Brief Communication

Environmental maintenance with effective and useful zoning to protect patients and medical staff from COVID-19 infection

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Aim: The coronavirus disease 2019 (COVID-19) pandemic has accelerated all over the world, and global health-care systems have become overwhelmed with potentially infectious patients seeking testing and care. It is essential to set up effective and useful zoning to prevent the spread of infection to and from medical staff or other patients with effective use of standard precautions with personal protective equipment (PPE).

Methods: We repurposed a general ward into an acute care unit for severe COVID-19 patients taking into consideration airflow, the direction of movement of medical staff, and prevention of the spread of infection to medical staff and other patients. We checked the daily condition and body temperature of all medical staff for 60 days.

Results: There was no evidence of COVID-19 infection in any medical staff or other patients during the period thanks to effective and useful zoning with PPE.

Conclusion: Special wards and rooms should be set up for future protection of medical staff and other patients, and prevent the explosion of COVID-19 infection with effective and useful zoning with PPE.

Key words: COVID-19, environmental maintenance, standard precaution, zoning

INTRODUCTION

The novel coronavirus (severe acute respiratory syndrome coronavirus-2; SARS-CoV-2) disease named COVID-19 by WHO on 11 February 2020) is currently causing concern in the medical community as the virus is spreading around the world.1 It is clear that our understanding of the clinical and radiological features of COVID-19 is almost complete with many published reports, and as it continues to spread rapidly, there is an urgent need to consolidate the emerging knowledge on its clinical profile. According to “Coronavirus COVID-19 Global Cases by the Center for Systems Science and Engineering at Johns Hopkins University”, as of 28 March 2020, the overall rate of deaths per number of diagnosed cases was 4.6%, ranging from 0.2% to 15% according to age group and other health problems. As of 1 April 2020, more than 882,000 cases of COVID-19 have been reported in 200 countries and territories, resulting in approximately 43,000 deaths.

Severe acute respiratory syndrome-CoV-2 is a positivesense single-stranded RNA virus with astounding abilities to spread and easily infect others, so we must consider the safety standard precautions and safety zones to prevent an explosion of infection to medical staff and other patients when we care for COVID-19 patients in the clinic. It is considered difficult to provide all staff members with various information related to individual infections in advance, while giving due consideration to patient privacy.

We report here the methodology of zoning with our concept for setting up a special ward and spaces for COVID-19...
patients to protect patients and medical staff from COVID-19 infection.

METHODS AND DISCUSSION

WHEN WE STARTED to receive COVID-19 patients in our hospital, we had just one bed for severe infectious disease with a negative pressure room in our acute care unit (ACU). We always used the ACU for patients from outpatient or the emergency room directly as an intensive care unit with six beds (five beds in open space and one bed on isolated space with negative pressure) (Fig. 1A). All beds in ACU are set up to undertake hemodialysis, full monitoring, and small operations like tracheostomy, except for extracorporeal membrane oxygenation. Bed 1 is used as a negative pressure room for uncertain infectious diseases, and other beds are used for other diseases. It was essential to set up a special ward for COVID-19 patients due to increase in the number of patients.

We established a special ward based on the Guidelines for Prevention of Isolation in One Hospital published by the US Centers for Disease Control and Prevention in 1996.2 It is one of the most common guidelines for infection control in hospital and its content is based on the concept of standard precautions and transmission-based precautions, which are the basics of infection control. Currently, the updated guideline in 2007 is frequently used for preventing transmission of infectious agents in health-care settings.3 Therefore, it is no exaggeration to say that it is no longer the stage of discussing the effectiveness of precautionary measures, but how thoroughly they can be implemented in a clinical setting to ensure their effectiveness. These guidelines have been recommended as substantive standards for improving the hospital environment for infection prevention.

First, we considered airflow in the ACU to prevent the expansion of SARS-CoV-2 by droplet infection, so we checked the upstream and downstream of the airflow in ACU. The air stream enters from the ICU side and exits in the direction of bed 6 (Fig. 1B, white arrow). The area of beds 5 and 6 was not a good space when we considered airflow, so we removed the beds and made a space for COVID-19 equipment, for example, personal protective equipment (PPE), sanitizer, and ventilators. We set up the special ward with a total of four beds (three beds on the open floor and 1 isolated bed with negative pressure).

Next, we focused on zoning to establish the most dangerous areas and where a safe zone could be established for medical staff to prevent transmission of COVID-19. The concept of “zoning” is that COVID-19 is always classified according to the route of infection, signs using color codes that have been established in advance are posted on medical sites, and each staff is required without special notice. The purpose is to build a situation where various infection countermeasures can be immediately recognized. Therefore, the point of view differs from the conventional concept of treating a specific ward or facility as a zone based on air cleanliness and air stream. In addition, we applied the concept of zoning for areas to educate medical staff as a series of zoning systems to prevent from COVID-19. In dangerous infection areas, we established four zones, red, yellow, green, and blue with tape. The red zone indicates the most infectious area around the personal area of the COVID-19 patient, in which medical staff undertake all procedures and take care of the COVID-19 patient personally. The yellow zone is the second most infectious area, which is a common passage outside of the personal area. We use the space as a route for staff and some equipment and release all PPE to prevent the expansion of the virus. After releasing all PPE, we move to the green zone, where we must wash own hands and sanitize with alcohol. Finally, we move to blue zone with just a surgical mask and normal status.

