

# **Recommendation of Hyperbaric Oxygen Therapy in the Treatment of Severe Patients with COVID-19 Pneumonia**

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**H**yperbaric oxygen therapy (HBOT) is the most powerful non-invasive oxygen therapy. Hypoxia is the important indicators of severity classification and the difficulty in the treatment of patients with novel coronavirus infectious diseases-2019 (COVID-19) pneumonia. As the massive practice of HBOT in treating refractory hypoxia of various diseases, it has initiated routinely as the other oxygen therapies such as mechanical ventilation to treat severe patients with COVID-19 pneumonia in February 11 in China. Although a small number of patients receipted HBOT, their consistent amazing clinical response confirmed the effectiveness is reliable and conformant to expectation according to the oxygenation mechanism of HBOT[1,2,3]. It is highly recommended that routine systemic supportive treatment adding HBOT can receive definite clinical benefits. Based on the experience in China, the recommendation of the clinical standard criteria and the infectious disease control process are showed as follows:

## **The recommendation for the regular HBO chamber**

### **Principled Consideration of Infectious Disease Control During HBOT.**

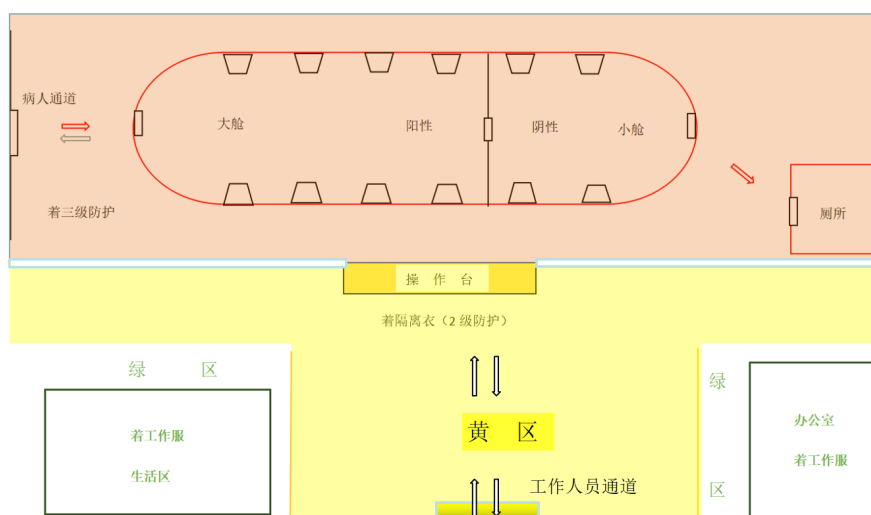
Although the infectious prevention and control measures are highly concerned in the usage of HBOT, it is concluded that there is no insurmountable obstacle for the existing disease control technology after thoroughly analysis. First of all, according to the professional requirements of heating and ventilation technology for indoor space disease control, HBO chamber air system and BIBS are a perfect gas management system. Its structure and functional characteristics include closed gas system, one-way air flow control system, all-fresh-air ventilation system, independent gas pipeline system for medical staff and the patients. The later one is superior to the ventilation system of the infection ward. The chamber is just a ward with higher atmospheric pressure. These characteristics determine that the risk of cross infection is not higher than that in infection ward. We also adopted the measures of independent pressurization of medical staff in the auxiliary chamber with the consideration that the air outside the personal protective equipment (PPE) may enter the body side space of PPE during the pressurization process. The disinfection and PPE requirements in the chamber comply with that in the infectious disease ward, and that outside the chamber comply with that of the infectious disease department. More than 30 HBOTs with zero infection among health care workers verify the reliability and feasibility of our disease control process.

