

ORIGINAL RESEARCH

Particle aerosolization with energy devices: A comparative study

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Abstract

Objective: To compare the degree of particle aerosolization with the use of several energy devices used in tonsillectomy and other common upper airway procedures.

Methods: Three different energy devices were measured. These included (a) monopolar electrocautery, (b) bipolar electrocautery, and (c) thermal welding device (TWD). Each device was applied to fresh cadaveric cow tongue and porcine nose. Aerosolized particles produced by these devices were measured using a calibrated electronic particle counter. Measurements were recorded over the course of 3 minutes. Particle sizes were measured at 0.3, 0.5, 1.0, 5, and 10 μm .

Results: In comparing types of tissues and particle sizes, TWD had the lowest aerosolizing burden among the three devices. By analyzing the highest particle value of TWD against both monopolar and bipolar, monopolar electrocautery proved to have the highest aerosolization exposure with statistical significance at 0.5 and 10 μm . No statistical significance was found when comparing TWD against monopolar electrocautery.

Discussion: Our study demonstrates there is a difference in aerosolization burden dependent on the type of device utilized. TWD proved to have the lowest burden whereas monopolar electrocautery had the highest.

Conclusion: TWD produces less aerosolization than conventional monopolar electrocautery when cauterizing or ablating tissue in an experimental setting. The degree of aerosolization was comparable to bipolar electrocautery.

Level of Evidence: 2.

KEYWORDS

bipolar electrocautery, ENTceps, monopolar electrocautery, SARS-CoV-2, thermal welding device, tonsillectomy

1 | INTRODUCTION

The novel acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has spread worldwide with more than 158 million confirmed cases and more

than 3 million confirmed deaths reported by the World Health Organization. Although the number of new cases is decreasing with the introduction of vaccines, the imminent threat of a resistant variant continues to be a motivating factor in reducing the spread of this virus.^{1,2}

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SARS-CoV-2 is transmitted via respiratory droplets and can be transported in aerosols of varying size.^{3,4} Given pandemic precautions, elective procedures of the head and neck involving mucosal surfaces continue to pose an inoculation threat to otolaryngologist and team members involved in surgery. Most head and neck surgeries are considered aerosol generating medical procedures; therefore, the risk of contamination is particularly high. Notably, tonsillectomies and other procedures involving the oropharyngeal mucosa have demonstrated a high viral load.⁵

A variety of surgical instruments and technologies are available for tonsillectomy. With each technology there is a varying degree of aerosolization.⁶ Among them, a novel bayonet-style thermal welding device (TWD) (ENTceps; Microline Surgical, Beverly, Massachusetts; Figure 1) utilizes pressure and heat to generate a temperature gradient. This allows the device to cut tissue between the forceps and coagulate mucosa peripherally to form a seal.⁷ In the context of SARS-CoV-2 and the introduction of this new technology, we set out to explore this instrument and its potential in reducing aerosolization in tonsillectomy.



FIGURE 1 ENTceps (Microline Surgical, Beverly, Massachusetts)

2 | METHODS

The study was performed at an outpatient surgical facility, in a 22'6" × 16'6" × 8' operating room. The equipment was tested and calibrated prior to measurements, according to manufacturer's instructions. Room temperature cow tongue and porcine nose tissue was selected as a surrogate for human upper airway tissue.

The lead author (P.L.S.) cauterized or ablated the tissue using different devices: (a) monopolar electrocautery (Electrosurgical Pencil; Covidien, Dublin, Ireland), (b) bipolar electrocautery (Bipolar electrocautery Bayonet Forceps; Covidien, Dublin, Ireland), and (c) thermal welding device (ENTceps; Microline Surgical, Beverly, Massachusetts). All devices were set to a higher than recommended setting for live human tissue. This was done to maximize the particle burden difference between the devices. The settings were as follows: 50 W cut and 60 W coagulation for monopolar electrocautery; 70 W for bipolar electrocautery, and setting 7 (1 is the lowest and 8 is the highest) equivalent to 8.3 W for ENTceps. Each device modality was used on both tissues. The tissues were each ablated or cauterized for 3 minutes at a time. Multiple measurements were taken at 1-, 2-, and 3-minute time points. Baseline ambient particle count was measured prior to each trial. Aerosolized particles were measured using an Exttech VPC300 electronic particle counter (Nashua, New Hampshire) placed 50 cm away from the cauterization site, which closely simulates the typical distance between the cauterization site and the surgeon's face. Particle sizes were measured at 0.3, 0.5, 1.0, 5, and 10 μm . The highest value recorded over the course of 3 minutes was used. The baseline ambient room measurement obtained prior to each trial was subtracted from these values. Statistical analysis was completed using Student's *t*-test; a *P*-value of <.05 was considered to be statistically significant.

