Chapter

Use of Computed Tomography (CT)-Scan in the Current Coronavirus Pandemic

Ibrahima Niang, Géraud Akpo,
Khadidiatou Ndiaye Diouf and Sokhna Ba

Abstract

CT is a medical imaging technique that uses X-rays to provide three-dimensional reconstructed images of the explored anatomical region. Its sensitivity has already been demonstrated in the exploration of pulmonary lesions of traumatic, neoplastic and especially infectious origin. In this chapter we present and highlight the usefulness of CT-scan imaging for diagnosis and management of the thoracic involvement of the COVID-19 pandemic. We also present the use of CT in extra-thoracic involvement, in particular, the angio-CT of the limbs in cases of suspected arterial thrombosis of the limbs during COVID-19. Finally, we evoke the other tools such as artificial intelligence which coupled with the CT-scan allows a greater accuracy and thus are to popularize in order to reinforce the CT as a tool of first plan in the fight against future pandemics with thoracic tropism.

Keywords: CT-scan, diagnosis, coronavirus, COVID-19, ground-glass opacity, post-mortem CT, mobile CT, Artificial Intelligence

1. Introduction

Computed tomography (CT) is a diagnostic tool that uses X-rays to visualize anatomical structures of the body with a good resolution [1]. It allows the identification of abnormalities related to a pathology. It has proven itself particularly in the exploration of lung parenchyma where it has a high sensitivity in the detection of neoplastic and infectious diseases [2]. Knowing that its realization lasts only about ten seconds and that the results can be immediately available, the CT scan is a tool of choice in case of high influx of symptomatic patients and requiring triage [3]. Since the occurrence of the COVID-19 pandemic, whose main symptoms are respiratory with lung parenchymal lesions responsible for a desaturation that can be rapidly fatal, CT has taken a place of choice in the management of both suspected and confirmed cases. This is due to the fact that the reference diagnostic tool, RT-PCR on nasopharyngeal swabs, has a low sensitivity despite a good specificity [4]. Moreover, this PCR test gives results delayed by one to several days, which does not facilitate the management of patients in emergency. Thus, CT is positioned both as an emergency triage tool and as a prognostic tool to assess the extent of lung parenchymal lesions while identifying other associated lesions or other complications such as pulmonary embolism [3, 5].

2. Technique

A thoracic CT scan is performed on a patient in dorsal recumbency, with the hands placed behind the head. The patient must maintain a deep inspiration during the acquisition, which lasts about ten seconds. This acquisition must cover the whole thorax from the apex to the costo-diaphragmatic cul-de-sac. Ideally, for patients with COVID or suspected COVID, it is better to perform the examination with a dose optimization protocol (low-dose) [6]. This will reduce the cumulative irradiation dose, when we know that these patients may have to undergo several CT scans depending on their evolution.

However, the examination should be performed with injection of iodinated contrast medium, in thoracic angio-CT, when there is a clinical suspicion of pulmonary embolism [7].

3. Results

3.1 Positive diagnosis

The CT scan essentially allows the identification of the elementary lesions attributable to COVID-19, which are ground-glass opacity, crazy-paving and non-systematized condensation [8, 9].

The ground-glass opacity, which corresponds to an opacity of the lung parenchyma that does not erase the pulmonary vessels (**Figure 1A** and **B**), is the most frequent sign found in COVID-19 between 88% and 94% [9, 10].

However, ground glass opacity is a non-specific sign of COVID-19 and therefore it is above all its distribution on the lung parenchyma that is decisive for the diagnosis. In the typical form, this distribution is in bilateral sub pleural patches, predominantly in the posterior and basal regions (**Figure 1A** and **B**) [11]. However, there are less typical forms with a central, unilateral, predominantly apical or nodular distribution [10].

Crazy-paving, which corresponds to ground-glass opacity associated with thickening of the lobular septa (**Figure 2A** and **B**), is usually found in the evolution of ground-glass lesions [12].

