

The impact of COVID-19 on human body

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Abstract. The SARS-CoV-2 virus has the potential to infect a number of organs and systems to varying degrees. Human immune system will respond to it within few days with symptoms such as the fever, cough and trouble breathing. Despite the fact that COVID-19 is considered as a disease that mostly affects the lungs, it may also have an impact on the kidneys, brain and heart. Many individuals mistakenly think that COVID is a temporary illness. However scientific research has shown that organ damage can result in both of short-term and long-term health issues that can continue for up to six months and have an irreversible impact on the body. However, clinically, the human body is not completely clear about the impact of the disease on the human body, especially after recovery, it will still be harassed by some symptoms. This paper aims to discuss how the coronavirus influences the human body.

Keywords: COVID-19, Impact, Various human systems.

1. Introduction

A brand-new coronavirus that first emerged in Wuhan, China at the end of 2019, afterwards quickly spreaded over the world. COVID-19 has been linked to 6.5 million fatalities and more than 615 million verified cases as of October 2022[1]. The SARS-CoV-2 virus, a positive-strand RNA (+ssRNA) virus. It is zoonotic which is transmitted between different species from humans to other mammals. Successfully, most countries have taken antiviral medications and preventative vaccinations to fight against this pandemic.

When the virus enters the body through the mucous membranes of the nose, mouth, and eyes, it begins to multiply in healthy cells. Symptoms such as fever, dry cough, runny nose and fatigue are common among patients. Some of them also experience digestive problems, including nausea and diarrhoea. However, a few infected individuals could be asymptomatic while still have the ability to infect others. These symptoms usually last for one week. And symptoms are more severe in the elderly but relatively mild in children. This article will discuss the impact of COVID-19 infection and rehabilitation on various human systems, with a view to providing more theoretical basis for understanding the disease.

2. Impact on human body during infection

The SARS-CoV-2 virus can infect various human organs and systems. When coronaviruses enter the body, they must fuse with the lipid membrane of host cell before transmitting their genetic material.

2.1. Respiratory System

It is well known that COVID-19 most affects the respiratory tract especially the lungs. About 80% of patients experience moderate symptoms, including dry cough and sore throat. Some patients may be scanned as “ground-glass opacity” in lungs via chest CT. Other 14% cases are severe; they usually have trouble-breathing because lungs fill with fluid and debris. According to the Centers for Disease Control and Prevention, 3-17% of COVID-19 patients have acute respiratory distress syndrome (ARDS) and cannot breathe regularly due to pulmonary emphysema or ventilation dysfunction.

Both the lower respiratory tract and the upper respiratory tract can be impacted by the novel coronavirus [2]. The presence of the protein angiotensin-converting enzyme 2 (ACE2), which is embedded on cell surfaces, is the primary criterion used by researchers to evaluate if this virus may infect humans. The SARS-CoV-2 entry site ACE2 functions as a receptor that transmits signals into the cell to control blood pressure [3]. The entry into epithelial cells is discovered to be aided by co-factors like transmembrane protease serines 2 (TMPRSS2), neuropilin-1 (NRP-1), CD147, histone protease L, and tyrosine protein kinase receptor UFO (AXL).

The respiratory and digestive systems express the cell surface protein TMPRSS2. When serine acts as the nucleophilic amino acid in the active site, it takes part in the breakage of peptide bonds in proteins. TMPRSS2 can activate the spike protein domain then achieve ACE2 binding on the cell surface. Therefore, the blockage of TMPRSS2 may be a crucial component of COVID-19 treatment.

2.2. Nervous System

Many patients could encounter neurological symptoms. They usually have headaches, muscle pain and loss taste and smell. It has been shown that COVID-19 can even the risk of stroke and dementia. In some cases, severe patients may appear disturbance of consciousness. Noticeably, nearly all neurological effects are more significant in the elderly patients.

Both the central nervous system (CNS) and peripheral nervous system (PNS) are impacted by COVID-19. However, in the majority of individuals with neurological symptoms, the coronavirus is not found in the CNS. To date, human autopsy studies have identified the virus has been found in the cerebrospinal fluid in brain tissues. But the precise process by which it enters the CNS is still unknown [4].

A research team used three distinct methods to examine the ability of SARS-CoV-2 to infect the brain. The virus can infect brain neurons. They discovered that the virus can make adjacent neurons die because of short supply of oxygen. So once the generation of ACE2 in neurons is blocked with antibodies, it will prevent the virus entering the brain. They used mice modelling over-expressing human ACE2, and discovered that SARS-CoV-2 neuroinvasion resulted dramatic changes in the blood vessels, thus disrupting the oxygen supply. They found that CNS infection is more lethal to mice than pulmonary infection. Besides, in autopsies from three patients who passed away from COVID-19, the virus was detected in cortical neurons and there is association between infection and ischemic infarcts in specific brain locations [5].

