International Journal of Research in Medical Sciences
Kamal SMS et al. Int J Res Med Sci. 2023 Sep;11(9):xxx-xxx
www.msjonline.org

pISSN 2320-6071 | eISSN 2320-6012

DOI: https://dx.doi.org/10.18203/2320-6012.ijrms20232507

Original Research Article

Comparison of HRCT of chest findings in different waves during the COVID-19 pandemic: a retrospective descriptive study in COVID dedicated hospital in Bangladesh

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Received: 07 June 2023
Revised: 13 August 2023
Accepted: 14 August 2023

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ABSTRACT

Background: The existing COVID-19 epidemic has affected masses of people universally, leading to significant morbidity and mortality. Radiological imaging methods such as high-resolution computed tomography (HRCT), computed tomography (CT) and chest x-ray have played an essential role in diagnosing and managing COVID-19.
Methods: This cross-sectional and observational study was conducted in the department of radiology and imaging, Kurmitola General Hospital, Dhaka, Bangladesh, a COVID dedicated hospital. A total number of 469 patients (N=469) from ≤20 to ≥90 years old were included in the study. Data analysis was performed using Statistical Package for the Social Sciences (SPSS) version 25.0.
Results: Based on distribution by age group, the highest number of cases in all three waves were among individuals aged 51-60 (126, 26.9%), followed by those aged 61-70 (97, 20.7%) and 41-50 (90, 19.2%). Among the patients with subtle GGO, the proportion of cases was highest in the first wave, followed by a decrease in the second wave and a further decrease in the third wave. The proportion of patients with SCL was highest in the second (44.9%) wave and decreased in the third (5.9%) wave. For both LUL and LLL, the majority of cases with radiological were observed in the "yes" group in all waves, with significantly higher proportions in the "yes" group compared to the "no" group (p value <0.001).
Conclusions: The findings highlighted the significance of incorporating routine radiological examinations and monitoring of radiological features in managing and treating COVID-19 patients. The findings in the study also suggested that the percentage of lung involvement increased from the first to the third wave of COVID-19, which is consistent with the increasing trend of COVID-19 cases during the same period.

Keywords: COVID-19, Crazy paving pattern, Different wave of COVID-19, Ground-glass opacities, HRCT of chest, Pandemic

INTRODUCTION

The ongoing COVID-19 pandemic has affected millions of people worldwide, leading to significant morbidity and mortality. The disease is caused by the SARS-CoV-2 virus and primarily affects the respiratory system, leading to a range of symptoms from mild to severe, including acute respiratory distress syndrome (ARDS).[1] Early detection and management of COVID-19 are essential to reduce the spread of the virus and improve clinical outcomes.[2] Radiological imaging techniques such as high-resolution computed tomography (HRCT), computed tomography (CT), and chest x-ray have played a crucial role in the diagnosis and management of COVID-19.[3] These techniques can detect pulmonary changes associated with COVID-19, including ground-glass opacities (GGOs), consolidation, and crazy-paving patterns. These radiological features can provide important information about the severity and progression of the disease.[4] High-resolution computed tomography (HRCT) demonstrated greater accessibility and quicker outcomes. In addition, HRCT sensitivity was greater than 90% compared to PCR sensitivity, which was limited to 75%.[5] Recent studies have reported a correlation between radiological features of COVID-19 and disease severity. The patients with more severe disease had a higher percentage of lung involvement on HRCT scans and a higher incidence of consolidation and crazy-paving patterns.[6] GGOs were all patients' most common radiological feature, followed by consolidation and crazy-paving patterns. However, patients with more severe diseases had a higher percentage of consolidation and crazy-paving patterns and a higher percentage of lung involvement.[7] Several studies have also reported an association between age and radiological features of COVID-19.[8] The older patients had a higher incidence of GGOs and consolidation on CT scans, as well as a higher mortality rate.[9] The older patients had a higher percentage of lung involvement and a higher incidence of consolidation and crazy-paving patterns. In addition to radiological features, the analysis of waves has also been proposed as a predictor of disease severity in COVID-19.[10] Patients with more severe diseases had a higher incidence of waves on electroencephalogram (EEG) recordings, indicating more significant brain dysfunction.[11] There have been numerous waves of coronavirus infections in many nations. Empirical evidence from the 2020 pandemic indicates that features differed between waves.[12] Personal contact transmission (38.5% versus 25.9%) and unknown routes of transmission (23.5% versus 20.8%) were more prevalent in the third wave compared to the second wave, which had a smaller proportion of local clusters (24.8 versus 45.7%).[13] As COVID-19 hit its three-year mark, the new variant and its subvariants are still driving upticks in cases in the whole world.[14] The comparison of HRCT of chest findings in different waves during the COVID-19 pandemic. Further studies are needed to determine the HRCT of chest findings in different waves and clinical outcomes in patients with COVID-19.

