ScientificScholar®
Knowledge is power
Publisher of Scientific Journals

Cardiopulmonary Imaging   *Review Article*

CO-RADS: Coronavirus Classification Review

Diana Penha[1], Erique Guedes Pinto[2], Fernando Matos[3], Bruno Hochhegger[4,5], Colin Monaghan[1], Luís Taborda-Barata[6,7], Klaus Irion[8], Edson Marchiori[9]

[1]Department of Radiology, Liverpool Heart and Chest Hospital NHS Foundation Trust, [2]Faculty of Health Sciences, University of Beira Interior, Covilhã, Portugal, [3]Department of Radiology, Centro Hospitalar Tondela-Viseu, Viseu, Portugal, [4]Department of Radiology, Hospital São Lucas da Pontifícia Universidade Catolica do Rio Grande do Sul, Escola de Medicina, Porto Alegre, Brazil, [5]Department of Radiology, Universidade Federal de Ciências da Saúde de Porto Alegre, Porto Alegre, Brazil, [6]Department of Immunoallergology, Cova da Beira University Hospital Centre, Covilhã, Portugal, [7]Faculty of Health Sciences, University of Beira Interior, Covilhã, Portugal, [8]Department of Radiology, Manchester University NHS Foundation Trust, Manchester, United Kingdom, [9]Department of Radiology, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil.

*Corresponding author:

Diana Penha,
Department of Radiology,
Liverpool Heart and Chest
Hospital NHS Foundation
Trust, United Kingdom.

dianapenha@gmail.com

Quick Response Code:

ABSTRACT

In mid-January of 2021, there were over 95 million diagnosed coronavirus disease 2019 (COVID-19) cases and approximately 2 million deaths worldwide. COVID-19 cases requiring hospitalization or intensive care show changes in computed tomography of the chest with improved sensitivity. Several radiology societies have attempted to standardize the reporting of pulmonary involvement by COVID-19. The COVID-19 Reporting and Data System (CO-RADS) builds on lessons learned during the peak of the first wave of the pandemic and shows good inter-observer reliability and good performance in predicting moderate to severe disease. We illustrate the application of the CO-RADS classification with imaging from confirmed cases of COVID-19 and discuss differences to other COVID-19 classifications.

Keywords: Coronavirus disease 2019, Coronavirus disease 2019 reporting and data system, Standards, Reporting, Chest, CT

INTRODUCTION

The diagnosis of pulmonary involvement by coronavirus disease 2019 (COVID-19) is based on the presence of typical symptoms (i.e., fever, dry cough, myalgia or fatigue, sputum production, headache, and shortness of breath), changes on chest imaging and confirmation by the demonstration of the virus RNA from a variety of possible samples using reverse-transcriptase polymerase chain reaction (RT-PCR) assays.[1,2]

While most patients with SARS-CoV-2 infection will be asymptomatic or have mild disease, severe COVID-19 may develop with pneumonia, pulmonary edema, acute respiratory distress syndrome, multiple organ failure, and even death.[2,3]

Several studies have reported RT-PCR assays' sensitivities for SARS-CoV-2 between 37% and 83%. The usefulness of RT-PCR assays is impacted by false-positive and false-negative results and limited availability of tests in some high-prevalence countries. Multiple reports show patients with positive findings on chest CT scans with a negative RT-PCR assay, which only later becomes positive.[1,4,5]

Chest CT sensitivity for COVID-19 has been reported between 80% and 90%, and specificity between 82.9% and 96% (higher than the RT-PCR assay), which underlines the need to

recognize, interpret, and communicate the imaging findings pertaining to the lungs.[6] CT findings, such as consolidation, linear opacities, crazy-paving, bronchial wall thickening, and elevated CT severity scores, have been linked to worst prognosis and the need for intensive care support.[7,8]

However, there is a significant overlap in imaging findings between COVID-19 and other infectious diseases, especially when we move past the first peak of the pandemic and into seasonal pandemics like influenza.[2,5,6]

Chest radiograph has been advocated by most international radiological societies as the first-line imaging modality to assess possible pulmonary involvement by COVID-19. The Fleischer Society suggests CT imaging as the first-line imaging modalities only in worsening patients or patients with functional and/or hypoxemia after recovery from COVID-19. Chest radiograph is insensitive in mild or early-stage disease but is useful for the diagnosis of more advanced disease or for the follow-up of hospitalized patients. Thus, the usefulness of chest radiograph is linked to national policies regarding the COVID-19 pandemic, meaning that, in countries where the public advice was for the patients to go to the hospital early (e.g., China), chest CT is preferred because a chest radiograph would have low sensitivity; while in countries where patients were encouraged to self-isolate before going to the hospital (e.g., in Europe), patients would present with an abnormal chest radiograph.[5]

The number of chest CT scans performed in patients under investigation for COVID-19 has increased during the pandemic, reflecting the increased understanding of the disease and its imaging findings. Precise and accurate communication of imaging findings is essential for effective epidemiological measures to control the pandemic. In March of 2020, the Radiological Society of North America (RSNA) proposed an initiative to standardize COVID-19 reporting.[9] The British Society of Thoracic Imaging (BSTI) proposed a similar initiative while also adding a descriptor for disease severity, making the distinction between mild and moderate/severe disease, although this effort is not based on evidence regarding patient outcome.[10-12] Most international radiological societies developed guidance based on these statements from RSNA and BSTI, which differ between each other in subtle but significant ways.

