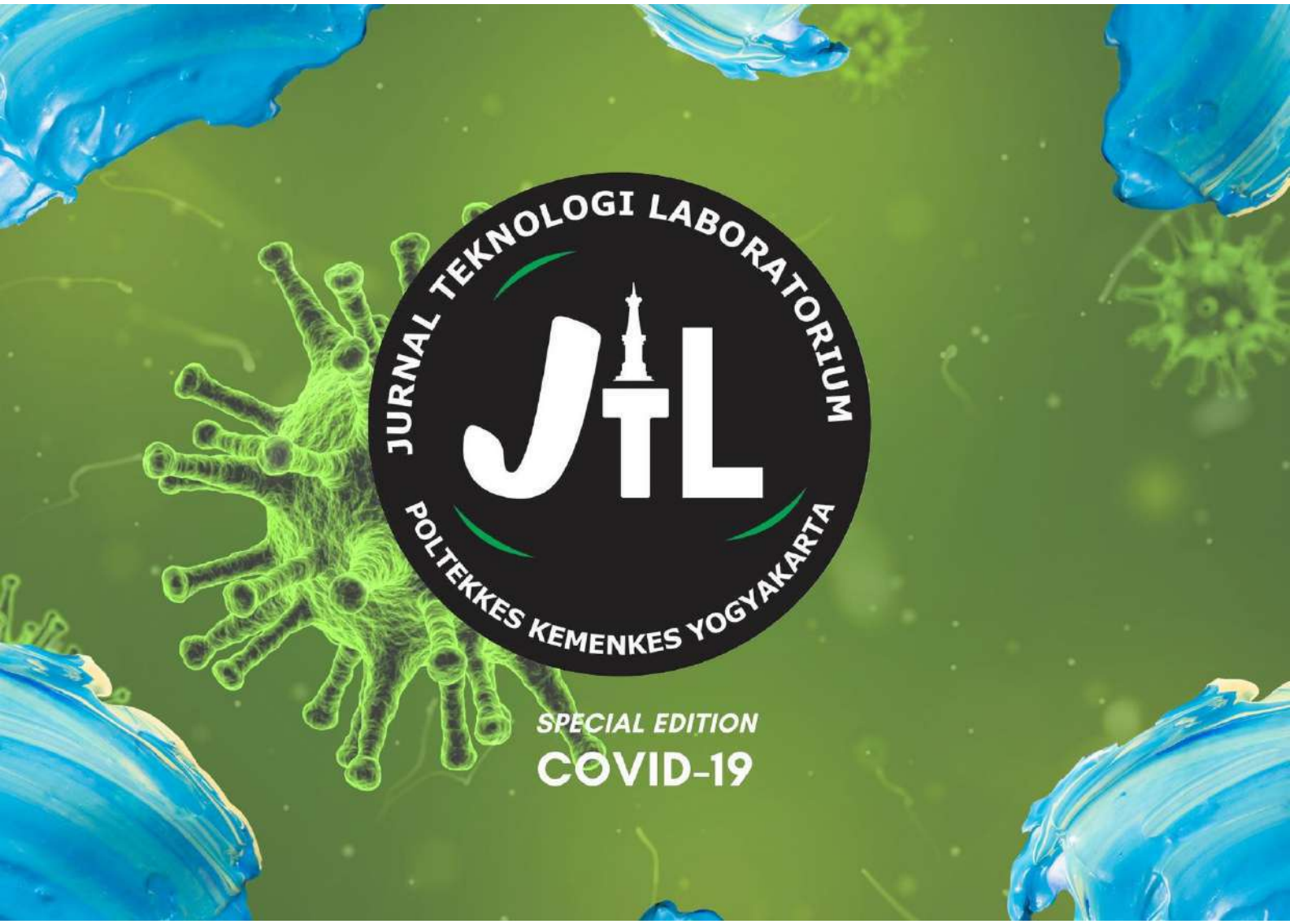
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COVID-19

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In this section, we published a special issue about COVID-19. All papers in this number have been reviewed with all our reviewers. We hope these papers will be useful for cope with COVID-19.

