Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Chinese experts' consensus on the Internet of Things-aided diagnosis and treatment of coronavirus disease 2019 (COVID-19)

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ABSTRACT

The aim is to diagnose COVID-19 earlier and to improve its treatment by applying medical technology, the "COVID-19 Intelligent Diagnosis and Treatment Assistant Program (nCapp)" based on the Internet of Things. Terminal eight functions can be implemented in real-time online communication with the "cloud" through the page selection key. According to existing data, questionnaires, and check results, the diagnosis is automatically generated as confirmed, suspected, or suspicious of 2019 novel coronavirus (2019-nCoV) infection. It classifies patients into mild, moderate, severe or critical pneumonia. nCapp can also establish an online COVID-19 real-time update database, and it updates the model of diagnosis in real time based on the latest real-world case data to improve diagnostic accuracy. Additionally, nCapp can guide treatment. Front-line physicians, experts, and managers are linked to perform consultation and prevention. nCapp also contributes to the long-term follow-up of patients with COVID-19. The ultimate goal is to enable different levels of COVID-19 diagnosis and treatment among different doctors from different hospitals to upgrade to the national and international through the intelligent assistance of the nCapp system. In this way, we can block disease transmission, avoid physician infection, and epidemic prevention and control as soon as possible.

Contents

The 2019 novel coronavirus (2019-nCoV, officially known as severe acute respiratory syndrome coronavirus 2) was detected in Wuhan at the end of 2019 in cases of unexplained pneumonia.[1,2] The 2019-nCoV, which is a new coronavirus strain that has never been previously reported in humans,[3,4] has aroused concern. On February 8, 2020, 2019-nCoV-induced pneumonia was officially named as novel coronavirus pneumonia in China.[5] On February 11, 2020, the World Health Organization named the disease caused by 2019-nCoV as coronavirus disease 2019 (COVID-19).[6]

The number of patients with COVID-19 has rapidly increased, with nearly 80,000 reported cases currently. The virus is transmitted mainly through infected respiratory droplets and on close contact with the infected person. The incubation period can be as long as 2 weeks or even longer, and it is highly contagious.[7] The main target organ is the lung. Some patients with severe infection gradually develop respiratory failure, even acute respiratory distress syndrome, multiple organ failure, and ultimately death.[8,9] Therefore, it is important to identify, report, isolate, and treat individuals at the early stages of the disease to control its spread. However, the current diagnosis of COVID-19 is mainly dependent on viral nucleic acid testing. The accuracy of current nucleic acid testing is approximately 30–50%. A large number of suspected or suspicious cases may be missed, which is not conducive to the isolation and treatment of patients.[10] The National Health Commission of the People's Republic of China promulgated the "Diagnosis and Treatment Scheme for Pneumonia of COVID-19 (Interim Version 5)",[11] which

proposed clinical diagnostic criteria based on chest imaging, and proposed Version 6.[12] However, considering the different levels of diagnosis and treatment among doctors in different regions and hospitals, some cases are still missed or misdiagnosed, especially when the nucleic acid test has a negative result. Additionally, patients suspected of having this disease have not been identified in the interim version. A study conducted at the Mount Sinai Hospital in New York[13] revealed that changes observed in computed tomography (CT) can precede the detection of nucleic acid tests in some patients. To control this epidemic in various regions, it is important to appropriately manage patients suspected of having the disease, immediately identify and isolate the source of infection, cut off the transmission route, and prevent viral transmission from these potential patients or virus carriers.

Therefore, we have formulated consensus version 1 by convening clinicians with rich clinical experience, clinicians supporting front-line work in Wuhan, and biomedical, statistical, and information technology engineers through the Internet.[14] We aimed to apply the COVID-19 Intelligent Diagnosis and Treatment Assistant Program (nCapp) based on the Internet of Things (IoT) medical technology to conduct clinical work during the COVID-19 epidemic, especially for outpatients, and quality control (QC) will assist the diagnosis and treatment, and achieve early identification, isolation, and treatment of patients with COVID-19. This consensus is appropriate for different specialists at all levels of hospitals and even managers at all levels of hospitals, local community development corporations, and public health centers. This will enable them with intelligent assistance to work in the timely discovery, isolation, and management of patients who are confirmed, suspected, and suspicious to have the disease through the nCapp.

