Research Paper

Chest CT abnormalities in COVID-19: a systematic review

**Ramy Abou Ghayda 1, 2, †, Keum Hwa Lee3, †, Jae Seok Kim4, †,SeulLee5, Sung Hwi Hong1, 5,**

**Kyeong Seok Kim5, Kyeong Eon Kim5, Jinhyn Seok5, Hajeong Kim5, Jangsuk Seo5, Seungmin**

**Lee5, Ai Koyanagi6, 7, Louis Jacob6, 8, Lee Smith9, Han Li10, Andreas Kronbichler11 and Jae Il Shin3,\***

1Division of Urology, Brigham and Women’s Hospital and Harvard Medical School Boston, MA 02115, USA

2Department of Global Health and Population, Harvard T.H. Chan School of Public Health, Boston, MA

02115, USA

3Department of Pediatrics, Yonsei University College of Medicine, Yonsei-ro 50, Seodaemun-gu, C.P.O Box 8044, Seoul 03722, Republic of Korea

4Department of Nephrology, Yonsei University Wonju College of Medicine, Ilsan-ro 20, Wonju 26426, Republic of Korea

5 Yonsei University College of Medicine, Seoul, Republic of Korea

6Research and Development Unit, Parc Sanitari Sant Joan de Déu, CIBERSAM, Dr. Antoni Pujadas, 42, Sant

Boi de Llobregat, 08830, Barcelona, Spain.

7ICREA, Pg, Lluis Companys 23, Barcelona, Spain

8Faculty of Medicine, University of Versailles Saint-Quentin-en-Yvelines, Montigny-le-Bretonneux, 78180,

Versailles, France.

9The Cambridge Centre for Sport and Exercise Sciences, Anglia Ruskin University, Cambridge CB1 1PT, UK

10University of Florida College of Medicine, Gainesville, FL 32610, USA

11Department of Internal Medicine IV, Nephrology and Hypertension, Medical University Innsbruck, Innsbruck, Austria

† These authors contributed equally

\* Correspondence: Prof. Jae Il Shin, MD, PhD

Address: Yonsei-ro 50, Seodaemun-gu, C.P.O. Box 8044, Department of Pediatrics, Yonsei University College of Medicine, Seoul 03722, Korea

Tel.: +82-2-2228-2050; Fax: +82-2-393-9118; E-mail: shinji@yuhs.ac

**Abstract**

Computed tomography (CT) of the chest is one of the main diagnostic tools for lung involvement in the pathophysiology of coronavirus disease 2019 (COVID-19) infection. There are no comprehensive studies collecting all case series studies on data regarding the findings on chest CT in patients with confirmed COVID-19 and their association with the clinical severity of the viral infection. To describe the clinical and laboratory data and treatment modalities of patients with COVID-19. We searched PubMed, MEDLINE, Embase, Web of Science (inception to May 4, 2020) and reviewed reference lists of previous systematic reviews. A total of 31 case reports (3,768 patients) on CT findings of COVID-19 were included. The most common comorbid conditions were hypertension (18.4%) and diabetes mellitus (8.3%). The most common symptom was fever (78.7%), followed by cough (60.2%). It took an average of 5.6 days from symptom onset to admission. The most common chest CT finding was vascular enlargement (84.8%), followed by ground-glass opacity (GGO) (60.1%), air-bronchogram (47.8%), and consolidation (41.4%). Most lung lesions were located in the lung periphery (72.2%) and involved bilateral lung (76%). Most patients showed normal range of laboratory findings such as white blood cell count (96.4%) and lymphocyte (87.2%). Compared to previous published meta-analyses, our study is the first to summarize the different radiologic characteristics of chest CT in a total of 3,768 COVID-19 patients by compiling case series studies. A comprehensive diagnostic approach should be adopted for patients with known COVID-19, suspected cases, and for exposed individuals.

**Keywords:** Coronavirus disease 2019 (COVID-19), Computed tomography (CT), Systematic review

1. Introduction

A cluster of patients presenting with pneumonia of unknown etiology was one of the first signs to trigger suspicion of a common epidemical etiology of cases, weeks before the identification of coronavirus disease 2019 (COVID-19), a novel coronavirus, as the culprit pathogen by the Chinese as well as the WHO authorities [1-3]. The mode of transmission was initially thought to be limited to direct exposure at a fish market in Wuhan, China. It was only later that healthcare workers recognized the ability of the virus to spread from person to person, in both symptomatic as well as asymptomatic individuals [4-6]. The number of confirmed cases has been greatly dynamic, increasing daily across the globe with multiple confirmed deaths. At the time of writing this manuscript, this pandemic’s positive cases were estimated to be 10,498,090 with 511,851 associated deaths [7].

COVID-19 is caused by single-stranded RNA virus belonging to the family Coronaviridae in the order of Nidoviarles and is enveloped with a positive sense [8]. Its respiratory manifestations are caused by the beta genre of this zoonotic virus, similar to the severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV) [8]. Transmission is achieved through large droplets generated by coughing or sneezing, as well as transport of the virus from surfaces into the mucosa of the mouth, nose, or eyes. Vertical transmission has also been reported [9]. Clinically, signs and symptoms of the diseases are variable and fall on a spectrum ranging from asymptomatic to multi-organ failure and unfortunate death [9]. Respiratory manifestations are similar to other respiratory infections. They include but are not limited to cough, sore throat, and shortness of breath. In a subset of infected individuals, pneumonia and respiratory failure develop as part of severe complications, such as acute respiratory distress syndrome (ARDS) and acute lung injury, leading to most of the morbidities and mortalities [9]. This latter severe manifestation of infection is thought to be due to the robust increase in inflammatory cytokines, including interleukins [2, 7] and TNF- α, among others [2, 9]. One of the main diagnostic tools for lung involvement in the pathophysiology of the infection include computed tomography (CT) of the chest. In fact, given the high clinical sensitivity and specificity of chest CT, this imaging modality has been used in suspected infections with negative molecular testing [9, 10].

Until now, there have been several systematic reviews and meta-analyses on chest CT findings associated with COVID-19 [11-15], but there are no comprehensive studies collecting all case series studies regarding the findings on chest CT in patients with confirmed COVID-19 and their association with clinical severity of viral infection. In this article, we show new perspectives on the most sensitive and specific CT imaging manifestations, the severity of the disease and the patient’s comorbidities. Previous studies have shown variable radiologic signs and findings of unknown clinical significance and prognosis. Findings from this review can serve as a guide and add to the growing knowledge of clinical perspectives of this pandemic.

2. Materials and Methods

*2.1. Literature search strategy and selection criteria*

The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines were followed for this systematic review and meta-analysis. We searched PubMed, MEDLINE, Embase, Web of Science, and limited the search to human findings and included reports published in any language. The search terms used were as follows: “coronavirus 19”, “COVID-19”, “and 2019-nCoV”, “novel coronavirus 2019”, “CT”, and “computed tomography”.

We reviewed papers describing the findings on chest CT findings of COVID-19 positive patients during the extraction process. Because of the scarcity of evidence, papers without patient numbers were included. After the search process, we selected case series on the association of chest CT findings with the severity of the disease and patient mortality rates. In this process, we excluded in vitro or in vivo studies, genetic studies, and conference abstracts. The search was restricted to studies in humans.

Four investigators did the search and manually screened the data. HK, JS, and SL separately extracted data, and KHL double-checked to determine whether the eligible articles met the inclusion criteria. The final search was carried out on May 24, 2020, and excluded 544 overlapping or duplicated data sets. We first excluded duplicate articles and then labeled all the articles by examining titles, abstracts, and full texts in order. From 806 articles, a total of 31 case series with 3,768 patients were included for the primary outcome. A flow-chart of literature search is presented in Figure 1.

*2.2. Analysis of included studies*

In this current review, descriptions of the lungs of COVID-19 infected patients based on CT scans reported in the studies were accessed. Studies only describing saturation and chest X-ray findings were not included when the diagnosis was not mentioned, and no CT scan was performed. Each case series is described in Table S4-S5. We organized the data of the patients’ characteristics, including age, sex, comorbidities, the period between symptom onset and admission/CT scan, clinical presentations, laboratory findings and types of treatments for analyses.

3. Results

3.1. Summary of previously published meta-analyses

A total of eleven meta-analyses on COVID-19 related to Chest CT findings have been published. Detailed description of each study is shown in Table 1. Three papers- Kim et al. [12], Xu et al [15] and Adams et al. [17] - summarized the sensitivity and specificity of chest CT as a diagnostic tool in COVID-19 pneumonia. However, there is no results about clinical presentations, laboratory findings, and treatment modalities. Four studies - Bao et al. [13], Zhu et al. [14], Sun et al. [20] and Lv et al. [21] - have conducted meta-analyses with only CT findings of COVID-19 patients, not describing clinical severity Only Wan et al. [18] summarized the both clinical characteristics and Chest CT findings of patients with COVID-19, but there is no results about laboratory findings and type of treatment. Other two papers - Park et al. [11] and Zheng et al. [16] - performed comparative analyses of CT findings comparing patients diagnosed in Wuhan with outside of Wuhan in China and the common patients with severe patients, respectively. Both studies contained no result about laboratory findings and treatment modalities. Chang et al. [18] summarized CT findings, clinical characteristics and outcomes only in small number of children without detailed laboratory findings or treatment in the manuscript.

3.2. Baseline characteristics of patients included in case series

We included a total of 3,768 patients with COVID-19 by compiling a total of 31 case series. Baseline characteristics are presented in Table 2. The mean age was 47.7 years. The percent ratio of males to females was approximately 48.5:51.7 (1826:1947). The most common comorbid conditions were hypertension (18.4%) and diabetes mellitus (8.3%). Cardio- (7.1%) and cerebrovascular diseases (5.9%) were also common. The most frequent symptom was fever (78.7%), followed by cough (60.2%). Non-specific symptoms such as anorexia and fatigue or weakness were also highly prevalent, with their prevalence being 40.2% and 26.5%, respectively. Of the 17 types of initial symptoms examined, six were respiratory symptoms: cough, sputum, sore throat, nasal congestion or runny nose, shortness of breath, and hemoptysis. It took an average of 5.6 days from the onset of symptoms to hospital admission.

3.3. Characteristics of CT findings in patients with COVID-19

Table 3 shows the characteristic CT findings in patients with COVID-19. The most common finding was vascular enlargement (84.8%), while the second most common feature was ground-glass opacity (GGO) (60.1%), followed by air-bronchogram (47.8%), and consolidation (41.4%). Other findings such as crazy paving, septal thickening, and pleural effusion accounted for a small percentage. Most lung lesions were located in the lung periphery (72.2%) and were present bilaterally (76%). Regarding lobe distribution, the right lower lobe (RLL) was the area where COVID-19 lesions most commonly occurred (72.2%), followed by the left lower lobe (LLL) (69.6%). Right upper and middle lobe (RUL, RML), and left upper lobe (LUL) were involved at a similar rate respectively (49.2, 49.5, 51.8 %).

3.4. Laboratory data of patients with COVID-19

Most patients showed a normal range of white blood cell (WBC) counts (96.4%), while increased or decreased WBCs were shown in only 2.2% and 1.4% of patients, respectively. Similarly, lymphocytes were in normal range in most cases (87.2%). C-reactive protein was elevated in 31.7% of patients. Liver enzymes including aspartate transaminase (mean= 36.93 U/L) and alanine aminotransferase (mean = 30.81 U/L) were within normal range, and lactic acid dehydrogenase (mean = 238.10 U/L) also showed normal level (Table 4).

3.5. Treatment of patients with COVID-19

About 17.7% of patients received antiviral treatment, and 9.9% of patients had oxygen treatment. In the intensive care unit, 41 (1.1%), 4 (0.1%), and 2 (0.05%) patients received mechanical ventilator, extracorporeal membrane oxygenation (ECMO), and continuous renal replacement therapy (CRRT), respectively. Interestingly, plasminogen therapy was also tried in 13 patients with COVID-19 (Table 5).

4. Discussion

Up to the best of our knowledge, there have been eleven meta-analyses about Chest CT findings of COVID-19 have been identified until now (Table 1). However, four papers [13, 14, 20, 21] simply described CT findings of patients with COVID-19. Another three meta-analyses [12, 15, 17] were only for sensitivity or specificity values of chest CT as a diagnostic tool of COVID-19. The other papers analyzed with partial sample sizes (comparative analyses between two groups [11, 16], children [18], ect.) Among these meta-analyses, there has been no comprehensive studies collecting all case series studies on data regarding the findings on chest CT in patients with confirmed COVID-19 and their association with the clinical severity, laboratory findings and treatment modalities of the viral infection.

