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Review

Evaluation of the effect of vaccination on transmissibility and pathogenicity of Omicron variant and its comparison with other SARS-CoV-2 variants

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Abstract

The new variant of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has once again sounded the alarm on healthcare systems worldwide and has caused concern in some countries. This variant has been identified in South Africa and initially called B.1.1.529 and later renamed Omicron by the WHO. The transmissibility and immune evasion in the Omicron variant (B.1.1.529) is higher than the previous variants. Compared to the previous dominant variant, which was called the Delta variant, the Omicron variant has a very high transmission power but luckily, Omicron's symptoms are less serious. According to the WHO, the Omicron variant has the potential to re-infect people who already have other variants of SARS-CoV-2. Omicron contains at least 32 mutations in the spike protein also other proteins that are required for viral replication and it is twice the size of delta variant. Half of the mutations in this variant occur in the area of the virus through which they bind to the cells of the human body and cause infection. The Omicron variant likely developed in one person during chronic infection with an immune system deficiency (possibly untreated HIV/AIDS). It is possible that injecting a booster dose of existing vaccines and subsequently increasing antibody levels will provide adequate protection and an appropriate barrier against Omicron. The purpose of this article is to evaluate the Omicron variant and compare it with other SARS-CoV-2 variants and the effect of a booster dose in preventing disease progression.

Keywords: SARS-CoV-2, Omicron, B.1.1.529, COVID-19, Vaccines

1. Introduction

The fire under the ashes of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) flared up again, this time from South Africa. The new SARS-CoV-2 variant was detected in specimens collected in Botswana on November 11, 2021, and in South Africa on November 14, 2021 [1]. The WHO reported the identified variant as variant B.1.1.529 on November 24, 2021. The new variant was initially called B.1.1.529 and was renamed Omicron by WHO later [2]. In this review article, we have tried to examine the new variant of SARS-CoV-2 called Omicron to take the necessary measures to reduce its prevalence.

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2. Origins of the Omicron variant

The Omicron variant likely developed in one person during chronic infection with an immune system deficiency (possibly untreated HIV/AIDS) [3]. The beta variant was identified in South Africa last year may also have originated from an HIV-infected person. The first reports of Omicron were of young people who usually had mild symptoms of COVID-19 due to their young age. South Africa has 7.7 million people living with HIV in 2019, the highest rate in the world [4]. In another hypothesis, one of the synthetic pathogens of COVID-19 for laboratory mice could be the cause of Omicron. The new variant of the SARS-CoV-2 may have been transmitted to humans from domestic animals or wild mice [5].

3. Comparison of Omicron variant with other variant of concern

The Omicron variant (lineage B.1.1.529) joins the four previous SARS-CoV-2 variants as a variant of concern (VOC). These four variants include the alpha variant from the United Kingdom (lineage B.1.1.7), the beta variant from South Africa (lineage B.1.351), the Gamma variant from Brazil (lineage P.1), and the delta variant from India (lineage B.1.617.2) [6]. In the last two years, various variants such as Alpha (B.1.1.7), Beta (B.1.351), Gamma (P.1), Delta (B.1.617.2), and other types such as Epsilon (B.1.427) / B.1.1429), Zeta (P.2), Eta (B.1.525), Theta (P3), Iota (B.1.526) and Kappa (B.1.617.1), were caused concern in all countries. Recently, the Delta variant has caused widespread deaths worldwide, which by vaccination have reduced. Research has shown that the Omicron variant easily escapes the trap of antibodies, thus likely to have a significant spread in people, especially vaccinated people [7, 8].

4. Comparison of Omicron variant with Delta variant

4.1 Transmissibility

Not much information is available about the transmissibility of Omicron, but its replacing with delta as the dominant species will increase concerns [1]. Importantly, due to the small number of patients in South Africa, it is difficult to determine the rate of Omicron transmission. Studies of Omicron spike protein mutations suggest that the Omicron variant may have a faster transmission rate than the original SARS-CoV-2 virus, but it is difficult to compare with the delta type. The Omicron variant is predicted to be more contagious than the delta variant but has milder symptoms than the delta variant [9].

