Considerations for Oxygen Therapy in Disasters

Originally published October 19, 2017

Updated March 8, 2018

Oxygen is used as a medical treatment for chronic and acute medical conditions and can be administered in medical facilities, by emergency medical service providers, and in home settings. In a disaster, access to oxygen can be challenging. Utility outages can impact electricity dependent machines, transportation and shipping difficulties can limit distribution of oxygen, and damage to oxygen generation and distribution plants can lead to reduction in supply. This ASPR TRACIE fact sheet provides information on the types of oxygen therapy and the types of oxygen supplies generally available. It also includes information on the typical sizes and length of use of various oxygen storage methods.

Storage and Sources of Oxygen

Liquid Oxygen Storage

This type of oxygen is stored as a liquid in vacuum insulated storage tanks, then vaporized and released as a gas. Because they are high-volume users, many hospitals and healthcare facilities use this method because it allows for storage of higher amounts of oxygen. Portable, dewar-based liquid oxygen delivery systems are available and designed to support single-patient use. The attached document from the Minnesota Department of Health describes a system set-up that could potentially support up to 60 patients.

Figure 1. Liquid Oxygen Storage Tanks, Image Courtesy of Chart Industries

Compressed Gas Storage

This type of oxygen is stored in gas cylinders at room temperature and can be used directly from the tank. Tanks vary in size from small, portable, short-term use tanks (designed to be used for a few hours) to large tanks that could last many hours to several days depending on use.

Instant Usage

An electrically powered oxygen concentrator is a device that uses regular air and through a chemical reaction, generates pure oxygen. Oxygen concentrators provide continuous oxygen, provided there is a continuous source of electricity and room air, for one patient. Industrial sized concentrators are available, but can only support a few patients per unit and are not really scalable. Oxygen concentrators are available from a variety of providers. Access this sample list of home concentrators for more information.

Photo courtesy of The Oxygen Concentrator Store by American Medical Sale and Rentals.

Delivery

Low Flow Oxygen Delivery

Low dose oxygen therapy is generally required for patients who need small amounts of oxygen to maintain adequate oxygenation. This is typically accomplished with a prescription of between 2-6 liters per minute of oxygen delivered through a nasal cannula or simple face mask.

High Flow Oxygen Delivery

High flow oxygen is generally delivered in acute care environments when the patient requires an oxygen concentration of near 100%. This is typically delivered at liter flows over 10 liters per minute and can be delivered by non-rebreather mask, or through a high flow nasal cannula.

Positive Pressure Delivery

Positive pressure delivery of oxygen is required for patients who cannot breathe on their own and can be delivered through a bag valve mask, intubation tube, or through the use of a mechanical ventilator.

Drug Delivery Route

In some patients, oxygen is used to deliver medication, such as through a nebulizer or other special equipment, and masks are used to deliver aerosolized medication.

Accessories Needed

In addition to the tanks, delivery accessories are required for effective oxygen treatment. These accessories can include nasal cannulas, oxygen masks, intubation tubes, reservoir tubing, humidifier bottles, carrying cases, and carts.

Oxygen Flow Rates and Use

The graphic below provides oxygen tank use timelines based on low flow use. If multiple patients are using the same tank or if patients are prescribed high flow oxygen treatment, the timeline will be shortened.