COVID-19 Reporting and Data System (CO-RADS) is another initiative for standardization, published in mid-March of 2020, which differs from the RSNA's approach as it is based in previous efforts such as Lung-RADS, PI-RADS, and BI-RADS, which grades the findings on how likely the diagnosis of COVID-19 is. This system was evaluated using 105 randomly selected chest CT scans of patients admitted to the emergency department with clinical suspicion of COVID-19.

It also promotes clear, descriptive terms that reduce report ambiguity, offer good performance in predicting moderate-to-severe disease and have a good interobserver agreement.[4,13,14]

In this review, we aim to describe the CO-RADS classification, provide illustrative examples, and discuss potential pitfalls that may arise from its application into clinical practice.

CO-RADS CLASSIFICATION

The CO-RADS assessment scheme allows for the categorization of a given non-enhanced chest CT scan into groups related to the likelihood of a patient having confirmed COVID-19 with lung involvement. The system was developed and tested in patients with moderate-to-severe clinical disease.

The main strength of this classification is its ease of use, which results in a moderate to substantial agreement among observers (Fleiss' kappa of 0.47 [95% CI 0.46–0.49]), even among radiologists with different experience. Another important strength of the classification is its capability to discriminate between radiological findings related to a low and high probability of COVID-19, tested against both a clinical diagnosis and positive results for RT-PCR assays.

There are seven categories of CO-RADS. Categories 1 to 6 follow an increasing risk for COVID-19, from very low risk (CO-RADS 1) to proven infection by a positive RT-PCR assay (CO-RADS 6).

CO-RADS 0

This CO-RADS category means that the scan does not have the diagnostic quality that would allow the reporting radiologist to either attribute or exclude one of the other CO-RADS categories (e.g., due to severe artifacts or missing parts of the lung). It should not be interpreted as a final assessment and should lead to a repeat scan if possible.

CO-RADS 1

The CO-RADS 1 category includes cases with either a normal chest CT scan or one that has abnormalities unequivocally attributed to non-infectious diseases. Findings that would justify this assessment include emphysema, perifissural nodules, lung tumors, or fibrosis. The presence of interlobular interstitial thickening with pleural effusion should be included in this category if interpreted as representing interstitial pulmonary edema [Figure 1].

This category implies a very low level of suspicion for pulmonary involvement by COVID-19.

CO-RADS 2

The CO-RADS 2 category includes cases with radiological findings in keeping with infectious diseases not compatible

with COVID-19, but that are typical of other lung infections, such as bronchitis, bronchiolitis, bronchopneumonia, centrilobular ground-glass opacities, lobar pneumonia, or pulmonary abscesses. Radiological signs such as tree-in-bud, centrilobular nodular pattern, lobar or segmental consolidation, and cavities should suggest diseases other than COVID-19, which must be presented as the most likely diagnosis [Figures 2 and 3].

This category implies a low level of suspicion for pulmonary involvement by COVID-19.

CO-RADS 3

The CO-RADS 3 category includes radiological findings associated with lung involvement of COVID-19, but that are also found in other viral pneumonias and non-

infectious diseases of the lungs. Findings that would justify the inclusion in this category include peri-hilar ground-glass, homogeneous, and extensive ground-glass opacities, ground-glass opacities associated with interlobular interstitial thickening and patterns of organizing pneumonia if other typical findings of COVID-19 are absent [Figures 4 and 5]. Sparing of some secondary pulmonary lobules may be present, as can pleural effusion if associated with ground-

Figure 3: CO-RADS 2 with tree-in-bud sign. A 27-year-old male attended the emergency department with a cough and fever. The CT images depicted a cavitating lesion in the superior segment of the right lower lobe with adjacent tree-in-bud centrilobular nodules, and extensive unilateral hilar, sub-carinal, and right paratracheal adenopathy. This patient was confirmed to have active pulmonary tuberculosis.

