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Morphological Changes of Human Brain due to COVID-19: A Review Report

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Abstract

COVID-19 pandemic started in Wuhan, Hubei province, China. COVID-19 affects the organs and organ systems including the lungs and heart in patients all over the world. The human brain's interaction with this virus is a topic of great importance to the modern medicine. The texts were selected through word search in the Google Scholar search engine where it was thoroughly and painstakingly analyzed, reviewed and selected for the report. This report focuses on the structural pathologies of the brain reported in patients affected by SARS-CoV-2 virus around the globe. The pathologies henceforth described relate to grey matter thickness, the global brain size, tissue contrasts in the orbitofrontal cortex and parahippocampal gyrus, brain white matter hyperintensities on MRI and hypodensities on CT, microhemorrhages, hemorrhages and infarcts, white matter abnormalities in bilateral anterior and posterior cerebral white matter; leukoencephalopathy, leukoaraiosis (a pathological appearance of the subcortical white matter of the brain during neuroimaging), intracerebral hemorrhagic lesions, signal abnormalities located in the medial temporal lobe, atherosclerosis in the brain acute hypoxic injury in the cerebrum, and cerebellum.

In conclusion, the most frequently reported incidences of morphological pathologies in the human brain related to the virus include the grey matter atrophy in the olfactory-related brain areas. Also common were the incidences of global brain and CSF volume. Less frequent were the reports of microhemorrhages, hemorrhages and strokes. Most frequent MRI findings were signal abnormalities in the medial temporal lobe. Atherosclerosis and brain infarcts were also found in patients with COVID-19 background.

Keywords: COVID-19; SARS-CoV-2; White matter pathologies; Grey matter pathologies; Olfactory bulb pathology; Leukoencephalopathy

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Introduction

COVID-19 pandemic started in Wuhan, Hubei province, China [1]. COVID-19 affects the organs and organ systems including the lungs and heart in patients all over the world [2]. The human brain's interaction with this virus is a topic of great importance to the modern medicine.

Purpose and Objective

This report focuses on the structural pathologies of the brain reported in patients affected by SARS-CoV-2 virus around the globe. The pathologies henceforth described relate to grey matter thickness, the global brain size, tissue contrasts in the orbitofrontal cortex and parahippocampal gyrus, brain white matter hyperintensities on MRI and hypodensities on CT, microhemorrhages, hemorrhages and infarcts, white matter abnormalities in bilateral anterior and posterior cerebral white matter; leukoencephalopathy, leukoaraiosis (a pathological appearance of the subcortical white matter of the brain during neuroimaging), intracerebral hemorrhagic lesions, signal abnormalities located in the medial temporal lobe, atherosclerosis in the brain acute hypoxic injury in the cerebrum, and cerebellum.

Material and Methods

The texts were selected through word search in the Google scholar search engine where it was thoroughly and painstakingly analyzed, reviewed and selected for the report.

Results and Discussion

In a study in the United Kingdom, it was found that about 86% of patients in the subacute

phase of COVID-19 were displaying signs of either hyposmia or anosmia. This indicated a loss of the sensory olfactory inputs that may lead to grey matter loss in olfactory-related brain regions; with both neuronal and supporting olfactory cells concentrated in the olfactory epithelium were found to be vulnerable to the virus invasions [3].

SARS-CoV-2 infection was found to be related to greater atrophy and expanded tissue damage within the cortical areas directly associated with the primary olfactory cortex. The global measurement of the brain and CSF volume was also infected by the virus. Such changes suggest further extended loss of grey matter observed in the olfactory-associated areas [3].

Evident involvement of the olfactory cortex and longitudinal changes in regions connected to the piriform cortex was seen. The most persistent abnormalities were found in the left parahippocampal gyrus, which is directly in connection with the piriform cortex and entorhinal cortex. Alteration In the orbitofrontal cortex was found in SARS-CoV-2 positive patients; anterior cingulate cortex and insular cortex had more pronounced increase in diffusion metrics indicating tissue damage [3].