DOI: https://doi.org/10.29238/teknolabjournal.v9i1

Modulation of severe acute respiratory syndrome coronavirus (SARS-CoV-2) in receptor, innate immunity and drug antiviral candidate

Indra Lasmana Tarigan, Kartika Arum

1-12

DOI 10.29238/teknolabjournal.v9i1.214

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Immunobioinformatics analysis and phylogenetic tree construction of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in Indonesia: spike glycoprotein gene

Arif Nur Muhammad Ansori, Viol Dhea Kharisma, Yulanda Antonius, Martia Rani Tacharina, Fedik Abdul Rantam

13-20

DOI 10.29238/teknolabjournal.v9i1.221

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Herd immunity and COVID-19 in Indonesia

Imam Agus Faizal, Nur Ariska Nugrahani

21-28

DOI 10.29238/teknolabjournal.v9i1.219

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Human immune response to SARS-CoV-2 infection

Lia Yosaneri Wina Nurtias, Dora Dayu Rahma Turista, Eka Puspitasari

29-40

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Investigation of revers-transcriptase polymerase chain reaction values of patients with COVID-19 findings in lung computed tomography results

Ozüdogru Osman, Gunes Bolatli, Fatih Tas

41-48

DOI 10.29238/teknolabjournal.v9i1.220

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Diagnosis and epidemiology of Coronavirus (COVID-19) outbreak in Indonesia

Sutaryono Sutaryono, Sholikhah Deti Andasari, Heru Subaris Kasjono

49-57

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Perspective of molecular immune response of SARS-COV-2 infection

Martina Kurnia Rohmah, Arif Rahman Nurdianto

58-66

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Indirect exposure to novel coronavirus (SARS-CoV-2): an overview of current knowledge

Christian Ebere Enyoh, Andrew Wirnkor Verla, Wang Qingyue, Dipak Kumar Yadav, Md Akhter Hossain Chowdhury, Beniah Obinna Isiuku, Tanzin Chowdhury, Francis Chizoruo Ibe, Evelyn Ngozi Verla, Tochukwu Oluwatosin Maduka

67 - 77

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Comparison of real-time reverse transcriptase polymerase chain reaction (RT-PCR) and IgM and IgG antibody test for the diagnosis of SARS-CoV-2 infection

Ömer ACER, Osman ÖZÜDOĞRU

78-86

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On the novel coronavirus (COVID-19): a global pandemic

James Louis-Jean, Magdonald Aime

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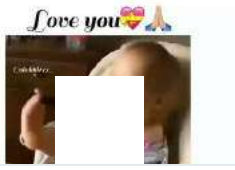

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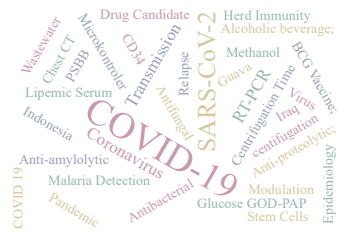

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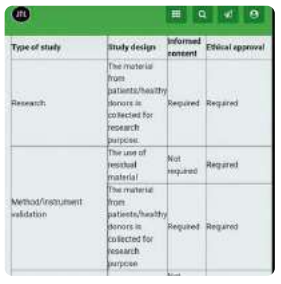

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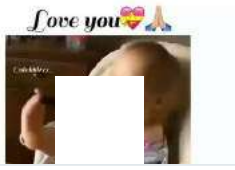

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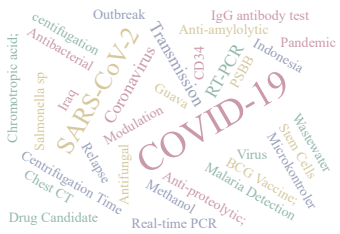

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Article Review

Perspective of molecular immune response of SARS-COV-2 infection

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HIGHLIGHTS

SARS-CoV-2 increases the number of neutrophils as APC, suppresses IFN, increases the activity of Th1 / Th17, B cells, CD8 + and CD4 +, and causes cytokine storms especially pro-inflammatory cytokines which can increase respiration disorders and multi-organ damage.

