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# Lacunar Infarct and Vascular Stenosis Finding on Patient Recovering from Coronavirus Disease 2019 (COVID-19): Role of Brain MRI and MRA

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**Abstract:- Coronavirus disease 2019 (COVID-19) which is also known as SARS-CoV-2 is an infectious disease caused by severe acute respiratory syndrome. Before spreading globally, first cases were seen in Wuhan, China, in December 2019. The most frequent findings are atypical or organizing pneumonia, often with a bilateral, peripheral, basal predominant distribution and airspace opacities, whether described as consolidation, GGO or crazy paving pattern. Recent research identified a higher than expected number of people recovering from the COVID-19 reported experiencing neurological symptoms in the brain such as nerve damage, stroke and brain inflammation; which are not always correlate with the severity of respiratory symptoms caused by COVID-19. One of the systems that involved in maintaining optimum conditions of the brain is the cerebral circulatory system. Blood must flow smoothly to regulates all activities in human body. Obstruction of blood flow can cause hypoxia (lack of oxygen) and can led damage to the surrounding tissue, causing paralysis and brain function disabilities.**

**Objectives: of this study describe the management of Brain MRI as a follow up study for patient recovering from coronavirus disease (COVID-19). Method of this study is descriptive qualitative. The research was conducted in July 2020, at Department of Radiology, Ciputra Mitra Hospital in Banjarmasin. Criteria of the samples are people without a history of serious health issues in the past, who have been infected COVID-19 in the severe category (as evidenced by PCR, Chest X-Ray and Chest CT); but has been declared cured of COVID-19 (as evidenced by negative PCR results 2 times in 24 hours). Results in this study: obtained imaging studies conducted on 1.5 Tesla GE MRI. Sequences performed were T1 weighted spin echo, diffusion weighted imaging (DWI), gradient echo T2 or susceptibility weighted imaging, FLAIR and, MRA. Conclusion: of this study showed ischemic stroke, multiple infarcts and several brain vascular stenosis.**

***Keywords:-*** *Brain MRI, COVID-19, FLAIR, lesion, vascular stenosis, ischemic stroke*

## I. INTRODUCTION

Coronavirus disease (COVID-19), which at the beginning of the emergence of flu disease manifested by pneumonia in the lung organs, in recent months been known to cause disturbances in other organs, namely in the brain, kidneys, blood vessel system and also the nervous system.[1,2] The corona virus can enter the nervous system directly through the olfactory nerve, or indirectly through the blood circulation and neural pathways and infects the body by attaching to the Angiotensin Converter Enzyme (ACE-2) receptors on the surface of cells.[3,4] After successfully entering, the corona virus attacks cells by duplicating and weakening the body's infection response.[5]

The main symptoms of COVID-19 are in the airways because 83% of the ACE-2 receptors are in the lungs.[4] ACE-2 receptors are also found in body cells such as the heart, intestines (epithelial cells), kidneys, blood vessels and cerebrovascular cells that allow the process of COVID-19 infection in other organs.[6] Few studies conducted in several countries found a large number of patients infected with COVID-19 also experienced complications in the brain and nervous system including; a study in China's Wuhan found 36.4 percent of 214 COVID-19 patients had neurological symptoms ranging from loss of smell and nerve pain, to seizures and strokes;[7] another study conducted in France found 50 percent of the 58 patients were confused, restless, and had inflammation;[8] then a study conducted by University College London found 43 patients with COVID-19 suffering from transient brain dysfunction, stroke, nerve damage or other serious brain disorders.[9]

In the brain organs and nervous system, COVID-19 can cause damage in three stages: first, the patient has an impaired sense of smell and taste; second, the patient has inflammation of the blood vessels and blood clots which can cause lack of oxygen or is known as hypoxia[10] (if it occurs in blood vessels in the brain it can cause small or large strokes);[11,12] and third, the patient has damage to brain blood vessels that causes blood and chemicals to leak into the brain tissue, death of brain cells, seizures, confusion, or bleeding in the brain.[13]

