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Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus–Infected Pneumonia in Wuhan, China

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IMPORTANCE In December 2019, novel coronavirus (2019-nCoV)–infected pneumonia (NCIP) occurred in Wuhan, China. The number of cases has increased rapidly but information on the clinical characteristics of affected patients is limited.

OBJECTIVE To describe the epidemiological and clinical characteristics of NCIP.

DESIGN, SETTING, AND PARTICIPANTS Retrospective, single-center case series of the 138 consecutive hospitalized patients with confirmed NCIP at Zhongnan Hospital of Wuhan University in Wuhan, China, from January 1 to January 28, 2020; final date of follow-up was February 3, 2020.

EXPOSURES Documented NCIP.

MAIN OUTCOMES AND MEASURES Epidemiological, demographic, clinical, laboratory, radiological, and treatment data were collected and analyzed. Outcomes of critically ill patients and noncritically ill patients were compared. Presumed hospital-related transmission was suspected if a cluster of health professionals or hospitalized patients in the same wards became infected and a possible source of infection could be tracked.

RESULTS Of 138 hospitalized patients with NCIP, the median age was 56 years (interquartile range, 42-68; range, 22-92 years) and 75 (54.3%) were men. Hospital-associated transmission was suspected as the presumed mechanism of infection for affected health professionals (40 [29%]) and hospitalized patients (17 [12.3%]). Common symptoms included fever (136 [98.6%]), fatigue (96 [69.6%]), and dry cough (82 [59.4%]). Lymphopenia (lymphocyte count, 0.8 × 10^9/L [interquartile range {IQR}, 0.6-1.1]) occurred in 97 patients (70.3%), prolonged prothrombin time (13.0 seconds [IQR, 12.3-13.7]) in 80 patients (58%), and elevated lactate dehydrogenase (261 U/L [IQR, 182-403]) in 55 patients (39.9%). Chest computed tomographic scans showed bilateral patchy shadows or ground glass opacity in the lungs of all patients. Most patients received antiviral therapy (oseltamivir, 124 [89.9%]), and many received antibacterial therapy (moxifloxacin, 89 [64.4%]; ceftriaxone, 34 [24.6%]; azithromycin, 25 [18.1%]) and glucocorticoid therapy (62 [44.9%]). Thirty-six patients (26.1%) were transferred to the intensive care unit (ICU) because of complications, including acute respiratory distress syndrome (22 [61.1%]), arrhythmia (16 [44.4%]), and shock (11 [30.6%]). The median time from first symptom to dyspnea was 5.0 days, to hospital admission was 7.0 days, and to ARDS was 8.0 days. Patients treated in the ICU (n = 36), compared with patients not treated in the ICU (n = 102), were older (median age, 66 years vs 51 years), were more likely to have underlying comorbidities (26 [72.2%] vs 38 [37.3%]), and were more likely to have dyspnea (23 [63.9%] vs 20 [19.6%]), and anorexia (24 [66.7%] vs 31 [30.4%]). Of the 36 cases in the ICU, 4 (11.1%) received high-flow oxygen therapy, 15 (41.7%) received noninvasive ventilation, and 17 (47.2%) received invasive ventilation (4 were switched to extracorporeal membrane oxygenation). As of February 3, 47 patients (34.1%) were discharged and 6 died (overall mortality, 4.3%), but the remaining patients are still hospitalized. Among those discharged alive (n = 47), the median hospital stay was 10 days (IQR, 7.0-14.0).

CONCLUSIONS AND RELEVANCE In this single-center case series of 138 hospitalized patients with confirmed NCIP in Wuhan, China, presumed hospital-related transmission of 2019-nCoV was suspected in 41% of patients, 26% of patients received ICU care, and mortality was 4.3%.

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In December 2019, a cluster of acute respiratory illness, now known as novel coronavirus–infected pneumonia (NCIP), occurred in Wuhan, Hubei Province, China.[1-5] The disease has rapidly spread from Wuhan to other areas. As of January 31, 2020, a total of 9692 NCIP cases in China have been confirmed. Internationally, cases have been reported in 24 countries and 5 continents.[6] On January 3, 2020, the 2019 novel coronavirus (2019-nCoV) was identified in samples of bronchoalveolar lavage fluid from a patient in Wuhan and was confirmed as the cause of the NCIP.[7] Full-genome sequencing and phylogenic analysis indicated that 2019-nCoV is a distinct clade from the betacoronaviruses associated with human severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS).[7] The 2019-nCoV has features typical of the coronavirus family and was classified in the betacoronavirus 2b lineage. The 2019-nCoV has close similarity to bat coronaviruses, and it has been postulated that bats are the primary source. While the origin of the 2019-nCoV is still being investigated, current evidence suggests spread to humans occurred via transmission from wild animals illegally sold in the Huanan Seafood Wholesale Market.[8]

Huang et al[9] first reported 41 cases of NCIP in which most patients had a history of exposure to Huanan Seafood Wholesale Market. Patients' clinical manifestations included fever, nonproductive cough, dyspnea, myalgia, fatigue, normal or decreased leukocyte counts, and radiographic evidence of pneumonia. Organ dysfunction (eg, shock, acute respiratory distress syndrome [ARDS], acute cardiac injury, and acute kidney injury) and death can occur in severe cases.[9] Subsequently, Chen et al[8] reported findings from 99 cases of NCIP from the same hospital and the results suggested that the 2019-nCoV infection clustered within groups of humans in close contact, was more likely to affect older men with comorbidities, and could result in ARDS. However, the difference in clinical characteristics between severe and nonsevere cases was not reported. Case reports confirmed human-to-human transmission of NCIP.[10,11] At present, there are no effective therapies or vaccines for NCIP. The objective of this case series was to describe the clinical characteristics of 138 hospitalized patients with NCIP and to compare severe cases who received intensive care unit (ICU) care with nonsevere cases who did not receive ICU care.