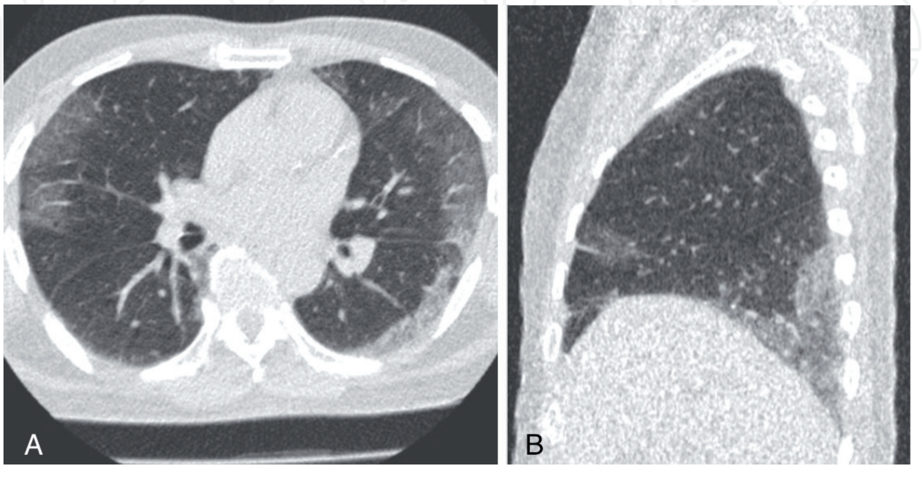

Figure 1.
Chest CT in lung window, axial section (A) and sagittal reconstruction (B) typical form of COVID-19 pulmonary lesions with bilateral areas of ground glass opacities limited to the sub pleura and predominantly at the lung bases.

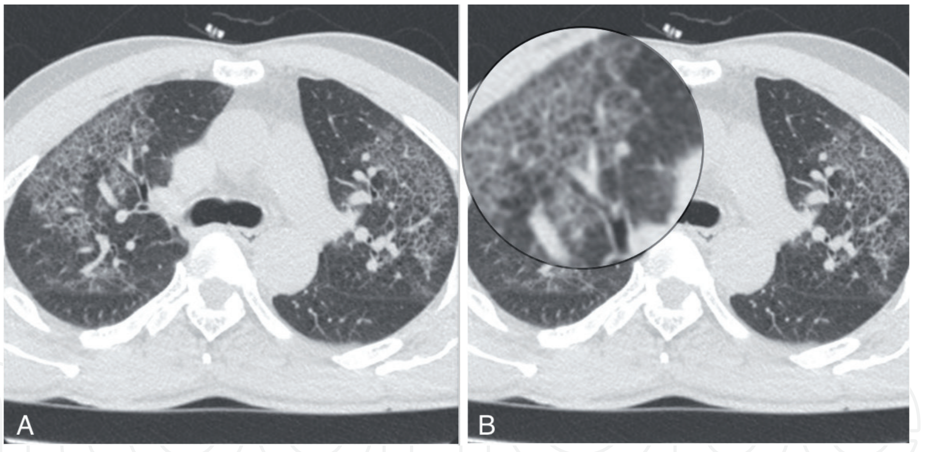

Figure 2.
Chest CT in lung window, axial sections (A and B). Thickening of the septa on a ground glass background giving the appearance of crazy-paving.

The same is true for non-systematic condensation which can occur by transformation of the initial lesions [12]. This condensation will appear as an increase in density of the lung parenchyma but unlike the ground-glass opacity, it will erase the pulmonary vessels (**Figure 3A** and **B**).

3.2 Differential diagnosis

As important as it is to know how to recognize CT signs compatible with COVID-19 infection, it is equally important to know how to differentiate it from other pathologies that require a different management and that can be life-threatening emergencies.

These differential diagnoses are first and foremost the other causes of ground-glass opacity. This is a long list covering several diffuse interstitial lung disease, acute pulmonary edema and alveolar hemorrhage among others [13]. Other causes of crazy-paving and condensation will also be a differential diagnosis, including several diffuse interstitial lung diseases, pneumonia, acute pulmonary edema, bronchioloalveolar carcinoma among others [14].