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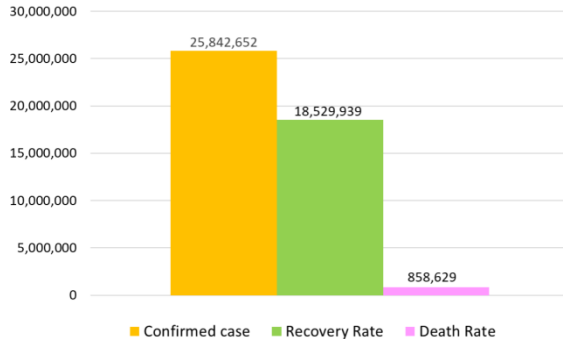
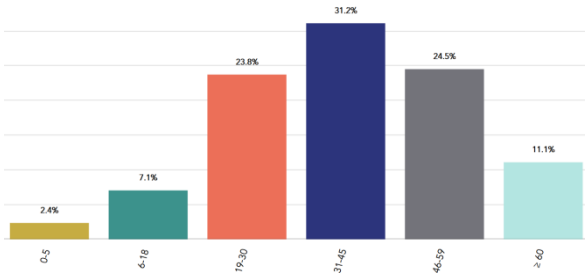
The latest data COVID-19 (as of September, 03, 2020) from the World Health Organization (WHO) on the official website https://covid19.who.int/ recorded the total number of global confirmed case is 25,842,652 people, 858,629 death rate. While the number of global recovery rates based on data on the website https://coronaboard.com/global/ is 18,529,329 people as seen in Graph 1.



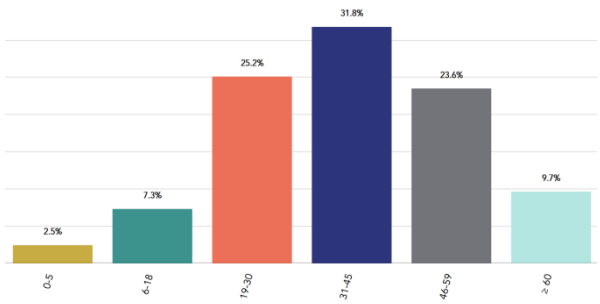

Graph 1:- Global rate confirmed case for COVID-19

Data and Information Center of the Indonesian Ministry of Health on the official website of the COVID-19 Handling Task Force https://covid19.go.id divided the total number of confirmed cases in Indonesia into six age group categories; 2.4 percent in the 0-5 year group, 7.1 percent in the 6-17 year age group, 23.8 percent in the 19-30 year age group, 31.2 percent in the 31-45 age group, 24.5 percent in the 46-59 age group, and 11.1 percent in aged ≥60 years (as per date September, 03, 2020) as seen in Graph 2.




Graph 2:- Age group for confirmed cases

Meanwhile, based on the age group category, the number of COVID-19 patients who were confirmed positive in the 0-5 year age group was 2.5 percent, in the 6-17 group was 7.3 percent, in the 19-30 year age group it was 25.2 percent , in the 31-45 age group it was 31.8 percent, in the 46-59 age group it was 23.6 percent and those aged ≥60 years it was 9.7 percent as seen in Graph 3.




Graph 3:- Age group recovery rate

From the data above, it is known that the cure rate for COVID-19 cases is quite high in the 31-45 years (31,8 percent), 19-30 years (25.2 percent), and 46-59 years age group (23.6 percent); which is included in the young and productive age category.[14] This recovery can be achieved because confirmed cases of COVID-19 are found early through examinations such as RT-PCR,[15] Chest X-Ray[16] and Chest CT.[17] Diagnosis is needed to detect disease and determine treatment and therapy for patients. An accurate diagnosis result can be useful in the process of analysis, treatment planning, and necessary medical actions.[18]

Magnetic Resonance Imaging (MRI) is a modern imaging technology that is indispensable in diagnosing disease. MRI examinations are carried out non-invasively to obtain anatomical and physiological information on the inside of the body by creating an image structure through the interaction of magnetic fields and radio waves on tissues without using ionizing radiation.[19] Following are the advantages of MRI compared to other medical imaging:[18] detects and visualizes abnormalities in soft tissues such as brain and bone marrow better than other imaging methods; gives more detailed description of the anatomy of the body; able to provide more informative results on functional examinations of the body; generate axial, coronal, and sagittal slice images without changing the patient's position, and; does not use ionizing radiation. The sequences use for brain MRI are spin echo, weighted spin echo, diffusion weighted imaging (DWI), gradient echo, T2 or susceptibility weighted imaging, FLAIR, and MRA.[19,20]

## II. METHOD

This research design is descriptive qualitative with primary data obtained through participatory observation process. The research was conducted in July 2020, at the Department of Radiology Ciputra Mitra Hospital in Banjarmasin. The research instruments used were worksheets, documentation tools and interviews. Criteria of the samples are people without a history of serious health problems in the past, who have been infected with COVID-19 in the severe category (as evidenced by the results of RT-PCR, Chest X-Ray and Chest CT); but has been declared cured of COVID-19 (as evidenced by negative PCR results 2 times in 24 hours). Sample can be canceled if there are indications of severe mental disorders and claustrophobia. All examination results are then evaluated and strengthened by the expertise of radiologist, so that conclusions can be drawn.

