



Interaction of Inflammatory Molecules in Tuberculosis and Sars-Cov-2 Infection

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Abstract

Hyper-inflammatory immune response is a chief reason for disease severity and mortality in patients. Generally, macrophages and dendritic cells sense and react to microbial or viral invasion by making inflammatory molecules that remove pathogens and help in tissue repair. During tuberculosis infection, alveolar macrophages activate alveolar dendritic cells, which move to lymph nodes. In lymph nodes, the proliferation of CD4⁺ T cells, CD8⁺ cells and $\gamma\delta$ T cells occur. *Mycobacterium tuberculosis* (MTB) bacteria further modify the host's immune system for their long survival period. Meanwhile, Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infects alveolar macrophages and releases inflammatory cytokine to produce and activate T-cells. MTB and SARS-CoV-2 infections together lead to an increase in the rate of pathogenesis. This type of co-infection in macrophages causes the production of pro- and anti-inflammatory cytokines, which further play an important role in immune-pathogenesis. However, the abnormal or dysregulated response of macrophages leads to harmful effects of the host, as observed in the macrophage activation syndrome induced by severe infections, including the virus SARS-CoV-2. Unlike macrophages, dendritic cells (DCs) act as antigen presenting cells. They connect innate and adaptive immunity cells. They are susceptible to cytokine-mediated activation and lead to cytokine production. The cytokine Interleukin-6 (IL-6) is an important and unique molecule that can act pro- as well as anti-inflammatory and helps in the development and differentiation of macrophages associated with numerous inflammatory diseases. In this review paper, we have emphasized the vital pathological role of macrophages, dendritic cells and IL-6 in tuberculosis and SARS-CoV-2 infection and prospective therapeutic strategies based upon IL-6 as the main target for preventing the cytokine storm and associated organ failure.

Keywords: SARS-CoV-2; COVID-19; Tuberculosis; Macrophages; Dendritic Cells; Interleukin-6

Abbreviations: MTB: Mycobacterium Tuberculosis; WHO: World Health Organization; TB: Tuberculosis; MDR: Multidrug-Resistant; XDR: Extensively Drug-Resistant; EPTB: Extra-Pulmonary Tuberculosis; PTB: Pulmonary

Tuberculosis; ORFs: Open Reading Frames; NSPs: Non-structural Proteins; PAMPs: Pathogen-Associated Molecular Patterns; AEC: Airway Epithelial Cells; NK: Natural Killer Cells; ROS: Reactive Oxygen Species.

Introduction

Tuberculosis (TB) is already present as a pandemic over many years. World Health Organization (WHO) declared it as a global health emergency in 1993 [1]. Tuberculosis is among the top 10 causes of death worldwide because of the single infectious agent *Mycobacterium tuberculosis*. Annually, millions of people continue to fall sick with TB. Around 10 million people were affected by this disease in 2020, and 1.6 million died worldwide [2]. Out of 10 million new cases, 2.74 million cases were from India alone, making it the highest TB burdened country. India accounts for more than 27% of total global incidence, the highest among the top 30 high TB burdened countries globally. Despite numerous TB elimination programs, around one-fourth of total global cases have been reported from India alone [2].

Recently, Coronavirus (COVID-19) has emerged as a highly destructive disease prevalent worldwide. It was first reported from Wuhan City of Hubei Province of China in December 2019 [3]. The causative agent responsible for COVID-19 is a virus named Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), a member of the Coronaviridae family, which also includes Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV) and the Middle East Respiratory Syndrome Coronavirus (MERS-CoV) [4]. The WHO has declared COVID-19 as a pandemic on March 11, 2020. It is the most damaging disease in recent history. Old age people are more susceptible to this disease due to their weakened immune system in terms of adaptive immunity. There have been 274,555,585 confirmed cases of COVID-19 and 5,367,175 deaths reported (as of December 19, 2021). A total of 8,337,664,456 vaccine doses have been given globally (as of December 15, 2021). India reported its first case on January 30, 2020. Since then, there have been 34,740,275 confirmed cases of COVID-19 with 477,422 deaths and a total of 1,294,608,045 vaccine doses have been given (as of December 6, 2021) [2].

