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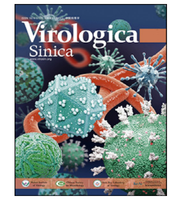

Letter

Similar aerosol emission rates and viral loads in upper respiratory tracts for COVID-19 patients with Delta and Omicron variant infection

Jiaming Li [a,1], Yidun Zhang [b,1], Lina Jiang [b,1], Hongliang Cheng [a], Jingjing Li [a], Li Li [b], Zehui Chen [b], Fei Tang [b], Yingying Fu [a], Yifei Jin [a], Bing Lu [a,*], Jing Zheng [b,*], Zhongyi Wang [a,*]

[a] *Academy of Military Medical Sciences, Academy of Military Sciences in Beijing, Beijing 100071, China*
[b] *Xiamen Center for Disease Control and Prevention, Xiamen 361021, China*

Dear Editor,

In 2021, the Delta variant of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) caused the coronavirus disease 2019 (COVID-19) pandemic to spread in the UK, Nepal, southeast Asia and elsewhere, which seems to be approximately 60% more transmissible than the already highly infectious Alpha variant in late 2020 (Callaway, 2021). In addition to the high efficiency of the invading infection and the acquired immune escape ability, changes in the aerodynamic characteristics of SARS-CoV-2 aerosols may be another important reason for the Delta variant spread. Previously, it was identified that SARS-CoV-2 can spread through close contact and airborne routes (Guo et al., 2020; Morawska and Milton, 2020). Exhalation of viral aerosols is the first step in causing airborne transmission (Zhang et al., 2021). In 2020, COVID-19 patients in earlier stages were found to exhale millions of SARS-CoV-2 aerosols per hour (Ma et al., 2021). Furthermore, studies on viral aerosol emission from patients with Omicron variant infection were also performed (Zheng et al., 2022). However, whether viral loads in exhaled air changed or not during the spread of different variants were still unknown. Here, we investigated viral loads of throat swabs and breath emission rates (BER) of Alpha, Delta or Omicron patients, to provide evidence for changing process during different SARS-CoV-2 variants spreading.

We recruited 96 patients with COVID-19 in hospital A, including 29 Alpha, 25 Delta, 42 Omicron patients (Supplementary Table S1). Patients infected with Omicron variant were selected from our previous study and the previous data of throat swab tests after admission were also discussed in this study (Zheng et al., 2022). Exhaled breath condensate (EBC) samples were collected from 25 Delta patients and 42 Omicron patients (Supplementary Table S1). EBC samples were collected using a BioScreen device purchased from Dingblue Technology Co., LTD (Beijing, China); the same as the device used in a previous study (Zheng et al., 2022). All samples collected were analyzed by using SARS-CoV-2 detection kit, targeting *ORF1ab* and *N* genes. Standard curve was used for viral load calculation based on SARS-CoV-2 RNA reference material containing (provided by China National Institute of Metrology and calculation details are provided in Supplementary Information). The virus breath emission rate and virus concentration in exhaled air of each patient were calculated by the equation which had been published in previous studies (Ma et al., 2021; Zheng et al., 2022).

As shown in Fig. 1A, positive rates of EBC samples from Delta or Omicron variant patients were 24.00% and 28.57%, respectively. The BER of patients with Delta variant infection ranged from 4.56×10^3 to 3.59×10^7 copies/h, with an average level 7.41×10^6 copies/h (Fig. 1B, Supplementary Table S1). The BER of patients with Omicron variant infection ranged from 2.01×10^3 to 1.47×10^6 copies/h, with an average level 7.02×10^5 copies/h (Fig. 1B, Supplementary Table S1). There was no significant difference among the BER of Delta and Omicron patients.

Furthermore, we explored the viral loads in upper respiratory tract of patients with Alpha, Delta and Omicron, and found that they were also similar based on the absolute quantification of *ORF1ab* and *N* genes (Fig. 1C). Besides, the vaccination condition determined the antibody level of humans, and might affect the viral loads in COVID-19 patients, so we further investigate the relationship between vaccination condition and viral load in upper respiratory tract. As shown in Fig. 1D, patients were grouped at different ages: 0–18, 19–45, 46–65 and > 65 years old. For Alpha variant patients, proportions of patients of different ages were 6.9%, 41.4%, 48.3% and 3.4%; for Delta variant patients, proportions of patients of different ages were 4.0%, 80.0%, 16.0% and 0.0%; for Omicron variant patients, proportions of patients of different ages were 2.4%, 76.2%, 19.0% and 2.4%. Meanwhile, 19 to 45-year-old patients with Delta variant infection were divided into two groups: vaccinated group and unvaccinated group, and we found that viral load in upper respiratory tract of vaccinated or unvaccinated Delta variant patients had no significant difference (*ORF1ab* gene, $P = 0.5275$; *N* gene, $P = 0.4272$) (Fig. 1E).

