MEASUREMENT OF BLOOD OXYGEN TENSION: HANDLING OF SAMPLES

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MEASUREMENT OF BLOOD OXYGEN TENSION

Much has been written on the changes and the significance of the blood carbon dioxide tension (Pco₂) during anaesthesia. Far less has been written about the oxygen tension (Po₂) although it is clear that a shortage of oxygen is far more dangerous than an excess of carbon dioxide. Lack of quantitative interest in oxygen is related to the dearth of measurements of Po₂ during anaesthesia and this stems from two principal causes. Firstly, many anaesthetists believe that they can assess the oxygenation of the patient with sufficient accuracy by watching for the development of cyanosis. Secondly, the estimation of blood Po₂ has been much more difficult than the estimation of Pco₂, particularly during nitrous oxide anaesthesia with high saturation of haemoglobin. However, in the last few years, the development of the polarograph has revolutionized the situation and it is now relatively simple to measure blood Po₂ throughout the range from 0 to 713 mm Hg in the presence of any anaesthetic agent.

TENSION, CONTENT, CAPACITY AND SATURATION

In the case of carbon dioxide, tension is much more important than content and the anaesthetist tends to focus his attention exclusively upon the tension. With oxygen the position is different. Tension is still important as the pressure head at which oxygen is delivered to the tissues. Content, however, is at least equally important as it governs the amount of oxygen which is made available to the body in unit time. This quantity, which may be called the “oxygen flux”, is the product of cardiac output and arterial oxygen content. The normal value is about 1,250 ml/min and it is clearly essential that the oxygen flux be maintained at a value which is comfortably in excess of the metabolic requirement. The capacity is the level to which the oxygen content rises when the blood is fully oxygenated and is, in fact, a function of the haemoglobin concentration. Finally the saturation is the link between tension and content and is also important because it is much the easiest to measure of the quantities we have discussed.

Oxygen tension (Po₂). The oxygen tension of a liquid may be defined as the tension (partial pressure) of oxygen in a gas mixture which is in equilibrium with the liquid. The units of measurement are those of pressure and are customarily expressed in millimetres of mercury. In a gas mixture, tension of a gas equals the total pressure multiplied by the fractional concentration of the gas. The Haldane apparatus indicates the fractional concentration of oxygen (Fo₂) in the dry gas phase of a gas mixture. The Po₂ of a gas mixture at a total pressure Pb, when saturated with water vapour at 37°C, is therefore

\[(Pb - 47) \times Fo₂ \quad \ldots \ldots \ldots (i)\]

47 mm Hg being the saturated vapour pressure of water at 37°C. For example, the Po₂ of air or of a liquid in equilibrium with air at normal barometric pressure and saturated with water vapour at 37°C is

\[(760 - 47) \times \frac{20.93}{100} = 149 \text{ mm Hg} \quad \ldots \ldots \ldots (ii)\]

Oxygen content (Co₂). The oxygen content of blood is the quantity of oxygen which may be extracted by vacuum from unit volume of blood. It is normally expressed in volumes of oxygen at standard temperature and pressure (dry) contained in 100 volumes of blood. The oxygen content of blood consists of two parts—oxygen in physical solution and oxygen in reversible chemical combination with haemoglobin. Oxygen in physical solution amounts to 0.003 vol per cent/mm Hg Po₂, when solution takes place at 37°C.
Oxygen capacity. The oxygen capacity is the volume of oxygen (STPD) carried by 100 volumes of blood after saturation with room air. The $P_{O_2}$ of room air is sufficient for almost complete conversion of haemoglobin to oxyhaemoglobin providing the temperature is down to about 20°C. Oxygenation is also aided by the low $P_{CO_2}$ which would result from exposure of blood to room air. It should be noted that a $P_{O_2}$ of about 300 mm Hg is required for complete oxygenation of haemoglobin at 37°C and a $P_{CO_2}$ of 40 mm Hg. The oxygen capacity includes oxygen carried by haemoglobin and oxygen in physical solution. After equilibration with room air, the latter amounts to 0.45 vol per cent at 37°C and 0.70 vol per cent at 20°C. Oxygen capacity less the oxygen in physical solution is directly proportional to the haemoglobin since 1 g of haemoglobin combines with 1.34 ml of oxygen (STPD).