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A B S T R A C T

COVID-19 is a type of Pneumonia that caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). When COVID-19 arise in Wuhan China and rapidly spread throughout to the World, we need to learn how pathogenesis and immune responses occur in the bodies in more detail. COVID-19 is third Severe Respiratory Disease outbreak caused by the Coronavirus in the past two decades after Severe Acute Respiratory Syndrome (SARS) in the 2002 and Middle East Respiratory Syndrome (MERS) in the 2012. The Articles from PUBMED and Research Gate were searched for studies on the immune response of COVID-19 infection by SARS-CoV-2. SARS-CoV-2 increases the number of neutrophils, suppresses IFN, increases the activity of Th1/Th17, B cells, CD8+ and CD4+, and causes cytokine storms especially pro-inflammatory cytokines which can increase respiration disorders and multi-organ damage. This review tries to explain about pathogenesis and immune responses of COVID-19 to provide a reference in designing the appropriate immune intervention for treatment and therapeutic such as drug or vaccine based on the recent research progress SARS-CoV-2 and previous studies about SARS CoV and MERS CoV.

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1. INTRODUCTION

Coronavirus Disease 2019 (COVID-19) is a pathogenic viral infection caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) that initially arises in Wuhan, Hubei Province, China and rapidly spread to the world. Initially, the cases arise in Wuhan's Hunan Seafood Wholesale Market which trade in fish and variety of live animals

such as bats, marmots, and snake. The causative agent for the disease was identified from throat swab samples conducted by the Chines Centre for Disease Control and Prevention (CCDC), and was subsequently named Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). The sequences-based analysis suggested that bat is a key reservoir of SARS-CoV-2 and can be transmitted to humans.[1] Furthermore, the transmission will occur from human to human as it is today.

On 30th January 2020, the World Health Organization (WHO) declared that COVID-19 from Wuhan was to be a Public Health Emergency of the International Concern posing a high risk to countries. WHO announces this disease outbreak a pandemic diseases. It is due to the rapid increase in the number of cases outside China over the past 2 weeks that has affected a growing number of countries in the world.[2] There were 7734 cases have been confirmed in China on that day. In a number of counties also confirmed 90 cases.[3] On 30th March 2020, WHO confirmed that there were 638.146 cases with 30105 death in 203 countries in the World.[4] In Indonesia, Ministry of Health Indonesia confirmed that there are 1285 positive cases with 114 deaths and 64 recovering on 30th March 2020.[5]

COVID-19 symptoms appear after an incubation period of approximately 5.2 days. The period from the onset of the symptoms to death ranges is from 6 to 41 days with a median of 14 days.[6,7] This period is dependent on the age of the patient and the status of the immune system. The most clinical symptoms at the onset of COVID-19 are fever, dry cough, and fatigue. The other symptoms include headache, sputum production, hemoptysis, diarrhea, dyspnea, lymphopenia, and bilateral lung infiltrates on imaging.[7]

The main problems of COVID-19 are high transmission and the absence of specific drugs and vaccines. For this problem, the immune system is an important aspect to support the host's self-defense and the patient's recovery. This review may help in designing the appropriate immune intervention for treatment and therapeutic such as drug or vaccine in preventing more wide transmission and in the development of the COVID-19 drugs based on the recent research progress SARS-CoV-2 and previous studies about SARS -CoV, and MERS-CoV.

2. REVIEW METHOD

We performed this review of the Pubmed and Research Gate databases from inception to 30 March 2020 to find articles providing information on the molecular immunopathogenesis of COVID-19 infection. The initial search identified 87 sources. Based on the inclusion criteria, we get 13 articles that discuss the Immunopathogenesis of Coronavirus including SARS-CoV, MERS-CoV, and SARS-CoV-2. Initially, this review explains the immune response in SARS-CoV and MERS-CoV, and subsequently, explains the pathogenesis and immune response in SARS-CoV-2. As a coronavirus family, we assume that the immune response of SARS-CoV-2 is similar to SARS-CoV and MERS-CoV. The search was expanded using a snowballing method applied to the references of retrieved papers.