General Description of Tuberculosis and Covid-19

Tuberculosis and COVID-19 share common immunopathology [5]. Even though COVID-19 and TB are quite similar in some aspects, some differences are also present. For example, their causative agents are different, but they show similar symptoms like fever, cough, breathlessness and weakness with varying severity in both cases [6]. Both are contagious and infectious diseases transmitted from one individual to another through aerosol or close contacts and mainly affect the lungs. TB is transmitted through droplet nuclei of aerosols transferred by an infected person with MTB. After inhalation of MTB, the contaminated aerosol host becomes infected. Depending upon the host, bacterial

and environmental factors, MTB infection may lead to the development of active TB in the form of pulmonary TB (PTB) or extra-pulmonary TB (EPTB). However, the incubation period of TB is longer with the slow onset of the disease. Depending upon drug resistance, active TB can also advance to multidrug-resistant (MDR) or extensively drug-resistant (XDR) TB forms causing additional threats to mankind. It has been observed that among MTB infected patients, about 10% lead towards active TB disease and roughly 90% of infected individuals maintain latent TB infection [7,8]. The vulnerability of those 10% individuals to TB mainly depends upon complex associations between MTB and the host immune system [9]. After going through the current situation of TB, the theme of world TB day 2021 is “the clock is ticking”, which means the COVID-19 pandemic has delayed the curing progress rate of TB. So this dreadful situation has to be overcome by effective and preventive measures.

On the other side, SARS-CoV-2 can transmit disease mainly through droplets and fomites but can also be through aerosols, and it also spreads through surface contamination [10]. Symptoms may appear 2-14 days after exposure, with a median incubation period of 5 days and latent period is not present in COVID-19. An infected person with SARS-CoV-2 can further transmit the infection to persons in close contact with each other, but an infected TB person can infect further 1-4 individuals. Risk factors responsible for them are the same such as advanced age, diabetes, smoking, chronic kidney disease, chronic respiratory disorders and immune-compromised state. If treatment of TB is disrupted in any case, it leads to poorer treatment outcomes and chances of COVID-19 disease severity also increase [11]. Although research is going on to find an association between these two comorbidities, full-proof data is not available to tell whether active or previously treated TB can enhance the severity of COVID-19 or not. However, the various epidemiological studies are also going on a large scale to find out the association between TB and COVID-19 [12].

Structural and Genomic Organization of Sars-Cov-2 (Coronavirus)

Coronaviruses are single stranded RNA viruses. The genome size ranges between 26-32kb and includes 6-11 open reading frames (ORFs) that encode 9680 amino acid polyproteins. The first ORF contains 16 non-structural proteins (nsps), while the remaining ORFs encode structural and accessory proteins. Four major structural proteins include spike surface glycoprotein (S), membrane, nucleocapsid protein (N) and envelope. The characteristic feature of coronaviruses is the presence of spike glycoprotein that comes out from the surface of the virion. It is a 1200 long amino-acid sequence of S-protein, belongs to class-I viral fusion proteins, and involves angiotensin-converting

enzyme 2 (ACE 2). SARS-CoV-2 target cells by attaching to ACE 2. Whenever S-protein binds to ACE2 for entry, it is primed by transmembrane protease serine 2 (TMPRSS2), an endothelial cell surface protein. ACE 2 is expressed in lungs, alveolar type 2 pneumocytes, and macrophages.

