REPEAT CHEST CT SCANS IN MODERATE-TO-SEVERE PATIENTS’ MANAGEMENT DURING THE COVID-19 PANDEMIC: OBSERVATIONS FROM A SINGLE CENTRE IN WUHAN, CHINA

Lang Chen†, Qiuxia Wang†, Hongyu Wu, Junwu Hu and Jing Zhang*
Department of Radiology, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430030, Hubei, China

*Corresponding author: hbclleo@163.com
†Lang Chen and Qiuxia Wang contributed equally to the work.

Received 23 June 2020; revised 23 June 2020; editorial decision 14 July 2020; accepted 14 July 2020

Objective To observe the rates of repeated computed tomographic scans (CTs) in a cohort of patients with coronavirus disease-2019 (COVID-19) and to assess the validity of repeat CTs.

Methods Each CT was recorded, and the validity of the repeated CTs was assessed.

Results The 394 patients underwent a total of 1493 CTs. Of the 394 patients, 260 received at least one non-value-added CT. Both the total number of CTs (median, 4; interquartile range (IQR), 3–5) and non-value-added CTs (median, 1; IQR, 0–1) per patient were strongly related to the disease duration (R² = 0.566 for total CTs, R² = 0.432 for non-value-added CTs, p < 0.001). The proportion of non-value-added CTs was potentially higher after 3 weeks from symptom onset (>35%).

Conclusions There was a high rate of repeat CTs for the COVID-19 patients, and the proportion of non-value-added CTs increased with disease duration. Follow-up CT should be avoided without clinical decline.

Advances in Knowledge. As COVID-19 is impacting healthcare systems across the globe, we believe in our findings that serial chest CT imaging has limited clinical utility in basically stable COVID-19 patients, will help relieve some of this burden.

INTRODUCTION
A case of pneumonia of unknown cause was detected in Wuhan, China, it was first reported to the WHO Country Office in China on 31 December 2019(1). The Chinese Centre for Disease Control and Prevention subsequently confirmed that this outbreak was caused by a novel coronavirus known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)(2). This is the third serious coronavirus outbreak in <20 years, following the SARS-CoV in 2002–2003 and Middle East respiratory syndrome coronavirus in 2012(3). Recent studies reported that the clinical characteristics and radiological findings of Coronavirus disease 2019 (COVID-19) mimic those of previously reported coronavirus infection. The most common symptoms of COVID-19 were fever, cough, and dyspnoea, consistent with the manifestation of lower respiratory tract infections(4,5). Computed tomographic (CT) scans from COVID-19 patients revealed clear destruction of the pulmonary parenchyma, including consolidation and interstitial inflammation(6).

For critical cases, chest CT is often unavailable due to uncooperation and life-support equipments. Contrastingly, chest CT has been widely applied in the clinical management of ordinary COVID-19 cases, including paediatric patients(7,8). However, performing repeat CT scans on COVID-19 patients may have negative consequences due to radiation exposure, a huge burden on radiology departments, and an immense challenge for infection control in the CT suite.

To determine the best practice for the safe use of CT in the management of COVID-19 patients, our study aims to: (1) assess the rates of repeat CT scans in a cohort of recovered and discharged COVID-19 patients who had lung opacities on the first CT, (2) assess the validity of repeat CT scans and (3) identify factors associated with repeat CT scans.

MATERIALS AND METHODS
Study design and participants
This retrospective study was performed at the largest hospital designated for the treatment of COVID-19 patients in Wuhan, China. This study was approved by the Ethics Committees of Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, and was performed in accordance with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent for this retrospective.
study was waived. Patients who were laboratory-confirmed positive for COVID-19 had pneumonia characterised by a chest CT, and these patients were discharged from our hospital, enrolled retrospectively, between 25 February and 06 March 2020. The initial chest CT was classified as positive or negative for pneumonia based on the medical records. The CT scans performed in our hospital were further confirmed by the consensus of two experienced radiologists (Z.J. and C.L. with 15 and 24 years of experience in interpreting chest CT imaging, respectively). All enrolled patients met the discharge criteria published by the China National Health Commission(9).

