Evaluation of Droplet Countermeasures by a Particle Visualization System in Simulated Bronchoscopy

Kei Morikawa, Hirotaka Kida, Hiroshi Handa, Takeo Inoue, and Masamichi Mineshita

Division of Respiratory Diseases, Department of Internal Medicine, St. Marianna University School of Medicine, Kawasaki City, Japan

ORCID ID: 0000-0002-0745-5118 (K.M.).

Coronavirus disease (COVID-19) has severely impacted respiratory care (1–3). Using a particle visualization system in a clean room (4, 5), we visually evaluated respiratory aerosol droplet dispersion by employing simple countermeasure techniques. First, by creating a pinhole through a surgical mask, pharyngo-anesthesia via conventional sprayer was administered, resulting in the reduction of direct respiratory droplets expelled by coughing (Figures 1A and 1B, Videos 1 and 2). In addition, aerosol generated by nebulizer was efficiently collected by a dental suction machine equipped with a high-efficiency particulate air filter (Figures 1C and 1D, Videos 3 and 4). We then created a simple technique for droplet reduction in the supine position to simulate bronchoscopy. By wrapping plastic over a standard mouthpiece, we saw a substantial reduction in droplets (Figures 2A and 2B, Videos 5 and 6). This novel mouthpiece has an expandable center hole through which the bronchoscope passes and an open side port for saliva suction (Figure 2C, and *see* Figure E1 in the online supplement). Compared with a standard mouthpiece, quantitative measurements (Figure E2) revealed that fine particles of 0.5 μm or more were significantly reduced from dispersing upward, with a limited amount of droplets escaping from the side port ($P < 0.01$) (Figure 2D). With the worldwide expansion of infectious respiratory diseases, new standards for aerosol droplet prevention during bronchoscopic examination should be considered. Sp_{O_2} measurements in a few cases have no safety issues (Figure E3), and continuous validation is needed. ■

Author disclosures are available with the text of this article at www.atsjournals.org.

Acknowledgment: The authors thank Shin Nippon Air Technologies Co., Ltd (Tokyo, Japan) for providing the particle visualization system (https://www.snk.co.jp/particle/particle_en.html), Tokyo Giken, Inc. (Tokyo, Japan) for providing an extraoral suction, and Free arm arteo and Boston Scientific Japan K. K. (Tokyo, Japan) for providing an original mouthpiece. The authors also thank Mr. Jason Tonge from St. Marianna University School of Medicine for the linguistic review of this manuscript.

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Author contributions: K.M., H.K., and H.H. were involved in study conception and design. K.M., H.K., H.H., T.I., and M.M. were involved in the analysis and interpretation of the data. K.M., H.H., and M.M. were involved in drafting the manuscript and revising the manuscript. All authors have read and approved the final manuscript.

This article has an online supplement, which is accessible from this issue's table of contents at www.atsjournals.org.

The uncompressed videos are accessible from this article's supplementary material page.

Am J Respir Crit Care Med Vol 204, Iss 5, pp 599–602, Sep 1, 2021

Originally Published in Press as DOI: 10.1164/rccm.202009-3430IM on June 25, 2021
Internet address: www.atsjournals.org