We then focused on just one direction of movement to prevent infection in patients without a definitive diagnosis because almost all viral infections are due to human-to-human transmission, which can lead to serious infections (blue arrow). We set up clockwise one-way root with one entrance and one exit to enter each zone, which cannot be reversed. By setting up the direction, we can take care of COVID-19 patients or patients without a diagnosis even if patients are mixed in the same floor. If we receive a patient without a diagnosis of COVID-19, we transfer the patient to an upstream bed or the isolation room and move COVID-19 patients to downstream beds. Then, if the test is positive, we move the patient to a bed further downstream and continue treatment in the same ward; conversely, if the test is negative, we remove the patient from the special ward and another team continues treatment for the patient in a general ward. By following this protocol, we protect others from COVID-19 transmission. However, according to the announcement of Japanese guidelines for infection control in hospitals for COVID-19,4 it is recommended that care of COVID-19 patients should be undertaken in a private room, and cohorting is not recommended for patients suspected of COVID-19 infection. However, as a regional core hospital, we had to accept a large number of COVID-19 patients immediately after the outbreak of COVID-19, and we originally did not have a specialized ward for infectious diseases. Because it had to be created in an existing ward, a specialized ward for COVID-19 was set up based on the zoning strategy described above. We had difficulty following the
Japanese guidelines under our particular circumstances, and we had to consider more reasonable methods to protect patients and medical staff in the real clinical field. After the epidemic of COVID-19 has subsided, this ward will be rebuilt with a private room under the guidelines to treat COVID-19 patients. In addition, under the environmental conditions, for personal protection of medical staff, we always undertake medical supportive care with PPE, with equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses, in yellow and red zones. The PPE usually consists of standard precautions: face protection, goggles and mask or face shield, gloves, gown or coverall, head cover, and shoe cover. All PPE are disposable, single use and personal use for each patient. No reuse, no mixed use. If we undertake intubation and extubation according to patient’s respiratory condition or replace the ventilator circuit, we wear full PPE with a Tyvek suit because the risk of droplet infection is increased. In this way, we protect ourselves from aerosol or droplet transmission of COVID-19 during all medical care. Under this situation, we have stopped the use of non-invasive positive-pressure ventilation (NIPPV) or bilevel positive airway pressure (BiPAP) for respiratory disorders that may need to be presumptively intubated, to exclude all medical staff from danger (use of NIPPV and BiPAP is contraindicated for patients with COVID-19 because of aerosolization of the virus under positive pressure).

Fig. 1. Zoning system in the acute care unit, considering air stream, direction of staff movement, and prevention of coronavirus disease 2019 (COVID-19) infection. A, Layout during normal operation. B, Revised layout to minimize spread of infection during the COVID-19 pandemic.
However, there are some disadvantages. It takes time to change clothes when responding to unexpected sudden changes and when it is necessary to put on and take off equipment in order to return to a patient because of the one-way system. One principle is that exchange is carried out once, so if this situation is prolonged, it is important to be able to provide medical care of the same quality in limited medical resources. However, as a countermeasure against this disadvantage, a system of one patient to one nursing staff member was adopted, the time of care was extended as much as possible, and the amount of work per session was increased. It is necessary to have at least one medical staff member who can move freely and prepare for emergencies and, if the patient is on ventilator management, perform a slightly deeper sedation management than usual, and if the patient needs more intensive treatment than extubation. In such cases, we ensure that at least two doctors and nursing staff were dedicated to the patient.

Therefore, since the beginning of the treatment of COVID-19 patients, we have educated all medical staff about the abovementioned infection control measures and zoning against COVID-19. To date, we have managed and taken care of 30 patients (12 severe COVID-19 patients, 8 moderate COVID-19 patients, and 10 suspected COVID-19 patients who were ultimately negative for COVID-19). All 40 members of staff were required to measure their own body temperature and physical condition, especially respiratory symptoms, every morning with a check sheet, including the medical doctors, nurses, rehabilitation staff, medical engineers, radiation engineers, and co-medical staff involved in treating patients. As a result, after 60 days of physical monitoring in the COVID-19 ward, there was no evidence of COVID-19 in medical staff or other patients; COVID-19 patients were always cared for during this period.

In terms of limitations, we were obliged to measure the body temperature and manage physical condition reports in our medical staff before they started work. However, as screening tests using polymerase chain reaction or other tests for COVID-19 were not carried out, we cannot judge comprehensively whether SARS-CoV-2 was negative or not. As a result, we have no evidence of subclinical COVID-19 in our medical staff, and it is inadequate to judge whether perfect protection has been achieved. In addition, this zoning method can probably only be used in the early phase of the COVID-19 pandemic. As the number of COVID-19 patients increases, an increase in PPE supply in response to this situation will require a large increase in PPE manufacturing, a process that will take time many health-care systems do not have. When such a situation arises, we should consider recycling PPE equipment with sterilization of used PPE with agents ranging from ethylene oxide, UV or gamma irradiation, ozone, and alcohol.

As Japan braces for a growing wave of patients with COVID-19 in our hospitals and ACUs, we must ensure that we have the key equipment needed to care for patients and to keep our health-care workforce safe. Failure to act in a coordinated manner would keep many patients from getting the care they need and would lead to the situation we see in other countries, in which frontline clinicians are making difficult decisions about who will and will not receive care. Furthermore, without adequate PPE, health-care workers will get sick, endangering the functioning of the entire health-care system.

CONCLUSION

DURING THIS COVID-19 pandemic, we should set up special wards and rooms with specialized equipment to protect health-care staff and other patients, and prevent the explosion of COVID-19 infection with effective and useful zoning with PPE.

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DISCLOSURE

Approval if the Research Protocol: Ethics approval for the study was given by the local ethics committee at Yokohama City University Hospital. Registry and the Registration no. of the Study/trial: N/A. Animal Studies: N/A. Conflict of Interest: None. Availability of Data and Materials: Please contact authors for data requests.

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