Data collection

Medical records were extracted from the patients’ electronic medical records in our hospital information system. Variables reviewed included demographics (age and gender), comorbidities, symptoms, clinical type, date of symptom onset, hospital admission, discharge, CT and diagnostic report. In our hospital, COVID-19 follow-up chest CT reports were divided into three categories: progression, remission and no obvious change (determined when compared with the last scan). Progression was defined as an increase in density and size of consolidative opacities, whereas remission was defined as either the reduction in density and size of the consolidative opacities or transformation of consolidative opacities to reticular and fibrous opacities. Neither apparent progression nor remission was defined as non-obvious change (Figure 1). Each chest CT scan was randomly allocated to two radiologists (one junior radiologist with >3 years of experience in interpreting chest CT imaging, one senior radiologist with >8 years of experience in interpreting chest CT imaging), and diagnosis was made in consensus. In our study, CT scans with the result of “non-obvious change” were assessed as non-value-added CT scans and reconfirmed by two radiologists (Z.J. and C.L.) in consensus. The chest CT scans were classified by the number of weeks (1–5 or ≥6) that had elapsed since symptom onset.

The severity of COVID-19 patients was defined according to the Guidelines for the Diagnosis and Treatment of New Coronavirus Pneumonia (Seventh Edition)(9). Patients with mild clinical symptoms and no radiological findings of pneumonia were defined as “mild” cases and did not meet the inclusion criteria of this study. Patients who had incomplete CT records or died before discharge were also excluded from this study.

Chest CT protocols

CT images from our hospital were obtained with patients in the supine position on one of the three CT systems (uCT780, United Imaging; Optima 660, GE; Somatom Definition AS+, Siemens). The main scanning parameters were as follows: tube voltage = 120kVp, automatic tube current modulation (30–70mAs), pitch = 0.99–1.22 mm, matrix = 512 × 512, slice thickness = 10 mm, field of view = 350 mm × 350 mm. All images were then reconstructed with a slice thickness of 0.625–0.125 mm with the same increment. The dose-length product and effective dose per CT scan ranged from 129.1 to 238 mGy cm and from 1.81 to 3.45 mSv, respectively.

Statistical analysis

The statistical analysis was performed using SPSS version 21.0 (SPSS Inc. Chicago, IL). A Shapiro–Wilk test was used to determine the distribution of the data. Normally distributed data are presented as mean ± standard deviation, non-normally distributed data as median (interquartile range (IQR)) and categorical variables as frequency (%). Comparisons between non-paired quantitative data were analysed using the Mann–Whitney U and Wilcoxon tests, whereas differences between groups were analysed using a Fisher’s exact test (for categorical data) or one-way analysis of variance (for continuous data). Spearman’s correlations were performed to evaluate the relationships between the CT examination counts and possible influential factors.

Results

A total of 394 confirmed patients were included in our study, including 345 (81.2%) moderate patients and 49 (18.8%) severe patients.

The median patient age was 56 years (IQR 42–67) and 48.2% were male. Of the 394 patients, 172 (43.7%) had a comorbidity; the most common symptoms were fever (N = 328, 83.2%) and cough (N = 320, 81.2%) (Table 1).

The mean time interval between illness onset and discharge was 31.68 ± 8.71 days and the median hospitalisation time was 19 days (IQR 15–26). There was no difference in the aforementioned times between moderate and severe cases (Z = −0.127 P = 0.899, Z = −0.662 p = 0.508, respectively).

The 394 patients underwent a total of 1493 chest CTs throughout the course of their illnesses. In all, 214 (54.3%) had at least one previous chest CT scan at another institution before admission to our hospital. As listed in Table 2, the median number of CT scans for each patient was 4 (IQR, 3–5); this number was not significantly different between men and women (Z = −1.329, p = 0.184) and had no relationship to age (R2 = −0.06, p = 0.184). There was also no significant difference in the number of CT scans between moderate and severe COVID-19 cases.
COVID-19 PANDEMIC: OBSERVATIONS FROM A SINGLE CENTRE IN WUHAN

Figure 1. Typical evolution of CT findings in a 53-year-old male patient with COVID-19 pneumonia. (a) Day 3 after symptom onset: multiple small regions of ground-glass opacity (GGO) with partial consolidation were demonstrated in the right superior and lower lobes. (b) Day 7 after symptom onset: a significant increase in density and size of lesions in right lung, and new area of opacity in left lung. (c) Day 11, partial resolution of the lesions in both lungs. (d) Day 19, continued resolution with minimal residual opacities. (e) Day 24, no obvious change compared with the last CT and was assessed as non-value-added CT scan.