After the consensus version 1 was published,[14] it was warmly welcomed. However, some improvements were required while applying this consensus. Hence, we have revised the consensus based on these valuable opinions and published it in English to meet more requirements.

1. Significance of applying the Internet of Things medical technology to diagnose and treat coronavirus disease 2019 (COVID-19)

The IoT was originally referred to as radio-frequency identification technology and equipment combined with the Internet based on the agreed communication protocol to achieve intelligent management of item information. Today, this concept has been expanded and deepened, that is, the use of communication technologies such as local networks or the Internet to connect sensors, machines, people, and things to achieve the connection between people and things, things and things, people-oriented informationization, and remote control and intelligent management. The most basic functional feature of the IoT is "ubiquitous connectivity." Its three basic processes are comprehensive perception → reliable transmission → intelligent processing. The application of the IoT to medicine is referred to as the medical IoT (MIoT),[15–18] which aims to establish a decision-oriented big data analysis model supported by information technology such as communication, electronics, biology, and medicine.

MIoT can also be used for the prevention and control of COVID-19. We can establish a three-level linkage nCapp system based on the medical theory and technology of the IoT to diagnose and treat COVID-19. The IoT nCapp cloud medical system platform contains the basic functions of the IoT and has a core graphics processing unit (GPU). Cloud computing systems connected to existing electronic medical records, image archiving, and picture archiving and communication can better assist in deep mining and intelligent diagnosis. The ten functions of the IoT (Table 1) are considered beneficial time assistance, supervision, and control of medical quality.[15–18]

Table 1
Ten functions of the nCapp diagnosis and treatment system for COVID-19 based on the Internet of Things.

Function	Significance of diagnosis and treatment of COVID-19
Online monitoring	Best for online monitoring, identifying COVID-19, and guiding graded diagnosis and treatment
Location tracking	Can be used to locate patients diagnosed with COVID-19 and guide treatment when problems are found
Alarm linkage	Can provide alarms to monitor the probability of COVID-19 and provide a three-linkage response function to guide graded diagnosis and treatment
Command and control	Facilitates the graded diagnosis and consultation of patients with COVID-19
Plan management	Presets management criteria for the graded diagnosis and treatment of patients with COVID-19 that can be set in advance for graded management and timely treatment of confirmed, suspected, and suspicious cases
Security privacy	Conducive to providing a corresponding safety guarantee mechanism for the graded diagnosis and treatment of patients with COVID-19
Remote maintenance	Networked services used for the graded diagnosis and treatment of patients with COVID-19
Online upgrade	Ensures the normal operation of the graded diagnosis and treatment of patients with COVID-19 and provides automatic medical service
Command management	Considered beneficial for experts or managers to deeply investigate or expand the diagnosis and treatment functions based on the massive information collected Guides how to better prevent and control COVID-19
Statistical decision	Considered beneficial for experts or managers in performing statistical analysis based on the data of graded diagnosis and treatment of patients with COVID-19 Summarizes experiences, identifies problems, and proposes solutions

Among them, the functions of online monitoring, location tracking, alarm linkage, and follow-up scheduling are conducive to online discovery, monitoring, management, and treatment assistance for COVID-19. Plan management, remote maintenance, command management, and statistical decision-making functions can expand the massive information mining of COVID-19 and complete management and timely treatment of COVID-19 by applying preset guidelines or standardized criteria. Security privacy and online upgrade functions are nCapp guarantee that can ensure the normal operation of the IoT cloud plus terminal system. It can also assist in asking questions; registering patients' details; coordinating with patients, community doctors, and experts; and providing safe diagnosis treatment programs and two-way referrals (Fig. 1).

