Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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BRIEF COMMUNICATIONS

A Proof of Concept Study: Esophagogastroduodenoscopy Is an Aerosol-Generating Procedure and Continuous Oral Suction During the Procedure Reduces the Amount of Aerosol Generated

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Keywords: Esophagogastroduodenoscopy; Health Care Workers; COVID-19; SARS-CoV-2.

Aerosol-generating procedures pose a potential threat to health care workers, especially during this COVID-19 (coronavirus disease 2019) pandemic. Esophagogastroduodenoscopy (EGD) was assumed to be an aerosol-generating procedure and recommendations, therefore, reflect evidence generated from non-gastrointestinal aerosol-generating procedures, such as bronchoscopy. However, there is no scientific evidence to support this claim. This study aims to provide scientific evidence on whether EGD is an aerosol-generating procedure and to examine ways of decreasing the amount of aerosol generated.

Methods

This study was a prospective observational trial to examine aerosol generation during EGD by applying a quantitative approach (see Supplementary Material for details).

All patients undergoing EGD at the endoscopy center of the Prince of Wales Hospital from May 7, 2020 to June 1, 2020 were included. Procedures were performed with the patient in the left lateral position with a mouthguard, using a 9.9-mm flexible video gastrointestinal scope (GIF-H290; Olympus Hong Kong and China Limited, Kowloon, Hong Kong SAR). Measurements were taken using the portable GT-526S Handheld Particle Counter (Met One Instruments, Inc, Grants Pass, OR). The 6-channel particle sizes were programmed at 0.3 μm, 0.5 μm, 0.7 μm, 1 μm, 5 μm, and 10 μm. The particle counter was placed within 10 cm of the mouth of the patient once the patient entered the room and measured for at least 1 minute before the start of the procedure. The measurement was continued during the procedure until after the patient left the endoscopy suite.

Statistical Analysis

Multilevel modeling was used to test all of the hypotheses in the study.[1] The particle counts per cubic feet of each particle size are presented in dCF. We tested the associations among the use of sedation, dental sucker, and Log(dCF). The interaction terms between sedation and procedure and between dental sucker and procedure were added to the multilevel models. Age, sex, endoscopist seniority, procedure length, diagnostic or therapeutic procedure, and use of biopsy were included as confounders. A random effect of repeated measures was accounted for in the models to capture the intra-subject variability for the changes in dCF over time.

Results

From May 7, 2020 to June 1, 2020, a total of 93 patients were recruited into the study. There were 59 unsedated patients (63.4%) and 34 sedated patients (36.6%). A dental sucker was used for 30 patients (32.3%). Most of the procedures were diagnostic procedures (n = 85 [91.4%]) with a biopsy taken (n = 68 [73.1%]). A multivariate analysis was also performed and the results are summarized in Table 1.

During the EGD procedure, the level of dCF of all sizes was significantly higher than during the baseline period ($P <$ .001 to .02). Use of the dental sucker significantly reduced the number of particles sized 0.3 μm, 0.5 μm, 0.7 μm, 1 μm, 5 μm, and 10 μm expelled during the procedure compared with baseline ($P <$ .001, $P <$ .001, $P <$ .001, $P =$ .02, $P <$ .01, and $P =$ 0.046, respectively). Simple slope tests revealed that when compared with baseline, the number of dCF_0.3, dCF_0.5, dCF _0.7, and dCF_1 during EGD was significantly increased among procedures performed without a dental sucker ($P <$ .01, $P <$ .01, $P <$ .01, and $P =$ .02 respectively), and decreased nonsignificantly among participants when the dental sucker was used. For larger particle sizes of 5 μm and 10 μm, use of the dental sucker was associated with a significantly smaller magnitude of increase in number of particles during the procedure ($P <$ .01 and $P <$ .01, respectively) (Supplementary Figure 1). There were no

Abbreviations used in this paper: **COVID-19, coronavirus disease 2019; EGD, esophagogastroduodenoscopy; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.**

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Table 1. The Association Between Sedation and Log(dCF_0.3, dCF_0.5, dCF_0.7, dCF_1, dCF_5, dCF_10)

