Development and evaluation of a novel surgical smoke evacuation device

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Background

Surgical smoke is produced during surgical process when using high frequency electrical current to cut and coagulate the tissue. Surgical smoke contains high concentration of particulate matters and hazards gases. This may pose health risks to medical personnel working in operation rooms. Surgical smoke is an important problem in the operation room. At present, local ventilation system is adopted in some operating rooms. However, local exhaust ventilation is sometimes blocked by blood clot and may generate high noise levels.

Objective:

To develop a novel surgical smoke removal device by using negative ions and evaluate its particle removal efficiency.

Materials and Methods

- **Surgical smoke generation and control methods**

To simulate the real situation of real electrosurgery, we use electrosurgical units (ESU) to cut the porcine tissue ,adopting the electrical power of 30 Watt at cutting mode.

We try to adopt several control methods and compare their removal efficiency to without any control methods. The control methods are listed below:

1. Local evacuation system
2. Negative ion

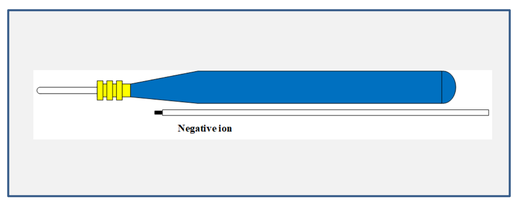

Fig. 1. The negative ionizer is attached on ESU

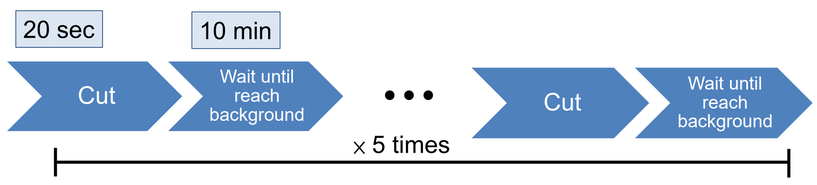

Fig. 2.
The process of experiment. Every sample continuously cut for 20 seconds and then wait until the particle concentration reaches background level (2000 particles/cm^3).

- **Measurement**

The particle concentration was measured by using the Fast mobility particle sizer (FMPS, Model 3091 series, TSI Inc., MN, USA) and DustTrak II (Model: 8530, TSI Inc., MN, USA). We measured the particle concentration at the source and the breathing zone.

