Management of a “suspected ward” in a COVID-19 designated hospital in Wuhan

Meng Kuang, MDa, Lanrong Zheng, PhDb, Chun Li, MDb, Huaping Deng, MDb, Chiqiu Jiang, MDb

Abstract
During December 2019, an outbreak of unexplained pneumonia occurred in Wuhan, Hubei Province. The disease was subsequently named coronavirus disease 2019 (COVID-19) and the causative virus as severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2). Based on experience, it is vital to exclude or diagnose suspected patients as soon as possible to prevent disease spread. Our hospital is a COVID-19 designated hospital in Wuhan. During the epidemic period, there was a reconstruction of the medical facilities to accommodate patients with different disease status. We document the development of “suspected ward,” a ward that cared for patients with suspected COVID-19, in a large designated hospital during the COVID-19 outbreak in Wuhan City, China, and explain the suspected ward spatial layout, organization structure, diagnosis, and treatment flow chart of suspected cases. The key characteristics of our “suspected ward” is isolation, triage, fast diagnosis, and rapid referral. Our description of this suspected ward provides a reference for further improvements in the care of patients with suspected disease in emergency medical institutions.

Abbreviations: COVID-19 = coronavirus disease 2019, MERS = Middle East respiratory syndrome, SARS = severe acute respiratory syndrome, SARS-CoV-2 = severe acute respiratory syndrome coronavirus-2.

Keywords: COVID-19, designated hospital, management, SARS-CoV-2, suspected ward

1. Introduction
Before coronavirus disease 2019 (COVID-19), there were 2 coronavirus epidemics during the past 2 decades. The first was the severe acute respiratory syndrome (SARS) epidemic during 2002 to 2003, in which there were 8422 people infected by SARS-CoV and 916 deaths (death rate: 11%). The second was the Middle East respiratory syndrome (MERS), in which MERS-CoV infected 2494 people and there were 858 deaths (death rate: 34%). Within 3 months since the discovery of a novel coronavirus in patients with pneumonia of unknown origin in Wuhan City, China, COVID-19 has spread rapidly throughout the world and is beating SARS-CoV and MERS-CoV in the number of confirmed cases and deaths. Viruses of the family coronavirus possess a single-strand, positive-sense RNA genome ranging from 26 to 32 kilo-bases in length. Its diameter is ~100 nm, and it has a round or oval shape with numerous spike (S) proteins on the surface. Based on hospitalized patient data, the majority of COVID-19 cases (about 80%) presented with asymptomatic or with mild symptoms while the remainder are severe or critical. Moreover, the number of virus RNA copies from one asymptomatic case was comparable to that of the rest of symptomatic cases. Available treatments are not curative, and transmission could occur even after treatment. This made it difficult to prevent and control the spread of this virus. The experience in China shows that quarantine, social distancing, and isolation of infected people can effectively control disease spread. Thus, it is very important to isolate all infected and possibly individuals from the general population. At present, many reports have confirmed the relevant management experiences of Fangcang Shelter Hospitals and various diagnosed population. Here we focus on the relevant management experience of the suspected ward in the designated hospital. We have developed a flow chart for the diagnosis and treatment of suspected cases, aiming to isolate, diagnosis and refer infected patients to Confirmed area as soon as possible, as well as reduced the risk of disease transmission. Finally, it provides experience for further standardization of the suspected areas.

2. Methods
The study was approved by the ethics committee of Jianghan University Affiliated Hubei Third People’s Hospital.
2.1. Design of a suspected ward

The Chinese government classified COVID-19 as a class B infectious disease, as stipulated by law of the People’s Republic of China regarding the prevention and control of infectious diseases, but currently manages it as a more serious class A infectious disease. Wuhan was a severely affected area and set up large-scale public emergency measures, such as a fever clinic, a COVID-19 designated hospital, contact isolation points, a shelter hospital for those with mild disease, and other interventions. Our department has a suspected ward in a designated hospital, and mainly receives patients with suspected disease from the fever clinic and the isolation point for the exclusion or confirmation of COVID-19.