3 | RESULTS

On both tissue types, TWD had the lowest absolute aerosolizing burden among the three devices (Table 1). TWD was compared independently against the highest particle value of both monopolar and bipolar electrocautery. Monopolar electrocautery proved to have the

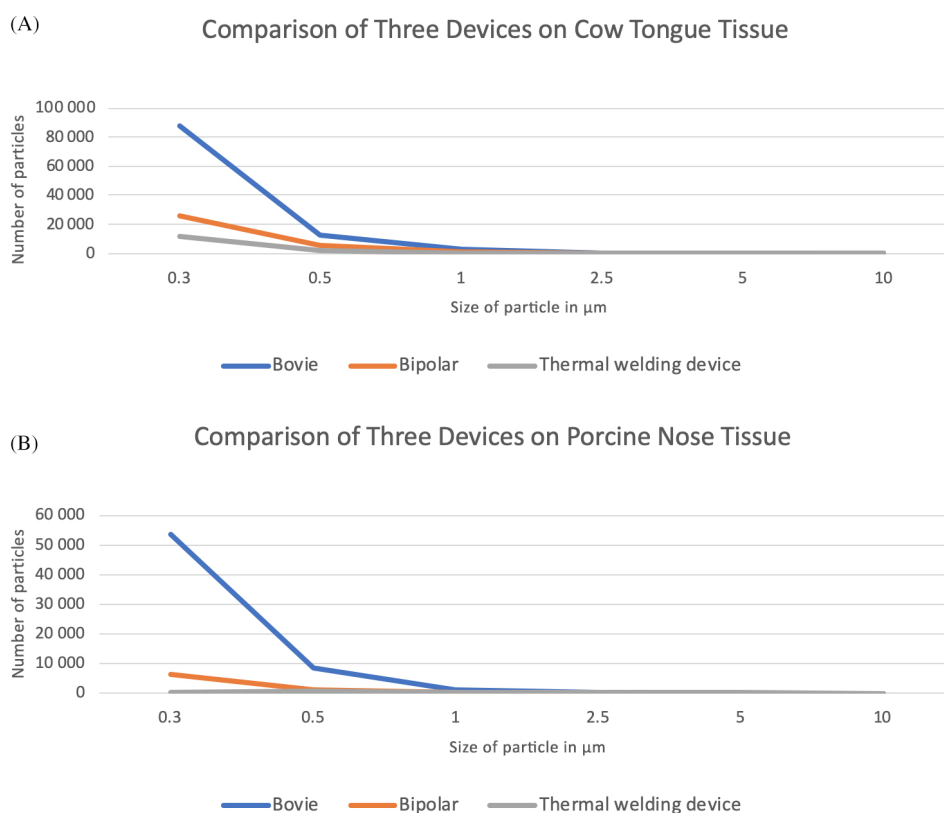
TABLE 1 statistical comparison obtained using student *t*-test

Particle size (μm)	Thermal welding device		Monopolar electrocautery ^a		<i>P</i> -value	Bipolar electrocautery ^a		<i>P</i> -value
	Nose	Tongue	Nose	Tongue		Nose	Tongue	
0.3	420	12 013	53 405	87 530	.7	6468	25 693	.472
0.5	502	1744	8455	12 609	.049*	1130	5228	.438
1.0	162	503	1305	2526	.13	306	1121	.479
2.5	48	44	192	99	.166	2	163	.695
5	12	18	0	11	.269	0	34	.918
10	9	7	2	1	.028*	2	21	.749

Note: **P*-value <.05 considered statistically significant.

