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Kidney damage due to coronavirus

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Abstract. Coronaviruses have a high risk of spreading and are particularly dangerous to renal tissue. Due to the presence of angiotensin converting enzyme type 2 (ACE2), transmembrane serine protease 2, and cathepsin L in the organs, which are thought to be targets for SARS-CoV-2, a new coronavirus infection can result in a variety of clinical abnormalities of the kidneys. The severity of numerous organ abnormalities might range from mild acute respiratory virus infections to other clinical symptoms.

Keywords: Covid-19, coronavirus infection, SARS-CoV-2, nephropathy, kidney.

The renin-angiotensin-aldosterone system damage, endothelial dysfunction, cytokine storm, hemodynamic and water metabolism abnormalities, and various clinical forms of kidney damage in COVID-19 are caused by a variety of pathogenetic mechanisms. These mechanisms include the direct cytopathic effect of the virus on kidney structures. The microvascular bed suffers when SARS-CoV-2 interacts with ACE2 receptors found on blood vessel endothelium. The production of pro-inflammatory interleukins, hypovolemia, and the buildup of angiotensin II and bradykinin are other factors that contribute to the destruction of renal tissue. Acute tubular necrosis, collapsing nephropathy, minimum change disease, membranous glomerulopathy, anti-GBM nephritis, worsening of autoimmune glomerulonephritis, and allograft rejection are some of the nosological manifestations of kidney injury seen in COVID-19 patients. A correlation between verified COVID-19 and the following laboratory results has been established via clinical observations by researchers from several nations: hematuria, proteinuria, increased blood urea

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nitrogen, serum creatinine, uric acid, and D-dimer. Current research has shown that renal failure, which is strongly related to greater mortality and morbidity and is a sign of survival in coronavirus infection, is a common ailment among coronavirus patients. Moreover, a patient's chronic renal disease, cardiovascular pathology, immunodeficiency states, use of nephrotoxic medicines, diabetes mellitus, hypertension, obesity, atherosclerosis, and advanced age are risk factors that aggravate the course of infection and impair the prognosis of the illness. The importance of researching this issue and coming up with solutions is therefore determined by the harmful impact of coronavirus on the body, namely the kidneys, and by the high death rate among patients with renal disease.

Humanity saw an epidemic of a pandemic-level new coronavirus infection (NCI) at the end of 2019. The high contagiousness of SARS-CoV-2, its affinity for different bodily tissues, and its capacity to produce a wide range of illnesses, from mild acute respiratory viral infections to serious multiple organ damage, are its defining traits.

The kidney is one of the most often impacted organs, despite the virus' primary target being lung tissue. Both the types of nephropathies and the methods by which kidney damage results from infection are varied.

The kidney is one of the most often impacted organs, despite the virus' primary target being lung tissue[5]. Both the types of nephropathies and the methods by which kidney damage results from infection are varied.

The cause of COVID-19's kidney injury is unknown.

There are multiple categories of several pathogenetic pathways that cause kidney disease in COVID-19 individuals, including:

1. An immediate cytotoxic action on kidney structures

As is well known, the angiotensin-converting enzyme type 2 receptor (ACE2), which is expressed in a variety of organs, including the lungs, heart, intestines, and kidneys,

is the major receptor for the entry of the SARS-CoV-2 virus into the cell [2-6]. This receptor is found in the proximal tubule cells, mesangial cells, parietal epithelium of Bowman's capsule, podocytes, and collecting ducts of the kidney [7].

According to the findings of RNA sequencing of human tissues, the expression of ACE2 is over a hundred times greater in the kidneys and gastrointestinal tract (GIT) organs than in the respiratory organs, as evidenced by the PubMed database [8]. Consequently, coronavirus may enter kidney cells via the ACE2 receptor to induce renal disease.

Data showing to the wide organotropism of SARS-CoV and demonstrating that renal tropism is a frequent cause of kidney impairment in patients with COVID-19 were obtained by V. G. Puelles, M. Lütgehetmann, M. T. Lindenmeyer, et al. ACE2 RNA, transmembrane serine protease 2, and cathepsin L, which are expected to be targets for SARS-CoV-2, are found in kidney cells, according to single-cell RNA sequencing.