Clinical deterioration by COVID-19 is characterized by ARDS due to acute lung injury, cytokine storm syndrome, and multiple organ failure. Among them, acute lung damage is the most representative clinical complication due to COVID-19 and is the starting point for all other serious clinical complications [22, 23]. As already shown in previous epidemics, including severe acute respiratory syndrome (SARS) and middle east respiratory syndrome (MERS), the coronavirus enters the cell by using angiotensin-converting enzyme-2 receptor (ACE2R) [24]. The ACE2Rs are mainly distributed in alveolar epithelial cells of the lungs, and thereby mediate direct lung injury by the coronavirus [25, 26]. However, careful analysis of serious complications might offer a window of opportunity in the management of the condition. The radiographic information of a chest CT scan has the potential to provide valuable information and assist healthcare workers in predicting the acuity of the infection and in categorizing patients at low, medium, and high risk of mortality from the disease.

Most medical guidelines consider a chest CT scan as a useful diagnostic measure to complement for a RT-PCR test in spite of low specificity and unwanted exposure of radiation [8, 27, 28]. Chest CT provides information to assess clinical severity and helps to predict clinical progress at the same time as diagnosis [29].

Pneumonia by various viruses, including novel coronavirus, shares radiologic characteristics that are different from bacterial pneumonia. Despite a few differences according to pathogenic mechanisms, viral pneumonia is commonly characterized by bilateral lung involvement and a GGO pattern that often show mixed appearance with consolidative lesions. In addition, viral pneumonia is mainly distributed in the lung periphery [30]. Especially, in the COVID-19 pandemic, the radiologic characteristics of pneumonia caused by SARS and MERS coronavirus are something to be noted. The two diseases have shown that the mixed lesions occur mainly in the peripheral and lower regions of both lungs [8].

Several researchers have reported the radiologic characteristics of COVID-19 since the initial outbreak [31]. Such information could provide important clues in understanding the pathogenic mechanism of SARS-CoV-2 and might play an important role in early diagnosis along with serologic testing [8, 31], even though the argument over the role of chest CT in COVID-19 diagnosis still persists [12, 28]. In a study of 51 patients diagnosed with COVID-19, pneumonia mainly involved both lungs (86% of total patients / 97% of total lesions), and the lung lesions were distributed across multiple sites in more than 4 lobes (63% / 90%) [32]. In addition, it occurred frequently in lower lobes (90% / 53%) and were mainly distributed in the posterior (80% / 89%) and peripheral areas of the lung (86% / 91%). Radiologic features of pneumonia from COVID-19 may depend on severity. A recent study divided COVID-19 into five stages (ultra-early, early, rapid progress, consolidation, and dissipation stages) and described the radiologic features of each stage [27]. According to this study, single, double, or scattered GGO lesions were observed in the ultra-early stage, and during the early stage, the GGO patterns gradually expanded with the onset of interlobular interstitial edema. In the rapid progress stage, as inflammation intensified, the exudate in alveoli spread into nearby alveoli and interstitial spaces, and the GGO lesion progressed to consolidation with signs of air-bronchogram. In the consolidation stage, large scale patchy consolidation was clearly present. Lastly, in the dissipation stage, the existing consolidation was gradually absorbed and faded, the interlobular septum became relatively clear, and opacity of the reticular pattern was mainly observed.

Compared to eleven previous published meta-analyses, our study showed different the radiologic characteristics of chest CT in a total of 3,768 COVID-19 patients by compiling case series studies. The most common feature of the CT findings of COVID-19 was vascular enlargement (or thickening) (Table 3). Although the finding is somewhat non-specific and the underlying mechanisms are unclear, a recent study indicated that it could be an important point that distinguishes COVID-19 pneumonia from non-COVID-19 pneumonia, and a useful indicator to suspect COVID-19 infection at an early stage [31, 33]. The second most common CT finding in COVID-19 pneumonia was GGO, which has already been considered as a typical feature in viral pneumonia, including COVID-19. The GGO is a radiologic opacity that does not obscure the contours of close broncho-vascular structures, which suggests the existence of transudate or exudate in alveoli, but the fluid amount is not large enough to make a large contrast with the surrounding air spaces. Thus, the GGO pattern suggests early lesions such as alveolitis, and, as the disease progresses, it develops into a consolidative lesion by the accumulation of fibrinous exudate. In the GGO lesion, the alveoli are relatively better aerated compared to the severity of radiologic findings, such that asymptomatic COVID-19 infections are often found with significant abnormal findings in chest radiography. Another common CT finding for COVID-19 was air-bronchogram. This was reported at a similar rate as consolidation in our study because it has the same clinical significance as a secondary lesion following consolidation. Consolidation in the lung means that the functional space of alveoli has been lost by inflammatory exudates, thus predicting clinical exacerbation. Many studies, including this study, report mixed GGO and consolidation as a typical feature of COVID-19 [34], and these mixed findings are understood as a process of transition in which the GGO lesions worsen into a consolidative stage rather than independent lesions. Other chest CT findings of COVID-19 included crazy paving, which is thought to be one of the worsening lesions of the GGOs that does not progress to consolidation. Based on the localization of chest CT findings of COVID-19 in this study, as in other existing studies, peripheral distribution is mainly shown, and the lesions usually involve the right lung and lower lobes. Although there is no clear evidence, these findings may be associated with the inflow of coronavirus particles through breathing. When the coronavirus particles enter the lung, it is easier to contact alveolar epithelial cells in the lung periphery where airflow slows down. Also, in regard to the preference for specific lung lobes in occurrence of COVID-19 pneumonia, we could understand such a tendency by referring to the volume of each lung segment. In a study of COPD patients, the assessment of the lung lobar volumes in the control group through three-dimensional (3D) CT showed that RLL had the largest volume and that the volumes got smaller in the order of LUL, LLL, RUL, and RML [35]. Although these results do not exactly correspond to the localization of pneumonia from COVID-19 shown in this study, the preferred area for the occurrence of pneumonia seems to be associated with the physiologic lobar volumes.

A comprehensive diagnostic approach should be adopted for patients with known COVID-19, suspected cases, and for exposed individuals. The radiologic imaging, clinical picture, laboratory testing, and molecular confirmatory assays should be analyzed in a complementary and accumulative manner. Healthcare providers should consider all clinical cues before planning management and treatment.

5. Conclusions

In this study, we provide information on the characteristics of CT findings of COVID-19 from a large number of patients through a comprehensive analysis of existing case series. The understanding of radiologic characteristics in COVID-19 can help assess and predict the clinical course of the disease, and provide a useful measure for early diagnosis of COVID-19. Above all, understanding the underlying mechanisms of radiologic patterns in COVID-19 is likely to provide a clue on the clinical properties of SARS-CoV-2 that causes serious lung damage with high infectivity. The findings and hallmarks in the chest CT could assist in predicting the severity and acuity, progression, prognosis, and risk of mortality of infection.

**Author Contributions:** JIS designed the study, KHL, HK, JS and SML collected the data and did the analysis. RAG, KHL, JSK, SL, SHH, KSK, KEK, AK, LJ, LS, HL, AK and JIS wrote the first draft of the manuscript and gave critical comments on manuscript draft. All authors had full access to all the study data. All authors reviewed wrote and approved the final version. The corresponding author had final responsibility for the decision to submit for publication.

**Funding:** This research received no external funding.

**Conflicts of Interest:** The authors declare no conflict of interest.

References

1. Zhu N, Zhang D, Wang W, Li X, Yang B, Song J, et al. A novel coronavirus from patients with pneumonia in China, 2019. N Engl J Med. 2020

2. Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet. 2020;395:507–513.

3. WHO  https://www.who.int/emergencies/en/ (Accessed June 14, 2020)

4. The Lancet Emerging understandings of 2019 nCoV. Lancet. 2020;395:311.

5. Chan JF, Yuan S, Kok KH, To KK, Chu H, Yang J, et al. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. Lancet. 2020

6. Rothe C, Schunk M, Sothmann P, Bretzel G, Froeschl G, Wallrauch C, et al. Transmission of 2019-nCoV infection from an asymptomatic contact in Germany. N Engl J Med. 2020

7. Johns Hopkins Whiting School of Engineering website. Coronavirus COVID-19 global cases. gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6. (Accessed July 01, 2020)

8. S Salehi, A Abedi, S Balakrishnan, A Gholamrezanezhad. Coronavirus Disease 2019 (COVID-19): A Systematic Review of Imaging Findings in 919 Patients. AJR Am J Roentgenol 2020;1-7.

9. Chen Huijun, Guo Juanjuan, Wang Chen, Luo Fan, Yu Xuechen, Zhang Wei, Li Jiafu, Zhao Dongchi, Xu Dan, Gong Qing, Liao Jing, Yang Huixia, Hou Wei, Zhang Yuanzhen. Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records. The Lancet. 2020;395(10226):809–815

10. Huang Peikai, Liu Tianzhu, Huang Lesheng, Liu Hailong, Lei Ming, Xu Wangdong, Hu Xiaolu, Chen Jun, Liu Bo. Use of Chest CT in Combination with Negative RT-PCR Assay for the 2019 Novel Coronavirus but High Clinical Suspicion. Radiology. 2020;295(1):22–23.

11. JH Park, W Jang, SW Kim, J Lee, YS Lim, CG Cho, SW Park, BH Kim. The Clinical Manifestations and Chest Computed Tomography Findings of Coronavirus Disease 2019 (COVID-19) Patients in China: A Proportion Meta-Analysis. Clin Exp Otorhinolaryngol.2020;13(2):95-105

12. H Kim, H Hong, SH Yoon. Diagnostic Performance of CT and Reverse Transcriptase-Polymerase Chain Reaction for Coronavirus Disease 2019: A Meta-Analysis. Radiology. 2020;201343

13. Bao C, Liu X, Zhang H, Li Y, Liu J. Coronavirus Disease 2019 (COVID-19) CT Findings: A Systematic Review and Meta-analysis. J Am Coll Radiol. 2020:S1546-1440(20)30262-3

14. J Zhu, Z Zhong, H Li, P Ji, J Pang, B Li, J Zhang. CT Imaging Features of 4121 Patients With COVID-19: A Meta-Analysis. J Med Virol. 2020 [Online ahead of print]

15. B Xu, Y Xing, J Peng, Z Zheng, W Tang, Y Sun, C Xu, F Peng. Chest CT for Detecting COVID-19: A Systematic Review and Meta-Analysis of Diagnostic Accuracy. Eur Radiol 2020;1-8.

16. Zheng Y, Wang L, Ben S. Meta-analysis of chest CT features of patients with COVID-19 pneumonia. Med Virol. 2020 Jun 24.

17. Adams HJA, Kwee TC, Yakar D, Hope MD, Kwee RM. Systematic Review and Meta-Analysis on the Value of Chest CT in the Diagnosis of Coronavirus Disease (COVID-19): Sol Scientiae, Illustra Nos. AJR Am J Roentgenol. 2020 Jun 1:1-9.

18. Chang TH, Wu JL, Chang LY. Clinical Characteristics and Diagnostic Challenges of Pediatric COVID-19: A Systematic Review and Meta-Analysis. J Formos Med Assoc. 2020;119(5):982-989.

19. Wan S, Li M, Ye Z, Yang C, Cai Q, Duan S, et al. CT Manifestations and Clinical Characteristics of 1115 Patients with Coronavirus Disease 2019 (COVID-19): A Systematic Review and Meta-analysis. Acad Radiol. 2020;27(7):910-921.

20. Sun Z, Zhang N, Li Y, Xu X. A systematic review of chest imaging findings in COVID-19. Quant Imaging Med Surg. 2020;10(5):1058-1079.

21. Lv M, Wang M, Yang N, Luo X, Li W, Chen X, et al. Chest computed tomography for the diagnosis of patients with coronavirus disease 2019 (COVID-19): a rapid review and meta-analysis. Ann Transl Med. 2020;8(10):622.

22. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 2020;395(10223):497-506.

23. Fu L, Wang B, Yuan T, Chen X, Ao Y, Fitzpatrick T, et al. Clinical characteristics of coronavirus disease 2019 (COVID-19) in China: A systematic review and meta-analysis. The Journal of infection. 2020;80(6):656-65.