Compared with other areas that treat COVID-19 patients, suspected disease areas are special. Because there is no definite diagnosis upon admission, infected and uninfected individuals are present, and there are many uncertainties in how to care for these individuals. Thus, a suspected ward has the same level of infection management as areas that treat patients with confirmed disease. Suspected cases should be treated in an isolation ward of an infectious disease department or designated hospital that has effective isolation and protection conditions. Because our hospital is a designated hospital for COVID-19, the whole hospital is designed according to the principle of “3 areas and 2 passages.” In particular, the “3 areas” refer to a clean area, a semi-contaminated area, and a contaminated area. Besides, there are not connected; There are 2 passages in the ward, one for patients and the other for health workers (Fig. 1).

The health workers can walk in the clean passage. All staff entering the contaminated area should be protected at third-level, and other staff should be protected at Secondary level. Third-level protection is the highest level of protection in our hospital, usually including: work clothes, disposable round cap, shoe cover, latex gloves, disposable medical surgical mask, goggles or face shield, N95 mask, disposable protective clothing, isolation gown. Secondary protection is slightly less than 3-level protection, including: work clothes, disposable round cap, disposable medical surgical mask, latex gloves, wear goggles or face shield if necessary. After taking appropriate protective measures, the patients exit the hospital, and are then examined and transferred to other departments, while passing through another passage. Besides, the 2 passages are not connected.

Suspected patients are not allowed to leave the ward except in special circumstances. As the intermediate link between diagnosis and exclusion, the suspected area should be between the radiology, laboratory, and confirmed areas. A special passage is established to connect the fever clinic, auxiliary examination room, suspected ward, and confirmed ward. Thus, it is convenient for patients to enter and leave the hospital, transfer to another department, undergo a physical examination, and have restricted access to other areas. Communication equipment, such as a dedicated landline telephone, a walkie-talkie, and a mobile phone, in the contaminated area should be used for timely communications between different areas.

There are general ward units and intensive care units in the suspected ward. The critical observation and treatment area is

![Figure 1. Spatial layout of suspected ward. White represents the clean area, light gray represents the semi-contaminated area, and dark gray represents the contaminated area. There is a password lock between the contaminated area and the semi-contaminated area to prevent random walking. The doors of the semi-contaminated area are restricted movement to 1 direction, and 2 doors cannot be opened at the same time. Medical workers who come from the contaminated area pass into a semi-contaminated area for cleaning and disinfection in one of 3 disinfection rooms using a specific protocol. Zigzag walking is used by health workers from contaminated area to semi-contaminated area, which can effectively reduce the risk of cross ventilation and infection during walking.](image-url)
relatively independent and is equipped with oxygen tanks, noninvasive ventilators, a rescue vehicle, a defibrillator, rescue medicines, monitoring and rescue equipment, a cart, and other equipment. Patients in the suspected ward are principally treated in single room that is equipped with numerous daily necessities. In particular, each room has a toilet and bath to eliminate the possibility of cross-infection of undiagnosed patients.

### 2.2. Staffing

The department is a temporary team that consists of individuals from the emergency department, general internal medicine, general surgery, pediatrics, and other departments. At present, the doctor:nurse:patient ratio is 1:3:2. Every 6 hours, the shift changes to ensure that every staff member has sufficient rest time and an acceptable combination of work and rest. To ensure normal, efficient, and safe operation, all departments of the medical institution are prepared to accept new challenges, work together, perform their duties, and face the epidemic together. We examined the hospital management plans to establish a standard framework for management of patients with suspected disease. This framework (Fig. 2) considers improving organizational structure, medical care, preventing hospital-acquired infections, logistics support, and an information submission module.

### 2.3. Operation of the suspected ward

According to the *Seventh edition of novel coronavirus pneumonia guidelines*\(^{[17]}\), the current cases can be divided into 3 diagnostic levels, excluding cases, suspected cases, and confirmed cases. Types of patients we will meet in the ward are listed as Table 1. The patients entering my department are mainly divided into the following 3 situations, close contact, no exclusion, suspicious. The relevant examination will be carried out after the patient is admitted to hospital, and then the infection can generally be diagnosed or eliminated. The confirmed patient will be transferred to the confirmed area for further treatment. Patients excluded from infection were isolated for at least 1 week before returning home. Figure 3 shows the detailed flow chart of suspected ward.