(Z = -0.387, p = 0.699). The disease duration was positively correlated with the number of CT scans a patient received (R² = 0.566, p < 0.001).

In total, 378 CT scans from 260 patients were identified as non-value-added CT scans: 164 patients had one non-value-added CT, 76 patients had two, 18 patients had 3 and 2 patients had 4. The number of non-value added CT scans did not differ between males and females (Z = -0.73, p = 0.466) and had no relationship with age (R² = -0.026, p = 0.611). There was also no significant difference in the number of non-value-added CT scans between moderate and
Table 1. Demographic characteristic and clinical symptoms of 394 moderate-to-severe COVID-19 patients in Wuhan, China

| Characteristics                        | All case patients | Moderate patients | Severe patients |
|----------------------------------------|-------------------|-------------------|-----------------|
| Male no. (%)                           | 190(48.2)         | 160(46.4)         | 30(61.2)        |
| Median(IQR) age(year)                  | 56(42–67)         | 56(41–67)         | 57(46–67)       |
| Age group(year)-no.(%)                 |                   |                   |                 |
| 14–39                                  | 85(21.6)          | 78(22.6)          | 7(14.3)         |
| 40–49                                  | 70(17.8)          | 62(18)            | 8(16.3)         |
| 50–59                                  | 73(18.5)          | 61(17.7)          | 12(24.5)        |
| 60–69                                  | 105(26.6)         | 93(27)            | 12(24.5)        |
| ≥70                                    | 61(15.5)          | 51(14.8)          | 10(20.4)        |
| Comorbidities no.(%)                   | 172(43.7)         | 127(36.8)         | 27(55)          |
| Hypertension                           | 85(21.6)          | 40(11.6)          | 6(12.2)         |
| Diabetes                               | 35(8.9)           | 10(2.9)           | 2(4.1)          |
| Coronary                               | 22(5.6)           | 4(1.2)            | 1(2)            |
| Recent surgery                         | 17(4.3)           | 10(2.9)           | 0(0)            |
| Chronic digestive disease              | 14(3.6)           | 5(1.4)            | 2(4.1)          |
| Chronic respiratory disease            | 11(2.8)           | 6(1.7)            | 1(2)            |
| Thyroidal dysfunction                  | 10(2.5)           | 5(1.4)            | 1(2)            |
| Carcinoma                              | 7(1.8)            | 1(0.3)            | 1(2)            |
| Others                                 | 18(4.6)           | 10(2.9)           | 3(6)            |
| Symptoms no.(%)                        |                   |                   |                 |
| Fever                                  | 328(83.2)         | 286(82.9)         | 42(85.8)        |
| Cough                                  | 320(81.2)         | 279(80.9)         | 41(83.7)        |
| Dyspnea                                | 112(28.4)         | 90(26.1)          | 22(44.9)        |
| Sputum production                      | 198(50.3)         | 173(50.1)         | 25(51)          |
| Fatigue                                | 186(47.2)         | 162(47)           | 24(49)          |
| Anorexia                               | 152(38.6)         | 127(36.8)         | 25(51)          |
| Diarrhoea                              | 116(29.4)         | 103(29.9)         | 13(26.5)        |
| Muscle pain                            | 77(19.5)          | 69(20)            | 8(16.3)         |
| Nausea                                 | 54(13.7)          | 48(13.9)          | 6(12.2)         |
| Headache                               | 46(11.7)          | 41(11.9)          | 5(10.2)         |
| Vomitting                              | 31(7.9)           | 27(7.8)           | 4(8.1)          |
| Sore throat                            | 27(6.9)           | 24(7)             | 2(4.1)          |

Note: Quantitative data were presented as median (interquartile range), while the counting data were presented as N (%).

Table 2. Numbers and percentages of patients according to CT counts

| CT counts over the disease course | Number of patients | Percentage of the total patients |
|----------------------------------|--------------------|----------------------------------|
| 1                                | 4                  | 1.02%                            |
| 2                                | 64                 | 16.24%                           |
| 3                                | 108                | 27.41%                           |
| 4                                | 103                | 26.14%                           |
| 5                                | 77                 | 19.54%                           |
| 6                                | 29                 | 7.36%                            |
| 7                                | 5                  | 1.27%                            |
| 8                                | 4                  | 1.02%                            |
| Total                            | 394                | 100%                             |

Note: Counting data were presented as count and percentage of the total (%).