Figure 1: CO-RADS 1 with emphysema and bronchial wall thickening. A 54-year-old male with known chronic obstructive pulmonary disease (COPD), recent worsening shortness of breath and persistent tachycardia. The chest CT shows extensive centrilobular and paraseptal emphysema (black arrow) and bilateral bronchial wall thickening (white arrow). Shortness of breath in this patient was interpreted as related to underlying COPD.
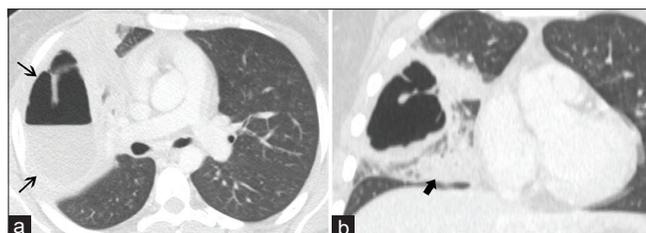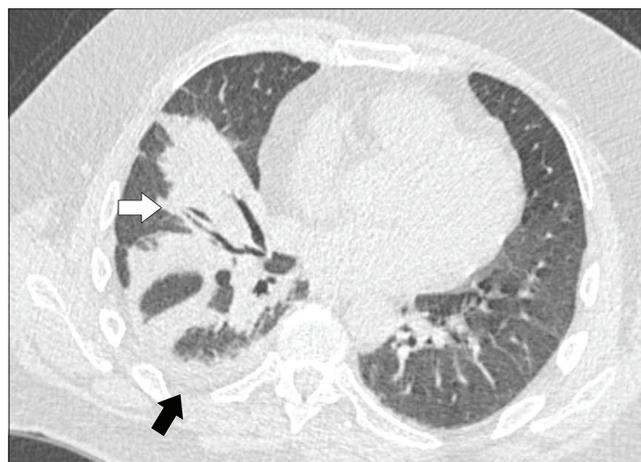

Figure 2: (a and b) CO-RADS 2 with cavitated lesion and lobar consolidation. A 27-year-old female was admitted with shortness of breath, productive cough, and hemoptysis. The chest CT depicted a thick wall cavitated lesion (thin arrows) with a fluid level and right middle lobe consolidation (thick arrow). This was confirmed to be an aspergillus cavity with associated intra-cavitary bleeding.

Figure 4: CO-RADS 3 with unilateral peribronchovascular consolidation with no ground-glass opacities. A 51-year-old male presented at the hospital with abdominal pain and vomiting, being later admitted to an intensive care unit and ventilated. CT scan showed a pattern of peribronchovascular consolidation on the right (white arrow) without other typical findings of COVID-19, loss of volume of the right lower lobe and small right-sided effusion (black arrow). The patient had one positive and two negative swab tests for SARS-CoV-2.

glass opacities that are not centrilobular or not located near the visceral pleura.

This category implies equivocal findings for pulmonary involvement by COVID-19.

CO-RADS 4

This category includes findings that, while typical for COVID-19, have some overlap with other viral pneumonias. Findings in this category are the same as in the category CO-RADS 5 but with an atypical distribution, specifically lack of contact with the visceral pleura, strictly unilateral [Figure 6], predominantly peribronchovascular [Figures 7 and 8] or when the findings are superimposed on severe and diffuse pre-existing pulmonary changes.

Figure 5: CO-RADS 3 with subtle ground-glass opacities and subpleural peripheral line. A 48-year-old female with atypical findings of subtle bilateral ground-glass opacities and subpleural peripheral lines in the posterior segments of both lower lobes (arrows). There was no fever or shortness of breath. The patient later tested positive on the nasopharyngeal swab for SARS-CoV-2.
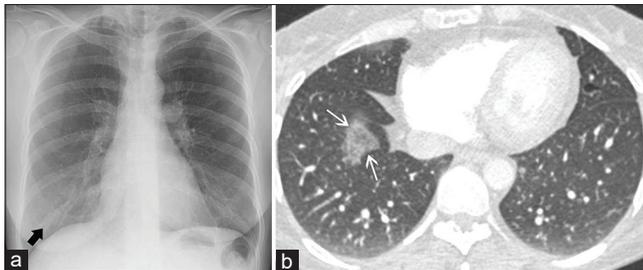

Figure 6: (a and b) CO-RADS 4 with unilateral distribution. A 45-year-old female with a previous history of pulmonary embolism, presented with left-sided dull chest pain and worsening cough. The chest radiograph was interpreted as possible basal pneumonia (thick arrow). A chest CT was requested to rule out pulmonary embolus depicts unilateral ground-glass and a subtle reversed halo sign in the right lung base (thin arrows). The patient was later confirmed to have a positive RT-PCR test for SARS-CoV-2.

This category implies a high level of suspicion for pulmonary involvement by COVID-19.

CO-RADS 5

The findings associated with this category can be broken down into two groups: Mandatory features, which must be present in all cases, and confirmatory patterns of features. At least one confirmatory pattern must be present.

Mandatory features include ground-glass opacities, with or without consolidation, located near visceral pleural surfaces
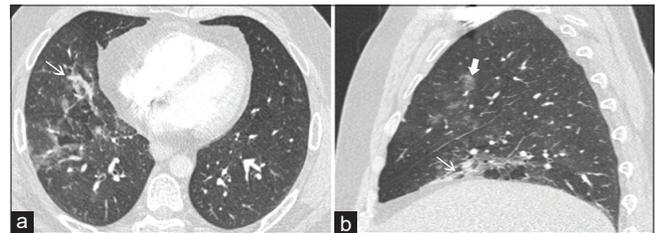

Figure 7: (a and b) CO-RADS 4 with unilateral and peribronchovascular distribution. A 51-year-old male was admitted with a 3-week history of symptoms consistent with COVID-19, later confirmed by swab test. He presented with worsening shortness of breath in the past 2 days. The chest CT shows unilateral ground-glass opacities (thick arrow) with subtle peribronchovascular consolidation in keeping with organizing pneumonia (thin arrows).

