RESEARCH

Open Access

Semi-quantitative CT imaging in improving visualization of faint ground glass opacities seen in early/mild coronavirus (covid-19) cases

Rasha Mostafa Mohamed Ali[1*] and Mai Bahgat Ibrahim Ghonimy[2]

Abstract

Background: Chest CT is an essential and simple diagnostic method for early detection of pulmonary changes in COVID-19 patients. Semi-quantitative technique depending on both visual and color coded images helps to improve the early detection of COVID-19 chest affection and thus help to control spread of infection.

Results: From first of May to July 15, 2020, 30 patients in Cairo, Egypt who have positive RT-PCR tests and positive pulmonary manifestation were included in our study, 26 patients (86.6%) with faint ground glass opacities were detected by both visual and color coded images, while in 4 patients (13.3%) were only visualized by color coded images and confirmed by CT density assessment.

Conclusion: The combined use of visual and color coded images enhance and improve the early detection of faint ground glass opacities seen in early COVID-19 affection.

Keywords: Semi-quantitative; CT imaging; faint GGO; early /mild COVID-19

Background

Chest CT plays a vital role in the assessment and follow up for patients with positive COVID-19 infection [1].

Radiological examinations are vital in early diagnosis and assessment of disease course, as most COVID-19 infected patients were diagnosed with characteristic CT imaging patterns [1].

In absence of specific therapeutic drugs or vaccines for 2019 novel coronavirus disease (COVID-19), it is essential to detect the diseases at an early stage, and immediately isolate the infected person from the healthy population [2].

Chest CT, as a routine imaging tool for pneumonia diagnosis, is relatively easy to perform and can produce fast diagnosis [3].

The chest CT scans showed a higher sensitivity for the diagnosis of COVID-19 infection than initial RT-PCR results [2].

Thin-slice chest CT plays a vital role in early detection, observation, and disease evaluation [4].

The aim of this study is to assess the significance of color coded images in the enhancement of visualization of faint ground glass opacities that were the only manifestation in early affected COVID-19 patients.

Methods

Ethical consideration

All patients provided written informed consent. The results of this research were used only in scientific purposes and not in any other aims.

Ethical approval wasn't applicable when we started our research in May 2020 due to current situation of coronavirus crisis.

* Correspondence: dr.rasha118@gmail.com
[1]Radiology Department, Kasr Alaini Hospitals Cairo University, Cairo, Egypt
Full list of author information is available at the end of the article

Study Design

This prospective study included 30 patients (21 males, 9 females) with age range from 25 to 65 years (mean age of 34.2 years) confirmed to be infected with SARS-CoV-2, referred for MSCT assessment of the chest (Table 1). MSCT of the chest was done to all patients as requested. The study was conducted between first of May and July 12, 2020, in Cairo, Egypt.

Inclusion criteria

Laboratory proven PCR positive COVID-19 patients with faint ground glass opacities in MSCT chest.

Exclusion criteria

Patient's CT showing consolidative patches.

Patients who recently experienced clinically defined pulmonary infection attributable to other pathogens.

Patients with severe artifacts on CT images.

Methods

All enrolled patients were subjected to:

- ❖ Through history taking.
- ❖ Laboratory assessment (patients with positive PCR test).
  - Computed tomography (CT) of the chest:
  - CT scan chest was done to all patients using 64 channels MSCT.

    The detailed parameters for CT acquisition were as follows:

- Tube voltage, 120–160 kVp.
- tube current, standard (reference mAs, 60–120)
- Slice thickness, 1.0 mm.
- Reconstruction interval, 1.0–3.0 mm
- Using a sharp reconstruction algorithm.
- CT images were obtained with the patient in the supine position with suspended full inspiration and without contrast medium (Table 1)
- All images were viewed on both lung (width, 1500 HU; level, – 700 HU) and mediastinal (width, 350 HU; level, 40 HU) settings.
  - VR (3 colors, 3D volume rendering lung images):
- The images acquired were sent to a separate workstation and using certain DICOM viewer to be processed, manipulated.

