Opinion Paper

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Laboratory diagnostics within a modular hospital at the time of Coronavirus disease 2019 (COVID-19) in Wuhan

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Abstract: An outbreak of the so-called Coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2), has been spreading rapidly nationwide in China since December 2019. Wuhan, Hubei Province, is the hardest-hit region, with a rise in confirmed cases and its hospitals overwhelmed. On 2nd February, 2020, Wuhan began to build a modular hospital to treat patients caught with mild illness. The mobile modular hospital is mainly composed of medical modules, technical support modules, ward units, living support units and transportation capacity under field conditions, and there are complete equipment and specialized personnel to treat patients. Due to the severity and particularity of SARS-CoV-2, taking granted from lessons learnt from mobile modular hospitals, we use the existing large venues to construct a new fixed modular hospital. As patients need to be treated and tested, it is important to develop a clinical laboratory in the modular hospital and ensure biosafety. The construction of a clinical laboratory in the modular hospital is faced with problems such as time pressure, limited site selection, high level of biosafety, lack of experience and so forth. This paper mainly discusses how to construct the clinical laboratory in the modular hospital quickly and safely and put it into use to provide testing service for patients under various limited conditions.

Keywords: biological safety; COVID-19; handheld system; modular hospital.

Introduction

Since December 2019, a new illness called Coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2), has originated and spread from Wuhan. On 11th February, 2020, the World Health Organization (WHO) officially defined the syndrome causes by SARS-CoV-2 as COVID-19 1, 2. After rapid diffusion within the country, the disease is also rapidly spreading overseas 3, thus posing a serious threat to public health security throughout the world. Wuhan is the worst-hit area, and the number of confirmed cases continues to rise. By March 1, 2020, a total of 66,337 cases had been confirmed in the Province of Hubei, with 18,816 beds in the city’s designated hospitals. Unfortunately, however, the number of diseased patients has led to saturation of the available beds in Wuhan, so the construction of a modular hospital has been started in the town 4. Overall, 14 modular hospitals with more than 10,000 beds have been built in Wuhan so far.

Clinical laboratory in modular hospitals

Constructing a clinical laboratory always requires fulfilling a number of specific issues 5, 6, and building one in a modular hospital makes no exception to this rule.
According to this latter aspect, a clinical laboratory constructed within a modular hospital will need to include a series of basic tests for management of patients, encompassing complete blood cell count (CBC), liver and kidney function tests, and molecular biology tests for virus detection and quantification, and also needs to face relevant challenges such as guaranteeing high biosafety level and counteracting the shortage of essential equipment.

Choosing the place

The identification of the most appropriate place for constructing the laboratory is one of the foremost issues for pacing problems such as high biosafety risk and shortage of essential equipment. According to the Report of Printing and Distributing Biosafety Guidelines (second) of Clinical Laboratory for NCP [7], only professional clinical laboratories are allowed to perform molecular biology tests for detecting SARS-CoV-2 [8]. Therefore, based on our previous experience, laboratory diagnostics can be carried out following two separate strategies in a modular hospital, namely, delivery of samples to existing clinical laboratories or establishment of new laboratory services within the modular hospital.

Most diagnostic tests can be performed in existing facilities when clinical laboratories are already inside or nearby the hospital. If the current biosafety conditions are sufficient, laboratory physicians would only need to adapt personal protection of level 3 (level 3 protection standard: wearing work clothes, disposable hat, medical protective mask [N95 and above], goggles or protective mask, a medical protective suit, disposable gloves and disposable shoe covers, and most importantly, wearing a mask, or switching from a surgical mask, goggles or mask to a full-on respirator or respirator with an electric ventilator.). On the other hand, when the clinical laboratory is far from the modular hospital, preanalytical sample management, especially the transportation procedure, will become critical, whereby inappropriate transport conditions may expose the samples to the significant risk of being damaged or undergoing deterioration [9]. Another important issue is the diagnostic delay resulting from shipping specimens at distant sites, which is actually incompatible with the urgency required for the rapid identification, clinical management, isolation and contention of affected cases. This will lead us to conclude that specimens shall not undergo long transportation from the modular hospital to the testing facility. In close cooperation with colleagues from China-Japan Friendship Hospital, Shanghai East Hospital, Jiangsu Province Hospital and six other hospitals, our laboratory physicians were able to expand the examination area of the clinical laboratory of Wuhan Jinyintan hospital to the entire modular hospitals belonging to Dongxihu District of Wuhan.