Table 2. Numbers and percentages of patients according to CT counts

| CT counts over the disease course | Number of patients | Percentage of the total patients |
|----------------------------------|--------------------|----------------------------------|
| 1                                | 4                  | 1.02%                            |
| 2                                | 64                 | 16.24%                           |
| 3                                | 108                | 27.41%                           |
| 4                                | 103                | 26.14%                           |
| 5                                | 77                 | 19.54%                           |
| 6                                | 29                 | 7.36%                            |
| 7                                | 5                  | 1.27%                            |
| 8                                | 4                  | 1.02%                            |
| Total                            | 394                | 100%                             |

Note: Counting data were presented as count and percentage of the total (%).

severe COVID-19 cases (Z = −0.346, p = 0.73). However, the number of non-value-added CT scans was positively correlated with the total number of CT scans a patient received (Z = 0.835, p < 0.001) and the disease duration (Z = 0.432, p < 0.001).

As shown in Figure 2, we grouped the number of CT scans into six time intervals. There was a significant difference in the ratio between the number of non-value-added CT scans and the total number of scans among the different time intervals (X2 = 84.88, p < 0.0001). The proportion of non-value-added CT scans was the highest in the Week ≥ 6 (40.7%), followed by the Week 4 group (38.3%).

Discussion

In Wuhan, China, chest CT scans had been employed as a first-line diagnostic and triage tool for COVID-19 due to long reverse transcription-polymerase chain reaction turnaround times and concerned test sensitivities. While viral testing remains the only true method of diagnosis, urgent decision-making and triaging are imperative in an environment where there is a high burden of scans a patient received (Z = 0.835, p < 0.001) and the disease duration (Z = 0.432, p < 0.001).

As shown in Figure 2, we grouped the number of CT scans into six time intervals. There was a significant difference in the ratio between the number of non-value-added CT scans and the total number of scans among the different time intervals (X2 = 84.88, p < 0.0001). The proportion of non-value-added CT scans was the highest in the Week ≥ 6 (40.7%), followed by the Week 4 group (38.3%).
disease and critical lack of resources. CT scans provide a baseline for future comparison, may establish manifestations of important comorbidities in patients with risk factors and is sensitive for disease progression. But CT also increases the risk of radiation exposure to the patient\(^{(10)}\), risk of SARS-CoV-2 transmission to uninfected healthcare workers and other patients and the need for environmental cleaning and decontamination of rooms\(^{(11,12)}\). The appropriate use of CT should be considered by keeping the above-mentioned issues in mind.

The findings of this study are from hospital-based patients with moderate-to-severe COVID-19 infection that required close clinical observation, including repeat CT scans. These scans were used to visualise the progression or absorption of lesions in the lungs, as inflammatory absorption of the lungs is one of the criteria for discharge\(^{(9)}\). In this study, we found high rates of repeated CT scanning, with 82.74% of patients having undergone at least three CT scans, and 1.02% of patients receiving eight CT scans throughout the duration of the disease. This is consistent with other published serial CT studies in Wuhan where per-patient CT examination counts also ranges from 3 to 6\(^{(6)}\).

The severity of lung changes on imaging is mostly related to the severity of disease itself. In the absence of specific treatment, the supportive treatments are primarily based on the severity of clinical symptoms/signs. For these basically stable cases, if follow-up CT is applied and lesions progression is detected, the clinical treatment management would remain the same. Some follow-up imaging studies in COVID-19 patients demonstrated that most patients showed initial radiographic deterioration within 2 weeks after initial onset of symptoms\(^{(6,13)}\). In a retrospective small sample cohort\(^{(5)}\), series of CT scans outlined the most common pattern of evolution (46% patients, 26/57) as an initial progression to a peak level through the first and second weeks,
followed by radiographic improvement in the third week. But no evidence reported showed that these repeat CT scans improved clinical outcomes or duration of illness for COVID-19 patients. A recent advice from the European Society of Radiology and the European Society of Thoracic Imaging advised that repeated CT scans are indicated in cases with suspected complications (e.g., superinfection and pulmonary embolism)\(^\text{12}\).

We found that nearly two-thirds (\(N = 260\)) of the 394 patients received at least one non-value-added CT scan. There were no differences in the total number of CT scans and non-value-added CT scans between moderate and severe COVID-19 cases. The total number of CT scans was most strongly related to the time interval between symptom onset and hospital discharge; as the number of CT scans increased for a patient, so did the probability of receiving a non-value added CT. The proportion of non-value-added CT scans increased over time, peaking after the third week, which is consistent with the time course of lung changes on chest CT scans during COVID-19 recovery; the disease changed rapidly within the first 10 days after symptom onset, after which changes tended to stabilise and resolve over a longer period\(^\text{14}\).