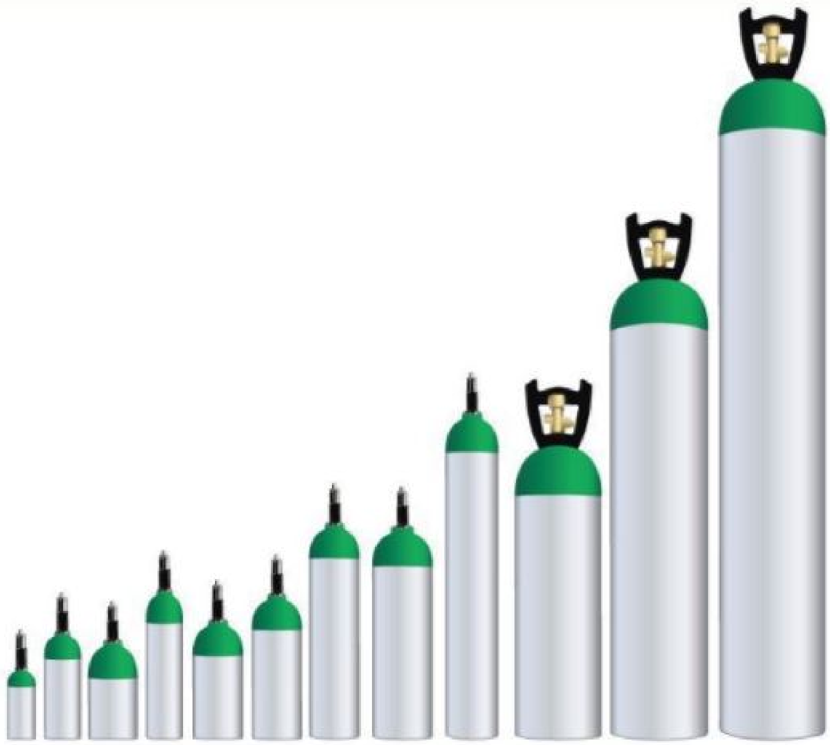
Oxygen Cylinder Use Timeline

	Flow Rate	Full Tank 2000 PSI	¾ Tank 1500 PSI	½ Tank 1000 PSI	¼ Tank 500 PSI
M - Cylinder	1⁄32	76 days	56 days	38 days	18 days
	1⁄16	38 days	28 days	19 days	9 days
	1⁄10	24 days	18 days	12 days	6 days
	⅛	19 days	14 days	9.5 days	4.5 days
	¼	9.5 days	7 days	4.5 days	2 days
	½	4.5 days	3.5 days	2 days	1 day
	1	2.4 days	43 hours	28.75 hours	14 hours
E - Cylinder	1⁄10	100 hours	75 hours	50 hours	25 hours
	⅛	83 hours	62 hours	41 hours	20 hours
	¼	41 hours	30 hours	20 hours	10 hours
	½	20 hours	15 hours	10 hours	5 hours
	1	13 hours	9 hours	6 hours	3 hours
	2	5 hours	3.5 hours	2.5 hours	1.1 hours
	3	3.4 hours	2.3 hours	1.5 hours	0.7 hours
	4	2.5 hours	1.75 hours	1.1 hours	0.5 hours
D - Cylinder	1⁄32	160 hours	96 hours	64 hours	48 hours
	1⁄16	80 hours	48 hours	32 hours	24 hours
	1⁄10	50 hours	30 hours	20 hours	15 hours
	⅛	40 hours	24 hours	16 hours	12 hours
	¼	23 hours	17 hours	12 hours	6 hours
	½	11 hours	9 hours	6 hours	3 hours
	¾	8 hours	6 hours	4 hours	2 hours
	1	5 hours	3 hours	2 hours	1.5 hours
	2	2.5 hours	1.5 hours	1 hour	0.75 hours
C - Cylinder	1⁄32	80 hours	60 hours	40 hours	20 hours
	1⁄16	40 hours	30 hours	20 hours	10 hours
	⅛	20 hours	15 hours	10 hours	5 hours
	¼	11.5 hours	8.6 hours	5.6 hours	2.8 hours
	½	5.5 hours	4.1 hours	2.75 hours	1.4 hours
	1	2.5 hours	1.9 hours	1.25 hours	0.63 hours
	2	1.25 hours	0.95 hours	0.75 hours	0.31 hours
	3	0.75 hours	0.56 hours	0.38 hours	0.2 hours

Figure 2. Graphic Courtesy of Intermountain Healthcare

Liquid oxygen calculations for home oxygen tanks estimate that a reservoir the size of 30-40 liters would last 8-10 days at a prescription dose of 2 liters per minute (Rees, 1998). One liter of liquid oxygen is equivalent to approximately 860 liters of gaseous oxygen. A typical bulk storage unit for home use is filled with approximately 40 liters of liquid oxygen, which would last up to 10 days for one patient's use on a prescription level of 2 liters per minute (Inogen, 2017).

This chart provides information on Liquid Oxygen Use Times for various tank model types, and Figure 3 illustrates cylinder sizes and related information.



Older Name		A		B		C	D	JD	E			H
Newer Name	M-2	M-4	ML-6	M-6	M-7	M-9	M-15	M-22	M-24	M-60	M/MM/M122	M250
Diameter (in.)	2.5	3.2	4.3	3.2	4.3	4.3	4.3	5.3	4.3	7.3	8	9
Height (in.)	5.3	8.5	7.6	11.5	9.1	11	16.5	16.5	25.5	23	36	52
Empty Weight (lb)	0.7	1.6	2.8	2.2	3.3	3.7	5.3	8	7.9	22.3	39.5	114
Capacity (L) at 2,200psi	42	113	165	164	198	255	425	640	680	1738	3455	7080
Transport Method	Carrier Bag	Carrier Bag	Carrier Bag	Carrier Bag	Carrier Bag	Carrier Bag	Carrier Bag	Carrier Bag	Wheelchair Bag or Cart	Not Portable	Not Portable	Not Portable
Regulator Type	CGA 870	CGA 870	CGA 870	CGA 870	CGA 870	CGA 870	CGA 870	CGA 870	CGA 870	CGA 540	CGA 540	CGA 540

Figure 3. Graphic Courtesy of Applied Home Healthcare Equipment

Oxygen Conservation in Disasters

The primary resource recommended by ASPR TRACIE subject matter experts for oxygen conservation strategies is the “Oxygen Card” found in card set included in the Minnesota Department of Health document Patient Care: Strategies for Scarce Resource Situations.

