

# Neurologic Imaging Of Covid-19 Patients in a Tertiary Referral Hospital in the Philippines: A Retrospective Study

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## ABSTRACT

**Background:** Coronavirus (COVID-19) is a recently discovered disease caused by severe acute respiratory syndrome COV2 virus (SARS COV-2) that led to a global pandemic. COVID-19, with its rapid spread, proved to be a global threat to health. Although it is known to mainly cause respiratory symptoms, neurologic sequelae have also been reported in a growing number of patients.

**Objectives:** This study aims to provide additional evidence regarding neuro-radiographic findings among Filipino patients inflicted with COVID-19.

**Methodology:** This paper is an analytical, retrospective study of COVID-19 confirmed patients who presented with neurologic manifestation and underwent cranial CT scans between April 2020 and April 2021 at Baguio General Hospital and Medical Center.

**Results:** A total of 22 patients were included in the study. Of these, 11 had acute infarcts, 5 had cerebral hemorrhage, 1 had cerebral venous thrombosis, and 5 had normal imaging findings. Fisher's test was done and revealed a significant difference between COVID-19 severity and abnormal CT scan findings.

**Conclusion:** Although relatively uncommon, the study showed that there is an increased incidence of abnormal neuroimaging findings among patients with COVID-19. The most common of which is cerebral infarction followed by macrohemorrhages. The severity of the disease is correlated with the increased incidence of abnormal neuroimaging findings among COVID-19 patients.

*Keywords: COVID-19, Neuroimaging, Neuroradiology*

## INTRODUCTION

### Background of the Study

COVID-19, a disease caused by SARS COV2, led to a global pandemic. With its rapid spread and devastating complications, it remains a global health threat. It has infected millions of people and taken thousands of

lives.<sup>2</sup> As of writing, the Philippines has recorded 892,880 cases and 15,447 deaths.<sup>13</sup>

Though it is known to primarily cause respiratory illness, neurologic sequelae have been reported. Acute to subacute infarcts, cerebral microhemorrhages, acute spontaneous intracerebral hemorrhages, and acute inflammatory/ infectious CNS syndromes were common findings. Out of these, infarcts were said to be the most common.<sup>14</sup>

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As the virus continues to spread, causing devastating health problems worldwide, there is still a paucity of available literature on the neuro-imaging findings among COVID-confirmed patients, especially in the Philippines. This study aims to provide additional evidence on the neuro-radiographic findings of COVID-inflicted patients presenting with neurologic symptoms.

**METHODS OF RESEARCH**

**Research Design and Population of the Study**

This paper is an analytical, retrospective study that included all patients aged 18 years old and above admitted at Baguio General Hospital and Medical Center (BGHMC) from April 2020 to April 2021. This cohort of patients presented with neurologic signs and symptoms, tested positive for

COVID-19 through a reverse transcription-polymerase chain reaction (RT-PCR), and underwent cranial CT scans. The exclusion of patients with previous neurologic diseases with or without neurologic deficits was done.

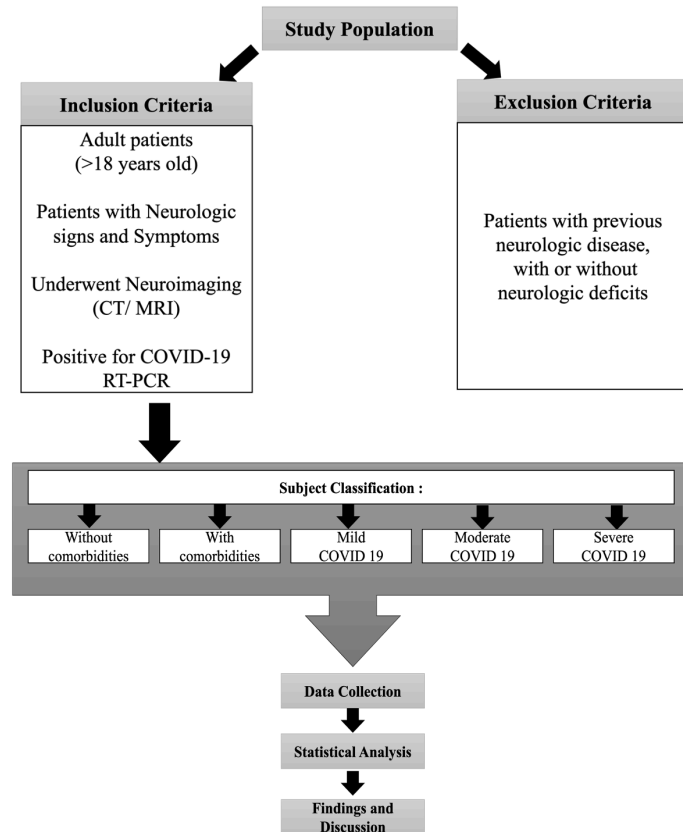
**Methods and Procedures**

This paper utilized secondary data collection. The data were gathered and analyzed after the re-evaluation and approval of the institution's ethics review committee. The study used charts and previous cranial CT scan images as sources of data. Further, these patients were clinically assessed by trainees and board-certified neurologists. Similarly, both trainees and board-certified radiologists interpreted the neuroimaging findings.

