

## Chapter 40

# OXYGEN THERAPY TECHNIQUES

100% Oxygen (O<sub>2</sub>) therapy is an essential technique in first-aid treatment of many diving emergencies. Unfortunately, the correct use of O<sub>2</sub> equipment is often poorly understood by divers. See Chapter 16 for details of the use of O<sub>2</sub> in decompression sickness.

### OXYGEN BREATHING EQUIPMENT

The apparatus for administering O<sub>2</sub> is not unlike a scuba system. It comprises a **cylinder** which holds the oxygen at a pressure comparable to scuba tank pressure, and a pressure **reducing valve (regulator)** connected either to a **demand valve** or to a **constant flow system**. There is a need to avoid the use of flammable lubricants (such as oils and silicone grease) which can cause explosions in the presence of O<sub>2</sub>.

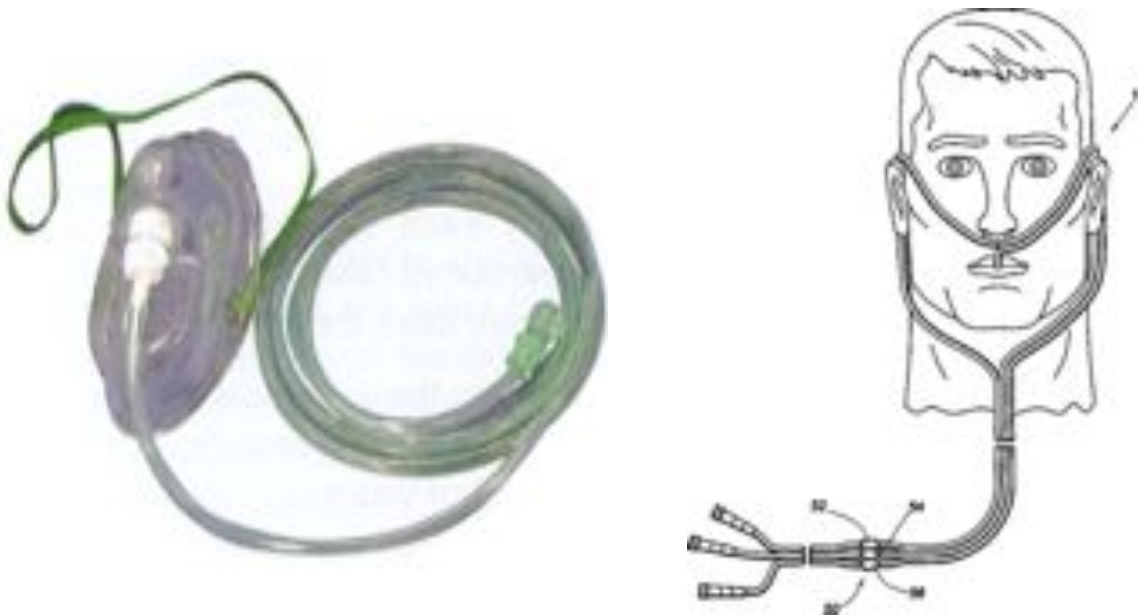
Oxygen can accelerate burning, cause spontaneous combustion, and can make ordinarily non-combustible materials burn furiously, so its use requires a strict fire prevention attitude. Oxygen should not be administered near heat sources, and smoking near O<sub>2</sub> is even more hazardous to your health than usual. Oxygen should not be used in poorly ventilated areas where high concentrations can build up. All equipment must be kept clean and the cylinder valve should be turned on slowly and the system purged before O<sub>2</sub> is given to the patient. If the patient is unconscious, always check that the apparatus is working by you or an attendant breathing on it first.

The O<sub>2</sub> can be delivered in high or low concentrations depending on the apparatus used. With a constant flow system, the O<sub>2</sub> can be delivered to the patient through either a cheap disposable (usually loose fitting) plastic **oxygen mask**, **nasal prongs**, a **nasal catheter** or a **bag-valve-mask resuscitator system**.

Where the administration of 100% O<sub>2</sub> is required (e.g. in first aid for decompression illness) this means that nothing but O<sub>2</sub> is inhaled by the diver. Many of the O<sub>2</sub> masks commonly used

in medicine have 100% O<sub>2</sub> delivered to the mask, but, the patient inhales only about 25-50% O<sub>2</sub> because the design of the mask allows this O<sub>2</sub> to mix with air, which dilutes the final breathing mixture. The disposable plastic O<sub>2</sub> masks in common use in ambulances and hospital casualty rooms are of this type.

These are **NOT** adequate for treating serious diving injuries.



**Fig. 40.1**  
These oro-nasal plastic masks, catheters and nasal prongs are not adequate for treating divers with 100% O<sub>2</sub>.