Oxygen saturation ($S_{O_2}$). The saturation is often loosely defined as

$$\text{oxygen content} \times 100 \quad \ldots \quad \ldots \quad (\text{iii})$$

$$\frac{\text{oxygen capacity}}{\text{oxygen in combination with haemoglobin}} \times 100 \quad \ldots \quad (\text{iv})$$

or

$$\frac{\text{oxygen content} - 0.003 P_{O_2} \times 100}{\text{oxygen capacity} - 0.7} \quad \ldots \quad (v)$$

(assuming that the body temperature of the patient was 37°C and that equilibration with room air for determination of capacity had taken place at 20°C).

$P_{O_2}$ and $S_{O_2}$ are linked by the oxygen dissociation curve (fig. 1). The curve is displaced to the

![Oxyhaemoglobin dissociation curves showing the displacement which results from uncompensated changes in $P_{CO_2}$.](https://academic.oup.com/bja/article-abstract/34/9/621/238947)
right by low pH, high Pco₂ and hyperthermia. It is displaced to the left by high pH, low Pco₂ and hypothermia.

MEASUREMENT OF BLOOD PO₂

**Equilibration method.**

Historically the earliest method of measurement of blood PO₂ is by equilibration of a large volume of arterial blood with a small gas bubble, followed by determination of the oxygen concentration of the bubble. The product of the dry barometric pressure and the fractional concentration of oxygen in the bubble then indicates the PO₂ of the blood. The technique in its latest development requires only 1 ml of blood and a bubble of 5 to 10 microlitres (Riley, Campbell and Shepard, 1957). It has been customary to measure the gaseous composition of the bubble by chemical absorption in a capillary tube where the length of the bubble is proportional to its volume before and after absorption of each constituent. Currently, physical methods of gas analysis are being investigated (Strang, 1961) and it is hoped that they will avoid the severe technical difficulty of the chemical absorption technique.

For the equilibration method to be a practicable possibility, it is important that the volume of the blood is reasonably small and yet the volume of the gas bubble is sufficiently large for analysis. The customary ratio of blood/bubble volume is about 100/1 but even under these conditions an appreciable transfer of gas to or from the bubble may significantly alter the gas tensions of the blood by the time equilibration is complete. This source of error is minimized by ensuring that the gas tensions of the bubble at the start of equilibration are close to the expected gas tensions of the blood. Barcroft and Nagahashi (1921) used alveolar gas for the initial bubble, while Riley (Riley, Campbell and Shepard, 1957) preferred to use a standard mock alveolar gas mixture and apply a correction factor to the final gas bubble tension depending on how much it deviated from the tension of the initial gas mixture. In either case there are serious difficulties when the PO₂ is in excess of about 95 mm Hg. Above this tension the dissociation curve is so flat that even small transfers of oxygen cause a large change in the PO₂ of the blood (fig. 1). Thus above a PO₂ of 95 mm Hg it is generally accepted that the equilibration method cannot be used. This is not a serious limitation in patients breathing air (particularly if their oxygenation is impaired) but it is a major disadvantage in anaesthetized patients who frequently have an arterial PO₂ in excess of 100 mm Hg.

The presence of nitrous oxide in the blood of patients introduces serious difficulties into the use of the equilibration technique for measurement of PO₂. Firstly, if the PN₂O of the initial bubble is considerably different from that of the arterial blood (as is likely to be the case) there will be a large volume change in the bubble and this is a serious source of error. Furthermore, the gas bubble after equilibration will contain nitrous oxide and this appears to be an insuperable obstacle to its chemical analysis within a capillary tube (Nunn, 1958).

Thus it will be seen that the equilibration method is not at all well suited to the conditions of anaesthesia and indeed has only been used during anaesthesia when inhalational agents were avoided (Campbell, Nunn and Peckett, 1958).