Variable	dCF_0.3		dCF_0.5		dCF_0.7		dCF_1		dCF_5		dCF_10	
	Estimate (SE)	95% CI	Estimate (SE)	95% CI	Estimate (SE)	95% CI	Estimate (SE)	95% CI	Estimate (SE)	95% CI	Estimate (SE)	95% CI
Procedure[a]	0.18 (0.03)[b]	0.12 to 0.24	0.30 (0.05)[b]	0.20 to 0.40	0.28 (0.07)[b]	0.14 to 0.42	0.22 (0.09)[c]	0.04 to 0.40	2.49 (0.29)[b]	1.92 to 3.06	1.53 (0.25)b[a]	1.04 to 2.02
Sedation[d]	−0.08 (0.17)	−0.39 to 0.23	−0.10 (0.17)	−0.43 to 0.23	−0.18 (0.12)	−0.42 to 0.06	−0.16 (0.12)	−0.40 to 0.08	−0.02 (0.30)	−0.61 to 0.57	−0.05 (0.26)	−.56 to .46
Dental sucker	0.64 (0.15)[b]	0.35 to 0.93	0.59 (0.14)[b]	0.32 to 0.86	0.19 (0.10)	−0.01 to 0.39	−0.07 (0.10)	−0.27 to 0.13	0.91 (0.29)[e]	0.34 to 1.48	0.71 (0.25)[c]	.21 to 1.21
Procedure × sedation[f]	−0.03 (0.04)	−0.11 to 0.04	−0.06 (0.07)	−0.20 to 0.08	−0.05 (0.10)	−0.25 to 0.15	−0.12 (0.12)	−0.26 to 0.12	−0.73 (0.39)	−1.49 to 0.03	−0.42 (0.34)	−1.09 to 0.25
Procedure × dental sucker[g]	−0.24 (0.04)[b]	−0.32 to −0.16	−0.36 (0.07)[b]	−0.50 to −0.22	−0.36 (0.10)[b]	−0.56 to −0.16	−0.32 (0.13)[c]	−0.57 to −0.07	−1.14 (0.40)[e]	−1.92 to −0.36	−0.71 (0.35)[c]	−1.40 to −0.02

NOTE. Age, sex, endoscopist seniority, procedure length, diagnostic or therapeutic, and whether take biopsy are potential confounders that controlled in the mode.
CI, confidence interval; dCF, differential count.
[a]Coefficient of procedure indicates the expected change in ln(dCF) during procedure.
[b]$P < .001$.
[c]$P < .05$.
[d]Coefficient of sedation indicates the expected change in ln(dCF) for sedation without adjustment of procedural time.
[e]$P < .01$.
[f]Coefficient of procedure × sedation indicate the expected change in ln(dCF) in the sedated group during procedure.
[g]Coefficient of procedure × dental sucker indicate the expected change in ln(dCF) in the dental sucker group during the procedure.

significant differences in the level of all dCF outcomes between the individuals with or without sedation ($P = .13$ to $.96$). Sedation did not affect the association between procedure time and all dCF outcomes. These results are summarized in Table 1.

One per-oral endoscopic myotomy was recorded. The procedure was performed under general anesthesia. The data showed that there was a surge in all particle sizes during the initial endoscope intubation and diagnostic EGD (Supplementary Figure 2).

Discussion

Currently, the term *droplet* is often used to refer to droplets >5 μm in diameter and the term *aerosol* refers to particles ≤5 μm in diameter that can remain suspended in air for a significant time, allowing them to be transmitted over longer distances of >1 m. The increase of particle size at 0.3 μm, 0.5 μm, 0.7 μm, and 1 μm supports EGD as an aerosol-generating procedure.

Another important finding of this study was that the use of dental sucker in the oral cavity for continuous suction during the procedure significantly decreased the particle counts of all sizes detected during EGD, suggesting the use of the dental sucker be recommended during EGD. The usual practice in our center was to provide intermittent oral suction via suction catheter. The postulation was continuous oral cavity suction reduced pooling of saliva and can therefore reduce aspiration and patients' coughing. Another reason might be that the dental sucker also partially suctioned out the particles that were generated during the procedure. The smaller particles might be subject to the negative pressure effect generated by the continuous suction of the dental sucker, causing a paradoxical drop in the particle counts during the procedure.