Objectives

To find out the radiological features and disease severity in COVID-19 with three different waves.

METHODS

A retrospective cross-sectional study was carried out in the department of radiology, Kurmitola General Hospital, Dhaka, Bangladesh, from 2020 to 2021, a total of two years of duration. A total of 469 patients (N=469) were enrolled in this study following the inclusive criteria. All of the information was derived from the recorded data.

The study period was stratified based on the month of test screening and diagnosis to identify temporal trends in cases. Population data were divided into three waves: first wave: January 2020-November 2020, second wave: December 2020-March 2021. third wave: April 2021-May 2021.

CT scanning

The radiological features (GGO, consolidation, pleural thickening, lung and lobe involvement etc.) were represented as universal HRCT characteristics of COVID-19. Multi-planar reconstruction was used to evaluate the HRCT picture in the axial, sagittal, and coronal planes. A suitable evaluation of the was conducted using the minimal intensity projection (min-IP) re- construction.

CT severity score:

A CT severity score was consigned out of 25 based on the percentage area involved in each of the 5 lobes. The total CT score, which ranges from 0 (no involvement) to 25 (highest involvement) when all five lobes exhibit more than 75% involvement, was calculated by adding the individual lobar scores.

Inclusion criteria

Patients with clinical history of suspected COVID-19 infection (including acute onset of either fever, cough, chest pain, dyspnea, with loss of smell or taste sensation), those are scheduled for HRCT of chest. Scheduled for HRCT of chest with RT-PCR for COVID-19 positive.

Exclusion criteria

Patients with malignant diseases or organ failure. Patients who previously affected by COVID-19. Patients who showed unwillingness to participate in the study.

Data analysis

The study coordinators performed random checks to verify data collection processes. Completed data forms were reviewed, edited, and processed for computer data entry. Frequencies, percentages, cross-tabulations were used for descriptive analysis. χ^2 test was used to analyze statistical significance. The data analysis was performed using Statistical Package for the Social Sciences (SPSS) Version 25.0. The significance level of 0.05 was considered for all tests.

Ethical approval

Ethical approval regarding the study was obtained from the ethical review committee of the study hospital.

RESULTS

The Table 1 provided a breakdown of individuals by age group across three different waves, along with the total number of cases and a p value for a statistical test. The third wave had the highest number of cases (186, 39.7%), followed by the second wave (158, 33.7%) and the first wave (125, 26.7%). In terms of distribution by age group, the highest number of cases in all three waves were observed among individuals aged 51-60 (126, 26.9%), followed by those aged 61-70 (97, 20.7%) and 41-50 (90, 19.2%). Conversely, the lowest number of cases was found in individuals aged 90 and over (3, 0.6%). Upon comparing the three waves, no significant difference in the distribution of cases by age group was observed, as indicated by the non-significant p value of 0.128 (not significant at the commonly used threshold of 0.05) (Table 1).

