Observation: Brief Research Report

Effectiveness of Surgical and Cotton Masks in Blocking SARS–CoV-2: A Controlled Comparison in 4 Patients

Background: During respiratory viral infection, face masks are thought to prevent transmission (1). Whether face masks worn by patients with coronavirus disease 2019 (COVID-19) prevent contamination of the environment is uncertain (2, 3). A previous study reported that surgical masks and N95 masks were equally effective in preventing the dissemination of influenza virus (4), so surgical masks might help prevent transmission of severe acute respiratory syndrome–coronavirus 2 (SARS–CoV-2). However, the SARS–CoV-2 pandemic has contributed to shortages of both N95 and surgical masks, and cotton masks have gained interest as a substitute.

Objective: To evaluate the effectiveness of surgical and cotton masks in filtering SARS–CoV-2.

Methods and Findings: The institutional review boards of 2 hospitals in Seoul, South Korea, approved the protocol, and we invited patients with COVID-19 to participate. After providing informed consent, patients were admitted to negative pressure isolation rooms. We compared disposable surgical masks (180 mm × 90 mm, 3 layers [inner surface mixed with polypropylene and polyethylene, polypropylene filter, and polypropylene outer surface], pleated, bulk packaged in cardboard; KM Dental Mask, KM Healthcare Corp) with reusable 100% cotton masks (160 mm × 135 mm, 2 layers, individually packaged in plastic; Seoulsa).

A petri dish (90 mm × 15 mm) containing 1 mL of viral transport media (sterile phosphate-buffered saline with bovine serum albumin, 0.1%; penicillin, 10 000 U/mL; streptomycin, 10 mg; and amphotericin B, 25 µg) was placed approximately 20 cm from the patients' mouths. Patients were instructed to cough 5 times each onto a petri dish while wearing the following sequence of masks: no mask, surgical mask, cotton mask, and again with no mask. A separate petri dish was used for each of the 5 coughing episodes. Mask surfaces were swabbed with aseptic Dacron swabs in the following sequence: outer surface of surgical mask, inner surface of surgical mask, outer surface of cotton mask, and inner surface of cotton mask.

The median viral loads of nasopharyngeal and saliva samples from the 4 participants were 5.66 log copies/mL and 4.00 log copies/mL, respectively. The median viral loads after coughs without a mask, with a surgical mask, and with a cotton mask were 2.56 log copies/mL, 2.42 log copies/mL, and 1.85 log copies/mL, respectively. All swabs from the outer mask surfaces of the masks were positive for SARS–CoV-2, whereas most swabs from the inner mask surfaces were negative (Table).

Discussion: Neither surgical nor cotton masks effectively filtered SARS–CoV-2 during coughs by infected patients. Prior evidence that surgical masks effectively filtered influenza virus (1) informed recommendations that patients with confirmed or suspected COVID-19 should wear face masks to prevent transmission (2). However, the size and concentrations of SARS–CoV-2 in aerosols generated during coughing are unknown. Oberg and Brousseau (3) demonstrated that surgical masks did not exhibit adequate filter performance against aerosols measuring 0.9, 2.0, and 3.1 µm in diameter. Lee and colleagues (4) showed that particles 0.04 to 0.2 µm can penetrate surgical masks. The size of the SARS–CoV particle from the 2002–2004 outbreak was estimated as 0.08 to 0.14 µm (5); assuming that SARS-CoV-2 has a similar size, surgical masks are unlikely to effectively filter this virus.

Of note, we found greater contamination on the outer than the inner mask surfaces. Although it is possible that virus particles may cross from the inner to the outer surface because of the physical pressure of swabbing, we swabbed the outer surface before the inner surface. The consistent finding of virus on the outer mask surface is unlikely to have been

Table. SARS–CoV-2 Viral Load in Patient Samples, Petri Dishes, and Mask Surfaces

Characteristic	Patient 1 (Hospital A)	Patient 2 (Hospital A)	Patient 3 (Hospital B)	Patient 4 (Hospital B)
Age, *y*	61	62	35	82
Sex	Male	Female	Male	Female
Clinical diagnosis	Pneumonia	Upper respiratory infection	Upper respiratory infection	Pneumonia with ARDS
Symptom onset before admission, *d*	24*	4	5	10
Timing of the mask test, *hospital days*	8	4	2	14
Viral load, *log copies/mL*				
Nasopharyngeal swab	7.68	5.42	5.98	3.57
Saliva	4.29	2.59	5.91	3.51
Petri dish				
Coughing without a mask (before control)	3.53	2.14	2.52	ND
Coughing with a surgical mask	3.26	1.80	2.21	ND
Coughing with a cotton mask	2.27	ND	1.42	ND
Coughing without a mask (after control)	3.23	2.06	2.64	2.44
Mask surface				
Outer surface of surgical mask	2.21	2.11	2.63	2.59
Inner surface of surgical mask	ND	ND	2.00	ND
Outer surface of cotton mask	2.76	2.66	3.61	2.58
Inner surface of cotton mask	ND	ND	3.70	ND

ARDS = acute respiratory distress syndrome; ND = not detected; SARS–CoV-2 = severe acute respiratory syndrome–coronavirus 2.
* Transferred from the other hospital.

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caused by experimental error or artifact. The mask's aerodynamic features may explain this finding. A turbulent jet due to air leakage around the mask edge could contaminate the outer surface. Alternatively, the small aerosols of SARS–CoV-2 generated during a high-velocity cough might penetrate the masks. However, this hypothesis may only be valid if the coughing patients did not exhale any large-sized particles, which would be expected to be deposited on the inner surface despite high velocity. These observations support the importance of hand hygiene after touching the outer surface of masks.

This experiment did not include N95 masks and does not reflect the actual transmission of infection from patients with COVID-19 wearing different types of masks. We do not know whether masks shorten the travel distance of droplets during coughing. Further study is needed to recommend whether face masks decrease transmission of virus from asymptomatic individuals or those with suspected COVID-19 who are not coughing.

In conclusion, both surgical and cotton masks seem to be ineffective in preventing the dissemination of SARS–CoV-2 from the coughs of patients with COVID-19 to the environment and external mask surface.

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Reproducible Research Statement: *Study protocol, statistical code, and data set:* Available from Dr. Sung-Han Kim (e-mail, kimsunghanmd@hotmail.com).

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