24. Li W, Moore MJ, Vasilieva N, Sui J, Wong SK, Berne MA, et al. Angiotensin-converting enzyme 2 is a functional receptor for the SARS coronavirus. Nature. 2003;426(6965):450-4.

25. Zou X, Chen K, Zou J, Han P, Hao J, Han Z. Single-cell RNA-seq data analysis on the receptor ACE2 expression reveals the potential risk of different human organs vulnerable to 2019-nCoV infection. Front Med. 2020;14(2):185-92.

26. Hamming I, Timens W, Bulthuis ML, Lely AT, Navis G, van Goor H. Tissue distribution of ACE2 protein, the functional receptor for SARS coronavirus. The first step in understanding SARS pathogenesis. J Pathol. 2004;203(2):631-7.

27. J in YH, Cai L, Cheng ZS, et al.; Zhongnan Hospital of Wuhan University Novel Coronavirus Management and Research Team; Evidence-Based Medicine Chapter of China International Exchange and Promotive Association for Medical and Health Care (CPAM). 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

28. Huang EP, Sung CW, Chen CH, Fan CY, Lai PC, Huang YT. Can Computed Tomography Be a Primary Tool for COVID-19 Detection? Evidence Appraisal Through Meta-Analysis. Crit Care. 2020;24(1):193.

29. Diao K, Han P, Pang T, Li Y, Yang Z. HRCT imaging features in representative imported cases of 2019 novel coronavirus pneumonia. Precis Clin Med 2020 Feb 11

30. Koo HJ, Lim S, Choe J, Choi SH, Sung H, Do KH. Radiographic and CT Features of Viral Pneumonia. Radiographics. 2018;38(3):719-39.

31. Bai HX, Hsieh B, Xiong Z, Halsey K, Choi JW, Tran TML, et al. Performance of radiologists in differentiating COVID-19 from viral pneumonia on chest CT. Radiology. 2020:200823.

32. Song F, Shi N, Shan F, Zhang Z, Shen J, Lu H, et al. Emerging 2019 Novel Coronavirus (2019-nCoV) Pneumonia. Radiology. 2020;295(1):210-7.

33. Li Y, Xia L. Coronavirus Disease 2019 (COVID-19): Role of Chest CT in Diagnosis and Management. AJR Am J Roentgenol. 2020;214(6):1280-6.

34. Zhao W, Zhong Z, Xie X, Yu Q, Liu J. Relation Between Chest CT Findings and Clinical Conditions of Coronavirus Disease (COVID-19) Pneumonia: A Multicenter Study. AJR Am J Roentgenol. 2020;214(5):1072-7.

35. Daimon T, Fujimoto K, Tanaka K, Yamamoto J, Nishimura K, Tanaka Y, et al. Volume of pulmonary lobes and segments in chronic obstructive pulmonary diseases calculated using newly developed three-dimensional software. Jpn J Radiol. 2009;27(3):115-22.

**Table 1. Main characteristics and findings of the previous published CT meta-analyses*.***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Authors** | **Included studies, n** | **Sample size** | **Study period** | **Description** | **Comment** |
| Park et al.  2020 [11] | 9 | 627 | Until March 17, 2020 | The role of chest CT in COVID-19 diagnosis is inconclusive based on this study. | A comparative analysis of clinical presentations and CT findings was performed between patients diagnosed in Wuhan and outside of Wuhan in China – no significant findings about CT findings and no data about laboratory findings and type of treatment |
| Kim et al.  2020 [12] | 68 | 6,218 | January 1 2020 to April 3 2020 | The pooled sensitivity was 94% (95% CI: 91%, 96%; I2=95%) and the pooled specificity was 37% (95% CI: 26%, 50%; I2=83%) for chest CT. | Summarized the sensitivity and specificity of chest CT as a diagnostic tool in COVID-19 pneumonia – there is no results about clinical presentations, laboratory findings, and treatment modalities |
| Bao et al. (2020) [13] | 13 | 2,738 | December 2019 to February 2020 | Typical CT signs were GGO (83.31%), GGO with mixed consolidation (58.42%). The incidences were highest in the right lower lobe (87.21%), left lower lobe (81.41%), and bilateral lower lobes (65.22%). | CT findings of patients with COVID-19 are summarized in this article – there is no results about clinical presentations, laboratory findings and type of treatment |
| Zhu et al. (2020) [14] | 7 | 4,121 | January 1 2020 to March 16 2020 | Most patients presented bilateral lung involvement (73.8%, 95% CI: 65.9%‐81.1%) and the most common changes in lesion density were GGO (68.1%, 95% CI: 56.9%‐78.2%). | CT findings of patients with COVID-19 are summarized in this article – not mentioning clinical presentations, laboratory findings, and type of treatment |
| Xu et al. (2020) [15] | 16 | 3,186 | Until March 12, 2020 | Chest CT has a high sensitivity 92% (95% CI = 86-96%), for detecting COVID-19, especially in a region with severe epidemic, which is helpful to early recognize suspicious cases and might contribute to confine epidemic.. | Summarized the sensitivity of chest CT as a diagnostic tool in COVID-19 pneumonia – there is no results about clinical presentations, laboratory findings, and treatment modalities |
| Zeng et al. (2020) [16] | 15 | 2,451 | December 1, 2019 to May 1, 2020 | Based on the CT images, the common patients were less frequent to exhibit consolidation (OR=0.31), pleural effusion (OR=0.19), lymphadenopathy (OR=0.17), crazy-paving pattern (OR=0.22), interlobular septal thickening (OR=0.27), reticulation (OR=0.20), traction bronchiectasis (OR=0.40) with over 2 lobes nvolved (OR=0.07) and central distribution (OR=0.18) while more frequent to bear unilateral pneumonia (OR=4.65) involving 1 lobe (OR =13.84) or 2 lobes (OR=6.95) when compared with severe patients. | The paper compared the common patients with severe patients – not comparing or mentioning about clinical presentations laboratory findings, and treatment modalities. |
| Adams et al.  (2020) [17] | 6 | 1,431 | Until April 12, 2020 | Chest CT appears to have a relatively high sensitivity (92.9% to 97.0%) in symptomatic patients at high risk of COVID-19, but it cannot exclude COVID-19. Specificity is poor (25.0% to 71.9%). | Summarized the sensitivity of chest CT as a diagnostic tool in COVID-19 pneumonia – there is no results clinical presentations, laboratory findings, and type of treatment |
| Chang et al.  (2020) [18] | 9 | 93 | Until Feburary 24, 2020 | In Fever occurred in 59% of the patients, while cough in 46%. Gastrointestinal symptoms (12%) were uncommon. There are 26% children are asymptomatic. The most common radiographic finding was GGO (48%). | The paper summarized CT findings, clinical characteristics and outcomes only in small number of children (not for adults) – detailed laboratory findings or treatment are not described in the manuscrupt |
| Wan et al.  (2020) [19] | 14 | 1,115 | January 24, 2020 to February 28, 2020 | Chest CTs showed pure GGO (69%, 95% CI 58-80%) and 70% (95% CI 46-95%) of cases showed a location preference for the right lower lobe, 65% (58-73%) of patients presented with ≥3 lobes involvement. In terms of clinical features, muscle soreness (21%, 95% CI 15-26%) and diarrhea (7%, 4-10%) were minor symptoms compared to fever (80%, 74-87%) and cough (53%, 33-72%). | CT findings and clinical presentations of patients with COVID-19 are summarized in this article – there is no results about laboratory findings and treatment modalities |
| Sun et al.  2020 [20] | 55 | NA | Until March 31, 2020 | Pulmonary lesions more often involved bilateral lungs (78%, 95% CI: 45–100%) and were more likely to have a peripheral (65.35%, 95% CI: 25.93–100%). GGO (58.05%, 95% CI: 16.67–100%), consolidation (44.18%, 95% CI: 1.61–71.46%) and GGO plus consolidation (52.99%, 95% CI: 19.05–76.79%) were the most common findings. | Investigation of CT findings of COVID-19 pneumonia– there is no findings about clinical presentations and laboratory findings |
| Lv et al.  2020 [21] | 103 | 5,673 | January 1, 2020 to March 31, 2020 | The sensitivity in case series was 96% (95% CI, 0.93-0.99). The most common imaging manifestation was GGO which was found in 75% (95% CI, 0.68-0.82) of the patients. The pooled probability of bilateral involvement was 84% (95% CI, 0.81-0.88). The most commonly involved lobes were the right lower lobe (84%, 95% CI, 0.78-0.90) and left lower lobe (81%, 95% CI, 0.74-0.87). | CT findings of patients with COVID-19 are summarized in this article – there is no results about clinical presentations, laboratory findings and treatment modalities |

**Abbreviations:** No: Number, CI: confidence interval, COVID-19: coronavirus disease 19, CT: computed tomography, GGO: Ground glass opacities, NA: not mentioned

**Table 2. Patient characteristics of included case series**

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | | **Number of Reported Cases**  **/ Total Number of Patients (n=3768)** | |
|  |
| **Age (years)** | | | |  |
| Mean | 47.7 | | |  |
| **Sex\*** | | | |  |
| Male | 1826 | | (48.5%) |  |
| Female | 1947 | | (51.7%) |  |
| **Underlying disease** | | | |  |
| Hypertension | 165/895 | | (18.4%) |  |
| DM | 65/782 | | (8.3%) |  |
| CVD | 52/737 | | (7.1%) |  |
| Cerebrovascular disease | 13/219 | | (5.9%) |  |
| Malignancy | 24/417 | | (5.8%) |  |
| COPD | 37/720 | | (5.1%) |  |
| Chronic liver disease | 12/297 | | (4.0%) |  |
| Pregnancy | 2/62 | | (3.2%) |  |
| CKD | 8/281 | | (2.8%) |  |
| Others\*\* |  | |  |  |
| **Initial symptoms**† | | | |  |
| Fever | 2066/2624 | | (78.7%) |  |
| Cough | 1438/2390 | | (60.2%) |  |
| Loss of appetite | 74/184 | | (40.2%) |  |
| Fatigue or Weakness | 457/1727 | | (26.5%) |  |
| Sputum | 425/1649 | | (25.8%) |  |
| Dyspnea | 211/1043 | | (20.2%) |  |
| Myalgia | 329/1937 | | (17.0%) |  |
| Sore throat | 189/1330 | | (14.2%) |  |
| Chest tightness | 71/635 | | (11.2%) |  |
| Chill | 46/448 | | (10.3%) |  |
| Headache | 147/1457 | | (10.1%) |  |
| Nasal congestion or Runny nose | 67/804 | | (8.3%) |  |
| Chest pain | 35/487 | | (7.2%) |  |
| GI symptom | 96/1523 | | (6.3%) |  |
| Shortness of breath | 46/869 | | (5.3%) |  |
| Hemoptysis | 13/651 | | (2.0%) |  |
| Others‡ |  | |  |  |
| **Period between symptom onset and admission (days)** | | | |  |
| Number of data samples | 351 | | |  |
| Average | 5.6 | | |  |

\* In the paper of [65], the total number of data is 116, and the number of males and the number of females is described as 56 and 65, respectively, so the sum does not match.

\*\* This contains diseases such as cerebral infarction (n=1 [52]), pulmonary emphysema (n=1 [58]), HIV infection (n=2 [68]), endocrine disease (n=3 [75]), surgical history (n=7 [75]), respiratory disease (n=5 [75])

†Symptoms described as 'expectoration', ‘sputum production’ are included in the 'sputum’, symptoms described as 'muscle ache', ’muscle soreness‘, ‘muscle pain’ are included in the 'myalgia’, symptoms described as 'abdominal pain', ‘diarrhea’, ‘gastrointestinal reaction’, ‘nausea’, ‘vomiting’ are included in the 'sputum’, symptoms described as 'nasal obstruction', ‘rhinorrhea’ are included in the ‘nasal congestion or runny nose’, symptoms described as ‘difficulty breathing’ is included in the ‘dyspnea’, symptom described as ‘throat pain’ is included in the ‘sore throat’, and symptom described as ‘dry cough’ is included in the ‘cough’, symptom described as ‘anorexia’ is included in the ‘loss of appetite’.

‡This contains symptoms such as lymphocytopenia (n=95 [47]), rhinobyon and snivel (n=13 [61])

Abbreviation: n: number; DM: diabetes mellitus; CVD: cardiovascular disease; COPD: chronic obstructive pulmonary disease; CKD: chronic kidney disease; GI: gastrointestinal; HIV: human immunodeficiency virus; Hx: history.