Figure 8: CO-RADS 4 with peribronchovascular distribution. A 60-year-old male with shortness of breath and decreased O_2 saturation attended the hospital. The chest CT shows ground-glass opacities with unsharp demarcation and predominant peribronchovascular distribution (arrow). The scan also demonstrates other areas of ground-glass opacities touching the visceral pleural surface and no significant crazy-paving pattern (not shown). Although this case had all mandatory features and one of the confirmatory patterns of CO-RADS 5, it also presents an atypical distribution, in this case, predominantly peribronchovascular.

(including the fissures), and multifocal bilateral distribution. Subpleural sparing is allowed.

There are three confirmatory patterns, which typically occur at different times along the course of the disease. At an early stage, this pattern presents multiple ground-glass areas, which can be rounded or half-rounded in shape and have unsharp demarcation, or multiple and sharply limited ground-glass areas outlining the limits of multiple adjacent secondary pulmonary lobules. Somewhat later in the course of the disease, visible intra-lobular interstitial thickening associated with the ground-glass opacities form a "crazy paving" pattern. At a later stage, the pattern evolves to one compatible with organizing pneumonia, which includes the reversed halo sign, ground-glass consolidation associated with extensive subpleural consolidations and air bronchogram, curvilinear subpleural bands, and bands
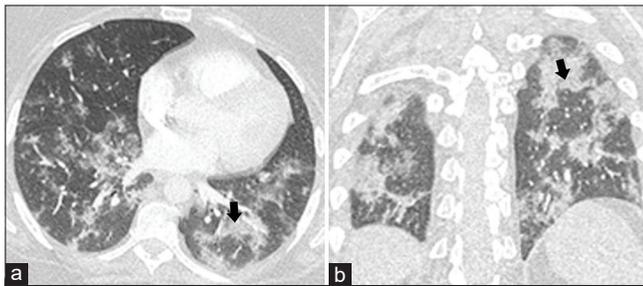
of ground-glass with or without consolidation, but with an arching pattern with pleural contact (i.e., arcade-like sign) [Figures 9-16].

Thickened vessels may occur in any of these confirmatory patterns [Figure 13].

Figure 9: CO-RADS 5 with round, unsharp demarcation of ground-glass opacities. A 41-year-old male with a background of asthma, and with a week-long history of cough and fever, decreased O_2 saturation, central cyanosis, widespread crackles. Imaging findings show bilateral ground-glass opacities, round, unsharp demarcation, and some perilobular distribution (arrows), in keeping with CO-RADS 5, with the confirmatory pattern usually seen in the early stages of the disease.
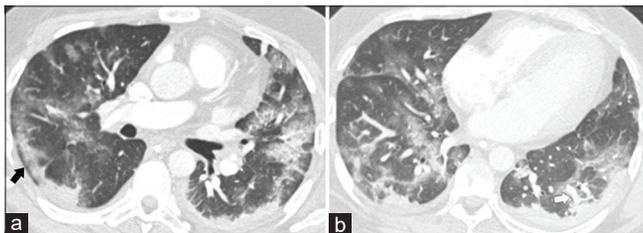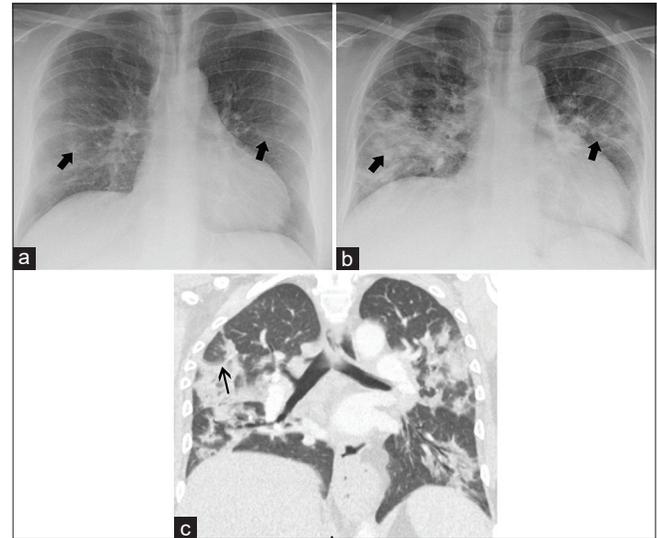

Figure 10: (a and b) CO-RADS 5 with organizing pneumonia pattern, subpleural sparing, and thickened vessels. A 26-year-old male admitted with COVID-19 symptoms (negative RT-PCR for SARS-CoV-2 but high suspicion on the chest radiograph). A sudden deterioration overnight required intubation and transfer to an intensive care unit. A CT scan performed to rule out pulmonary embolism shows ground-glass opacities, and areas of consolidation, close to visceral pleural surfaces (including the fissures), with subpleural sparing (black arrow), multifocal, bilateral and peri-lobular distribution (organizing pneumonia pattern), and evidence of thickened vessels (white arrow) in the lung bases.