After the patient enters the hospital, completes the related medical examination, according to the examination result, there will appear various situations, as follows:

1. Nucleic acid positive, IgM and IgG negative: It may be that serum viral antibodies have not been produced yet and could be undetectable in the early stage of the disease\(^{[18]}\);
2. Nucleic acid positive, IgM positive, IgG negative: The patient may be in the early stage of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) infection. The immune response of the body is the first to produce antibody IgM. The IgG content does not reach the detection limit of diagnostic reagent\(^{[19]}\);
3. Nucleic acid positive, IgM negative, IgG positive: The patient may be in the middle and late stage of SARS-CoV-2 infection or recurrent infection, and can be diagnosed. When IgG in recovery period is 4 times or more than that in acute period, it can be diagnosed as recurrent infection;
4. Nucleic acid positive, IgM positive, IgG positive: Active period of infection, confirmed;
5. Nucleic acid negative, IgM positive, IgG negative: The positive IgM suggests that it is highly likely to be in the acute stage of SARS-CoV-2 infection, and the result of nucleic acid detection is questionable. It cannot be ruled out that SARS-CoV-2 infection and should be confirmed repeatedly;
6. Nucleic acid negative, IgM negative, IgG positive: The patient was recently infected with SARS-CoV-2 and was in the recovery period. Or nucleic acid test results false negative, the patient is in the active stage of infection;
7. Nucleic acid negative, weak IgM positive, IgG negative: It is suggested that the patient first infected with very low amount of SARS-CoV-2 and was in the early stage. The body produced a small amount of IgM, but no IgG, false positive is not excluded;
8. Nucleic acid negative, IgM positive, IgG positive: The patient was recently infected with SARS-CoV-2 and was in the recovery period. Or nucleic acid test results false negative, the patient is in the active stage of infection;

---

**Figure 2.** Standardized structural framework of the suspected ward.
Table 1
Types of patients encountered in the ward.

| Types of patients and definition |
|----------------------------------|
| Close contact case:              |
| According to the Department for Disease Control and Prevention (“Notice on Issuance of Guidelines for Investigation and Management of Close Contacts of New Coronavirus Pneumonia Cases (Trial Version),” a close contact is a person who had no protection during close contact (<1 m) with a suspected case, a clinically diagnosed case, or a confirmed case has symptoms or symptoms within 2 days, or asymptomatic infection samples within 2 days.
| Do not exclude case:              |
| COVID-19 cannot be excluded for cases that do not meet the criteria for suspected cases (described below). |
| Suspected case:                  |
| A suspected case is a person with any 1 of 4 epidemiological factors and any 2 of 3 clinical manifestations, or with all 3 clinical manifestations if there is no epidemiological factor: |
| 1. Epidemiological factors:      |
| (1) History of travel or residence in Wuhan and surrounding areas or other communities with case reports within 14 days before the onset of illness; |
| (2) History of contact with new SARS-CoV-2 infection (positive nucleic acid test) within 14 days before the onset of illness; |
| (3) Fever or respiratory symptoms and from Wuhan and surrounding areas, or from communities with case reports, within 14 days before the onset of illness; |
| (4) Aggressive onset and presence in a small area, such as home, office, school class, etc, in which there were 2 or more cases with fever or respiratory symptoms within 14 days before onset of illness. |
| 2. Clinical manifestations:      |
| (1) Fever and/or respiratory symptoms; |
| (2) Lung imaging characteristics of COVID-19 pneumonia; |
| (3) Normal or decreased white blood cell count, and normal or decreased lymphocyte count during the early stage of onset. |
| Confirmed case:                  |
| A confirmed case is a suspected case with one of the following: |
| A positive result in real-time fluorescence RT-PCR detection of SARS-CoV-2 nucleic acid; |
| Viral gene sequencing indicating high homology to SARS-CoV-2; |
| A positive result for serum SARS-CoV-2-specific IgG antibody and IgM antibody; A change from serum SARS-CoV-2-specific IgG antibody negative to positive or the recovery period increased by 4 times or more than the acute phase. |
| Exclusion of suspected case:     |
| According to the seventh edition of the New Coronavirus Pneumonia Diagnosis and Treatment Guidelines, our department has unified standards to assure patient safety. A suspected case is excluded if there are 2 negative results in the SARS-CoV-2 nucleic acid test (sampling time interval of at least 24h), and 2 negative results for SARS-CoV-2-specific IgG antibodies and IgM antibodies. |

(9) The second nucleic acid and antibody examination may appear such as I to K cases. Generally, if the nucleic acid is positive, the infection can be diagnosed. However, serum IgM and IgG need to be combined with the results of the previous examination. If the level is significantly higher, the infection is highly suspected.