On imaging, it is important to differentiate the lesions of covid-19 with those of acute pulmonary edema and alveolar hemorrhage which are high emergencies and require specific treatment. What helps in this distinction is essentially the

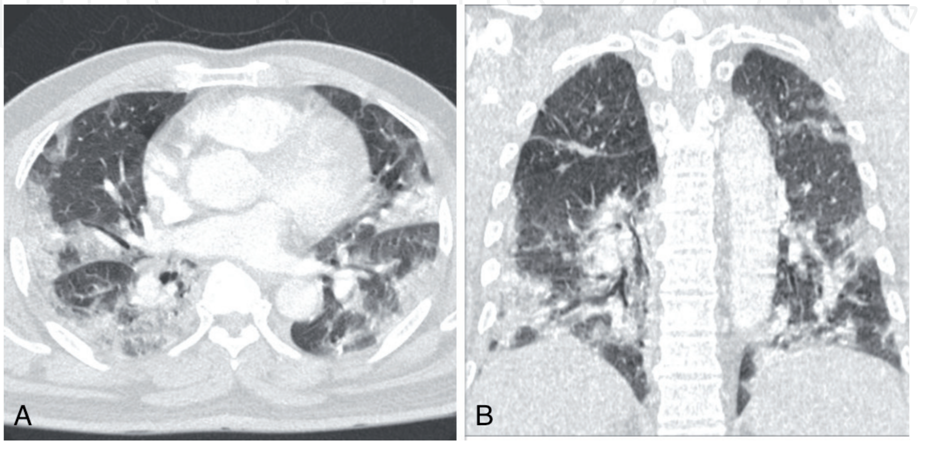

Figure 3.
Chest CT in lung window, axial section (A) and coronal reconstruction (B) bilateral patches of non-systematic sub pleural condensation, corresponding to an evolution of ground glass lesions in relation to COVID-19.

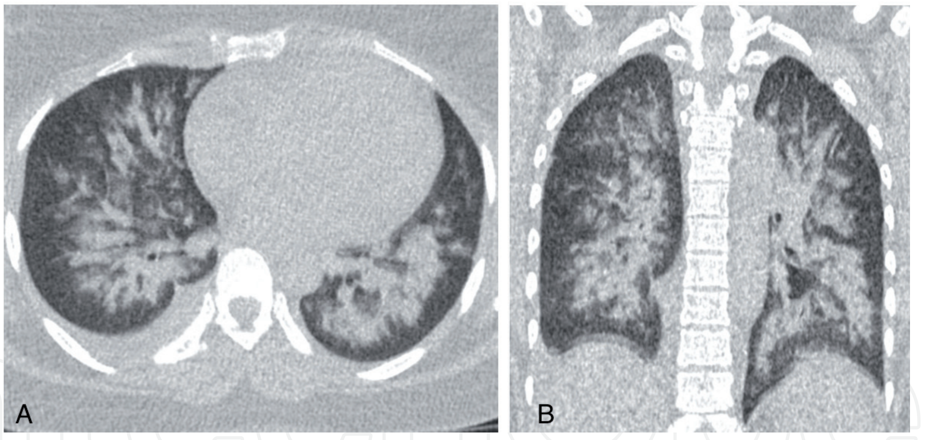

Figure 4.
Chest CT in lung window, axial section (A) and coronal reconstruction (B) bilateral areas of condensation and ground glass opacities, confluent, centrally distributed, clearly sparing the sub pleural regions. This gives the butterfly wing appearance which is in favor of pulmonary edema and rules out the suspicion of Covid-19 in the patient.

distribution of the lesions which are typically sub pleural in COVID-19 and on the contrary spares the sub pleural regions in alveolar hemorrhage and acute pulmonary edema (**Figure 4A** and **B**) [15].

However, in each case, this differential diagnosis must consider the clinical elements, the evolution and the biological data.

