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Structured HRCT Chest Reporting in COVID-19

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Abstract: ***Purpose: Our objective is to develop a systematic approach for reporting of COVID-19 pneumonia on CT scans. In this study, we sought to use certain image reading techniques to construct a format which guides the consulting physician towards the appropriate management and treatment. Method: RT-PCR positive tested patients with COVID-19 pneumonia who attended our radiology CT scan clinic underwent chest HRCT investigations and a thorough retrospective review of each patient helped to classify them according to a structured reporting template with five categories as follows: Normal, Unlikely, Indeterminate, High Suspicion and Characteristic. Structured reports were written by an expert radiologist which included a CORAD-Classification List, Severity Index Score and Initial/Final Impressions. Results: The study involved scanning in a total of 12 COVID-19 RT-PCR positive patients of the ages ranging from 22-80 years, mean age ± standard deviation, 50 years ± 18 and the following features were evident: Equivocal findings for COVID 19 infection, abnormalities suspicious for COVID-19 infection and typical COVID-19 findings like Ground glass opacities, Crazy paving, Reverse halo, Consolidations, Honeycombing and Inter-septal thickening. Conclusions: This study supports the effective use of structured reports (SRs) of chest HRCTs in COVID-19 patients, to optimize reporting time, for better simplification of patient awareness and education of their condition and to provide a qualitative accuracy for documented information.***

Keywords: COVID-19, Structured Report, CO-RADS

1. Background

As of December 2020, more than 68.000.000 of infected people and approximately 1.500.000 deaths related to COVID-19, an ongoing pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV2) have been confirmed worldwide. While Reverse Transcription Polymerase Chain Reaction (RT-PCR) is established as a highly specific gold standard pathological laboratory test for the diagnosis of COVID-19 **[1, 2],** most radiology professional organizations and societies have recommended against performing screening CT for the identification of COVID-19 [**3, 4].** As the debate on the use of chest HRCT as a screening tool for COVID-19 continues**,** this imaging modality plays a key role in management and follow-up of COVID-19 patients [**5].** In particular, structured reports use a template with standardized headings targeted to provide a complete evaluation of all key features that are relevant to the disease, therefore adopting a standardized COVID-19 reporting language could help clinical decision making, potentially influencing patients' outcome in management [**6]** and it is also anticipated that patients will have incidental lung findings on CT obtained for unrelated reasons that could be attributable to COVID-19 [**7].**

In the face of a tight work schedule and a soaring number of patients during peak waves of this pandemic insurgence, the discussed SR template was tailored for patients with a confirmed positive RT-PCR test, diagnosing COVID-19 pneumonia at the time of CT scan at our facility and the imaging studies was performed to learn about disease progression and final evaluation.

2. Materials and Methods

The study derivation cohort was built up by including 12 patients who consecutively underwent chest HRCT at the Sterling and Pooja Diagnostics triage in Gujarat in Nov 2020 with moderate to severe pulmonary involvement. Presumptive diagnosis was not necessary as all patients were RT-PCR positive for COVID-19 Pneumonia at the time of scanning so purely based on the clinical-radiological findings, STRs were considered to facilitate swift decision making such as discharge, recommendation for home quarantine, or hospitalization in dedicated COVID-19 pavilions or wards.

The imaging equipment used for three of these patients in this study was a 96 slice CT scanner (Siemens Somatom Dual Force) with a slice thickness of 1mm, tube voltage of 120 kVp, tube current modulation of 350–440 mA, and spiral pitch factor of 1.4. The remaining of the nine patients, in a general hospital setting underwent imaging performed using a Revolution ACT CT scanner (GE Healthcare) and a slice thickness of 5 mm, tube voltage of 120 kVp, tube current modulation of 41 mA, and spiral pitch factor of 1.8. Scans performed in the supine position were acquired in end-inspiration for patients who were able to comply with breathing instructions. No IV or oral contrast medium was administered. Dicom images reviewed on a PACS workstation were interpreted from both mediastinal and lung windows in the axial plane.