(10) We need to combine the results of the patient’s lung CT when both nucleic acids and antibodies are negative. It needs to reexamine nucleic acid and antibody if typical disease appeared. Otherwise, we can exclude infection.

At present our hospital uses real-time fluorescence RT-PCR to detect SARS-CoV-2 nucleic acids for testing nasopharynx swab samples, and SARS-CoV-2-specific IgG antibodies and IgM antibodies for serum testing. Patients in the suspected ward are those who were close contacts who have fever diagnosis at admission, CT manifestations typical of COVID-19 pneumonia, and changes in hemogram typical of COVID-19, or patients with unrecognized clinical manifestations at the isolation point. Determination of treatment location according to a patient’s condition as follows.

(1) Suspected cases were maintained and treated in isolation and confirmed cases were transferred to the diagnosis department for comprehensive treatment;
(2) Patients who were not excluded were treated in a single room in the original ward;
(3) Critical cases were admitted to the ICU and isolated in single rooms for treatment as soon as possible;
(4) After a suspected case is excluded, the community staff is contacted and asked to isolate and observe the patient at a fixed isolation point for another week before go home.

2.4. Follow-up
When a suspected patient was excluded, this was reported to the hospital. Due to the mode of virus transmission, the long incubation period, and other features of this epidemic, the patient continued to be isolated for observation. Thus, our hospital contacted community workers, transferred excluded patients to isolation points to continue medical observation for 14 days, with regular follow-ups. Various methods can be used for follow-ups. According to our previous experience, there are many possible reasons for poor execution of follow-ups:

(1) The medical staff are busy with work, and follow-up requires significant manpower, material resources, and energy;
(2) Elderly patients who are unfamiliar with electronic equipment need to use basic and time-consuming follow-up methods;
(3) Patients with mild symptoms may be complacent and uncooperative with follow-up exams;
(4) The follow-up time may be long, and making it difficult for the medical personnel to continue following large numbers of patients.

Therefore, our department adopted a follow-up model based on the methods we used before. In combination with the unique...
characteristics of the disease, we first distinguished patients by age, use electronic questionnaires under 70 years of age, and simple closed questions are set for patients to check mark; the elderly over 70 years old are individually marked and followed up with original telephone.

3. Results

A total of 845 confirmed and suspected COVID-19 infections have been treated in the 2 branch districts of our hospital since the outbreak of the epidemic. Among them, 724 cases were diagnosed with COVID-19 and 121 cases were excluded. Four hundred sixty-seven cases were cured and discharged, 327 cases were transferred to hospital, and 51 cases died.

As of midnight on June 30, 2020, there were no hospital group infection incidents, no major medical personnel casualties, and the mental health status of all medical staff was stable. We performed follow-up of these discharged patients, none of exclusion case had clinical manifestations indicative of COVID-19. Patients with COVID-19 receive standardized and orderly diagnosis and treatment and are returned home as soon as possible. The initial results from the emergency management strategy of the suspected ward in our hospital can be used as a foundation for establishment of such centers at other hospitals in China that are in the same category.