As a general rule, **decompression sickness**, **gas embolism** (and other manifestations of **pulmonary barotrauma**), carbon monoxide poisoning and **near drowning** cases should be given 100% O<sub>2</sub> from the outset.

Other diving accidents which produce shock or hypoxia can sometimes be helped with lower concentrations of O<sub>2</sub>. In general, if the patient is cyanosed (blue) they need O<sub>2</sub> in a sufficient concentration to make them pink again. Usually, 100% O<sub>2</sub> is needed for treatment of diving accidents.

## CONSTANT FLOW SYSTEMS

Such devices deliver a constant flow of O<sub>2</sub> to a mask or an alternative delivery system.

There are several types of plastic **disposable oxygen masks** available, the **Hudson** mask being typical. Each is normally accompanied by instructions which specify the correct O<sub>2</sub>

flow to use, most masks using a flow of about 4–6 litres per minute. These masks allow the O<sub>2</sub> flow to be diluted by inspired air, the flow of which varies during inspiration and peaks at about 30 litres per minute. Because of this, the concentration of O<sub>2</sub> which the patient actually inhales is reduced from 100% to about 40 or 50%.

To increase the inspired O<sub>2</sub> percentage, increase the O<sub>2</sub> flow. Unless this is increased beyond 30 litres per minute an inspired percentage of 100% is not attainable. Such high flow rates rapidly deplete most divers' O<sub>2</sub> supply.

A device known as a **nasal prong** (see above photo) is available which delivers O<sub>2</sub> by small tubes directly into the patient's nostrils. An elastic head strap holds the prongs in place. This system has a similar efficiency to the common loose fitting O<sub>2</sub> mask but is more comfortable and more effective for long term use because it is less likely to dislodge when the patient sleeps.

These systems are acceptable when O<sub>2</sub> supplementation in low concentrations is all that is required. Cases in this category would include typical general medical conditions found in hospitals such as heart attack, and mild recovering cases of near drowning, salt water aspiration syndrome and shock associated with serious trauma or shark attack.

## HIGH CONCENTRATION OXYGEN SYSTEMS

When near 100% O<sub>2</sub> delivery is required in cases such as decompression sickness, pulmonary barotrauma or near drowning, a more efficient O<sub>2</sub> delivery system is necessary.

This can be achieved by a **demand valve**, an O<sub>2</sub> circuit incorporating a **rebreathing bag**, or a bag–valve–mask device with an O<sub>2</sub> inlet and a reservoir bag with a very high O<sub>2</sub> flow rate.

### Demand Valves

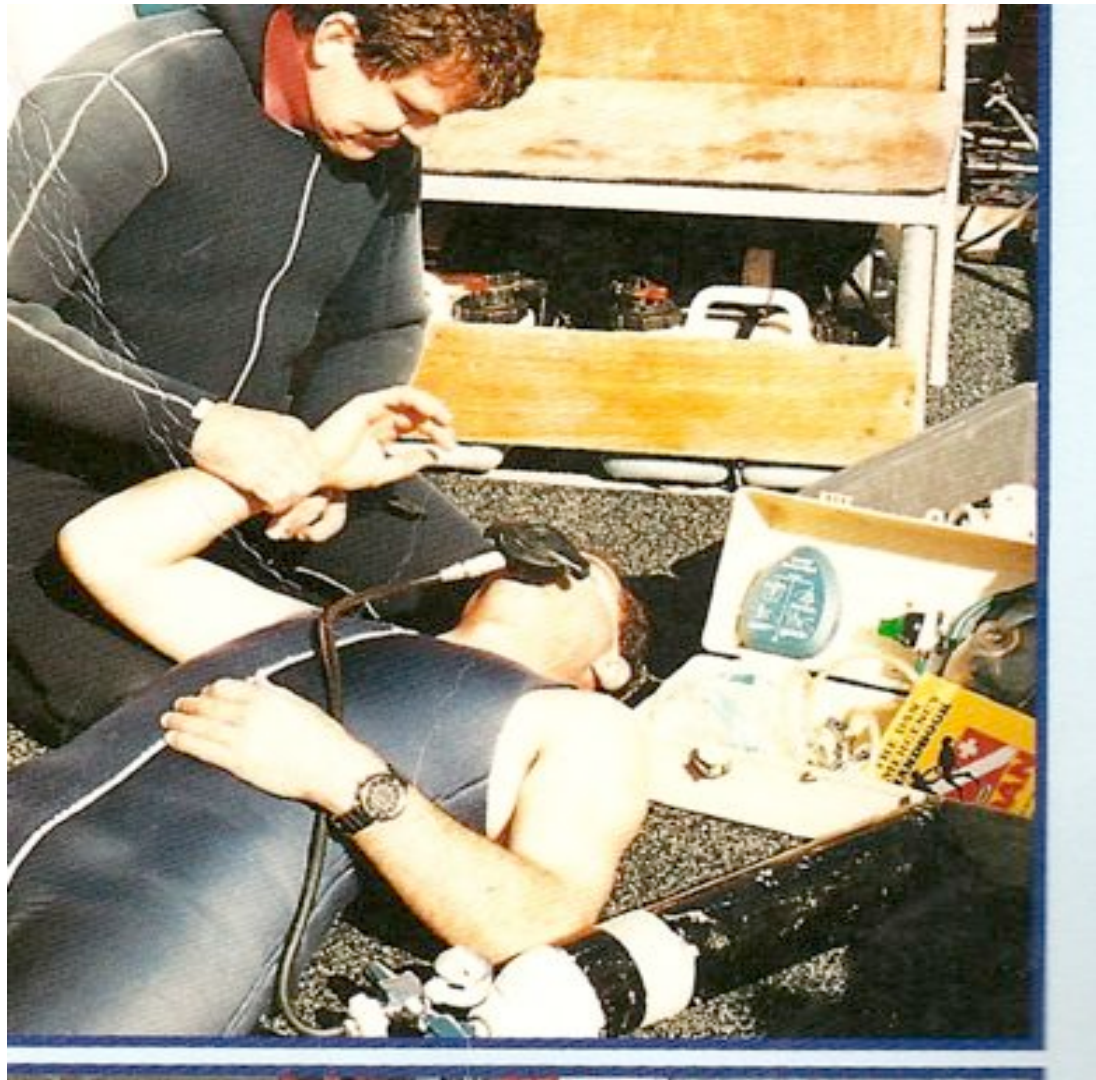
The simplest and most effective way to deliver 100% O<sub>2</sub> is via a **demand valve** - like a second stage regulator.