Key Points

Question What are the clinical characteristics of hospitalized patients with 2019 novel coronavirus (2019-nCoV)–infected pneumonia (NCIP) in Wuhan, China?

Findings In this single-center case series involving 138 patients with NCIP, 26% of patients required admission to the intensive care unit and 4.3% died. Presumed human-to-human hospital-associated transmission of 2019-nCoV was suspected in 41% of patients.

Meaning In this case series in Wuhan, China, NCIP was frequently associated with presumed hospital-related transmission, 26% of patients required intensive care unit treatment, and mortality was 4.3%.

Methods

Study Design and Participants

This case series was approved by the institutional ethics board of Zhongnan Hospital of Wuhan University (No. 2020020). All consecutive patients with confirmed NCIP admitted to Zhongnan Hospital of Wuhan University from January 1 to January 28, 2020, were enrolled. Oral consent was obtained from patients. Zhongnan Hospital, located in Wuhan, Hubei Province, the endemic areas of NCIP, is one of the major tertiary teaching hospitals and is responsible for the treatments for NCIP assigned by the government. All patients with NCIP enrolled in this study were diagnosed according to World Health Organization interim guidance.[12] The clinical outcomes (ie, discharges, mortality, length of stay) were monitored up to February 3, 2020, the final date of follow-up.

Data Collection

The medical records of patients were analyzed by the research team of the Department of Critical Care Medicine, Zhongnan Hospital of Wuhan University. Epidemiological, clinical, laboratory, and radiological characteristics and treatment and outcomes data were obtained with data collection forms from electronic medical records. The data were reviewed by a trained team of physicians. Information recorded included demographic data, medical history, exposure history, underlying comorbidities, symptoms, signs, laboratory findings, chest computed tomographic (CT) scans, and treatment measures (ie, antiviral therapy, corticosteroid therapy, respiratory support, kidney replacement therapy). The date of disease onset was defined as the day when the symptom was noticed. Symptoms, signs, laboratory values, chest CT scan, and treatment measures during the hospital stay were collected. ARDS was defined according to the Berlin definition.[13] Acute kidney injury was identified according to the Kidney Disease: Improving Global Outcomes definition.[14] Cardiac injury was defined if the serum levels of cardiac biomarkers (eg, troponin I) were above the 99th percentile upper reference limit or new abnormalities were shown in electrocardiography and echocardiography.[9] For patients admitted to the ICU, the Glasgow Coma Scale, Sequential Organ Failure Assessment, and Acute Physiology and Chronic Health Evaluation II scores were determined on the day of ICU admission. The durations from onset of disease to hospital admission, dyspnea, ARDS, and ICU admission were recorded.

Presumed hospital-related transmission was suspected if a cluster of medical professionals or hospitalized patients in the same wards became infected in a certain time period and a possible source of infection could be tracked.

Real-Time Reverse Transcription Polymerase Chain Reaction Assay for nCoV

Throat swab samples were collected for extracting 2019-nCoV RNA from patients suspected of having 2019-nCoV infection. After collection, the throat swabs were placed into a collection tube with 150 μL of virus preservation solution, and total RNA was

Table 1. Baseline Characteristics of Patients Infected With 2019-nCoV

	No. (%)			
	Total (N = 138)	ICU (n = 36)	Non-ICU (n = 102)	*P* Value[a]
Age, median (IQR), y	56 (42-68)	66 (57-78)	51 (37-62)	<.001
Sex				
Female	63 (45.7)	14 (38.9)	49 (48.0)	.34
Male	75 (54.3)	22 (61.1)	53 (52.0)	
Huanan Seafood Wholesale Market exposure	12 (8.7)	5 (13.9)	7 (6.9)	.30
Infected				
Hospitalized patients	17 (12.3)	9 (25.0)	8 (7.8)	.02
Medical staff	40 (29)	1 (2.8)	39 (38.2)	<.001
Comorbidities	64 (46.4)	26 (72.2)	38 (37.3)	<.001
Hypertension	43 (31.2)	21 (58.3)	22 (21.6)	<.001
Cardiovascular disease	20 (14.5)	9 (25.0)	11 (10.8)	.04
Diabetes	14 (10.1)	8 (22.2)	6 (5.9)	.009
Malignancy	10 (7.2)	4 (11.1)	6 (5.9)	.29
Cerebrovascular disease	7 (5.1)	6 (16.7)	1 (1.0)	.001
COPD	4 (2.9)	3 (8.3)	1 (1.0)	.054
Chronic kidney disease	4 (2.9)	2 (5.6)	2 (2.0)	.28
Chronic liver disease	4 (2.9)	0	4 (3.9)	.57
HIV infection	2 (1.4)	0	2 (2.0)	>.99
Signs and symptoms				
Fever	136 (98.6)	36 (100)	100 (98.0)	>.99
Fatigue	96 (69.6)	29 (80.6)	67 (65.7)	.10
Dry cough	82 (59.4)	21 (58.3)	61 (59.8)	.88
Anorexia	55 (39.9)	24 (66.7)	31 (30.4)	<.001
Myalgia	48 (34.8)	12 (33.3)	36 (35.3)	.83
Dyspnea	43 (31.2)	23 (63.9)	20 (19.6)	<.001
Expectoration	37 (26.8)	8 (22.2)	29 (28.4)	.35
Pharyngalgia	24 (17.4)	12 (33.3)	12 (11.8)	.003
Diarrhea	14 (10.1)	6 (16.7)	8 (7.8)	.20
Nausea	14 (10.1)	4 (11.1)	10 (9.8)	>.99
Dizziness	13 (9.4)	8 (22.2)	5 (4.9)	.007
Headache	9 (6.5)	3 (8.3)	6 (5.9)	.70
Vomiting	5 (3.6)	3 (8.3)	2 (2.0)	.13
Abdominal pain	3 (2.2)	3 (8.3)	0 (0)	.02
Onset of symptom to, median (IQR), d				
Hospital admission	7.0 (4.0-8.0)	8.0 (4.5-10.0)	6.0 (3.0-7.0)	.009
Dyspnea	5.0 (1.0-10.0)	6.5 (3.0-10.8)	2.5 (0.0-7.3)	.02
ARDS	8.0 (6.0-12.0)	8.0 (6.0-12.0)	8.0 (6.3-11.3)	.97
Heart rate, median (IQR), bpm	88 (78-97)	89 (81-101)	86 (77-96)	.14
Respiratory rate, median (IQR)	20 (19-21)	20 (16-25)	20 (19-21)	.57
Mean arterial pressure, median (IQR), mm Hg	90 (84-97)	91 (78-96)	90 (85-98)	.33