3. RESULTS AND DISCUSSION

As the coronavirus family, the immune response of SARS-CoV-2 is similar to SARS-CoV and MERS-CoV, although it has little difference in clinical manifestation. The summary of the immune response is described in table 1**.**

Table 1. Immune Response Summary of SARS-CoV, MERS-CoV, and SARS-CoV-2

Coronaviruses	Immune Responses	Source
SARS-CoV	1. Cytotoxic T Lymphocyte (CTL)	[8]
	2. MHC class I and II (HLA)	[8]
	3. HLA-B * 4601, HLA-B * 0703, HLA-DR B1 * 1202	[9]
	4. HLA-Cw * 0801	[10]
	5. HLA-DR0301, HLA-Cw 1502 and HLA-A * 0201	[11]
	6. CD8 + T cells	[12]
	7. Cytokine (IL-1β, IL-6, IL-12, IL-18, IL-33, TNF-α, TGF-β) and Chemokines (CCL2, CCL3, CCL5, CXCL8, CXCL9, CXCL10)	[38, 39, 40]

Coronaviruses		Immune Responses	Source
MERS-CoV	1.	MHC class II molecules: HLA-DRB1 * 11: 01 and HLA-DQB1 * 02: 0	[13]
	2.	Mannose Binding Lectine (MBL) gene polymorphism associated with APC	[14]
	3.	CD8+ T cells	[15]
SARS-CoV-2	1.	Neutrofil as APC	[15]
	2.	High Proinflammatory cytokine: IL6, IP-10, MCP-1, MIP-1A, and TNFα.2	[15]
	3.	Th1/Th17	[15]
	4.	Low Antiinflammatory cytokine: Type I IFN	[15]
	5.	B cell, IgM, and IgG	[16]
	6.	CD4+ CD8+ T cells	[17]

Immune response to SARS-CoV-2 infection based on clinical manifestation approach, clinical laboratory test results, and studies of immune response on SARS-CoV and MERS-CoV can be shown in figure 1.

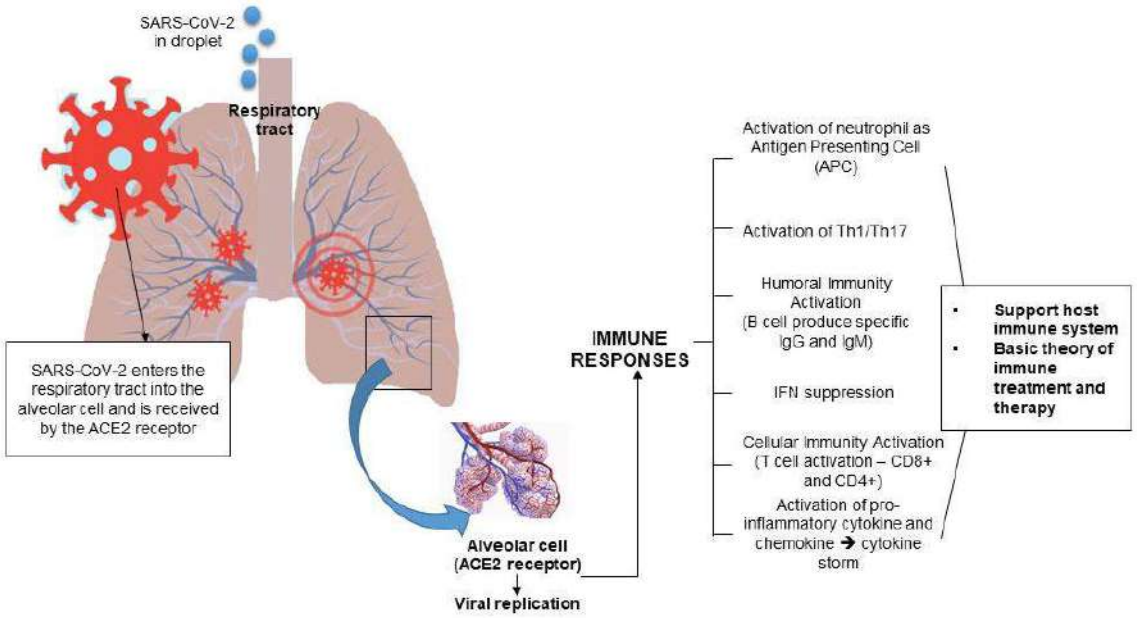

Figure 1. Host immune responses prediction during SARS-CoV-2 infection

According to genotypically and serologically, coronavirus is divided into 4 genera such as α, β, ɣ, and δ Coronaviruses. The subfamily α and β CoV usually causes Human CoV infections. SARS CoV and MERS CoV is included in β CoV. The SARS-CoV-2 is novel β CoV was named by the International Virus Classification Commission.[18,16]