3.3 Severity and complications

The most important factor of severity is the degree of extent of the lesions on the lung parenchyma. A visual grading of these lung lesions has been proposed by the Society of Thoracic Imaging (STI) in five stages ranging from less than 10% involvement (minimal) to more than 75% involvement (critical) [16]. This degree of lung involvement is important to specify because it constitutes a prognostic element.

Other elements of severity are the existence of sequelae or evolving pulmonary lesions (pulmonary emphysema, sequelae of granulomatosis, active tuberculosis infection, among others).

Among the complications, the most feared and expected is pulmonary embolism [17]. The risk of embolism is high because of the significant inflammatory response during COVID-19, which makes it a highly thrombogenic pathology [18]. The search for a clinically suspected pulmonary embolism is the main indication for thoracic angio-CT in COVID-19 (**Figure 5A** and **B**) [7].

Other complications are pneumothorax and pneumomediastinum, which may occur spontaneously or as a result of mechanical ventilation [19].

Bacterial reinfection can also occur in COVID-19 pneumonia. In this case, there is a systematized condensation at a lobe or a segment, unlike the condensations related to COVID which follow the distribution of ground glass lesions, remaining sub pleural and not systematized [20].

All these elements of severity and complications influence the prognosis of the patient, which makes thoracic CT an important prognostic tool.

3.4 Evolution

The evolution of COVID-19 lung disease can be towards a regression of the lesions with possible restitution ad integrum if an adequate treatment has been

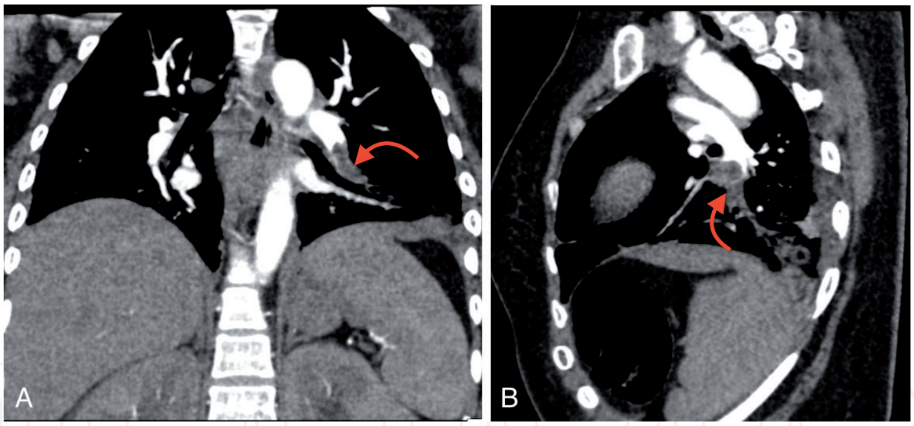

Figure 5.
Thoracic CT angiography in mediastinal window with coronal (A) and sagittal (B) reconstruction pulmonary embolism with endoluminal defect at the level of a left posterobasal segmental pulmonary artery branch (red arrows).

initiated in time. However, it should be kept in mind that regression of lesions on CT is lagging behind clinical improvement [21]. Therefore, it is important to avoid too frequent CT scans, which would be a source of unnecessary irradiation.

The evolution may also take the form of fibrosing parenchymal sequelae [21].

Furthermore, it should be borne in mind that pulmonary embolism may occur during the evolution of the disease.

4. Use of CT in extra-thoracic disease

COVID 19 is a systemic disease, although thoracic and particularly pulmonary involvement is prominent. CT can be an important tool for some of these extra thoracic conditions [22].