Abbreviations: ARDS, acute respiratory distress syndrome; bpm, beats per minute; COPD, chronic obstructive pulmonary disease; ICU, intensive care unit; IQR, interquartile range; 2019-nCoV, 2019 novel coronavirus.

[a] *P* values indicate differences between ICU and non-ICU patients. *P* < .05 was considered statistically significant.

extracted within 2 hours using the respiratory sample RNA isolation kit (Zhongzhi, Wuhan, China). In brief, 40 µL of cell lysates were transferred into a collection tube followed by vortex for 10 seconds. After standing at room temperature for 10 minutes, the collection tube was centrifugated at 1000 rpm/min for 5 minutes. The suspension was used for real-time reverse transcription polymerase chain reaction (RT-PCR) assay of 2019-nCoV RNA. Two target genes, including open reading frame 1ab (*ORF1ab*) and nucleocapsid protein (N), were simultaneously amplified and tested during the real-time RT-PCR assay. Target 1 (*ORF1ab*): forward primer CCCTGTGGGTTTTACACTTAA; reverse primer ACGATTGTGCATCAGCTGA; and the probe 5′-VIC-CCGTCTGCGGTATGTGGAAAGGTTATGG-BHQ1-3′. Target 2 (N): forward primer GGGGAACTTCTCCTGCTAGAAT; reverse primer CAGACATTTTGCTCTCAAGCTG; and the probe 5′-FAM- TTGCTGCTGCTTGACAGATT-TAMRA-3′. The real-time RT-PCR assay was performed using a 2019-nCoV nucleic acid detection kit according to the manufacturer's protocol (Shanghai bio-germ Medical Technology Co Ltd). Reaction mixture contains 12 µL of reaction buffer, 4 µL of enzyme solution, 4 µL of Probe primers solution, 3 µL of diethyl pyrocarbonate-treated water, and 2 µL of RNA template. RT-PCR assay was

Table 2. Laboratory Findings of Patients Infected With 2019-nCoV on Admission to Hospital

		Median (IQR)			
	Normal Range	Total (N = 138)	ICU (n = 36)	Non-ICU (n = 102)	*P* Value[a]
White blood cell count, $\times 10^9$/L	3.5-9.5	4.5 (3.3-6.2)	6.6 (3.6-9.8)	4.3 (3.3-5.4)	.003
Neutrophil count, $\times 10^9$/L	1.8-6.3	3.0 (2.0-4.9)	4.6 (2.6-7.9)	2.7 (1.9-3.9)	<.001
Lymphocyte count, $\times 10^9$/L	1.1-3.2	0.8 (0.6-1.1)	0.8 (0.5-0.9)	0.9 (0.6-1.2)	.03
Monocyte count, $\times 10^9$/L	0.1-0.6	0.4 (0.3-0.5)	0.4 (0.3-0.5)	0.4 (0.3-0.5)	.96
Platelet count, $\times 10^9$/L	125-350	163 (123-191)	142 (119-202)	165 (125-188)	.78
Prothrombin time, s	9.4-12.5	13.0 (12.3-13.7)	13.2 (12.3-14.5)	12.9 (12.3-13.4)	.37
Activated partial thromboplastin time, s	25.1-36.5	31.4 (29.4-33.5)	30.4 (28.0-33.5)	31.7 (29.6-33.5)	.09
D-dimer, mg/L	0-500	203 (121-403)	414 (191-1324)	166 (101-285)	<.001
Creatine kinase, U/L	<171	92 (56-130)	102 (62-252)	87 (54-121)	.08
Creatine kinase-MB, U/L	<25	14 (10-18)	18 (12-35)	13 (10-14)	<.001
Lactate dehydrogenase, U/L	125-243	261 (182-403)	435 (302-596)	212 (171-291)	<.001
Alanine aminotransferase, U/L	9-50	24 (16-40)	35 (19-57)	23 (15-36)	.007
Aspartate aminotransferase, U/L	15-40	31 (24-51)	52 (30-70)	29 (21-38)	<.001
Total bilirubin, mmol/L	5-21	9.8 (8.4-14.1)	11.5 (9.6-18.6)	9.3 (8.2-12.8)	.02
Blood urea nitrogen, mmol/L	2.8-7.6	4.4 (3.4-5.8)	5.9 (4.3-9.6)	4.0 (3.1-5.1)	<.001
Creatinine, μmol/L	64-104	72 (60-87)	80 (66-106)	71 (58-84)	.04
Hypersensitive troponin I, pg/mL	<26.2	6.4 (2.8-18.5)	11.0 (5.6-26.4)	5.1 (2.1-9.8)	.004
Procalcitonin, ng/mL					
≥0.05, No. (%)	<0.05	49 (35.5)	27 (75.0)	22 (21.6)	<.001
Bilateral distribution of patchy shadows or ground glass opacity, No. (%)	NA	138 (100)	36 (100)	102 (100)	>.99

Abbreviations: ICU, intensive care unit; IQR, interquartile range; MB, muscle and brain type; NA, not available; 2019-nCoV, 2019 novel coronavirus.