### **Pollution Area and Passageway in the HBO Room**

According to Chinese standards “the requirements of technical code for hospital isolation” (WS/T311-2009) [4] and “the code for prevention and control of nosocomial infection by air-borne diseases” (WS/T511-2016) [5], the whole work area in the HBO room is divided into pollution area (red), semi-pollution area (yellow) and clean area (green), and the separate passageway for medical staff or the patients. the division of pollution area and the requirements of PPE are shown as *Figure 1* in the HBOT Department of Wuhan General Hospital of the Yangtze River shipping. The patients enter and exit through the patient's special passageway in the red area. Chamber operating personnel enter the yellow area with second-class PPE. The layout of each hyperbaric oxygen department is different, please take measures according to local conditions.

### **Disinfection of exhaust gases**

It is recommended to install a formal medical exhaust gas disinfection and purification device. If the absence of such a device, a temporary alternative may prolong the gases outlet with hose into the 84 disinfectant tank filled with disinfectant. And the warning sign of no access is set the area of 10 meter around.



**Figure 1 Sketch Map of pollution area and passageway in HBO department**

### Standard Operation Process

**Chamber preparation:** Open the lock of chamber, the oxygen mask and three-way valve disinfect by wiping with 75% alcohol. The other surface disinfect by spraying with 75% alcohol. Ventilate at least 10 minutes after disinfection.

**Patients preparation:** All the pre-HBOT preparations such as medical documents, consultation records, signature of informed consent and so on were completed in the isolation ward.

**Hyperbaric exposure:** The patients enter the cabin directly through a special channel. After sitting down or position the sickbed, the patients will wear on the mask connected to BIBS immediately, and continuously breath oxygen supply on primary reducing valves without air-break under pressure, which is to reduce the possible pollution to chamber air by exhale gas of patients for reducing the risk of medical staff when necessary under pressure. The chamber is compressing with high pressure air supply at a constant speed not be greater than 1 m/min. Decompression is started after completion of the scheduled bottom time with a rate about 0.5 m/min. Chamber is ventilated with fresh air through the whole course. After lock opened, health care worker in third class PPE assists the patient to remove the oxygen mask and put on common mask, and transport back to the ward through the patient passageway.

**Independent compression of medical staff:** The medical personnel for emergency medical care in the chamber on third-class PPE enter the auxiliary cabin (lockout chamber) from the semi-polluted area, and are compressed to a pressure with little difference, eg. 0.1 ATA, from the treatment chamber, which keep the hatch closed. Then they breath oxygen on the oxygen mask connecting to BIBS. If necessary, they can balance the pressure of the treatment and auxiliary chamber, open the access doors, enter the treatment chamber, give emergency medical care immediately. And then they are decompressed along with the patients, and escort the patients back to the ward. If there is no emergency, they are independently decompressed in the auxiliary cabin.

**Disinfection after treatment:** After treatment, the oxygen mask and its connecting hose are wiped and sterilized regularly and then left in the chamber to continuous disinfection with a Plasma sterilizer for 20 minutes. Then the lock is keep opened for natural ventilation. During the treatment, the routine disinfection in the HBO room should be carried out once a day at least, including wiping the operating platform, door handle, tables and chairs inside and outside the chamber with disinfectant. The ground disinfects with 84 disinfectant, and the indoor environment with ultraviolet.

### Patients selection criteria

According to our experience, HBOT is applicable to all patients with COVID-19, from mild patients to the critical patients with tracheal intubation, except for absolute contraindications of HBOT<sup>[6]</sup>. However, the critical patients with tracheal intubation needs to consider the medical support equipment and the rescue ability in the chamber, so as to guarantee the emergency management

under the pressure. The patients with the relative contraindications<sup>[6,7]</sup> need careful assessment by doctor in charge of treatment.

In general, the normobaric oxygen inhalation can meet the need of mild patients. Presently, there is no sufficient evidence to support HBOT is better than normobaric oxygen therapies in the treatment of mild patients with COVID-19. But it is harmless and supposed to have clinical benefits according to the underlying mechanism. The therapeutic effect of HBOT to those severe or critically ill patients with progressive hypoxemia and hypoxia has been proved to be very significant<sup>[3]</sup>.