Figure 11: CO-RADS 5 with organizing pneumonia pattern. A 54-year-old female admitted with shortness of breath and low pO_2. (a) Chest radiograph shows subtle ground-glass opacities (arrows), (b) which later coalesced around small areas of consolidation on the chest radiograph (thick arrows). (c) Chest CT scan performed afterward shows consolidative changes with peribronchovascular distribution, bilaterally, with the arcade-like sign (thin arrow), in keeping with organizing pneumonia.
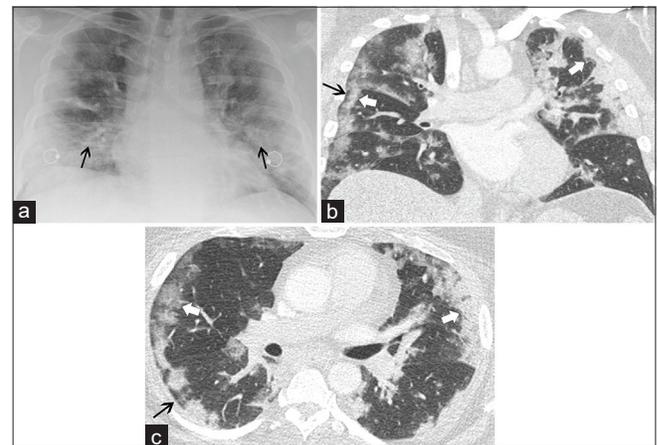

Figure 12: (a-c) CO-RADS 5 with subpleural sparing. A 44-year-old male was admitted with a 10-day history of dry cough, fever, worsening shortness of breath and malaise, requiring supplemental O_2. First chest radiograph was already in keeping with suspicious findings, and chest CT confirmed peripheral distribution of ground-glass areas and consolidations (white arrows), with subpleural sparing on the right side (black arrow).
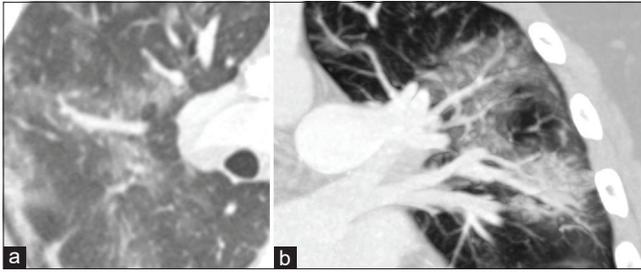
Figure 13: (a and b) Vascular thickening in CO-RADS 5. Vascular thickening is often seen in areas of pulmonary involvement by COVID-19 and may be present in any of the confirmatory patterns of CO-RADS 5.
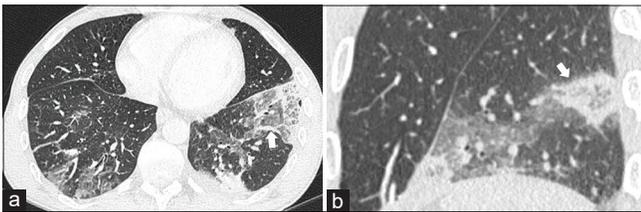

Figure 14: (a and b) CO-RADS 5 with bilateral ground-glass opacities, subpleural sparing reversed halo sign, and crazy-paving. A 45-year-old male admitted with shortness of breath, cough, and hemoptysis. Initial RT-PCR test for SARS-CoV-2 was negative, but eventually, COVID-19 was confirmed by subsequent swab only after the chest CT scan which showed pulmonary embolism, subpleural sparing on the right, and reversed halo sign on the left lung with ground-glass and crazy-paving pattern (arrow).

This category implies a very high level of suspicion for pulmonary involvement by COVID-19.

CO-RADS 6

The CO-RADS 6 category indicated proven COVID-19 after a positive RT-PCR for the SARS-CoV-2 virus.

DISCUSSION

A comparison with previously published guidelines is essential to clarify some pitfalls and confusion, which may lead to miscategorized scans. The RSNA consensus statement describes four categories for COVID-19 pneumonia imaging classification. These are typical appearance, indeterminate appearance, atypical appearance, and negative for pneumonia.[9] There is largely a one-to-one relation between the CO-RADS 1 category and the "negative for pneumonia," between the CO-RADS 2 category and the "atypical appearance" RSNA category, as well as between the CO-RADS 5 category and the "typical appearance" RSNA category. There is partial overlap between the CO-RADS 3 and 4 categories and the "indeterminate appearance" RSNA category.[4] Regarding the BSTI guideline statement category, it has some similarities with the RSNA category since it has also four categories: Non-COVID (70% confidence for
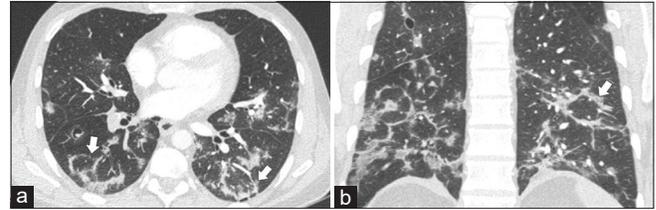

