Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Visual Case Discussion

Identifying pulmonary manifestations of COVID-19 on CT

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1. Introduction

In March 11, 2020, the declared pandemic of COVID-19 set tasks for health care workers to provide timely, rapid and accurate diagnostics and treatment. At present, information on the clinical characteristics, prevention and treatment of this disease is constantly being supplemented. At this time, it is believed that the main route of transmission is through droplet spread from an infected person.

It is known that COVID-19 strikes primarily respiratory and cardiovascular systems, and can pass through the hematoencephalic barrier. The most common clinical manifestation of the new variant of coronavirus infection is bilateral pneumonia, whereas 3-4 per cent of patients have developed acute respiratory distress syndrome [1, 2]. The principal task for every doctor of any specialty, a paramedic, a resident or any other health care professional when providing emergency treatment is to be able to use the diagnostic tactics that are essential for identifying main radiological signs, such as ground glass opacity (GGO), crazy paving (GGO + inter-/intralobular septal thickening), air space opacification, peribronchial and perivascular thickening, and try to have the minimum ability to differentiate between viral and bacterial infections.

Chest CT is an important area of ongoing research in COVID-19 diagnostics and disease progression. Plain two-dimensional radiography has low informative value in primary diagnostics of interstitial changes and GGO due to its superimposition effect. But the role of it is indispensable for estimating dynamics in an intensive care ward. However, with development of secondary bacterial infection or acute respiratory distress syndrome, the diagnostic value of the method significantly increases.

The purpose of our work is to show a clinical case and educate a wide range of readers on main radiological markers in chest CT practice.

2. Visual case discussion

Male patient, 33 y.o., without any related diseases or bad habits. The disease started acutely with a fever of 39°C and weakness on April 4, 2020. He took paracetamol, stayed in self-isolation, however, his general condition worsened: weakness increased, the temperature remained high up to 38°C, and shortness of breath appeared. On April 10, 2020 he was taken to an infectious disease hospital in an ambulance, an express test for COVID-19 was positive and $SpO_2 = 88\%$. CBC made on April 10, 2020 showed: RBC – 4×10^{12}/L, Hb – 138 g/L, WBC – 4.0×10^{9}/L, segmented neutrophils – 43%, lymphocytes – 38%, stab cells – 5%, metamyelocytes – 1%, monocytes – 9%, platelets – 382×10^{9}/L, ESR – 36 mm/h.

AST – 46.13 IU/L, ALT – 41.5 IU/L, total bilirubin – 9.0 μmol/L, plasma glucose – 5.1 mmol/L, creatinin – 115.5 μmol/L, urea – 3.26 μmol/L. SRP – 68 mg/L.

ECG: sinus rhythm, heart rate 65, normal heart axis.

Initial chest CT series made on the admission date, April 10, 2020 (Fig. 1a, b):

After receiving CT data and results of laboratory tests, treatment began: ceftriaxone 1.0 g 2 times a day and hydroxichloroquine 200 mg 3 times a day, heparin and euphylline.

The patient was transferred to an intensive care unit on April 12, 2020, as there was no significant increase in SpO_2, ceftriaxone was replaced with ciprofloxacin 400 mg/day. SpO_2 increased to 94-95%

