Oxygen Therapy

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SUMMARY

Oxygen, properly administered, often is a valuable therapeutic agent in many conditions such as hemorrhage, heart disease, respiratory diseases, anemia, shock, infection with fever and others in which there is direct or indirect interference with normal oxygenation of tissues.

In severe heart disease or acute respiratory conditions, administration of oxygen under pressure may be necessary in order to deliver the required amount to the tissues in want. For conditions in which oxygen want is less critical, 50 per cent concentration of the gas in the inspired atmosphere is effective and more easily carried out.

Patients with chronic heart disease may be greatly helped by taking oxygen at home under the direction of a physician.

OXYGEN is a drug and there are indications for its use and techniques for its administration, but there appears to be no contraindication. Oxygen as it is given clinically has no harmful effects. Although it is possible to produce toxic symptoms experimentally after 18 to 24 hours of continuous administration of 100 per cent oxygen, the problem of the practicing physician is how to get therapeutic concentrations.

INDICATIONS FOR OXYGEN THERAPY

Any situation in which the patient cannot supply adequate tissue oxygenation without the expenditure of energy beyond the ordinary effort of normal respiration constitutes an indication for oxygen therapy. It is apparent that this definition includes a multitude of clinical situations.

To list all the conditions in which oxygen is of benefit to the patient would be extremely time-consuming, but it is worth while to consider at least the classes of pathological states in which oxygen has definite value.

1. Hemorrhagic conditions in which the total quantity of hemoglobin is diminished, resulting in increased respiratory rate and tachycardia—both energy-consuming phenomena.

2. Cyanotic states in which the quantity of blood presented to the lungs does not become saturated, or in which the circulation is so impaired that the circulating blood is excessively desaturated. These conditions may be produced by a variety of clinical conditions such as (a) obstruction of air passages at any point, including an alveolus, (b) paralysis or paresia with a resulting loss of power of the muscles of respiration with a reduction in alveolar dilution, (c) cardiac or circulatory failure, including shock, resulting in a slowing of the circulation.

3. Demand states, which include fever, hyperthyroidism and other conditions in which none of the foregoing conditions exist, but in which the effort required to produce normal content of oxygen in the blood is at an ever-increasing cost in terms of energy expended.

4. Energy-sparing states including cardiac and respiratory conditions in which the patient gets along all right at a reduced level of activity but fatigues rapidly if that level is exceeded. Some patients with valvular heart disease, angina, and coronary disease are examples as are patients with asthma, emphysema, or fibrotic disease of the lungs.

MECHANISM OF ACTION OF OXYGEN THERAPY

It is not difficult to visualize the manner in which increasing the oxygen tension of inspired air is of benefit in conditions wherein the blood in its course through the lungs does not normally become exposed to a sufficiently high oxygen tension to thoroughly oxygenate it, as is the case in cyanotic conditions. When the oxygen content of the inspired air is increased, some of the nitrogen is displaced and the amount of oxygen in relation to the area of the lungs is increased. Thus, in these situations the elimination of carbon dioxide is enhanced by the effect that oxygen has on the dissociation of carbon dioxide from hemoglobin.

Less obvious are the reasons for the value of oxygen therapy in hemorrhagic conditions and in demand states and energy-sparing states. Probably that is why it is too little used in those conditions. For, although the hemoglobin is fully oxygenated as determined by tension studies, the amount of oxygen delivered to the tissues is subnormal. In anemia and other hemorrhagic conditions, even though every available gram of hemoglobin be saturated, there may be too little hemoglobin to carry enough oxygen for normal oxygenation of tissue. In demand and energy-sparing conditions, both oxygen tension and the content of oxygen in the blood may be within normal limits yet the tissues receive less than is needed. In the case of demand states, this is because of the inability of normally saturated blood to supply sufficient oxygen to the tissues without an increase in the rate of circulation of the blood—and to increase the rate would entail increased demand. In the energy-sparing states the reason for deficiency in tissue oxygenation in the presence of normal con-

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tent of oxygen in the blood is that the heart or lungs cannot do more than a limited amount of work without fatigue or failure and the patient spares the heart and lungs by curtailing activity to a comfortable level.

The value of oxygen therapy in these conditions rests in the fact that plasma has the ability of carrying oxygen in a small but significant amount, and the amount is determined by the tension of oxygen in the inspired air. The tension of oxygen in the plasma is, in the final analysis, the important factor in tissue oxygenation, for hemoglobin does not supply oxygen directly to tissues. Hemoglobin gives up oxygen to the plasma in direct proportion to the difference between oxygen tension of the plasma and that of the surrounding tissues: Plasma gives up oxygen to tissue with less oxygen tension, and the oxygen tension of the plasma is replenished from the oxygen carried in hemoglobin. The process is continuous until equilibrium is reached.

It has been observed that the administration of 100 per cent oxygen to non-cyanotic patients for as little as five minutes will increase the oxygen content of the whole blood to 110 per cent of its calculated capacity. The surcharge comes about entirely through an increase in the amount of oxygen in the plasma, which is in direct proportion to the oxygen tension in the inspired atmosphere. Often the increase thus attained makes the difference between hypoxia and adequate oxygenation.