SI conversion factors: To convert alanine aminotransferase to μkat/L, multiply by 0.0167; aspartate aminotransferase to μkat/L, multiply by 0.0167; creatine kinase to μkat/L, multiply by 0.0167; and lactate dehydrogenase to μkat/L, multiply by 0.0167.

[a] *P* values indicate differences between ICU and non-ICU patients. *P* < .05 was considered statistically significant.

performed under the following conditions: incubation at 50 °C for 15 minutes and 95 °C for 5 minutes, 40 cycles of denaturation at 94 °C for 15 seconds, and extending and collecting fluorescence signal at 55 °C for 45 seconds. A cycle threshold value (Ct-value) less than 37 was defined as a positive test result, and a Ct-value of 40 or more was defined as a negative test. These diagnostic criteria were based on the recommendation by the National Institute for Viral Disease Control and Prevention (China) (http://ivdc.chinacdc.cn/kyjz/202001/t20200121_211337.html). A medium load, defined as a Ct-value of 37 to less than 40, required confirmation by retesting.

Statistical Analysis

Categorical variables were described as frequency rates and percentages, and continuous variables were described using mean, median, and interquartile range (IQR) values. Means for continuous variables were compared using independent group *t* tests when the data were normally distributed; otherwise, the Mann-Whitney test was used. Data (nonnormal distribution) from repeated measures were compared using the generalized linear mixed model. Proportions for categorical variables were compared using the χ^2 test, although the Fisher exact test was used when the data were limited. All statistical analyses were performed using SPSS (Statistical Package for the Social Sciences) version 13.0 software (SPSS Inc). For unadjusted comparisons, a 2-sided α of less than .05 was considered statistically significant. The analyses have not been adjusted for multiple comparisons and, given the potential for type I error, the findings should be interpreted as exploratory and descriptive.

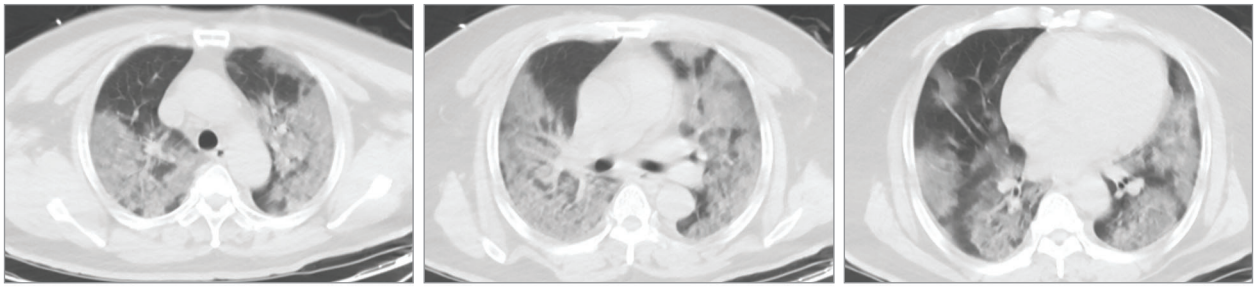
Results

Presenting Characteristics

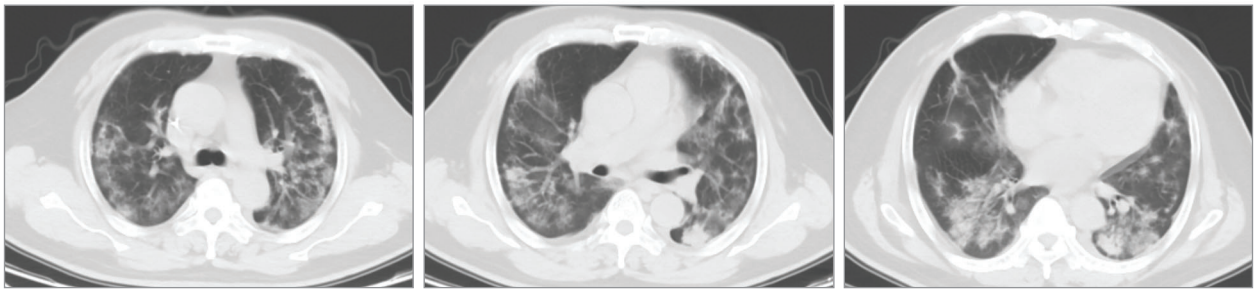
The study population included 138 hospitalized patients with confirmed NCIP. The median age was 56 years (IQR, 42-68; range, 22-92 years), and 75 (54.3%) were men. Of these patients, 102 (73.9%) were admitted to isolation wards, and 36 (26.1%) were admitted and transferred to the ICU because of the development of organ dysfunction (**Table 1**). The median durations from first symptoms to dyspnea, hospital admission, and ARDS were 5 days (IQR, 1-10), 7 days (IQR, 4-8), and 8 days (IQR, 6-12), respectively (Table 1). Of the 138 patients, 64 (46.4%) had 1 or more coexisting medical conditions. Hypertension (43 [31.2%]), diabetes (14 [10.1%]), cardiovascular disease (20 [14.5%]), and malignancy (10 [7.2%]) were the most common coexisting conditions.

