Short communication

Provision of emergency hyperbaric oxygen treatment for a patient during the COVID-19 pandemic

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Abstract

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The experience of managing a critically ill severe carbon monoxide poisoning patient suspected of possibly also suffering COVID-19 and requiring emergency hyperbaric oxygen treatment is described. Strategies used to minimise infection risk, modifications to practice and lessons learnt are described. All aerosol generating procedures such as endotracheal tube manipulation and suctioning should be undertaken in a negative pressure room. In the absence of in-chamber aerosol generating procedures, an intubated patient presents less risk than that of a non-intubated, symptomatically coughing patient. Strict infection control practices, contact precautions, hospital workflows and teamwork are required for the successful HBOT administration to an intubated COVID-19 suspect patient.

Introduction

In March 2020, the World Health Organization (WHO) declared a novel coronavirus disease SARS-CoV-2 (COVID-19) a global pandemic.[1] During the pandemic, the Singapore General Hospital (SGH) Hyperbaric and Diving Medicine Centre (HDMC) had a policy on providing hyperbaric oxygen treatment (HBOT) as an intervention for COVID-19 confluent with major hyperbaric committees worldwide.[2–4] The centre did not treat any COVID-19 positive patients. However, as in other clinical services, there was always the possibility that a COVID-19 infected patient, or a patient suspected at high risk of being infected, might require HBOT for another indication. This short communication describes the emergency management of a carbon monoxide poisoning patient whose COVID-19 status was uncertain prior to treatment. The report takes the form of an evolving clinical case description. The patient provided written consent for publication of case information.

Case description

HDMC received this case on 19 June 2020. A 21 year-old female was found unconscious in an enclosed room with burning charcoal after a suicide attempt. She was last seen 14 hours before that. She was conveyed via ambulance to a district hospital and was found to have a carboxyhemoglobin (COHb) level of 23%. She also sustained third degree 5% total body surface area burns on her limbs. She was intubated for airway protection as she was drowsy. In view of the severity of the CO poisoning (high COHb level, altered mental state, and end organ involvement), HDMC was contacted. The patient had a single episode of fever at 38.1 degrees Celsius on arrival at the district hospital emergency department (ED) and one of her family members was an asymptomatic frontline worker involved in screening travellers in the airport.

PREVENTING TRANSMISSION OF COVID-19: PATIENT SCREENING

All patients entering SGH are assessed for COVID-19 risk using temperature monitoring and a standard hospital screening questionnaire, created by the SGH Campus Disease Outbreak Task Force. The questionnaire is based on the Ministry of Health criteria for suspected COVID-19 infections. Patients with respiratory symptoms, and risk factors such as close contact with COVID-19 cases or significant travel history are not allowed into the HDMC for treatment.

INTERHOSPITAL TRANSFER

Inter-hospital transfers are allowed only for cases requiring urgent clinical expertise that is not available in the referring hospital. SGH hospital workflow requires the infectious diseases (ID) physician on-call to perform a COVID-19 risk assessment prior to receiving inter-hospital transfers. Based on the screening questions and investigations such as a chest x-ray, patients are stratified into low, moderate and high risk for COVID-19 infection. Patients with moderate and high risk for infection are admitted to a single or a negative pressure room. A minimum of two negative COVID-19 PCR swab tests done at least 24 hours apart are required for clearance and de-isolation.

Case description, continued

Despite having a normal chest X-ray, this patient was deemed to have a moderate risk for COVID-19 infection as she was febrile, had increased airway secretions and had been intubated. This was a logistical challenge as she required an interhospital transfer, and HBOT, which was not previously offered to COVID-19 suspect patients.

IMPLEMENTING EMERGENCY HBOT WORKFLOW FOR A COVID-19 SUSPECT CASE

The ID physician visited the HDMC to understand the HBOT process and work area to identify areas of increased risks and ways to mitigate it. Once both the ID and HDMC teams were satisfied that the HDMC staff would not be exposed to an unnecessarily high risk of infection, HBOT was offered to the patient.

COORDINATION AND PATIENT TRANSFER WITHIN THE HOSPITAL

Pre-planning of the transport route was done, and the shortest route with minimal human traffic was selected. Transfer commenced only when the receiving location and staff were ready, and the transfer route cordoned off with help from the security department. To minimise risk of cross-infections to other patients, the patient was treated in isolation.