Simultaneously, the three-linkage IoT cloud plus terminal nCapp COVID-19 diagnosis and treatment system uses the Fifth Generation (5G) technology, network performance characteristics and advantages, combines with the overall system's network requirements for network liquidity, efficiency, high load, and high capacity platform. 5G technology is an important part of the overall technical support of the platform to ensure the normal and efficient operation of the three-linkage IoT cloud plus terminal nCapp intelligent assisting the diagnosis and treatment system of COVID-19.[19,20]

Compared with the previous generations of mobile networks, the abilities of 5G networks are significantly better.[19] For example, the peak downlink data rate can reach 20 Gbps, and the peak uplink data rate can exceed 10 Gbps. Additionally, 5G will significantly reduce latency and improve overall network efficiency. The simplified network will provide terminal-to-terminal latency of less than 5 ms. The Mobile Beyond Giga, Real-Time World, and All-Online 5G will provide an era of opportunities, an attractive operating model for IoT healthcare can efficiently provide various

Fig. 1. Three-level linkage of the nCapp diagnosis and treatment system for COVID-19 based on the Internet of Things "cloud plus terminal".

new services for different service levels and performance requirements.

Additionally, based on the WeChat,[20] nCapp can coordinate the division of labor in the diagnosis and treatment of COVID-19 in one-, two-, and three-tier hospitals[14] and perform three-level linkage among experts, primary doctors and service providers. This model contributes to prevent and control of COVID-19 and other sudden respiratory infectious diseases in China.

2. Applying nCapp assisted diagnosis and treatment of COVID-19

2.1. Introduction of the nCapp assisted COVID-19 diagnosis and treatment system

To reflect the three basic processes of "comprehensive perception → reliable transmission → intelligent processing" of the IoT technology and assist the GPU to manage the nCapp assisted three-level linked cloud plus terminal platform, we designed 15 easy-to-use questionnaires and nucleic acid detection information for deep mining and intelligent processing (Fig. 2). The diagnosis and treatment recommendations are automatically generated and transmitted to doctors and experts for reference. Physicians and experts can use smartphone nCapp assistant software to participate in the three-linkage IoT cloud plus platform according to their needs (Fig. 2).[14,19,20]

The three-cascade IoT "cloud plus terminal" nCapp[14] can assist in the intelligent management, command, and diagnosis of COVID-19. "Cloud" is a general term for cloud technology, which can be further subdivided into network technology, information technology, integration technology, management platform technology, and application technology based on the application of the cloud computing model. The terminal is a physician's smartphone that can implement the following eight functions in real-time online communication with the "cloud" through the page selection key (Fig. 3):

(1) Patient registration. The basic information of the patient is registered online.

(2) Start the consultation. After the patient is admitted, the page will display the item-by-item questions (Fig. 4), and the patient selects the answer button, which transfer the data back to the cloud online.

(3) Intelligent assisted diagnosis. Diagnostic suggestions are automatically generated for reference.

(4) Intelligent assisted treatment. Treatment recommendation based on the severity of the disease are provided.

Fig. 2. "Cloud plus terminal" nCapp intelligent assisted diagnosis and treatment system for COVID-19.

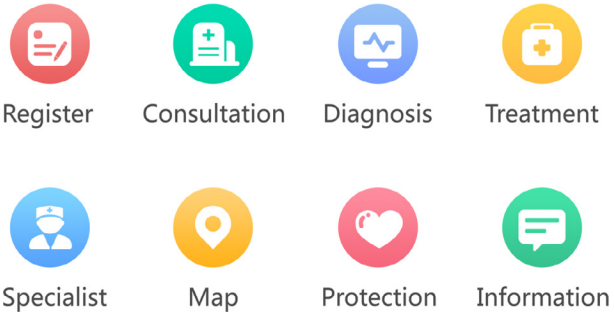

Fig. 3. The eight functions of nCapp in a smartphone.