Immune Host Responses in Tb and Covid-19

With respect to host immune response, macrophages and dendritic cells (DCs) provide the first line of defence by their recruitment at the very first site of infection and have multiple roles in the innate immune system. They can phagocytose bacteria and viruses to initiate and trigger an immune response [13]. They interact with bacteria and viruses by employing various cell surfaces and nuclear receptors. Interactions of bacterial pathogen-associated molecular patterns (PAMPs) with these host-cell receptors result in bacteria uptake and entanglement in the phagosomes of macrophage and DCs [14-18]. Based on several pieces of evidence, it has been confirmed that people affected with COVID-19 could lead to cytokine storm syndrome where there is an increase in inflammatory [19,20]. This syndrome causes lung damage or injury in severely ill-defined COVID-19 patients. During SARS-CoV-2 infection, there is the secretion of IL-6 in macrophages induces apoptosis in lymphocytes. Along with IL-6 other inflammatory cytokines such as IL-12, IL-8, TGF- β , TNF- α , IL-1 β , IFN- γ and various chemokine's such as CCL2, CXCL10 and CXCL9 is associated with macrophage activation syndrome and adult respiratory distress syndrome [21]. It has been observed that there is a decrease in T-cells in severe cases and an increase in neutrophil and monocyte-lymphocyte ratio [22].

Role of Innate Immune Response in MTB Infection

Innate immunity plays a crucial role in fighting against MTB. A study has revealed that disturbance in the structure of the innate axis causes lethal clinical awareness or presentation of TB [23]. Airway epithelial cells (AEC), macrophages, natural killer cells (NK), neutrophils, dendritic cells (DCs), mast cells and the complement system are the vital performer of immunity tasks. When breathing in, MTB comes across through the first line of defence comprising air route epithelial cells (AECs), neutrophils, monocytes, and dendritic cells [7,24]. If it succeeds in abolishing MTB rapidly, the infection terminates. Otherwise, phagocytes get infected, and MTB proliferate inside the cells, then they initially cause clinical indications and progression of disease depending on the complex relationship between bacterial and host factors [25]. Besides host factors, virulent form of bacteria plays a major role in evaluating the risk of TB infection. Virulence is unrestricted to bacterial strain or bacterial burden in the respiratory tract; differential MTB gene expression has been

considered in the different phases of infection. MTB deficit virulence factors and its ability which protect it from host immunity depend on altered lipid metabolism, protease, metal-transporter, proteins, and proteins inhibiting macrophages, which are antibacterial [26].

The Prominent Role of Macrophages in MTB Infection

Macrophages are innate immune cells that are the part of first line of defense. Still, they are only capable of this if the ratio of cells and invading microbes favour the situation, i.e. if the number of cells is greater than a load of microbes, they can prevent the infection [27]. Otherwise, they promote pathogenesis because the gradual proliferation of the MTB carried out as macrophages serve as the initial niche for microbes. During the latent phase of infection, the number increase to hundreds inside the phagosomes. Different categories of death-related factors that resist macrophages attempts in suppressing the pathogen expressed by MTB. Various activities inhibited by MTB in the host are apoptosis, autophagy, intracellular trafficking, reactive oxygen species (ROS) and toxic metal [28]. Macrophages have IFN- γ as the main player to restrict MTB, which is controlled by vitamin D to perform its functions [29].

Variety of genes like hCAP-18 encodes cathelicidiniscationic antibacterial peptide, which stimulates gene transcription related to autophagy. Credit for this phenomenon goes to vitamin D, which enhances macrophage maturation [30]. With the help of early secretory antigenic target (ESAT-6) protein secretion (ESX), MTB can escape from the immune system by exporting anti-immunogenic transport protein. IFN- γ axis is disturbed by secretion of ESX-system, due to which IFN- γ makes so much effort to promote the phagolysosomal activity so that they can tackle with MTB. MTB proliferation occurs in the lack of vitamin D [31]. The role of Nitric oxide (NO) in humans is comparatively low with respect to animal models in macrophages [28].