## III. RESULT

The results of this study were obtained images from MRI scans in 1 sample of 26 year old women without a history of serious health problems in the past, who had been infected with COVID-19 in the severe category (as evidenced by the results of RT-PCR, Chest X-Ray, Chest CT and patient medical records during 58 days hospitalized); but has been declared cured of COVID-19 (as evidenced by negative PCR results 2 times in 24 hours). The scans were carried out on a GE Signa Explorer 1.5 Tesla

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MRI machine with a 16-channel head coil. The sequences used are spin echo, weighted spin echo, diffusion weighted imaging (DWI), gradient echo, T2 or susceptibility weighted imaging, FLAIR, and MRA.

## IV. DISCUSSION

The T1WI sequence is used to evaluate the anatomy of the entire head as well as covering the soft tissues under the base of the skull. Following are the parameters of the T1WI sequence in Table 1.

| Parameter | Value |
|---|---|
| *Time Repetition (TR)* | 599 |
| *Time Echo (TE)* | 7,5 |
| *Slice Thickness* | 4 mm |
| *Flip Angle* | 160 |
| *Phase Encoding* | AP |
| *Matrix* | 260 x 280 |
| *FOV* | 220 mm |

Table 1:- T1WI sequence parameter

The image results from the T1WI sequence show hypointense lesions with indistinct borders with multiple lacunar shapes in the right lateral periventricular area of the anterior horn, right frontal cortical, right-left temporal cortical, left cerebellum, right-left corona radiata, right-left semi-oval center.

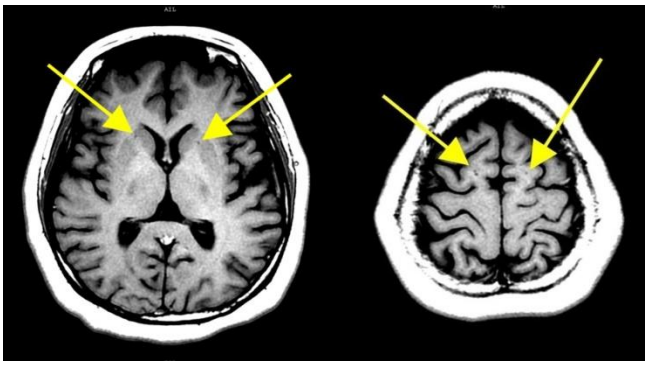

Fig 1:- Hypointense lesions in the T1WI

The T2WI, SWI or GRE sequences are used to evaluate the basal cistern region, ventricular system, calcification and flow to the vessels and subdural vessels. The following are the parameters of the T2WI sequence in Table 2.

| Parameter | Value |
|---|---|
| *Time Repetition (TR)* | 5942 |
| *Time Echo (TE)* | 99,2 |
| *Slice Thickness* | 4 mm |
| *Flip Angle* | 160 |
| *Phase Encoding* | AP |
| *Matrix* | 320 x 320 |
| *FOV* | 220 mm |

Table 2:- T2WI sequence parameter

The FLAIR and DWI sequences were used, among others, to assess abnormalities in white matter and identify ischemic strokes. Following are the parameters of the FLAIR sequence in Table 3 and the parameters of the DWI sequence in Table 4.

| Parameter | Value |
|---|---|
| *Time Repetition (TR)* | 11.000 |
| *Time Echo (TE)* | 120 |
| *Slice Thickness* | 4 mm |
| *Flip Angle* | 160 |
| *Phase Encoding* | AP |
| *Matrix* | 288 x 192 |
| *FOV* | 220 mm |

Table 3:- FLAIR sequence parameter

| Parameter | Value |
|---|---|
| *Time Repetition (TR)* | 6180 |
| *Time Echo (TE)* | 85 |
| *Slice Thickness* | 4 mm |
| *Flip Angle* | 160 |
| *Phase Encoding* | AP |
| *Matrix* | 288 x 192 |
| *FOV* | 220 mm |

Table 4:- DWI sequence parameter

The image results from the T2WI and FLAIR sequences show hyperintense white matter in the juxtacortical temporal and right parietal lobe. Hyperintense features of multiple lesions in the right lateral periventricular area of the anterior horn, right frontal cortical and left cerebellum are seen. And there is a hyperintense signal of the ventricular system which indicates a mild dilation as shown in Figure 2.

