Clinical Characteristics and Imaging Manifestations of the 2019 Novel Coronavirus Disease (COVID-19) Patients in a Fangcang Shelter Hospital

Si Chen[1], Wei Gao[1], Mingming Zhang[1], Huize Han[1], Pei Zhao[1], Chuan Liu[2], Jing Hua[1], and Qiang Li[1]

[1]Shanghai East Hospital
[2]Shanghai General Hospital, Shanghai Jiaotong University, School of Medicine

June 22, 2020

Abstract

Background We sought to delineate the clinical characteristics and imaging manifestations of the COVID-19 patients in a Fangcang shelter hospital in Wuhan. Methods From Feb 11, 2020 to March 8, 2020, the clinical, laboratory and HRCT features of 189 COVID-19 patients (23-74 years, 97 males, 92 females) were retrospectively collected and analyzed. Clinical and radiological data of patients with different sub-groups were compared. Results 127 (67.19%) patients have a BMI higher than 23 kg/m2. The most common symptoms of the patients were fever (154/189, 81.48%), cough (135/189, 71.43%) and fatigue (61/189, 32.28%). The average time for two consecutive negative nucleic acid tests was 15.44±4.50 days. The average time of hospitalization was 17.48±3.93 days. The majority of the patients had a normal white blood cell count (141/178, 79.21%), neutrophil percent (106/178, 59.55%), lymphocyte percent (107/178, 60.11%) and platelet count (162/177, 91.53%). Positive correlations were found between age and CT parameters ($p<0.05$), BMI and CT parameters ($p<0.05$) and temperature and CT parameters ($p<0.05$). Severity of CT parameters were not correlated to time for nucleic acid tests turning negative and duration of hospitalization ($p>0.05$). Patients with mild CT changes presented with slower recovery by follow-up compared with those more severe on initial ($p<0.05$). Conclusion Patients with COVID-19 infection usually have respiratory and non-respiratory symptoms and presented with typical ground-glass-opacities and other CT features, which showed significant correlations with age, BMI and highest temperature. Patients with mild opacifications on initial CT presented with slower recovery compared with those who were more severe on initial.

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Running head: COVID-19 Patients in a Fangcang Shelter Hospital

Si Chen, MD, PhD[1#], Wei Gao, MD, PhD[1#], Mingming Zhang, MD[2#], Huize Han, MD, PhD[1], Pei Zhao, MD[1], Chuan Liu, MD, PhD[3], Jing Hua, MD[1*], Qiang Li, MD, PhD[1*]

1 Department of Pulmonary and Critical Care Medicine, Shanghai East Hospital, Tongji University School of Medicine, Shanghai, 200123, China

2 Department of Radiology, Shanghai East Hospital, Tongji University School of Medicine, Shanghai, 200123, China

3 Department of Oncology, Shanghai General Hospital, Shanghai Jiaotong University, School of Medicine, Shanghai, China.

Co-first authors: Si Chen, Wei Gao and Mingming Zhang

Corresponding author:

Jing Hua, MD

Department of Pulmonary and Critical Care Medicine, Shanghai East Hospital, Tongji University School of Medicine, Shanghai, 200123, China

erichua@163.com

Qiang Li, MD, PhD

Department of Pulmonary and Critical Care Medicine, Shanghai East Hospital, Tongji University School of Medicine, Shanghai, 200123, China

liqiang_ressh@hotmail.com or liqressh@hotmail.com

Keyword: COVID-19, SARS-CoV-2, Fangcang Shelter Hospital, clinical features, Computed Tomography manifestations

Funding: This study was supported by "Gaoyuan" project of Pudong Health and Family Planning Commission (PWYgy2018-06) and the National Natural Science Foundation of China (grant numbers: 81870064).

Author's contribution : Si Chen, Wei Gao and Mingming Zhang contributed equally to this paper. Qiang Li and Jing Hua designed the study; Si Chen, Wei Gao, Jing Hua and Mingming Zhang reviewed the CT images; Jing Hua, Huize Han and Chuan Liu collected data; Si Chen, Wei Gao, Pei Zhao and Qiang Li performed data analysis; Si Chen, Wei Gao and Jing Hua drafted the manuscript; all authors provided critical review of the manuscript and approved the final draft for publication.