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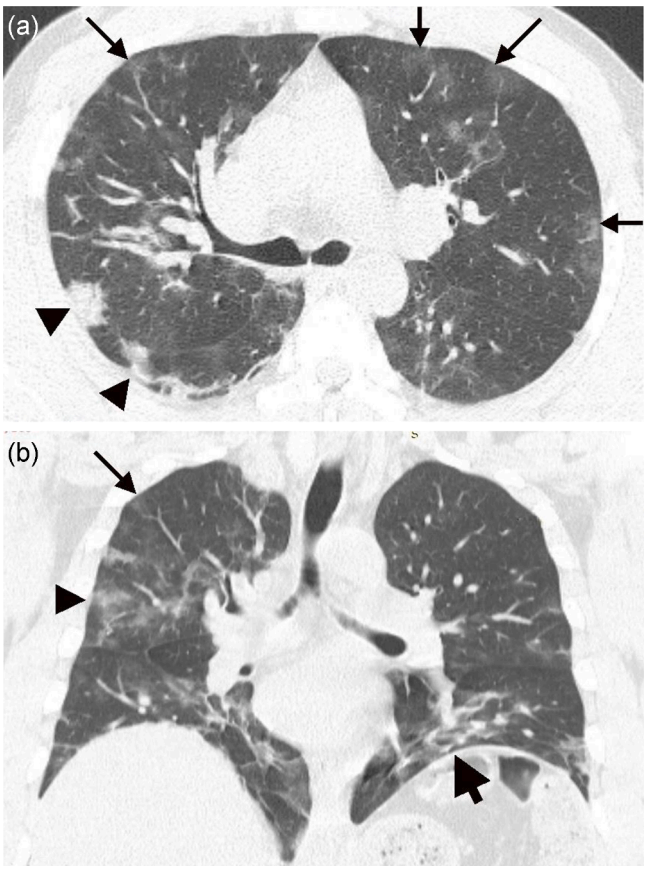

Fig. 1. **(a)** Long arrows show bilateral multifocal ground-glass opacities in the upper lobes, while arrowheads point on to consolidation foci in S2 of the right lung. Notice linear opacities due to interstitial component in S2 and peribronchial ground-glass opacity in the hila region of the right lung. **(b)** Subpleural round-glass opacity (long arrow) and slight consolidation foci (arrowhead) in the upper lobe of the right lung. Air space consolidation with perivascular thickening (short arrow) in basal areas of the lungs, more prominent in the left lung. No signs of pleural effusion.

with unassisted breathing with constant oxygen supply through a nose catheter. On April 15, 2020 he was transferred to the general ward, and later discharged from hospital in a satisfactory condition, was prescribed hydroxichloroquine 400 mg/day for 7 days.

No further complaints of fever, dyspnea or weakness after hospital discharge.

Patient underwent a CT scan on May 12, 2020 to assess the dynamics (Fig. 2).

Follow-up CT image shows dynamics of coronaviral lung injury: starts and ends as ground glass opacity.

Multiple choice questions

1. A 66-year-old patient with confirmed COVID-19, BMI = 32, stable angina pectoris, a smoker, got hospitalized. On admission, a CT scan revealed multiple bilateral peripheral ground-glass opacities foci with basal prevalence, thickening of intralobular and interlobular septa – involvement of 40% of the lung parenchyma – small pericardial effusion. PaO2 = 76 mm. Hg, and later the patient was put on an oxygen support. Procalcitonin – 0.49 ng/mL. Two days after the admission, patient's condition began to deteriorate rapidly with development of dizziness, tachypnea at rest and tachycardia. Repeated chest x-ray revealed bilateral asymmetric infiltrates throughout the pulmonary fields with no dilatation of the cardiac shadow. What complication can be suspected and what kind of radiologic pattern do we expect to see?
   a. ARDS, "anteroposterior density gradient": dense consolidation in dependent, i.e. posterior zones merging into ground glass opacities in the middle and intact lung parenchyma anterior (depending on the position of the patient).
   b. Pulmonary embolism, Hampton hump and a filling defect can be detected on CT pulmonary angiography.
   c. Bacterial pneumonia, «tree in buds» and lobar consolidation independent of patient's position.
   d. Bilateral pleural effusion, accumulation of free fluid on ultrasound and CT
   e. Left heart failure, ground glass opacities, interlobar septa thickening, bronchovascular bundle thickening
2. A patient undergoing outpatient treatment for COVID began to complain of acute chest pains, exacerbated by deep inhalation and coughing, dyspnea and tachycardia, was later delivered to the hospital. PaO2 = 60 mm/Hg. ECG shows sinus tachycardia with a heart rate of 110 beats per minute, right axis deviation, deep S wave in lead I, Q and T waves inversion in lead III, prominent R wave in lead V1. On the chest X-ray of former areas of bilateral ground glass opacities, enlargement of the right heart and right pulmonary artery was detected. What condition should be suspected and to which additional imaging method patient should be referred to?
   a. Bacterial pneumonia, determination of CRP, procalcitonin
   b. ARDS, chest CT
   c. Pulmonary embolism, CT pulmonary angiography