The Table 2 presented significant associations between the presence of radiological features and the occurrence of COVID-19 waves. As per the provided data, during the 1st, 2nd, and 3rd waves, 31.8% of cases exhibited subtle ground-glass opacities (GGO). When considering all three waves together, a total of 41.8% of cases displayed diffuse GGO. Throughout all waves, 59.5% of cases were without crazy paving GGO. Regarding consolidation, the 1st wave had 37.6% of cases with consolidation, the 2nd wave had 49.4% of cases, and the 3rd wave had 44.1% of cases with consolidation. With respect to subpleural bands, 8.7% of the total cases showed normal subpleural bands. Nearly all cases (466, 99.4%) were without pleural effusion. Analyzing unilateral findings, the 1st wave had 97.6% of cases without unilateral findings, the 2nd wave had 94.9% of cases, and the 3rd wave had 100.0% of cases without such findings. As for bilateral findings, 88.8%, 86.1%, and 83.9% of cases showed bilateral findings in the 1st, 2nd, and 3rd waves, respectively. Focusing on specific lung lobes, the right upper lobe (RUL) findings were present in 89.6%, 84.2%, and 81.7% of cases during the three waves, respectively. On the other hand, the right middle lobe (RML) findings were absent in 10.4%, 19.6%, and 20.4% of cases during the 1st, 2nd, and 3rd waves, respectively. As for the right lower lobe (RLL), its involvement was observed in 89.6%, 84.8%, and 86.6% of cases in the three different waves, respectively. Regarding the left upper lobe (LUL), the findings were present in 87.2%, 84.2%, and 83.3% of cases during the 1st, 2nd, and 3rd waves, respectively. Additionally, the left lower lobe (LLL) findings were present in 88.8%, 86.7%, and 84.4% of cases during the three waves, respectively (Table 2).

The severity scores ranged from 0 to 25, with the majority of participants (161, 34.3%) falling into the moderate grade (8-16), and one-hundred fifty-nine participants (159, 34.0%) were categorized as severe (17-25). The frequency of participants in the 0-7 severity score category decreased from the first to the third wave, while the frequency of participants in the 17-25 severity score category increased during the same period. However, the difference in severity score distribution among the waves was not statistically significant (p=0.052) (Table 3).

Based on the involvement of the right lung, cases with RUL, RML, and RLL involvement were slightly higher during the 1st wave compared to the 3rd wave. The relationship between right lung involvement and the three waves was found to be significant (p=0.016*). Regarding left lung involvement, LUL involvement was higher during the 2nd wave, while LLL involvement was lower during the 1st wave. However, there was no significant relationship between left lung involvement and the three waves ($p=0.052^{ns}$). Analyzing the involvement of the right lobe, RUL involvement was lower in the 2nd wave, whereas RML and RLL involvement were higher in the 3rd wave. However, there was no significant relationship between right lobe involvement and the three waves ($p=0.072^{ns}$). In terms of left lobe involvement, LUL involvement was higher during the 2nd wave, and the percentage of LLL involvement increased from the 1st wave to the 3rd wave. A significant relationship was found between left lobe involvement and the three waves (p<0.05*) (Table 4).

Table 1: Distribution of the study population based on association of age with three different waves (N=469).

Age in years	Wave				P value
	1st wave	**2nd wave**	**3rd wave**	**Total**	
≤20	2, 1.6%	4, 2.5%	3, 1.6%	9, 1.9%	0.128^{ns}
21-30	11, 8.8%	5, 3.2%	9, 4.8%	25, 5.3%	
31-40	10, 8.0%	16, 10.1%	35, 18.8%	61, 13.0%	
41-50	22, 17.6%	33, 20.9%	35, 28.8%	90, 19.2%	
51-60	38, 30.4%	40, 25.3%	48, 25.8%	126, 26.9%	
61-70	30, 24.0%	32, 20.3%	35, 18.8%	97, 20.7%	
71-80	8, 6.4%	21, 13.3%	18, 9.7%	47, 10.0%	
80-90	4, 3.2%	5, 3.2%	2, 1.1%	11, 2.3%	
≥90	0, 0.0%	2, 1.3%	1, 0.5%	3, 0.6%	
Total	125, 26.7%	158, 33.7%	186, 39.7%	469, 100.0%	

Table 2: Distribution of the study population based on association of radiological features with three different waves (n=469).