* Corresponding authors:
E-mail addresses: 13693506666@163.com (B. Lu), zhengjing1103@foxmail.com (J. Zheng), zhongyi_wang@foxmail.com (Z. Wang).

[1] Jiaming Li, Yidun Zhang, and Lina Jiang contributed equally to this article.

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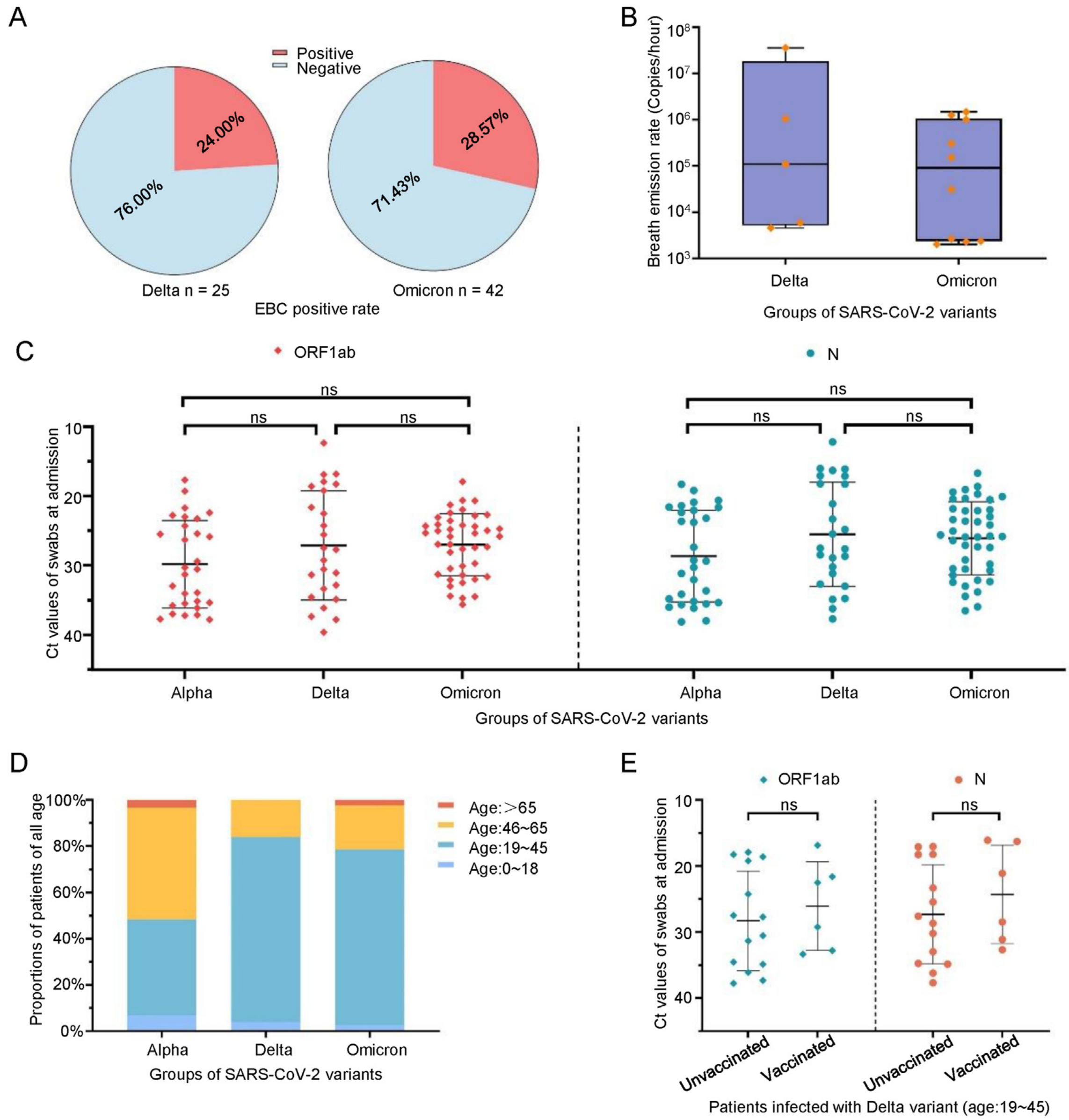