Additionally, in three of the six patients who underwent autopsy, the viral load of SARS-CoV-2 was determined in all the studied parts of the kidneys with a predominant lesion of glomerular cells [9] when quantifying the viral load of SARS-CoV-2 in specific renal structures obtained by tissue microdissection.

2. Endothelial impairment

It is a significant contributor to the probability of COVID-19-related coagulopathy developing. SARS-CoV-2 interacts with ACE2 receptors on blood vessel endothelium, resulting in endothelial dysfunction. Vasoconstriction, vascular hyperpermeability, impaired microcirculation, the development of vascular thrombophilia, multiple microthromboses, and ultimately edema, hemorrhage, necrosis, and hemorrhagic infarction of various organs can result from these complications. Moreover, the organs with the most severe modifications are those whose microvascular beds already have diseases [10, 11].

The research by Z. Varga, A. J. Flammer, P. Steiger, et al. shown that COVID-19 kidney and other organ damage results from the production of endotheliitis brought on by direct viral infection and the inflammatory response of the host. Virion inclusions were discovered in vascular endothelial cells by electron microscopy on a portion of a donated kidney from a patient who passed away from multiple organ failure that occurred in the context of NCI. A histological analysis revealed inflammatory cell infiltration of the endothelium. The examination of histological specimens taken from further patients also supports the discovery of endotheliitis in a number of organs, including the lungs, heart, kidneys, liver, and intestines.

These ideas suggest that COVID-19 is a pathogenetically important arteriole damage-associated widespread viral vasculitis [12].

3. The acute respiratory distress syndrome is linked to cytokine storm and acute renal failure.

In response to the propagation and reproduction of the virus, an aberrant immune response occurs, which is characterized by the production of a significant number of pro-inflammatory chemokines (cytokine storm) and inflammatory interleukins (IL-1, IL-6, tumor necrosis factor, etc.). The expanding vicious loop damages the tissues that are the center of the inflammation, spreads to other tissues, and takes on a systemic nature. The cytokine storm is thought to play a significant role in both the onset and progression of extrapulmonary multiple organ failure. [6,10]

Acute kidney failure (AKI), which arises in conjunction with acute respiratory distress syndrome (ARDS), affects 35 to 50% of patients and dramatically raises the risk of mortality. Hemodynamic effects (lead to increased pressure in the pulmonary artery, right ventricular failure, venous congestion, and increased intra-abdominal / intrathoracic pressure), impaired gas exchange - hypoxemia/hypercapnia (leads to a decrease in renal blood flow and an imbalance in acid-base balance),

hyperinflammation, and neurohormonal effects (e.g., activation of the renin-angiotensin-aldesteron system ; RAAS) [13, 14].

In a retrospective analysis of 357 patients with ARDS who did not have chronic kidney disease (CKD) or AKI prior to the beginning of ARDS, A. Panitchote, O. Mehkri, A. Hastings, T. Hanane et al. showed that 244 (68.3%) individuals acquired AKI after the onset of ARDS. Moreover, older age, high body mass index, diabetes mellitus, a history of heart failure, greater peak airway pressure, and a higher sequential organ failure score were all linked to more severe AKI [15].

4. Hemodynamic conditions

Other COVID-19 problems, such as right and left ventricular failure, can also be brought on by AKI. The first results in blood pooling in the kidneys, whereas the second lowers cardiac output and causes renal hypoperfusion[14-16].

5. Abuse of the water metabolism

Fever and tachypnea-induced hypovolemia may have an adverse effect on the kidneys via a prerenal mechanism. Because of this disease, there is renal hypoperfusion, which leads to renal failure. This syndrome is also accompanied by hyperkalemia, metabolic acidosis, and rhabdomyolysis. This significantly affects the decline in kidney function and, in turn, the development of AKI [14].

6. Renin-angiotensin-aldosterone system harm

Moreover, it happens as a result of the virus's interaction with the ACE2 receptor, which causes the RAAS to be disrupted, an accumulation of angiotensin II and bradykinin to create ARDS, pulmonary edema, and myocarditis, as well as promotes vasodilation and natriuresis [7, 10].