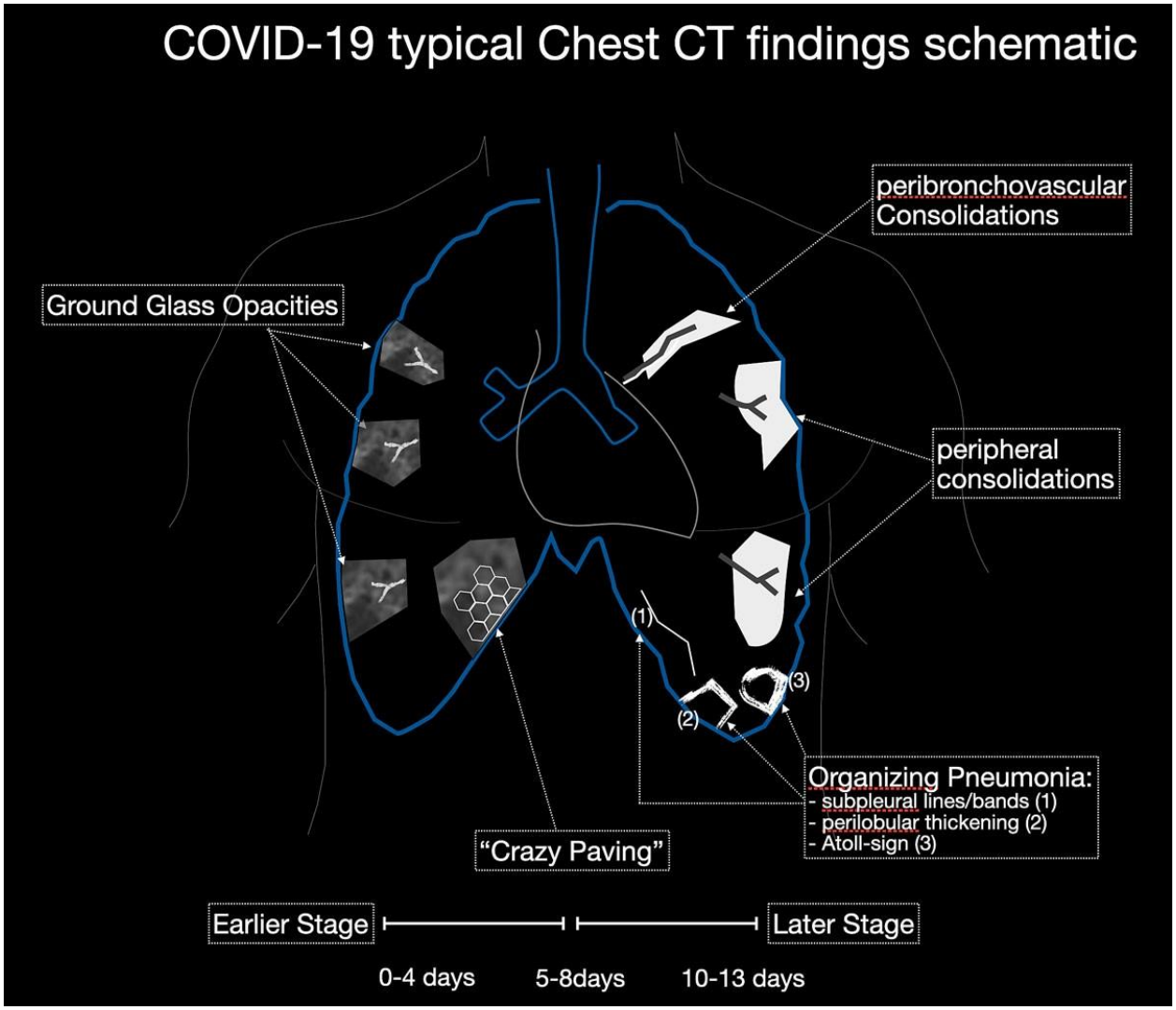


Figure 1: COVID-19 typical CT chest findings schematic (Diagram) [21]

Typical CT characteristics of all the 12 COVID-19 positive patients were patchy or confluent ground-glass opacities (GGO), GGOs superimposed on interlobular septal thickening (i. e., crazy paving pattern), surrounding ring of consolidation (i. e., a reverse halo sign), and central consolidation (i. e., a halo sign), sub-pleural banding and air bronchograms. The percentage of involvement is classified according to the grading system by Chung et al. Each of the five lung lobes was assessed for degree of involvement, which was classified as none (0%), minimal (1–25%), mild (26–50%), moderate (51–75%), or severe (76–100%) **[8, 9].**

CT Severity Score (Total Score 25) [10]

TWO LUNGS: Right lung and Left lung.
Right lung is divided into three lobes: Right Upper Lobe, Right Middle Lobe and Right Lower Lobe.
Left lung is divided into two lobes: Left Upper Lobe and Left Lower Lobe.
Each lobe is given the score of 1 to 5 based on the amount of lung volume involvement.