Figure 1. Chest Computed Tomographic Images of a 52-Year-Old Patient Infected With 2019 Novel Coronavirus (2019-nCoV)

A Computed tomography images on day 5 after symptom onset



B Computed tomography images after treatment on day 19 after symptom onset



A, Chest computed tomographic images obtained on January 7, 2020, show ground glass opacity in both lungs on day 5 after symptom onset. B, Images taken on January 21, 2020, show the absorption of bilateral ground glass opacity after the treatment of extracorporeal membrane oxygenation from January 7 to 12 in the intensive care unit.

The most common symptoms at onset of illness were fever (136 [98.6%]), fatigue (96 [69.6%]), dry cough (82 [59.4%]), myalgia (48 [34.8%]), and dyspnea (43 [31.2%]). Less common symptoms were headache, dizziness, abdominal pain, diarrhea, nausea, and vomiting (Table 1). A total of 14 patients (10.1%) initially presented with diarrhea and nausea 1 to 2 days prior to development of fever and dyspnea.

Compared with patients who did not receive ICU care (n = 102), patients who required ICU care (n = 36) were significantly older (median age, 66 years [IQR, 57-78] vs 51 years [IQR, 37-62]; $P < .001$) and were more likely to have underlying comorbidities, including hypertension (21 [58.3%] vs 22 [21.6%], diabetes (8 [22.2%] vs 6 [5.9%]), cardiovascular disease (9 [25.0%] vs 11 [10.8%]), and cerebrovascular disease (6 [16.7%] vs 1 [1.0%]). Compared with the non-ICU patients, patients admitted to the ICU were more likely to report pharyngeal pain, dyspnea, dizziness, abdominal pain, and anorexia.

Vital Signs and Laboratory Parameters in ICU and Non-ICU Patients

Heart rate, respiratory rate, and mean arterial pressure did not differ between patients who received ICU care and patients who did not receive ICU care. These measures were recorded on day of hospital admission for all patients, then divided into those who were later admitted to the ICU or not. There were numerous differences in laboratory findings between patients admitted to the ICU and those not admitted to the ICU (**Table 2**), including higher white blood cell and neutrophil counts, as well as higher levels of D-dimer, creatine kinase, and creatine. All of the 138 enrolled patients showed bilateral involvement of chest CT scan (**Figure 1**). The median time from onset of symptoms to ICU admission was 10 days (IQR, 6-12) (**Table 3**). On the day of ICU admission, the median Glasgow Coma Scale; Acute Physiology and Chronic Health Evaluation II; and Sequential Organ Failure Assessment scores were 15 (IQR, 9-15), 17 (IQR, 10-22), and 5 (IQR, 3-6), respectively (Table 3). The median partial pressure

Table 3. Severity of Illness Scores and Blood Gas Analysis of Patients Infected With 2019-nCoV in the ICU

	Normal Range	Median (IQR)
No. of patients		36
Onset of symptom to ICU admission, d	NA	10 (6-12)
Time from hospital admission to ICU admission, d	NA	1 (0-3)
Glasgow Coma Scale score	NA	15 (9-15)
APACHE II	NA	17 (10-22)
SOFA	NA	5 (3-6)
PH	7.35-7.45	7.43 (7.39-7.47)
Lactate, mmol/L	0.5-1.6	1.3 (0.7-2.0)
Pao_2, mm Hg	83-108	68 (56-89)
Pao_2:Fio_2, mm Hg	400-500	136 (103-234)
$Paco_2$, mm Hg	35-48	34 (30-38)

Abbreviations: APACHE II, Acute Physiology and Chronic Health Evaluation II; Fio_2, fraction of inspired oxygen; ICU, intensive care unit; IQR, interquartile range; NA, not available; 2019-nCoV, 2019 novel coronavirus; $Paco_2$, partial pressure of carbon dioxide; Pao_2, partial pressure of oxygen; SOFA, Sequential Organ Failure Assessment.

Table 4. Complications and Treatments of Patients Infected With 2019-nCoV

	No. (%)			
	Total (N = 138)	ICU (n = 36)	Non-ICU (n = 102)	*P* Value[a]
Complications				
Shock	12 (8.7)	11 (30.6)	1 (1.0)	<.001
Acute cardiac injury	10 (7.2)	8 (22.2)	2 (2.0)	<.001
Arrhythmia	23 (16.7)	16 (44.4)	7 (6.9)	<.001
ARDS	27 (19.6)	22 (61.1)	5 (4.9)	<.001
AKI	5 (3.6)	3 (8.3)	2 (2.0)	.11
Treatment				
Antiviral therapy	124 (89.9)	34 (94.4)	90 (88.2)	.36
Glucocorticoid therapy	62 (44.9)	26 (72.2)	36 (35.3)	<.001
CKRT	2 (1.45)	2 (5.56)	0	>.99
Oxygen inhalation	106 (76.81)	4 (11.11)	102 (100)	<.001
NIV	15 (10.9)	15 (41.7)	0	<.001
IMV	17 (12.32)	17 (47.22)	0	<.001
ECMO	4 (2.9)	4 (11.1)	0	.004

Abbreviations: AKI, acute kidney injury; ARDS, acute respiratory distress syndrome; CKRT, continuous kidney replacement therapy; ECMO, extracorporeal membrane oxygenation; ICU, intensive care unit; IMV, invasive mechanical ventilation; NIV, noninvasive ventilation; 2019-nCoV, 2019 novel coronavirus.

[a] *P* values indicate differences between ICU and non-ICU patients. *P* < .05 was considered statistically significant.

of oxygen level was 68 mm Hg (IQR, 56-89) and the median of partial pressure of oxygen to fraction of inspired oxygen ratio was 136 mm Hg (IQR, 103-234).

