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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Editorial

Clear plastic bags effectively limit aerosolization and droplet spray during extubation in the era of COVID-19

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To the Editor,

Coronavirus disease 2019 (COVID-19) results from an infection caused by respirable droplets of <10 μm in diameter that enter the respiratory tract during breathing (i.e., aerosol infection) and inspirable droplets of 10 to 100 μm in diameter that adhere to the mucous membranes above the respiratory tract (i.e., droplet infection) [1]. The infection is estimated to peak before the onset of symptoms [2], and the use of personal protective equipment (PPE) reportedly prevents nosocomial infection [3,4]. It is critical to implement preventive measures against iatrogenic infection. Various reports, including those involving the use of an aerosol box, have described the prevention of dispersed droplets from adhering to the mucosa of medical staff members [5–9].

The availability of aerosol boxes is limited. We conducted a simulated extubation study with an airway management training mannequin (AirSim®; TruCorp Ltd., Lurgan, Northern Ireland) and compared the degree of environmental contamination with the use of an easy-to-obtain clear plastic bag versus an aerosol box. The Tokai University School of Medicine System Review Committee waived the requirement for ethics approval.

The aerosol box had a 620-mm-long outer frame of polyvinyl chloride pipes and acrylic plates with clear plastic sheets inside. The clear plastic bag was created by cutting a long piece of a commercially available 45-L poly bag (0.02 mm × 65 cm × 80 cm) and spreading it to cover the head of the mannequin with the opposite piece on the front side (Fig. 1).

For the simulated light dispersal study, we used an ATP assay in which the organic matter of simulated sputum reacted with an ATP reagent, allowing quantitative assessment of contamination. Determination of the ATP content requires the amount of luminescence [measured in relative light units (RLU)] reacted and issued by luciferin and luciferase in the presence of magnesium ions to be proportional to the amount of ATP. More contamination results in a higher RLU value.

The experiments were performed under air conditioning with normal laminar flow. An endotracheal spray tube (10-16R104; Hakko Co., Ltd., Nagano, Japan), which had 40 holes at the tip and allowed the fluid to be sprayed 360 degrees, was fixed to the incisor portion at a position 6 cm from the tip of the mannequin so that the spray direction remained constant. When the anesthesiologist removed the endotracheal tube, the assistant immediately pushed the syringe containing the spray with 1 ml of simulated sputum and saliva made of orange juice and 4 ml of air to disperse the simulated sputum and saliva.

The measurement points on the anesthesiologist wearing PPE were the dorsum of the left hand, dorsum of the right hand, left elbow (forearm side), right elbow, goggles, mask, neck, chest, and abdominal area. Those on the mannequin to assess exposure on the patient side were the left cheek and chest. Those on the outside of the aerosol box and clear plastic bag to assess the surrounding environment were the left head side, right head side, floor of the shoulder level, and floor of the ventral level of the mannequin. At each location, a 6- × 6-cm area was measured with an ATP measuring kit (Lumitester PD-10 N™; Kikkoman Co., Ltd., Noda City, Japan) with five reciprocations left and right and five reciprocations up and down.

The required sample size was determined to be five based on previous report [10]. SPSS version 25.0 (IBM Corp., Armonk, NY, USA) was used for the statistical analysis. Each measurement is presented as median and interquartile range, and the Mann–Whitney *U* test was used for comparison between the clear plastic bag and aerosol box. Bonferroni-corrected *P*-values of <0.006, <0.025, and < 0.013 were considered statistically significant for the anesthesiologist, mannequin, and surrounding environment, respectively.