Some demand valves have been specially designed for O<sub>2</sub> administration. Some, such as the Oxiden and LSP demand valves, are designated to provide O<sub>2</sub> only to spontaneously breathing patients. Others, such as the Robert Shaw (which is used on the Oxy Viva, marketed in Australia) and the Elder demand valves, can produce 100% O<sub>2</sub> to a spontaneously breathing patient as well as provide O<sub>2</sub> resuscitation to a non-breathing casualty via a manual trigger. DAN also supplies an oxygen kit with this type of valve.

These demand valves are usually used with a tight fitting anaesthetic type mask. However, some can be fitted with a scuba mouthpiece to provide O<sub>2</sub> to a breathing diver (in this case the diver's nose should be sealed with a nose clip or by some other means).

In an emergency in remote locations, certain demand valves can be adapted to deliver O<sub>2</sub>, with an adaptor connected to an O<sub>2</sub> reducing valve, or alternatively by connecting the diver's first stage regulator to an O<sub>2</sub> cylinder, using the specialised adaptor. It is essential if this system is used that all components in the breathing system (including the lubricants) are O<sub>2</sub>

compatible. Otherwise the diving illness may be complicated by fire, explosion, or shrapnel injuries. When using this type of system the regulator should be tested for safety by purging it before anyone breathes from the system.



**Fig. 40.2**

A system designed by DAN (USA) specific for divers and incorporating a demand valve for 100% O<sub>2</sub> inhalation. The diver must be breathing spontaneously.

## **Rebreathing System**

Oxygen use can be reduced if the diver breathes from a system which permits him to rebreathe some of his exhaled gas. This requires the nitrogen to be flushed from the breathing circuit after a few minutes rebreathing, and the exhaled CO<sub>2</sub> to be absorbed in a soda line (or similar chemical) canister. There are commercially available units using this system. Technical divers frequently use diving sets that can be used for 100% O<sub>2</sub>.

## PSA Oxygen Concentrator

These devices use a molecular sieve to filter nitrogen from air and deliver high concentrations of oxygen. They are available in a portable size and can be battery powered.

## Bag-Valve-Mask Respirator

These devices comprise a self inflating rubber or plastic bag and a valve system which allows the patient to be ventilated with air through a mask by squeezing the bag. Oxygen can be piped into the circuit to increase the inspired O<sub>2</sub> concentration. If a reservoir bag is attached to the inflation bag, the inspired O<sub>2</sub> concentration can be increased to almost 100% by using a large O<sub>2</sub> flow (approx. 12–14 litres per minute), providing a good seal is achieved and the patient's respiratory volume is not excessive. The valve system also allows the patient to breath spontaneously from the device. Details of the operation of these devices vary between manufacturers and are outlined in the instruction manual supplied.