In this study, we found that conscious sedation was not able to reduce the amount of aerosol and droplets generated during the procedure. This may be due to small sample size and the presence of confounding factors. We also found that there was still a surge of all particle sizes during general anesthesia, which suggests that general anesthesia might not eliminate the aerosol generated.

However, the increase in aerosol does not equate to an increase in the infectivity of respiratory viruses during EGD. Despite numerous studies on the transmission routes of respiratory viruses, the results remained inconclusive.[2] The SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) RNA, however, has been found in fecal samples of infected patients for a prolonged period of time.[3] The role of the gastrointestinal tract in the transmission of SARS-CoV-2 remains uncertain.

EGD is an aerosol-generating procedure and the use of a dental sucker can decrease the

amount of aerosol generated, which decreases the risk to health care workers. These findings can inform current guidelines in infection control and the most appropriate personal protective equipment during digestive endoscopy.

Supplementary Material

Note: To access the supplementary material accompanying this article, visit the online version of *Gastroenterology* at www.gastrojournal.org, and at http://dxdoi.org/10.1053/j.gastro.2020.07.002.

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Conflicts of interest
The authors disclose no conflicts.

Supplementary Methods

In this study, we included adult patients (18 years and older) who underwent EGD in an elective or emergency setting for either a diagnostic or therapeutic indication. Exclusion criteria were patients undergoing endoscopy other than EGD, patients undergoing EGD outside of the designated procedure room, patients under general anesthesia, patients in whom EGD had to be terminated due to the patient's general condition or intolerance to procedure, and pregnant patients. This study was conducted according to the principles of the 59th Declaration of Helsinki (World Medical Association Declaration of Helsinki, Seoul, 2008), ISO 14155:2011, and good clinical practice. The study was approved by the Joint Chinese University of Hong Kong-New-Territories East Cluster Clinical Research Ethics Committee (Joint CUHK-NTEC CREC) (CREC reference 2020.200).

Setting and Data Collection

All procedures (except for per-oral endoscopic myotomy) were performed with air insufflation with high flow setting used in all patients. All EGD were conducted in a designated procedure room (including the per-oral endoscopic myotomy) measuring 37 m^2, with a total supply of 6 air changes per hour with internal recirculation at 23°C ± 1°C and humidity ≤60%.

Reflecting on our institutional practice, endoscopy was performed by both surgeons and physicians, and conscious sedation was provided by the endoscopists. During the COVID-19 pandemic, the procedures were performed either by a specialist or by trainees with at least 4 years of experience in EGD. All patients were given 8 puffs of 10% topical xylocaine before the procedure. The decision for conscious sedation was at the endoscopist's discretion, usually depending on the patient's condition, the anticipated difficulty, or duration of the procedure. Conscious sedation was provided by intravenous midazolam with or without intravenous pethidine. The endoscopy team included the chief endoscopist, endoscopy nurse, and airway nurse. Extra personnel were strictly forbidden once the patient entered the room to minimize the disturbance to the room's airflow and particle flow. All staff wore surgical N95 face masks and enhanced personal protective equipment per the recent Asian Pacific Society for Digestive Endoscopy position statements for the practice of endoscopy during the COVID-19 pandemic.[1] A dental sucker (DIS-110 Saliva Ejector; Svenska Dentorama AB, Sweden) was also placed in the oral cavity in the latter part of the study to provide continuous suction during the procedure. The suction pressure was set at 30 kPa. Patient demographic characteristics, seniority of endoscopists, use of conscious sedation, use of dental sucker, patient flow and endoscopy timing, and air particle count (particles/cubic feet, dCF) were recorded. Timing was marked for patients entering the room, scope in, scope out, and when patients left the room.

