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Guidelines

Oxygen Facilities for Covid-19 Patients

Objective

To quantify oxygen demand, to identify oxygen sources that are available, and select appropriate surge sources to best respond to COVID-19 patients' needs. These guidelines are intended for health facility administrators, clinical decision-makers, procurement officers, planning officers, biomedical engineers, infrastructure engineers and policy-makers.

Rationale

COVID-19 is a public health crisis without parallel in recent history. But it is also an opportunity to turn the spotlight on medical oxygen as one of the defining health equity issues of our age. Oxygen therapy is recommended for all severe and critical COVID-19 patients, with low doses to moderate flow rates or higher flow rates.

Instructions

About 15 % of people with Covid-19 have moderate/severe illness requiring oxygen therapy, and 5% will be critically ill requiring intensive care unit treatment. For these reasons, COVID-19 treatment health-care facilities should be equipped with pulse oximeters, functioning oxygen systems including single-use oxygen delivery interfaces.

- Oxygen therapy is recommended for all severe and critical COVID-19 patients, with low doses ranging from 1-2 L/min in children and starting at 5 L/min in adults with nasal cannula, moderate flow rates for use with venturi mask (6-10 L/min); or higher flow rates (10-15 L/min) using a mask with reservoir bag attached as Annexure A.

Oxygen can be delivered at higher flow rates and in higher concentrations using non-invasive ventilation (NIV) and invasive ventilation devices. The high-flow nasal cannula (HFNC) device can be used to deliever oxygen at higher flow rates and in higher concentrations but is not used as a first line of oxygen therapy as this is not a very common device, it will consume more oxygen.

Oxygen sources

Medical oxygen contains at least 82% pure oxygen. Only high quality, medical-grade oxygen should be given to patients. Oxygen systems must consist of an oxygen source, or production combined with storage. Common oxygen sources are: oxygen generating plants and liquid oxygen in bulk storage tanks, and oxygen concentrators. The most common source of oxygen storage used in health-care settings is a cylinder.

The appropriate choice of oxygen source depends on many factors, including: the amount of oxygen needed at the treatment centre; the available infrastructure, cost, capacity and supply chain for local production of medicinal gases; the reliability of electrical supply; and access to maintenance services and spare parts, etc.

Liquid oxygen plants: The liquid oxygen tank supplies a centrally piped system throughout the health facility by self-vaporization and for which a power supply is not required. The use of liquid oxygen relies on external supply chain mechanisms and needs a bit more caution with respect to transport and storage due to the risks associated with higher pressures. Extra care should be taken in more extreme environments. It is best practice to also have cylinders as a backup supply.

PSA oxygen plant: A pressure swing adsorption (PSA) oxygen plant serves as a large, central source of oxygen generation using PSA technology (similar to concentrators) that can be located on-site at medical facilities. Oxygen from a PSA plant can either be piped directly to bedside terminal units within patient areas or, with a booster compressor, be used to refill cylinders for oxygen distribution (either on-site or to neighbouring health facilities) or for backup oxygen supply. Oxygen plants require a reliable source of power. It is best practice to also have cylinders as a backup supply.

Oxygen concentrators: An oxygen concentrator is a self-contained, electrically powered medical device designed to concentrate oxygen from ambient air. An oxygen concentrator uses PSA technology to draw in air from the environment, removing the nitrogen to produce a continuous source of more than 90% concentrated oxygen. It should not be used if the oxygen concentration falls below 82%.

Oxygen storage and intra-hospital distribution

***Oxygen cylinders*:** Oxygen gas can be compressed and stored in cylinders and can be piped to specific areas of the health facility, even at the ward level. When cylinders are the only source of oxygen in a health facility, a strong supply-chain is required to ensure ongoing availability. Once filled, cylinders themselves do not require electricity, but they do require several accessories and fittings to deliver oxygen, such as pressure gauges, regulators, flowmeters, and in some cases, humidifiers. Cylinders also require periodic maintenance, commonly provided by gas suppliers at the point of refilling. Storage or transportation of medical oxygen in cylinders must be done carefully and by trained personnel as the contents are under extreme pressure.

Pipeline intra-hospital distribution networks are helpful to supply oxygen at high pressure to equipment such as anaesthetic machines and ventilators. A key advantage of pipeline systems is that they obviate the need for handling and transporting heavy cylinders between hospital wards. However, the high cost and complexity of installing centralized oxygen sources with copper pipelines and the associated specialized maintenance required for this, makes pipeline systems less accessible for turn-key installations.

Oxygen needs Estimation

About 75% of the COVID-19 patients requiring hospitalization will be classified as “moderate or severe”, and 25% as “critical”. Thus, the total supply of medical oxygen required can be estimated based on the recommended flow rates for each patient severity category (Annex B).

Please refer to “Annexure A” for Oxygen flow categories, “Annexure B” for Sample oxygen flow planning per 100 bed facility and “Annexure C” for comparison of oxygen sources and storage.

Note: The above recommendations are being regularly reviewed by the Ministry of National Health Services, Regulations & Coordination and will be updated based on the international & national recommendations and best practices.