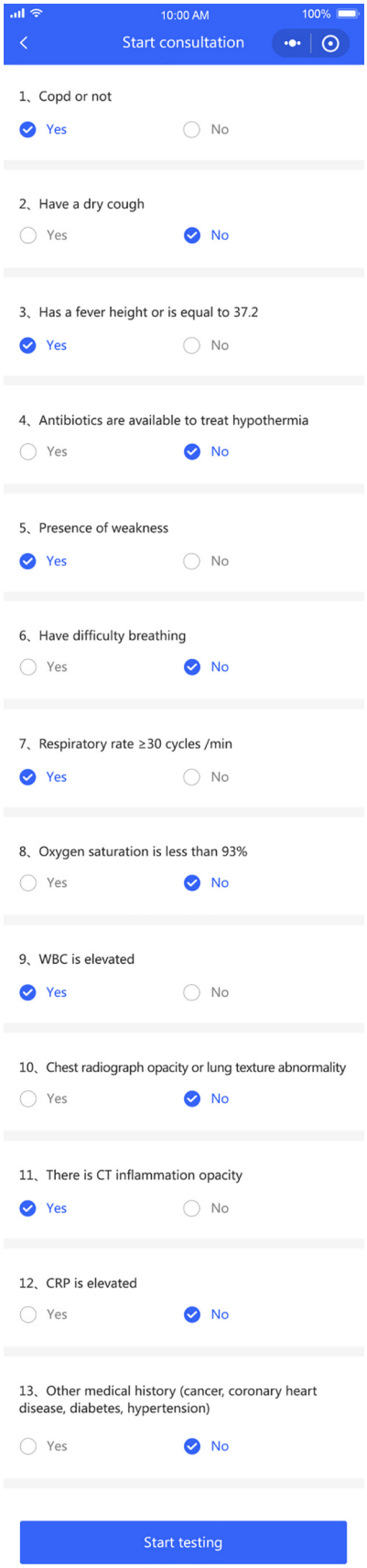

Fig. 4. Questionnaire page in nCapp smartphone software.

(5) Talent experts. Relevant information of local relevant experts and first-line experts and clinicians is provided.

(6) Self-control. Relevant information about self-control is provided.

(7) Map positioning. Information about COVID-19 cases around the user's area is provided.

(8) Related information. Relevant guidelines, diagnosis and treatment specifications, expert lectures, research papers, and links are provided.

Additionally, nCapp can also be used by visualization techniques. The data visualization method of the system, with the cloud plus augmented reality BRM all-in-one (Fig. 5), make doctors and patients communicate in an augmented reality way, thus reduces cross infection.

Physicians use the data transmitted on their smartphones to automatically respond to the prompts generated by nCapp to assist patients in their diagnosis and treatment, ensuring their safety and effectiveness. When the data exceed the normal value range or an emergency occurs, the monitoring system will issue an alarm to remind the physician to take corrective measures quickly.[15–18] This system makes the diagnosis and treatment more convenient and also enhances the efficiency of remedial measures in emergency situations, guarantees the safety and effectiveness of the diagnosis and treatment of COVID-19, and improves the medical service capabilities of hospitals in preventing and controlling COVID-19.

Simultaneously, as the nCapp intelligent assisted COVID-19 diagnosis system collects a large amount of clinical diagnostic data from patients with COVID-19, through data feature engineering and statistical methods, the data can be further clustered and analyzed to achieve a more intelligent distinction between suspected and suspicious cases in patients with a negative nucleic acid test result.

Fig. 5. BRM all-in-one machine.

2.2. Advantages of nCapp intelligent assisted diagnosis and treatment of COVID-19

Compared with the traditional medical model, the application of nCapp assisted management of COVID-19 can better meet the requirements of P4 medicine (predictive, preventative, personalized, and participatory). nCapp can conduct the online monitoring, location tracking, alarm linkage, command and dispatch functions, in favor of online and full-time monitoring of changes in symptoms and diseases severity and guiding treatment. Plan maintenance, remote maintenance, management command, and statistical decision-making functions can expand the deep mining and management of big data, subsequently achieve management and timely intervention on acute infectious diseases and improve the effect of detecting and managing COVID-19.

3. The process of cloud plus terminal Internet of Things nCapp assisting the diagnosis and treatment of COVID-19

3.1. nCapp assists patient registration

According to consensus, patients must register the necessary information when making an appointment or in the outpatient department,[14] including the following: (1) history of residence or visits in the epidemic area, (2) history of contact with people in the epidemic area, (3) history of contacting patient with cough in last 3 weeks, (4) history of contacting COVID-19 patients, and (5) whether the 2019-nCoV nucleic acid test was conducted.

3.2. nCapp assistance to obtain necessary information

It is advisable to provide the information available online before the visit. At the time of appointment registration (recommended) or at the outpatient clinic, the patient or his guardian answers the following in the questionnaire[14]: (1) whether the patient has chronic obstructive pulmonary disease, (2) whether the patient has any other medical history (e.g., coronary heart disease, hypertension, diabetes, tumor), (3) whether the patient has a high fever or whether his/her body temperature is $\geq$ 37.2 °C, (4) whether the patient has a dry cough, (5) whether the patient's body temperature does not decrease with antibiotics, (6) whether the patient manifests weakness, and (7) whether the patient has dyspnea.