### **HBOT Protocol**

The following protocol is not unique. Each doctor can adopt the familiar protocol and adjust the treatment for each specific patient. Our recommendation show as follows:

1. For the patients whose SpO<sub>2</sub> is lower than 70% or has a long history of hypoxemia before compression, higher bottom pressure of HBOT once a day is recommended not be lower than 2.0 ATA, the maximum 2.8 ATA. The bottom time is 90min. Twice a day if necessary.

2. For the patients with SpO<sub>2</sub> between 70% - 80%, the bottom pressure of HBOT once a day is 2.0 ATA. The bottom time is 90min. Twice a day if necessary.

3. For the patients with SpO<sub>2</sub> between 80% ~ 90%, the bottom pressure of HBOT once a day is 1.6 ATA ~ 2.0 ATA. The bottom time is 60min.

4. For the patients whose SpO<sub>2</sub> is more than 90%, the recommended pressure of HBOT once a day is 1.6 ATA. The bottom time is 60min.

5. If the lowest value of daily SpO<sub>2</sub> is more than 95% in two consecutive days, HBOT can be stopped. But it is recommended to give a full course of treatment (10 days).

### **The recommendation for the single air chamber**

If without a standard medical air chamber, alternative is suitable with a single air chamber or a portable single air chamber, which shall meet the requirements of breathing pure oxygen on the oxygen mask under pressure of at least 1.6 ATA, with good medical monitoring ability under pressure and disinfection and purification measures for exhausted gas. 6 m (1.6 ATA) is the depth of no-decompressing diving. When forewarn of patients is found, beforehand decompressing to surface is as quickly as possible (within 3 minutes) to ensure the patient obtain emergency medical care in time. Single oxygen tank and portable pressurized tank can be deployed in the ward. There are not special disease control measures. The exhaust gas outlet is better to be equipped with disinfection and purification device.

### **Patients selection**

The basic principle of patient selection is: no absolute contraindication of HBOT; autonomous breathing; conscious; and no signs of obstructed respiratory tract; it is unlikely that emergency medical treatment will be needed within 120 minutes under the condition of sufficient oxygen supplement. Patients on Non invasive mechanical ventilation should be used with caution, on invasive mechanical ventilation is not recommended, but not absolutely excluded. It needs the assessment of the doctor in charge according to the above principles.

### **HBOT Protocol**

The following protocol is recommended, but not unique. The doctor in charge can adopt it according to their own clinical habits, but they should fully understand the limitations of equipment performance and the risk of single air chamber.

Once a day HBOT is bottom 1.6 ATA and 100min on mask breathing with pure oxygen, which has inhaled oxygen partial pressure about 160 kPa. If the duration of progressive hypoxemia is long and the clinical manifestations of hypoxic injury are obvious, it can be increased to twice a day. HBOT can be stopped if the lowest value of daily SpO<sub>2</sub> monitoring is more than 95% for two consecutive days, but it is recommended to give a full course of treatment.

For the first HBOT, it is suggested to extend the oxygen absorption time properly, and the longest time is not more than 120min. Under the condition that the doctor in-charge has confidence to the patient's condition, the bottom pressure can be increased to 2.0 ATA ~ 2.2 ATA, but not more than 2.5 ATA. It means that the decompressing time is more than 10 min.

## Authors Statement of interest conflict

During the development of this proposal, no financial support from pharmaceutical manufacturers and instrument manufacturers was received, including financial and conference service support. There is no interest conflict between the working group and pharmaceutical manufacturers or instrument manufacturers in the development and modification process of the proposal.

The above recommended disease control process and standard protocol are not unique, especially when using regular hyperbaric oxygen chamber treatment. However, when single air chamber is used, the adjustment of the recommendation needs to fully understanding to the performance of the equipment used and the patient's condition. At the same time, it is emphasized that this recommendation is based on the existing treatment experience. It is to be keep refreshment and improvement according to the following practice in the HBOT treatment of severe patients with COVID-19.

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