**Table 3.** CT findings of patients with COVID-19

|  |  |  |
| --- | --- | --- |
| **CT findings** | **Number of Reported Cases**  **/ Total Number of Patients (n=3768)** | |
|  |
| **Imaging finding** | | |  |
| Vascular enlargement | 412/486 | (84.8%) |  |
| GGO | 1311/2182 | (60.1%) |  |
| Air bronchogram | 406/850 | (47.8%) |  |
| Consolidation | 811/1960 | (41.4%) |  |
| Crazy paving | 240/841 | (28.5%) |  |
| Septal thickening | 280/1317 | (21.3%) |  |
| Pleural effusion | 43/635 | (6.8%) |  |
| **Transverse distribution** | | |  |
| Central | 51/264 | (19.3%) |  |
| Peripheral | 574/795 | (72.2%) |  |
| Central and Peripheral | 71/170 | (41.8%) |  |
| **Lung region distribution** | | |  |
| Unilateral | 40/225 | (17.8%) |  |
| Bilateral | 1335/1757 | (76.0%) |  |
| **Lobe distribution** | | |  |
| RUL | 147/299 | (49.2%) |  |
| RML | 148/299 | (49.5%) |  |
| RLL | 216/299 | (72.2%) |  |
| LUL | 155/299 | (51.8%) |  |
| LLL | 208/299 | (69.6%) |  |

Abbreviation : CT : computer tomography; COVID-19 : coronavirus disease 2019; n : number; GGO : ground glass opacity; RUL : right upper lobe; RML : right middle lobe; RLL : right lower lobe; LUL : left upper lobe; LLL : left lower lobe.

**Table 4.** Laboratory findings of patients with COVID-19\*

|  |  |  |  |
| --- | --- | --- | --- |
| **Lab findings** | | **Number of Reported Cases**  **/ Total Number of Patients (n=3768)** | |
|  |
| **WBC(×109/L)** | | | |  |
| Mean (n=1171) | 5.18 | | |  |
| Normal | 1166/1210 | | (96.4%) |  |
| Increased | 27/1210 | | (2.2%) |  |
| Decreased | 17/1210 | | (1.4%) |  |
| **Neutrophil(×109/L)** | | | |  |
| Mean (n=1004) | 3.50 | | |  |
| **Lymphocyte(×109/L)** |  | |  |  |
| Mean (n=1329) | 1.27 | | |  |
| Normal | 1130/1297 | | (87.2%) |  |
| Increased | 55/1297 | | (4.2%) |  |
| Decreased | 112/1297 | | (8.6%) |  |
| **C-Reactive Protein(mg/L)** | | | |  |
| Mean (n=1187) | 13.70 | | |  |
| Increased | 376/1187 | | (31.7%) |  |
| **Aspartate transaminase(U/L)** | | | |  |
| Mean (n=259) | 36.93 | | |  |
| **Alanine aminotransferase(U/L)** | | | |  |
| Mean (n=259) | 30.81 | | |  |
| **Lactic acid dehydrogenase(U/L)** | | | |  |
| Mean (n=1082) | 238.10 | | |  |

\*The criteria for increased and decreased WBC, Neutrophil, Lymphocyte and C-reactive protein are different for each paper.

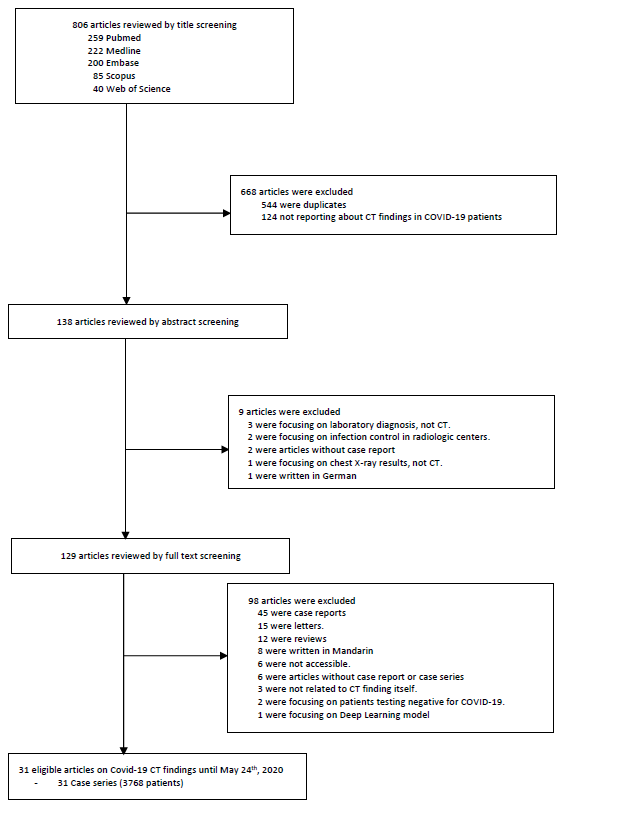
Abbreviation: COVID-19: coronavirus disease 2019; n: number; WBC: white blood cell.

**Table 5.** Treatment of case-series patients with COVID-19

|  |  |
| --- | --- |
| **Treatments** | **Reported case-series among total number of patients (n=3768)** |
| Anti-coronavirus treatment | 668 (17.7%) |
| Glucocorticoid | 139 (3.7%) |
| Oxygen therapy | 373 (9.9%) |
| Mechanical ventilator | 41 (1.1%) |
| Plasminogen therapy | 13 (0.3%) |
| ECMO | 4 (0.1%) |
| CRRT | 2 (0.05%) |

Abbreviation: COVID-19: coronavirus disease 2019; ECMO: Extracorporeal membrane oxygenation; CRRT: Continuous Renal Replacement Therapy

**Figure 1.** Flow chart of literature search.



**Supplementary Appendix**

**: “Chest CT abnormalities in COVID-19: a systematic review”**

**Table of contents**

1. PRISMA Checklist ..........................................................................................................................................1

2. Search strategy ............................................................................................................................................3

3. Reasons for study exclusion.........................................................................................................................4

4. Detailed distribution of patients on the studies included studies.................................................................5

**1.** **PRISMA Checklist**

**Table S1. Checklist summarizing compliance with PRISMA guidelines\***

|  |  |  |  |
| --- | --- | --- | --- |
| **Section/topic** | **#** | **Checklist item** | **Reported on page #** |
| **TITLE** | | |  |
| Title | 1 | Identify the report as a systematic review, meta-analysis, or both. | Title |
| ABSTRACT | | |  |
| Structured summary | 2 | Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number. | 1 |
| INTRODUCTION | | |  |
| Rationale | 3 | Describe the rationale for the review in the context of what is already known. | 2 |
| Objectives | 4 | Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS). | 2 |
| METHODS | | |  |
| Protocol and registration | 5 | Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number. | N/A |
| Eligibility criteria | 6 | Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale. | 2-3 |
| Information sources | 7 | Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched. | 2-3 |
| Search | 8 | Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. | 2-3 |
| Study selection | 9 | State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis). | 2-3  (Figure1) |
| Data collection process | 10 | Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators. | 2-3 |
| Data items | 11 | List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made. | 2-3 |
| Risk of bias in individual studies | 12 | Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis. | N/A |
| Summary measures | 13 | State the principal summary measures (e.g., risk ratio, difference in means). | 2-3 |
| Synthesis of results | 14 | Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I2) for each meta-analysis. | 4 |

|  |  |  |  |
| --- | --- | --- | --- |
| Section/topic | # | Checklist item | Reported on page # |
| Risk of bias across studies | 15 | Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies). | N/A |
| Additional analyses | 16 | Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified. | N/A |
| RESULTS | | |  |
| Study selection | 17 | Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram. | 4-6 |
| Study characteristics | 18 | For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations. | 4-6, Table 2, Supplementary tables |
| Risk of bias within studies | 19 | Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12). | Supplementary tables |
| Results of individual studies | 20 | For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot. | 5-8, Supplementary tables |
| Synthesis of results | 21 | Present results of each meta-analysis done, including confidence intervals and measures of consistency. | 5-8 |
| Risk of bias across studies | 22 | Present results of any assessment of risk of bias across studies (see Item 15). | N/A |
| Additional analysis | 23 | Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]). | N/A |
| DISCUSSION | | |  |
| Summary of evidence | 24 | Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers). | 8-9 |
| Limitations | 25 | Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias). | 9-10 |
| Conclusions | 26 | Provide a general interpretation of the results in the context of other evidence, and implications for future research. | 10 |
| FUNDING | | |  |
| Funding | 27 | Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review. | 10 |

\*Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. J Clin Epidemiol 62:1006-1012.

**2. Search strategy**

We searched PubMed, MEDLINE, Scopus, Embase and Web of Science for reports published only in English until May 4, 20200, that assessed the association between CT finding and all informations of patients with COVID-19. We searched all fields for coronavirus (search terms:“Coronavirus 19”, “COVID-19”, “SARS-CoV-2”, “2019-nCoV”, “novel coronavirus 2019") and terms of CT (search terms:”CT”, “Computed Tomography”).

Full search strategies for each database are given in Table S2.

**Table S2. Search strategy**

|  |  |  |
| --- | --- | --- |
| Database | Number of studies | Search terrns |
| PubMed | 259 | (“Coronavirus 19” OR “COVID-19” OR “SARS-CoV-2” OR “2019-nCoV” OR “novel coronavirus 2019")  AND  (“CT” OR “computed tomography”) |
| Medline | 222 | (“Coronavirus 19” OR “COVID-19” OR “SARS-CoV-2” OR “2019-nCoV” OR “novel coronavirus 2019")  AND  (“CT” OR “computed tomography”) |
| Scopus | 85 | TITLE-ABS-KEY(“Coronavirus 19” OR “COVID-19” OR “SARS-CoV-2” OR “2019-nCoV” OR “novel coronavirus 2019)  AND TITLE-ABS-KEY(CT OR “computed tomography”) |
| Embase | 200 | (‘Coronavirus 19’ OR ‘COVID-19’ OR ‘SARS-CoV-2’ OR ‘2019-nCoV’ OR ‘novel coronavirus 2019’)  AND  (CT OR ‘computed tomography’) |
| Web of Science | 40 | ((TS=Coronavirus 19) OR (TS=COVID-19) OR (TS=SARS-CoV-2) OR (TS=2019-nCoV) OR (TS=novel coronavirus 2019))  AND  ((TS=CT)OR (TS=computed tomography)) |

**3. Reasons for study exclusion**

We manually screened the retrieved articles which were met inclusion criteria. After excluding studies by examining titles and abstracts, full texts of 31 studies were eligible for inclusion.