Besides, in comparison to those who were not infected, COVID-19-infected people (the majority of whom had moderate cases) lost 0.2% to 2% more brain tissue in areas of the brain related to scent. It means that the key docking site for SARS-CoV-2 is absent in the olfactory neurons.

2.3. Digestive System

In the early pandemic, Chinese researchers had discovered that, aside from the respiratory system, the digestive tract was the primary location where SARS-CoV-2 might persist. They suggested that viruses may reproduce actively in the digestive tract. Symptoms like nausea, vomiting, diarrhea, even hemorrhage.

Coronavirus also results in irregular liver function because it infects cells of the bile duct. This can be revealed in blood tests. But the majority of liver injuries are moderate and temporary. And it is more likely for patients with chronic liver disease and cirrhosis to be infected.

According to the most recent statistics, 14.8%-53.1% of COVID-19 patients showed minor elevations in blood bilirubin levels but had irregular levels of the aspartate aminotransferase (AST) and alanine aminotransferase (ALT).

Scientists discovered that the pancreas produced more ACE2 mRNA than the lung did. So, they deduced that SARS-CoV-2 virus can harm the pancreas. By taking research on 121 patients in middle-aged group. The results showed that 1.85% of those with minor cases showed higher than normal levels of amylase and lipase. Amylase and lipase levels were higher in 17.91% and 16.41%, respectively, of individuals with severe COVID-19[6].

However nowadays, most scientists believe the virus particularly infects gastrointestinal (GI) tract in the digestive system through fecal-oral transmission route. According to recent research, about 25.9% of COVID-19 patients experienced gastrointestinal problems. And the most typical symptom is loss of appetite.

The infection can also decrease those pro-biotic microorganisms inside the gut and cause inflammation and diarrhea in the small intestine and colon.

SARS-CoV-2 can enter host cells because ACE2 is widely expressed in the apical membrane of glandular cells of the stomach, duodenum, and rectal epithelium [7]. The neutral sodium-dependent amino acid transporter B0AT1 (SLC6A19) stabilizes ACE2 messenger RNA (mRNA) in the gastrointestinal system. These parts come together to form a quaternary complex called a [ACE2:B0AT1]₂ dimer-of-heterodimer that may control SARS-CoV-2 tropism in the GI tract.

2.4. Cardiovascular System

Cardiac dysfunction may potentially result from SARS-CoV-2 infection. Patients sometimes have symptoms such as palpitations, fatigue and chest pain.

Patients can develop cardiovascular events such as acute myocardial injury, arrhythmia, cardiac insufficiency and coronary atherosclerotic heart disease. Some brain samples from people who died from COVID-19 showed damage to arterioles and capillaries.

According to one analyzed study in China, 187 patients treated in a hospital in Wuhan from in the early 2020, 35% of them revealed cardiovascular problems [8].

Acute cardiac injuries are more common in severe illness and were discovered in 12% of patients hospitalized with an infection to a hospital in Wuhan, China. Of the 41 patients diagnosed with COVID-19, 5 patients developed myocardial injury. They showed an increase in the level of high-sensitivity cardiac troponinI (hs-cTnI) in the blood [9].

ACE2 receptors have a role in cardiac function and are abundantly expressed in the heart. Therefore, these receptors may be connected to acute myocardial damage.

The University of Queensland in Australia has released latest news that SARS-CoV-2 has the direct effect on DNA of the heart, rather than just triggering inflammation by chains of reaction. But the precise mechanism is still unknown.

2.5. Urinary System

Although SARS-CoV-2 can also infect human kidneys, it is unknown if this would result in acute kidney injury (AKI). AKI can affect proximally straight tubular cells and podocytes. Additionally, individuals with COVID-19 may develop gut dysbiosis as a result of acute kidney injury (AKI). Age and individuals with coexisting illnesses increase the risk of AKI (such as hypertension and heart failure).

There is a wide variation in the incidence of renal injury, this may be related to the large differences in the sample size and judging criteria. However, most patients showed an increase in the blood concentrations of urea nitrogen and creatinine [10].

2.6. Blood System

Scientists found that COVID-19 patients have significantly less lymphocytes, neutrophils, eosinophils, and platelets than healthy individuals. Besides, 20% patients showed coagulation abnormalities [9]. While the blood level of inflammatory factors such as monocyte chemoattractant protein-1 (MCP-1), inducible protein 10, gamma interferon, and IL-1B is relatively higher [11]. Above all, it reflects that SARS-CoV-2 infection has certain effect on individual's blood system.