STAFF PROTECTION

Frontline healthcare staff involved in high risk aerosol generating procedures (AGP) such as intubations, endotracheal tube manipulations (i.e., replacing air in the ETT cuff with saline), procedures involving ventilator disconnections, and open suctioning had undergone personal protective equipment (PPE) training and competency tests on the use of National Institute of Occupational Safety and Health (NIOSH)-certified N95 respirators. All staff working at the HDMC were mask fitted.

During the treatment, staff present within the compound was minimised, and the entrance into the HDMC was locked to prevent unnecessary staff movement. Prominent signage indicating that an infective case treatment was in progress were placed to alert other staff. As the HDMC does not have a negative pressure room, all staff present within the vicinity wore N95 masks for the entire treatment duration.

The hyperbaric physician and in-chamber nurse, who were in direct contact with the patient, wore full PPE[5] – including goggles or face shield, N95 mask, cap, gown and gloves.

IN-CHAMBER STAFF

As this was a high-risk case, an experienced in-chamber nurse accompanied the patient. The in-chamber nurse performed a single breath hold while changing from the N95 mask to the built-in-breathing-system (BIBS) mask for the end of treatment nitrogen off-gassing. In this case, the N95 mask did not impede the staff from performing Valsalva manoeuver. An alternative method which does not require mask removal, such as the voluntary tubal opening technique can be employed for equalisation of the middle ears.

For hospital staff who failed N95 mask fit, SGH stocks alternative systems such as the CleanSpaceR HALO™, and the 3M™Jupiter™ Personal Air Purifying Respirator. Such systems cannot be used in the hyperbaric chamber as they are not pressure tested. They rely on lithium batteries, which pose a fire risk.

Although N95 masks are recommended by WHO, the masks have not been tested under hyperbaric conditions, which may potentially affect the seal and efficacy. Nonetheless, it is worthwhile to remember that the air flow in the chamber is not static. The multiplace chamber utilises a continuous high air flow ventilation system with an optional flushing system to maintain the chamber pressure. Furthermore, the risk of aerosol generation in a patient who is sedated, intubated, and ventilated using a closed system ventilator in the hyperbaric chamber is lower than in an un-intubated patient.

Potential alternatives to the N95 for the in-chamber staff would be personalised air delivery systems via hoods or BIBS.[6] However, the staff movement within the chamber would be restricted by the length of the gas delivery tubing.

Fire safety of the polypropylene PPE gown needs to be taken into account especially in chambers which use 100% oxygen for compression as there is a risk of static electricity generation. In the multiplace chamber which uses air for compression, continuous in-chamber oxygen level monitoring was done to minimise fire risk. The risk of fire from the PPE gown needs to be weighed against the risk of in-chamber staff infection and psychological well-being.

HDMC uses washable shoes for chamber work, thus shoe covers are not required. The shoes were washed in sodium hypochlorite after use. SGH infectious disease protocol requires all HDMC staff in contact with COVID-19 suspect patients to shower within the HDMC compound, and change into clean clothes prior to leaving HDMC.

MANAGEMENT OF A POTENTIALLY INFECTIOUS INTUBATED AND VENTILATED PATIENT FOR HBOT

As HBOT treatments are time critical, the usual HBOT workflow in SGH would be for an intubated patient to be transferred directly from the ambulance bay in the emergency department (ED) to the HDMC for treatment. During the COVID-19 outbreak, the ideal location to review a COVID-19 suspect patient would be in a negative pressure isolation room, which is only available in the intensive care units (ICU). The workflow was modified to transfer the patient from the ambulance bay directly into the burns ICU (BICU), bypassing the ED. In BICU, the patient was stabilised and prepared for HBOT by the hyperbaric physician.

High risk AGPs[7] should be done within the negative pressure ICU room. The patient should be kept deeply sedated or paralysed to prevent coughing. During ventilator change, clamping the ETT with a large artery forceps after full expiration, switching off the ventilator prior to disconnection minimises aerosol generation.[8] In the absence of ETT manipulation, open suctioning or circuit disconnection, the risk of aerosol generation is minimal in a closed ventilator circuit.