Additionally, to establish a differential diagnosis, the following test results must be obtained: (1) respiratory frequency $\geq$30 times/min, (2) blood oxygen saturation $\leq$93%, (3) oxygenation index $\leq$300 mmHg, (4) normal or decreased white blood cell count in the early stage of the disease, (5) decreased lymphocyte count (in this consensus, registration of specific data is recommended, and the cloud will automatically generate results indicating a decreased or increased lymphocyte count), (6) presence of lymphopenia (registration of specific data in this consensus is recommended, and the cloud will automatically generate results indicating a decreased or increased lymphocyte count), (7) presence of pulmonary opacity or thickened lung texture based on chest radiographs (CT equipment is not available), (8) presence of inflammatory opacity on CT, and (9) increased C-reactive protein (CRP) level.

3.3. Intelligent diagnosis by nCapp

3.3.1. Intelligent assisted diagnosis

According to the registration information and 15 questions, nCapp generates the following automatic prompts at the doctor's terminal[14]:

3.3.1.1. Confirmed diagnosis. According to the "Novel Coronavirus Pneumonia Diagnosis and Treatment Program (Interim Version 6)," a patient with the positive nucleic acid testing of 2019 nCoV is considered the confirmed case. When meeting the diagnostic criteria, nCapp automatically generates a prompt "confirmed diagnosis," and the patient needs to be reported and transferred to the designated hospital.

3.3.1.2. Suspected diagnosis. A patient with any one in A or any three in B is considered the suspected case: A1 (history of residence or visit in the epidemic area), A2 (history of contact with the people in the epidemic area, A3 (contact with the confirmed cases of novel coronavirus infection), B1 (high fever or temperature $\geq$ 37.2℃), B2 (normal or decreased white blood cell count in the early stage of the disease), B3 (presence of lymphopenia), and B4 (Characteristic CT manifestations such as conspicuous ground-glass opacity lesions in the peripheral and posterior lungs on CT images). When meeting the criteria of suspected diagnosis in the "Novel Coronavirus Pneumonia Diagnosis and Treatment Program (Interim Version 6)," nCapp automatically generates a prompt "suspected diagnosis".[12] The patient needs to be isolated and observed, and a doctor should collect specimens for the detection of new coronavirus nucleic acid to establish a clear diagnosis as soon as possible.

3.3.1.3. Suspicious diagnosis. For a patient with suspicious diagnosis of 2019-nCOV infection, the epidemiological history is unclear. However, a patient who has been exposed to patients with cough in the past 3 weeks and who also manifests any of following is also suspicious of 2019-nCOV infection: fever with dry cough, fatigue, fever persists after antibiotic treatment, characteristic CT manifestations such as conspicuous ground-glass opacity lesions in the peripheral and posterior lungs on CT images and increased CRP level. According to the expert consensus of Shanghai Quality Control Center[11] or the requirements of local hospitals, nCapp automatically generates a prompt "suspicious diagnosis," and the patient needs to be isolated and observed for 14 days.

3.3.2. Intelligent assisted severity stratification

According to the registration information and 15 questions, if nCapp automatically generate a prompt "confirmed diagnosis," and the patient needs to be transferred to the designated hospital. Subsequently, the physician establishes a severity of "mild, moderate, severe, and critical pneumonia" based on symptoms and oxygenation index.

3.3.2.1. Mild. For mild, the clinical symptoms are slight, and there is no sign of pneumonia on CT images.

3.3.2.2. Moderate. For moderate, patients with pneumonia on CT images do not meet the criteria of severe and critical cases. This will be reported automatically to the QC cloud after the diagnosis.

3.3.2.3. Severe. For severe, patients with pneumonia on CT images meet one of the following criteria: respiratory rate $\geq$30 times/min, resting oxygen saturation $\leq$93%, and oxygenation index $\leq$300 mmHg. After the establishment of the diagnosis, the case will be automatically reported and transmitted to the QC Cloud.