**Interpolation (indirect) method.**

The oxygen tension of blood may be determined by interpolation of the saturation in the oxyhaemoglobin dissociation curve (fig. 1). It is necessary to know the following:

1. The saturation.
2. The position or intercept of the dissociation curve.

Saturation is classically determined from content and capacity as indicated above (v). However, the determination of oxygen content or capacity by the manometric method of Van Slyke and Neill (1924) is so time-consuming that much thought has been devoted to the development of alternative methods (Nilsson, 1960).

Photometric methods of determination of saturation are based on the following relationship:

\[
\text{percentage saturation} = \frac{\text{HbO}_2}{\text{Hb} + \text{HbO}_2} \times 100 \quad \text{(vi)}
\]

The optical density

\[
\log_{10} \left( \frac{\text{intensity of incident light}}{\text{intensity after transmission}} \right)
\]

of a solution is directly proportional to the concentration of a light-absorbing solute. Thus for light of a wavelength at which the absorptions of Hb and HbO₂ are different.
percentage saturation = \frac{DHb - Dmixed}{DHb - DHbO_2} \times 100 \ (vii)

where DHb is the optical density of the blood sample when totally reduced, Dmixed is the optical density of the blood sample as drawn, and DHbO_2 is the optical density of the blood sample when fully oxygenated. There is, therefore, a linear relationship between oxygen saturation and optical density: the slope is steepest (and the sensitivity greatest) with light of wavelength about 6,100 Å at which there is the greatest difference between the optical density of Hb and HbO_2. The slope will also depend upon the total haemoglobin concentration. Three measurements are required:

1. Optical density of blood sample as drawn.
2. Optical density of blood sample after full oxygenation.
3. Optical density of blood sample after full reduction.

Full oxygenation may be attained by passing a stream of oxygen or air through the blood at room temperature. Reduction is usually accomplished with sodium hydrosulphite (Dithionite) (Wade et al., 1953).

Alternatively the total haemoglobin concentration (Hb + HbO_2) may be derived from the optical density of the blood to light of isobestic wavelength (e.g. 8,000 Å in the infra-red range) at which the absorptions of Hb and HbO_2 are identical (Catton, 1957). The use of monochromatic light is preferable and prisms or diffraction gratings may be used. However, it is cheaper to employ filters which pass a broad band of the spectrum. For determination of optical density, the blood should be diluted and haemolyzed, the solution used for this purpose being gas-free.

There has been considerable development, chiefly in Holland, of the use of reflected light for determination of saturation. This technique offers certain advantages. Firstly, the intensity of the reflected light is, under certain circumstances, largely independent of the total haemoglobin concentration and the logarithm of the intensity of the reflected light bears a linear relationship to the saturation over a wide range. Secondly, the change in light intensity per unit change in saturation is much higher than with the transmission method. Thirdly, haemolysis of the sample is unnecessary. Light of only one wavelength is required and the highest sensitivity is again in the region of 6,100 Å. Reference should be made to the monograph of Zijlstra (1958).

Clinical estimation of saturation is notoriously difficult (Comroe and Botelho, 1947). It is true that dangerous hypoxia is unlikely to occur without cyanosis becoming apparent. However, the saturation may fall to 80 per cent without cyanosis being noticed by either surgeon or anaesthetist. Since this is accompanied by a fall of Po_2 to about 45 mm Hg, it is clear that the appearance of cyanosis is of limited value for the estimation of Po_2. Cyanosis does, however, indicate that the patient’s slender reserves of oxygen are exhausted and that the stage is set for a precipitous descent down the steepest part of the dissociation curve. It is thus a sign which should not be elicited during anaesthesia.

Desaturation may be more accurately detected with an ear oximeter. These devices commonly use the two wavelengths detailed above, and thereby avoid the necessity of making a control reading at zero saturation! Results in normal patients are reasonably good, but unfortunately ear oximetry is less reliable in the presence of certain pathological conditions. Thus, in the presence of a large shunt it may be impossible to make a control reading at 100 per cent saturation. The chief drawback is that the saturation of the blood in the ear is flow-dependent and, under certain conditions, vasoconstriction may occur in spite of local heating and histamine iontophoresis. The problem is rather similar to the determination of arterial Pco_2 by sampling of venous blood from the back of the hand or capillary blood from the ear (Brookes and Wynn, 1959; Cooper and Smith, 1961).