Reactive oxygen species (ROS) production on the phagosome membrane is regulated by the catalytic activity of nicotinamide adenine dinucleotide phosphate (NADPH-oxidase 2). Mutation in the catalytic subunit of NADPH-oxidase 2 has been seen in TB susceptible patients, showing impaired ROS production [32,33]. MTB controls the NADPH-oxidase component and its tasks by interacting with small guanosinetriphosphatases (GTPases) through nucleoside diphosphate kinase (Npk) [34]. There is a battleground in macrophages for the MTB to sort metals and cells [35]. The macrophages recruit an inaccurate load of zinc and copper; their high concentrations are poisonous to MTB. MTB displays protective signalling processes that counteract such

situations like an inappropriate load of metals and oxidation; up-regulation of cation-transporting P-type ATPase (ctpC) gene restricts metal poisoning [35,36]. To counterbalance this, macrophages put efforts to prevent the entry of metal nutrients to the MTB. These nutrients are manganese and iron [35].

The Link between Covid-19 and Macrophages

There are different strategies used by immune cells to combat the virus after its entry through viral membrane protein through Fc gamma receptors present on activated immunocytes like macrophages, neutrophils, monocytes and natural killer cells. This leads to the release of perforins and granzymes containing granules which kill the infected cells. This phenomenon is considered to be ADCC which is efficient participation of immune response towards different viruses and various studies examined during RSV infection and during anti-RSV vaccine designing. Antibodies that are formed against SARS coronavirus show a two-edged result on the progression of infection and characterize both favourable and objectionable events through the assistance of immune system mechanisms, including NK cells facilitated by antibody-dependent cell cytotoxicity mechanism and macrophages, specifically alveolar macrophages by Fc gamma receptor (FcγRs) containing cells, monocytes-derived infiltrating macrophages, monocytes, and complement-antibody complex pathways. Phagocytic cells through SARS-CoV specific show a major role in the clearance of virus-infected pulmonary cells by antibodies alveolar macrophages and monocyte-derived infiltrating macrophage. Tissue-damaging and immunopathological complications may cause due to extreme Fc mediated phenomenon while eliminating infected cells.

Antibody-dependent enhancement (ADE) happens when antiviral antibodies cannot neutralize the virus. ADE cause increases the infection of cells that have FCR through the interactions between kinds of receptors and the virus-antibody immune complex [19]. The exciting fact is that ADE may be tempted by both non-neutralizing and neutralizing antibodies. Studies reveal that ADE might arise during viral infections with Zika, Ebola, dengue, influenza, and HIV [19]. Few disorders are the results of novel coronavirus disease. Studies showed that the severity of disease caused by passive approaches after production of antibodies due to the prior immunity. It has been described in various studies that macrophages have a significant role in the escalating immunopathogenesis of SARS-CoV-2 by enhancing ADE owing to their FCR. It has been projected that alveolar macrophages might participate in worsening COVID-19 through facilitating ADE by FcγRIIA(CD32A) high level. The production of inflammatory cytokines induced by IgG

binding to the FcγRIIA. Surprisingly a rise in the number of macrophages by replication in antibodies against SARS-CoV-2 has been seen under in vitro conditions.

Macrophages are crucial infectious innate immune cells against any infectious agent [37,38]. They are extremely versatile innate cells that can act differentially in function and morphologically to evade pathogenic organisms, cancerous cells, virus-infected cells, and other macrophages that help heal and parasite infections [39,40]. A balanced immune system is required to activate both kinds of macrophages, M1 and M2, through complex and diverse innate cells [41,42]. During ageing and chronic inflammatory diseases, macrophages may shift to a more M2-like phenotype [43,44]. Importantly, nearly all identified high-risk factors for severe COVID19 disease, like cardiovascular disease, diabetes, age, chronic obstructive pulmonary disease, and smoking, generally share a shift from more M1 to more M2 phenotype and function [45]. Classical activation of M1 macrophages is induced by LPS/IFN-γ exposure, while alternately activated M2 macrophages are stimulated by IL-4, IL-10, IL-13 and glucocorticoids [46]. The activation of innate immune cells such as macrophages can be heavily influenced by the character of the T cell response and, in particular, the cytokines produced by T cells during infection [47]. SARS-CoV replication has previously been shown in human peripheral monocytes and macrophages, with varying efficacy. Importantly, the infection efficiency was shown to be donor-dependent, with 100% infection in some and less than 5% in others [48].