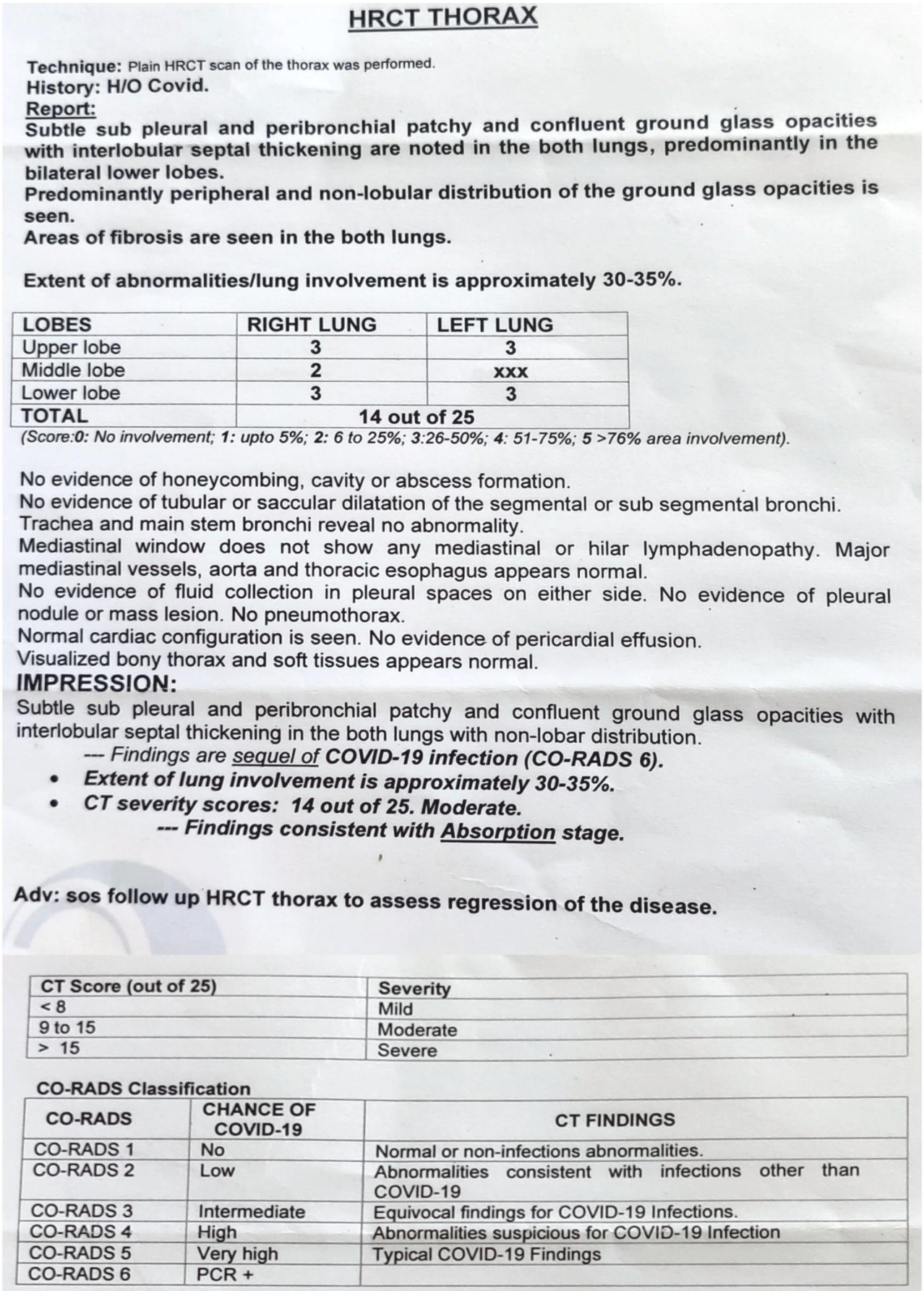
Scoring system (SINGLE LOBE):
5% INFECTED: SCORE 1
5%-25% INFECTED: SCORE 2
25%-50% INFECTED: SCORE 3
50%-75% INFECTED: SCORE 4
75%-100% INFECTED: SCORE 5

