

Aerosol generation with common rhinologic devices: cadaveric study conducted in a surgical suite

To the Editor:

Adding to the understanding of aerosol generation of rhinologic instruments in recently published data, we evaluated additional instruments typically used for in-office procedures and analyzed generation of submicron-sized aerosols. We found that in addition to the bipolar cautery and high-speed drill, bipolar radiofrequency (RF) ablation (coblation) and cryotherapy were aerosol-generating procedures (AGPs), and other than the high-speed drill, these AGPs generated aerosols skewed toward the submicron size. An aerosol suction device placed in the nasopharynx reduced aerosol escape from the nasal cavity by >99.8% for all AGPs.

The World Health Organization, along with hundreds of medical experts, recognize that aerosol transmission of severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2), the virus associated with the coronavirus 2019 disease (COVID-19) pandemic, can lead to infection.¹ Overall, particles <100 μm can be infectious with those >20 μm subject to gravity.² However, particles <10 μm follow air-flow streamlines and can deposit in the upper airway, and those 5 to 10 μm or smaller are capable of penetrating the lower airway to the alveoli.³

This cadaveric study simulated real-world conditions by modeling intubated patients in the operating room and awake patients during in-office procedures to evaluate submicron and greater aerosol production of rhinologic instruments. Set in an operating room within an ambulatory surgery center (2058 cubic feet), a thawed cadaver head was placed supine on the operating room table with a laser diode-based particle counter (Lasair III 310C; Particle Measuring Systems, Boulder, CO) flow intake positioned at the tip of the nose above the nostril. The intake flow

rate measuring total particle counts (0.3 μm to 25.0 μm) as well as counts by particle size was constant at 1 cubic feet/minute (28.3 L/min). To simulate an in-office awake patient, a plastic suction tubing (6-foot tube with 3/8-inch inner diameter; Medi-Vac® non-conductive suction tubing; Cardinal Health, Dublin, OH) was placed in the nasopharynx via the oral cavity, and the oral cavity was sealed with saline-soaked gauze using the same cadaver head as described earlier in this paragraph. A simulated exhalation was produced by 1 of the authors (B.L.) exhaling through the suction tubing into the nasopharynx at approximately 12 breaths/minute. Inhalation was not simulated.

Instruments tested include (1) bipolar cautery (bayonet bipolar forceps, at setting of 20 W; Medtronic ENT, Jacksonville, FL); (2) powered microdebrider with in-line suction (4-mm Tricut Blade at 3000 oscillations/minute; Medtronic ENT); (3) powered drilling with in-line suction (4-mm tapered diamond burr at 30,000 rpm; Medtronic ENT); and (4) bipolar RF ablation with in-line suction (Coblator II ENT, setting at 7 coblation and 3 coagulation; Smith & Nephew, Andover, MA). Using the exhalation model, the temperature-controlled bipolar RF ablation (Vivaer ARC Stylus; 3 manufacturer set cycles completed, with the use of lubricating jelly; Aerin Medical, Austin, TX) and nitrous oxide cryotherapy (Clarifix cryotherapy balloon, two 30-second-cycles of a full nitrous oxide canister each; Stryker, Kalamazoo, MI) were evaluated. All instruments were used continuously for the 1.5-minute particle count reading while the cryotherapy was used for 1 minute per to the time limitation set by the nitrous oxide canister. In this situation, two instead of three 30-second samplings were obtained. Before each new instrumentation, the nasal cavity was suctioned for 2 minutes to clear excess particles and a background count reading for 1.5 minutes (three 30-second samplings) was obtained.

Instruments that generated particles over the background counts were then tested with a novel aerosol evacuation device (CoronaVac; Hemostasis, LLC, Saint Paul, MN) placed in the contralateral posterior nasal cavity and attached to wall suction at 200 mmHg. The device consists of a 12-French suction tube with an inner diameter of 2.4 millimeters with a foam seal that seals the opening of the nare.

To determine the number of aerosols generated by each instrument procedure, the calculated mean background particle count/per cubic foot for each instrument was then subtracted from the mean total particle counts/per cubic foot for each instrument.