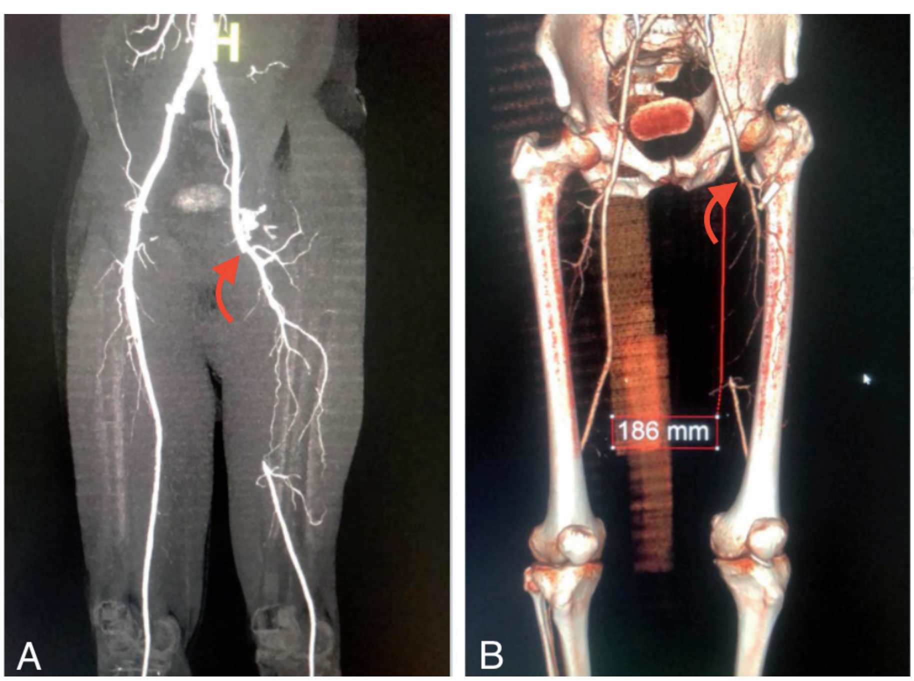

Figure 6.
Angio-CT of the lower limbs in a COVID patient with ischemia of the left lower limb. (A) Angiographic reconstruction showing the thrombosis of the superficial femoral artery from its origin (red arrow) to its lower third with revascularization by collaterals from the deep femoral artery. (B) VRT reconstruction showing the thrombosis extending over a height of 18.6 cm.

Among the extra thoracic uses of CT, we note in particular the angio-CT of the limbs in cases of suspected arterial thrombosis of the limbs during COVID-19 (**Figure 6A** and **B**).

5. Advantages and disadvantages of CT compared to other diagnostic tools

5.1 Advantages

CT has the advantage of having good spatial resolution but also availability and speed of image acquisition, which only takes about ten seconds. The reading of the images is also fast and quite easy compared to other imaging methods.

In addition, CT has good sensitivity in the detection of COVID-19 lung lesions, when compared with the reference diagnostic tool that is RT-PCR [23].

Another advantage is its contribution to the prognosis of patients by providing an overview of the lung volume affected by the lesions.

5.2 Disadvantages

The main disadvantage of CT is the irradiation, which justifies the use of dose optimization (low-dose CT) to minimize the consequences that could result from it [24].

The other disadvantage is the low specificity of lesions on CT, compared to RT-PCR. This should be considered to avoid overdiagnosis of COVID-19 on CT [23].

6. New features and perspectives

6.1 Mobile CT

The mobile CT allows to palliate the need for specialized transport of patients with or suspected of having COVID-19 for whom a CT scan is necessary. This transport may require particularly important logistics, especially for patients in intensive care [25]. For these patients, it is often easier and safer to bring a mobile device to their bedside than to move them to the imaging department, hence the importance of mobile CT in their management. And this mobile CT provides good quality images with a sensitivity that remains superior to the PCR test [25, 26].

6.2 Post mortem CT

Postmortem CT has positioned itself as an alternative to autopsy in deceased COVID-19 patients or in those suspected of having COVID-19. In these patients there is a high risk of contamination during the autopsy and this examination requires protective equipment that is not always available [27]. The thanatoradiological semiology of COVID-19 on CT is identical to that of living patients.

6.3 Artificial intelligence

Artificial intelligence is increasingly used as a means of fluidity and ease in several fields using technology, imaging and particularly CT is no exception. In the case of Covid-19, artificial intelligence associated with CT helps to make the diagnosis more accurate and also provides greater precision on the lung volume affected by the lesions [28].