- Score calculation is done based on each lobe involvement
- Each lobe has a maximum score of 5. And so all lobes have a total score of 25.
- For example score 5 means that lobe has more than 75% lung volume affected by COVID-19 or involvement.

Mild involvement= 1-8 out of 25
Moderate involvement= 9-15 out of 25
Severe involvement= 15-25 out of 25

Imaging Review
All the CT scans were fully reviewed by a chief consultant radiologist with 15 years of experience and a respiratory medicine specialist. After co-relating each patient's clinical aspects with their image presentation and ample of discussion, both reviewers agreed to the Total Severity Scores (TSS), CORAD scores and stage findings without any discrepancies. The pulmonary findings were discussed according to lobar involvement (with findings considered multi-lobar if they involved two or more lobes), attenuations defined as ground-glass opacity, consolidations and other findings like interstitial thickening or fibrotic bands.

3. Results



HRCT THORAX

Technique: Plain HRCT scan of the thorax was performed.
History: H/O Covid.
Report:
Subtle sub pleural and peribronchial patchy and confluent ground glass opacities with interlobular septal thickening are noted in the both lungs, predominantly in the bilateral lower lobes.
Predominantly peripheral and non-lobular distribution of the ground glass opacities is seen.
Areas of fibrosis are seen in the both lungs.

Extent of abnormalities/lung involvement is approximately 30-35%.

LOBES	RIGHT LUNG	LEFT LUNG
Upper lobe	3	3
Middle lobe	2	xxx
Lower lobe	3	3
TOTAL	14 out of 25	

(Score:0: No involvement; 1: upto 5%; 2: 6 to 25%; 3:26-50%; 4: 51-75%; 5 >76% area involvement).

No evidence of honeycombing, cavity or abscess formation.
No evidence of tubular or saccular dilatation of the segmental or sub segmental bronchi.
Trachea and main stem bronchi reveal no abnormality.
Mediastinal window does not show any mediastinal or hilar lymphadenopathy. Major mediastinal vessels, aorta and thoracic esophagus appears normal.
No evidence of fluid collection in pleural spaces on either side. No evidence of pleural nodule or mass lesion. No pneumothorax.
Normal cardiac configuration is seen. No evidence of pericardial effusion.
Visualized bony thorax and soft tissues appears normal.

IMPRESSION:

Subtle sub pleural and peribronchial patchy and confluent ground glass opacities with interlobular septal thickening in the both lungs with non-lobar distribution.

*--- Findings are sequel of **COVID-19 infection (CO-RADS 6).***

- ***Extent of lung involvement is approximately 30-35%.***
- ***CT severity scores: 14 out of 25. Moderate.***

--- Findings consistent with Absorption stage.

Adv: sos follow up HRCT thorax to assess regression of the disease.

CT Score (out of 25)	Severity
< 8	Mild
9 to 15	Moderate
> 15	Severe

CO-RADS Classification

CO-RADS	CHANCE OF COVID-19	CT FINDINGS
CO-RADS 1	No	Normal or non-infections abnormalities.
CO-RADS 2	Low	Abnormalities consistent with infections other than COVID-19
CO-RADS 3	Intermediate	Equivocal findings for COVID-19 Infections.
CO-RADS 4	High	Abnormalities suspicious for COVID-19 Infection
CO-RADS 5	Very high	Typical COVID-19 Findings
CO-RADS 6	PCR +	

Figure 2: Sample Review of the Structured Report

Age of the Patients: 22, 25, 39, 41, 42, 46, 50, 54, 60, 70, 71, 80.