Abstract

Background

We sought to delineate the clinical characteristics and imaging manifestations of the COVID-19 patients in a Fangcang shelter hospital in Wuhan.

Methods

From Feb 11, 2020 to March 8, 2020, the clinical, laboratory and HRCT features of 189 COVID-19 patients (23-74 years, 97 males, 92 females) were retrospectively collected and analyzed. Clinical and radiological data of patients with different sub-groups were compared.

Results

127 (67.19%) patients have a BMI higher than 23 kg/m2. The most common symptoms of the patients were fever (154/189, 81.48%), cough (135/189, 71.43%) and fatigue (61/189, 32.28%). The average time for two consecutive negative nucleic acid tests was 15.44±4.50 days. The average time of hospitalization was 17.48±3.93 days. The majority of the patients had a normal white blood cell count (141/178, 79.21%), neutrophil percent (106/178, 59.55%), lymphocyte percent (107/178, 60.11%) and platelet count (162/177, 91.53%). Positive correlations were found between age and CT parameters ($p<0.05$), BMI and CT parameters ($p<0.05$) and temperature and CT parameters ($p<0.05$). Severity of CT parameters were not correlated to time for nucleic acid tests turning negative and duration of hospitalization ($p>0.05$). Patients with mild CT changes presented with slower recovery by follow-up compared with those more severe on initial ($p<0.05$).

Conclusion

Patients with COVID-19 infection usually have respiratory and non-respiratory symptoms and presented with typical ground-glass-opacities and other CT features, which showed significant correlations with age, BMI and highest temperature. Patients with mild opacifications on initial CT presented with slower recovery compared with those who were more severe on initial.

Keywords: COVID-19, SARS-CoV-2, Fangcang Shelter Hospital, clinical features, Computed Tomography manifestations

Introduction

Starting in December 2019, Chinese health authorities have been closely monitoring a cluster of pneumonia cases in Wuhan, capital of Central China's Hubei province, the pathogen of which is similar to the 2003 epidemic of Severe Acute Respiratory Syndrome (SARS). This newly identified β-coronavirus was initially named as the 2019-novel coronavirus (2019-nCoV) on 12 January 2020 by World Health Organization (WHO) and then officially named as SARS-CoV-2 by Coronavirus Study Group (CSG) of the International Committee on 11 February 2020[1]. The coronavirus disease 2019 (COVID-19) has spread throughout China and generated global trend of spreading. As of 5 May 2020, a cumulative total of 3,585,357 COVID-19 confirmed cases were reported globally, among which 83,966 were in China based on the data by the Center for Systems Science and Engineering (CSSE), Johns Hopkins University [2].

After two-months of lockdown in Wuhan and every citizen's contribution against the virus, China has seen a sustained positive momentum of epidemic containment with the daily number of reported new cases hitting a record low. However, it is spreading with an astonishing speed out of China, the worst-affected countries include the United States, Spain, Italy, France and Germany.

Back in early February, to alleviate the shortage of beds in hospitals of Wuhan, the epicenter of the outbreak of COVID-19, National Health Commission adopted the advocation of Wang Chen, president of the Chinese Academy of Medical Sciences, converted public facilities such as conference venues, exhibition halls and sports stadiums into Fangcang shelter hospitals to accommodate COVID-19 patients with mild symptoms [3]. Fangcang is the Chinese name for makeshift or military field hospitals and were mostly converted within 24-72 hours, have proved their crucial role in the fight against SARS-CoV-2. After just over a month, more than 12,000 patients had been cured in 16 such temporary hospitals, which constitutes 20% of COVID-19 patients in Wuhan.

In this retrospective study, chest CT scan manifestations and clinical characteristics of 191 confirmed COVID-19 cases with mild symptoms treated at region A and B of Dongxihu Fangcang shelter hospital from February 11, 2020 to March 8, 2020 were collected and summarized. Correlational Analysis between underlying/potential factors and imaging severity was also conducted.