Measurements were taken using the portable GT-526S Handheld Particle Counter (Met One Instruments, Inc) and extracted using Comet Deploy software, version 2.0.4 (Met One Instruments, Inc). The 6-channel particle sizes were programmed at 0.3 μm, 0.5 μm, 0.7 μm, 1 μm, 5 μm, and 10 μm. The 0.3–10 μm range selected represents the minimum and maximum particle sizes detectable by this device. Samples were collected during periods of 5 seconds with continuous monitoring, and there were no intervals between measurements. The particle counter was calibrated at the beginning of each endoscopy session at least 30 minutes before the first procedure to ensure a stable baseline reading. The particle counter was placed within 10 cm from the mouth of the patient once the patient entered the room and measured for at least 1 minute before the start of the procedure. The measurement was continued during the procedure until after the patient left the endoscopy suite. The endoscopy team was blinded to the measurements of the particle counter.

The methodology used in this study was to use laser particle counters to detect a change in the concentration of particles before and during EGD. Laser particle counters are used to count the size of particles suspended in both air and liquids. They are predominantly used as a tool for characterizing clean rooms and other contamination-controlled areas. To count particles, laser light is used to reflect light from the particles as they pass through the laser beam. Airborne particle counters using laser diode technology count particles by collecting scattered light inside the sensor of the particle counter. There are inherently a certain number of particles in the environment as a baseline. When a person talks or coughs, there will be an increase in the number of particles directly in front of their mouth. Depending on the ventilation of the room, this increase in particles may be transient and carried away by the airflow or may suspend in the room for some time. According to the 2001 edition of the *Guidelines for Design and Construction of Hospital and Health Care Facilities*, a minimum of 6 air changes per hour is required for the endoscopy room.[2] The minimum size of an endoscopy room is also recommended by the World Endoscopy Organization[3] to be 6 × 5 m^6 or 36 m^2 by the International Health Facility Guidelines.[4] The endoscopy room in our center strictly follows the international recommendation for the design of an endoscopy unit. The room used for this observational cohort measures 37 m^2 with 6 air changes per hour. The particle counter was placed directly in front of the patient's mouth before and during the procedure. Personnel in the room were restricted to the endoscopist, airway nurse, and endoscopy nurse, and the doors were closed during the procedure. They were all equipped with enhanced personal protective equipment with N95 masks according to international guidelines. It also served to minimize the change of particles in the air introduced by the talking and breathing of the team. The number of particles of different sizes in the room were relatively stable just before the procedure, which was

regarded as the baseline. Therefore, any increase in particle counts during the procedure should be generated by the procedure itself.