Table 1 MDST technique

Tube voltage	120 kVp
Tube current	60 – 120 mAp
Slice thickness	1 mm
Reconstruction interval	1 mm
Patient position	Supine
Respiration	Breath hold full inspiration
Matrix size	512 × 512

- Threshold limits of -500 to -1024 HU were applied to exclude soft tissue surrounding the lung and large vessels within the lung
- Selecting lung density analysis preset, the lungs are automatically segmented from chest wall, mediastinum, airways and vessels.
- This software and Dicom viewer automatically analyses the density distribution of the lungs into different colors by using color mask tool, by entering the density range, selecting the desired color, which indicates the area that the HU ranges occupy in the image.
- Normally aerated (%NAL, – 501, – 900 HU) and the value range of – 750 HU to – 300 HU and – 300 HU to 50 HU was defined as GGO and consolidation, respectively [5]
  - The chest CT scan was evaluated by two expert radiologist separately searching for the faint ground glass opacities in axial lung window images as well as color coded images.
  - Semi-quantitative method depends on measuring HU unit of the lesion as well as it relays on the color coded image assessment while the quantitative method is an objective method that depend only upon HU values calculation.

Statistical analysis

Owing to small sample size, findings are presented as medians and interquartile ranges.

Results

This cross section study included 30 patients (21 males, 9 females) with age range from 25 to 65 years (mean age of 34.2 years) confirmed to be infected with SARS-CoV-2 using RT-PCR test. MSCT of the chest was performed to all patients and processed in a separate work station and certain DICOM viewer.

All patients had history of direct or indirect contact with COVID-19 infected people. The interval from onset symptoms to first chest CT scan was 6–8 days. The common first symptoms were fever seen in 23 patients (77.4%), dry cough in 18 patients (60%), while 10 patients (33.3%) presented with dyspnea.

The most imminent radiological finding was ground glass opacity seen in 26 patients (86.6%) were detected by both visual and color coded images, while in 4

Table 2 Ground glass distribution

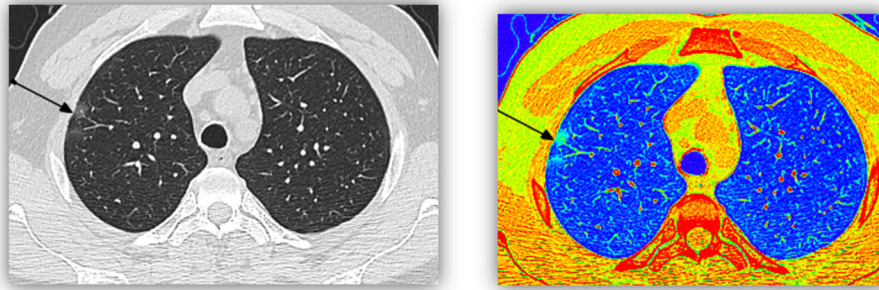| Percent	Number of cases	Predominant distribution
80%	24	lower lobe predominance
6.6%	2	Upper lobe predominance
13.3%	4	Equal distribution in upper and lower lobe
93.3%	28	Peripheral distribution
6.6%	2	Peripheral and perihilar distribution

Fig. 1 A male patient 32 years old, presented with mild dyspnea and COVID-19 positive PCR. MDCT was done with color coded images, MDCT showed right upper lobe tiny ground glass pulmonary nodule (2 mm) which was confirmed in color coded image (as a green nodule whose HU above -750 HU and normal lung appear blue color -750 to -950 HU)

patients (13.3%) the GGO were very faint and were only visualized by color coded images and confirmed by CT density assessment.

The size of the lesions ranged in diameter from 1 to 3 cm. 24 patients showed lower zone predominance (80%), 4 patients showed equal distribution between the upper and lower zones (13.3%) and two patients showed upper zone predominant changes (6.6%) (Table 2).

The faint ground-glass opacities were peripheral in most patients 28 (93.3%), while 2 patients showed both peripheral & peri-hilar distribution (6.6%) (Table 2).

Discussion

The crisis of Coronavirus disease 2019 (COVID-19) has recently attracted the attention all over the world. (COVID-19), is a highly infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [6].

Currently, there are no validated anti-viral medications or other specific therapies targeted toward the treatment of COVID-19. Management of this disease is symptomatic and, more importantly, focused on public health

measures which slow the spread of disease, an epidemiological concept referred to as "flattening the curve" [7].

Therefore, early recognition of patients with COVID-19 (radiologic or otherwise) is critical in order to isolate these cases and prevent additional infection [8].

Computed tomography (CT) is an important and essential method for the diagnosis and evaluation of the severity of COVID-19 as well as monitoring disease progression and evaluating the therapeutic efficiency [9].

Quantitative imaging analysis (QIA), which allows for precise identification of lung tissue density by Hounsfield units (HU), can help differentiate otherwise subtle radiographic diagnoses (Fig. 1) [10].