Materials and Methods

Patients and clinical data collection

This retrospective study was approved by our institutional review board. Informed consent was waived since no potential risk would impose on patients. From Feb 11, 2020 to March 8, 2020, Dongxihu Fangcang shelter hospital accommodated 1760 patients whose diagnosis of COVID-19 infection was confirmed with a positive result of real-time reverse transcriptase polymerase chain reaction assay for SARS-CoV-2 nucleic acid of nasopharyngeal swab specimens while exhibited no severe symptoms. To ensure the accuracy and integrity of this study, we included 191 patients treated by our team at region B of this Fangcang shelter hospital with complete clinical data. The 97 male and 92 female patients have an average age of 48.58 ± 11.90 years (range, 23–74 years old). Epidemic, laboratory and imaging information, including signs and symptoms, time from onset to hospital, time of nucleic acid turning negative, duration time, white blood cell count, neutrophil percent, lymphocyte percent, C-reactive protein (CRP), etc. were retrospectively collected.

Imaging Acquisition

Chest CT images were obtained with two scanners: ScintCare CT 16 (MinFound, Medical System, Zhejiang, China) and UCT528 (United Imaging, Shanghai, China). A tube voltage of 100kV or 120 kV and automatic tube current modulation (100 - 400mA) were applied. Images were reconstructed with a slice thickness of 1.0mm or 1.25mm and an interval of 1.0mm or 1.25mm, respectively. All 191 patients underwent initial CT scans, 92 of whom underwent at least follow-up CT scans for once to evaluate the progression of the disease

after a short period of standardized treatment. The mean interval time from initial to follow-up examinations was 7.78±2.86 days (range, 3-17 days; median, 7 days).

Imaging Interpretation

All CT images were independently reviewed by one radiologist (Z.M.M., 6 years of experience) and three pulmonologists (C.S., G.W. and H.J., with 5,5 and 14 years of clinical experience, respectively) using Picture Archiving and Communication System (PACS). HRCT images were viewed at a window width and level of 1000 - 1500 HU and -400 to -700 HU, respectively, for lung parenchyma, and 300 - 400 HU and 20 - 50 HU, respectively, for mediastinum. Decisions were reached by consensus. For each of the 191 patients, the initial and follow-up CT images were evaluated for: (1) presence of ground-glass opacities (GGO), consolidation, interstitial thickening or reticulation, fibrous stripes and air bronchograms, (2) severity of opacifications, (3) other manifestations, such as the location of the lesion (peripheral, central, both central and peripheral), pleural effusion, mediastinal lymph node changes (enlargement or increased number of lymph nodes). GGO was defined as increased lung attenuation with preservation of bronchial and vascular margins and consolidation was defined as opacification in which the underlying vasculature was obscured.

The number of lobes infected was recorded. Each lobe of the lung was assessed for opacifications and the lesion size was graded as 0 (none), 1 (<10% of the lobe), 2 (<30% of the lobe), 3 (30%-50% of the lobe) or 4 (50%-100% of the lobe) with reference to previously described methods [4] with some modification. All five lobar scores were summed to calculate the overall score for the severity of opacifications. The largest cross section of the most severe lesion of the lung on the initial CT was defined as region-of interest (ROI), and the maximum area (cm^2) and highest density (HU) of ROI were recorded. The correlation between the severity of initial CT and clinical characteristics was evaluated. Furthermore, available follow-up CT scans were also reviewed and compared with initial based on overall score for opacifications, the maximum area (cm^2) of ROI and the highest HU of ROI.

Statistical Analysis

All statistical analysis was conducted with SPSS 24.0 software (IBM, Armonk, NY). Enumeration data were expressed as median (range). Measurement data were expressed as mean ± standard deviation. The Kolmogorov-Smirnov test was used to evaluate distribution type. Homogeneity of variance was evaluated by Bartlett test. Independent sample t -test, Mann–Whitney U test, Kruskal-Wallis test and Dunn's multiple comparisons test were used to compare the differences between clinical and radiological data of patients with different sub-groups as appropriate. Correlation coefficients were then calculated between clinical, laboratory findings and CT features, using Spearman correlation. $p<0.05$ was considered statistically significant.