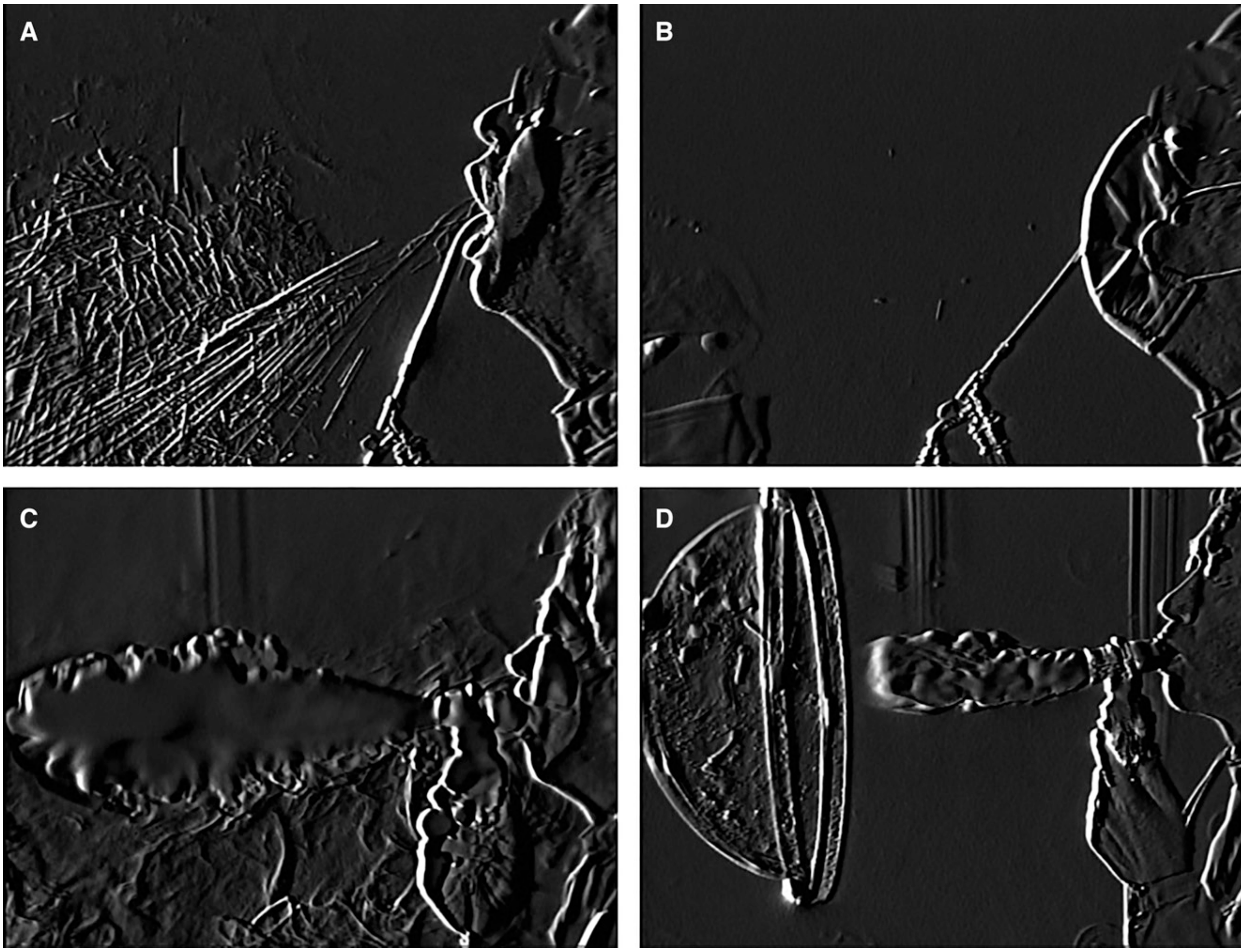
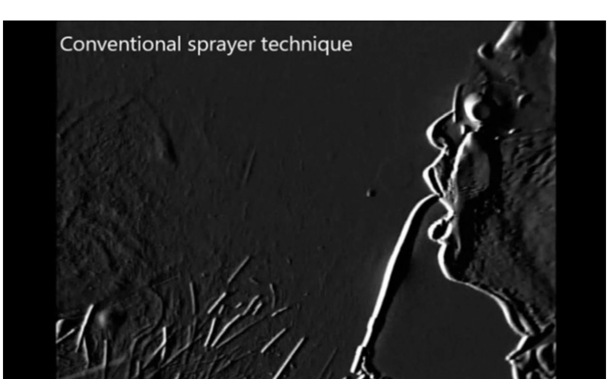
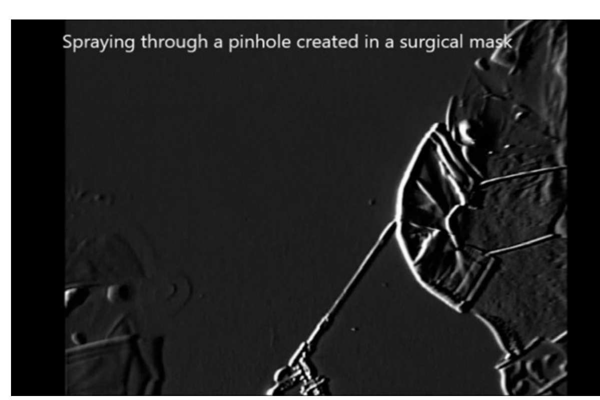