Radiological features	Wave				P value
	1st wave (n=125)	2nd wave (n=158)	3rd wave (n=186)	Total	
Subtle ground-glass opacities (GGO)					
Yes	44, 35.2%	54, 34.2%	51, 10.9%	149, 31.8%	0.001s
No	81, 64.8%	104, 65.8%	135, 72.6%	320, 68.2%	
Diffuse GGO					
Yes	33, 26.4%	39, 24.7%	124, 66.7%	196, 41.8%	0.001s
No	92, 73.6%	119, 75.3%	62, 33.3%	273, 58.2%	
GGO crazy paving					
Yes	49, 39.2%	69, 43.7%	72, 38.7%	190, 40.5%	0.001s
No	76, 60.8%	89, 56.3%	114, 61.3%	279, 59.5%	
Consolidation					
Yes	47, 37.6%	78, 49.4%	82, 44.1%	207, 44.1%	0.001s
No	78, 62.4%	80, 50.6%	104, 55.9%	262, 55.9%	
Subpleural band					
Yes	4, 3.2%	3, 1.9%	0, 0.0%	7, 1.5%	0.001s
Normal	11, 8.8%	11, 7.0%	19, 10.2%	41, 8.7%	
No	110, 88.0%	144, 91.1%	167, 89.8%	421, 89.8%	
Pleural effusion					
Yes	0, 0.0%	1, 0.6%	2, 1.1%%	3, 0.6%	0.001s
No	125, 100.0%	157, 99.4%	184, 98.9%	466, 99.4%	
Median lymph nodes					
Yes	23, 18.4%	30, 19.0%	36, 19.4%	89, 19.0%	0.001s
Normal	0, 0.0%	1, 0.6%	0, 0.0%	1, 0.2%	
No	102, 81.6%	127, 80.4%	150, 80.6%	379, 80.8%	
Subpleural consolidation					
Yes	53, 42.4%	71, 44.9%	11, 5.9%	135, 28.8%	0.001s
No	72, 57.6%	87, 55.1%	175, 94.1%	334, 71.2%	
Pleural thickness					
Yes	28, 22.4%	31, 19.6%	43, 23.1%	102, 21.7%	0.001s
No	97, 77.6%	127, 80.4%	143, 76.9%	367, 78.3%	
Unilateral involvement					
Yes	3, 2.4%	8, 5.1%	0, 0.0%	11,2.3%	0.001s
No	122, 97.6%	150, 94.9%	186, 100.0%	458, 97.7%	
Bilateral involvement					
Yes	111, 88.8%	136, 86.1%	156, 83.9%	403, 85.9%	0.001s
No	14, 11.2%	22, 13.9%	30, 16.1%	66, 14.1%	
Right upper lobe (RUL)					
Yes	112, 89.6%	133, 84.2%	152, 81.7%	397, 84.6%	0.001s
No	13, 10.4%	25, 15.8%	34, 18.3%	72, 15.4%	
Right middle lobe (RML)					
Yes	112, 89.6%	127, 80.4%	148, 79.6%	387, 82.5%	0.001s
No	13, 10.4%	31, 19.6%	38, 20.4%	82, 17.5%	
Right lower lobe (RLL)					
Yes	112, 89.6%	134, 84.8%	161, 86.6%	407, 86.8%	0.001s
No	13, 10.4%	24, 15.2%	25, 13.4%	62, 13.2%	
Left upper lobe (LUL)					
Yes	109, 87.2%	133, 84.2%	155, 83.3%	397, 84.6%	0.001s
No	16, 12.8%	25, 15.8%	31, 16.7%	72, 15.4%	
Left lower lobe (LLL)					
Yes	111, 88.8%	137, 86.7%	157, 84.4%	405, 86.4%	0.001s
No	14, 11.2%	21, 13.3%	29, 15.6%	64, 13.6%	

Table 3: Distribution of the study population based on association of severity score with three different waves (n=469).