This cross section study included 30 patients (21 males, 9 females) with male predominance 70%. Age range from 25 to 65 years (mean age of 34.2 years). All patients confirmed to be infected with SARS-CoV-2 using RT-PCR test.

MSCT of the chest was done to all patients as requested & the acquired images were sent to a separate workstation using certain DICOM viewer to be processed & manipulated.
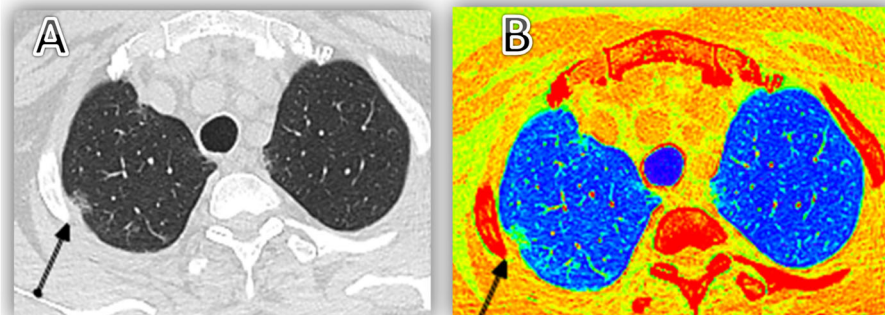

Fig. 2 56 years old male patient presented with fever & chest symptoms including dry cough, yet CT chest was unremarkable (**a**) except for right upper lobe apical segment subpleural ill-defined faint small ground glass opacity, Which became more obvious in color coded images (**b**) (green in color)
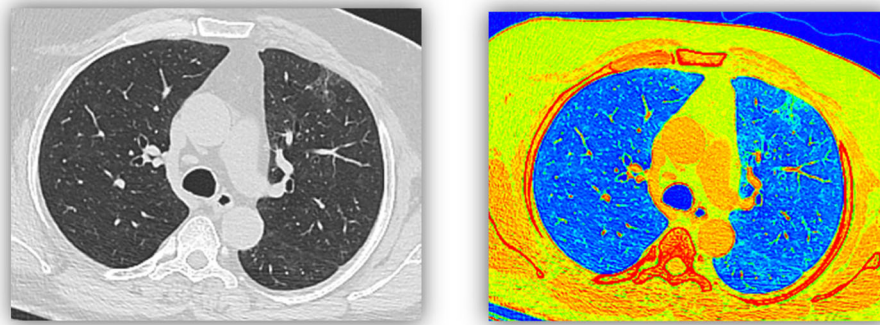
Fig. 3 34 years old male patient who had mild fever, with postive PCR. MDCT was done showing left upper lobar anterior segment suspected faint subpleural opacity, which was much prominent in color coded images (as small green patch)

The study was conducted between first of May and July 12, 2020, in Cairo, Egypt.

The interval from onset symptoms to first chest CT scan was 6–8 days. The common first symptoms were fever seen in 23 patients (77.4%), dry cough in 18 patients (60%), while 10 patients (33.3%) presented with dyspnea which agrees with study done by Dong Sun, et al. [11].

In our study we noted, ground-glass opacity (GGO) is the main CT findings in patients with mild/early COVID-19 and was seen in 26 patients (86.6%) & it was essentially associated with the course and severity of the disease which agrees with the study done by and Feng Z et al. [12].

The detection and recognition of GGO is based on a subjective assessment of lung attenuation at CT, therefore, CT should be performed within objective parameters that make lesion depiction reliable and reproducible (Fig. 2) [13].

GGOs may not always be obvious on CT images, and they may be missed. The recognition of GGO is based on a subjective assessment of lung attenuation at CT (Fig. 3) [14].

In the present study, ground glass opacity seen in 26 patients (86.6%) were detected by both visual and color coded images, while in 4 patients (13.3%) the GGO were very faint and were only visualized by color coded images and confirmed by CT density assessment (Fig. 4).

The size of the lesions ranged in diameter from 1 cm–3 cm. and that goes with study of Dong Sun, et al. that showed correlation between size of lesion and severity of symptoms [11].

The early identification of patients and assessment of the severity of COVID-19 may guide clinical treatment options and reduce the mortality rate. In the present study, a using both visual and color coded images helped in confirming diagnosis of mild/early cases of COVID-19 and that was confirmed by study done by Dong Sun, et al. (Fig. 5) [11].