During vaccination to rhesus macaques with SARS-CoV-2 vaccine, which is constructed keeping in view anti-S IgG, it is discovered that there is crucial relation between SARS-CoV-2 development of severity of disease, immune response and release of antibodies against it. It is found that vaccine before clearing the viral load results in acute lung injury via staffing of pro-inflammatory alveolar macrophages. They lead to the production of a huge amount of MCP-1 and IL-8 chemokines, which cause swelling [49,50]. Numerous studies confirmed similar outcomes in which lung damage was worse in mice and African green monkeys after SARS coronavirus vaccination [51,52]. A similar provocative response outline has been observed in several phases of COVID-19 cases.

Immune Response of Il-6 in Covid-19

Human IL-6 consists of 212 amino acids, counting a 28-amino-acid signal peptide, and its gene is present on chromosome 7p21. Although the central protein is ~20 kDa, natural IL-6 is 21–26kDa. The cytokine IL-6 is a unique molecule that can act as pro as well as anti-inflammatory. IL-6 may be harmful in mycobacterial infections, as it inhibits the production of TNF-α and promotes in vitro growth of *M.*

avium. The production of anti-inflammatory cytokines help to regulate this inflammatory process; nevertheless, this can give a chance to MTB for its growth in host tissue. It can be speculated that genetically determined high and low production of cytokines may render an individual vulnerable or resistant to MTB infection depending upon the nature of cytokines. Other reports support a protective role for IL-6; IL-6-deficient mice display increased susceptibility to infection with MTB which seems related to a deficient production of IFN- γ early in the infection before adaptive T-cell immunity has fully developed. IL-6 has shown a peculiar association with TB, where it can render the host susceptible to TB as it interferes with TNF- α production. Its deficiency has also been reported to be making mouse models vulnerable to MTB infection. IL-6 is needed for optimal T-cell development. Indeed, high levels of IL-6 cytokine are produced in response to MTB infection [53], and its role seems especially critical when the bacterial burden is high.

Macrophages and monocytes produce other inflammatory phenomena during Covid-19, known as cytokine storm, which is known by cytokine release syndrome (CRS) and hyper-cytokemia, which are extremely stimulated due to infectious or non-infectious agents and produce a decent number of cytokines that participate in hyper inflammation through prompting and enrolling of leucocytes [54-58].

Cytokine storm has chief participation in the severity of Covid-19 and lung damage in the diseased patients [59,60]. Series of cytokines released during the event, which include IL-17, IL-9, IL-7, β IL-2, IL-1, IL-10, TNF- α , G-CSF, GM-CSF, IFN- γ , MIP1A, MCP1, MIP1B, CXCL8 and CXCL10 in the recently found new corona virus-diseased individuals which can lead to the immunopathological development of COVID-19. CRS is closely connected with macrophage activation syndrome (MAS), characterized by several clinical indications such as liver failure, hyperferritinemia, pancytopenia, neurological disorders and coagulopathy. Excessive production of differentiated macrophages leads to MAS, resulting in various clinical manifestations like hypercytokinemia and hemophagocytosis [61,62].