98 studies were retrieved following reasons**:**

**Table S3: Reason for exclusion during full text screening**

|  |  |
| --- | --- |
| Number of studies | Reason |
| 45 | Case reports |
| 15 | Letters |
| 12 | Reviews |
| 8 | Written in Mandarin |
| 6 | Not accessible |
| 6 | Articles without case report or case series |
| 3 | Not related to CT finding itself |
| 2 | Focusing on patients testing negative for COVID-19 |
| 1 | Focusing on Deep Learning model |

CT: computed tomography, COVID-19: Coronavirus disease 19

**4. Detailed description of included studies**

**Table S4: Detailed description about basal characteristics of included case-series**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **No.** | **Authors** | **Sample size** | **Mean**  **Age** | **Sex**  **(M:F)** | **Initial symptoms** | | **Period between symptom onset and admission (day)** | **Period between symptom onset (or admission) and CT scan (day)** | **CT image feature** | | | | |
| Fever | Other | **Distribution** | **Lobes** | **Appearance** | **Specific signs** | **CT score\*** |
| **1** | **Zhao D et al. (2020 March) [1]** | 19 | 48 (IQR:27~56) | 11:8 | 15/19 (78.95%). | Cough 9/19 (47.37%) sore throat 4/19 (21.05%) headache 2/19 (10.53%), fatigue 2/19 (10.53%), Diarrhea 1/19 (5.26%), Chest tightness 1/19 (5.26%) | 5 (IQR: 3~9) | 3.76±2.22 (1-10) // 5.2±1.2 (4-8) times | - | N/A | Multiple mottling and GGO 17/19(89.47%) | N/A | N/A |
| **2** | **Caruso. D et al. (2020 April) [2]** | 158 | 57  ±17 | 83:75 | 97/158 (61%) | Cough 88/158 (56%), dyspnea 52/158 (33%), lymphocytopenia 95/158 (60%) | N/A | N/A | Right upper lobe 53/58(91%), Right middle lobe 48/58(82%), Right lower lobe 54/58(93%) Left upper lobe 49/58(84%) Left lower lobe 53/58(91%) | N : 4.41±2.26 | GGO 58/58 (100%), Consolidation 42/58 (72%), | Crazy-paving: 23/58 (39%) Rounded morphology: 19/58(32%) Linear oppacities16/58(27%) Air bronchogram 21/58(36%) Interlobular septal thickening 8/58(13%) | N/A |
| **3** | **A Bernheim et al. (2020 Feb) [3]** | 121 | 45±15.6 (18-80) | 61:60 | 74/121 (61%) | Cough 58/121 (48%), sputum production 20/121(17%) | N/A | Early (0-2days): 36/121(29.7%) intermediate (3-5days): 33/121(27.2%) Late: 25/121(20.6%) | Right upper lobe 53/121(44%), Right middle lobe 50/121(41%), Right lower lobe 79/121(65%) Left upper lobe 58/121(48%) Left lower lobe 76/121(63%) | - | - | Crazy-paving: 6/121 (5%) Rounded morphology: 65/121(54%) Linear oppacities 9/121(7%) Bronchial wall thickening 14/121(12%) | N/A |
| **4** | **J Wu et al. (2020 Feb) [4]** | 80 | 44±11 | 38:42 | 18/21 (86%). Low (<38) 19/80 (24%), Moderate (38.1-39) 38/80 (47%), High (>39.1) 3/80 (4%) | Cough 58/80 (73%), Expectortation 11/80(14%), Chest pain 5/80 (6%), Muscle ache 13/80(16%) Dyspnea 7/80(9%) Abdominal pain& diarrhea 7/80(9%) | 7±4 | N/A | Subpleural distribution 42 (53%) Diffuse distribution 7 (9%) Peribronchial distribution 3 (4%) Mixed distribution 24 (30%) | Average lung segments involved 12 (6) Dorsal segment of the right lower lobe 69 (86%) Lateral basal segment of the right lower lobe 64 (80%) Posterior basal segment of the right lower lobe 68 (85%) Dorsal segment of the left lower lobe 61 (76%) Posterior basal segment of the left lower lobe 65 (81%) PII value 34% (20%) | GGO 73/80 (91%) Consolidation 50 (63%) | Crazy paving pattern 23 (29%) Spider web sign 20 (25%) Subpleural line 16 (20%) Bronchial wall thickening 9 (11%) Lymph node enlargement 3 (4%) Pericardial effusion 4 (5%) Pleural effusion 5 (6%) | 4.3 (1-11) |
| **5** | **YH Xu et al. (2020 Apr 17) [5]** | 50 | 40.0±10 (27-60) | 29:21 | 37.3–38 °C (22 or 44%) 38.1–39 °C (16 or 32%) >39 °C (5 or 10%) | Cough 20 (40%), Expectoration7 (14%), headache 5(10%) Fatigue 8 (16%), Muscle ache 8 (16%) Chest tightness and dyspnea 4 (8%) Gastrointestinal reaction 1 (2%) | - | 4 (1-7) | - | - | GGO (76.5%), consolidation (11%) | Enlarged pulmonary vessels (70.6%), adjacent pleura thickening (41.2%), crazy paving (35.3%), air brochograms (29.4%), interlobar fissure (23.5%) | 4.3 (1-11) |
| **6** | **Tao Ai et al. (2020 ) [6]** | 1049 | 51±15 (2-95) | 467:582 | - | - | - | - | Consistent with viral pneumonia = 888 (88%) | - | GGO 409/888 (46%), consolidation 447/888 (50%) | Reticulation/thickened interlobular septa 8/888 (1%), nodular lesions 24/888 (3%) |  |
| **7** | **Shuchang Zhou et al. (2020 Feb 19) [7]** | 62 | 52.8±12.2 (30-77) | 39:23 | 54/62 | coughing and sputum 28/62, fatigue 14/62, shortness of breath 15/62, muscle pain 20/62, abdominal pain or diarrhea 9/62 | - |  | Peripheral 48 (77.4%), peripheral and central 14 (22.6%) | - | GGO 25/62 (40.3%), consolidation 21/62 (33.9%) | Air bronchogram 45/62 (72.6%), thickening of pleura 30/62 (48.4%), pleural effusion 6/62 (9.7%) | left 5.9±5.1, right 6.2 ± 5.3, upper 3.0±3.4, middle 4.5±3.8, lower 4.5±3.7, anterior 4.4±4.1, posterior 7.7±6.3 |
| **8** | **Rui Zhang et al. (2020 Apr 1) [8]** | 120 | 45.4±15.6 | 43:77 | 81 (68%) | Cough 74 (63%), dyspnea 38 (32%), myalgia or fatigue 57 (48%), headache 28 (23%), | - |  | Bilateral 68 (57%), peripheral 109 (91%), central 39 (33%) | Upper right lobe 41 (34%), middle right lobe 50 (42%), lower right lobe 83 (69%), upper left lobe 48 (40%), lower left lobe 79 (66%) | GGO 111 (93%), consolidation 66 (55%) | Crazy paving 30 (25%), bronchiectasis 14 (12%), effusion 9 (8%) | - |
| **9** | **Kunwei Li et al. (2020 Mar 16) [9]** | 78 | 44.6±17.9 | 38:40 | 54 (69.2%) | Chills 5 (6.4%), cough 36 (46.2%), sputum 16 (20.5%), hemoptysis 2 (2.6%), sore throat 8 (10.3%), nasal congestion and runny nose 10 (12.8%), headache and dizziness 6 (7.7%) | 3±2 (0-15) |  | Bilateral 45 (57.7%), peripheral 49/56 (87.5%) | More than two lung lobes 40 (51.3%) | GGO 45/56 (80.4%), consolidation 12/56 (21.4%) | Interlobular septal thickening 25/56 (44.6%), air brochogram 41/56 (73.2%), | - |
| **10** | **Michael Chung et al. (2020) [10]** | 21 | 51±14 (29-77) | 13:8 | 14/21 (67%) | Fatigue 3 (14%), headache 3 (14%), cough 9 (43%), muscle soreness 3 (14%), nausea 1 (5%) | - |  | Bilateral 16 (76%) | More than two lung lobes 15 (71%) | GGO 18/21 (86%), consolidation 6 (29%) | Crazy paving pattern 4 (19%), peripheral distribution 7 (33%) | - |
| **11** | **Kai-Cai Liu et al. (2020 Mar 7) [11]** | 73. | 41.6±14.5 (5-86) | 41:32 | 68/73 (93%) | Cough 60 (82%), fatigue 55 (75%), sputum 39 (53%), anorexia 20 (27%) | - |  | Unilateral 15/73 (20%), bilateral 55/73 (75%) | - | GGO 65/73 (89%), consolidation 8/73 (10%) | Paving stone sign 28 (38%), bronchial wall thickening 19 (26%) | - |
| **12** | **Chunqin Long et al. (2020 Mar 11) [12]** | 36 | 44.8±18.2 | 20:16 | 36/36 (100%) | Cough 27/36 (75%), myalgia or fatigue 14/36 (38.9%), nausea or diarrhea 6/36 (16.6%) | - |  | Peripheral distribution 26/36 (72.2%), central distribution 10 (27.8%) | Multiple CT abnormalities 25/36 (69.4%) | GGO 11/36 (30.6%), consolidation 6/36 (16.7%), GGO with consolidation 19/36 (52.7%) | Lymphadenopathy 1/36 (2.78%), pleural effusion 2/36 (5.56%) | - |
| **13** | **Yuki Himoto et al. (2020 Mar 18) [13]** | 6 | 58.5 (45-81) | 5:1 | - | - | 9.5 (4-25) |  | Peripheral predominance 6/6 (100%), bilateral 6/6 (100%) | - | GGO 4/6 (66%), GGO with consolidation 2/6 (33%) | Pulmonary nodules 2/6 (33.3%) | - |
| **14** | **Rui Han et al. (2020 Feb 15) [14]** | 108 | 45 (21-90) | 38:70 | 94/108 (87%) | Dry cough 65 (60%), fatigue 42 (39%), chest distress 17 (16%), pharyngeal pain 14 (13%), headache 14 (13%), muscle pain 12 (11%) | - | median 1 (1-3) | Peripheral 97 (90%), central 2 (2%), peripheral and central 9 (8%) | - | GGO 65 (60%), consolidation 6 (6%), GGO with consolidation 44 (41%) | Vascular thickening 86 (80%), crazy paving pattern 43 (40%), air bronchogram sign 52 (48%), halo sign 69 (64%) | - |