In our study, patients were discharged from the hospital between late February to early March and no one developed into critical illness. We speculate that a significant number of repeated CT scans were adopted as regular routine examinations, not in response to clinical worsening.

It is estimated that CT can increases oncogenic risk by 0.05–0.7% for a single scan, while this risk ranges from 2.7 to 12% in those who receive multiple CT scans\(^\text{15}\). This risk is even higher in younger patients, as they have a greater proportion of actively dividing cells as well as as longer life spans, during which a malignant transformation could occur, compared with older patients. People are generally susceptible to the SARS-CoV-2 without obvious age patterns. This study cohort included 85 patients younger than 40 years. There was no age association in the per-patient total number of CT scans (\(Z = -0.441\) \(p = 0.659\)) nor per-patient number of non-value-added CT scans (\(Z = -0.764\) \(p = 0.445\)) measured with 40 years of age as a cut point.

A chest X-ray (CXR) delivers a radiation dosage of \(~0.05\text{ mSv}\), whereas a chest CT delivers 4–7 mSv, \(~80–140\text{ times more radiation}\). One study from Hong Kong\(^\text{16}\) compared CXR with chest CT findings in 28 COVID-19 patients. Of the 28 patients, 25 had a positive CT, of whom 24 also had positive CXR findings; only one patient had a false-negative CXR, in which ground-glass opacities were missed that could be visualised by CT. These findings, in combination with a case report from the USA\(^\text{17}\), suggest that CXR could be a good modality for imaging the lungs, particularly for serial monitoring in COVID-19 cases.

Additionally, when CT scans are so often performed, issues related to infection control in healthcare facilities, including the use of imaging equipment, must be considered. Droplet transmission, followed by contaminated surfaces, is believed to be the main modes of SARS-CoV-2 spread in CT suites. All patients undergoing CT should be masked and imaged using a single dedicated CT scanner that is cleaned and disinfected after each patient encounter. Ventilation is an important consideration for the control of airborne transmission in health care facilities\(^\text{18}\). These measures place a huge burden on radiology departments and pose an immense challenge for infection control in closed CT scanner rooms. Overuse of CT scanners also poses the risk of draining hospital resources and exposing staff that are performing the examinations.

The study has several limitations. First, this was a single-centre study that included only 394 patients discharged within 10 days. A multicentre study and/or one that includes more cases would provide more information on CT utilisation, appropriateness and optimal recurrent-interval option. Second, we were unable to observe and inquire the clinical staff about why repeated CT scans were performed, which would be invaluable in analysing the factors that lead to CT overuse. Third, we did not estimate the total effective radiation dose that patients received because we could not obtain data on CT scanning performed at other institutions.

In conclusion, this single-centre retrospective study demonstrated that there were high rates of repeat CT scanning, accompanied by non-value-added CT scans, in moderate-to-severe COVID-19 patients. The Director-General of World Health Organization gave remark on 24 April 2020 that ‘we have a long way to go. This virus will be with us for a long time’. Thus far, no known therapies have altered the course of COVID-19, there is no known cure, and there is no vaccine for prevention. The hazards of wide deployment of follow-up CTs in COVID-19 patient’s management must be acknowledged. These risks include cumulative radiation exposure, incrementally increasing cancer risk, overuse of hospital resources and increased disease transmission and exposure to other patients and hospital staff. We urge caution on the choice of CT scans, particularly for serial monitoring in COVID-19 patients.

**ABBREVIATIONS**

China CDC Chinese Centre for Disease Control and Prevention; COVID-19 Coronavirus disease 2019; SARS-CoV-2 severe acute respiratory syndrome coronavirus 2; CXR Chest X-ray; ED Effective dose; HIS Hospital information system; IQR Interquartile range; MERS Middle
East respiratory syndrome; SARS Severe acute respiratory syndrome; WHO World Health Organization

ACKNOWLEDGEMENTS
None.