Fig. 1. Aerosol emission characteristics of SARS-CoV-2 Delta variant and the relationship between viral load in upper respiratory tract and vaccination of COVID-19 patients. **A** The proportion of positive and negative EBCs. These data were obtained from 25 patients infected with Delta and 42 patients infected with Omicron. Red represents positive EBCs and blue represents negative EBCs. **B** BER of patients with Delta or Omicron variant infection. Orange dots represent each data, the horizontal lines represent maximum value, 25% percentile, 50% percentile (median), 75% percentile and minimum value (from bottom to top), respectively. **C** Ct values of throat swabs at admission. The data in the figure are RNA test data of throat swabs from the 96 patients at admission. Red and green represent *ORF1ab* gene and *N* gene of SARS-CoV-2, respectively. Statistical significance between each two variants was calculated by unpaired Student's *t*-test. Values are expressed as the mean ± standard error of the mean (SEM). ns means $P > 0.05$. **D** The proportions of patients of different ages infected with Alpha, Delta or Omicron variant. Light blue, dark blue, yellow, and orange represent patients aged 0–18, 19–45, 46–65 and over 65 years old, respectively. **E** Ct values of throat swabs at admission from vaccinated or unvaccinated patients with Delta variant infection. The RNA test data of throat swabs were from 20 patients aged from 19 to 45 years old. Green and red represent *ORF1ab* gene and *N* gene of SARS-CoV-2, respectively.

After a patient exhales viral aerosols under the influence of airflow in the room, virus particles floating in the air may generate a potential infection risk through the aerosol route, while the virus particles deposited on the surface of the object may generate the potential infection risk through the contact route (Liu et al., 2020; Guo et al., 2022). So the monitoring of viral loads in exhaled air from COVID-19 patients may provide important clues for transmission prevention and control. No significant difference was observed in the viral aerosol emission between patients infected with Alpha, Delta or Omicron variant, and the viral load in upper respiratory tract had the same variation trend. However, we cannot ignore the risk of aerosol transmission because the BER of COVID-19 was still at a high level. In particular, the surgery and other special care work scenarios give medical staff more opportunities to contact patients closely, and the protection level for droplet and aerosol transmission needs to be strengthened. For example, positive pressure head cover should be worn to reduce the risk of airborne infection when necessary. It should be pointed out that the infectious virus particles were not measured due to the experimental conditions and working time constraints, which is a limitation of this study. Live virus quantitation assay should be performed in future monitoring work.

Overall, these results indicate that monitoring of the SARS-CoV-2 breath emission rate in SARS-CoV-2 variant-infected patients should be conducted regularly to evaluate the changing transmission capacity of SARS-CoV-2 and to strengthen the prevention of nosocomial infection.

Footnotes

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References

Callaway, E., 2021. Delta coronavirus variant: scientists brace for impact. Nature 595, 17–18.

Guo, W., Fu, Y., Jia, R.,, Guo, Z., Su, C., Li, J., Zhao, X., Jin, Y., Li, P., Fan, J., Zhang, C., Qu, P., Cui, H., Gao, S., Cheng, H., Li, J., Li, X., Lu, B., Xu, X., Wang, Z., 2022. Visualization of the infection risk assessment of SARS-CoV-2 through aerosol and surface transmission in a negative-pressure ward. Environ. Int. 162, 107153.

Guo, Z.D., Wang, Z.Y., Zhang, S.F., Li, X., Li, L., Li, C., Cui, Y., Fu, R.B., Dong, Y.Z., Chi, X.Y., Zhang, M.Y., Liu, K., Cao, C., Liu, B., Zhang, K., Gao, Y.W., Lu, B., Chen, W., 2020. Aerosol and surface distribution of severe acute respiratory syndrome coronavirus 2 in hospital wards, Wuhan, China, 2020. Emerg. Infect. Dis. 26, 1583–1591.

Liu, Y., Ning, Z., Chen, Y., Guo, M., Liu, Y., Gali, N.K., Sun, L., Duan, Y., Cai, J., Westerdahl, D., Liu, X., Xu, K., Ho, K.F., Kan, H., Fu, Q., Lan, K., 2020. Aerodynamic analysis of SARS-CoV-2 in two Wuhan hospitals. Nature 582, 557–560.

Ma, J., Qi, X., Chen, H., Li, X., Zhang, Z., Wang, H., Sun, L., Zhang, L., Guo, J., Morawska, L., Grinshpun, S.A., Biswas, P., Flagan, R.C., Yao, M., 2021. Coronavirus disease 2019 patients in earlier stages exhaled millions of severe acute respiratory syndrome coronavirus 2 per hour. Clin. Infect. Dis. 72, e652–e654.

Morawska, L., Milton, D.K., 2020. It is time to address airborne transmission of coronavirus disease 2019 (COVID-19). Clin. Infect. Dis. 71, 2311–2313.

Zhang, C., Guo, Z., Zhao, Z., Wang, T., Li, L., Miao, F., Zhang, C., Li, Y., Gao, Y., 2021. SARS-CoV-2 aerosol exhaled by experimentally infected cynomolgus monkeys. Emerg. Infect. Dis. 27, 1979–1981.

Zheng, J., Wang, Z., Li, J., Zhang, Y.,, Jiang, L., Fu, Y., Jin, Y., Cheng, H., Li, J., Chen, Z., Tang, F., Lu, B., Li, L., Zhang, X., 2022. High amounts of SARS-CoV-2 in aerosols exhaled by patients with Omicron variant infection. J. Infect. 84, e126–e128.