| **15** | **Xiaoli Zhang et al. (2020 Mar 15) [15]** | 573 | 46.65±13.82 | 295:278 | 492/573 (85.9%) | Cough 392/573 (68.4%), expectoration 208 (36.3%), hemoptysis 11 (2%), sore throat 80 (14%), nasal obstruction 29 (5.1%), muscle ache 66 (11.5%), fatigue 109 (19%), shortness of breath 26 (4.5%), diarrhea 45 (7.9%), nausea and vomiting 22 (3.8%), headache 65 (11.3%) | - |  | Bilateral 432 /573 (75.3%) | More than 2 lobes affected 230/573 (40.1%) | GGO or consolidation 573 (100%) | - | - |
| **16** | **Xiaoli Zhang et al. (2020 Mar 15) [15]** | 72 | 34.9±14.20 | 33:39 | 48/72 (66.7%) | Cough 33/72 (45.8%), expectoration 17 (23.6%), sore throat 17 (23.6%), nasal obstruction 7 (9.7%), muscle ache 5 (7.0%), fatigue 9 (12.5%), diarrhea 8 (11.1%), headache 2 (2.8%), | - | - | - | - | Absence of both GGO and consolidation 72 (100%) | - | - |
| **17** | **Hui Dai et al. (2020 Apr 1) [16]** | 234 | 44.6±14.8 (7-82) | 136:98 | 170 (72.6%) | pharyngeal discomfort (15%), fatigue (13.2%), chill (9.8%), muscle ache (9.0%), rhinobyon and snivel (5.6%), diarrhea (3.8%), chest pain (3.4%), chest tightness (5.6%), short of breath (2.1%), difficulty breathing (3%), nausea and vomiting (2.1%) | - | - | Bilateral multiple lung lobes 192/219 (87.6%), periphery and/or lower lungs 208/219 (94.98%) | - | - | VES 207/219, interlobular septal thickening 205/219, air bronchus sign 184/219, intralesional and/or perilesional bronchiectasis 173/219, pleural thickening 170/219, solid nodules 138/219, reticular/mosaic sign 135/219 | - |
| **18** | **Xi Xu et al. (2020 Feb 28) [17]** | 90 | 50 (18-86) | 39:51 | 70 (78%) | Cough 57 (63%), sputum 11 (12%), fatigue 19 (21%), myalgia 25 (28%), sore throat 23 (26%), chills 6 (7%), headache 4 (4%), diarrhea 5 (6%) | - | - | Periphery 46 (51%), bilateral 53 (59%), multifocal 62 (69%) | More than two lobes 53 (59%) | GGO 65 (72%), consolidation 12 (13%) | Crazy paving pattern 11 (12%), interlobular septal thickening 33 (37%), linear opacities combined 55 (61%), air bronchogram sign 7 (8%), adjacent pleura effusion 4 (4%) | - |
| **19** | **Chun Shuang Guan et al. (2020 Mar 6) [18]** | 53 | 42 (1-86) | 25:28 | - | - | - | - | Bilateral 37/47 (78.72%), subpleural distribution 44/47 (93.6%) | - | GGO 47 (100%), consolidation 30 (63.8%) | Crazy-paving 42 (89.3%), air bronchogram 36 (76.6%), | - |
| **20** | **K. Wang et al. (2020 Mar 4) [19]** | 114 | 53 (23-78) | 58:56 | 107/114 (93.9%) | Cough 91/114 (79.8%), sputum 9 (7.9%), sore throat 6 (5.3%), chest tightness 27 (23.7%), dyspnea 27 (23.7%), diarrhea 3 (2.7%) | - | - | Peripheral 48 (43.6%), bilateral 62 (56.4%) | - | GGO 30/114 (27.3%), consolidation 30 (27.3%), GGO with consolidation 50 (45.4%) | Pleural effusion 1 /114 (0.9%) |  |
| **21** | **Wanbo Zhu et al. (2020 Mar 10) [20]** | 116 | 40 (27-53) | 56:65 | 84/116 (72%) | Cough 73/116 (63%), myalgia or fatigue 11 (9%), expectoration 22 (19%), chest stuffiness 5 (4%) | - | - | Bilateral 29/32 (91%) | - | GGO 15/32 (47%), consolidation 4 (13%) | Crazy-paving pattern 1/32 (3%), pleural effusion 2/32 (6%) |  |
| **22** | **Pan F et al. (2020 Feb 13) [21]** | 21 | 40±9 (25-63) | 6:15 | Fever 84/116 (72%) | Throat pain 4/21 (19%), Cough 12/21 (57%), Expectoration 6/21 (29%), Chills 6/21 (29%), Fatigue 11/21 (52%), Loss of appetite 9/21 (43%), Myalgia 5/21 (24%), Chest pain 2/21 (9.5%) | 2±2 (0-9) | 2±2 (0-9) / Mean interval 4±1 (1-8), 4±1 (3-6) times | Single lobe 3/21 (14%), Bilateral Multilobe 18/21 (86%); Peripheral 13/21 (62%), Random 7/21 (33%), Diffuse 1/21 (4.8%) | N : 2±2 (0-5) | GGO 15/21 (71%), Consolidation 19/21 (91%), | Crazy-paving: 4/21 (19%) | Total 2±2 (0-6). LUL 0±1 (0-2), LLL 1±1 (0-3), RUL 0±1 (0-2), RML 0±1 (0-2), RLL 1±1 (0-2) |
| **23** | **Huang G et al. (2020 Mar 30) [22]** | 25 | 46.9±15.8 (20-81) | 14:11 | 18/21 (86%). Low (<38) 6/21 (29%), Moderate (38.1-39) 7/21 (33%), High (>39.1) 5/21 (24%) | Thorat pain 2/25 (8%), Cough 18/25 (72%), Expectoration 5/25 (20%), Chills 6/25 (24%), Fatiuge 10/25 (40%), Loss of apetite 10/25 (40%), Myalgia 3/25 (12%), Chest pain 2/25 (8%) | Onset to diagnosis and treatment : 3.76±2.22 (1-10) | 3.76±2.22 (1-10) // 5.2±1.2 (4-8) times | - | - | - | - | - |
| **24** | **Wang D et al. (2020 Mar 17) [23]** | 138 | 56 (IQR 42-68) | 75:63 | 21/25 (84%). Range 37.3-39.1 | Pharyngyalgia 24/138 (17.4%), Dry cough 82/138 (59.4%), Expectoration 37/138 (26.8%), Fatigue 96/138 (69.6%), Anorexia 55/138 (39.9%), Myalgia 48/138 (34.8%), Dyspnea 43/138 (31.2%), Diarrhea 14/138 (10.1%), Nausea 14/138 (10.1%), Dizziness 13/138 (9.4%), Headache 9/138 (6.5%), Vomiting 5/138 (3.6%), Abdominal pain 3/138 (2.2%) | Median 7.0 (IQR 4.0-8.0) |  | Bilateral 138/138 (100%) | - | - | - | - |
| **25** | **Xiaoyu Han et al. (2020 Apr 17) [24]** | 17 | 40.0±10 (27-60) | 6:11 | 136/138 (98.6%). | Cough 7/17 (41%), weakness 2/17 (11%), sputum 2/17 (11%), headache 2/17(11%) | - | 4 (1-7) | Unilateral (29.4%), bilateral (70.6%) | - | GGO (76.5%), consolidation (11%) | Enlarged pulmonary vessels (70.6%), adjacent pleura thickening (41.2%), crazy paving (35.3%), air brochograms (29.4%), interlobar fissure (23.5%) | 4.3 (1-11) |
| **26** | **Shen Q et al. (2020) [25]** | 9 | 8 (1-12) | 3:6 | 14/17 (82.4%) among which 12 > 38 (85.7%) | Sore throat 1/9 (11%), Cough 1/9 (11%), Diarrhea 2/9 (22%) | Median 3 (0-17) |  |  | Unilateral 2/2 | GGO 2/9 (22%) | None |  |
| **27** | **Wu Y et al. (2020)**  **[26]** | 13 | 48 (30-78) | 10:3 | 4/9 (44.4%). Mean 37.3, Range 36.5-39.1 | - | - | - | - | - | - | - | - |
| **28** | **Gao L et al. (2020) [27]** | 6 | 40±10 | 1:5 | - | cough, sore throat, fatigue |  | all within 2 days | Single lesion 2/6, multiple lesion 4/6 Subpleural 2/6, peribronchial 1/6 | Unilateral 4/6, bilateral 2/6 | GGO 5/6 | Lobar septal thickening 1/6, bronchial wall thickening 2/6, halo sign 2/6, crazy-paving 1/6, tree-in-bud 1/6 |  |
| **29** | **Shi H et al. (2020) [28]** | 81 | 49.5±11 | 42:39 | fever | Dyspnea 34/81(42%), chest tightness 18 (22%), cough 48 (59%), sputum 15 (19%), rhinorrhea 21 (26%), weakness 7 (9%), headache 5 (6%), vomiting 4, diarrhea 3, dizziness 2, anorexia 1 |  |  | Bilateral 64 (79%), peripheral 44 (54%), ill-defined 66 (81%) | Involved lung segments: 10.5±6.4. | GGO 53 (65%) -> mainly RLL (27%) |  |  |
| **30** | **Zhao W et al. (2020 Feb) [29]** | 101 | 44.44±12.32 (17-75) | 56:45 | 59/81 (73%) : <37.3 (30%), 37.3-38 (25%), 38-39 (28%), >39 (17%) | cough 63 (62.4%), myalgia/fatigue 17(16.8%), sore throat 12 (11.9%), dyspnea 1, diarrhea 3, nausea/vomiting 2 |  | admission to CT : 1 (0-7) | Peripheral 87.1%; Upper lung dominant 5.9%, lower lung dominant 54.5%, no craniocaudal 31.7%; Bilateral 82.2%, unilateral 9.9%; Focal 5.9%, multifocal 54.5%, diffuse 31.7% |  | GGO 87 (86.1%), consolidation 44 (43.6%) | Architectural distortion (21.8%), bronchial wall thickening (28.7%), reticulation 48.5%, subpleural bands 27.7%, traction bronchiectasis 52.5%, pleural effusion 13.9%, vascular enlargement 71.3% | Extent score 6/39 (0-20) |
| **31** | **Zhou Y et al. (2020 Mar) [30]** | 17 | (18-70) | 6:11 | 79/101(78.2%) | Cough 8 (47.1%), dyspnea 2 (11.8%), fatigue 3 (17.6%), diarrhea 0 |  | - | Bilateral 8 (47.1%), single lobe 4 (23.5%), normal 5 (41.7%) | - | - | - | - |
| **32** | **Wang Y et al. (2020) [31]** | 90 | 45±14 | 33:57 | 11/17 (64.7%) | Cough 20 (22%), Hypodynamia 22 (24%), Chest tightness 8 (9%), Sore throat 7 (8%), Diarrhea 6 (7%), Headache 4 (4%), Muscle pain 4 (4%) |  | - | - | - | GGO 35/78(45%)-49/79(62%) | - | - |