To avoid environmental pollution within the HDMC complex, the transport ventilator was changed to the in-chamber ventilator within the hyperbaric chamber. Unless absolutely necessary, ETT manipulation and ETT in-line suctioning was avoided. Ventilator tubing and connections should be tightened to minimise circuit leaks. As per usual hospital practice, expired air from the patient passed through two (2) high efficiency particulate air (HEPA) filters – a low dead space filter (Portex® Thermovent® HEPA Low Deadspace Heat and Moisture Exchange Filter) was placed at the end of the ETT, and the second filter (MAQUET Servo Duo Guard) between the expiratory limb and the machine. An additional HEPA filter (MAQUET Servo Duo Guard) was placed between the ventilator outflow tubing and the chamber outflow port to filter exhaust to minimise environmental contamination within the hyperbaric chamber (Figure 1).

Post-procedure, the HBOT ventilator (Maquet Servo 900C Ventilator, Siemens) parts were soaked in ethanol 70% for one hour according to the manufacturer's instruction, and the external surface of the ventilator was wiped down.

Figure 1
Ventilator set up indicating one low dead space HEPA filter at the end of the ETT, one HEPA filter at the gas inflow to the ventilator and one HEPA filter before the chamber outflow port

Although the usual practice is to rapidly wean off sedation to assess GCS score during the HBOT session, this patient was kept sedated until she was transferred back to BICU to minimise coughing and risk of circuit disconnections.

ENVIRONMENT AND EQUIPMENT

One method to minimise contamination for suspect COVID-19 is to remove unnecessary equipment and to cover non-removable objects or surfaces with plastic sheets or wraps. As part of our usual practice, only essential items are kept in the chamber.

It is important to ensure that chemicals used for disinfection are safe to use on acrylic surfaces - this should be checked with the chamber manufacturer.[9] In SGH, the chamber and equipment are wiped down with Mikrozid® sensitive wipes (Schülke & Mayr GmbH, Vienna, Austria). As an added precaution, all surfaces within the hyperbaric chamber are cleaned with sodium hypochlorite 1000PPM, with a contact time of five minutes on top of regular cleaning. To prevent prolonged contact of sodium hypochlorite with the metal surfaces which could cause rusting, a second wipe down with water after 5 minutes was done.

In SGH wards, ultraviolet (UV) light irradiation is used for terminal cleaning. It was not used in this case as UV light sterilisation is only effective for surface areas exposed to the light and may not be effective in our multiplace chamber which has fixed seating and thus many shadow-generating obstructions. It is important to cover UV sensitive acrylic viewports if UV light is used.[10] Simple rubber gloves have been used for this purpose.[11]

Footnote: * Appendix1 is available on DHM Journal's website: https://www.dhmjournal.com/index.php/journals?id=84

Case description continued

The patient underwent two HBOT sessions within 24 hours, and the first HBOT session was started within six hours of presentation. Two samples of endotracheal aspirates, each collected 24 hours apart were sent for COVID-19 PCR testing. Both samples tested negative for COVID-19. The patient subsequently received surgical treatment for her burns and she recovered well.

Lesson learned and future improvements

The successful management of this case could be attributed to three main factors. First, hospital wide infectious control precautions/practices were in place, and had become a part of the daily routine for all staff since the start of the pandemic. Second, the ID physician visited the HDMC personally to walk through the HBOT process and helped to identify potential issues and ways to minimise infection risk. Third, the experienced HDMC team who were trained and comfortable in managing critically ill and intubated patients were key in caring for the patient whilst in full PPE.

An area for improvement would be to employ the use of simulation for a dry run prior to the actual case. Simulation was employed for emergency operation cases in SGH major operating theatres when the COVID-19 outbreak started.[8] Although simulation is resource intensive, one of the main benefits is the ability to identify latent threats not previously anticipated, while concurrently training staff. We recommend that simulation training be carried out if manpower permits and expertise is available. Appendix 1* can serve as a guide for units providing emergency HBOT during the COVID-19 pandemic.

Evidence for HBOT for CO poisoning is controversial at best,[12] and during a pandemic we recommend a risk-benefit evaluation for every case. As COVID-19 is expected to remain endemic, continued vigilance and strict infection control measures are required to prevent disease transmission.

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Appendix 1. Suggested workflow for the provision of emergency hyperbaric oxygen treatment during the COVID-19 pandemic

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