Why oxygen therapy for periods of 15 to 20 minutes two or three times a day is so effective in relieving symptoms in patients with chronic cardiac and respiratory conditions is not clear, but that it is has been demonstrated many times. To illustrate:

A patient with severe mitral stenosis became thoroughly fatigued and mildly dyspneic on effort and could tolerate little activity. When 100 per cent oxygen was given by mask for 20-minute periods three times a day the patient more than doubled the degree of activity without dyspnea or evidence of fatigue. She was able to lie supine without discomfort, although she otherwise slept propped with several pillows. The organic state of the heart was not improved, but the patient was enabled to lead a more useful life.

METHODS OF ADMINISTRATION

The effectiveness of oxygen therapy depends upon the means of administration and the concentration of the gas in the inspired atmosphere. It is frequently desirable to administer 100 per cent oxygen, and in certain circumstances at increased pressure during the inspiratory phase. Therapy of that kind is particularly useful in cases of respiratory obstruction and in some energy-demand states such as acute heart failure or severe shock.

For administration of 100 per cent oxygen at or above atmospheric pressure it is necessary to use a face-fitting mask or other gas-tight mechanism such as an endotracheal tube. The flow of oxygen must be equal to or greater than a patient's minimum respiratory volume. It is, therefore, an expensive technique. There must be a reservoir bag in the system to accommodate the demand for instantaneous flow on inspiration, and this system must have a capacity equal to or larger than the patient's tidal air. Most commercial systems such as those made by Oxygen Equipment Manufacturing Corporation or Bennett-Megee have bags of 750 to 1,000 cc. capacity when they are distended and the gas flow is adjusted so that the bag is not quite collapsed at the end of the inspiratory phase.

Owing to the presence of water vapor and carbon dioxide, even though the inhaled atmosphere is 100 per cent oxygen by volume the maximum concentration that can be delivered to the alveoli is about 90 per cent.

By the use of intermittent positive pressure, the plasma content of oxygen can be made greater than is possible by other means. In this procedure, oxygen is delivered under pressure 5 to 20 cm. (water) more than atmospheric pressure. The technique requires apparatus with special valves, but it is very effective in cases in which not only high oxygen concentration but augmented ventilation is needed—for treatment of patients with carbon monoxide or barbiturate intoxication, for example.

Since it is necessary that close-fitting masks be used in the techniques described, it is important to guard against the possibility of stoppage of the flow of oxygen and to maintain constant supervision.

For the administration of oxygen in concentrations of from 100 per cent to 40 per cent the Oxygen Equipment and Bennett-Megee appliances are equipped with dilution orifices. The orifice is opened enough to supply the desired concentration and the oxygen flow is adjusted to keep the breathing bag properly filled. It is also possible, by special adaptation, to use the intermittent positive pressure apparatus for administration of concentrations of oxygen down to 20 per cent.

A more commonly used technique is the administration of oxygen through a catheter or a loose-fitting face-piece such as a Lombard mask. By such means, more acceptable to the patient and less demanding of supervision, oxygen concentrations of up to 40 per cent in the inspired atmosphere can be obtained. For supportive therapy in conditions such as fever and hyperthyroidism, and in postoperative recovery periods they are generally satisfactory. To supply concentrations of 30 to 40 per cent in the inspired atmosphere, oxygen flow of 7 or 8 liters per minute is necessary for the average adult. If given in lesser quantity, it is essentially wasted; if in greater, the flow of the oxygen may be extremely uncomfortable.

Because rapidly flowing oxygen dries mucous membrane, it should be humidified by passing it through fine orifices in a humidifier before it is administered. It is unwise to give oxygen by nasal catheter in cases in which the patient has suction tubes placed in the nose, for the restlessness that is

caused thereby, due to additional irritation, may in itself increase the oxygen requirements and defeat the purpose.

Oxygen tents have definite value in certain instances, particularly if cooling of the environment of the patient is desired. Supplying oxygen by this means is expensive and usually not satisfactory because of the meticulous attention required and the difficulty of keeping the tent gas-tight. The newer clear plastic hoods that seal about the neck, leaving the patient free to turn or be turned, are more effective for oxygen administration where other techniques are not feasible. With the hoods, the maximum concentration that can be obtained is 50 or 60 per cent.

Administration of oxygen intravenously was recently revived by Cole. The big problem with this technique is to introduce oxygen in bubbles so small that the gas is rapidly absorbed by the blood. Other methods of parenteral administration of oxygen have not been satisfactory.

Except in cases in which oxygen is used regularly two or three times a day, patients given oxygen therapy must be "weaned" ultimately in order that they may live on the amount of oxygen normally in the air. Abruptly discontinuing oxygen administration, and starting it again only if the patient obviously is in critical condition, is not in the best interest of the patient. If oxygen has been given at 100 per cent concentration, the concentration may be diminished and the pulse, respiration and blood pressure carefully observed. If the pulse rate and the respiration rate increase (the blood pressure may or may not decrease), the oxygen tension should be increased and then gradually diminished over a period of hours, with the pulse and respiratory rate as guides. The color of the skin is an unreliable and tardy indication of the condition of the patient. For patients who have been getting oxygen in 40 to 50 per cent concentration, weaning may be accomplished by turning the flow off for ten minutes, then on for ten minutes and gradually shortening the periods of flow until air alone is sufficient.

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REFERENCE

Cole, F.: Intravenous oxygen, Anesthesiology, 12:181-188, March 1951.