Of the 6 instruments evaluated, 4 were noted to generate aerosols over background: bipolar cautery, powered high-speed drill, bipolar RF ablation (coblation), and

Correspondence to: Amber U. Luong, MD, PhD, McGovern Medical School at the University of Texas Health Science Center at Houston, Department of Otorhinolaryngology–Head & Neck Surgery, 6431 Fannin Street, MSB 5.036, Houston, TX 77030; e-mail: amber.u.luong@uth.tmc.edu

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Potential conflict of interest: M.J.C. serves as a consultant for Acclarent (Irvine, CA), BioMed ENT (San Antonio, TX), Inquis Medical (Atherton, CA), MicroGenDx (Lubbock, TX), and Stryker (Kalamazoo, MI). A.U.L. serves as a consultant for Inquis Medical (Atherton, CA), Medtronic (Jacksonville, FL), and Stryker (Kalamazoo, MI); she is on the advisory board for ENTvantage (Austin, TX), and has served on advisory boards for Genetech (San Francisco, CA) and Sanofi (Paris, France). W.C.Y. serves as a consultant for Stryker (Kalamazoo, MI) and speaker for Optinose (Yardley, PA).

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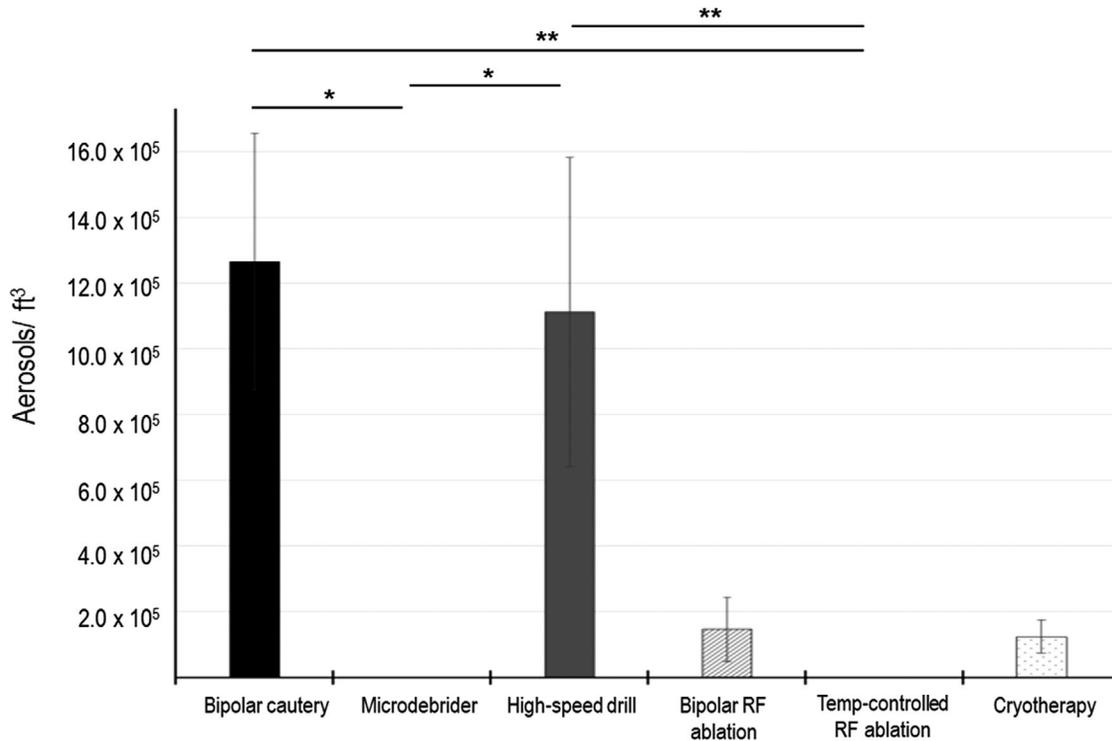


FIGURE 1. Aerosols generated from common rhinologic instruments. Mean total particle counts per cubic foot over the background reading with error bars representing the standard deviation. Bipolar cautery, microdebrider, high-speed drill, and bipolar radiofrequency ablation were tested in the intubated patient simulation. Temperature-controlled RF ablation and cryotherapy were tested with the in-office awake patient simulation in which exhalation was modeled. * $p < 0.05$, ** $p < 0.005$. RF = radiofrequency.