Organ Dysfunctions and Main Interventions

The organ dysfunction and treatment of the 138 patients are shown in **Table 4**. As of February 3, 2020, 85 patients (61.6%) were still hospitalized. A total of 47 patients (34.1%) had been discharged, and 6 patients (4.3%) had died. Of the 36 patients admitted to the ICU, 11 were still in the ICU, 9 had been discharged to home, 10 had been transferred to the general wards, and 6 had died. Of the 11 patients who remained in the ICU, 6 received invasive ventilation (1 switched to extracorporeal membrane oxygenation) and 5 to noninvasive ventilations). Common complications among the 138 patients included shock (12 [8.7%]), ARDS (27 [19.6%]), arrhythmia (23 [16.7%]), and acute cardiac injury (10 [7.2%]). Patients who received care in the ICU were more likely to have one of these complications than non-ICU patients.

Most patients received antiviral therapy (oseltamivir, 124 [89.9%]), and many received antibacterial therapy (moxifloxacin, 89 [64.4%]; ceftriaxone, 34 [24.6%]; azithromycin, 25 [18.1%]) and glucocorticoid therapy (62 [44.9%]). In the ICU, 4 patients (11.1%) received high-flow oxygen and 15 (44.4%) received noninvasive ventilation. Invasive mechanical ventilation was required in 17 patients (47.2%), 4 of whom received extracorporeal membrane oxygenation as rescue therapy. A total of 13 patients received vasopressors, and 2 patients received kidney replacement therapy.

Dynamic Profile of Laboratory Findings in Patients With NCIP

To determine the major clinical features that appeared during NCIP progression, the dynamic changes in 6 clinical laboratory parameters, including hematological and biochemical parameters, were tracked from day 1 to day 19 after the onset of the disease at 2-day intervals. At the end of January 28, 2020, data from 33 patients with complete clinical course were analyzed (**Figure 2**). During hospitalization, most patients had marked lymphopenia, and nonsurvivors developed more severe lymphopenia over time. White blood cell counts and neutrophil counts were higher in nonsurvivors than those in survivors. The level of D-dimer was higher in nonsurvivors than in survivors. Similarly, as the disease progressed and clinical status deteriorated, the levels of blood urea and creatinine progressively increased before death.

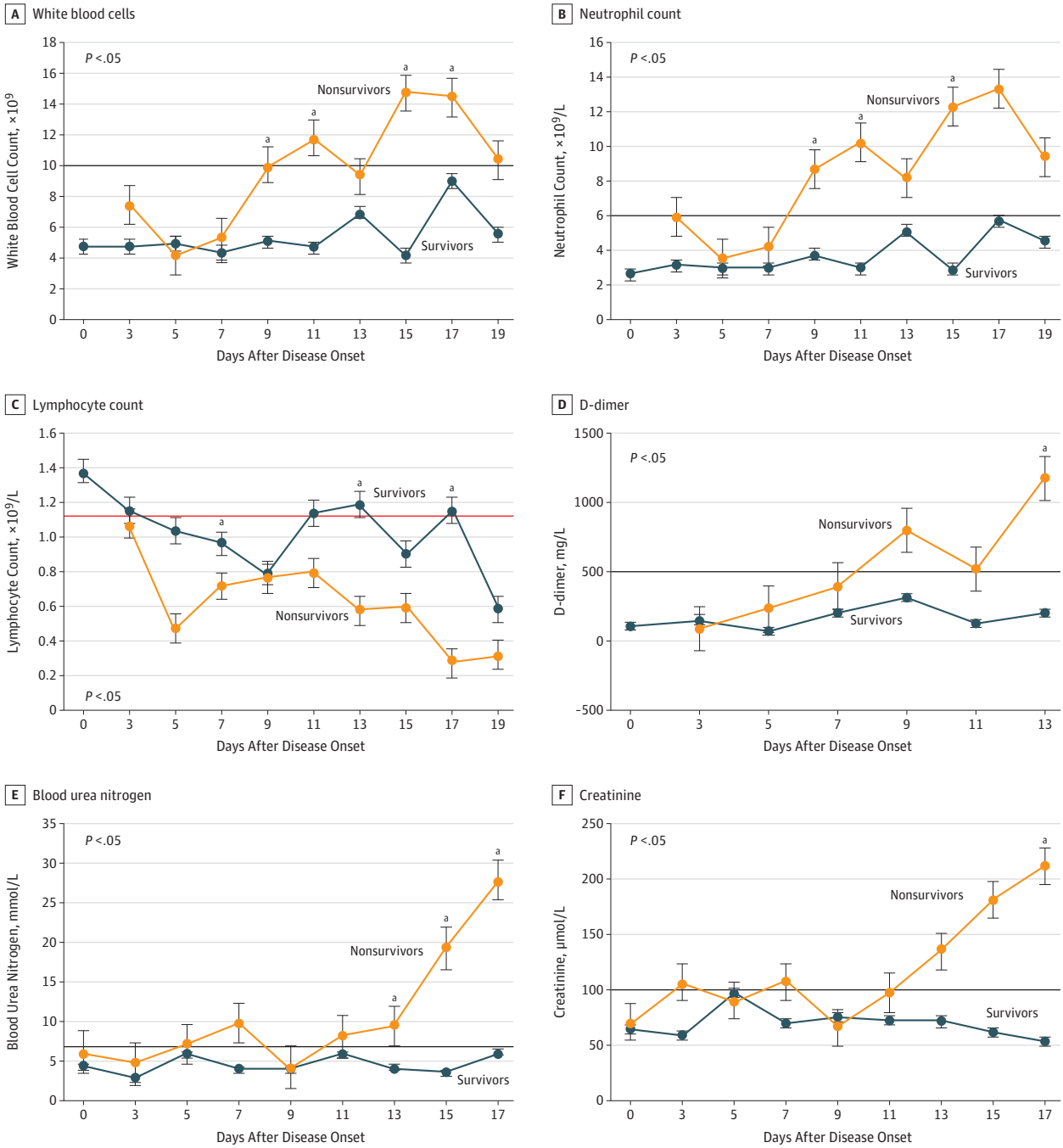
Presumed Hospital-Related Transmission and Infection