Figure 15: (a and b) CO-RADS 5 with organizing pneumonia pattern. A 34-year-old male, presented with isolated low-grade fever, tachycardia, and shortness of breath. Chest CT scan shows bilateral changes with a confirmatory pattern with organizing pneumonia with a peri-lobular distribution (arrows).
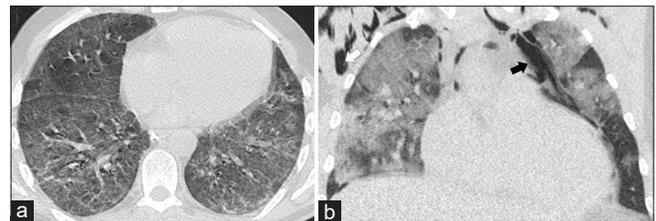

Figure 16: CO-RADS 5 in an intubated patient, complicated with pneumomediastinum. A 44-year-old female admitted for COVID-19. (a) Initial chest CT scan shows diffuse bilateral ground-glass opacities with extensive coverage of the lung parenchyma and focal areas of mosaic pattern. The patient underwent invasive ventilation. (b) Chest CT scan from 1 week later shows progression with consolidation and extensive pneumomediastinum (black arrow) and subcutaneous emphysema (white arrow) as a complication of mechanical ventilation.

alternative); indeterminate (<70% confidence for COVID); Probable COVID-19 (71–99% confidence for COVID); and Classic COVID-19 (100% confidence for COVID). One aspect that should be stated is that unlike the RSNA consensus, the BSTI guideline takes into consideration the existence of the previous cardiopulmonary diseases, which downgrade the "Classic" and "Probable" categories, resulting in a higher specificity for the BSTI and a higher sensitivity for the RSNA consensus statement.[13] Table 1 summarizes the similarities and differences between CO-RADS, the RSNA consensus statement and the BSTI guideline statement category.

Unlike BI-RADS, where BI-RADS 1 category describes normal findings only, CO-RADS 1 category allows for benign changes, which are frequent in the lung. In this sense, CO-RADS 1 category is like Lung-RADS 1 or BI-RADS 2 categories which includes changes suggestive of a benign etiology.[4]

The presence of smooth interlobular septal thickening may fit CO-RADS 1 or CO-RADS 3 categories, depending on the perceived underlying cause. The rationale is to factor out cardiac causes for the interstitial thickening, and as such, the presence of interlobular interstitial septal thickening should be categorized as CO-RADS 1 if interpreted as related

to pulmonary edema, or as CO-RADS 3 in the presence of ground-glass opacities mimicking pulmonary involvement by COVID-19.[4]

The presence of ground-glass opacities is included in the CO-RADS 3 category, unless centrilobular in distribution (CO-RADS 2), located close to the visceral pleura (CO-RADS 4), or to the fissures, if bilateral and multifocal in distribution (CO-RADS 5).[4]

The CO-RADS 5 category must include ground-glass opacities with or without consolidation, located near pleural surfaces, and allowing for subpleural sparing. The typical distribution also includes regions near the fissures, but unlike the RSNA or the BSTI classification, the CO-RADS assessment scheme does not emphasize lower lobe predominance. In addition to these mandatory features, findings must also include at least one confirmatory pattern, which is in line with the changing imaging presentation of COVID-19 throughout the course of the disease.[4]

The natural disease progression of COVID-19 has been recognized as encompassing several stages. The rapid advice guidelines from the Wuhan University described five stages of the disease: The ultra-early stage, the early stage, the rapid progression stage, the consolidation stage, and the dissipation stage.[14] The CO-RADS assessment scheme describes three stages of the disease: An early stage where ground-glass regions predominate, followed by a stage where visible intra-lobular lines define a crazy-paving pattern, and finally followed by the pattern resembling organizing pneumonia. All the confirmatory patterns of pulmonary involvement show variable evidence of thickened vessels within abnormal parenchyma, reflecting its cardiovascular involvement.[4,15]

Comparing with the guidelines from Wuhan, the CO-RADS assessment scheme emphasizes the presence of these imaging findings, where the guidelines from Wuhan recognize that these findings do not appear in isolation and present considerable overlap in time.[14] However, the CO-RADS assessment scheme does not try to infer on the progression of the disease, but instead uses the known patterns of disease as confirmation of a very high likelihood of the diagnosis.[4]

The category CO-RADS 4 differs from the category CO-RADS 5 in its distribution, meaning that it is either unilateral or not in contact with the visceral pleura, is predominantly peribronchovascular or there are pre-existing severe pulmonary abnormalities which may justify a weaker confidence on the diagnosis.[4]

Table 2 summarizes the discriminating imaging findings of the CO-RADS classification.