**Fig. 40.3**

A resuscitator showing anaesthetic-type mask, hand-squeezed breathing bag, oxygen reservoir bag and head strap to secure mask to diver's face.

## Multiple Systems

Most countries have a variety of multi-purpose near 100% O<sub>2</sub> delivery systems available. Aga, AG, CIG, Ambu, LSP, Drager and Laerdal and DAN manufacture such units. Self-contained O<sub>2</sub> therapy units and resuscitation devices are now available with a demand valve allowing the patient to either breathe spontaneously out of the device, be given positive pressure ventilation by manual pressure, or use a breathing bag. A flow meter can be fitted to another part of the system, to allow O<sub>2</sub> to be delivered to a mask at a high continuous flow rate. The details vary between resuscitators and are explained in instructions supplied with them. The entire device should be contained in a sturdy rustproof metal or heavy duty plastic box which is compact, water resistant and easy to carry. It should have an adaptor and be able to be supplemented by connection to a larger O<sub>2</sub> cylinder, if necessary.

## GENERAL INFORMATION

### Oxygen Toxicity

(See Chapter 21). 100% O<sub>2</sub> will cause some reversible damage to lungs after 18–24 hours. This has to be balanced against the benefit of the condition being treated and this will usually be physician's decision. If medical advice cannot be obtained, in decompression sickness and gas embolism cases, or with near-drownings or carbon monoxide toxicity, O<sub>2</sub> toxicity is generally the lesser of two evils, and it is usually best to continue giving 100% O<sub>2</sub> until expert advice to the contrary is given.

Oxygen toxicity is generally not a consideration with low concentration devices as they do not delivery much more than 40% O<sub>2</sub>, which is probably below the threshold for toxicity for the estimated duration of exposure.

### Contraindications to O<sub>2</sub> Therapy

In addition to the problems of O<sub>2</sub> toxicity, there are some problems associated with oxygen usage in the general community.

There is a theoretical risk to premature babies (eye damage) and to sufferers of emphysema (respiratory depression). Neither of these groups are numerous in the diving population.

In recent years a problem of sensitivity to O<sub>2</sub> has emerged in cancer sufferers who have been treated with the drug **Bleomycin**, and similar substances. These people can suffer from severe, permanent lung damage if given O<sub>2</sub> in concentrations greater than 21% (air). This problem is not likely to be frequently encountered, as these people should be excluded from scuba diving.

### Practicalities of O<sub>2</sub> Administration

The main disadvantage of resuscitation apparatus is the limited O<sub>2</sub> supply available from the contained O<sub>2</sub> cylinder, because sufficient O<sub>2</sub> must be supplied to allow for transport of the diver from the accident site to an appropriate medical facility. This can be overcome by carrying additional cylinders or by an adaptor which allows a connection to a larger O<sub>2</sub> cylinder. Estimate the rate of consumption of O<sub>2</sub>, the supply available, and plan accordingly. During transport, and whenever O<sub>2</sub> is given, attention must be paid to adequate ventilation to prevent O<sub>2</sub> build up to dangerous levels.

All divers are encouraged to undergo additional training in resuscitation and O<sub>2</sub> administration. This should be mandatory for dive masters and dive instructors.

Cases such as gas embolism and decompression sickness generally require **100% inspired O<sub>2</sub>** from the outset. A system capable of delivering 100% O<sub>2</sub> must be chosen. Even then, an ill fitting mask may allow air to be breathed around the seal, diluting the O<sub>2</sub>. Attention to the mask fit and attachment is necessary to prevent this. It is especially likely if the patient sleeps. If a demand valve is used, make sure the patient does not breathe air through the nose at the same time. This can be prevented by using a nose clip (improvise if necessary) or a diver's face mask.

Whenever O<sub>2</sub> is administered there is a serious **fire hazard** since increased concentrations of O<sub>2</sub> accelerate burning and can make ordinarily non-combustible materials burn furiously. The area where the O<sub>2</sub> is administered should be well ventilated and sources of ignition and combustible materials (including cigarettes) should be avoided. The system should be turned on slowly and should be tried and running before it is applied to the patient's face.

Further information may be obtained from the text "Oxygen First Aid for Divers" — by John Lippmann, J.L. Publications, Australia.



Guedel Airways

**Fig 40.4**

**A portable oxygen resuscitator. This system allows positive pressure ventilation with 100% O<sub>2</sub> for a non-breathing diver, or passive demand supply for a breathing diver. A long supply hose can be fitted to a larger cylinder containing 100% O<sub>2</sub> for prolonged use. The airways and suction appliance are included**