3.3.2.4. Critical. For critical, patients with pneumonia on CT images meet one of the following criteria: respiratory failure requiring mechanical ventilation, shock, other organ failures requiring intensive care unit treatment, and oxygenation index $\leq$100 mmHg (proposed by the authors of this consensus). After confirming the diagnosis, it will be automatically reported and transmitted to the QC Cloud.

3.4. Intelligent assisted treatment using nCapp

3.4.1. Intelligent assisted treatment for patients with mild and moderate pneumonia[14]

nCapp automatically generates treatment recommendations in accordance with the guidelines of the "Novel Coronavirus Pneumonia Diagnosis and Treatment Program (Interim Version 6)".[12] In case of treatment difficulties, doctors can request the assistance of a cloud link to interact with experts or front-line experienced physicians online.

The patient should rest on bed, be monitored for vital signs (heart rate, pulse oxygen saturation, respiratory rate, and blood pressure), and provided with nutrition support to ensure sufficient energy intake. Moreover, the amount of water consumed by the patient, his/her electrolyte and acid–base levels, and other internal environmental factors should be comprehensively monitored.

Furthermore, the patient should undergo blood cell count, urine test, CRP, organ function (liver enzyme, myocardial enzyme, and renal function), and coagulation function tests, arterial blood gas analysis, and chest imaging. If possible, the patient's blood cytokine level should be determined.

The patient should be provided with effective oxygen therapy, including nasal catheter therapy, mask oxygen therapy, and high-flow nasal oxygen therapy (HFNO).

3.4.1.1. Antiviral treatment. At present, there are no effective antiviral drugs against 2019 nCoV. The α-interferon atomization inhalation can be considered (5 million U per time for adults in 2-ml sterile injection water, twice a day). Lopinavir/ritonavir (200 mg/50 mg per capsule) orally, 2 capsules each time, twice a day, can also be considered. Ribavirin (500 mg/time, intravenous infusion 2 to 3 times a day, no more than 10 days) in combination with interferon or lopinavir/ritonavir is recommended. Chloroquine phosphate (500 mg for adults, twice a day, no more than 10 days) and abidor (200 mg for adults, three times a day, no more than 10 days) can be also considered. We should pay attention to the adverse reactions of lopinavir/ritonavir, such as diarrhea, nausea, vomiting, and liver dysfunction, and the interaction with other drugs. Using three or more antiviral drugs simultaneously is not recommended. In case of intolerable side effects, the relevant drugs should be discontinued.

3.4.1.2. Antibacterial treatment. Avoid inappropriate use of antibacterial drugs, specifically the combination of broad-spectrum antibacterial drugs.

Traditional Chinese medicine treatment. Traditional Chinese medicine treatment is recommended according to the "Novel Coronavirus Pneumonia Diagnosis and Treatment Program (Interim Version 6)".[12]

3.5. Intelligent assisted treatment for patients with severe pneumonia

nCapp automatically generates a prompt treatment recommendations in accordance with the 'Novel Coronavirus Pneumonia Diagnosis and Treatment Program (Interim Version 6)'.[12] In case of treatment difficulties, doctors can request for the assistance of doctors can request for the assistance of a cloud link to interact with online experts or front-line experienced physicians on line.[14]

3.5.1. Principles of treatment

Treat the patients to ease the symptoms and treat underlying diseases, actively prevent emergence of potential complications including secondary infection, and provide organ function support in a timely manner.

3.5.2. Respiratory support

Oxygen therapy. Severe patients should be provided with effective oxygen therapy, including nasal catheter and mask oxygen therapies. Physicians should timely assess whether respiratory distress and/or hypoxemia is relieved.

HFNO or noninvasive ventilation (NIV). When respiratory distress and/or hypoxemia cannot be relieved after standard oxygen therapy, HFNO or noninvasive ventilation (NIV) can be considered. If respiratory distress still exists or even worsens dramatically within a short time (1–2 h), endotracheal intubation and invasive mechanical ventilation should be implemented as soon as possible.

Invasive mechanical ventilation. Lung protective ventilation should be implemented to reduce ventilator-associated lung injury by decreasing the tidal volume (4–8 ml/kg) and plateau pressure (<30 cmH_2O). Sedation and muscle relaxation strategies should be administrated while patient-ventilator asynchrony occur,

3.5.3. Circulatory support

For an adequate fluid resuscitation, vasoactive drugs that improve microcirculation should be administered and hemodynamic status should be monitored if necessary.