4.2 The severity of the disease

Presently, the severity of the disease is unclear in Omicron infection. Given the small number of cases attributed to the Omicron variant to date, it's far hard to evaluate the severity of the disease. Data from infected people in South Africa show that there aren't abnormal symptoms associated with the Omicron variant, and in some people, it is asymptomatic or may have mild symptoms [10].

5. Mutations

As mentioned, the CDC and WHO have separately classified the new SARS-CoV-2 variants into two groups: variants of concern (VoCs) and variants of interest (VoIs). Table 1 show the mutations of the spike protein of the VoCs and VoIs proteins [11, 12]. The VoIs are variants that contain specific biomarkers linked with modifications. VoIs can lower the antibiotic neutralization caused by natural infection or vaccination, and can also reduce the effectiveness of a vaccine [13].

As mentioned, the rate of mutations in Omicron is significantly higher. In this variant, there are at least 32 mutations in the spike protein and other proteins that are required for virus replication, such as NSP12 and NSP14.2. In contrast, in the highly infectious variant of Delta, there were 16 mutations, of which 9 mutations occurred in the virus protein spike [14].

There are 30 amino acid substitutions in the spike protein of Omicron, including three small deletions and one small insertion. Totally, 15 of the 30 amino acid substitutions are in the receptor-binding domain (RBD) which facilitates the transmission of the virus into cells (Table 2). There are also other changes and deletions in other regions of the genome. At least three Omicron mutations help the virus escape detection by immune system antibodies [12, 15].

6. Expansion of Omicron variant in the world

Omicron cases in many countries such as South Africa, Botswana, Netherlands, Portugal, United Kingdom (England and Scotland), Australia, Hong Kong, Canada, Denmark, Austria, Italy, Belgium, Czech Republic, France, Sweden, Spain, US, and Iran

Table 1. The mutations of the spike protein of the VoCs and VoIs proteins

Variants of concern (VoCs)	
Types of variant	Mutations of the spike protein
Alpha (B.1.1.7)	69/70/144del, N501Y, A570D, P681H, T716I, S982A, D1118H
Beta (B.1.351)	L18F, D80A, D215G, R246I, K417N, E484K, N501Y, D614G, A701V
Gamma (P.1)	L18F, T20N, P26S, D138Y, R190S, H655Y, T1027I, D614G, K417T, E484K, N501Y
Delta (B.1.617.2)	T19R, G142D, 156/157del, R158G, L452R, T478K, D614G, P681R, D950N
Omicron (B.1.1.529)	69–70/142–144/211del A67V, T95I, Y145D, L212I, ins214EPE, T547K, D614G, H655Y, N679K, P681H, N764K, D796Y, N856K, Q954H, N969K, L981F
Variants of interest (VoIs)	
Epsilon (B.1.427)	L452R, D614G
Epsilon (B.1.429)	S13I, W152C, L452R, D614G
Zeta (P.2)	L18F, T20N, P26S, F157L, E484K, D614G, S929I, V1176F
Eta (B.1.525)	A67V, 69/70/144del, E484K, D614G, Q677H, F888LL5F
Iota (B.1.526)	T95I, D253G, S477N, E484K, D614G, A701V
Theta (P.3)	141/142/143del, E484K, N501Y, P681HT95I, G142D
Kappa (B.1.617.1)	E154K, L452R, E484Q, D614G, P681R, and Q1071H

Table 2. Amino acid substitutions in the spike protein of Omicron and RBD substitutions

Amino acid substitutions in the spike protein of Omicron	**RBD substitutions**
del69-70, A67V, del142-144, Y145D, del211, L212I, ins214EPE, T547K, D614G, H655Y, N679K, P681H, N764K, D796Y, N856K, Q954H, N969K, T95I, L981F	G339D, S371L, S373P, S375F, K417N, N440K, G446S, S477N, T478K, E484A, Q493R, G496S, Q498R, N501Y, Y505H

have been approved. Based on mathematical models, Omicron is expected to cause over half of all coronavirus infections in the European Union in the coming months [16].