Association of IL-6 with Covid-19

The harshness of the disease Covid-19 is connected with the elevated levels of chemokines and cytokines, which are pro-inflammatory in nature. These include IL-7, IL-10, IL-2, IL-6, TNF (tumour necrosis factor), MCP1 (monocyte chemoattractant protein-1), G-CSF (granulocyte colony-stimulating factor), CXCL10 (CXC-chemokine ligand) [63-69]. Studies suggested that IL-6 is vastly correlated with COVID-19 severity above all cytokines, comparable IL-6 levels in the blood noticed between COVID-19 fighters and non-survivors [70]. It is one of the causes of disease mortality

due to cytokine release syndrome (CRS), also known as cytokine storm [21,71]. Cytokine storm is an exciting link in COVID-19 infectious individuals. It is found that patients with the disease severity have high IL-6 levels and show hyperactive inflammatory immune response, which causes pulmonary inflammation, lung injury, and multiple organ failure, leading to the death of the patient [72]. A recent study disclosed that elevated levels of pro-inflammatory mediator cytokines in serum such as IL6, IL1 β , IFN γ , IL12, IP10 and MCP1 were associated with clinical lung manifestation in SARS patients. These were found in severe covid patients who are responsible for the cause of immune cell response of activated T-helper-1 (Th1) [73-75]. IL-6 is a key cytokine that helps develop and differentiate macrophages and is associated with numerous inflammatory diseases. Moreover, SARS-CoV-2 diseased people had minute levels of suppressor of cytokine signaling-3 and low count of CD8+ and CD4, which controls negative feedback mechanism of IL-6 and TNF [76,77]. In addition, new studies presented that higher IL-6, IL-10 and CRP levels were weightier than other cytokines in the critical group of COVID-19 infected individuals' patients [78].

Role of Dendritic Cells in MTB Infection

Dendritic cells (DCs) operationally active one of the main cells are connecting, innate and adaptive immune retaliation via a distinctive role in arresting, operating and antigen presenting to T cells in the context of both MHC class I and II. Macrophages get activated by T cells, secrete tumour necrosis factor (TNF) and interferon (IFN-gamma) to kill or eliminate micro-bacterium [79]; besides this, macrophages play significant participation in mobilizing of cells by releasing pro-inflammatory cytokines IL-6 and IL-1 at the area of disease or infection caused by bacterial invasion [53]. These cytokines have potential activity on the lymphocytes cluster of differentiation (CD4) [80]. DCs have controversial status in controlling the TB disease. Few studies reveal whether these cells nourish the immunity against MTB or sometimes MTB modulate their action, decreasing T-cells' function. Quickly DCs act as a niche or reservoir for MTB [81].

CD209 provides a specific route to MTB by binding with 3-grabbing non-integrin receptor (DC-SIGN) inside the DCs and act as a specific intercellular adhesion molecule [81]. Under normal internal eco-friendly conditions, CD209 serve as a receptor for CD54 and favours DC movements in the cell. By coupling with the lipoarabinomannan mannose (ManLAM), a component of MTB membrane, CD209 allow its penetration into the cell, which enhances IL-10 secretion and reduce IL-12 production, which leads to alternation of DCs activity, disguise the pathogen and disturbed stimulating phenomenon that represents antigen by T lymphocytes [82,83]. MTB gets benefitted from this

and grows rapidly [84]. Vaccination strategy against MTB uses DC-SIGN mechanism as a potential target to promote immunity. It also balances inflammatory status by releasing IL-12 in the host and protecting it from infection and tissue pathogenesis [85,86]. Some studies have reported the fate of DCs maturation, which depends on the type of receptors during recognition. Interactions of MTB with TLR result in DC activation characterized by high IL-12 secretion during early infections. On the other hand, interactions with DCSIGN prevent DC activation by blocking TNF- κ B activation, resulting in increased secretion of IL-10 [87].

Dendritic Cells in Covid-19

Dendritic cells are widely distributed in the respiratory tract, and various pathogens attack them. DCs act like antigen presenting cells having a role in antiviral immune responses and have a role in SARS-COV infection [10,88,89]. DCs mainly express ACE2 on their receptors and lead to SARS-COV infection. These cells played an important role in the pathogenesis of SARS. There is a significant increase in the production of RANTES and their specific receptors such as CCR-1, CCR-3 and CCR-5 mRNA in DCs infected with SARS-COV. When there is high production of RANTES, it leads to the death of SARS patients. More studies relevant to this topic are required to reduce RANTES production [90]. Another factor is there, which is known as TRAIL gene expression in adult and cord blood DCs after SARS-COV infection. It leads to destroyer DCs gene expression. So based on this study, further gene expression studies are required to combat increased TRAIL gene expression in DCs to reduce the risk of lymphopaenia. Due to various complex mechanisms, the development and function of DCs need to be revealed further.