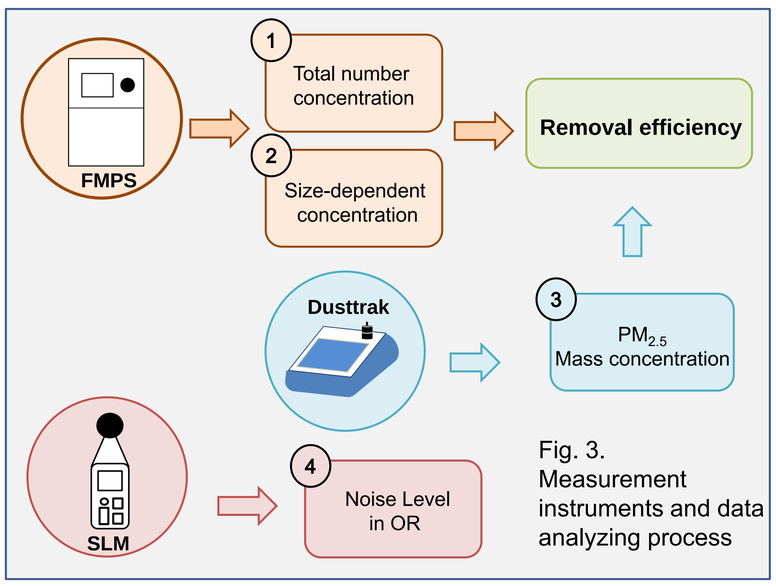

Fig. 3.
Measurement instruments and data analyzing process

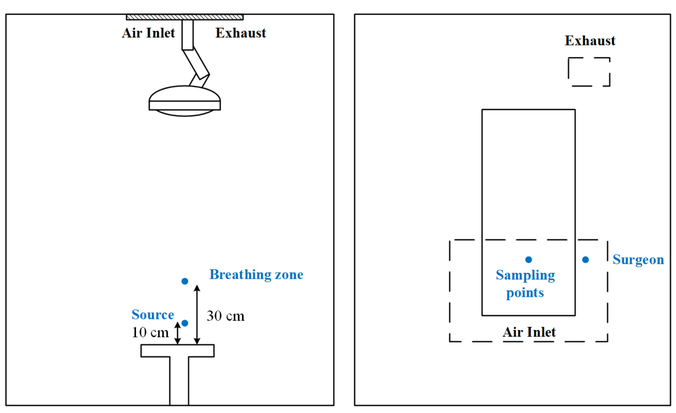

Fig. 4.
The experiment was performed at the operating room (OR) of Laboratory animal center, National Cheng Kung University. The size of this OR is 4 m wide, 2.4 m height and 5 m length and with the ventilation rate of 11 to 12 ACH.
• Indicates measurement points during the experiment in operating room.

Collection efficiency (E) is calculated by the following equation, where C is the number or mass concentration in different control method:

$$E = 1 - \frac{C_{with\ control\ mrthod}}{C_{without\ control\ method}}$$

Results

The results show that the number and mass concentration at the breathing zone was 2.2×10^5 particles/cm^3 and 1.69 mg/m^3, respectively. In addition, the number and mass concentration near the source was 1.3×10^6 particles/cm^3 and 18.9 mg/m^3. This indicates the current ventilation system in the operation room might not be enough to help protect the workers. The local evacuation device with the flow rate of 40 L/min can reduce nearly 80% in particle number and mass concentration. However, local evacuation device also increases the noise from 50 dBA to 75 dBA. When turning on the ionizer, the particle collection efficiency is about 60% to 70%. Fig.5 shows that when using ionizer can help increase the collection of surgical smoke.

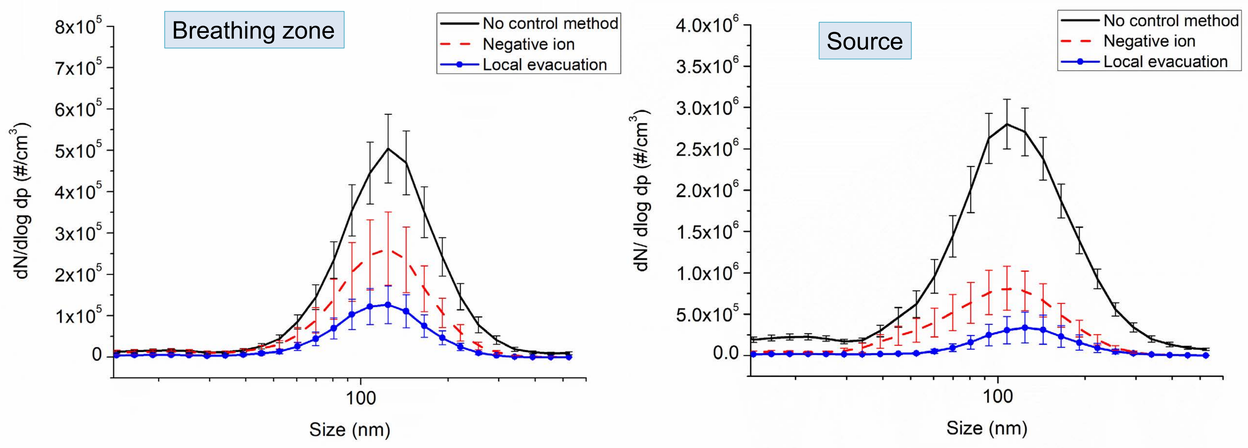

Fig. 5.
Size distribution of with and without control methods at source (10 cm height) and breathing zone (30 cm height).