7. Conclusion

This chapter has demonstrated the great usefulness of CT-scan in the fight against coronavirus pandemic, due to its rapid image acquisition, its immediate availability of results, its good spatial resolution and especially its high sensitivity in the detection of COVID-19 lesions. These assets are reinforced by mobile CT facilitating access to quality imaging in intensive care patients and the coupling with artificial intelligence tools providing greater diagnostic accuracy and assessment of lesion extent.

All of this should give CT a primary place in the response to future lung-tropic pandemics, such as the coronavirus.

Conflict of interest

The authors declare no conflict of interest.

Author details

Ibrahima Niang[1]*, Géraud Akpo[1,2], Khadidiatou Ndiaye Diouf[1] and Sokhna Ba[1]

1 Radiology Department, Fann University Hospital Center, Dakar, Senegal

2 Radiology Department, Aristide Le Dantec University Hospital Center, Dakar, Senegal

*Address all correspondence to: niangibrahimaniang@gmail.com

References

[1] Blum A, Walter F, Ludig T, Zhu X, Roland J. Multislice CT: Principles and new CT-scan applications. Journal of Radiology. 2000;**81**(11):1597-1614

[2] Raju S, Ghosh S, Mehta AC. Chest CT signs in pulmonary disease: A pictorial review. Chest. 2017;**151**(6):1356-1374

[3] Niang I, Diallo I, Diouf JCN, Ly M, Toure MH, Diouf KN, et al. Sorting and detection of COVID-19 by low-dose thoracic CT scan in patients consulting the radiology department of Fann hospital (Dakar-Senegal). The Pan African Medical Journal. 2020;**37** (Suppl 1):22-22

[4] Abbasi-Oshaghi E, Mirzaei F, Farahani F, Khodadadi I, Tayebinia H. Diagnosis and treatment of coronavirus disease 2019 (COVID-19): Laboratory, PCR, and chest CT imaging findings. International Journal of Surgery. 2020;**79**:143-153

[5] Albtoush OM, Al-Shdefat RB, Al-Akaileh A. Chest CT scan features from 302 patients with COVID-19 in Jordan. European Journal of Radiology Open. 2020;**7**:100295

[6] Dangis A, Gieraerts C, Bruecker YD, Janssen L, Valgaeren H, Obbels D, et al. Accuracy and reproducibility of low-dose submillisievert chest CT for the diagnosis of COVID-19. Radiology: Cardiothoracic Imaging. 2020;**2**(2): e200196

[7] Grillet F, Behr J, Calame P, Aubry S, Delabrousse E. Acute pulmonary embolism associated with COVID-19 pneumonia detected with pulmonary CT angiography. Radiology. 2020; **296**(3):E186-E188

[8] Caruso D, Zerunian M, Polici M, Pucciarelli F, Polidori T, Rucci C, et al. Chest CT features of COVID-19 in Rome, Italy. Radiology. 2020;**296**(2): E79-E85

[9] Jalaber C, Lapotre T, Morcet-Delattre T, Ribet F, Jouneau S, Lederlin M. Chest CT in COVID-19 pneumonia: A review of current knowledge. Diagnostic and Interventional Imaging. 2020;**101**(7-8): 431-437

[10] Salehi S, Abedi A, Balakrishnan S, Gholamrezanezhad A. Coronavirus disease 2019 (COVID-19): A systematic review of imaging findings in 919 patients. American Journal of Roentgenology. 2020;**215**(1):87-93

[11] Goyal N, Chung M, Bernheim A, Keir G, Mei X, Huang M, et al. Computed tomography features of coronavirus disease 2019 (COVID-19): A review for radiologists. Journal of Thoracic Imaging. 2020;**35**(4):211-218

[12] Bernheim A, Mei X, Huang M, Yang Y, Fayad ZA, Zhang N, et al. Chest CT findings in coronavirus disease-19 (COVID-19): Relationship to duration of infection. Radiology. 2020;**295**(3): 200463

[13] Bai HX, Hsieh B, Xiong Z, Halsey K, Choi JW, Tran TML, et al. Performance of Radiologists in Differentiating COVID-19 from Non-COVID-19 Viral Pneumonia at Chest CT. Radiology. 2020;**296**(2):E46-E54.