Coronaviruses (CoV) are enveloped viruses, non-segmented, and positive-sense single-stranded RNA (ssRNA) virus genomes in the size 26 to 32 kb, the largest known viral RNA genome. SARS-CoV-2 had a length of 29.9 kb. SARS-CoV-2 has four main structural proteins including Spike Glycoprotein (S), small envelope glycoprotein (E), membrane glycoprotein (M), and nucleocapsid protein (N), and several accessory protein. The structure of CoV virion is shown in figure 1.[16]

The Spike glycoprotein (S protein) is a transmembrane protein with a molecular weight of about 150 kDa, forms homotrimers stand out in the viral surface. S protein facilitates the binding of envelope viruses to Angiotensin-Converting Enzyme 2 (ACE-2) receptors in lower respiratory tract cells. S protein consist of 2 part, S1 and S2. S1 is responsible for the determination of the host-virus range and cellular tropism with the receptor-binding domain make-up while S2 functions to mediate virus fusion in transmitting host cells[18,16]

SARS-CoV-2 rapidly is transmitted from human to human pathogen and causes a wide spectrum of clinical manifestations in COVID-19 patients. The major clinical manifestation of

COVID-19 is similar to other human CoV infection. In general, SARS-CoV-2 is associated with high viral loads in upper respiratory tract secretion. COVID-19 is developed into Severe Acute Respiratory Infections and Acute Distress Syndrome especially in elderly, comorbidities, and immunosuppression patient.[19]

Human to human transmission of COVID-19 mainly occurs via respiratory droplets when patients with coughs, sneezes, or talks can infect another person via direct contact with the mucous membranes. The infection can also occur if a person touches an infected surface and then touches their eye, nose, or mouth. The droplet does not travel that 2 meters and not linger than 3 hours in the air.[20]

Based on the presence of clinical features, COVID-19 is divided into 2 groups such as asymptomatic and symptomatic infection. Asymptomatic COVID-19 infection shows positive SARS-CoV-2 nucleic acid testing of the pharyngeal swab samples but does not show the clinical feature until the first day of continuous negative tests (1-21 days). Only 20.8% asymptomatic cases develop into symptoms cases during hospitalization such as fever, cough, fatigue and etc, 50% cases showed typical CT images of the ground-glass chest, and five (20.8%) presented stripe shadowing in the lungs. The remaining 29.2% cases showed a normal CT image and had no symptoms during hospitalization (young patient estimated 14 years). However, no one cases develop into severe COVID-19 pneumonia or died. Asymptomatic carrier patient has the potential to transmit the disease to others. This study also shows that Asymptomatic COVID-19 carrier can transmit the virus into his family that develops to Severe COVID-19 pneumonia.[21]

According to some studies, an incubation period of COVID-19 is 5 – 14 days following exposure and cause the respiratory and systemic disorder.[13] The spectrum of symptomatic COVID-19 infection ranges from mild to critical. The mild stage is signed with high fever, dry cough, headache, fatigue, sputum production, lymphopenia, and diarrhea. COVID-19 infection cause cough (days 1 – 14), chills (days 1 – 9), high fever (days 7 – 9), fatigue (days 9 – 14), and shortness of breath (days 9-14). The severe stage is signed with dyspnea and hypoxia. The pathological finding of COVID-19 associated with acute respiratory disruption syndrome. The critical disease is signed with respiratory failure, shock, or multi-organ dysfunction. COVID-19 infection causes acute respiratory distress syndrome (ARDS) until death.[6]

The infection show laboratory features such as lymphopenia and elevated some molecules (liver enzymes, lactate dehydrogenase, elevated inflammatory markers, D-dimer, prothrombin time, troponin, creatine phosphokinase, and acute kidney injury. The laboratory testing shows positive in Viral RNA PCR testing and Immunoglobulin M (IgM), and there is ground-glass chest, stripe shadowing in the lungs in CT Scan, and pneumonia in x-ray test.[22,23]

COVID-19 is a positive-sense single-stranded RNA (ssRNA) that entry to the patient via respiratory droplets when patients with coughs, sneezes, or talks can infect another person via direct contact with the mucous membranes and touching the infected surface the body (eye, nose or mouth).