Glucocorticoids can be administered in a short period (3–5 days) for patients with rapid reduction of oxygenation index, rapid progression of the disease based on CT images and activation of inflammatory response. The recommended dose of glucocorticoid is equivalent to 1–2 mg/kg methylprednisolone per day. Because of the immunosuppressive effect of glucocorticoids, virus clearance will be delayed. Xue Bi Jing 100 ml/time can be administered intravenously, twice a day. Intestinal microecological regulators can be used to maintain intestinal microecological balance and prevent secondary bacterial infections. For patients with critical pneumonia with high inflammatory reactions, extracorporeal blood purification technology, such as plasma exchange, adsorption, perfusion, and blood/plasma filtration, can be considered.

Patients frequently experience anxiety and fear; thus, psychological counseling should be adopted.

Traditional Chinese medicine treatment. Traditional Chinese medicine treatment is recommended according to the "Novel Coronavirus Pneumonia Diagnosis and Treatment Program (Interim Version 6)".[12]

3.6. Intelligently assisted treatment for patients with critical pneumonia

nCapp automatically generates a prompt treatment recommedations in accordance with the 'Novel Coronavirus Pneumonia Diagnosis and Treatment Program (Interim Version 6)'.[12] In case of treatment difficulties, doctors can request for the assistance of a cloud expert link to interact with experts or front-line experienced physicians online.

3.6.1. Principles of treatment

Treat the patients to improve the symptoms and underlying diseases, actively prevent emergence of potential complications including secondary infection, and provide organ function support in a timely manner.

3.6.2. Respiratory support

HFNO or NIV: When respiratory distress and/or hypoxemia cannot be relieved after standard oxygen therapy, HFNO or NIV can be considered. If respiratory distress still exists or even worsens dramatically within a short time (1–2 h), endotracheal intubation and invasive mechanical ventilation should be implemented as soon as possible.

Invasive mechanical ventilation. Lung protective ventilation should be implemented to reduce ventilator-associated lung injury

by decreasing the tidal volume (4–8 ml/kg) and plateau pressure (<30 cmH_2O). Sedation and muscle relaxation strategies should be administrated while patient-ventilator asynchrony occur.

Salvage treatment: For patients with severe acute respiratory distress syndrome, lung expansion is recommended. If possible, prone ventilation should be performed for more than 12 h per day. In patients with poor prone ventilation, extracorporeal membrane oxygenation should be considered as soon as possible.

Circulatory support: For an adequate fluid resuscitation, vasoactive drugs that improve microcirculation should be administered and hemodynamic status should be monitored if necessary.

Glucocorticoids can be administered in a short period (3–5 days) for patients rapid reduction of oxygenation index and rapid progression of the disease based on CT images, and activation of inflammatory response. The recommended dose of glucocorticoid is equivalent to 1–2 mg/kg methylprednisolone per day. Because of the immunosuppressive effect of glucocorticoids, coronavirus clearance will be delayed. Xue Bi Jing 100 ml/time can be administered intravenously, twice a day. Intestinal microecological regulators can be used to maintain intestinal microecological balance and prevent secondary bacterial infections. For patients with critical pneumonia with high inflammatory reactions, extracorporeal blood purification technology, such as plasma exchange, adsorption, perfusion, and blood/plasma filtration, can be considered.

Patients frequently experience anxiety and fear; hence, psychological counseling should be adopted.

Traditional Chinese medicine treatment: Traditional Chinese medicine treatment is recommended according to the "Novel Coronavirus Pneumonia Diagnosis and Treatment Program (Interim Version 6)".[12]

3.7. nCapp intelligent assisted treatment and management for patients suspected of COVID-19

nCapp automatically generates prompt diagnosis according to the national guidelines, and patients who meet the criteria are suggested to be reported or transferred to the designated hospitals. To avoid missed diagnosis, these suspected patients should be isolated and monitored until a confirmed or excluded diagnosis is established in the designated hospitals. The patients' body temperature should be normal for more than 3 days, and the respiratory symptoms should improve significantly. During the treatment, superior doctors and high level hospitals are well informed about the patients' status by using nCapp. Doctors can continue the original treatment which focuses on relieving symptoms from fever and cough. In case of treatment difficulties, doctors can request for the assistance of a cloud expert link to interact with experts or front-line experienced physicians online.[14]