Figure 1. (*A*) Face-to-face anesthesia administration using conventional sprayer technique can expose the operator to large amounts of respiratory droplets, especially in the event of coughing. (*B*) By spraying anesthesia through a pinhole created in a surgical mask, the risk of direct respiratory droplet exposure was greatly reduced. (*C*) Aerosol generated by nebulizer could be efficiently collected by (*D*) dental suction machine equipped with a HEPA filter.



Video 1. Pharyngo-anesthesia using conventional sprayer technique.



Video 2. Spraying anesthesia through a pinhole created in a surgical mask. Direct respiratory droplet exposure is greatly reduced, but some fine particle aerosol diffused directly from the surgical mask.

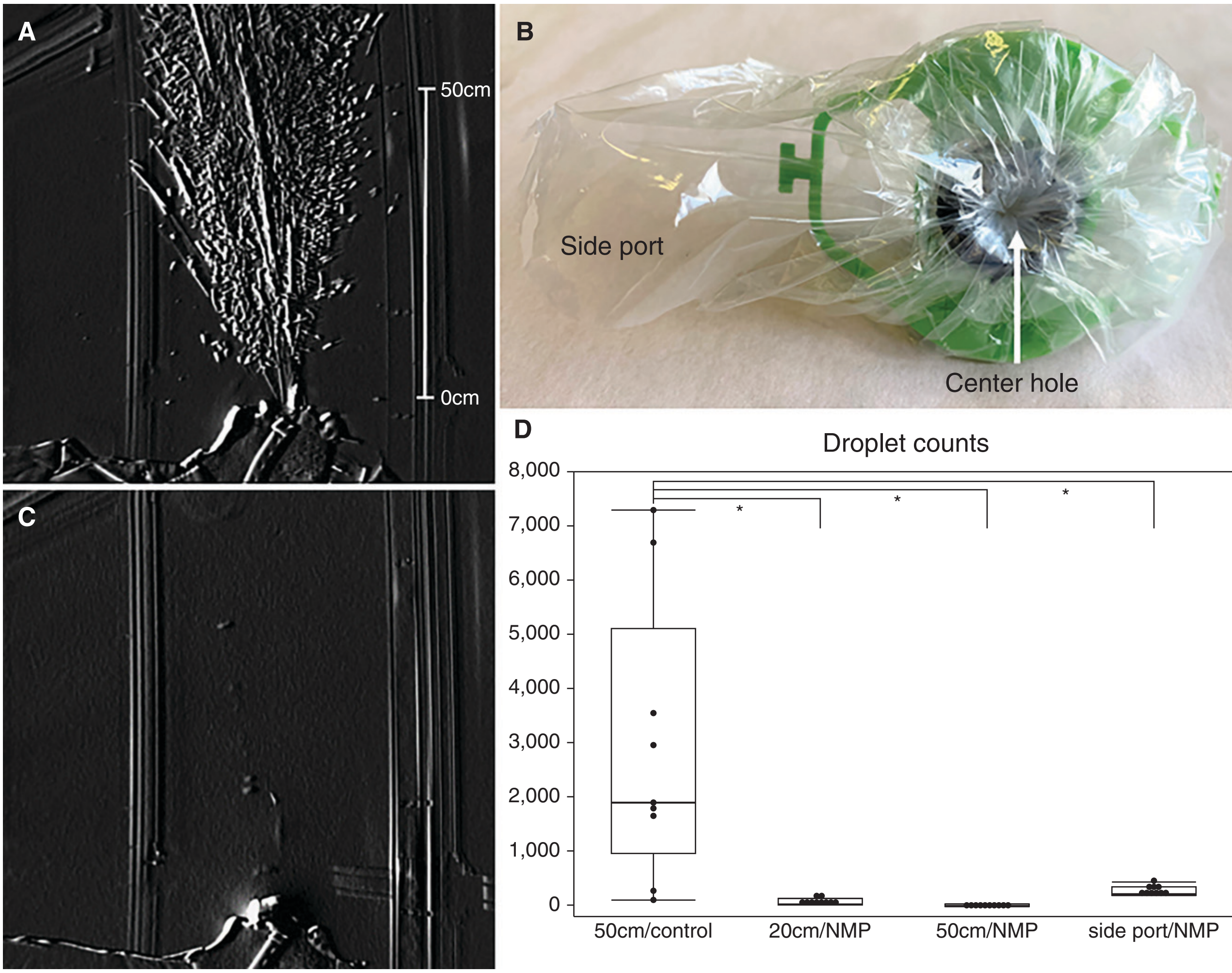
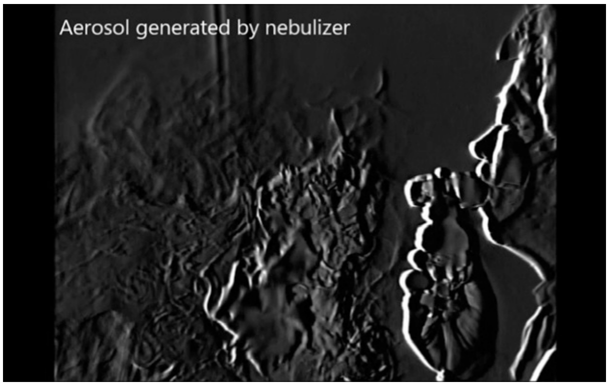
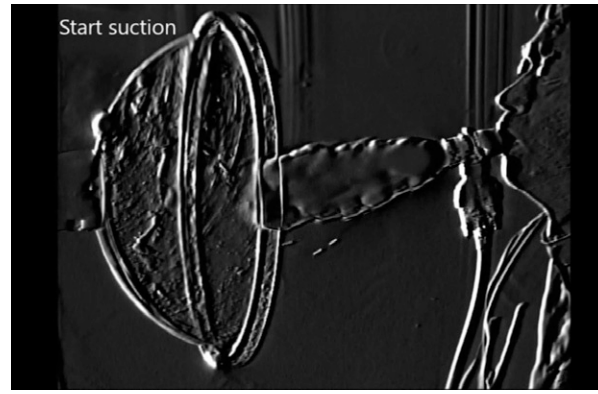