Of the 138 patients, 57 (41.3%) were presumed to have been infected in hospital, including 17 patients (12.3%) who were already hospitalized for other reasons and 40 health care workers (29%). Of the hospitalized patients, 7 patients were from the surgical department, 5 were from internal medicine, and 5 were from the oncology department. Of the infected health care workers, 31 (77.5%) worked on general wards, 7 (17.5%) in the emergency department, and 2 (5%) in the ICU. One patient in the current study presented with abdominal symptoms and was admitted to the surgical department. More than 10 health care workers in this department were presumed to have been infected by this patient. Patient-to-patient transmission also was presumed to have occurred, and at least 4 hospitalized patients in the same ward were infected, and all presented with atypical abdominal symptoms. One of the 4 patients had fever and was diagnosed as having nCoV infection during hospitalization. Then, the patient was isolated. Subsequently, the other 3 patients in the same ward had fever, presented with abdominal symptoms, and were diagnosed as having nCoV infection.

Discussion

This report, to our knowledge, is the largest case series to date of hospitalized patients with NCIP. As of February 3, 2020, of the 138 patients included in this study, 26% required

Figure 2. Dynamic Profile of Laboratory Parameters in 33 Patients With Novel Coronavirus–Infected Pneumonia (NCIP)



Timeline charts illustrate the laboratory parameters in 33 patients with NCIP (5 nonsurvivors and 28 survivors) every other day based on the days after the onset of illness. The solid lines in black show the upper normal limit of each parameter, and the solid line in red shows the lower normal limit of lymphocyte count.

[a] $P < .05$ for nonsurvivors vs survivors.

ICU care, 34.1% were discharged, 6 died (4.3%), and 61.6% remain hospitalized. For those who were discharged (n = 47), the hospital stay was 10 days (IQR, 7.0-14.0). The time from onset to dyspnea was 5.0 days, 7.0 days to hospital admission, and 8.0 days to ARDS. Common symptoms at onset of illness were fever, dry cough, myalgia, fatigue, dyspnea, and anorexia. However, a significant proportion of patients presented initially with atypical symptoms, such as diarrhea and nausea. Major complications during hospitalization included ARDS, arrhythmia, and shock. Bilateral distribution of patchy shadows and ground glass opacity was a typical hallmark of CT scan for NCIP. Most critical ill patients were older and had more underlying conditions than patients not admitted to the ICU. Most patients required oxygen therapy

and a minority of the patients needed invasive ventilation or even extracorporeal membrane oxygenation.

The data in this study suggest rapid person-to-person transmission of 2019-nCoV may have occurred. The main reason is derived from the estimation of the basic reproductive number (R_0) based on a previous study.[15] R_0 indicates how contagious an infectious disease is. As an infection spreads to new people, it reproduces itself; R_0 indicates the average number of additional individuals that one affected case infects during the course of their illness and specifically applies to a population of people who were previously free of infection and have not been vaccinated. Based on the report, R_0 from nCoV is 2.2, which estimated that, on average, each patient has been spreading infection to 2.2 other people.[15] One reason for the rapid spread may be related to the atypical symptoms in the early stage in some patients infected with nCoV.

A recent study showed that nCoV was detected in stool samples of patients with abdominal symptoms.[16] However, it is difficult to differentiate and screen patients with atypical symptoms. Nevertheless, the rapid human-to-human transmission among close contacts is an important feature in nCoV pneumonia.[10,11,15]

The patients admitted to the ICU were older and had a greater number of comorbid conditions than those not admitted to the ICU. This suggests that age and comorbidity may be risk factors for poor outcome. However, there was no difference in the proportion of men and women between ICU patients and non-ICU patients. These data differ from the recent report that showed 2019-nCoV infection is more likely to affect males.[8] The possible explanation is that the nCoV infection in patients in the previous report was related to exposure associated with the Huanan Seafood Wholesale Market, and most of the affected patients were male workers. Compared with symptoms in non-ICU patients, symptoms were more common in critically ill patients, including dyspnea, abdominal pain, and anorexia. The onset of symptoms may help physicians identify the patients with poor prognosis. In this cohort, the overall rates of severe hypoxia and invasive ventilation were higher than those in the previous study,[9] likely because the cases in the previous study were from the early epidemic stage of the NCIP, and the current cases are from the stage of outbreak.

The most common laboratory abnormalities observed in this study were depressed total lymphocytes, prolonged prothrombin time, and elevated lactate dehydrogenase. Compared with non-ICU patients, patients who received ICU care had numerous laboratory abnormalities. These abnormalities suggest that 2019-nCoV infection may be associated with cellular immune deficiency, coagulation activation, myocardia injury, hepatic injury, and kidney injury. These laboratory abnormalities are similar to those previously observed in patients with MERS-CoV and SARS-CoV infection.