The results are shown in Table 1. The pre-experimental values were measured five times (minimum, 5 RLU; maximum, 53 RLU). The mean ATP values ranged from 16.0 to 38.8 RLR; however, these values were small and hence ignored. Therefore, the real ATP value at each experimental site was used. Exposure to the patient side resulted in a significantly lower amount of ATP on the mannequin's chest using a clear

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Fig. 1. The clear plastic bag was created by cutting a long piece of a plastic bag (right upper) and spreading to cover the head of the mannequin with the opposite piece on the front side.

plastic bag ($P = 0.009$) (aerosol box, 16,295 RLU; clear plastic bag, 9 RLU). The use of the aerosol box significantly reduced the amount of ATP on the left cheek of the mannequin ($P = 0.009$) (aerosol box, 2618 RLU; clear plastic bag, 30,237 RLU). The other areas ranged from 6 to 70 RLU with no significant differences. In the present study, the clear plastic bag was equivalent to the aerosol box for the prevention of droplet-induced infection by aerosolization to the circumference of the extubation area.

This experiment has several limitations. First, it was difficult to reproduce a cough through a tracheal tube during extubation. Therefore, a cough was simulated using a tracheal spray. Second, this experiment was performed to investigate environmental contamination by droplets during only extubation. Because no clinical operations such as applying an oxygen mask were performed after extubation, it was not possible to investigate how the environment was contaminated by the end of the extubation procedure.

When using an aerosol box, the inside of the box must be cleaned after use, and the risk of infection must be kept in mind. When using a clear plastic bag, the extubated tracheal tube can be temporarily placed in the bag, and when the bag is removed from the patient's face, it can be wrapped from outside to inside and discarded together with the clear plastic bag. Thus, the post-treatment handling of the clear plastic bag is considered easier and safer than that of the aerosol box, and it is clinically useful.

After extubation, medical staff directly touch the patient for clothing. Using plastic bags is considered more effective than using aerosol boxes in preventing infection by droplets adhering to the patient's chest.

In conclusion, when the aerosol box is not available, extubation maneuvers using readily available clear plastic bags are useful to reduce ambient environmental contamination and prevent infection of medical staff by droplets adhering to the patient's chest. We strongly recommend the use of clear plastic bags for extubation maneuvers.

Table 1
ATP value at each measurement point.

	Aerosol box			Clear plastic bag			
		IQR			IQR		
	Median	25%	75%	Median	25%	75%	*P*-value*
Dorsum of left hand of anesthesiologist	59.0	50.0	589.0	16.0	10.0	28.5	0.008
Dorsum of right hand of anesthesiologist	18.0	13.5	21.0	30.0	20.0	68.0	0.075
Left elbow of anesthesiologist	70.0	38.0	77.0	30.0	16.0	46.0	0.465
Right elbow of anesthesiologist	33.0	20.0	67.0	48.0	44.0	78.0	0.602
Goggles of anesthesiologist	25.0	13.0	60.0	28.0	8.0	36.0	0.754
Mask of anesthesiologist	57.0	43.0	59.0	32.0	31.0	48.0	0.295
Neck of anesthesiologist	25.0	18.0	28.0	31.0	28.0	38.0	0.248
Chest of anesthesiologist	17.0	16.0	27.0	22.0	21.0	27.0	0.675
Abdomial area of anesthesiologist	43.0	26.0	47.0	40.0	38.0	43.0	0.834
Left cheek of mannequin	2618.0	2321.0	3841.0	30,237.0	10,101.0	59,591.0	0.009
Chest of mannequin	16,295.0	9197.0	27,000.0	9.0	7.0	10.0	0.009
Left head side: surrounding environment	13.0	12.0	30.0	9.0	8.0	9.0	0.116
Right head side: surrounding environment	9.0	8.0	9.0	11.0	9.0	11.0	0.340
Floor of shoulder level of mannequin: surrounding environment	7.0	6.0	8.0	7.0	6.0	8.0	0.916
Floor of ventral level of mannequin: surrounding environment	6.0	5.0	7.0	9.0	10.0	10.0	0.401

ATP, adenosine triphosphate; IQR, interquartile range.

* Bonferroni-corrected *P*-values of <0.006, <0.025, and < 0.013 were considered statistically significant for the anesthesiologist, mannequin, and surrounding environment, respectively.

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Informed consent

The Tokai University School of Medicine System Review Committee waived the requirement for ethics approval.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

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