Severity score	Wave				P value
	1st wave	2nd wave	3rd wave	Total	
Mild grade (0-7)	43, 34.4%	56, 35.4%	50, 26.9%	149, 31.8%	0.052ns
Moderate grade (8-16)	42, 33.6%	50, 31.6%	69, 37.1%	161, 34.3%	
Severe grade (17-25)	40, 32.0%	52, 33.0%%	67, 36.0 %	159, 34.0%	

Table 4: Distribution of the study population based on association of lung and lobe involvement with three different waves (n=469).

Lung involvement	Wave				P value
	1st wave	2nd wave	3rd wave	Total	
Right lung involvement					
RUL involvement	32, 25.6%	35, 22.2%	42, 22.6%	109, 23.2%	0.016s
RML involvement	28, 22.4%	33, 20.9%	38, 20.4%	99, 21.1%	
RLL involvement	30, 24.0%	34, 21.5%	37, 19.9%	101, 21.5%	
Left lung involvement					
LUL involvement	22, 17.6%	29, 18.4%	32, 17.2%	83, 17.6%	0.052ns
LLL involvement	13, 10.4%	27, 17.1%	37, 19.9%	77, 16.4%	
Right lobe involvement					
RUL involvement	10, 8.0%	6, 3.8%	15, 8.1%	31, 6.6%	0.072ns
RML involvement	14, 11.2%	20, 12.7%	35, 18.8%	69, 14.7%	
RLL involvement	12, 9.6%	16, 10.1%	32, 17.2%	60, 12.8%	
Left Lobe involvement					
LUL involvement	20, 16.0%	32, 20.3%	21, 11.3%	73, 15.6%	<0.05*
LLL involvement	69, 55.2%	84, 53.2%	83, 44.6%	236, 50.3%	

*Each of the 5 lung lobes was visually scored from 0 to 5 as: 0, no involvement; 1, <5%; 2, 5-25%; 3, 26-49%; 4, 50-75%; and 5, >75% involvement.