Results

Clinical and Laboratory Findings

The average BMI was 24.81±3.31 kg/m^2 and 127 (67.2%) patients have a BMI higher than 23 kg/m^2, a more appropriate BMI cut-off point for overweight or obesity of Asian population [5]. The most common symptoms of the patients were fever (154/189, 81.5%), cough (135/189, 71.4%) and fatigue (61/189, 32.3%). Other complaints included chest distress or shortness of breath (58/189, 30.7%), sputum production (54/189, 28.6%), muscular soreness (38/189, 20.1%), diarrhea (24/189, 12.7%), headache (21/189, 11.1%), pharyngalgia (19/189, 10.1%) nasal obstruction (15/189, 7.9%), chest pain (14/189, 7.4%), nausea and vomiting (1/189, 4.2%), chills (6/189, 3.2%), hemoptysis (6/189, 3.2%) and anorexia (3/189, 1.6%). 3(1.6%) patients were asymptomatic.

The majority of the patients had a normal white blood cell count (141/178, 79.2%), neutrophil percent (106/178, 59.6%), lymphocyte percent (107/178, 60.1%) and platelet count (162/177, 91.5%). Some patients had reduced white blood cell count (32/178, 18.0%) and reduced lymphocyte percent (56/178, 31.5%) and increased CRP (65/99, 65.7%).

The average time from disease onset to medical consultation, from consultation to confirmed diagnosis and

from disease onset to confirmed diagnosis was 2.93±3.03 days, 4.19±2.77 and 9.82±4.64, respectively. Time for diagnosis confirmation was greatly shortened since Feb 1st, 2020. The waiting time from diagnosis to hospitalization was 1.64±1.17 days since Feb 7th and 5.26±2.55 before. The average time for two consecutive negative nucleic acid tests was 15.44±4.50 days. The average time of hospitalization was 17.48±3.93 days. Details of demographic information, symptoms and laboratory findings of the study group were listed in Table 1.

CT Features

6 (3.2%) patients presented with no obvious image changes of any lobe. 10 of 189 patients (11.1%) had opacities in one lobe, 20 (10.6%) had opacities in two lobes and 142 patients (75.1%) had three or more lobes affected. The lower lobes were most vulnerable since 90.0% (170/189) patients showed opacifications in the right lower lobe and 83.1% (157/189) patients in the left lower lobe, the score representing the severity of opacifications were 1.59±1.01 and 1.32±0.97 respectively. The right middle lobe was the least affected lobe (92/189, 48.7%) in this study dataset with an average severity score of 0.65±0.77. From the perspective of lesions location, most patients had peripheral (89/189, 47.1%) or both central and peripheral (94/189, 49.7%) lesions, central only lesions were scarcely seen on patients (6/189, 3.2%).

Most chest CT (180/189, 95.2%) showed single or multiple Ground-glass opacities. Consolidation (52/189, 27.5%), mixed ground-glass opacities and consolidation (51/189, 27.0%), interstitial thickening or reticulation (135/189, 71.4%), fibrous strips (127/189, 67.2%), air bronchograms (60/189, 31.8%), pleural effusion (2/189, 1.1%) and mediastinal lymph node changes (3/189, 1.6%) could also be seen (detailed in Table 2 and Figure 1).

The average interval time of follow-up CT was 7.78±2.86 days. Patients with various degrees of severity (0-5, 6-10 and >10) on initial CT presented with different recovery extent by follow-up CT. Improvement in overall score for opacifications were 0.48±0.75, 2.10±1.68 and 3.15±2.34 for patients of initial severity score of 0-5, 6-10 and >10, respectively($p<0.05$). Improvement in the maximum area (cm2) of ROI were 1.47±1.79, 3.28±2.66 and 3.07±3.40 for initial severity score of 0-5, 6-10 and >10, respectively($p<0.05$). Improvement in the highest HU of ROI were 115.20±101.16, 121.10±115.31 and 141.77±122.59 for initial severity score of 0-5, 6-10 and >10, respectively($p>0.05$). Patients with a mild degree of opacifications on initial CT presented with slighter recovery by follow-up CT compared with those severe on initial (detailed in Table 3, Figure 2 and Figure 3).