Figure 2. (*A*) Simulating bronchoscopy with a standard mouthpiece, a large volume of respiratory droplets was dispersed after coughing in the supine position. (*B*) By wrapping a transparent plastic wrap over the mouthpiece, the volume of respiratory droplets after coughing (*C*) was greatly reduced. (*D*) Quantitative measurements of fine particles 0.5 μm or more in the supine position. Measurements were conducted at a height of 50 cm from a standard (control) mouthpiece, 20 cm from our novel mouthpiece (NMP) technique center hole, 50 cm from the NMP center hole, and 20 cm from the side port of the NMP. The mean (range) particle counts per one cough were 2,900 (91–7,291), 50 (2–108), 0 (0), and 270 (181–425), respectively. Measurements were taken 9 to 10 times from each distance. The NMP technique significantly reduced the dispersion of droplets. Statistical analysis was performed with JMP software. $^*P < 0.01$.

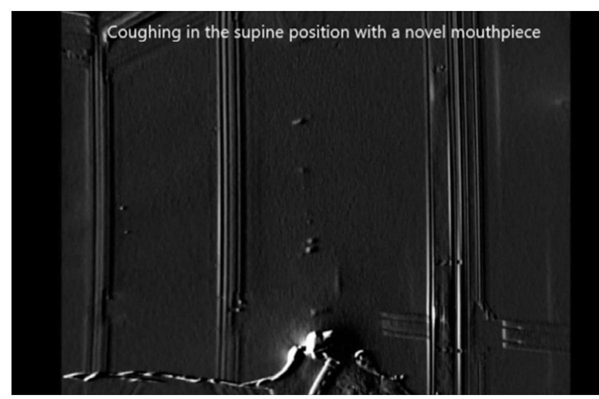


Video 3. Aerosol generated by nebulizer.



Video 4. Nebulizer with a dental suction machine.

Video 5. Coughing in the supine position with a standard mouthpiece.



Video 6. Coughing in the supine position with a novel mouthpiece.