particulates. Cautery, commonly used during orthopaedic procedures, generates particles in the range of 0.07 to 0.42 µm. Inhalation of particles 10 µm and smaller can cause irritation and has been linked to complications such as CAD, CHF, asthma, and COPD. Additionally, particles 2.5 µm and smaller are known to deposit in the bronchioles and alveoli.
Standard surgical masks provide filtration of particles 5 µm and larger while N95 masks offer better protection filtering particles down to 0.3 µm. Surgical smoke contains roughly 150 chemicals, 16 of which are labeled by the EPA as priority pollutants, toxic and carcinogenic substances along with blood products, viruses, and bacteria. These risks are the impetus for mandating the use of smoke evacuation, but few studies have investigated their efficacy in vivo.
This is the largest known patient cohort to study smoke evacuation systems in the operating room during live surgery and to the author's knowledge, the first in orthopaedic surgery. Our results are in agreement with prior studies in other fields and show a significant reduction in average and peak smoke levels with the use of evacuation. Our results further suggest there may be a benefit to the use of a para incisional vacuum versus cautery evacuation pencil. Given the risks associated with exposure to surgical smoke, the use of smoke evacuation has the potential to provide a significant risk reduction to operating room personnel.

Spearman Correlation Coefficients, N = 117 Prob > |r| under H0: Rho=0		
	avg_03	**peak_03**
Room Size ***correlation coefficient***	-0.40	-0.43
p-value	<.0001	<.0001
Levels ***correlation coefficient***	0.22	0.09
p-value	0.0177	0.3252

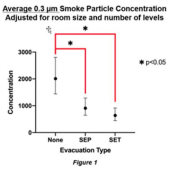

Figure 1

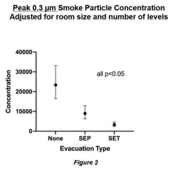

Figure 2

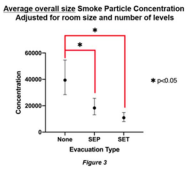

Figure 3