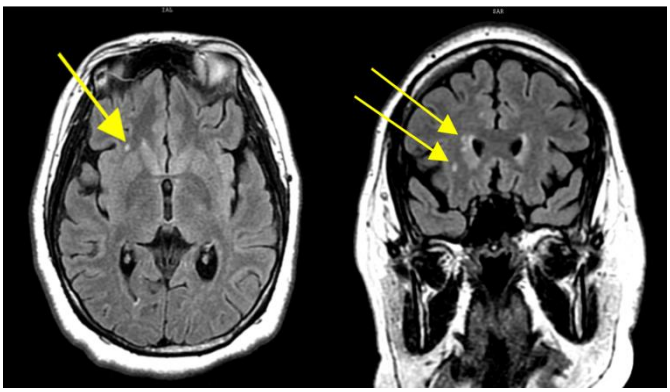

Fig 2:- Hyperintense stroke and lesion in FLAIR

Hyperintense lesions were also present on both sides of the cortical temporal, both sides of the corona radiata and both sides of the semi-oval centrum. Hyperintense visualized cortical groove infarction in the FLAIR and DWI sequences as shown in Figure 3.

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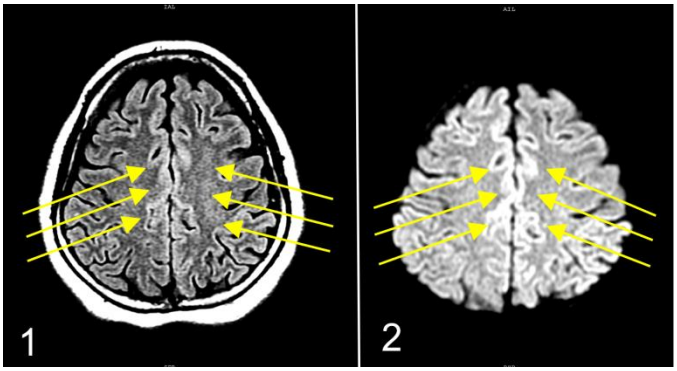

Fig 3:- Hyperintense cortical sulcus infarction in FLAIR (1) and DWI (2)

The MRA sequence was used to assess the diameter and luminal occlusion of blood vessels in the head. Following are the parameters of the MRA sequence in Table 5.

| Parameter | Value |
|---|---|
| *Time Repetition (TR)* | 26 |
| *Time Echo (TE)* | 2,9 |
| *Slice Thickness* | 1,2 mm |
| *Flip Angle* | 20 |
| *Phase Encoding* | AP |
| *Matrix* | 320 x 192 |
| *FOV* | 220 mm |

Table 5:- MRA sequence parameter

The MRA sequence showed diameter and luminal of the Right Anterior Cerebral Artery (ACA) A1 segmentation smaller than the left side; and the Left Superior Cerebral Artery (SCA) is less visualized than the right side.

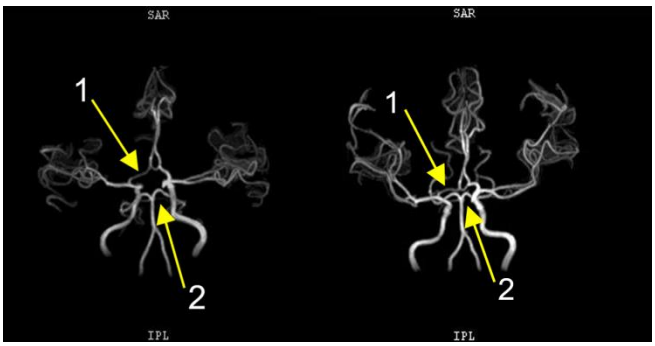

Fig 4:- Stenosis on Right ACA (1), and Left SCA (2)

## V. CONCLUSION

Brain MRI scans of patients after recovering from COVID-19 showed white matter in the juxtacortical temporal and right parietal lobe; lesions in the right lateral periventricular area, anterior corn, right frontal cortical, left cerebellum, right-left temporal cortical, right-left corona radiata, and right-left semi-oval centrum will be seen hypointense in T1WI sequence while and will be seen hyperintense in the sequence T2WI and FLAIR. Meanwhile, the visualized hyperintense cortical sulcus infarction in the FLAIR sequence. The MRA sequence showed the Right Anterior Cerebral Artery (ACA) A1 segmentation smaller than the left side; and the Left Superior Cerebral Artery (SCA) is less visualized than the right side. The conclusion is that the sample experienced sub-acute ischemic stroke and multiple lacunar cerebral infarction in the right lateral periventricular area of the anterior horn, right frontal cortical, left cerebellum, also on both sides of the temporal cortical, both sides of the corona radiata and both sides of the semi-oval centrum. And experiencing stenosis (narrowing) of the blood vessels of the Right Anterior Cerebral Artery (ACA) A1 segmentation and Left Superior Cerebral Artery (SCA).