[14] Luo L, Luo Z, Jia Y, Zhou C, He J, Lyu J, et al. CT differential diagnosis of COVID-19 and non-COVID-19 in symptomatic suspects: A practical scoring method. BMC Pulmonary Medicine. 2020;**20**(1):129

[15] Raptis CA, Hammer MM, Short RG, Shah A, Bhalla S, Bierhals AJ, et al. Chest CT and coronavirus disease (COVID-19): A critical review of the literature to date. American Journal of Roentgenology. 2020;**215**(4):839-842

[16] COVID-19: EN DIRECT. SFR e-Bulletin; [cité 6 mars 2021]. Available

from: https://ebulletin.radiologie.fr/covid19

[17] Martínez Chamorro E, Revilla Ostolaza TY, Pérez Núñez M, Borruel Nacenta S, Cruz-Conde Rodríguez-Guerra C, Ibáñez Sanz L. Pulmonary embolisms in patients with COVID-19: A prevalence study in a tertiary hospital. Radiologia (Engl Ed). 2021;**63**(1):13-21

[18] Connors JM, Levy JH. Thromboinflammation and the hypercoagulability of COVID-19. Journal of Thrombosis and Haemostasis. 2020;**18**(7):1559-1561

[19] Shan S, Guangming L, Wei L, Xuedong Y. Spontaneous pneumomediastinum, pneumothorax and subcutaneous emphysema in COVID-19: Case report and literature review. Revista do Instituto de Medicina Tropical de São Paulo. 2020;**62**:e76

[20] Langford BJ, So M, Raybardhan S, Leung V, Westwood D, MacFadden DR, et al. Bacterial co-infection and secondary infection in patients with COVID-19: A living rapid review and meta-analysis. Clinical Microbiology and Infection. 2020;**26**(12):1622-1629

[21] Kong M, Yang H, Li X, Shen J, Xu X, Lv D. Evolution of chest CT manifestations of COVID-19: A longitudinal study. Journal of Thoracic Disease. 2020;**12**(9):4892-4907

[22] Palacios S, Schiappacasse G, Valdes R, Maldonado I, Varela C. COVID-19: Abdominal and pelvic imaging findings: A primer for radiologists. Journal of Computer Assisted Tomography. 2021;**45**(3): 352-358

[23] Ai T, Yang Z, Hou H, Zhan C, Chen C, Lv W, et al. Correlation of Chest CT and RT-PCR Testing for Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases. Radiology. 2020 Aug;**296**(2):E32-E40

[24] Kang Z, Li X, Zhou S. Recommendation of low-dose CT in the detection and management of COVID-2019. European Radiology. 2020;**30**(8): 4356-4357

[25] Rho JY, Yoon KH, Jeong S, Lee JH, Park C, Kim HW. Usefulness of mobile computed tomography in patients with coronavirus disease 2019 pneumonia: A case series. Korean Journal of Radiology. 2020;**21**(8):1018-1023

[26] Liu X, Sun Z, Wang X, Chen Y, Wang L, Yu L, et al. Application of mobile helical computed tomography in combatting COVID-19. Iranian Journal of Radiology. 2021 [cité 18 sept 2021];**18**(1) Available from: https://sites.kowsarpub.com/iranjradiol/articles/106204.html#abstract

[27] De-Giorgio F, Cittadini F, Cina A, Cavarretta E, Biondi-Zoccai G, Vetrugno G, et al. Use of post-mortem chest computed tomography in Covid-19 pneumonia. Forensic Science International. 2021;**325**:110851

[28] Moezzi M, Shirbandi K, Shahvandi HK, Arjmand B, Rahim F. The diagnostic accuracy of Artificial Intelligence-Assisted CT imaging in COVID-19 disease: A systematic review and meta-analysis. Informatics in Medicine Unlocked. 2021;**24**:100591