^aValues are the highest recorded value within a 3-minute interval.

FIGURE 2 Line graph delineating number of particles aerosolized when tissue is cauterized or ablated, depending on device: (a) number of particles measured on cow tongue tissue. (b) Number of particles measured on porcine nose tissue



highest aerosolization value with statistical significance detected at 0.5 and 10 μm . No difference was detected when comparing TWD against bipolar electrocautery.

4 | DISCUSSION

This is the first study that specifically measures the particle burden of TWD in comparison to other devices used in oropharyngeal procedures. Our study demonstrates a difference in aerosolization burden dependent on the type of device that is used with TWD having the lowest burden and monopolar electrocautery having the highest (Figure 2). This difference in particle burden was statistically significant for particle size of 0.5 and 10 μm when comparing TWD against monopolar electrocautery (Table 1).

Tonsillectomy is one of the most common surgical procedures in the United States with more than 200,000 tonsillectomies performed on patients 15 years or older and over 500,000 performed in younger patients.^{6,8} Prior studies have repeatedly demonstrated that viral particles are viable in aerosolizing surgical procedures using energy devices and electrocautery.⁹ Although there is no conclusive evidence regarding risk of transmission, measures to protect health care staff using PPE, smoke evacuation, and filtration are commonly implemented. For smoke evacuation in particular, studies have demonstrated their efficacy in reducing aerosolization particle exposure in tonsillectomies.¹⁰ In addition to the common practices mentioned above, the decision of which surgical devices to use in such a common

procedure is also important in the effort of minimizing the propagation of SARS-CoV-2 and other viral particles.

Studies have detected SARS-CoV-2 DNA in droplet particles ranging from <5 to 10 μm .¹¹

Although there is no statistical significance when comparing TWD against bipolar electrocautery, the utility of bipolar electrocautery can be limited in tonsillectomy. Bipolar is excellent at hemostasis however is inefficient at cutting tonsillar tissue and therefore lengthens dissection time. Recent advances in the field have introduced new technologies aside from monopolar electrocautery including, ultrasonic devices (Harmonic Scalpel, Ethicon Endo-Surgery, Cincinnati, Ohio), and plasma-assisted radiofrequency ablation (Coblation, ArthroCare Corporation, Sunnyvale, California). Among this new generation of devices are TWD. This technology is unique in that it uses pressure assisted forceps to deliver low voltage direct current through tissue. The forceps tips are coated by a silicone boot that generates a temperature gradient between the forceps. This results in a high temperature centrally to allow the tissue to be cut and lower temperatures on the periphery to allow coagulation of the superficial mucosa. Furthermore, the pressure exerted by forceps allows crimping of the vessel wall sealing the mucosa.⁷ The use of this technology has proven its ability in providing effective hemostasis in previous studies. Randomized control studies have shown the same or decreased pain associated with TWD when compared with bipolar or monopolar cautery.^{7,12,13} Thus, the use of TWD offers an alternative approach to monopolar/bipolar electrocautery by providing a favorable aerosolizing burden along with an efficient means of performing the surgery.

There are a number of limitations to this study, the first of which includes the tissue used. Although cow tongue and porcine nose may be similar to human mucosa, they fall short when compared with well vascularized living mucosa of the human oropharynx. Thus, the measurements resulting from this study may not be accurately reflecting the aerosolization resulting from an oropharyngeal procedure. Secondly, only the “hot” tonsillectomy technique was measured in this study. The use of “cold” technique with scalpel or snare would presumably yield lower aerosolization. However, the use of energy devices for cauterization is still usually needed to some degree to achieve hemostasis.¹⁴ Lastly, according to the World Health Organization, the infectious dose of viable SARS-CoV-2 required to cause infection remains unknown.² Future studies may extend beyond our findings and further investigate the degree of protection that PPE offer in conjunction with the impact of energy device selection.

5 | CONCLUSION

Thermal welding device produces less aerosolization than conventional monopolar electrocautery when cauterizing or ablating tissue in an experimental setting. The degree of aerosolization was comparable to bipolar electrocautery.

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