The author suggests that further research can be carried out to obtain complete information about potential complications in patients who have been infected with COVID-19. The goal is to find disease early so that therapy and treatment can be given faster. Recovery rate for COVID-19 patients is quite high and dominated by the productive age group; if complications after COVID-19 are not handled quickly can led to serious health problems in the future, which will reduce the quality of life for the survivors of COVID-19.

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## REFERENCES

[1]. South AM, Brady TM, Flynn JT. ACE2, COVID-19, and ACE inhibitor and angiotensin II receptor blocker use during the pandemic: The pediatric perspective. Hypertension. 2020;2(Angiotensin II):16-22.
[2]. Baig AM, Khaleeq A, Ali U, Syeda H. Evidence of the COVID-19 Virus Targeting the CNS: Tissue Distribution, Host-Virus Interaction, and Proposed Neurotropic Mechanisms. ACS Chem Neurosci. 2020.
[3]. Invivogen. Spotlight on COVID-19. The infection cycle of SARS-CoV-2. Rev InvivoGen. 2020;33(December 2019):6-7.
[4]. Bourgonje AR, Abdulle AE, Timens W, et al. ACE2, SARS-CoV-2 and the pathophysiology of coronavirus disease 2019. J Pathol. 2020;251(3):228-248.
[5]. Walls AC, Park YJ, Tortorici MA, Wall A, McGuire AT, Veesler D. Structure, Function, and Antigenicity of the SARS-CoV-2 Spike Glycoprotein. Cell. 2020;181(2):281-292.e6.

[6]. Leung JM, Yang CX, Tam A, et al. ACE-2 expression in the small airway epithelia of smokers and COPD patients: implications for COVID-19. Eur Respir J. 2020;55(5).
[7]. Mao L, Jin H, Wang M, et al. Neurologic Manifestations of Hospitalized Patients with Coronavirus Disease 2019 in Wuhan, China. JAMA Neurol. 2020.
[8]. Varatharaj A, Thomas N, Ellul MA, et al. Neurological and neuropsychiatric complications of COVID-19 in 153 patients: a UK-wide surveillance study. The Lancet Psychiatry. 2020;2(20):1-8.
[9]. Paterson RW, Brown RL, Benjamin L, et al. The emerging spectrum of COVID-19 neurology: clinical, radiological and laboratory findings. Brain. 2020.
[10]. Cafaro RP. Hypoxia: Its Causes and Symptoms. J Am Dent Soc Anesthesiol. 1960;7(4):4-8.
[11]. Mir MA, Al-Baradie RS, Alhussainawi MD. Pathophysiology of Strokes.; 2015.
[12]. Reddy ST, Garg T, et al. Cerebrovascular Disease in Patients with COVID-19: A Review of the Literature and Case Series Rep Neurol. 2020;77030:199-209.
[13]. Girardeau Y, Gallois Y, Bonnecaze Gde, et al. Confirmed central olfactory system lesions on brain MRI in COVID-19 patients with anosmia a case-series. Medrxiv. 2020:2020.07.08.20148692.
[14]. Working Age / Productive Age Group. 2019;(January).
[15]. Delamarre L, Gollion C, Grouteau G, et al. COVID-19-associated acute necrotising encephalopathy successfully treated with steroids and polyvalent immunoglobulin with unusual IgG targeting cerebral fibre network. J Neurol Neurosurg Psychiatry. 2020.
[16]. Shoskes A, Migdady I, Fernandez A, Ruggieri P, Rae-Grant A. Cerebral Microhemorrhage and Purpuric Rash in COVID-19: The Case for a Secondary Microangiopathy. J Stroke Cerebrovasc Dis. 2020.
[17]. Ai T, Yang Z, Hou H, et al. Correlation of Chest CT and RT-PCR Testing for Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases. Radiology. 2020.
[18]. Soesanti I, Susanto A, Sri T, Maesadji W. Ekstraksi Ciri dan Identifikasi Citra Otak MRI Berbasis Eigenbrain Image. Forum Tek. 2011;34(1):47-52.
[19]. Westbrook C. Handbook of MRI.; 2013.
[20]. Kremer S, Lersy F, de Sèze J, et al. Brain MRI Findings in Severe COVID-19: A Retrospective Observational Study. Radiology. 2020:202222.