The dynamic profile of laboratory findings was tracked in 33 patients with NCIP (5 nonsurvivors and 28 survivors). In the nonsurvivors, the neutrophil count, D-dimer, blood urea, and creatinine levels continued to increase, and the lymphocyte counts continued to decrease until death occurred. Neutrophilia may be related to cytokine storm induced by virus invasion, coagulation activation could have been related to sustained inflammatory response, and acute kidney injury could have been related to direct effects of the virus, hypoxia, and shock. The 3 pathologic mechanisms may be associated with the death of patients with NCIP.

Until now, no specific treatment has been recommended for coronavirus infection except for meticulous supportive care.[17] Currently, the approach to this disease is to control the source of infection; use of personal protection precaution to reduce the risk of transmission; and early diagnosis, isolation, and supportive treatments for affected patients. Antibacterial agents are ineffective. In addition, no antiviral agents have been found to provide benefit for treating SARS and MERS. All of the patients in this study received antibacterial agents, 90% received antiviral therapy, and 45% received methylprednisolone. The dose of oseltamivir and methylprednisolone varied depending on disease severity. However, no effective outcomes were observed.

This study has several limitations. First, respiratory tract specimens were used to diagnose NCIP through RT-PCR. The serum of patients was not obtained to evaluate the viremia. The viral load is a potentially useful marker associated with disease severity of coronavirus infection, and this should be determined in NCIP. Second, hospital-related transmission/infection could not be definitively proven but was suspected and presumed based on timing and patterns of exposure to infected patients and subsequent development of infection. Third, among the 138 cases, most patients are still hospitalized at the time of manuscript submission. Therefore, it is difficult to assess risk factors for poor outcome, and continued observations of the natural history of the disease are needed.

Conclusions

In this single-center case series of 138 hospitalized patients with confirmed NCIP in Wuhan, China, presumed hospital-related transmission of 2019-nCoV was suspected in 41% of patients, 26% of patients received ICU care, and mortality was 4.3%.

ARTICLE INFORMATION

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Correction: This article was corrected on February 20, 2020, to add the correct data for female patients in Table 1.

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REFERENCES

1. Lu H, Stratton CW, Tang YW. Outbreak of pneumonia of unknown etiology in Wuhan China: the mystery and the miracle [published January 16, 2020]. *J Med Virol*. 2020. doi:10.1002/jmv.25678

2. Hui DS, I Azhar E, Madani TA, et al. The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health: the latest 2019 novel coronavirus outbreak in Wuhan, China [published January 14, 2020]. *Int J Infect Dis*. 2020; 91:264-266. doi:10.1016/j.ijid.2020.01.009

3. Wuhan Municipal Health Commission. Report of novel coronavirus-infected pneumonia in China. Published January 20, 2020. Accessed January 31, 2020. http://wjw.wuhan.gov.cn/front/web/showDetail/2020012009077

4. Paules CI, Marston HD, Fauci AS. Coronavirus infections—more than just the common cold [published January 23, 2020]. *JAMA*. doi:10.1001/jama.2020.0757

5. Wuhan Municipal Health Commission. Report of clustering pneumonia of unknown etiology in Wuhan City. Published December 31, 2019. Accessed January 31, 2020. http://wjw.wuhan.gov.cn/front/web/showDetail/2019123108989

6. World Health Organization. Novel coronavirus(2019-nCoV): situation report—15. Accessed February 5, 2020. https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200204-sitrep-15-ncov.pdf

7. Zhu N, Zhang D, Wang W, et al; China Novel Coronavirus Investigating and Research Team. A novel coronavirus from patients with pneumonia in China, 2019 [published January 24, 2020]. *N Engl J Med*. doi:10.1056/NEJMoa2001017

8. Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study [published January 29, 2020]. *Lancet*. doi:10.1016/S0140-6736(20)30211-7

9. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China [published January 24, 2020]. *Lancet*. doi:10.1016/S0140-6736(20)30183-5

10. Chan JF-W, Yuan S, Kok K-H, et al. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster [published January 24, 2020]. *Lancet*. 2020;S0140-6736(20)30154-9. doi:10.1016/S0140-6736(20)30154-9

11. Phan LT, Nguyen TV, Luong QC, et al. Importation and human-to-human transmission of a novel coronavirus in Vietnam [published January 28, 2020]. *N Engl J Med*. doi:10.1056/NEJMc2001272

12. World Health Organization. Clinical management of severe acute respiratory infection when novel coronavirus (nCoV) infection is suspected: interim guidance. Published January 28, 2020. Accessed January 31, 2020. https://www.who.int/publications-detail/clinical-management-of-severe-acute-respiratory-infection-when-novel-coronavirus-(ncov)-infection-is-suspected

13. Ranieri VM, Rubenfeld GD, Thompson BT, et al; ARDS Definition Task Force. Acute respiratory distress syndrome: the Berlin definition. *JAMA*. 2012;307(23):2526-2533. doi:10.1001/jama.2012.5669

14. Kidney Disease: Improving Global Outcomes (KDIGO) Acute Kidney Injury Work Group. KDIGO Clinical Practice Guideline for Acute Kidney Injury. *Kidney Int Suppl*. 2012;2:1.

15. Li Q, Guan X, Wu P, et al. early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. [published on January 29, 2020]. *N Engl J Med*. 2020. doi:10.1056/NEJMoa2001316

16. Zhang H, Kang ZJ, Gong HY, et al. The digestive system is a potential route of 2019 nCoV infection: a bioinformatics analysis based on single-cell transcriptomes. Preprint. Posted online January 31, 2020. bioRxiv 927806. doi:10.1101/2020.01.30.927806

17. de Wit E, van Doremalen N, Falzarano D, Munster VJ. SARS and MERS: recent insights into emerging coronaviruses. *Nat Rev Microbiol*. 2016;14(8):523-534. doi:10.1038/nrmicro.2016.81