7. Effectiveness and safety of vaccines

The total dose of vaccine available worldwide to date is approximately 10 billion and 936 million, of which 4 billion and 467 million have been fully vaccinated. Research on the effectiveness and safety of vaccines in recipients after a few months of vaccination shows that a third dose of the vaccine, especially in some populations such as the elderly and people with weak immune systems, is necessary to maintain community safety. Regarding the effect of vaccination on Omicron, currently there is no data to assess the serum ability of vaccinated individuals or those who have previously had SARS-CoV-2 disease. In immunization resulting from vaccination, the spike protein is the primary target. In the Omicron variant, the rate of mutations in the spike protein is higher than in other variants. Based on the number and location of these mutations and their comparison with previous variants, serum neutralizing activity have been expected to decrease significantly in vaccinated or previously infected individuals. Injections of the third dose have been expected to reduce the incidence. Vaccination will also reduce hospitalization and mortality [17, 18]. According to preliminary data, Sinopharm, Sputnik, and Johnson & Johnson vaccines are less safe than the Omicron variant, but mRNA-based vaccines, such as Pfizer, Moderna, and AstraZeneca are safer against the Omicron variant. mRNA-based technology in vaccine development plays a more effective role in SARS-CoV2 inhibition [19, 20]. According to research at the Kirby Institute, neither the two doses of AstraZeneca nor Pfizer were able to elicit a strong immune response to neutralize Omicron in the samples tested. For this reason, it is necessary to inject a booster dose more than before

Table 3. People who are eligible for a booster dose

Vaccines types	Who receives the booster dose?	When should receive the booster dose?	Which vaccine can be given as a booster?
Pfizer	People 18 years and older	Normally at least 6 months after the first dose of the COVID-19 vaccine	Pfizer or Moderna
Moderna	People 18 years and older	Normally at least 6 months after the first dose of the COVID-19 vaccine	Pfizer or Moderna
Johnson & Johnson's	People 18 years and older	Normally at least 2 months after receiving your J&J/Janssen COVID-19 vaccination	Pfizer or Moderna

[8]. In the United States, three COVID-19 vaccines, Pfizer, Moderna, and Johnson & Johnson's, have been approved by the WHO to prevent COVID-19 disease. Pfizer or Moderna are preferred. People may get Johnson & Johnson's Janssen COVID-19 vaccine in some countries depending on the circumstances (Table 3) [21].

The Pfizer and Moderna vaccines companies have did announced that they can produce the Omicron vaccine in 100 days. The UK Health Security Agency (UKHSA) has suggested that vaccine immunity within 25 weeks of receiving the second dose is less than 10% for the Omicron type and 40% for the delta variant. According to research at the University of Oxford, a triple vaccination program against Omicron is required. Mutations in Omicron are similar to other VOC, so vaccination may inhibit the Omicron variant. As mentioned, there are more than 30 mutations in the spike protein of the Omicron variant, so researchers are focusing on Omicron sequencing data. Based on this information, immunization from vaccination can to some extent prevent SARS-CoV-2 from entering cells. Cellular immunity will develop after vaccination and then T lymphocytes attack the virus-infected cells and by producing perforin and protease enzymes (caspase), induce apoptosis. In general, T lymphocytes are involved in the prevention of severe disease, and with the completion of research, vaccine efficacy data may indicate that the new Omicron variant will not significantly cause death in vaccinated populations. Currently, the most important and best solution is to increase vaccination and booster dose injection. But billions of people around the world are not vaccinated. Only 7% of the African population has received both doses of the vaccine [22, 23].

8. Conclusion

After overcoming the high mortality rate by the Delta variant, the sudden emergence of the Omicron variant with a high number of mutations has caused concern. In this study, Omicron was shown to be about ten times more infectious than the other variants and twice as infectious as the Delta variant. Also, the ability to vaccine-escape in Omicron is more than other variants and twice more than the delta variant. We showed that the booster dose injection would positively affect the severity of the disease, and we also tried to investigate spike protein mutations in different variants and Omicron. Currently, there is little information about the new variant of Omicron, so masks, gloves, three-layer masks, quarantine of infected people, and vaccination (preferably mRNA vaccines) should still be used to prevent the spread of the disease. The risk of death from people with the Omicron variant isn't yet fully understood, but in the elderly, people with a history of diseases such as high blood pressure, diabetes, and those who haven't been vaccinated are at higher risk for death.

Authors' contributions

NS, HH conducted the study design. ND, MK, AR data collection. HH, ND, MK, AR drafting the article. NS, HH critical revisions. All authors read and approved the final version of article.

Conflict of interests

There is no conflict of interest.

Ethical declarations

Not applicable.

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