All 12 chest HRCT reports and findings raised concern for the confirmatory diagnosis of COVID-19, co-relating with their positive RT-PCR test results and clinical presentations. The reported clinical indications included inspiratory chest pain, fever, cough, headache, body ache, nausea and diarrhea. The mean time from clinical symptom onset to corona disease image findings in the chest HRCT was 6 to 7 days.

Special attention was given to make an addition to the structured reports, another criteria was considered over the radiologist's recommendation on patient's status of isolation. Despite that this area of judgment high ranked the radiologist's opinion and solely belonged to the consultant treating the patient, it caused no conflict but instead highlighted its significance and further understanding of management to both patient and his referring physician.

Criteria added to the structured report to define patients with suspected symptoms [11]

- No.1: In home isolation and care after assessment by doctor. (gold standard)
- No.2: With a fever less than 38 degrees C.
- No.3: The fever can go down by itself.
- No.4: No dyspnea, No asthma.
- No.5: With or without cough.
- No.6: No underlying chronic disease, e. g. heart, lung and kidney disease.

Patients with mild symptoms and suspected infection were considered for in-home isolation and home care (weak recommendation) and patients suspected of severe infectious symptoms were considered for admission in hospital for observation (strong recommendation).

It was also noted if:

1) The suspected patients should be given in-home isolation and care or not with careful clinical evaluation and safety assessment by professionals.
2) The suspected patients do not get improvement in the symptoms or even worsened in condition during home care, they need to rush to the doctor for treatment.
3) During the period of home care, the patient's medication and symptoms should be closely recorded and their caregivers should also monitor their body temperature daily.
4) Throughout the period of home care, healthcare personnel should perform regular (e. g., daily) follow-up through face-to-face visits or phone interviews (ideally, if feasible) to follow the progress of symptoms and, if necessary, specific diagnostic tests should be conducted **[12, 13, 14].**

4. Discussion

Even though all the 12 patients in this cohort study were COVID-19 positive at the time of imaging and while RT-PCR testing for early diagnosis of COVID-19 is the gold standard investigation, the results do take a day or two and during the surge even test capacities were limited. Chest HRCT with structured reporting played a provisional diagnostic role in being readily available to present the most frequent characteristic CT features of COVID-19 pneumonia such as:

Multifocal patchy or polycyclic ground-glass opacities (GGO) and/or Consolidations [**15, 16, 17]**

And in doing so shedding light over the progress of the disease and the necessary measures that can be taken to manage it.

Using a simple five-point scale (CO-RADS) to indicate the probability of COVID-19 pneumonia and RT-PCR as reference standard, the following patients were classified in accordance with their HRCT scans in the respective categories:

Annexure-1
CO-RADS: Definition and Evaluation [18]
CO-RADS 0 – NOT INTERPRETABLE
CT FINDINGS: N/A
SUMMARY: N/A

CO-RADS 1 – VERY LOW
CT FINDINGS – Normal or mild or severe emphysema, peri-fissural nodules, lung tumors and fibrosis. (Negative for pneumonia as per the RSNA consensus statement)

SUMMARY: Normal or Non-Infectious.

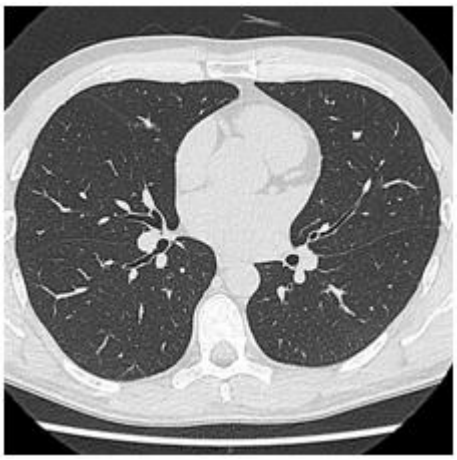


Figure 3: Normal (Consent taken for a patient's scan from outside the study)

CO-RADS 2 – LOW

CT FINDINGS: Findings suggestive of bronchitis, bronchiolitis, bronchopneumonia, lobar pneumonia and pulmonary abscess. Features include tree in bud sign, centrilobular nodular pattern, lobar or segmental consolidation and lung cavitation. (Atypical as per the RSNS consensus statement)

SUMMARY: Typical for other infections but not COVID-19.