COVID-19 S protein (envelope spike glycoprotein) will bind to ACE2 for SARS-CoV,[19] ACE2 SARS-CoV-2,[24] CD209L (a C lectin or called L-SIGN) for SARS-CoV,[25] DPP4 for MERS-CoV[26] then occur fusion between the viral cell membrane and the target cell.[27] Proteolytic cleavage occurs in S SARS-CoV protein in position (S2') mediated by membrane fusion and virus infectivity.[28] MERS-CoV has also evolved through the activation of two abnormal steps for furin membrane fusion.[29] In addition to membrane fusion, clathrin-dependent and clathrin-independent endocytosis also mediate the process of SARS-CoV virus entry into cells.[30,31]

After that viral RNA enters the cytoplasm of cells in the form of polyproteins and structural proteins which then replicates into new viral RNA. The cell will then be controlled by the structural protein SARS-CoV to form an envelope protein that will be inserted into the endoplasmic reticulum (ER) and Golgi apparatus while the nucleocapsid is formed by a combination of viral RNA genomes and nucleocapsid proteins. In the end, the virus particles will be brought to endoplasmic reticulum-Golgi intermediate compartment (ERGIC) for maturation and will then be removed by ERGIC with vesicles containing infectious viruses

through vesicle vesicles which will docking with membranes so that the virus will be released again and ready to infect other healthy cells.[19]

Viral antigen entry stimulates an immune response. COVID-19 viral antigen will be presented to the antigen-presenting cell (APC). The antigenic peptide will be presented by MHC (human leukocyte antigen or HLA in humans) to the specific cytotoxic T lymphocyte virus. MHC Class I played the most role in this Ag COVID-19 presentation, although MHC class II also played a role.[8] The COVID-19 presentation antigen was not fully understood but can be associated with antigen presentation on SARS-CoV or MERS-CoV. Certain HLA polymorphisms have a risk of being susceptible to SARS-CoV infection, namely HLA-B * 4601, HLA-B * 0703, HLA-DR B1 * 1202[9] and HLA-Cw * 0801,[10] while HLA-DR0301, HLA-Cw 1502 and HLA-A * 0201 has protection against SARS infection.[11] MHC class II molecules cause susceptibility to MERS-CoV infection,[13] such as HLA-DRB1 * 11: 01 and HLA-DQB1 * 02: 0. In addition, the Mannose Binding Lectine (MBL) gene polymorphism associated with antigen presentation is associated with susceptibility to SARS-CoV infection.[14]

SARS-CoV-2 stimulate innate and adaptive immune responses. SARS-CoV-2 leads to infection of ACE2 expressing target cells such as alveolar type 2 cells or other cell in lung. SARS-CoV-2 causes an increase in total neutrophils, reduces total lymphocytes, increases serum IL-6, and increases C-reactive protein. Increased neutrophils and decreased lymphocytes also correlate with disease severity and death. COVID-19 has higher plasma levels of many pro inflammatory cytokines, IP-10, MCP-1, MIP-1A, and TNFα.2 that show highly pro-inflammatory conditions in the disease progression and severity. Activation of neutrophil as Antigen Presenting Cell (APC) increase Th1/Th17 expression. Th1/Th17 is induced adaptive response by increase specific antibodies production. Viral antigen may decrease antiviral IFN responses resulting in uncontrolled viral replication whereas IFN is effective innate immune response against viral infection and induce effective adaptive immune response. Type I IFN suppression and hyper pro-inflammatory cytokine production be the basis of viral infection treatment including SARS-CoV infection.[15]

In adaptive immune response, COVID-19 viral antigen will stimulate humoral and cell mediated immunity by B cells and T cells. B cells will form IgM and IgG anti SARS-CoV. IgM will disappear on the 12th day while IgG will last a long time in the body which will function as a protector against infection with the same virus strain.[16] IgG anti SARS-CoV is S-specific and N-specific.[19] In general, Th1 plays a dominant role in an adaptive immunity against to viral infections. Specific Th1/Th17 may be activated and contributes to exacerbate inflammatory responses. B cells/plasma cells produce SARS-CoV-2 specific antibodies that may help neutralize viruses. In previous study showed the peak of specific IgM at day 9 after disease onset and the switching to IgG by week 2. Whether the titer of specific antibody correlates with disease severity remains to be investigated.[15]