This card set can help facilitate an orderly approach to resource shortfalls at a healthcare facility. It is a decision support tool to be used by key personnel, along with incident management, who are familiar with ethical frameworks and processes that underlie these decisions. The first card on page 5 – and presented in Appendix A below – focuses on oxygen allocation options.

The ASPR TRACIE Crisis Standards of Care Topic Collection has links to numerous tools, templates, and guidance documents that discuss allocation of scarce resource and specifically highlights the work of the Institute of Medicine on Crisis Standards of Care.

An article written by Hick, et al. (2012) summarizes the recommendations of The Institute of Medicine documents and highlights these general strategies to be implemented for scarce resource situations (also applied in the Minnesota document in Appendix A):

- **Prepare:** Optimally, planning can identify and mitigate resource shortfalls by stockpiling commonly needed (and often inexpensive) items such as morphine and intubation equipment.17 Preparation also includes methods to maintain the equipment and supplies; for example, adherence to preventative maintenance, stock rotation, and restocking schedules.
- **Conserve:** Restrictions are placed on the use of certain therapies or interventions to maintain supply (for example, N95 masks, oxygen).
- **Substitute**: A functionally equivalent medication or device is used (for example, using benzodiazepines instead of propofol for sedation of a tracheally intubated patient).
- **Adapt:** Use of a device for purposes for which it was not intended (for example, using an anesthesia machine or Bi-level positive airway pressure machine as temporary ventilator or using an oxygen saturation monitor with high/low rate alarms instead of cardiac monitor to detect tachy or bradydysrhythmias).
- **Reuse:** After appropriate cleaning, disinfection, or sterilization, the majority of material resources can be reused.
- **Reallocate:** Certain critical resources (ventilators, extracorporeal membrane oxygenation) may have to be allocated to those patients most likely to benefit, in extreme situations this may involve removal from one patient to give substantially better chance of a good outcome. This, clearly, is a last resort and should be done only when no other options exist and no relief is possible.

Glossary of Terms and Conversions

Oxygen Cylinders and Storage Capacity of Gaseous Oxygen

Size of Cylinder	Liters (at 2200 psi)	Cubic Feet	Time in Use Estimate (at 10 L/min)	Time in Use Estimate (at 15 L/min)
C	255	9	17 min	11 min
D	425	15	34 min	22 min
E	680	24	68 min	44 min
F	1360	48	2 hr 16 min	1 h 30 min
H	7080	252	11 hr 48 min	7 hr 52 min
MM	3455	123	5 hr 45 min	3 hr 50 min

From: Oxygen Cylinder Sizes and Info, Medical Gas Cylinder and Bulk Tank Storage and Cylinder Duration Calculator (this is a calculator with variable inputs for users)

When discussing volume, 1 cubic foot is equal to roughly 28 liters, but the pressure under which the gas is housed and temperature of storage will alter these calculation estimates and there are slight differences with each manufacturer. For time in use estimates, these will vary based on patient respiratory rate and pressure.

Liquid Oxygen to Gaseous Oxygen Conversion

Copied directly from: Unit Conversion Data for Oxygen

	Weight		Gas		Liquid	
	pounds (lb)	kilograms (kg)	cubic feet (scf)	cu meters (Nm^3)	gallons (gal)	liters (l)
1 pound	1.0	0.4536	12.076	0.3174	0.105	0.3977
1 kilogram	2.205	1.0	26.62	0.6998	0.2316	0.8767
1 scf gas	0.08281	0.03756	1.0	0.02628	0.008691	0.0329
1 Nm^3 gas	3.151	1.4291	38.04	1.0	0.3310	1.2528
1 gallon liquid	9.527	4.322	115.1	3.025	1.0	3.785
1 liter liquid	2.517	1.1417	30.38	0.7983	0.2642	1.0
1 short ton	2000	907.2	24160	635	209.9	794.5

Scf (standard cubic foot) gas measured at 1 atmosphere and 70°F.
Nm3 (normal cubic meter) gas measured at 1 atmosphere and 0°C.
Liquid measured at 1 atmosphere and boiling temperature.

This website provides a calculator as well: http://www.uigi.com/o2_conv.html

This website also provides a calculator for liquid oxygen to gaseous oxygen conversion: http://www.airproducts.com/products/Gases/gas-facts/conversion-formulas/weight-and-volume-equivalents/oxygen.aspx

Glossary (in addition to the terms described above)

Concentrator: term for an electrically powered machine that produces medical oxygen from surrounding air

Cylinder: name for the tanks that contain gaseous oxygen

Dewar: large fixed container for liquid oxygen used to refill portable containers and supports healthcare facility use

Flow Meter: device used to display oxygen flow pressure

LOX: liquid oxygen abbreviation

LPM: liters per minute abbreviation. Used to measure the proper dose to the patient.