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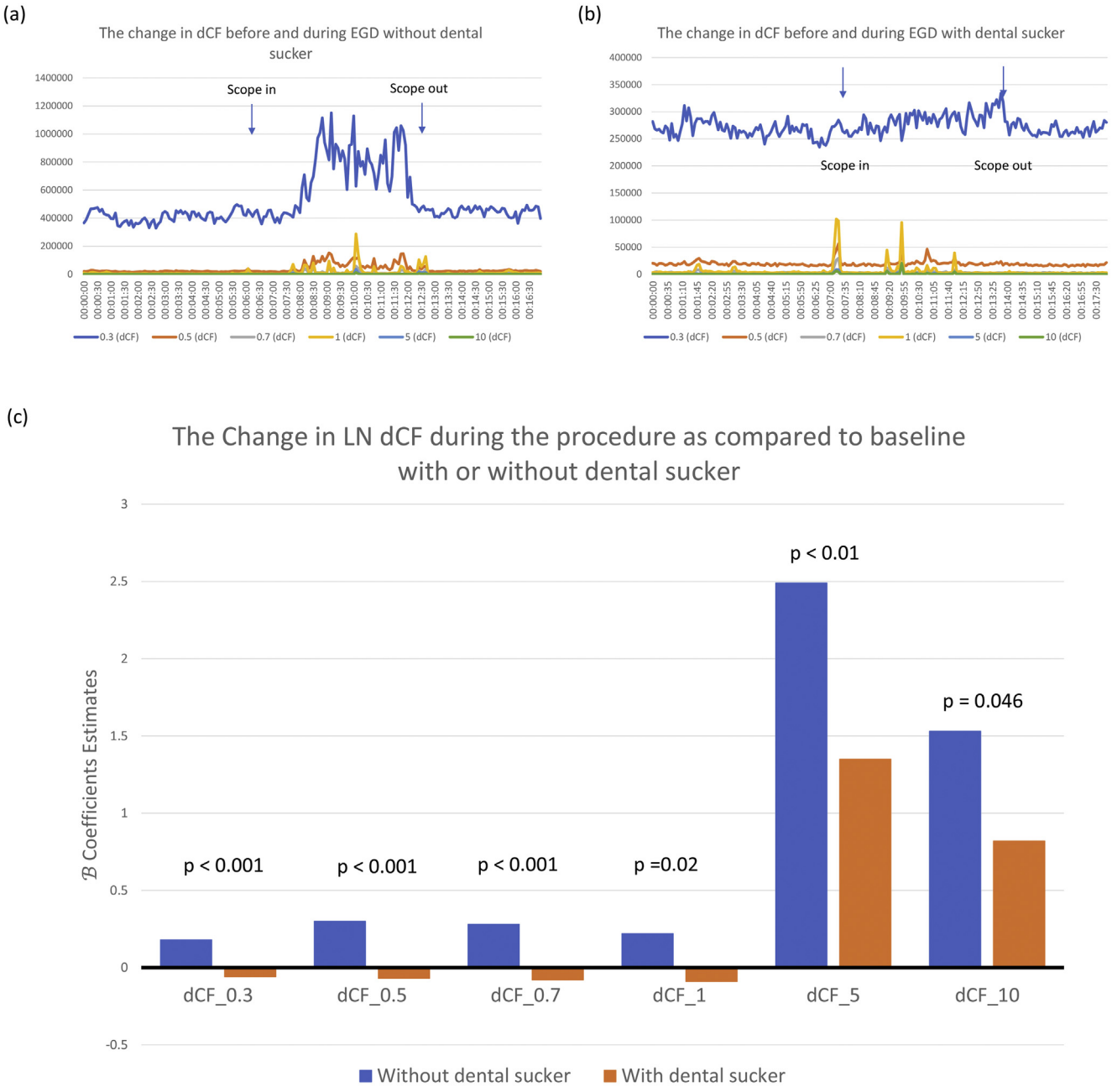
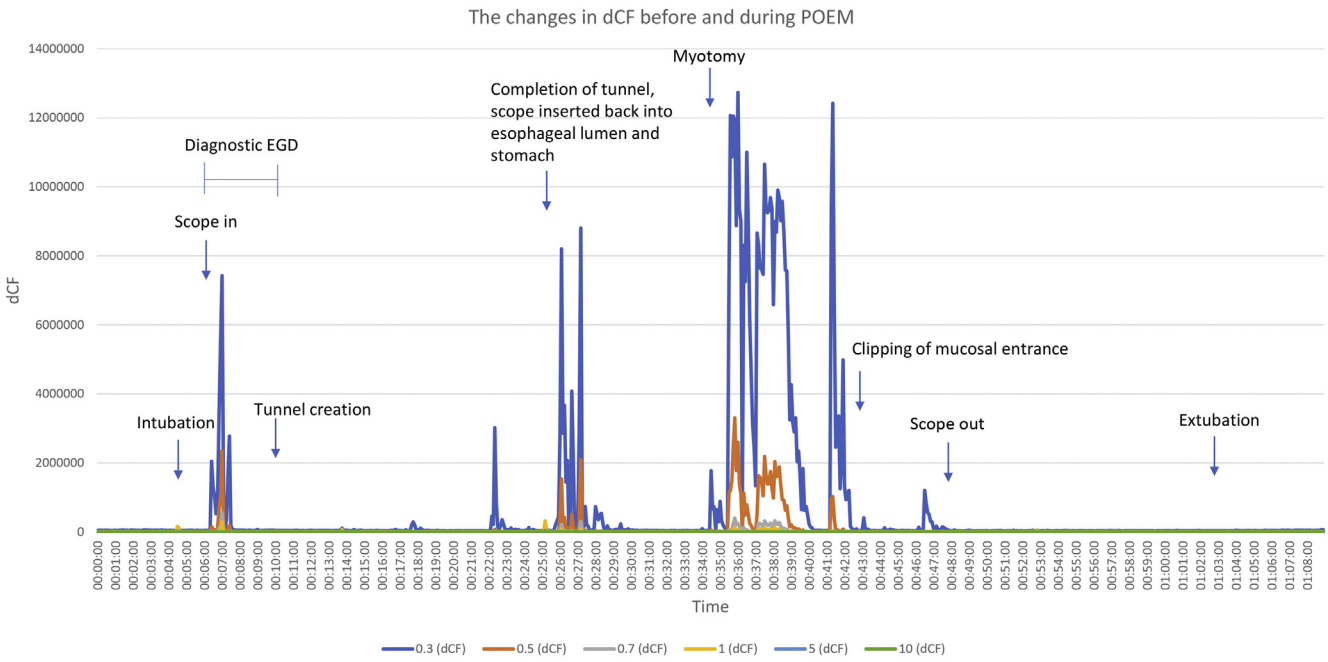