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References

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http://covid.gov.pk/

http://nhsrc.gov.pk/ https://www.facebook.com/NHSRCOfficial
http://www.hsa.edu.pk/ https://twitter.com/nhsrcofficial
https://www.nih.org.pk/ https://www.youtube.com/channel/UCdYuzeSP4Ug1f__ZZ

Annex 'A'

Proposed Bed Categories/Treatment options

Oxygen beds for low flow oxygen	• Low flow Oxygen with Mask (up to 5-6 liters/min) • Additional flow with by adding Bag to mask
High Dependency Unit (HDU) /Non-invasive high flow oxygen	• High Flow Nasal Canula (HFNC uses more oxygen and not recommended for first line use) • CPAP Machine • BPAP Machine
ICU/Mechanical Ventilation	• Mechanical ventilation with intubation

Proposed ratio for planning purpose of any COVID-19 facility is 3:3:1

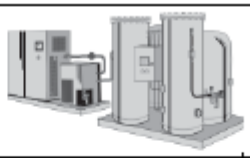
Annex 'B'

Sample Oxygen Flow Planning per 100 Bed Facility

Hypothetical 100 bed COVID-19 treatment facility				
Disease severity	Avg. O_2 flow rate		Size of solutions of scale*	
	per patient	Total	PSA Plant	Bulk liquid
Severe 75 patients	10 L/min	75 * 10 * 60 = 45,000 L/hr	= 45 m^3/hr	= 1.25 m^3/day
Critical 25 patients	30 L/min	25 x 30 x 60 = 45,000 L/hr	= 45 m^3/hr	= 1.25 m^3/day
			= 90 m^3/hr	= 2.5 m^3/day

Annex 'C'

Comparison of Oxygen Sources and Storage

	Cylinders	Concentrators (PSA)	Oxygen plant (PSA)	Liquid oxygen
General characteristic				
Image				
Description	A refillable cylindrical storage vessel used to store and transport oxygen in compressed gas form. Cylinders are refilled at a gas generating plant and thus require transportation to and from the plant	A self-contained, electrically powered medical device designed to concentrate oxygen from ambient air, using PSA technology.	An onsite oxygen generating system using PSA technology, which supplies high-pressure oxygen throughout a facility via a central pipeline system, or via cylinders refilled by the plant.	Bulk liquid oxygen generated off-site and stored in a large tank and supplied throughout a health facility pipeline system. Tank requires refilling by liquid oxygen supplier.
Clinical application and/or use case	Can be used for all oxygen needs, including high-pressure supply and in facilities where power supply is intermittent or unreliable. Also used for ambulatory service or patient transport. Used as a backup for other systems.	Used to deliver oxygen at the bedside or within close proximity to patient areas. A single concentrator can service several beds with the use of a flowmeter stand to split output flow.	Can be used for all oxygen needs, including high-pressure supply.	Can be used for all oxygen needs, including high- pressure supply and in facilities where power supply is intermittent or unreliable.
Distribution mechanism	Connected to manifold of central/sub-central pipeline distribution system, or directly connected to patient with flowmeter and tubing.	Direct to patient with tubing or through a flowmeter stand.	Central/ sub-central pipeline distribution system, or can be used to refill cylinders that can be connected to manifold systems in the facility.	Central pipeline distribution system.
Electricity requirement	No	Yes	Yes	No
Maintenance requirement	Limited maintenance required by trained technicians.	Moderate maintenance required by trained technicians, who could be in-house.	Significant maintenance of system and piping required by highly trained technicians and engineers, can be provided as part of contract.	Significant maintenance of system and piping required by highly trained technicians and engineers, can be provided as part of contract.
User care	Moderate; regular checks of fittings and connections, regular checks of oxygen levels, cleaning exterior.	Moderate; cleaning of filters and device exterior.	Minimal; at terminal unit only.	Minimal; at terminal unit only.
Merits	– No power source.	– Continuous oxygen supply (if power available) at low running cost. – Output flow can be split among multiple patients.	– Can be cost-effective for large facilities. – Continuous oxygen supply.	– 99% oxygen obtained. – High oxygen output for small space requirement.
Drawbacks	– Requires transport/ supply chain. – Exhaustible supply. – Highly reliant upon supplier. – Risk of gas leakage. – Risk of unwanted relocation.	– Low pressure output, usually not suitable for CPAP or ventilators. – Requires uninterrupted power. – Requires backup cylinder supply. – Requires maintenance.	– High capital investments. – Requires uninterrupted power. Needs adequate infrastructure. – High maintenance for piping. – Requires backup cylinder supply. – Risk of gas leakage from piping system.	– Requires transport/ supply chain. – Exhaustible supply. – High maintenance for piping. – Needs adequate infrastructure. – Requires backup cylinder supply. – Risk of gas leakage from piping system.

References

1. https://www.who.int/publications/i/item/oxygen-sources-and-distribution-for-covid-19-treatment-centres
2. WHO-UNICEF technical specifications and guidance for oxygen therapy devices; WHO medical device technical series; Geneva: World Health Organization and United Nations Children's Fund (UNICEF); 2019 (https://apps.who.int/iris/bitstream/handle/10665/329874/9789241516914-eng.pdf?ua=1)