Abbreviation : No. : Number; CT : computer tomography; GGO : ground glass opacity; WBC : white blood cell; CRP : C-reactive protein; ESR : erythrocyte sedimentation rate; N/A : not available

\* The degree of involvement in each lung zone was scored

**Table S5: Detailed description about basal characteristics of included case-series**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **No.** | **Authors** | **Initial symptoms** | | | | **Underlying disease** | **Clinical outcome / Course / Therapy** | | | **Comments** |
| **CBC** | **CRP/ESR** (mg/dL) | **Other inflammatory biomarkers** | **Blood chemistry** | **Clinical outcome / Course** | **Therapy** | **Complications** |
| **1** | **Zhao D et al. (2020 March) [1]** | WBC 4.92 (1.26-7.63), ratio of neutrophil 74.02 (55.30-93), Lymphocyte 0.97 (0.3-2.03) | CRP 26.47 (10-127.1) | IL-6 19.34 (8.7-45.3) | AST 34.9(17.6-103.8) ALT 36.37(11.8-85.0) | N/A | N/A | N/A | N/A | Admission data was recruited 19 NCOVID-19 patients and 15 NON-COVID-19 patients from Jan 23 to Feb 5, 2020, at the Second Affiliated Hospital of Anhui Medical University and Suzhou Municipal Hospital in Anhui province, China 23 to Feb 5, 2020. |
| **2** | **Caruso. D et al. (2020 April) [2]** | Lymphocyte 1.08±0.47 | CRP (13.64 ± 38.68) | N/A | LDH 339.5±124.153 | N/A | N/A | N/A | N/A | CT feature was classified only in RT-PCR confirmed patients  Other features were about both RT-PCR confirmed patients and not confirmed patients (There were no Raw data) |
| **3** | **A Bernheim et al. (2020 Feb) [3]** | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | CT Feature were classified according to the time of admission |
| **4** | **J Wu et al. (2020 Feb) [4]** | WBC 5.40 (4.20–6.95) Neutrophil 3.74 (2.67–5.20); lymphocyte 1.15 (0.76–1.40) | CRP 12.39 (2.71–50.61) | N/A | N/A | COPD 1/17 (5%), HTN (5%), type 2 DM 2/17 (11%) | N/A | N/A | N/A | N/A |
| **5** | **YH Xu et al. (2020 Apr 17) [5]** | leukocyte 4.6±1.9, lymphocyte 1.2±0.4 | CRP 11.7 (11.8), ESR 34 (16) \*(interquartile range) | N/A | AST 33 (24.5), 31 (22) (interquartile range) | N/A | mean treatment time : 22 (18-31) | anti-viral drug, empirical antibacterial drug, abidol hydrochloride | N/A | - |
| **6** | **Tao Ai et al. (2020 ) [6]** | - | - | - | - | N/A | - | - | - | From Jan 6 to Feb 6, 2020, a total of 1049 patients who were suspected of novel coronavirus infection and underwent both chest CT imaging and laboratory virus nucleic acid test were retrospectively enrolled in Tongji Hospital of Tongji Medical College of Huazhong University of Science and Technology, Wuhan, Hubeim China |
| **7** | **Shuchang Zhou et al. (2020 Feb 19) [7]** | leukopenia 6/30, decreased lymphocyte count 24/30, | increased hs-CRP 27/27, increased ESR 1/27 | - | - | HTN 4/62, DM 4/62, cerebral infarction 1/62, CKD 1/62, pregnancy 2/62 | - | - | - | A retrospective study of 62 consecutive patients with laboratory-confirmed COVID-19 pneumonia was performed. |
| **8** | **Rui Zhang et al. (2020 Apr 1) [8]** | WBC 5.0±2.2, neutrophil 2.0±1.7, lymphocyte 2.4±1.8 | - | - | LDH 235.6±109.6 | Diabetes 7 (6%), HTN 19 (16%), CVD 9 (8%), COPD 4 (3%), Malignancy 7 (6%) | - | - | - | this was a retrospective analysis of the clinical and thoracic CT features of 120 consecutive patients with confirmed SARS-CoV-2 pneumonia admitted to a tertiary university hospital between January 10 and February 10, 2020, in Wuhan city, China |
| **9** | **Kunwei Li et al. (2020 Mar 16) [9]** | - | - | - | - | HTN 10 (12.8%), DM 4 (5.1%), chronic liver disease 1 (1.3%), COPD 9 (11.5%), heart disease 2 (2.6%), tumor 3 (3.8%) | - | - | - | The authors conducted a retrospective single-center study on patients with COVID-10 from Jan. 18, 2020 to Feb 7, 2020 in Zhuhai, China. |
| **10** | **Michael Chung et al. (2020) [10]** | - | - | - | - | - | - | - | - | From January 18, 2020, until January 27, 2020, 21 patients admitted to three hospitals in three provinces in China with confirmed 2019-nCoV underwent chest CT. Ten patients were from Zhuhai (Guangdong Province) and were imaged with 1-mm-thick slices with a UCT 760 scanner (United Imaging, Shanghai, China). Nine patients were from Nanchang (Jiangxi Province) and were imaged with 8-mm-thick slices with an Emotion 16 scanner (Siemens Healthineers, Erlangen, Germany). Two patients were from Qingdao (Shandong Province) and were imaged with 5-mm-thick slices, one with a Bright Speed scanner (GE Medical Systems, Milwaukee, Wis) and one with an Aquilion ONE scanner (Toshiba Medical Systems, Tokyo, Japan). |
| **11** | **Kai-Cai Liu et al. (2020 Mar 7) [11]** | - | - | - | - | - | - | - | - | The data of patients were collected from 6 hospitals in Anhui province, China from Jan 21 to Feb 3, 2020. |
| **12** | **Chunqin Long et al. (2020 Mar 11) [12]** | Leukocyte count (normal or decreased) 33/36 (91.7%), decreased lymphocytes 23/36 (63.8%) | Leukocyte count (normal or decreased) 33/36 (91.7%), decreased lymphocytes 23/36 (63.8%) | - | - | - | - | - | - | From January 20th, 2019 to February 8th, 2020, a total of 204 patients suspected for COVID-19 underwent chest CT examinations. Of the patients, 106 were not tested using rRT-PCR. Eleven other patients were transferred to other hospitals and were also excluded. The remaining 87 patients underwent both CT and rRT-PCR in our hospital. The gold standard fora ﬁnal diagnosis was positivity of ﬁrst or repeated rRT-PCR tests. Amongst the 87 included cases, 36 patients were ﬁnally diagnosed with COVID-19 pneumonia. The other 51 patients without COVID-19 pneumonia served as the control group |
| **13** | **Yuki Himoto et al. (2020 Mar 18) [13]** | - | - | - | - | Pulmonary emphysema 1/6 (16.6%) | - | - | - | This retrospective study included 21 patients clinically suspected COVID-19 pneumonia and underwent chest CT more than 3 days after the symptom onset: six patients confirmed COVID-19 pneumonia by real-time RT-PCR and 15 patients proved uninfected. |
| **14** | **Rui Han et al. (2020 Feb 15) [14]** | Decreased WBC count 11 (10%), decreased lymphocte count 65 (60%) | High CRP 107 (99%) | - | - | - | - | - | - | This retrospective study received local ethics committee approval. Patients with confirmed COVID-19 pneumonia confirmed by SARS-CoV-2 nucleic acid test (reverse transcription–polymerase chain reaction) at our hospital ( Wuhan No. 1 Hospital) from January 4 to February 3, 2020, were enrolled in this retrospective study |
| **15** | **Xiaoli Zhang et al. (2020 Mar 15) [15]** | leucocytes 5.01±1.87, neutrophils 3.29±1.68, lymphocytes 1.23±0.52 | CRP 8.8 (3.1-22.0) | Procalcitonin 0.05 (0.04-0.08) | LDH 213.0 (173-268), CK 73 (48-111), Glc 6.62±2.91, serum Cr 69.17±24.52, BUN 4.04±1.69, TB 11.26±8.04 | - | ARDS 14 (2.4%), shock 2 (0.3%), liver function abnormality 75 (13.1%), AKI 2 (0.3%) | Anti-coronavirus treatment 488 (85.2%), glucocorticoids 77 (13.4%), oxygen therapy 250 (43.6%), mechanical ventilation 9 (1.6%) | - | Patients confirmed with SARS-CoV-2 infection of Zhejiang province from Jan 17 to Feb 8 underwent CT or x-ray were enrolled. Epidemiological, clinical data were analyzed between those with abnormal or normal imaging findings. This group had abnormal imaging findings. |
| **16** | **Xiaoli Zhang et al. (2020 Mar 15) [15]** | leucocytes 5.42±2.00, neutrophils 3.48±1.88, lymphocytes 1.39±0.61 | CRP 2.3 (0.9-9.5) | Procalcitonin 0.05 (0.04-0.07) | LDH 174.5 (148-235.5), CK 62.5 (47-83.75), Glc 6.57±3.24, serum Cr 65.54±13.16, BUN 3.90±1.13, TB 9.11±4.86 | - | Liver function abnormality 6 (8.3%) | Anti-coronavirus treatment 56 (77.8%), oxygen therapy 8 (11.1%) | - | Patients confirmed with SARS-CoV-2 infection of Zhejiang province from Jan 17 to Feb 8 underwent CT or x-ray were enrolled. Epidemiological, clinical data were analyzed between those with abnormal or normal imaging findings. This group had normal imaging findings. |
| **17** | **Hui Dai et al. (2020 Apr 1) [16]** | - | - | - |  | - | - | - | - | This was a multi-centered study included 234 inpatients from 13 hospitals during 113  17 days (from January 10th to February 7th 2020) in Jiangsu. All the cases were confirmed with 114  the criteria for SARS-CoV-2 infection established by National Health Commission, which was 115  consistent with one of the following two conditions, based on the pathogenic evidence |
| **18** | **Xi Xu et al. (2020 Feb 28) [17]** | Normal leucocytes 68 (76%) | Increased CRP 38 (42%), normal CRP 52 (58%) | - | - | HTN 17 (19%), DM 5 (6%), CVD 3 (3%), COPD 1 (1%) | - | - | - | All patients with laboratory-identified SARS-CoV-2 infection by real-time polymerase chain reaction (PCR) were collected between January 23, 2020, and February 4, 2020, in a designated hospital (Guangzhou Eighth People’s Hospital). |
| **19** | **Chun Shuang Guan et al. (2020 Mar 6) [18]** | - | - | - | - | - | - | - | - | A total of 53 patients diagnosed with COVID-19 from January 12 to February 28, 2020, were enrolled. |
| **20** | **K. Wang et al. (2020 Mar 4) [19]** | - | - | - | - | HTN 33/114 (28.9%), CVD 7 (6.1%) | - | - | - | The study comprised 114 patients with confirmed COVID-19 treated at Xiaogan Hospital from 25 January 2020, to 9 February 2020, with complete medical records. |
| **21** | **Wanbo Zhu et al. (2020 Mar 10) [20]** | - | CRP 20.7±24.0 (0.5-112), ESR 42.4±33.6 (6-119) | - | - | HTN 22/116 (19%), DM 10 (9%), COPD 6 (5%), CVD 5 (4%) | - | - | - | This retrospective study focused on the initial clinical features of patients with suspected COVID-19 who presented to the ED of the First Affiliated Hospital of USTC and the Infectious Hospital of the First Affiliated Hospital of USTC for the first time between 24 January 2020 and 20 February 2020. |
| **22** | **Pan F et al. (2020 Feb 13) [21]** | WBC 4.9±1.0 (3.1-6.9), Neutrophil 3.1±0.8 (2.1-4.6), Lymphocyte 1.4±0.5 (0.7-2.5) | CRP 17.2±20.0 (3.1-88.6), ESR 33±27 (5-93) |  | AST 42±31 (12-107), ALT 32±20 (15-95), LDH 242±73 (156-377), D-dimer 0.93±1.43 (0.17-4.70) | N/A | Mean hospitalization: 17±4 (11-26) Mild pneumonia 21/21 (100%). | Oxygen Tx 0/21, Mechanical ventilation 0/21 (excluded) | N/A | Patients diagnosed with COVID-19 pneumonia were reviewed retrospectively for the period from 12 January 2020 to 6 February 2020 in this single center study. Patients with severe pneumonia (SpO2 <90% or RR >30 or oxygen/mechanical ventilator required) during the disease course were excluded. |
| **23** | **Huang G et al. (2020 Mar 30) [22]** | - | - | - | - | N/A | - | - | - | Thirty patients were admitted to Wuhu Second People’s Hospital with confirmed COVID-19 from January 22, 2020, through February 28, 2020. Patients who did not have positive CT findings or who had not yet met the conditions for discharge from the hospital were excluded from the study. |
| **24** | **Wang D et al. (2020 Mar 17) [23]** | Median (IQR) WBC 4.5 (3.3-6.2), Neutrophil 3.0 (2.0-4.9), Lymphocyte 0.8 (0.6-1.1) | N/A |  | Median (IQR) AST 31 (24-51), ALT 24 (16-40), TB 9.8 mmol/L (8.4-14.1), BUN 4.4 mmol/L (3.4-5.8), Cr 72 umol/L (60-87), CK 92 (56-130), CK-MB 14 (10-18), LDH 261 (182-403), D-dimer 203 (121-403), PT 13.0 (12.3-13.7), aPTT 31.4 (29.4-33.5) | Total 64 (46.4%). HTN 43 (31.2%), CVD 20 (14.5%), DM 14 (10.1%), Malignancy 10 (7.2%), Cerebrovascular disease 7 (5.1%), COPD 4 (2.9%), CKD 4 (2.9%), Chronic liver disease 4 (2.9%), HIV infection 2 (1.4%) | ICU 36/138 (26.1%), median time of symptom to ICU 10 (IQR 6-12), median admission to ICU 1 (IQR 0-3) ARDS 27/138 (19.6%), median time of onset to ARDS 8.0 (IQR 6.0-12.0) | Antiviral Tx 124/138 (89.9%), Glucocorticoid therapy 62/138 (44.9%), CRRT 2/138 (1.45%), Oxygen inhalation 106/138 (76.8%), NIV 15/138 (10.9%), IMV 17/138 (12.3%), ECMO 4/138 (2.9%) | Complications: Shock 12/138 (8.7%), Acute cardiac injury 10/138 (7.2%), Arrhythymia 23/138 (16.7%), ARDS 27/138 (19.6%), AKI 5/138 (3.6%) | - |
| **25** | **Xiaoyu Han et al. (2020 Apr 17) [24]** | leukocyte 4.6±1.9, lymphocyte 1.2±0.4 | CRP 11.7 (11.8), ESR 34 (16) \*(interquartile range) |  | AST 33 (24.5), 31 (22) \*(interquartile range) | COPD 1/17 (5%), HTN (5%), type 2 DM 2/17 (11%) | mean treatment time : 22 (18-31) | anti-viral drug, empirical antibacterial drug, abidol hydrochloride | N/A | - |
| **26** | **Shen Q et al. (2020) [25]** | WBC elevation 1/9 (11%), Lymphocyte elevation 1/9 (11%) | CRP elevation 2/9 (22%), ESR elevation 1/9 (11%) |  | LDH elevation 0/9 (0%), AST elevation 2/9 (22%) | - |  | Oxygen Tx 9/9, ICU care 0/9, mechanical vent 0/9 | Severe Cx 0/9 | all hospitalized children diagnosed with COVID‐19 between January 8, 2019 and February 19, 2020, in Changsha Public Health Clinic Center |
| **27** | **Wu Y et al. (2020)**  **[26]** | - | - | - | - | - | Moderate 5, Severe 6, Critical 2 | Plasminogen Tx 13/13 |  | A total of 219 patients with both positive COVID-19 by RT-PCR and abnormal chest CT findings were retrospectively identified from 7 Chinese hospitals in Hunan Providence, China from January 6 to February 20, 2020. A total of 205 patients with positive Respiratory Pathogen Panel for viral pneumonia and CT findings consistent with or highly suspicious for pneumonia by original radiology interpretation within 7 days of each other were identified from Rhode Island Hospital in Providence, RI. |
| **28** | **Gao L et al. (2020) [27]** | - | - | - | - | - | - | - | - | - |
| **29** | **Shi H et al. (2020) [28]** | - | - | - | AST 46.2±29.5, ALT 40.8±17.9 | Any 21(26%), chronic pulmonary disease 9(11%), DM 10(12%), HTN 12(15%), CKD 3(4%), cardiovascular disease 8(10%), cerebrovascular disease 6(7%), malignancy 4(5%), hepatitis or liver cirrhosis 7(9%) | - | - | - | - |
| **30** | **Zhao W et al. (2020 Feb) [29]** | - | - | - | - | Any 30 (29.7%), Cardio/cerebrovascular 16 (15.8%), surgical Hx 7 (6.9%), GI disease 6 (5.9%), respiratory disease 5 (4.9%), endocrine disease 3 (3.0%) | - | - | - | Data on 101 cases of COVID-19 pneumonia were retrospectively collected from four institutions in Hunan, China. Basic clinical characteristics and detailed imaging features were evaluated and compared between two groups on the basis of clinical status: nonemergency (mild or common disease) and emergency (severe or fatal disease). |
| **31** | **Zhou Y et al. (2020 Mar) [30]** | - | - | - | - | - | aggravated 5, non-aggravated 12 | ICU, mechanical vent 0/17 | no severe Cx | - |
| **32** | **Wang Y et al. (2020) [31]** | - | - | - | - | - | Discharged 70 (78%), In admission 17 (19%), Died 2 (2%), Transferred 1 (1%) | - | - | - |