3.8. nCapp intelligent assisted treatment and management for suspicious patients

The "Novel Coronavirus Pneumonia Diagnosis and Treatment Program (Interim Version 6)[12]" has not yet defined suspicious patients and has not explained how to manage suspicious patients. However, if these patients are misdiagnosed, it will lead to serious consequences. Hence, suspicious patients can be defined as those whose epidemiological history is unclear and whose clinical manifestations and CT images are similar to COVID-19, but do not meet the suspected criteria.[21] In case of treatment difficulties, doctors can request the assistance of a cloud expert linkage to interact with experts or front-line experienced physicians online. To avoid misdiagnosis, suspected patients should be isolated and monitored for 14 days. The patients' body temperature should be normal for more than 3 days, and the respiratory symptoms should significantly improve.

3.9. nCapp intelligent assisted self-prevention and management

Clinicians should be trained about how to prevent and treat respiratory infectious diseases. Due to the lack of protective equipment and awareness at the beginning of the epidemic, doctors were accidentally infected in Wuhan at the outset of the epidemic. Medical institutions should standardize the process of disinfection, isolation, and protection, reserve qualified and sufficient protective materials, such as disinfection products, medical surgical masks, medical protective masks, isolation gowns, and eye masks, to ensure the personal protection of medical personnel. Based on the strict implementation of standard prevention, medical institutions should strengthen measures to prevent and control viral transmission through contact, infected droplets, and airborne transmission. Wearing of masks and hand hygiene are key measures for infection prevention and control.[21]

4. Applying nCapp intelligent assisted management in the diagnosis and treatment of COVID-19

The main purpose of nCapp is to improve the diagnosis and treatment, management, and command with different levels to a national standard, quickly identify and isolate infectious sources and cut off the transmission, and win the fight against COVID-19 as soon as possible. To achieve these goals, the close cooperation of intelligent assisted diagnosis and treatment and on interaction with experts or front-line experienced physicians online is provided by nCapp.[14]

To achieve the accurate diagnosis and management, the following scientific and accurate nCapp technologies are required:

(1) Accurate intelligent assisted diagnosis including confirming of the diagnosis. With the registered data and answer results, nCapp can automatically generate a prompt "confirmed, suspected, or suspicious." Regarding typing, with the registered data and answer replies, nCapp can determine the severity of the patient, including mild, moderate, severe, or critical. The first online update of the nCapp patients database with COVID-19 in China, through automatic data upload, update, and intelligent maintenance, was established. It can update and optimize the intelligent diagnosis model in real-time, and improve diagnostic accuracy.
(2) Precise and intelligent treatment. According to the severity of disease, treatment and long-term follow-up recommendations are provided. To achieve this, users are required to perform QC on the three-linkage cloud platform. This requires not only the understanding of IoT medical equipment but also the cooperation among primary care physicians, experts, and patients in the process. In addition to general training, QC (homogenization) is required in clinical practice. It needs to monitor and supervise the authenticity and reliability of the data uploaded to the cloud.

The nCapp currently used has been a scientific and accurate technology. However, it also requires close cooperation between users and managers to ensure the authenticity and reliability of the uploaded data, and continuous training and correction should be performed not only for the clinical diagnosis and treatment but also for professional QC center and even the intelligent system of command and management. nCapp can improve the management of suspected and suspicious patients, early control of COVID-19, and even can be applied to prevent and control emerging infectious diseases that may occur in the future.

5. nCapp intelligent auxiliary services

(1) nCapp assists in identifying experts

nCapp assists in identifying volunteer experts for expert consultation (assist in checking the outpatient time of interested doctors in each hospital), online consultation (expert consultation of volunteers, only limited to the questions of the doctors instructed), and lecture training, including training guide consensus, diagnosis and treatment technology, QC consensus, science education, and expert forum.[14]

(2) nCapp auxiliary map positioning.

For details, please scan Fig. 2.[14]

(3) nCapp provides relevant information.

For details, please scan Fig. 2.[14]

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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