Additional Resources

Daniel, M. (2012). Resource Stewardship in Disasters: A Provider's Dilemma Practicing in an Ethical Gap. (Abstract only.) Journal of Clinical Ethics. 23(4):331-5.

Devereaux, A. (n.d.). Delivering Acute Care to Chronically Ill Adults in Shelters.

Georgia Hospital Association Research and Education Foundation, Inc. (GHAREF) et al.(2010). Regional Planning Guide for Maintaining Essential Health Services in a Scarce Resource Environment.

Hanfling, D., Altevogt, B.M., Viswanathan, K., and Gostin, L.O (eds.). (2012). Crisis Standards of Care: A Systems Framework for Catastrophic Disaster Response. Institute of Medicine, Washington, DC: National Academies Press.

Hick, J.L., Hanfling, D., and Cantrill, S.V. (2012). Allocating Scarce Resources in Disasters: Emergency Department Principles. Annals of Emergency Medicine. 59(3): 177-187.

Hick, J.L., and O'Laughlin, D.T. (2006). Concept of Operations for Triage of Mechanical Ventilation in an Epidemic. Academic Emergency Medicine. 13(2): 223-9.

Minnesota Department of Health. (n.d.). Disaster Oxygen Delivery System. (attached)

National Home Oxygen Patients Association. (2013). Understanding Oxygen Therapy: A Patient Guide to Long-Term Supplemental Oxygen.

Rees, P. (1998). Provision of Oxygen at Home.

Appendix A: Minnesota Strategies for Scarce Resource Situations – OXYGEN

OXYGEN
STRATEGIES FOR SCARCE RESOURCE SITUATIONS

MINNESOTA HEALTHCARE SYSTEM PREPAREDNESS PROGRAM

RECOMMENDATIONS	***Strategy***	***Conventional***	***Contingency***	***Crisis***
Inhaled Medications • Restrict the use of Small Volume Nebulizers when inhaler substitutes are available. • Restrict continuous nebulization therapy. • Minimize frequency through medication substitution that results in fewer treatments (6h-12h instead of 4h-6h applications).	*Substitute & Conserve*			
High-Flow Applications • Restrict the use of high-flow cannula systems as these can demand 12 to 40 LPM flows. • Restrict the use of simple and partial rebreathing masks to 10 LPM maximum. • Restrict use of Gas Injection Nebulizers as they generally require oxygen flows between 10 LPM and 75 LPM. • Eliminate the use of oxygen-powered venturi suction systems as they may consume 15 to 50 LPM.	*Conserve*			
Air-Oxygen Blenders • Eliminate the low-flow reference bleed occurring with any low-flow metered oxygen blender use. This can amount to an additional 12 LPM. Reserve air-oxygen blender use for mechanical ventilators using high-flow non-metered outlets. (These do not utilize reference bleeds). • Disconnect blenders when not in use.	*Conserve*			
Oxygen Conservation Devices • Use reservoir cannulas at 1/2 the flow setting of standard cannulas. • Replace simple and partial rebreather mask use with reservoir cannulas at flowrates of 6-10 LPM.	*Substitute & Adapt*			
Oxygen Concentrators If Electrical Power Is Present • Use hospital-based or independent home medical equipment supplier oxygen concentrators if available to provide low-flow cannula oxygen for patients and preserve the primary oxygen supply for more critical applications.	*Substitute & Conserve*			
Monitor Use and Revise Clinical Targets • Employ oxygen titration protocols to optimize flow or % to match targets for SPO2 or PaO2. • Minimize overall oxygen use by optimization of flow. • Discontinue oxygen at earliest possible time. (see example table below)	*Conserve*			
Expendable Oxygen Appliances • Use terminal sterilization or high-level disinfection procedures for oxygen appliances, small & large-bore tubing, and ventilator circuits. Bleach concentrations of 1:10, high-level chemical disinfection, or irradiation may be suitable. Ethylene oxide gas sterilization is optimal, but requires a 12-hour aeration cycle to prevent ethylene chlorohydrin formation with polyvinyl chloride plastics.	*Re-use*			
Oxygen Re-Allocation • Prioritize patients for oxygen administration during severe resource limitations.	*Re-Allocate*			

Starting Example	Initiate O2	O2 Target
Normal Lung Adults	SPO2 <90%	SPO2 90%
Infants & Peds	SPO2 <90%	SPO2 90-95%
Severe COPD History	SPO2 <85%	SPO2 90%

Note: Targets may be adjusted further downward depending on resources available, the patient's clinical presentation, or measured PaO2 determination.