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Concise Communication

Impacts of indoor masks wearing on air contamination during 10-minute speaking in patients with SARS-CoV-2 omicron variant infection

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Abstract

In 10-minute speaking, N95 respirators significantly decreased SARS-CoV-2 emissions compared with no-mask wearing. However, SARS-CoV-2 was detected in the air even when wearing N95 and surgical masks in patients with high viral loads. Therefore, universal masking of infected and uninfected persons is important for preventing COVID-19 transmission via the air.

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Abbreviations: COVID-19 = coronavirus disease 2019; Ct = cycle threshold; IQR = interquartile range; PCR = polymerase chain reaction; RNA = ribonucleic acid; RT-PCR = reverse transcription polymerase chain reaction; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2; VTM = viral transport media

Introduction

Despite widespread vaccination against coronavirus disease 2019 (COVID-19), breakthrough infection and reinfection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) continue.[1] Transmission via the air has been revealed as a major transmission route for COVID-19.[2] Therefore, mask wearing, as a non-pharmacological intervention, is important for preventing the transmission of COVID-19, especially in inadequately ventilated enclosed spaces.[2] We previously assessed the effectiveness of various masks in COVID-19 patients who are coughing.[3,4] However, we could not test the presence of SARS-CoV-2 in the air, as procedures that are more likely to generate higher levels of aerosols were not feasible in the enrolled patients due to old age and severe disease.[3,4] Here, we evaluated the impact of mask wearing for source control on the detection of SARS-CoV-2 in the air in patients with SARS-CoV-2 Omicron variant infection during 10-minute speaking, simulating close contacts in inadequately ventilated spaces. Furthermore, we assessed the clinical characteristics of patients in whom air contamination was identified.

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Methods

Adult patients with confirmed COVID-19, who were admitted to a community treatment center in Seoul, South Korea, from January 2022 to February 2022, during a large outbreak of the B.1.1.529 (Omicron) variant, were invited to participate in the speaking test. To include patients with high viral loads, only those who had developed symptoms within 6 days were enrolled. The study protocol was approved by the Institutional Review Boards of Soonchunhyang University Hospital and Chung-Ang University Hospital.

Using real-time reverse transcription polymerase chain reaction (RT-PCR) assay targeting the *N* gene of SARS-CoV-2, we tested the presence of SARS-CoV-2 in inner and outer surfaces of N95 respirators and surgical masks, petri-dish at a distance of 30 cm, and air sample at a distance of 90 cm, when the patients sequentially wore N95 respirators (3M™ Aura™ Particulate Respirator 9205+, 3M Corp.); surgical masks with elastic ear loops (Dental Mask, No. 82001, Yuhan-Kimberly Corp.); and no-mask. While wearing an N95 respirator, a surgical mask, and no-mask, the patients were instructed to read prescriptive sentences aloud—the words of the National Anthem of South Korea—for 10 minutes. Details of the 10-minute speaking process, sampling and laboratory procedures, and statistical analysis are described in the Supplemental Materials.

Results

A total of 29 patients with confirmed COVID-19 were enrolled. All patients had mild symptomatic disease. The clinical characteristics of the patients are presented in Table 1. The median age of the patients was 28 years, and 48% were male. The median interval

Table 1. Clinical and virological characteristics of the patients with SARS-CoV-2 Omicron variant infection who underwent the 10-minute speaking test

	Total patients (n = 29)
Age (years), median (IQR)	28 (22–37)
Male sex (%)	14 (48)
From symptom onset to the test (days), median (IQR)	4 (3–5)
From admission to the test (days), median (IQR)	2 (1–2)
Nasopharyngeal swab	
Ct value for *N* gene, median (IQR)	22.3 (20.4–26.8)
Saliva	
Ct value for *N* gene, median (IQR)	26.9 (22.1–32.0)

Abbreviations: Ct, cycle threshold; IQR, interquartile range; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

Table 2. Detection of SARS-CoV-2 in RT-PCR assay during the 10-minute speaking test

	N95 respirator (n = 29)	Surgical mask (n = 29)	No-mask (n = 29)
Inner surface of the mask	7 (24)	3 (10)	N/A
Outer surface of the mask	0	0	N/A
Petri-dish at a distance of 30 cm	0[a]	1 (3)[b]	5 (17)[a,b]
Air sampling at a distance of 90 cm	1 (3)	1 (3)	2 (7)

Note. Data are presented as number (%) of patients, unless otherwise indicated.
[a]These results were significantly different (*P*-value = 0.05).
[b]These results were not significantly different (*P*-value = 0.19).
Abbreviations: N/A, not available; RT-PCR, reverse transcription polymerase chain reaction; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

between symptom onset and the test was 4 days. The median cycle threshold (Ct) values for the *N* gene in the nasopharyngeal swabs and saliva were 22.3 and 26.9, respectively.