Figure 4: (Consent taken for a patient's scan from outside the study)

CO-RADS 3 – EQUIVOCAL/UNSURE

CT FINDINGS: Findings that can also be found in other non-infectious viral causes or pneumonias. Includes peri-hilar ground glass opacities, Homogenous extensive ground glass opacities with or without sparing of some secondary pulmonary lobules or ground glass opacities together with smooth interlobular septal thickening with or without pleural effusion in the absence of other typical CT findings.

Also includes small ground glass opacities that are not centrilobular (otherwise they would be CO-RADS category 2) or not located close to the visceral pleura (otherwise they would be CO-RADS category 4).

In addition, it contains patterns of consolidation compatible with organizing pneumonia without other typical findings of COVID-19. Partially overlaps the "indeterminate appearance "category of the RSNA consensus statement (Lower likelihood for COVID-19).

SUMMARY: Features compatible with COVID-19 but also with other diseases.

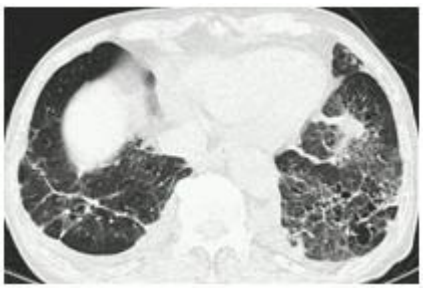


Figure 5

CO-RADS 4 – HIGH

CT FINDINGS: Findings that are typical for COVID-19 but also show some overlap with other viral pneumonias. CT Findings are similar to that of CO-RADS category 5; however, they are not in contact with the visceral pleura nor are they located strictly unilaterally in a predominant peri-bronchovasciular distribution or superimposed on severe diffuse preexisting pulmonary abnormalities.

"Indeterminate" category of RSNA consensus statement (higher likelihood for COVID-19).

SUMMARY – Suspicious for COVID-19.

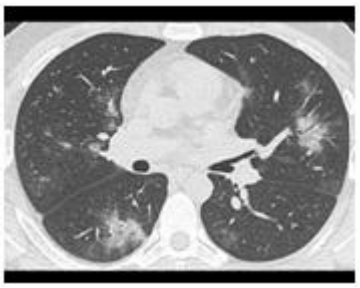


Figure 6

CO-RADS 5 – VERY HIGH

CT Findings: Typical CT Findings: Mandatory features are GGOs with consolidations in lung regions close to visceral pleural surfaces, including the fissures and a multifocal bilateral distribution. Sub-pleural sparing can be present. Requires the presence of at least one confirmatory pattern that aligns with the temporal evolution of the disease.

The pattern that has been described early in the course of COVID-19 is dominated by multiple GGOs which often show half rounded and sharp demarcation but can be accompanied by sharply delineated GGOs that outline the shape multiple adjacent secondary pulmonary lobules.

The crazy paving pattern that has been described as appearing later in the course of the disease shows visible intra-lobular lines.

As the disease progresses, more consolidations occur within the areas of GGOs. Finally opacities that resemble organizing pneumonia occur such as reverse halo signs or GGOs with extensive sub-pleural consolidations and air-bronchograms.

Sub-pleural curvilinear bands or bands of GGOs with or without consolidation in a tethered arching pattern with small connections to the pleura are also considered typical findings. Thickened vessels within lung abnormalities are typical and are frequently found in all other confirmatory patterns.

"Typical appearance" of the RSNA consensus statement.

Summary: Typical for COVID-19

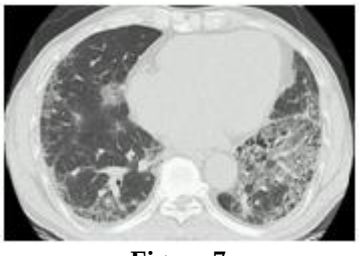


Figure 7

CO-RADS 6 – PROVEN

CT FINDINGS: Indicates proven COVID-19 as per RT-PCR tests. (No separate category under RSNA consensus statement)

SUMMARY: RT-PCR positive for SARS-COV-2.

ANNEXURE – 2

Proposed Reporting Language for CT Findings Related to COVID-19 [19]

COVID-19 Pneumonia Imaging Classification: Negative for pneumonia.