4. Discussion

4.1. Summary of work experience in the suspected ward

Our work in the suspected ward described here and a review of recent reports suggest that several issues need further attention. Clinical testing indicated that some patients with COVID-19 had multiple false-negative nucleic acid tests during early-stage disease, and that clinical diagnosis and disease control was only implemented after the results were positive. These individuals could potentially spread disease before their diagnosis. There are many family clusters of COVID-19, and a single negative nucleic acid test should not be used as a basis for exclusion. Thus, medical workers should take samples from multiple locations.
hygiene should be recommended to children and those in behaviors, a balanced diet, regular sleep, and good personal treatment teams should ensure the safety of medical staff and need of treatment should be managed separately, and special available to more critically ill patients. Second, patients in urgent problems and the workload of medical staff and to make beds urgent medical attention. Patients without no symptoms and capable of self-care, or having a severe disease and the need for classi for improvement as follows. First, a COVID-19 patient can be in-hospital examination, we need to pay attention to them. As well as those patients who are infected during the process of infection of medical workers in the process of treating patients. The majority of patients have greater anxiety and depression scores were related to Sudden illness, especially females. Thus, suspected patients in the isolation area face great psychological stress because of their fear of a prolonged illness, and this can lead to depression, boredom, lack of information, family economic loss, and other hardships. Isolation of suspected patients will undoubtedly increase the risk of psychological problems, which will be the second biggest problem in suspected ward. The last problem is hospital acquired infection. We should be alert to the infection on the medical staff in the process of treating patients. As well as those patients who are infected during the process of in-hospital examination, we need to pay attention to them.

4.2. Limitations
The design of the suspected ward in our hospital is still in the exploratory stage, and although there has been some success, our experience also indicated some shortcomings. First, the conditions in the suspected ward are much better than waiting in line outside the clinic in a disaster area such as Wuhan. At present, medical resources are in short supply, so it is urgent to increase the utilization of suspected wards, and reduce the work burden of health workers. Sprang and Silman showed that the average posttraumatic stress score of isolated children was 4-times higher than that of non isolated children. Previous research suggests, the majority of patients have greater anxiety and depression scores related to Sudden illness, especially females. Thus, suspected patients in the isolation area face great psychological stress because of their fear of a prolonged illness, and this can lead to depression, boredom, lack of information, family economic loss, and other hardships. Isolation of suspected patients will undoubtedly increase the risk of psychological problems, which will be the second biggest problem in suspected ward. The last problem is hospital acquired infection. We should be alert to the infection on the medical staff in the process of treating patients. As well as those patients who are infected during the process of in-hospital examination, we need to pay attention to them.

4.3. Strategies for improvement
Based on the above considerations, we can summarize our plans for improvement as follows. First, a COVID-19 patient can be classified as having no symptoms, having mild symptoms but capable of self-care, or having a severe disease and the need for urgent medical attention. Patients without any symptoms and those who have mild symptoms but capable of self-care can be put into a group but still single room to reduce procedural problems and the workload of medical staff and to make beds available to more critically ill patients. Second, patients in urgent need of treatment should be managed separately, and special treatment teams should ensure the safety of medical staff and patients. Last, patients in single rooms may experience stress and need more psychological care than patients in other areas. The nursing staff can help to relieve emotional problems in these patients during their daily inspections, encourage them to communicate with others outside the hospital, and urge them to seek social support. During the COVID-19 outbreak, healthy behaviors, a balanced diet, regular sleep, and good personal hygiene should be recommended to children and those in suspected wards. Encouraging appropriate physical activities, such as square dancing and Taijiquan, may reduce stress and help patients to face the epidemic with a positive and peaceful attitude.

4.4. Prospect
The COVID-19 epidemic developed rapidly. There was initially a shortage of medical supplies, but the accumulation of clinical experience and research suggests that some measures still need improvement, while reducing the cost of manpower and material resources, to provide the best protection of patients and caregivers. As medical workers, we are responsible for the use of effective prevention and control procedures during an epidemic. All kinds of medical institutions at all levels throughout the country should consider the susceptibility of different individuals to COVID-19 and the serious situation of the current pandemic. The early diagnosis and isolation of suspected patients is necessary to prevent further spread of the virus and to win the battle against this pandemic.

Author contributions
Conceptualization: Meng Kuang, Liuqing Sheng, Chiqiu Jiang. Data curation: Meng Kuang. Formal analysis: Meng Kuang, Liuqing Sheng. Resources: Meng Kuang, Chiqiu Jiang. Software: Meng Kuang, Chun Li. Supervision: Lanrong Zheng Writing – original draft: Meng Kuang, Chun Li. Writing – review & editing: Min Qi, Huiping Deng, Lanrong Zheng, Chiqiu Jiang.