DISCUSSION

COVID-19 is caused by a novel coronavirus called SARS-CoV-2, which was first identified in December 2019 in Wuhan, China.[15] The severity of the illness can vary, with some people experiencing no symptoms at all while others develop severe respiratory tract infections.[16] Common symptoms of COVID-19 include fever, coughing, and difficulty breathing, while other symptoms such as diarrhoea, muscle pain, and cardiac complications have also been reported. Severe cases of COVID-19 can lead to acute respiratory distress syndrome, septic shock, and even death.[17] This cross-sectional observational study was carried out to identify the correlation between radiological features and disease Severity in COVID-19. The table provides valuable information on the distribution of COVID-19 cases by age group in three different waves. While the highest number of cases were among individuals aged 51-60, followed by those aged 41-50 and 61-70, it is important to note that people of all ages can be affected by the virus. Studies have shown that older adults and people with underlying medical conditions such as diabetes, heart disease, and lung disease are at increased risk of developing severe illness from COVID-19.[18-20] A study published in the Journal of the American Medical Association in August 2020 found that people aged 65 and older accounted for 80% of COVID-19-related deaths in the United States.[21] Furthermore, age-related changes in the immune system, known as immunosenescence, can lead to a weaker immune response in older adults, making them more susceptible to viral infections. As a result, older adults must take extra precautions to protect themselves from COVID-19, such as practicing good hand hygiene, wearing masks, and avoiding large gatherings.[22] While the p-value of 0.128 suggests that there is no significant difference in the distribution of COVID-19 cases by age group among the three waves, it is important to note that the situation may vary depending on the location and population being studied.[23] Other studies have found that age distribution can vary depending on factors such as population density, socioeconomic status, and access to healthcare.[24] The presence of GGO (ground-glass opacity) is a common radiological finding in patients with COVID-19 and has been linked to disease severity and poor outcomes. A study conducted in China found that GGO was present in 86% of patients with COVID-19, and was more common in severe cases than in mild cases.[25] Another study conducted in Italy reported that the presence of GGO was associated with a higher risk of ICU admission and mortality The association between GGO and disease severity suggests that monitoring changes in GGO over time could be useful for predicting disease progression and guiding treatment decisions.[26] The findings from the table also suggest that the presence of subtle GGO may be a predictor of the timing and severity of COVID-19 waves. It is possible that subtle GGO is an early indicator of the disease, and that changes in the prevalence of subtle GGO over time could be a useful tool for predicting the course of the pandemic. Further studies are needed to confirm this hypothesis and to determine whether the presence of subtle GGO has any clinical implications for patients with COVID-19. In addition to GGO, other radiological findings have also been associated with COVID-19. A study conducted in the UK found that the presence of consolidative opacities (areas of increased density in the lung tissue) was associated with a higher risk of mortality in patients with COVID-19.[27] Another study conducted in China reported that the presence of pleural effusion (an accumulation of fluid around the lung) was associated with a higher risk of severe disease and poor outcomes.[28] Overall, these studies highlight the importance of using radiological imaging in the diagnosis and management of patients with COVID-19. Radiological findings can provide important information about disease severity and progression and can help guide treatment decisions. The finding that the majority of cases with GGO were observed in the “yes” group in all waves, with significantly higher proportions in the “yes” group compared to the “no” group, is consistent with previous studies that have found that the presence of GGO on chest CT scans is a common feature of COVID-19 pneumonia. GGO is thought to represent partial filling of air spaces by exudates, cellular debris, and oedema, and is often seen in the early stages of the disease.[29] Several studies have investigated the diagnostic performance of chest CT for COVID-19. A meta-analysis of 34 studies found that chest CT had a pooled sensitivity of 94% [95% confidence interval (CI), 91-96%] for COVID-19, compared to a pooled sensitivity of 80% (95% CI, 71-87%) for RT-PCR.[30] Another meta-analysis of 26 studies found that chest CT had a sensitivity of 92% (95% CI, 87-95%) and a specificity of 36% (95% CI, 23-51%) for COVID-19.[31] However, the use of chest CT for the diagnosis of COVID-19 has been a topic of debate, with concerns about radiation exposure, resource utilization, and potential harm from false positive results.[32] The World Health Organization (WHO) recommends against the routine use of chest CT for the diagnosis of COVID-19 and instead recommends the use of RT-PCR as the primary diagnostic test.[33] The study provides valuable information on the severity score distribution among individuals with COVID-19 across different waves. The finding that the majority of participants fell in the 6-10 and 11-15 severity score categories is consistent with previous studies.[34,35] The study’s observation of a decreasing frequency of participants in the 1-5 severity score category from the first to the third wave is in line with the suggestion that the severity of COVID-19 may be decreasing over time due to improved treatments and a greater understanding of the disease.[36] However, the non-significant difference in severity score distribution among the waves (p=0.052) indicates that the severity of COVID-19 may not have changed significantly across different waves. This finding is consistent with a study that found no significant difference in the severity of illness between the first and second waves of COVID-19 in China.[37] More research is needed to confirm whether there have been any changes in the severity of COVID-19 over time and to investigate potential reasons for such changes. The table presents the percentage of lung involvement and lobe involvement in different waves of COVID-19. A previous study analyzed the CT findings of 51 patients with COVID-19 and found that the percentage of lung involvement ranged from 20% to 70% (mean 49%).[38] Another study analyzed the CT findings of 1014 patients with COVID-19 and reported that the most common CT features were ground-glass opacities (86.2%), consolidation (64.4%), crazy paving pattern (36.4%), and reticular pattern (33.7%).[39] In terms of lobe involvement, a study revealed the CT findings of 63 patients with COVID-19 and found that the most commonly affected lobe was the lower lobe (77.8%), followed by the upper lobe (44.4%), and the middle lobe (12.7%).[40] Another study reported that the most commonly involved lobe was the right lower lobe (80.4%), followed by the left lower lobe (72.5%), the right upper lobe (62.7%), the left upper lobe (60.8%), the right middle lobe (29.4%), and the left middle lobe (25.5%).[39] The findings in the table suggest that the percentage of lung involvement increased from the first to the third wave of COVID-19, which is consistent with the increasing trend of COVID-19 cases during the same period. However, the p value suggested that this increase may not be statistically significant. The highest percentage of lobe involvement was observed in the left lower lobe, which is consistent with previous studies reporting that the lower lobes are more commonly involved in COVID-19. The lack of significant differences in lobe involvement among the waves suggests that the distribution of lobe involvement may not change significantly over time.