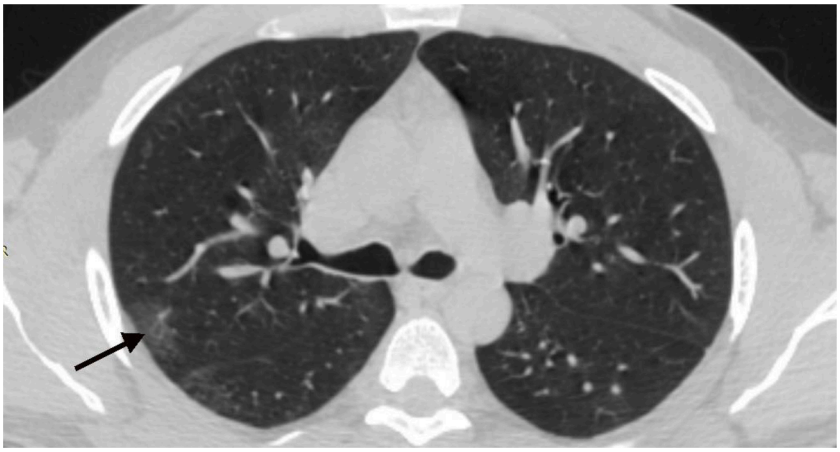

Fig. 2. Air space consolidation in S2 of the right lung transformed in to a small focus of ground glass opacity (long arrow). Previous foci of ground glass opacity were reversed.

d. Exudative pleurisy, ultrasonography of the pleural cavities
e. Left heart failure, echocardiography, determination of troponin levels

Answers

1. Answer a- Under the conditions of the task, during his hospital stay patient's poor general condition and supine position are noted. For PE, bilateral attenuation isn't typical, since there is formation of lung infarction areas due to arterial occlusion. For cardiogenic edema as a result of left heart failure, symmetric lung damage with thickening of the vascular pattern and enlargement of the left heart is typical. In bacterial pneumonia, consolidation does not depend on the position of the patient and level of procalcitonin level is higher than 0.49 ng/mL, tree in bud sign is uncommon for COVID. Bilateral pleural effusion, in turn, rarely occurs without cardiogenic causes and microbial infection, which were excluded above, and is easily differentiated using ultrasound of the pleural cavities. Based on this, it is appropriate to assume that a sudden deterioration of the patient's condition is associated with development of ARDS and requires alertness on doctor's side. Also, there is a clear dependence of the radiographic pattern on the position of the patient's body.
2. Answer c- It is correct to suspect pulmonary thromboembolism as a complication of COVID-19, based on the presented data. CT angiography will allow visualizing the thrombi themselves as a filling defect and the degree of blood supply distal to the thrombus, as well as gaining detailed information on other pulmonary pathology (for example, identifying pneumonia and excluding PE as a cause of hypoxia or pleurisy as the cause of chest pain).

CRediT authorship contribution statement

A. Kadyrova: Conceptualization, Methodology, Validation. **B. Kulbaeva:** Writing - original draft. **I. Antipina:** Writing - review & editing. **K. Pan:** Resources, Data curation. **I. Baudinov:** Project administration. **N. Amiraev:** Visualization, Software. **M. Ali Mohhamed:** Writing - original draft.

Declaration of Competing Interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.visj.2020.100902.

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