Establishing on-field modular clinical laboratory

According to the preamble of the previous paragraph, establishment of an on-field modular clinical laboratory shall be seen as the more favorable strategy, despite the fact that this also brings about some additional issues. According to the third edition of the new diagnosis and treatment program for coronary pneumonia issued by the National Health Commission, the same patient should be tested negative for nucleic acid in two consecutive respiratory tract samples (at least 1 day apart) to meet the discharge criteria [10]. Until now, there are 14 modular hospitals in Wuhan, while only three of them are equipped with P3 mobile laboratories for SARS-CoV-2 nucleic acid assessment. Due to the high technical requirements and high price of mobile P3 laboratory construction, only a few countries can manufacture. At present, there are only three modular hospitals in Wuhan, with the remaining 14 square cabin hospitals being not equipped. However, the 17 modular hospitals that have been constructed and the impressive volume of samples make it impossible for many modular hospitals to be equipped with a mobile P3 laboratory. Therefore, it is necessary to adapt to the local environment by selecting an appropriate location and establishing a temporary laboratory section of molecular biology. According to our experience, molecular biology laboratory shall be partitioned in separate sections. Specifically, we suggest that it should be built into two tents where different activities can be performed. The first tent may contain all those biohazardous activities connected to specimen preparation, incubation and nucleic acid extraction, whereas amplification should be carried out in a second between two tents, with a simple buffer zone to prevent infection.

The location of the laboratory must also consider outdoor wind direction and laboratory airflow to avoid locating the facility close to access pathways of medical staff and patients.

Other related clinical laboratories

During the treatment, we find that some patients in the modular hospital have caught underlying diseases such
as diabetes and CHD. Faced with such problems, doctors should know whether the indicators related to underlying diseases have changed during the treatment, so that they can provide more effective treatments for the patients. It is worth noting that some drugs developed to treat COVID-19 patients have been found to have liver toxicity [11]. Therefore, it is urgent to conduct liver and kidney function tests in order to early identify potentially toxic side effects. Considering these services, we set the clinical laboratory up in a temporary tent, including the buffer zone and corresponding equipment. As the diagnostics of SARS-CoV-2 also involves serological testing, the facility shall be equipped with a biosafety cabinet, UV lamps and other equipment which increase the level of biosafety, thus ensuring that all samples can be pre-processed in the biosafety cabinet and preventing the risk of biological exposure.

Transporting samples from the clinical laboratory of the modular hospital

SARS-CoV-2 is mainly transmitted from person-to-person by respiratory droplets that people sneeze, cough, exhale or contact. So the external transportation of specimens should fulfill some basic requirements [12]. If the safety protection of the transporter meet the level 2 biosafety protection and meet the requirements of CDC, the driver must not be transferred alone. It should arrive at the laboratory immediately after collection, not exceeding 2 h, etc. If handled improperly, occupational exposure will become almost likely. In our current organization, those who carry and/or transport specimens should be subjected to three levels of protection. Once the specimen has been collected, it shall be immediately sealed within sealed bags and transferred into a double-layer transfer box. The personnel transporting the samples shall undergo secondary protection, whereby they would need to be sprayed with disinfectant upon receipt of the sample. The specimens should only be opened within the biosafety cabinet upon arrival at the inspection department. Once the specimens have been extracted from the box, the box itself must be decontaminated by immediately spraying disinfectant inside and then transported to another site where external disinfection will be carried out. Sample pre-treatment before analysis shall be carried out in the biosafety cabinet, and the personnel needs to wear a biosafety secondary protection device. The requirements for medical personnel include wearing work clothes, disposable caps, medical protective masks (N95 and above), goggles or protective masks, a medical protective clothing, disposable gloves and disposable shoe covers.

Constructing an information system in the clinical laboratory in the modular hospital

In order to minimize occupational exposure, contact transmission should be avoided or substantially reduced. When producing the inspection report, paper printing has been minimized, whereby the handheld system provided by the Sichuan emergency rescue team to the modular hospital has been adopted. This system has allowed to reduce the risk of contagion from paper-based test orders and radiological examination reports.

<p>| Table 1: The most important interventions of the laboratory within a modular hospital. |</p>
<table>
<thead>
<tr>
<th>On-field modular clinical laboratory (nucleic acid detection)</th>
<th>Other related clinical laboratories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biosafety cabinet</td>
<td>Requisite</td>
</tr>
<tr>
<td>Laboratory ventilation requirements</td>
<td>The airflow is organized to form a directional airflow, which flows from the clean area to the polluted area</td>
</tr>
<tr>
<td>Laboratory zoning requirements</td>
<td>Nucleic acid extraction and sample amplification must be established</td>
</tr>
<tr>
<td>Laboratory buffer requirement</td>
<td>Requisite</td>
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<tr>
<td>Ultraviolet lamp</td>
<td>Requisite</td>
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<tr>
<td>Air sterilizer</td>
<td>Requisite</td>
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<tr>
<td>Electric incubator</td>
<td>Requisite</td>
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<tr>
<td>Centrifugal machine</td>
<td>Unnecessary</td>
</tr>
</tbody>
</table>
Conclusions

A modular hospital is an unprecedented measure, which is not only a key measure in the critical period of our country, but also a major innovation of our country’s public health security and medicine [13]. We must ensure that the most important measures are taken in the construction of the cabin laboratory (Table 1). Constructing a clinical laboratory in a modular hospital will face many problems, but we will adapt to local conditions and then provide better service for the public. Until now, we have our own duties to protect ourselves and fight against the virus, and as clinical doctors, we will exert all-out efforts in the treatment of patients.

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References