3. Impacts on human body after recovery (post-COVID-19 syndrome)

At the beginning of the pandemic, a lot of people thought COVID-19 was only a short-term illness. Long-term effects, however, could be caused by organ damage brought on by blood clots or a lack of

oxygen [12]. Patients with COVID-19 experience different symptoms. The likelihood that vital organs will be damaged rises as COVID-19 symptoms worsen. Recent studies examined the long-term impacts of COVID-19 on several human organs, particularly lung injury, repercussions on neurocognition, heart damage, and renal failure.

3.1. Short-term Syndrome

3.1.1. Respiratory System

Dyspnea, quick tiredness, and a considerable decline in physical endurance are seen during the recovery phase. A decrease in the capacity to disperse carbon dioxide is frequently seen during diagnostic examinations. Furthermore, pulmonary fibrosis, or the scarring of respiratory tissue, is frequently detected on CT scans. Another research team, Angelo Carfi et al., reported their findings in the August 2020 issue of JAMA. They found that, sixty days following the commencement of COVID-19, 87% of patients were still experiencing symptoms when they were released from Rome hospitals. The most common symptoms were tiredness and dyspnea, and 55% of patients had three or more symptoms, compared to 32% who reported one or two. Fatigue (53%), dyspnea (43%), joint discomfort (27%), and chest pain (22%) are still frequently reported symptoms [12]. Five patients out of ten said their quality of life had declined.

3.1.2. Nervous System

The most frequent sequelae are brain fog and cognitive impairment; the immune system may have overreacted to generate them. The complex of symptoms that are present in Lyme disease, neurosis, Lesnevsky-Crohn illness, chronic fatigue syndrome, fibromyalgia, or celiac disease are commonly referred to as "brain fog" in studies on the long-term effects of COVID-19[15]. General disorientation, forgetfulness, confusion, short-term memory loss, and serious focus and attention issues are a few of these symptoms.

3.1.3. Sensory System

With 33.9% of individuals found to have at least one sort of smell or taste disorder and 18.3% to have both, loss of smell accounted for 40% of infection cases [16]. In a different study, 83% of participants reported loss of scent as their initial symptom, and 2/3 of them were female [17]. These signs persisted for around two months. At least three months following the onset of symptoms, a survey was given to 2696 individuals between the ages of 18 and 55[16]. Olfactory and gustatory abnormalities were the most frequent symptoms of COVID-19 long-acting syndrome, which affected 62.3% of these individuals. 40% of SARS-CoV-2 infections are caused with post-viral olfactory loss, compared to 10-15% of cases in earlier coronavirus outbreaks.

3.1.4. Reproductive System

Recent studies suggest that COVID-19 may have an effect on the health of male reproduction. The ACE2 cell receptor, which is primarily involved in fertility, is the vehicle via which the virus enters host cells. Patients noticed aberrant sex hormone levels, decreased sperm quality, and significant inflammatory lesions in the testes both during and after COVID-19 recovery. The patients had considerably worse overall sperm quality than healthy controls in terms of sperm concentration, total sperm count, and overall mobility when 74 men with a median recovery period of 80 days were investigated. Data on the sperm quality of those who recovered more slowly were worse[14].

3.2. Long-term Syndrome

3.2.1. Cardiovascular System

Additionally, vascular damage and pathological cardiac abnormalities may be seen in COVID-19 patients. According to a German study, heart-related issues like inflammation and scarring were present in 78 out of 100 patients who just recovered [19]. Additionally, 40% of COVID-19 deaths were reported to have heart issues. Myocarditis heart disease is linked to COVID-19, according to the CDC, myocardial injury may be associated with myocarditis and ischaemic infection. Long-lasting

symptoms including palpitations, chest pain, and shortness of breath can also be attributed to this heart injury. Myocardial damage was found in 20% of COVID-19 patients, which can greatly raise the risk of death [21]. It is frequently observed that right ventricular (RV) dilatation (39%) followed by left ventricular (LV) diastolic dysfunction (16%).