The identification of SARS-CoV-2 when the N95 respirator, surgical mask, and no-mask were worn during 10-minute speaking is shown in Table 2. SARS-CoV-2 was found on the inner surfaces of N95 respirators (7 [24%] patients) and surgical masks (3 [10%] patients), but not on the outer surfaces of the respirators or masks. Compared with no-mask wearing (5 [17%] patients), N95 respirators (0 patients) significantly decreased arrival of SARS-CoV-2 in the petri-dish at a distance of 30 cm ($P = 0.05$), but surgical masks (1 [3%] patient) did not lead to a significant difference ($P = 0.19$). In air sampling at a distance of 90 cm, SARS-CoV-2 was identified in the air not only when a mask was not applied (2 [7%] patients), but when wearing N95 respirators (1 [3%] patient) and surgical masks (1 [3%] patient).

We compared the clinical characteristics of patients with and without air contamination by SARS-CoV-2 (Supplementary Table 1). The virus was detected in the air around 4 (14%) patients. Patients with air contamination tended to have higher viral loads in nasopharyngeal swabs (median Ct value, 20.4) than those without air contamination (median Ct value, 23.7) ($P = 0.08$). However, other clinical characteristics including age, sex, timing of the test, and saliva Ct value were not different.

Discussion

In 10-minute speaking, SARS-CoV-2 was detected on the inner surface of the N95 respirators and surgical masks, but the outer surfaces of the respirators and masks were not contaminated by the virus. N95 respirators decreased the arrival of SARS-CoV-2 at a distance of 30 cm compared with no-mask wearing. Taken together, N95 respirators blocked the emission of SARS-CoV-2-containing particles. However, SARS-CoV-2 was identified in the air even when patients wore N95 respirators and surgical masks. Therefore, our findings suggest that universal N95 respirator or mask wearing by infected patients for source control and uninfected persons for inhalation protection is important to prevent COVID-19 transmission via the air in inadequately ventilated spaces.

We found that SARS-CoV-2 was detected in the air even when N95 respirators and surgical masks were used, especially in patients with high viral loads. There are several possible explanations for the results. First, preexisting SARS-CoV-2 might have been floating in the air of the patients' rooms, which were inadequately ventilated, before the mask wearing. Bushmaker et al. showed that SARS-CoV-2 Omicron variant were durable in the air with a half-life of 2.15 hours.[5] Second, suboptimal fitting of N95 respirators and outward leakage of exhaled air might be associated with air contamination. Similarly, a previous study reported that even N95 respirators did not completely block emission of SARS-CoV-2-containing aerosols in laboratory setting.[6] Third, possible penetration of virus-containing aerosols through surgical masks might contribute to air contamination.[4]

The Omicron variant of SARS-CoV-2 is thought to have higher transmissibility via the air than prior variants.[7,8] It might be attributable to the Omicron variant having greater tissue tropism for conducting airways than lung parenchyma compared to previous variants.[9] High concentration of Omicron variant in conducting airways might be likely to generate SARS-CoV-2-containing aerosols in daily life via bubble film burst mechanism.[7] We tried to identify the risk factors of air contamination by Omicron variant in the study. In consistent with previous studies,[7,8] the risk of air contamination was associated with a high nasopharyngeal viral load of patients. However, Lai et al. reported that saliva viral load showed stronger association with air contamination than nasopharyngeal viral load,[7] whereas saliva viral load was not different between patients with and without air contamination in our study. The discrepancy might be due to absence of standardized procedures for saliva collection, heterogenous processing of saliva, and reduced sensitivity of PCR assay in saliva sample.[10] In clinical characteristics, there were no discernible differences between patients with and without air contamination. The unpredictability of air contamination also highlights the importance of universal masking.

Our study had several limitations. First, the small number of patients makes it difficult to draw hard conclusions. However, given the limited data regarding the spread of SARS-CoV-2 in real-life patients with COVID-19 wearing masks, our findings could be helpful in understanding COVID-19 transmission via the air. Second, baseline and downtime air samplings were not performed. Preexisting SARS-CoV-2 and carry-over effects that lead to SARS-CoV-2 accumulation in the air over time might influence the results. Third, we did not measure the quality of the speaking such as loudness that might affect the virus release. Finally, we did not exam viability of SARS-CoV-2. However, we tried to enroll patients in early periods from symptom onset who are likely to shed viable virus.

In conclusion, universal masking in infected and uninfected individuals is important to prevent COVID-19 transmission via the air in inadequately ventilated environments.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/ice.2024.139

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Competing interests. The authors declare no potential conflicts of interest.

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