Rationale: No features of pneumonia.

CT Findings: No CT findings to suggest pneumonia.

Suggested Reporting Language: No CT findings present to indicate pneumonia (Note: CT maybe negative in the early stages of COVID-19)

Figure 8: Normal (Consent taken for a patient's scan from outside the study)

COVID-19 Pneumonia Imaging Classification: Atypical appearance.

Rationale: Uncommonly or unreported features of COVID-19.

CT Findings: Absence of typical or indeterminate features of COVID-19 and presence of: Isolated lobar or segmental consolidation without GGO, discreet small nodules (centrilobular, tree in bud pattern). Lung cavitation and smooth interlobular septal thickening with pleural effusion.

Suggested Reporting Language: Imaging features are atypical and uncommonly reported COVID-19 pneumonia. Alternative diagnosis should be considered.

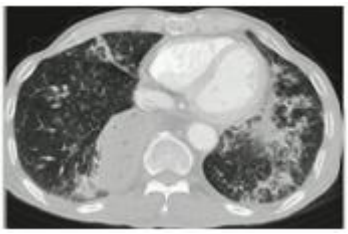


Figure 9: (Consent taken for a patient's scan from outside the study)

COVID-19 Pneumonia Imaging Classification: Indeterminate appearance.

Rationale: Non-specific imaging features of COVID-19 pneumonia.

CT Findings: Absence of typical features of COVID-19 and presence of: Multi-focal, diffuse, peri-hilar or unilateral GGOs with or without consolidations lacking a specific distribution and are non-rounded or non-peripheral.

Suggested Reporting Language: Imaging features can be seen with COVID-19 pneumonia, though are non-specific and can occur with a variety of infectious and non-infectious processes.

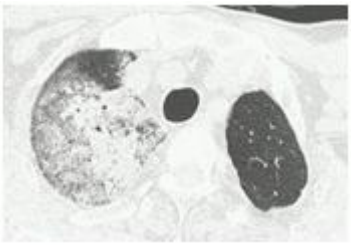


Figure 10

COVID-19 Pneumonia Imaging Classification: Typical appearance.

Rationale: Commonly reported imaging features of greater specificity of COVID-19 pneumonia.

CT Findings: Peripheral, bilateral, GGO with or without consolidation or visible intra-lobular lines (crazy paving). Multi-focal GGOs of rounded morphology with or without consolidation or visible intra-lobular lines (crazy paving). Reverse halo sign or other signs of organizing pneumonia (seen later in the disease).

Suggested Reporting Language: Commonly reported imaging features of COVID-19 pneumonia are present. Other processes such as influenza pneumonia and organizing pneumonia can be seen with drug toxicity and connective tissue disease and cause a similar imaging pattern.

Figure 11

Pros and Cons of Standardized Reporting for Chest CT findings Related to COVID-19 Pneumonia [20]

Pros

- Clinicians maybe unsuspecting of COVID-19 in atypical presentations.
- Initial RT-PCR maybe negative and typical features may encourage repeat confirmatory testing.
- Standardized reporting language can improve quality and clarity by ensuring consistent terminology.
- Reporting data can be used for further teaching, research, clinical quality improvement and future management pathways.

Cons

- The true sensitivity and specificity of CT are unknown. Even patients with normal chest CT or only atypical features may have COVID-19.
- Clinicians may feel having 'COVID-19' in a report boxes them in and limits their options for patient management.
- Patients may be apprehensive about having terminology like 'COVID-19' or 'coronavirus' in their reports and medical records.

5. Conclusion

By introducing a standardized approach to reporting, the proposed COVID-RADS and common lexicon may improve the communication of findings to referring consultants, other healthcare providers and patients thus facilitating the diagnosis and management of COVID-19 patients.

6. Acknowledgements

This study was instrumental in determining how physicians and patients formulate the understanding of COVID-19 infection's manifestation and management through STRs and this was achieved by the support of Dr. (Consulting Radiologist) and Dr. (Consulting Respiratory Medicine Specialist)

7. Funding information

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8. Conflict of interest

The author of this manuscript declares no relationships with any companies whose products or services may be related to the subject matter of the article.

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