During SARS-CoV-2 infection, DC cells increase DC-SIGN and furin expressions, which ultimately further cause a high rate of infection [91]. Advanced age can also negatively impact DCs number [92]. So both factors, i.e. SARS-CoV infection and the ageing process, promote dendritic cell dysfunction or death, which causes high viral infection load, cytokine release syndrome, and sepsis [93]. The diseased state of DCs in the form of dysfunction and death may be responsible for a bad outcome in COVID-19 disease leading to more complications and deaths [94,95]. Patients already affected with COVID-19 lead to viral sepsis, and there is a decrease in the number of dendritic cells; moreover, the body's functional impairment is also there [20,96]. In view of this, deep knowledge and a better understanding of the immune functions mediated by DCs should be essential to combat the adverse effects of dendritic cell-mediated treatment and vaccines.

Nowadays, many drugs emerge as therapeutic agents for COVID-19 [97,98]. The names of drugs are remdesivir, hydroxychloroquine, chloroquine, azithromycin, lopinavir

and ritonavir. Dendritic cell-based vaccines are also widely used to cure tumours and pathogens. Vaccines for SARS-CoV-2 infection based on DC are under clinical trial and development for future use [99]. Although, new antiviral vaccines are now available for the treatment of this disease, such as COVAXIN and COVSHIELD, which are quite effective against it.

Role of BCG Vaccine in Covid-19

There is some evidence showing that people who have latent TB infection could lead to severe SARS-CoV-2 infection [100]. Patients with COVID-19 disease could lead to a worse infection if left untreated because they were previously also infected with TB disease, in which their lung is more affected [10,101-107]. As we all know, the Bacillus Calmette-Guerin (BCG) vaccine is useful in TB disease. BCG vaccination protects newborns and infants from pulmonary TB [109-111]. It also protects against other infectious diseases, so it is proposed that BCG vaccination could also provide immunity against COVID-19 disease. In many countries where continuous use of BCG vaccine in neonates was given in that case, the rate of reported cases of COVID-19 infections was less in number. Due to lack of proper evidence, BCG is not recommended to prevent COVID-19. Some epidemiological studies show an association between the BCG vaccine and COVID-19 also irrespective of TB disease. But these studies are not sufficient to establish causality between BCG vaccination and protection from severe COVID-19 [10].

Conclusion

The present situation is very harmful due to the ongoing pandemic of COVID-19, which is causing devastating health-related issues directly linked to our immune system. We should take proper safety care measures to stop the transmission of this disease. We should always keep in mind that "Prevention is the key to success" and rebuild our medical tools to tackle this pandemic situation for combating this menace of disease. Macrophages and dendritic cells are crucial immune cells with a broad range of defensive phenomenon against numerous micro-pathogenic agents such as bacteria and viruses. In life-threatening emergencies like COVID-19, these macrophages induce pathogenic activities like elevating inflammatory cytokines and chemokines and excessive interaction with the immune cells, which cause severe tissue damage and disease severity.

The immune system's response in relation to macrophages, dendritic cells, and IL-6 has to be determined. Proper monitoring should be done on patients with COVID-19 disease. During the treatment of patients, the higher levels of IL-6 should be regularly monitored. IL-6 may be the new earmark for the effective treatment of COVID-19.

We all know that this disease mainly causes pulmonary and extra-pulmonary organ damage associated with cytokine storms. So an effective therapeutic drug should be designed via targeting IL-6 against COVID-19 disease.

Conflict of Interest

The authors declare no conflict of interest.

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