The main strengths of CO-RADS are its interobserver agreement and its ability to distinguish between low and high-probability of COVID-19. Interobserver agreement is the highest when categorizing CO-RADS 1 and CO-RADS 5 (Fleiss' kappa of 0.58 and 0.68, respectively). In the initial study, 80% of observations agreed between cases belonging to either low to very low risk (CO-RADS 1 or 2), or high to very high risk of COVID-19 (CO-RADS 4 or 5). The overall interobserver agreement of the CO-RADS assessment scheme (kappa of 0.47) lies between the values for PI-RADS (kappa of 0.24) and Lung-RADS (kappa of 0.67).[4]

This was, however, a small study with only 105 patients with clinical suspicion of COVID-19 and moderate-to-severe symptoms. The study was also performed close to the peak

Table 1: Comparison between different chest CT classification systems in COVID-19.

Coronavirus disease 2019 level of suspicion	CO-RADS	RSNA	BSTI
Not interpretable	CO-RADS 0	Not categorized	Not categorized
Very low	CO-RADS 1 - normal scan/non-infectious	Negative for pneumonia	Non-COVID (Level of confidence for alternative: 70%)
Low	CO-RADS 2 - typical for other infections	Atypical appearance (uncommon/not reported features for COVID)	
Unsure/equivocal	CO-RADS 3: Features compatible with COVID but present in other diseases	Indeterminate appearance (non-specific features of COVID-19)	Indeterminate (Level of confidence for COVID: <70%)
High	CO-RADS 4: suspicious		Probable COVID-19 (Level of confidence for COVID: 71–99%)
Very High	CO-RADS 5: typical	Typical appearance (commonly reported imaging findings; highly specific for COVID-19)	Classic COVID-19 (Level of confidence for COVID: 100%)
Proven	CO-RADS 6: confirmed diagnosis: RT-PCR for SARS CoV-2	Not categorized	Not categorized

CO-RADS: COVID-19 Reporting and Data System, BSTI: The BSTI statement guideline, RSNA: The RSNA expert consensus statement category

Table 2: Overview of the CO-RADS assessment scheme.

	CO-RADS 0	CO-RADS 1	CO-RADS 2	CO-RADS 3	CO-RADS 4	CO-RADS 5	CO-RADS 6
Scan quality							
Non-diagnostic	X						
Diagnostic		X	X	X	X	X	
Imaging findings							
Emphysema, Perifissural nodules, Lung tumors, Fibrosis		X	X				
Tree-in-bud sign, Centrilobular nodular pattern, Lobar or segmental consolidation, Cavities			X				
Interlobular interstitial thickening							
Associated with pleural effusion (related to pulmonary edema)		X					
Associated with GGO (crazy-paving pattern)				X	X	X	
Ground-glass opacities							
Centrilobular			X				
Peri-hilar, homogeneous				X			
Not in contact with the visceral pleural, unilateral, peribronchovascular or superimposed with pre-existing lung changes (atypical distribution)				X	X		
Located near visceral pleural surfaces (including fissures), multifocal and bilateral distribution					X	X	
Organizing pneumonia patterns							
Without other typical findings of COVID-19				X			
Reverse halo sign					X	X	
Arcade-like sign					X	X	
GGO with subpleural consolidations and air bronchograms					X	X	
Proven COVID-19 diagnosis by positive RT-PCR assay							X
Degree of suspicion for COVID-19	Non-diagnostic	Very low Normal findings or related to non-infectious diseases	Low Findings related to other infectious diseases	Intermediate Compatible findings with COVID-19 but also found in other viral pneumonias and non-infectious diseases	High Typical findings for COVID-19 but with overlap with other viral pneumonias	Very high Typical findings for COVID-19	Confirmed

The most discriminating imaging findings are ground-glass opacities which must be present to a variable extent and whose distribution allows the distinction between CO-RADS 3, 4, and 5 categories (from intermediate to very high probability of pulmonary involvement by COVID-19). Patterns of organizing pneumonia are frequent in CO-RADS 4 and CO-RADS 5, often indicating a later stage of the disease. CO-RADS 3 category may also present with patterns of organizing pneumonia if there are no additional typical findings of COVID-19

of the pandemic when pre-test likelihood is known to be the highest. How the scheme performs in a surveillance stage to detect early signs of a new wave of the pandemic remains to be tested.[4]

The usefulness of CO-RADS in patients with suspected COVID-19 infection was assessed by other groups. One study with 154 patients with clinically suspected COVID-19 concluded that the average sensitivity was 87.8% (range, 80.2–93.4%), specificity was 66.4% (range, 51.3–84.5%), and AUC was 0.859 (range, 0.847–0.881). The interobserver agreement was assessed through the intraclass correlation coefficient of readers that were 0.840 (range, 0.800–0.874; $P < 0.001$).[16] A larger study, that included of 859 patients with COVID-19 symptoms and 1138 controls, has shown that CO-RADS had good diagnostic performance ($P < 0.001$) in both symptomatic (AUC = 0.89) and asymptomatic (AUC = 0.7) individuals. They concluded that the incidental detection of CO-RADS ≥3 in asymptomatic individuals should trigger testing for respiratory pathogens.[17] This particular statement is crucial, especially when hospitals are now dealing with a second and third wave of infections, this being a secondary pathway for testing patients that otherwise might be discharged with no diagnosis.