References
[1] Tanu S, Singhal . A review of coronavirus disease-2019 (COVID-19). Indian J Pediatr 2020;87:281–6.
[2] Hui DS, Azhar EI, Kim YJ, et al. Middle East respiratory syndrome coronavirus: risk factors and determinants of primary, household, and nosocomial transmission. Lancet Infect Dis 2018;18:e217–27.
[3] Park SE. Epidemiology, virology, and clinical features of severe acute respiratory syndrome -coronavirus-2 (SARS-CoV-2; Coronavirus Disease-19). Clin Exp Pediatr, 2020;63:119–24.
[4] Lu R, Zhao X, Li J, et al. Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. Lancet 2020;395:563–74.
[5] Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 2020;395:497–506.
[6] Chan JF, Yuan S, Kok KH, et al. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. Lancet 2020;395:514–23.
[7] Anderson RM, Heesterbeek H, Klinkenberg D, et al. How will country-based mitigation measures influence the course of the COVID-19 epidemic? Lancet 2020;395:931–4.
[8] Giuseppe P, Alessandro S, Chiara L P, et al. COVID-19 diagnosis and management: a comprehensive review. J Intern Med 2020:288:192–206.
[9] Yuan Liu, Zhi Ning, Yu Chen, et al. Aerodynamic analysis of SARS-CoV-2 in two Wuhan hospitals. Nature 2020;582:557–60.
[10] Tasleng Li. Diagnosis and clinical management of severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2) infection: an operational recommendation of Peking Union Medical College Hospital (V2.0). Emerg Microbes Infect 2020;9:582–5.
[11] Lia T, Lub H, Zhang W. Clinical observation and management of COVID-19 patients. Emerg Microbes Infect. 2020;9:687–90.
[12] Xiang YT, Zhao YJ, Liu ZH, et al. The COVID-19 outbreak and psychiatric hospitals in China: managing challenges through mental health service reform. Int J Biol Sci 2020;16:1741–4.
[13] Chao JY, Derespina KR, Herold RC, et al. Clinical characteristics and outcomes of hospitalized and critically Ill children and adolescents with coronavirus disease 2019 (COVID-19) at a tertiary care medical center in New York City. J Pediatr. 2020;S0022-3476(20)30580–1.
[14] Fong D, Rauch S, Peter C, et al. Infection rate and clinical management of cancer patients during the COVID-19 pandemic: experience from a tertiary care hospital in Northern Italy. ESMO Open 2020;5:e000810.
[15] Lateef F. Hospital design for better infection control. J Emerg Trauma Shock 2009;2:175–9.
[16] Bataille J, Brosqui P. Building an intelligent hospital to fight contagion. Clin Infect Dis 2017;65(suppl_1):S4–11.
[17] Novel coronavirus pneumonia case investigation and Management Guide notice (trial version). China Center for Disease Control and prevention. http://www.chinacdc.cn/jkzt/crb/zl/szl/11803/jszl_11815/202003a20200305_214142.htm.

[18] Laperche S. Blood safety and nucleic acid testing in Europe. Euro Surveill 2005;10:3-4.

[19] Fricker-Hidalgo H, Bailly S, Marie-Pierre B, et al. How to estimate time of infection with Toxoplasma gondii in the pregnant women. Use of specific IgG and IgM kinetics by 7 techniques on 691 sera. Diagn Microbiol Infect Dis 2020;15:114987.

[20] Corman VM, Landt O, Kaiser M, et al. Detection of 2019 novel coronavirus (2019-nCoV) by real-time RT-PCR. Euro Surveill 2020;25:2000045.

[21] Sprang G, Silman M. Posttraumatic stress disorder in parents and youth after health-related disasters. Disaster Med Public Health Prep 2013;7:105-10.

[22] Abar B, Holub A, Lee J, et al. Depression and anxiety among emergency department patients: utilization and barriers to care. Acad Emerg Med 2017;24:1286-9.

[23] Serpytis P, Navickas P, Lukaviciute L, et al. Gender-based differences in anxiety and depression following acute myocardial infarction. Arq Bras Cardio 2018;111:676-83.

[24] Wang G, Zhang Y, Zhao J, et al. Mitigate the effects of home confinement on children during the COVID-19 outbreak. Lancet 2020;395:945-7.