In summary, this study revealed that the combined use of visual and color coded images enhance and improve the early detection of faint ground glass opacities seen in early COVID-19 affection which could help in improving the disease prognosis as well as limiting spread of this highly contagious disease.
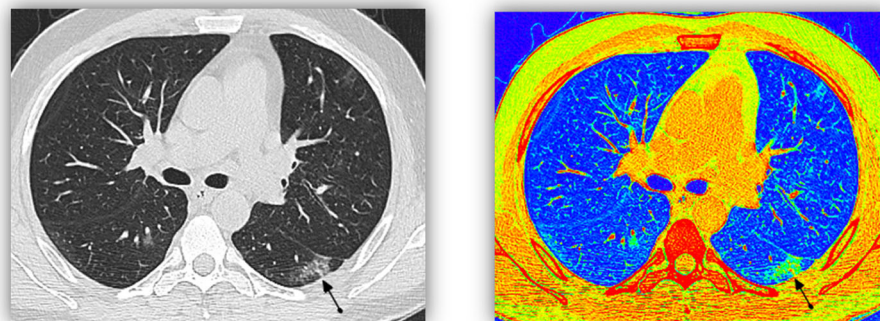

Fig. 4 22 years old male patient with high grade fever and cough. MDCT was done showing left lower lobe apical segment subpleural patchy area of ground glass opacity. On doing additional color coded images two additional small nodular opacities became more clear in the right lower lobe apical eggment and left upper lobe
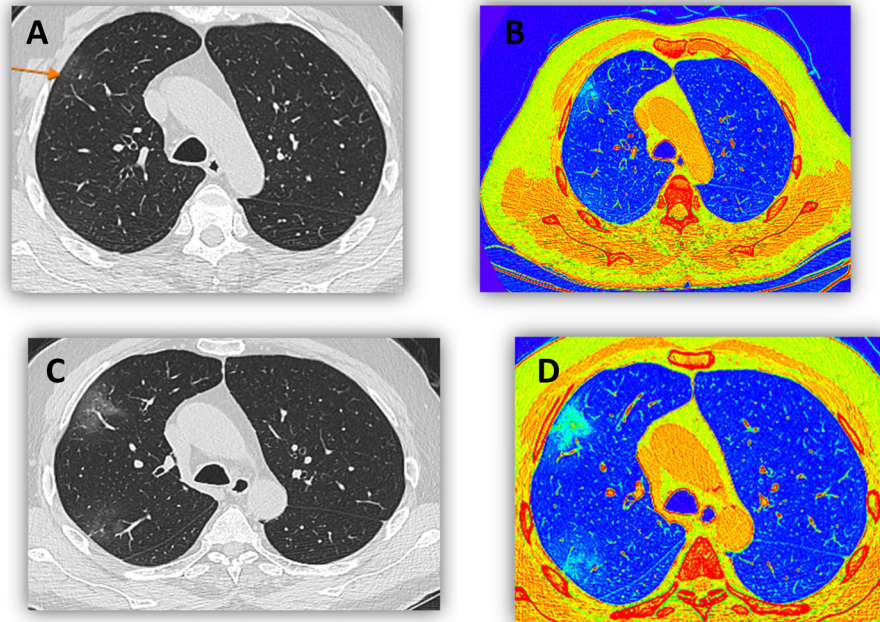
Fig. 5 A male patient 42 years old, presented with dull aching chest pain with PCR postive tests. First MDCT (image **a**) was done, showing suspected faint ground glass opacity, additional color coded images (**b**) showed a right upper lobar apical segment area of abnoraml green color (HU more than -750). Follow up CT done after 8 days (C& D) showed bilateral scattered mainly peripheral ground glass opacities

Conclusion

In absence of specific therapeutic drugs or vaccines for (COVID-19), the early identification of COVID-19 is of great value as it may guide clinical treatment options and reduce the mortality rate.

GGO diagnosis remains a diagnostic challenge, Although CT represents a fundamental diagnostic tool because of its sensitivity, and it still needs to be integrated with clinical data to achieve the best clinical management.

The combined use of visual and color coded images enhance and improve the early detection of faint ground glass opacities seen in early COVID-19 affection which could help in improving the disease prognosis as well as limiting spread of this highly contagious disease.