Correlations among Clinical, Laboratory Findings and CT Features

Table 4 summarizes the correlations among clinical, laboratory findings and CT parameters. Significant positive correlations were found between age and CT parameters including an overall score for the severity of opacifications (R=0.38), maximum size of ROI (R=0.27) and highest HU of ROI (R=0.28) (Figure 4). BMI seemed to have moderate positive correlations (R=0.20) with an overall score for the severity of opacifications as well as the maximum size of ROI, and negative correlation (R=-0.23) with the time to medical consultation (Figure 4). Temperature showed a weak correlation with an overall score for the severity of opacifications (R=0.18) and the maximum size of ROI (R=0.16) (Figure 4). White blood cell count, neutrophil percent, lymphocyte percent, platelet count and CRP were not correlated to any CT parameters ($p>0.05$). Respiratory or non-respiratory symptoms were not correlated to any CT parameters ($p>0.05$). The severity of CT parameters were not correlated to the time for nucleic acid tests turning negative and the duration of hospitalization ($p>0.05$) (Figure 5). Other correlations were weak, including a correlation between temperature and gender(R=0.16), WBC with gender(R=0.21), NC% with gender (R=0.19) and Non-respiratory symptoms with fever (R=0.18).

Discussion

As SARS-CoV-2 is a newly identified pathogen, there is no known pre-existing immunity in humans and no available vaccines nor therapeutic. Based on current investigation concerning epidemiologic characteristics, everyone is assumed to be susceptible, elder males with underlying diseases are more vulnerable and prone

to serious outcomes[6,7]. Our findings are compatible with previous publications concerning the factor of age. According to our results, higher BMI might be another predisposing factor for SARS-CoV-2 infection. As manifested in this research, most infected COVID-19 patients have a BMI higher than 23 kg/m^2 and BMI was positively correlated with the severity of lung abnormalities quantified on chest CT.

Approximately 80% of laboratory confirmed patients have had mild to moderate disease, including non-pneumonia and pneumonia cases[8]. Severe to critical diseases may be associated with acute respiratory distress syndrome (ARDS) and cytokine storm[9]. It is notable that SARS-CoV-2 infections can transmit during the incubation period of patients, in whom the illness was brief and nonspecific[10,11]. Asymptomatic infection cases were reported [12-14] and confirmed again in our research, which may warrant a reassessment of transmission dynamics of the current outbreak. We recommend that people should avoid going to crowded places, wearing a face mask in public places and practice social distancing seriously.

COVID-19 is mainly transmitted via droplets and fomites during close unprotected contact between an infector and infectee, airborne spread and fecal-oral route[15,16]. The most common clinical symptoms of COVID-19 patients were non-specific, including fever, cough, fatigue, gastrointestinal symptoms, etc.. Angiotensin-converting enzyme 2 (ACE2) protein, known as cell receptor for SARS-CoV and SARS-CoV-2 and regulates both the cross-species and human-to-human transmission, presents in abundance on lung alveolar epithelial cells and enterocytes of small intestine abundantly, which may help understand the routes of infection and disease manifestations [16-18].

Tao et. al[19] reported that the improvement of follow-up chest CT scans were preliminary to the RT-PCR results turning negative in half patients. Interestingly, we found that the severity of CT parameters on initial were not correlated to the time for nucleic acid tests turning negative and the duration of hospitalization, and patients with mild opacifications on initial CT presented with slower recovery by follow-up CT compared with those severe on initial. Thus, we speculated that the improvement rate on CT were more relevant to the time for nucleic acid tests turning negative.

As the number of new infections continued to decline,China suspended all Fangcang shelter hospitals on March [3]. China has seen a sustained positive momentum of epidemic containment with extraordinary mobilization to implement fundamental public health principles and approach in the absence of a vaccine or drugs. Strengthen cooperation and coordination with other countries in health, customs, immigration and education to prevent the import and export of COVID-19 cases represent the general trend.

This study has some limitations. First, this research only restricted to patients with mild to moderate symptoms and they were at different course of COVID-19 at admission considering the variance in time from disease onset to hospitalization. The variance can be attributed to the shortage of beds or fear of cross-infection during the height of the epidemic in late January and early February 2020, so that many residents with mild symptoms were quarantined at home instead of in hospitals. Fangcang shelter hospitals have played a crucial role in the fight against novel coronavirus, by allowing patients to be admitted and treated quickly at the earliest and curbing the spread of the virus. Besides, at the time of data collection as well as the close of Dongxihu Fangcang shelter hospital, a proportion of patients were transferred to regular hospitals so that more information of their clinical characteristics were not traced. In future studies, more effort could be made to identify the clinical and imaging features at different course of the disease and comparisons could be made between patients with mild-moderate and severe-critical symptoms.