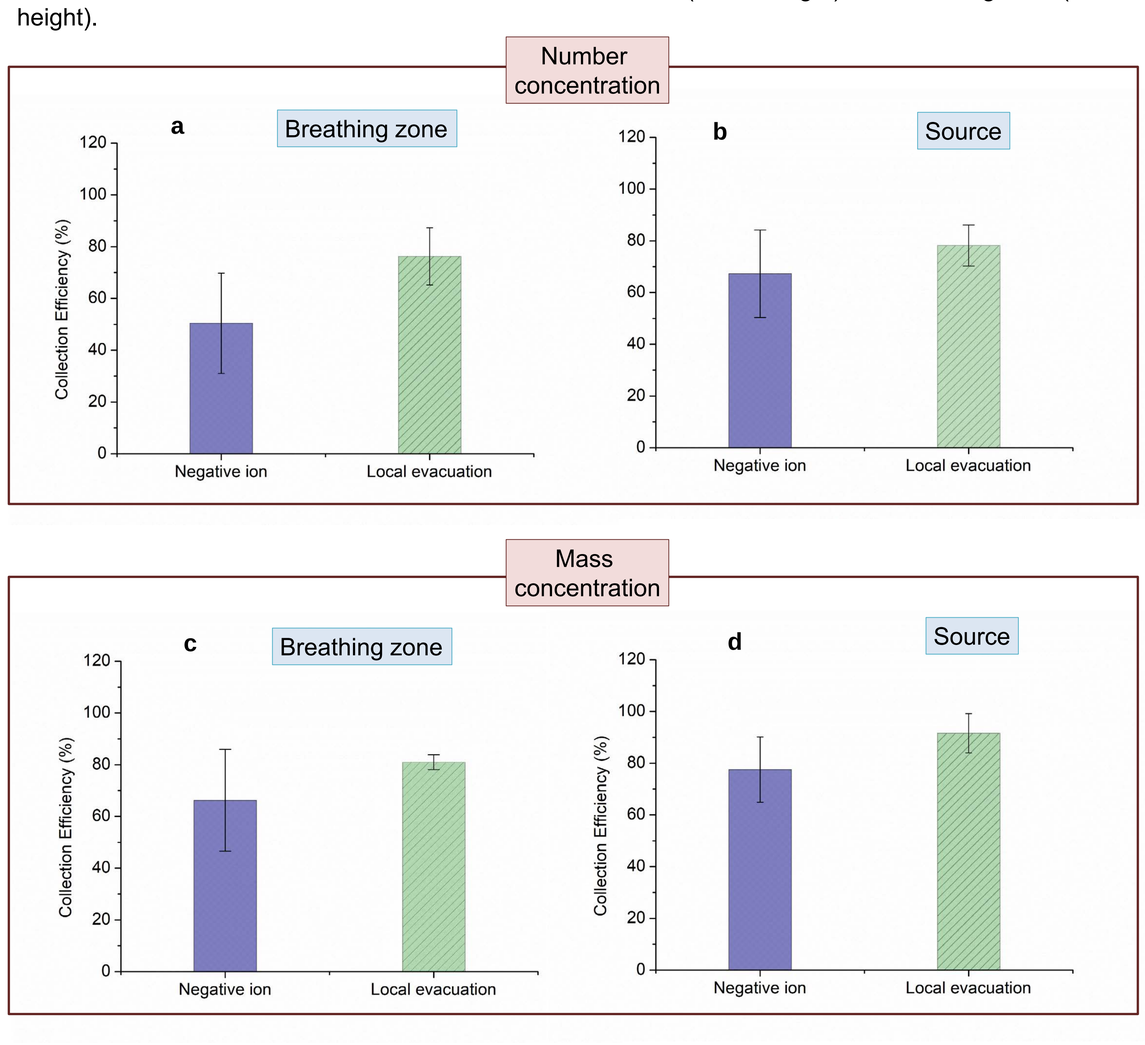

Fig. 6.
Particle collection efficiency of different control methods. 6a and 6b are the efficiency of total number concentration at breathing zone and source. 6c and 6d are the collection efficiency of mass at 2 different sampling points.

Conclusion

1. Local exhaust ventilation can reduce the surgical smoke particle number concentration by about 70% to 80%, but it also create noise problem.
2. Adding the negative ionizer can not only help reduce about 60% to 80% of the particle number concentration, but also will not generate additional noise.
3. This novel surgical smoke removal device provides an alternative way to reduce the workplace hazard and protect the health workers.
4. In the future, we will continue evaluation the reduction of VOCs by using this novel surgical smoke removal device.