Abbreviations
2019-nCOV: 2019 Novel coronavirus; ARDS: Acute respiratory distress syndrome; COVID-19: Corona Virus Disease; CT: Computed Tomography; DICOM: Digital Imaging and Communications in Medicine; GGO: Ground glass opacity; HU: House field Unit; IV: Intra-Venous; MDCT: Multi-Detector Computed Tomography; MSCT: Multi-slice Computed Tomography; NAL: Normally aerated lung; RT-PCR: Reverse transcriptase polymerase chain reaction; PCR: Polymerase chain reaction; SARS-cov-2: Severe acute respiratory syndrome coronavirus 2

Authors' contributions
MG and RM have designed this study together. MG contributed to the data collection, RM contributed to data analysis. MF and RM contributed to data processing. MF and RM shared in writing the manuscript together. The authors read and approved the final manuscript.

Availability of data and materials
Data available within the article or its supplementary materials.

Ethics approval and consent to participate
We started our research in May 2020, Ethical approval wasn't applicable at that time due to situation of coronavirus crisis.
A written consent was taken from all patients accepting to participate in our research work.
Consent for publication.
All patients included in this research gave written informed consent to publish the data contained within this study.

Competing interests
The authors declared that they have no conflicts of interest.

Author details
[1]Radiology Department, Kasr Alaini Hospitals Cairo University, Cairo, Egypt. [2]Diagnostic & Interventional Radiology Department, Thoracic and Gastrointestinal Tract Imaging Units, Kasr Al-Aini Hospitals, Faculty of Medicine Cairo University, Cairo, Egypt.

References
1. Chung M, Bernheim A, Mei X et al (2020) CT Imaging Features of 2019 Novel Coronavirus (2019-nCoV). Radiology 195:1
2. A Bernheim X Mei M Huang et al Chest CT findings in coronavirus disease-19 (COVID-19): relationship to duration of infection 2020 https://doi.org/10.1148/radiol.2020200463
3. Ai T, Yang Z, Hou H et al (2020) Correlation of chest CT and RT-PCR testing in coronavirus disease 2019 (COVID-19) in China: A report of 1014 cases. Radiology 195:2

4. X Xie Z Zhong W Zhao et al (2020) Chest CT for typical 2019-nCoV pneumonia: relationship to negative RT-PCR testing Radiology 296(2):E41–E45

5. Kauczor HU, Heitmann K, Heussel CP, Marwede D, Uthmann T, Thelen M (2000) Automatic detection and quantification of ground-glass opacities on high-resolution CT using multiple neural networks: comparison with a density mask. AJR Am J Roentgenol 175(5):1329–1334

6. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J et al (2020) Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. JAMA 323:1061–1069 [PMC free article] [PubMed] [Google Scholar]

7. S Simpson F Kay S Abbara S Bhalla J Chung M Chung et al (2020) Radiological society of north america expert consensus statement on reporting chest CT findings related to COVID-19 Soc Thoracic Radiol Am CollRadiol RSNA Radiol 35(4):219–227

8. Kakodkar P, Kaka N, Baig MN (2020) A comprehensive literature review on the clinical presentation, and management of the pandemic coronavirus disease 2019 (COVID-19). Cureus 12(4):e7560. https://doi.org/10.7759/cureus.7560 (Published 2020 Apr 6)

9. Mahase E (2020) China coronavirus: WHO declares international emergency as death toll exceeds 200. BMJ. https://doi.org/10.1136/bmj.m408 ([Epub][PubMed][CrossRef][GoogleScholar])

10. Kim SS, Seo JB, Kim N et al (2014) Improved correlation between CT emphysema quantification and pulmonary function test by density correction of volumetric CT data based on air and aortic density. Eur J Radiol 83:57–63

11. Sun D, Li X, Guo D et al (2020) CT Quantitative analysis and its relationship with clinical features for assessing the severity of patients with COVID-19. Korean J Radiol 21(7):859–868

12. Feng Z, Yu Q, Yao S, Luo L, Duan J, Yan Z, et al. Early prediction of disease progression in 2019 novel coronavirus pneumonia patients outside Wuhan with CT and clinical characteristics. MedRxiv; 2020. [Accessed 23 Feb 2020]. Available at: https://www.medrxiv.org/content/10.1101/2020.02.19.20025296v1. [Google Scholar]

13. Nambu A, Araki T, Taguchi Y et al (2005) Focal area of ground-glass opacity and ground-glass opacity predominance on thin-section CT: discrimination between neoplastic and non-neoplastic lesions. ClinRadiol 60:1006–1017 (CrossRefPubMedWeb of Science Google Scholar)

14. Terry SF (2015) Obama's precision medicine initiative. Genet Test Mol Biomarkers 19(3):113–114. https://doi.org/10.1089/gtmb.2015.1563

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.