Our clinical and radiologic study findings show that age, BMI and highest temperature are positively correlated with the severity of lung abnormalities quantified on CT. People infected with SARS-CoV-2 who have mild to moderate symptoms were mostly discharged from hospital in 3 weeks after two consecutive negative nucleic acid tests. Asymptomatic infection was confirmed in our research and a small proportion of confirmed cases presented with no obvious image changes on chest CT. The severity of CT parameters were not correlated to the time for nucleic acid tests turning negative and the duration of hospitalization. Patients with mild opacifications on initial CT presented with slower recovery by follow-up CT compared with those severe on initial. Being familiarized with the clinical, CT features and susceptibility factor of COVID-19 is

of paramount importance for diagnosis and treatment.

Conflicts of Interest: The authors have no potential conflicts of interest to disclose.

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Figure legends

Figure 1. Chest CT manifestations. **A:** The HRCT image at admission of a 61-year-old female patient (9 days from disease onset). Single ground-glass opacities (GGO) was shown in this cross-section. **B:** The HRCT images at admission of a 50-year-old male patient (16 days from disease onset). Multiple ground-glass opacities (GGO) and reticulation are shown in this cross-section.**C-D:** The HRCT images of a 49-year-old male patient (17 days from onset). Diffuse opacities and consolidation, as well as air bronchograms can be seen. **E-F:** The HRCT images of a 66-year-old female patient (20 days from onset). interlobular septal thickening and fibrous stripes are shown in different cross-sections.

Figure 2. Patients with mild and severe opacities on initial CT presented with different recovery extent with follow-up CT.**A1-A4:** The HRCT images of a 56-year old male patient (13 days from onset). **A1-A2:** Multiple GGO distributed bilaterally, presented with interstitial thickening and thin fibrous stripes.**A3-A4:** Seven days later, less opacities with smaller size and lower HU were seen bilaterally. Interstitial thickening and fibrous stripes remained. **B1-B4:** The HRCT images of a 52-year-old male patient (13 days from onset). **B1-B2:** Multiple GGO are shown.**B3-B4:** Fourteen days later, the lesion size remained the same and the density was slightly decreased.

Figure 3. Patients with various degrees of severity (0-5, 6-10 and >10) on initial CT presented with different recovery extent with follow-up CT by Kruskal-Wallis & Dunn's multiple comparisons test or One-way ANOVA & Tukey's multiple comparisons test ($p<0.05$ was considered statistically significant.).**A.** Comparison of recovery extent by overall score. **B.**Comparison of recovery extent in accordance with maximum size of ROI in cross-section (cm^2). **C.** Comparison of recovery extent based on the Highest HU of ROI in cross-section.

Figure 4. Correlations between clinical and CT features were shown with Spearman correlation coefficients (r) and P values, with correlation deemed significant if $P<0.05$. **(A)** between age and overall score of opacifications ($R=0.38$, $p<0.0001$),**(B)** between BMI and overall score of opacifications ($R=0.20$, $p=0.007$), **(C)** between highest temperature and overall score of opacifications ($R=0.18$, $p=0.01$) , **(D)** between age and maximum area of ROI in cross-section (cm^2) ($R=0.27$, $p=0.0002$),**(E)** between BMI maximum area of ROI in cross-section (cm^2) ($R=0.20$, $p=0.005$), **(F)** between highest temperature and maximum area of ROI in cross-section (cm^2)($R=0.15$, $p=0.03$), **(G)** between age and Highest HU of ROI in cross-section ($R=0.28$, $p=0.0001$), **(H)**between BMI and the time from disease onset to medical consultant ($R=-0.23$, $p=0.0015$)

Figure 5. Patients with various degrees of severity on CT parameters presented no difference in the days for nucleic acid test turning negative by Kruskal-Wallis test ($p<0.05$ was considered statistically significant. Comparisons). **A.** Patients were stratified into 3 groups (0-5, 6-10 and >10) according to overall score of opacifications severity ($p=0.669$), **B.** Patients were divided into 5 groups (0-5, 5.1-10, 10.1-15, 15.1-20 and >20) in accordance with maximum size of ROI in cross-section (cm2) ($p=0.6039$). **C.** Patients were classified into 3 groups (<-300, -300-0, >0) based on the Highest HU of ROI in cross-section ($p=0.6051$).

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