In COVID-19, the presence of the risk factors for kidney disease in a patient includes CKD, cardiovascular pathology, congestive heart failure and, consequently, the formation of cardiorenal syndrome, the existence of immunodeficiency conditions, and the use of nephrotoxic medications. In addition to being risk factors

for SARS-CoV-2 infection, diabetes mellitus, hypertension, obesity, atherosclerosis, and advanced age all affect the disease's prognosis and complicate its clinical course. The International Society of Nephrology reports that severe COVID-19 results in renal injury in 25–50% of patients [10, 14, 17].

Renal pathology in COVID-19: Clinical symptoms

NCI comprises kidney injury in a variety of nosological manifestations, including collapsing nephropathy, minimum change disease, membranous glomerulopathy, anti-GBM nephritis, acute tubular necrosis, and allograft rejection. New York-based researchers that examined a series of biopsies of 14 native and 3 allotransplanted kidneys from COVID-19 patients came to this result [21]. The findings of a research involving 220 patients from Moscow also allow one to assess the prevalence of CKD in individuals with CCI (15%). Nevertheless, there was no correlation between the prevalence of acute renal disease and starting kidney function [18].

Acute renal damage was seen to develop in about a third of the 1280 COVID-19 hospitalized patients in the trial.

In a trial involving 1280 COVID-19 patients who were hospitalized, nearly a third (28.1%) developed acute renal damage. The following laboratory data were also collected at the same time: leukocyturia was found in 282 (22.0%) patients with COVID-19, hematuria in 77 (6.0%), and moderate proteinuria in 648 (50.6%) individuals with COVID-19 [19].

Chinese researchers have also identified a problem in the form of acute renal injury in critically sick COVID-19 patients. Acute tubular damage was the main pathology finding. AKI was more likely in people who were older and had higher blood IL-6 levels. Death was unavoidably caused by acute renal injury in the third stage [20-25].

Another Chinese study gathered laboratory information, clinical symptom information, and organ function information from 193 adult patients with laboratory-confirmed COVID-19. Three groups were used to compare the results: non-severe

(128), severe (65) COVID-19 patients, and a control group. AKI and recurrent renal dysfunction have been linked to COVID-19 individuals, according to research. Proteinuria, hematuria, increased blood urea nitrogen, serum creatinine, uric acid, and D-dimer levels were all substantially linked with mortality in COVID-19 patients, according to a univariate Cox regression analysis. Moreover, Cox regression analysis revealed that patients with COVID-19-induced AKI had a 5.3-fold greater risk of dying than patients without AKI, which is significantly higher than that of patients with chronic comorbidities [3].

In Wuhan, a prospective cohort study was undertaken on 701 COVID-19 patients who had been hospitalized to a tertiary clinical hospital, and 113 (16.1%) of them passed away there. Patients exhibited hematuria in 26.7% of cases and proteinuria in 43.9% at the time of admission. Elevated blood urea nitrogen, increased serum creatinine, and an estimated glomerular filtration rate less than 60 ml/min/1.73 m2 were also rather common, with corresponding prevalences of 14.4%, 13.1%, and 13.1%. AKI occurred in 5.1% of patients over the research period. According to the Kaplan-Meier study, patients with renal disease had a considerably increased probability of dying in the hospital [16].

Conclusion. We may thus infer that the kidneys are frequently the target of the SARS-CoV-2 virus after studying scholarly literature from Russia and other countries.

The development of the pathological process involves a number of interrelated pathogenetic mechanisms that can spiral out of control. These mechanisms include the cytotoxic effect of the virus on the renal tissue and blood vessels because the ACE2 receptor is expressed; the cytokine storm and systemic inflammatory response that results in coagulopathy and the formation of multiple microthrombi; and the emergence of systemic vasculitis of the organs and tissues. Throughout the course of study, many specialists from all over the world have been able to pinpoint a

connection between coronavirus exposure and the incidence of different types of nephropathies, from acute kidney damage to kidney failure. If the patient has risk factors, the prognosis is even worse. Hence, research on how NCI affects kidney health as well as efforts to lessen mortality from severe nephropathies are still important.

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