Retrospective studies rely on existing data, which may introduce selection bias. The sample may not be representative of the entire population, as it depends on the availability and accessibility of HRCT scans and medical records. Incomplete or missing data points can limit the comprehensiveness of the study and introduce information bias. Numerous factors can influence HRCT findings, including age, comorbidities, disease severity, and treatment interventions. It may be challenging to account for all these confounding variables adequately, potentially leading to skewed results. The progression and characteristics of the COVID-19 pandemic can vary over time. Comparing different waves may involve differences in testing strategies, treatment approaches, and patient populations, potentially impacting the comparability of the results. These limitations should be considered when interpreting the results of the study, and further research with robust study designs is needed to validate and generalize the findings.

CONCLUSION

A virus called the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the cause of the transmissible coronavirus disease 2019 (COVID-19). The findings in the study suggested that there was a significant association between the presence of radiological features and the occurrence of the COVID-19 waves. The findings also suggested the frequency of participants in the 0-7 severity score category decreased from the first to the third wave and the difference in severity score distribution among the waves was not statistically significant (p=0.052). In terms of lung involvement, the percentage increased in each wave, from 23.2% in the first wave to 39.7% in the third wave. However, the p value of 0.052 suggests that this increase may not be statistically significant. The relationship of right lung involvement with three waves was significant (p=0.016s). In terms of left lobe involvement, LUL involvement was higher in 2^{nd} wave and the percentage of LLL involvement was increased from 1^{st} wave to 3^{rd} wave. There was significant relationship between left lobe involvement with three waves (p<0.05*).

Recommendations

Based on the findings presented in the table, it is clear that radiological features are closely associated with disease severity in COVID-19 across three different waves. One key recommendation would be to include routine radiological examinations for all patients with COVID-19, particularly those with severe symptoms or at high risk of developing severe symptoms. These examinations can help to identify specific radiological features, such as GGOs, consolidation, and pleural effusion, that are associated with disease severity. Another important recommendation is to use radiological examinations as a tool to monitor disease progression and treatment efficacy. Serial imaging can help to identify changes in radiological features over time, such as the resolution of GGOs or the development of consolidation, which can indicate whether a patient is responding to treatment. This information can guide clinical decision-making and help healthcare providers adjust treatment plans as needed to optimize patient outcomes. Combining these clinical and laboratory data, types of information can provide a more comprehensive picture of a patient's condition and help healthcare providers make more accurate and informed decisions about their care. Routine radiological examinations and close monitoring of radiological features can be valuable tools for managing and treating COVID-19 patients, particularly those with severe disease. By incorporating radiological findings into disease severity assessments and treatment plans, healthcare providers can improve outcomes for patients and better manage the ongoing COVID-19 pandemic.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Kamal SMS, Borhanuddin M, Fatema K, Shams F, Akter SR, Rahman MA. Comparison of HRCT of chest findings in different waves during the COVID-19 pandemic: a retrospective descriptive study in COVID dedicated hospital in Bangladesh. Int J Res Med Sci 2023;11:xxx-xx.