**Statistical Analysis**

The gathered data were analyzed using frequency distribution table and descriptive statistics using SPSS version 15.

Fig. 1. Research Paradigm Identification of the Study Population



**Table 1.** Frequency of patients by age group

Age	Number of Patients	Percentage
21-40	5	22.7
41-60	8	36.4
61-80	9	40.9
TOTAL	22	100

**Table 2.** Frequency of Sex of Patients

Sex	Number of Patients	Percentage
Male	11	50
Female	11	50
TOTAL	22	100

**Table 3.** Comorbidity

Co-morbidity	Number of Patients	Percentage
With Co-morbidity	18	81.8
Without Co-morbidity	4	18.2
TOTAL	22	100

**Table 3.1** Specific co-morbidity of patients

Co-morbidity	Number of Patients	Percentage
Hypertension	9	40.9
Obesity	3	13.6
No co-morbidity	4	18.2
HIV	1	4.5
Hypertension and Obesity	2	9.1
Hypertension and Diabetes	3	13.6
TOTAL	22	100

Fisher's Exact Test was used for statistical analysis to determine the association between co-morbidities, the severity of disease, and neuroimaging abnormalities. P-values less than 0.05 will be considered statistically significant.

## RESULTS

A total of 22 COVID-19 confirmed patients with neurologic manifestations who underwent cranial CT scans were included in the study. The mean age of the patients was 41.8 (SD=12.09), and the majority of the patients belong to the 61-80 years old age group (40.9%), followed by the 41-60 age group (36.36%) (Table 1).

There is an equal distribution between males (50%) and females (50%) (Table 2).

Patients with co-morbidities comprise most of the cohort (81.81%) compared to those with no co-morbidities (Table 3). 40.9% of patients with co-morbidities had hypertension (Table 3.1).

There is equal distribution of patients between moderate COVID-19 (50%) and severe COVID-19 (50%) (Table 4).

A more significant portion of COVID-19 patients with neurologic signs and symptoms presented with abnormal CT scan findings (77.3%) compared to those with neurologic signs and symptoms with normal CT scan findings (22.7%) (Table 5). Half of 50% of the patients with abnormal CT scan findings had cerebral infarction, while 22.7% had cerebral hemorrhage (Table 5.1)

Among the eleven (11) patients with infarction, eight (8) presented with large vessel occlusions, and three (3) were lacunar in nature. Six (6) of these patients were under the severe/critical category of the COVID-19 disease, five (5) under the mild end. Three (3)

of the critically ill patients have died from the illness.

Among those who presented with intracerebral hemorrhage (5 patients), the area affected was the basal ganglia, all of whom were classified under the severe/critical category. In this same subpopulation, four died during hospitalization.

One (1) patient had cerebral venous thrombosis with secondary hemorrhage in the right parieto-occipital area. He was under the moderate disease category of COVID-19 and was discharged improved.

Of the five (5) patients who presented with normal CT Scan findings, one (1) was diagnosed with myasthenia gravis, one (1) with epilepsy, one (1) with encephalopathy, one (1) with peripheral vertigo, and one (1) presented with memory loss from vascular dementia versus Parkinson’s disease. All of whom were with moderate COVID-19 disease and were discharged improved.

Fisher's exact test was used to determine the association between abnormal neuroimaging findings and comorbidities among COVID-19 patients in BGHMC (Table 6). The test revealed no significant association between abnormal neuroimaging findings and comorbidities among COVID-19 patients (p-value 0.210).

Fisher's exact test was likewise used to determine the association between abnormal neuroimaging findings and the severity of COVID-19 disease (Table 7). The test showed a significant association between the severity of COVID-19 disease and abnormal neuroimaging findings in BGHMC (p-value 0.035). Those who have abnormal cranial imaging findings have severe COVID-19 Status.

**DISCUSSION**

It is well known that COVID-19 primarily affects the pulmonary system;

**Table 4.** Frequency of COVID-19 severity

COVID-19 Severity	Number of Patients	Percentage
Morbidity	11	50
Severe	11	50
TOTAL	22	100

**Table 5.** CT Scan Findings

CT Scan Findings	Number of Patients	Percentage
Normal	5	22.7
Abnormal	17	77.3
TOTAL	22	100

**Table 5.1.** Incidence of Specific Abnormal CT scan findings of patients

CT Scan Findings	Number of Patients	Percentage
Normal	5	22.7
Hemorrhage	5	22.7
Infarct	11	50.0
Cerebral Venous Thrombosis and Hemorrhage	1	4.5
TOTAL	22	100

**Table 6.** Association between abnormal neuroimaging findings and co-morbidities among COVID-19 patients

CT Scan Findings	With co-morbidity	Without co-morbidity	P Value
Normal	3	2	0.210
Abnormal	15	2	0.210
MEAN	9	2	0.210