Brain white matter hyperintensities and hypodensities observed in 76% of affected cases were a priori to leukoencephalopathy, leukoaraiosis or rarefied white matter. Notable bilateral medial temporal lobe, frontal, occipital and parietal lobe abnormalities due to hyperintensities in cerebral white matter was observed in 53% of affected cases. Such changes were registered in the insular cortex, subinsular regions, cingulate gyri, cerebral peduncle and internal capsule, thalamus, midbrain, pons, parahippocampal gyrus and basal ganglia, splenium of corpus callosum, olfactory nerve/bulb, and gyrus rectus. Thus, the brain abnormalities were suggestive of COVID-19 patients in acute/subacute phase [4].

Studies showed brain abnormalities such as microhemorrhages in the white matter in 13% of affected cases which was presented by bilateral diffuse in corpus callosum and putamen, bilateral juxtacortical white matter and internal capsule [4].

Other brain abnormalities observed and reported were brain infarcts which comprise about 10% of affected cases, and involved bilateral anterior and posterior circulation territories [4].

Hemorrhages were seen in 6% of affected cases and included the bilateral posterior parieto-occipital area, amygdala, left frontal, occipital areas, right temporal area, temporal plus frontal lobes and Sylvian fissure, brainstem and pons, corpus callosum and intraventricular layering in the occipital horns of lateral ventricles [4].

Roughly 50% of affected cases with COVID-19 presented brain abnormalities located in either anterior or posterior regions or in both. Bilateral affection in the anterior regions was in 36% of patients, this involved juxta/subcortical and deep white matter hyperintensities in medial temporal lobe and well as frontal lobe [4].

In the posterior regions of the brain, 18% of patients were presented with bilateral brain abnormalities. Cortical white matter hypodensities that reached from occipito-parieto-temporal towards the posterior frontal tracts were present in one patient [4].

Studies indicated 3% of affected cases to have diffuse leukoencephalopathy in the bilateral cerebellar hemisphere and middle cerebellar peduncles. Restricted diffusion was seen to be associated with edema. Furthermore, white matter abnormalities implied changes to leukoencephalopathy, leukoaraiosis or rarefied white matter not confined to periventricular area [4].

It was seen that leukoaraiosis is considered a characteristic of brain ageing which is most often asymptomatic but with further analyses the prevalence of leukoaraiosis was higher in such patient population rather than expected for age and to that, encephalitis may be considered a possible interpretation [4].

Intracerebral hemorrhagic lesions were frequently shown to be associated with intensive care units in comparison between patients with or without lesions. Such differences indicated that patients with lesions were about 100% *vs.* patients without lesions were 71%. Moreover, patients with intracerebral hemorrhagic lesions had a longer duration of time between the onset of symptoms (most commonly respiratory) and brain MRI [5].

The most frequent MRI findings in 43% of patients with severe coronavirus disease 2019 was signal abnormalities located in the medial temporal lobe. Other frequency findings included: nonconfluent multifocal white matter hyperintense lesions on FLAIR (frequently observed in case of infectious encephalitis or in association with autoimmune limbic encephalitis) and diffusion-weighted images with variable enhancement which is associated with hemorrhagic lesions; and extensive and isolated white matter microhemorrhages [5].

Microscopic examinations revealed acute hypoxic injury in the cerebrum, and cerebellum in all patients. Such results were accompanied by loss of neurons in the cerebral cortex, hippocampus, and cerebellar Purkinje cell layer with no thrombi or vasculitis. In gross inspection of the patients, moderate atherosclerosis (in 14 brain specimens) and chronic infarcts were revealed and residual anaplastic astrocytoma was seen in patients diagnosed with anaplastic astrocytoma [6].

Conclusion

In conclusion, the most frequently reported incidences of morphological pathologies in the human brain related to the virus include the grey matter atrophy in the olfactory-related brain areas. Also common were the incidences of global brain and CSF volume. Less frequent were the reports of microhemorrhages, hemorrhages and strokes. Most frequent MRI findings were signal abnormalities in the medial temporal lobe. Atherosclerosis and brain infarcts were also found in patients with COVID-19 background.

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