In cellular immune response, the number of $CD4^+$ and $CD8^+$ cellular immunity in peripheral blood will drop significantly in SARS-CoV-2 infection.[17] Patients recovering from SARS-CoV will have $CD4^+$ and $CD8^+$ memory T cells that last for 4 years so that when there is repeated viral exposure the body will be able to produce IFN-4.[32] In some patients the specific T cell memory of SARS-CoV can still be identified.[12] CD8 + T cells specific to MERS CoV are also found in mice that are infected with the virus.[12] In general, CD8+ T cell responses are more frequent with greater magnitude than CD4+ T cell responses in SARS Coronavirus. Strong T cell responses correlated significantly with higher neutralizing antibody while more serum Th2 cytokines (IL-4, IL-5, IL-10). In MERS-CoV infection, early rise of CD8+ T cells correlates with disease severity and at the convalescent phase, dominant Th1 type helper T cells are observed. In an animal model, airway memory CD4+ T cells specific for conserved epitope are protective against lethal challenge and can cross react with SARS-CoV and MERS-CoV. Th1 type and CD8+ T cell are keys for successful control of SARS-CoV and MERS-CoV and probably true for SARS-CoV-2 as well to suppress lung pathogenesis.[15]

The leading cause of death in COVID-19 infection is Acute Respiratory Distress Syndrome (ARDS) and multi-organ dysfunction. ARDS is the leading cause of death. This ARDS is an immuno-pathological event from SARS-Cov-2, SARS-CoV and MERS-CoV infections.[16] More patients also developed lymphopenia and pneumonia with characteristic pulmonary ground

glass opacity changes on chest CT. COVID-19 infection also show cytokine storm. Cytokine storm is inflammation that cannot be controlled and is very deadly due to the body's response due to the large production of inflammatory cytokines such as (IFN-α, IFN-γ, IL-1β, IL-6, IL-12 , IL-18, IL-33, TNF-α, TGF-β etc.), as well as some chemokines such as (CCL2, CCL3, CCL5, CXCL8, CXCL9, CXCL10 etc) produced by several immune effector cells produced by SARS-CoV infection.[33,34,35] For example in patients with severe MERS-CoV infection, an increase in the production of cytokines IL-6, IFN-α, CCL5, CCL8 and CXCL-10 in their serum compared with patients who have mild to moderate symptoms.[36] The production of pro-inflammatory cytokines mentioned above causes the patient's body to experience ARDS which can cause multiple organ failure (MOF) and ARDS until death. The presence of lymphopenia and cytokine storm may important role in COVID-19 pathogenesis. The Cytokine storm can initiate viral sepsis and inflammatory-induced lung injury which lead to other complications including pneumonitis, ARDS, respiratory failure, shock, multi-organ failure and potentially death.[17]

SARS-CoV and MERS-CoV use various strategies in order to survive against host immunity. Microbes have pathogen-associated molecular patterns (PAMPs) that can be recognized by pattern recognition receptors (PRRs). SARS-CoV and MERS-CoV can induce the production of double membrane vesicles containing little PRRs and can replicate in these vesicles, so that SARS-CoV dsRNA can avoid detection of the host immune system.[37] Hosts can produce IFN-α and IFN-β which can protect the effects of SARS-CoV infection.[38,39] Another corona virus, MERS-CoV, has a protein accessory molecule 4a that can inhibit MDA5 activation to induce IFN production by interacting directly with dsRNA.[40] MERS-CoV also has ORF4a, ORF4b, ORF5 and viral protein membranes that can inhibit the transport of IFN regulatory factor 3 (IRF3) and inhibit the activation of IFN-β promoters.[41] MERS CoV can also hold genes that play a role in the presentation of Ag viruses.[42]

4. CONCLUSION

Specific studies on the immune response to SARS-CoV-2 are still developing. Various study approaches can be carried out by looking at the clinical manifestations that emerge, the results of examinations and literature review from their predecessors, namely SARS-CoV and MERS-CoV. So far, it can be concluded that molecular studies related to SARS-CoV-2 immunopathology states that SARS-CoV-2 increases pro-inflammatory cytokine production, suppresses IFN, increases neutrophil count, increases Th1/Th17 expression, B cell response, and CD8+ and CD4+ responses. Cytokine storms are known to be a trigger for serious respiratory problems and multi-organ damage that can cause death.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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