**Table 7.** Association between abnormal neuroimaging findings and the severity of COVID-19 disease

CT Scan Findings	Moderate COVID	Severe COVID	P Value
Normal	5	0	0.035
Abnormal	6	11	0.035
MEAN	5.5	5.5	0.035

however, recent studies have shown the involvement of the nervous system.<sup>1</sup> Several mechanisms have been described as to its disease process, including direct attachment of inflammatory mediators in nerve endings in the Peripheral Nervous System and transmission into the Central Nervous System, and indirect injuries related to the cytokine storm and viral sepsis.<sup>2</sup> Several neuroimaging findings have subsequently been described.

Among the twenty-two (22) patients included in this study, seventeen (17) of them had abnormal CT Scan findings. The most common of which is cerebral ischemia (11), followed by hemorrhage (5) and cerebral venous thrombosis with secondary hemorrhage (1). This finding is similar to a study done by BC Yoon et al., involving 26 of 150 COVID-19 patients having abnormal neuroimaging studies, where infarction (13) and cerebral hemorrhage (11) were the most common findings.<sup>3</sup>

In a literature review done by E. Gulko et al., involving 22 articles with a total of 126 patients, acute or subacute infarction (32) were also the most common findings described. White matter abnormalities (17) consistent with leukoencephalopathy, cortical FLAIR signal abnormalities (15), and microhemorrhages (14) came next.<sup>4</sup> On the other hand, the study of AR Egbert et al. showed white matter abnormalities in MRI to be the most common (66/124) finding. These WM hyperintensities were said to be related to leukoencephalopathy, leukoaraiosis, or rarefied WM.<sup>5</sup>

White matter abnormalities were not appreciated in any of our patients since no MRI studies were not done during the entire span of the study. Precautionary measures were maintained per protocol during the interval time of the study. Further, none of the cases included were deemed to undergo cranial MRI by the neurology department.

V. Sawlani et al. evaluated COVID-19 patients using both cranial MRI and CT scans. Among patients who underwent cranial CT scans, the most common abnormalities observed were subacute (8/18) and acute (7) infarcts. On the other hand, MRI findings showed microhemorrhages as the most common abnormality (12/20) followed by WM hyperintensities (4).<sup>6</sup>

Finally, E Lin et al. described that though ischemic strokes and intracranial hemorrhages are similar in appearance to those in patients without COVID-19, they are seemingly more common in the COVID-19 patient population.<sup>7</sup>

Most of the patients in the study have comorbidities and most of which have hypertension. Statistically, this proved no significant association in developing abnormal neuroimaging findings among patients with COVID-19. A study done by L. Buttner et al. supports this. They found no difference between patients with or without cranial imaging abnormal findings in relation to comorbidities.<sup>8</sup> However, some literature would say otherwise.<sup>9</sup>

This paper resulted in a significant association between the severity of COVID-19 and the acquisition of abnormal neuroimaging findings. This is similar to a study by V. Jegatheeswaran et al. showing ICU patients to more likely have abnormal neuroimaging findings, particularly ischemia and macrohemorrhages.<sup>10</sup>

BC Yoon et al. also described correlation with markers for COVID-19 severity suggesting patients who have severe forms of the disease may have higher rates of neuroimaging abnormalities.<sup>3</sup>

A systematic review done by JI Guerrero et al. showed that aside from thromboembolic events being the most

common neuroimaging finding, critical neurological events were also more frequent among patients with a severe infection than those with mild disease.<sup>11</sup> RK Garg also noted that patients who had a stroke in their study were under the severe category of COVID-19.<sup>9</sup>

Finally, LB Buttner, in a large cohort of COVID-19-positive patients, analyzed that pathological neuroimaging findings seem to be relatively rare in general but do occur in a substantial proportion of critically ill patients or with severe COVID-19 disease.<sup>8</sup>

Several limitations are noted in this paper. First, cranial MRI was not used among the population studied-- a tool more sensitive and specific for brain abnormalities. Second, small sample size is apparent, limiting its power and external validity. Third, there was no follow-up on the long-term sequelae of abnormal neuroimaging findings. Despite these, the imaging findings extracted from the study show similarity to other published studies abroad, which supports our results.

### Conclusion and Recommendation

Although relatively unusual, the study showed a reasonable incidence of abnormal neuro-radiographic findings among patients with COVID-19 manifesting with neurologic deficits. The most common of which is cerebral infarction followed by macrohemorrhages. Noteworthy in this study is that severity of the disease has shown a correlation in the increased incidence of abnormal neuroimaging among COVID-19 patients.

Cranial CT imaging can reveal parenchymal abnormalities; however, it is still prudent to use cranial MRI in this subpopulation. Larger sample size and a study that challenges long-term sequelae are recommended further to investigate the relationship between abnormal neuroimaging findings and COVID-19.

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