Lung (or respiratory) disease is the primary classification of COVID-19. Patients with lung conditions may be more likely to experience problems. It may take months or even longer than a year after infection for lung function to recover to normal [13]. A known side effect of acute respiratory distress syndrome (ARDS) and pneumonia following COVID-19 is pulmonary fibrosis. According to the information that is currently available, ARDS will affect 40% of COVID-19 patients, and 20% of these cases will be severe. The effects of COVID-19 were examined in 58 individuals with mild to severe COVID-19 2-3 months after onset in an Oxford University research in October [12]. The results showed that a sizable portion of COVID-19 patients who were released from the hospital experienced persistent dyspnea (64%), tiredness (55%), anxiety, and depression 2-3 months after commencement. Pulmonary MRI results from a 3-month follow-up revealed persisting parenchymal abnormalities. High-resolution lung computed tomography (CT) revealed persisting fibrous inflammatory alterations that were evident in 70% of COVID-19 pneumonia survivors at 3 months after discharge, all of which indicated the amount of lung inflammation. Breathlessness and a diminished ability to exercise can also result from consequences such as chronic cough, bronchiectasis, and fibrotic lung disease.

Six months following recovery, the majority of patients still have respiratory dysfunction. Chronic weariness or a severe decline in physical ability, a persistent cough, and exercise-induced dyspnea were the primary symptoms [18]. Fibrosis was seen in most of the patients examined in trials on alterations in CT images. In September 2020, a study involving 112 hospitalized and 2001 outpatient COVID-19 positive individuals was published in Belgium and the Netherlands. This study found that even in patients with mild symptoms, protracted symptoms like muscle pain, dizziness, headaches, fatigue, and loss of smell could last for several months [12].

3.2.2. Nervous System

The virus is neurotropic, which means that it can infiltrate the nervous system and disrupt it, increasing the risk that it will have long-term effects, as shown by a number of studies. Numerous international studies have documented neurological issues in COVID-19 individuals. Symptoms can range from brain inflammation and delirium to neurological impairment, stroke, and decreased consciousness in up to 30% of people. One of the main causes of sequelae from COVID-19 is neuronal damage, and the CNS (central nervous system) may sustain lifelong injury. 20% of the population may be affected by long-term neuropsychiatric effects. Insomnia, sadness, anxiety, and psychosis are the most frequently stated. The virus can potentially seriously harm the brain, with common complications including cerebral infarction, meningoencephalitis, peripheral neuropathy, and hemorrhage. More than a third of the 241 COVID-19 patients, according to a recent study, had numerous neurological conditions, such as severe cerebrovascular disease, skeletal muscle degeneration, and decreased consciousness [20].

3.2.3. Urinary System

Long-term impacts including kidney-related disorders observed in recovering patients facing effects such as proteinuria, oliguria or haematuria [19]. This might be caused by immune system overreaction in human body. In COVID-19 patients, the etiology of renal injury may be multifaceted and involve intricate mechanisms, such as complement dysregulation, thrombotic microangiopathy, and the emergence of a "cytokine storm" syndrome. The damage will have an impact on homeostasis regulation. Therefore, professionals suggest these patients to take regular tests.

3.2.4. Cognitive function

Even in those with minor symptoms, COVID-19 has a negative influence on cognitive function, which is one of the disease's long-term effects. Cognitive dysfunction is often associated with non-CNS systemic injury from ARDS, hypoxia, and multi-organ dysfunction, underlying psychological

anguish as well (e.g., post-traumatic stress disorder, depression and anxiety). Younger patients and women are more likely to experience the psychological aftereffects of emotional and mental health issues in the intensive care unit (ICU). Anxiety, sadness, and post-traumatic stress disorder are reportedly consequences of this ICU stay and are reported in 8–57% of PICS patients. Cognitive forgetfulness, memory loss, and lack of attention are the main symptoms. Patients' feelings of solitude and fewer social connections stimulate their minds, which has a significant effect on their mental and emotional well-being. Up to 40% of PICS patients are unable to perform at their previous level, which might result in unemployment and financial difficulty [12].

4. Conclusions

The public has faced a serious threat from COVID-19 all over the world. Many organs and systems in human body are capable of having the SARS-CoV-2 viral infection. The most vulnerable systems are respiratory system and cardiovascular system. The virus also influences nervous, digestive and urinal systems. Some patients showed different degrees of damage in the brain, liver, kidney and lung tissues. However, the available research data used in this paper may not be adequate enough due to relatively small sample size and short experiment duration.

A number of individuals would have post-COVID-19 syndrome after the infection. Such symptoms may last for three months or longer. Their respiratory, neurological, sensory and reproductive systems will still be affected in the short term. However, the cardiac and urinal systems may be affected longer. The lungs may even get irreversibly damaged. Besides, due to prolonged hospitalization or isolation, the patient's cognitive function and mental state cannot be recovered quickly. So, they are supposed to take regular health background surveillance even after recovery.

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