Abbreviation : COVID-19: Coronavirus disease 2019; SARS-CoV-2: severe acute respiratory syndrome–coronavirus 2; CBC: Complete blood cell count; WBC : white blood cell; CRP : C-reactive protein; ESR : erythrocyte sedimentation rate; IL: interleukin; AST: aspartate transaminase; ALT: alanine transferase; BUN: blood urea nitrogen; Cr: creatinine; LDH: lactate dehydrogenase; CK: creatine kinase; TB: total bilirubin; Glc: glucose; PT: prothrombin; PTT: partial thromboplastin time; RT-PCR : reverse transcription-polymerase chain reaction; CT : computer tomography; DM: diabetes mellitus; COPD: chronic obstructive pulmonary disease; HTN: hypertension; CVD: cardiovascular disease; CKD: chronic kidney disease; GI: gastrointestinal; HIV: human immunodeficiency virus; ARDS : acute respiratory distress syndrome; Tx: therapy; Cx: complication; Hx: history; ICU: intensive care unit; CRRT: continuous renal replacement therapy; NIV: non-invasive ventilation; IMV: intermittent mandatory ventilation; ECMO: Extracorporeal membrane oxygenation; N/A: non-available; (-): no information

**Reference**

1. Zhao D, Yao F, Wang L, Zheng L, Gao Y, Ye J, Guo F, Zhao H, Gao R. A comparative study on the clinical features of COVID-19 pneumonia to other pneumonias. Clin Infect Dis 2020 Mar 12 pii: ciaa247 doi: 101093/cid/ciaa247 Epub ahead of print
2. Caruso D, Zerunian M, Polici M, Pucciarelli F, Polidori T, Rucci C, Guido G, Bracci B, de Dominicis C, Laghi A. Chest CT Features of COVID-19 in Rome, Italy. Radiology 2020 Apr 3:201237 doi: 101148/radiol2020201237 Epub ahead of print
3. Bernheim A, Mei X, Huang M, Yang Y, Fayad ZA, Zhang N, Diao K, Lin B, Zhu X, Li K, Li S, Shan H, Jacobi A, Chung M. Chest CT Findings in Coronavirus Disease-19 COVID-19: Relationship to Duration of Infection Radiology 2020 Feb 20:200463 doi: 101148/radiol2020200463 Epub ahead of print
4. Wu J, Wu X, Zeng W, Guo D, Fang Z, Chen L, Huang H, Li C. Chest CT Findings in Patients With Coronavirus Disease 2019 and Its Relationship With Clinical Features. Invest Radiol 2020 May;555:257-261 doi: 101097/RLI0000000000000670
5. Xu YH, Dong JH, An WM, Lv XY, Yin XP, Zhang JZ, Dong L, Ma X, Zhang HJ, Gao BL. Clinical and computed tomographic imaging features of novel coronavirus pneumonia caused by SARS-CoV-2. J Infect 2020 Apr;804:394-400 doi: 101016/jjinf202002017 Epub 2020 Feb 25
6. Ai T, Yang Z, Hou H, Zhan C, Chen C, Lv W, Tao Q, Sun Z, Xia L. Correlation of Chest CT and RT-PCR Testing in Coronavirus Disease 2019 COVID-19 in China: A Report of 1014 Cases. Radiology 2020 Feb 26:200642 doi: 101148/radiol2020200642 Epub ahead of print
7. Zhou S, Wang Y, Zhu T, Xia L. CT Features of Coronavirus Disease 2019 COVID-19 Pneumonia in 62 Patients in Wuhan, China AJR Am J Roentgenol 2020 Mar 5:1-8 doi: 102214/AJR2022975 Epub ahead of print
8. Zhang R, Ouyang H, Fu L, Wang S, Han J, Huang K, Jia M, Song Q, Fu Z. CT features of SARS-CoV-2 pneumonia according to clinical presentation: a retrospective analysis of 120 consecutive patients from Wuhan city. Eur Radiol 2020 Apr 11 doi: 101007/s00330-020-06854-1 Epub ahead of print
9. Li K, Fang Y, Li W, Pan C, Qin P, Zhong Y, Liu X, Huang M, Liao Y, Li S. CT image visual quantitative evaluation and clinical classification of coronavirus disease COVID-19. Eur Radiol 2020 Mar 25 doi: 101007/s00330-020-06817-6 Epub ahead of print
10. Chung M, Bernheim A, Mei X, Zhang N, Huang M, Zeng X, Cui J, Xu W, Yang Y, Fayad ZA, Jacobi A, Li K, Li S, Shan H. CT Imaging Features of 2019 Novel Coronavirus 2019-nCoV. Radiology 2020 Apr;2951:202-207 doi: 101148/radiol2020200230 Epub 2020 Feb 4
11. Liu KC, Xu P, Lv WF, Qiu XH, Yao JL, Gu JF, Wei W. CT manifestations of coronavirus disease-2019: A retrospective analysis of 73 cases by disease severity. Eur J Radiol 2020 Mar 12;126:108941 doi: 101016/jejrad2020108941 Epub ahead of print
12. Long C, Xu H, Shen Q, Zhang X, Fan B, Wang C, Zeng B, Li Z, Li X, Li H. Diagnosis of the Coronavirus disease COVID-19: rRT-PCR or CT? Eur J Radiol 2020 Mar 25;126:108961 doi: 101016/jejrad2020108961 Epub ahead of print
13. Himoto Y, Sakata A, Kirita M, Hiroi T, Kobayashi KI, Kubo K, Kim H, Nishimoto A, Maeda C, Kawamura A, Komiya N, Umeoka S. Diagnostic performance of chest CT to differentiate COVID-19 pneumonia in non-high-epidemic area in Japan. Jpn J Radiol 2020 Mar 30 doi: 101007/s11604-020-00958-w Epub ahead of print
14. Han R, Huang L, Jiang H, Dong J, Peng H, Zhang D. Early Clinical and CT Manifestations of Coronavirus Disease 2019 COVID-19 Pneumonia. AJR Am J Roentgenol 2020 Mar 17:1-6 doi: 102214/AJR2022961 Epub ahead of print
15. Zhang X, Cai H, Hu J, Lian J, Gu J, Zhang S, Ye C, Lu Y, Jin C, Yu G, Jia H, Zhang Y, Sheng J, Li L, Yang Y. Epidemiological, clinical characteristics of cases of SARS-CoV-2 infection with abnormal imaging findings. Int J Infect Dis 2020 Mar 20 pii: S1201-97122030172-7 doi: 101016/jijid202003040 Epub ahead of print
16. Dai H, Zhang X, Xia J, Zhang T, Shang Y, Huang R, Liu R, Wang D, Li M, Wu J, Xu Q, Li Y. High-resolution Chest CT Features and Clinical Characteristics of Patients Infected with COVID-19 in Jiangsu, China. Int J Infect Dis 2020 Apr 6 pii: S1201-97122030218-6 doi: 101016/jijid202004003 Epub ahead of print
17. Xu X, Yu C, Qu J, Zhang L, Jiang S, Huang D, Chen B, Zhang Z, Guan W, Ling Z, Jiang R, Hu T, Ding Y, Lin L, Gan Q, Luo L, Tang X, Liu J. Imaging and clinical features of patients with 2019 novel coronavirus SARS-CoV-2 Eur J Nucl Med Mol Imaging 2020 May;475:1275-1280 doi: 101007/s00259-020-04735-9 Epub 2020 Feb 28
18. Guan CS, Lv ZB, Yan S, Du YN, Chen H, Wei LG, Xie RM, Chen BD. Imaging Features of Coronavirus disease 2019 COVID-19: Evaluation on Thin-Section CT. Acad Radiol 2020 Mar 20 pii: S1076-63322030143-4 doi: 101016/jacra202003002 Epub ahead of print
19. Wang K, Kang S, Tian R, Zhang X, Zhang X, Wang Y. Imaging manifestations and diagnostic value of chest CT of coronavirus disease 2019 COVID-19 in the Xiaogan area. Clin Radiol 2020 May;755:341-347 doi: 101016/jcrad202003004 Epub 2020 Mar 23
20. Zhu W, Xie K, Lu H, Xu L, Zhou S, Fang S. Initial clinical features of suspected coronavirus disease 2019 in two emergency departments outside of Hubei, China. J Med Virol 2020 Mar 13 doi: 101002/jmv25763 Epub ahead of print
21. Pan F, Ye T, Sun P, Gui S, Liang B, Li L, Zheng D, Wang J, Hesketh RL, Yang L, Zheng C. Time Course of Lung Changes On Chest CT During Recovery From 2019 Novel Coronavirus COVID-19 Pneumonia. Radiology 2020 Feb 13:200370 doi: 101148/radiol2020200370 Epub ahead of print
22. Huang G, Gong T, Wang G, Wang J, Guo X, Cai E, Li S, Li X, Yu Y, Lin L. Timely Diagnosis and Treatment Shortens the Time to Resolution of Coronavirus Disease COVID-19 Pneumonia and Lowers the Highest and Last CT Scores From Sequential Chest CT. AJR Am J Roentgenol 2020 Mar 30:1-7 doi: 102214/AJR2023078 Epub ahead of print
23. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, Wang B, Xiang H, Cheng Z, Xiong Y, Zhao Y, Li Y, Wang X, Peng Z. Clinical Characteristics of 138 Hospitalized Patients with 2019 Novel Coronavirus-Infected Pneumonia in Wuhan, China. JAMA - Journal of the American Medical Association 2020 323:11 1061-1069 Date of Publication: 17 Mar 2020
24. Han X, Cao Y, Jiang N, Chen Y, Alwalid O, Zhang X, Gu J, Dai M, Liu J, Zhu W, Zheng C, Shi H. Novel Coronavirus Pneumonia COVID-19 Progression Course in 17 Discharged Patients: Comparison of Clinical and Thin-Section CT Features During Recovery. Clin Infect Dis 2020 Mar 30 pii: ciaa271 doi: 101093/cid/ciaa271 Epub ahead of print
25. Shen Q, Guo W, Guo T, Li J, He W, Ni S, Ouyang X, Liu J, Xie Y, Tan X, Zhou Z, Peng H. Novel coronavirus infection in children outside of Wuhan, China Pediatr Pulmonol 2020 Apr 7 doi: 101002/ppul24762 Epub ahead of print
26. Wu Y, Wang T, Guo C, Zhang D, Ge X, Huang Z, Zhou X, Li Y, Peng Q, Li J. Plasminogen improves lung lesions and hypoxemia in patients with COVID-19. QJM 2020 Apr 10 pii: hcaa121 doi: 101093/qjmed/hcaa121 Epub ahead of print
27. Gao L, Zhang J. Pulmonary High-Resolution Computed Tomography HRCT Findings of Patients with Early-Stage Coronavirus Disease 2019 COVID-19 in Hangzhou, China. Med Sci Monit 2020 Apr 4;26:e923885 doi: 1012659/MSM923885
28. Shi H, Han X, Jiang N, Cao Y, Alwalid O, Gu J, Fan Y, Zheng C. Radiological findings from 81 patients with COVID-19 pneumonia in Wuhan, China: a descriptive study. Lancet Infect Dis 2020 Apr;204:425-434 doi: 101016/S1473-30992030086-4 Epub 2020 Feb 24
29. Zhao W, Zhong Z, Xie X, Yu Q, Liu J. Relation Between Chest CT Findings and Clinical Conditions of Coronavirus Disease COVID-19 Pneumonia: A Multicenter Study. AJR Am J Roentgenol 2020 Mar 3:1-6 doi: 102214/AJR2022976 Epub ahead of print
30. Zhou Y, Zhang Z, Tian J, Xiong S. Risk factors associated with disease progression in a cohort of patients infected with the 2019 novel coronavirus. Ann Palliat Med 2020 Mar;92:428-436 doi: 1021037/apm20200326 Epub 2020 Mar 17
31. Wang Y, Dong C, Hu Y, Li C, Ren Q, Zhang X, Shi H, Zhou M. Temporal Changes of CT Findings in 90 Patients with COVID-19 Pneumonia: A Longitudinal Study. Radiology 2020 Mar 19:200843 doi: 101148/radiol2020200843 Epub ahead of print