As the research on COVID-19 continues to shed light on this disease, revisions will likely be necessary in the future to reflect new knowledge on how CT findings are related to patient-outcome, prognosis, treatment responsiveness or even chronic changes caused by the disease.

CONCLUSION

CO-RADS provides a standardized assessment scheme for reporting non-enhanced chest CT scans of patients under investigation for COVID-19 that has good interobserver agreement and good performance at discriminating cases with low or high risk for the disease.

Understanding the rationale for the CO-RADS proposal and how this scheme differs from previously published guidelines on reporting COVID-19 cases is essential to avoid miscategorization and to help in the control of the disease.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Wang X, Tan L, Wang X, Liu W, Lu Y, Cheng L, *et al*. Comparison of nasopharyngeal and oropharyngeal swabs for SARS-CoV-2 detection in 353 patients received tests with both specimens simultaneously. Int J Infect Dis 2020;94:107-9.
2. Wu D, Wu T, Liu Q, Yang Z. The SARS-CoV-2 outbreak: What we know. Int J Infect Dis 2020;94:44-8.
3. Chen C, Zhou Y, Wang DW. SARS-CoV-2: A potential novel etiology of fulminant myocarditis. Herz 2020;45:230-2.
4. Prokop M, van Everdingen W, van Rees Vellinga T, van Ufford JQ, Stöger L, Beenen L, *et al*. CO-RADS: A categorical CT assessment scheme for patients suspected of having COVID-19-definition and evaluation. Radiology 2020;296:E97-104.
5. Rubin GD, Haramati LB, Sverzellati N, Jeffrey I, Kanne P, Schluger NW, *et al*. The role of chest imaging in patient management during the COVID-19 pandemic: A multinational consensus statement from the Fleischner society. Chest 2020;158:106-16.
6. Majidi H, Niksolat F. Chest CT in patients suspected of COVID-19 infection: A reliable alternative for RT-PCR. Am J Emerg Med 2020;38:2730-2.
7. Xu PP, Tian RH, Luo S, Zu ZY, Fan B, Wang XM, *et al*. Risk factors for adverse clinical outcomes with COVID-19 in China: A multicenter, retrospective, observational study. Theranostics 2020;10:6372-83.
8. Li K, Wu J, Wu F, Guo D, Chen L, Fang Z, *et al*. The clinical and chest CT features associated with severe and critical COVID-19 pneumonia. Invest Radiol 2020;55:327-31.
9. Simpson S, Kay FU, Abbara S, Bhalla S, Chung JH, Chung M, *et al*. Radiological society of North America expert consensus statement on reporting chest CT findings related to COVID-19. Endorsed by the society of thoracic radiology, the American college of radiology, and RSNA-secondary publication. J Thorac Imaging 2020;35:219-27.
10. Updated BSTI COVID-19 Guidance for the Reporting Radiologist. The British Society of Thoracic Imaging; 2020. Available from: https://www.bsti.org.uk/standards-clinical-guidelines/clinical-guidelines/bsti-covid-19-guidance-for-the-reporting-radiologist. [Last accessed on 2020 Jul 15].
11. Rodrigues JCL, Hare SS, Edey A, Devaraj A, Jacob J, Johnstone A, *et al*. An update on COVID-19 for the radiologist-A British society of thoracic imaging statement. Clin Radiol 2020;75:323-5.
12. Guidelines for CT Chest and Chest Radiograph Reporting in Patients with Suspected COVID-19 Infection. The Royal Australian and New Zealand College; 2020. Available from: https://www.ranzcr.com/college/document-library/guidelines-for-ct-chest-and-chest-radiograph-reporting-in-patients-with-suspected-covid-19-infection. [Last accessed on 2020 Jul 15].
13. Inui S, Kurokawa R, Nakai Y, Watanabe Y, Kurokawa M, Sakurai K, *et al*. Comparison of chest CT grading systems in Coronavirus disease 2019 (COVID-19) pneumonia. Radiol Cardiothorac Imaging 2020;2:e200492.
14. Jin YH, Cai L, Cheng ZS, Cheng H, Deng T, Fan YP, *et al*. A rapid advice guideline for the diagnosis and treatment of 2019 novel Coronavirus (2019-nCoV) infected pneumonia

(standard version). Mil Med Res 2020;7:4.

15. Bertoncelli D, Guidarini M, Greca AD, Ratti C, Falcinella F, Iovane B, *et al.* COVID19: Potential cardiovascular issues in pediatric patients. Acta Biomed 2020;91:177-83.

16. Fujioka T, Takahashi M, Mori M, Tsuchiya J, Yamaga E, Horii T, *et al.* Evaluation of the usefulness of CO-RADS for chest CT in patients suspected of having COVID-19. Diagnostics (Basel) 2020;10:608.

17. de Smet K, de Smet D, Ryckaert T, Laridon E, Heremans B, Vandenbulcke R, *et al.* Diagnostic performance of chest CT for SARS-CoV-2 infection in individuals with or without COVID-19 symptoms. Radiology 2020;298:E30-7.