Supplementary Figure 1. (*A*) Line graphs of particle counts sizes 0.3, 0.5, 0.7, 1, 5, and 10 μm of an unsedated diagnostic procedure without the use of dental sucker. (*B*) *Line graph*s of particle counts sizes 0.3, 0.5, 0.7, 1, 5, and 10 μm of an unsedated diagnostic procedure with the use of dental sucker. (*C*) The change in LN_dCF during the procedure compared with baseline with or without sucker. The use of dental sucker reduced the association between timing of procedure (before vs during) and dCF_0.3 (estimate = −0.24 [SE = 0.04]; 95% confidence interval [CI], −0.32 to −0.16; $P < .001$), dCF_0.5 (estimate = −0.36 [SE = 0.07]; 95% CI, −.50 to −.22; $P < .001$), dCF_0.7 (estimate = −.36 [SE = .10]; 95% CI, −0.56 to −0.16; $P < .001$), dCF_1 (estimate = −0.32 [SE = 0.13]; 95% CI, −0.57 to −0.07; $P = .02$), dCF_5 (estimate = −1.14 [SE = .40]; 95% CI, −1.92 to −0.36; $P < .01$), and dCF_10 (estimate = −0.71 [SE = 0.35]; 95% CI, −1.40 to −.02; $P = .046$). In other words, the use of dental sucker significantly reduced the amount of particles of all sizes expelled during the procedure compared with baseline. Simple slope tests revealed that when compared with baseline, particles of all sizes during EGD were significantly increased in procedures performed without dental sucker (dCF_0.3 estimate = 0.18, $t = 6.30$; $P < .01$; dCF_0.5 estimate = .30, $t = 5.54$; $P < .01$; dCF_0.7 estimate = .28, $t = 3.89$; $P < .01$; dCF_1 estimate = .22, $t = 2.43$; $P = .02$; dCF_5 estimate = 2.49, $t = 8.54$; $P < .01$; dCF_10 estimate = 1.53, $t = 6.03$; $P < .01$). The number of dCF_0.3, dCF_0.5, dCF_0.7, and dCF_1 during EGD were nonsignificantly decreased among participants when dental sucker was used (dCF_0.3 estimate = −0.06, $t = -1.22$; $P = .23$; dCF_0.5 estimate = −0.07, $t = -2.35$; $P = .02$; dCF_0.7 estimate = −0.08, $t = -1.06$; $P = .29$; dCF_1 estimate = −0.09, $t = -0.84$; $P = .40$). For particles dCF_5 and dCF_10, the magnitude of the increase was significantly smaller with the use of dental sucker (dCF_5 estimate = 1.35, $t = 3.69$; $P < .01$; dCF_10 estimate = .82, $t = 2.78$; $P < .01$). Confounders were controlled at the multilevel modeling.



Supplementary Figure 2. The *line gr*aph showing the change in dCF during a per-oral endoscopic myotomy procedure performed under general anesthesia with CO_2 insufflation. There was a surge seen in all particle sizes during the initial intubation of the endoscope and diagnostic EGD. There was also a significant increase in all particles generated once the energy cutting devices were used. These findings suggest that general anesthesia might not have a protective effect on the amount of aerosol generated and the use of energy cutting devices generates a significant amount of aerosols.