REFERENCES
1. World Health Organization (2020) Novel coronavirus – China. World Health Organization, Geneva. Available from https://www.who.int/csr/don/12-january-2020-novel-coronavirus-china/en/
2. Lu, R., Zhao, X., Li, J. et al. Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. Lancet 395, 565–574 (2020). https://doi.org/10.1016/S0140-6736(20)30251-8.
3. Yang, Y., Peng, F., Wang, R. et al. The deadly coronaviruses: the 2003 SARS pandemic and the 2020 novel coronavirus epidemic in China. J. Autoimmun. 109, 102434 (2020). https://doi.org/10.1016/j.jaut.2020.102434.
4. Guan, W. J., Ni, Z. Y., Hu, Y. et al. Clinical characteristics of coronavirus disease 2019 in China. N. Engl. J. Med. 382, 1708–1720 (2020). doi:10.1056/NEJMoa2002032.
5. Shi H, Han X, Jiang N, et al (2020) Radiological findings from 81 patients with COVID-19 pneumonia in Wuhan, China: a descriptive study. Lancet Infect. Dis. 20:425–434. https://doi.org/10.1016/S1473-3099(20)30086-4.
6. Pan, F., Ye, T., Sun, P. et al. Time course of lung changes on chest CT during recovery from 2019 novel coronavirus (COVID-19) pneumonia. Radiology (2020). doi: 10.1148/radiol.2020200370. https://doi.org/.
7. Raptis CA, Hammer MM, Short RG et al (2020) Chest CT and coronavirus disease (COVID-19): a critical review of the literature to date. Am. J. Roentgenol. 16:1–4. http://doi.org/10.2214/AJR.20.23202
8. Duan, Y. N., Zhu, Y. Q., Tang, L. L. et al. CT features of novel coronavirus pneumonia (COVID-19) in children. Eur. Radiol. Online (2020). doi: https://doi.org/10.1007/s00330-020-06860-3.
9. China National Health Commission. Diagnosis and treatment of 2019-nCoV pneumonia in China. Available from http://www.nhc.gov.cn/yzygj/s7652/m/202003/a31911442e29474e98be3d5579d5af95.shtml Accessed March 4, 2020. [Chinese]
10. Sodickson, A., Baeyens, P. F., Andriole, K. P. et al. Recurrent CT, cumulative radiation exposure, and associated radiation-induced cancer risks from CT of adults. Radiology 251, 175–184 (2009). doi:10.1148/radiol.2511081296.
11. Rubin, G. D., Ryerson, C. J., Haramati, L. B. et al. The role of chest imaging in patient management during the COVID-19 pandemic: a multinational consensus statement from the Fleischner society. Radiology (2020). https://doi.org/10.1148/radiol.2020201365.
12. Revel, M.-P., Parkar, A. P., Prosch, H. et al. COVID-19 patients and the radiology department – advice from the European Society of Radiology (ESR) and the European Society of Thoracic Imaging (ESTI). Eur. Radiol. (2020). https://doi.org/10.1007/s00330-020-06865-y.
13. Pan Y, Guan H, Zhou S, et al (2020). Initial CT findings and temporal changes in patients with the novel coronavirus pneumonia (2019-nCoV); a study of 63 patients in Wuhan, China. Eur. Radiol. 13:1–4. https://doi.org/10.1007/s00330-020-06731-x.
14. Ding, X., Xu, J., Zhou, J. et al. Chest CT findings of COVID-19 pneumonia by duration of symptoms. Eur. J. Radiol. (2020). doi: https://doi.org/ 10.1016/j.ejrad.2020.109009.
15. Wang, Y. X. J., Liu, W. H., Yang, M. et al. The role of CT for Covid-19 patient’s management remains poorly defined. Ann. Transl. Med. 8, 145 (2020). https://doi.org/10.21037/atm.2020.02.71.
16. Wong HYF, Lam HYS, Fong AH et al (2020) Frequency and distribution of chest radiographic findings in COVID-19 positive patients. Radiology 27: 201160. https://doi.org/10.1148/radiol.2020201160.
17. Holshue, M. L., DeBolt, C., Lindquist, S. et al. First case of 2019 novel coronavirus in the United States. N. Engl. J. Med. 382, 929–936 (2020). https://doi.org/10.1056/NEJMoa2001191.
18. Kooraki, S., Hosseiny, M., Myers, L., Gholamrezanezhad, A. et al. Coronavirus (COVID-19) outbreak: what the Department of Radiology Should Know. J. Am. Coll. Radiol. 17, 447–451 (2020). https://doi.org/10.1016/j.jacr.2020.02.008,