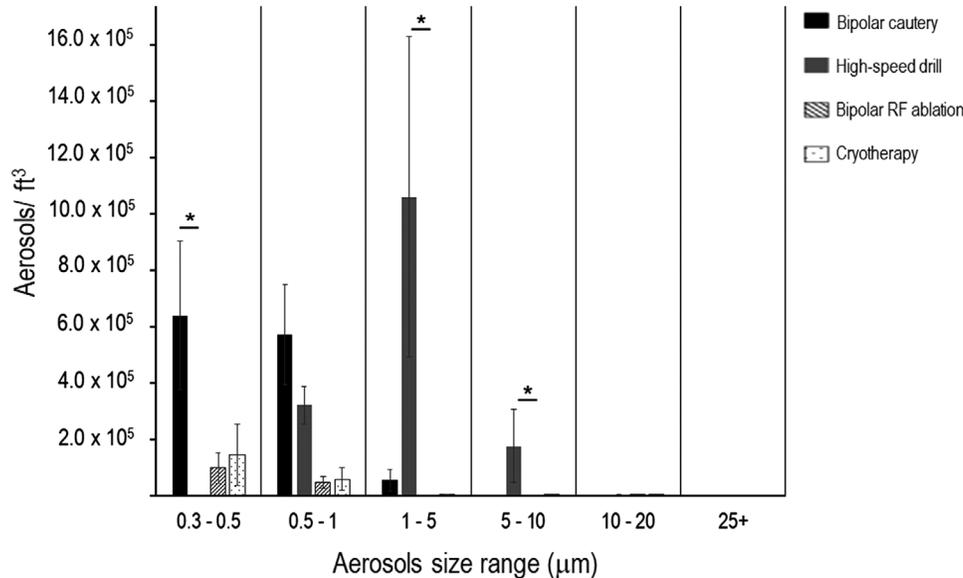


FIGURE 2. Size distribution of aerosol-generating producers. Mean particle counts by micron per cubic foot of those procedures generating particles over the background reading with error bars representing the standard deviation. * $p < 0.05$ and ** $p < 0.005$.

cryotherapy (Fig. 1). When evaluating the size distribution of the aerosols generated, the high-speed drill was the only instrument that generated a significant amount of aerosols $\geq 1 \mu\text{m}$ (Fig. 2). The other AGPs generated more aerosols $< 1 \mu\text{m}$ than $\geq 1 \mu\text{m}$. No significant aerosols $\geq 10 \mu\text{m}$ were generated from any instruments.

In the presence of a novel aerosol evacuation device placed in the contralateral nasopharynx, the hands-free device captured $>99.8\%$ of generated aerosols of all sizes between 0.3 and $25+ \mu\text{m}$.

Similar to Workman et al.,^{4,5} we confirmed that the high-speed drill and bipolar cautery were both significant aerosol

producers, whereas the microdebrider with in-line suction was not. We found that the bipolar RF ablation with in-line suction (coblation) also created aerosols, but to a lesser extent than the bipolar cautery. Despite the in-line suction associated with the bipolar RF ablation and high-speed drill, the suction produced was insufficient to prevent the generated aerosols from escaping out of the nasal cavity.

Of the 2 instruments tested with the exhalation model, the cryotherapy device generated aerosols, mainly in the range of 0.3 to 1.0 μm , but overall produced noticeably fewer aerosols than the bipolar cautery or high-speed drill (Figs. 1 and 2). Even without tissue contact, the cooling of the device balloon during activation generated a visible plume that would be detected as aerosols by the particle counter.

With the exception of the high-speed drill, the other AGPs generally produced submicron-sized aerosols. The distribution of aerosol size with the high-speed drill skewed to $\geq 1 \mu\text{m}$; however, submicron aerosols were also produced. This is an important observation given aerosols $< 10 \mu\text{m}$ can be suspended in a gas and inspired.² Aerosols $< 5 \mu\text{m}$, the majority of the aerosols generated in this study, are able to penetrate to the alveolar spaces, with smaller aerosols penetrating deeper.² The SARS-CoV-2 spike protein receptor used for viral attachment is highly expressed on type II airway pneumocytes,⁶ making exposure to these cells an important pathway for infection.

It is important to note that this study only demonstrates that aerosols were generated with instrumentation. It is not possible to make a firm determination on the makeup of these particles or whether they were able to carry a virus such as SARS-CoV-2.

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Bailey LeConte, MD , Garren M.I. Low, MD,
Martin J. Citardi, MD, William C. Yao, MD  and
Arturo A. Eguia, MD

Department of Otorhinolaryngology-Head and Neck Surgery,
McGovern Medical School at the University of Texas Health Science
Center, Houston, TX

Amber U. Luong, MD, PhD 

Department of Otorhinolaryngology-Head and Neck Surgery,
McGovern Medical School at the University of Texas Health Science
Center, Houston, TX and Center for Immunology and Autoimmune
Diseases, Institute of Molecular Medicine McGovern Medical School at
the University of Texas Health Science Center, Houston, TX, USA

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