The oxygen tension is derived by interpolation of the value for the saturation in the oxyhaemoglobin dissociation curve. While it is assumed that the shape of the dissociation curve does not change, it is well known that it may be markedly displaced to the right or left by changes in pH, Pco_2 or temperature. It is, therefore, essential that the temperature and, if possible, both the pH and Pco_2 of the blood be known before interpolation can be attempted. Dissociation curves under various conditions of temperature and pH can be prepared from the data of Severinghaus in the Handbook of Respiration (Dittmer, 1958).
The major limitation in the determination of \( P_O \), from \( S_O \), results from the flatness of the dissociation curve in its upper range. Accuracy is high up to a \( P_O \) of 50 mm Hg (\( S_O = 85 \) per cent) and compares favourably with any other available method. However, above this level the accuracy rapidly declines up to a \( P_O \) of 75 mm Hg (\( S_O = 95 \) per cent) beyond which the interpolation method is of little value.

From the anaesthetist's point of view, the interpolation method is attractive because of the simplicity of measurement of \( S_O \) by photometric techniques. Furthermore, the technique is quite uninfluenced by the presence of anaesthetic agents. However, the application of the method is limited by the high arterial \( P_O \) which is found in a well-conducted anaesthetic. Nevertheless, the method is satisfactory under conditions of moderate desaturation and has been used by Frumin et al. (1959) in a study of alveolar-to-arterial \( P_O \) gradients during anaesthesia.

**\( P_O \) from plasma oxygen content.**

Since the plasma oxygen content is a function of the \( P_O \), this measurement can be used to derive the \( P_O \) from the expression

\[
P_O = \frac{\text{plasma } O_2 \text{ content}}{\text{solubility factor}}
\]

At 38°C, the solubility factor is usually assumed to be 0.003 vol per cent/mm Hg. The obvious advantage of the method is that it is independent of the shape of the oxyhaemoglobin dissociation curve and is, therefore, applicable to oxygen tensions above the range of the methods previously described. Unfortunately, the accuracy is severely limited by the small amount of oxygen in the plasma. The normal amount in arterial blood is only 0.3 vol per cent and this approximates to the degree of repeatability obtainable between duplicate estimates of oxygen content with the van Slyke manometric apparatus. Alternatively, the spectrophotometric method of Smith and Pask (1959) may be used for the determination of plasma oxygen content (Stark and Smith, 1960), although no information is available concerning the accuracy of the determination of \( P_O \) by this method. This technique requires centrifuging of blood and raises difficult problems of anaerobic handling, oxygen consumption by the blood, and partitioning of oxygen between cells and plasma at different temperatures. Large errors would be introduced by small degrees of haemolysis.

**Polarography principle.**

Polarographic estimation of the concentration of substances in aqueous solution is based on the measurement of the current passed by an electrolytic cell at various applied voltages. Oxygen is one of a very large number of substances which can be estimated in this way. Figure 2 shows the current passed when a steadily increasing voltage is applied to an electrolytic cell consisting of a platinum cathode, a silver/silver chloride anode and an electrolyte which, at the surface of the cathode, has been equilibrated at various tensions of oxygen. It will be seen that the current rises to a plateau between an applied voltage of 500 and 900 mV. Over a part of this range, the plateau height is a linear function of the \( P_O \). A small background current passes when the electrolyte is at zero \( P_O \). For further details of the principles of polarography as applied to \( P_O \) measurement, reference should be made to Milner (1957) and Bishop (1961).

**Electrodes.** The first type of electrode to be used for biological measurement of \( P_O \) was the dropping mercury electrode. It has now been superseded but it was used during anaesthesia by Gordh, Linderholm and Norlander (1958), who give a valuable list of references relating to the technique. The principal difficulty in the polarographic estimation of blood \( P_O \) is poisoning of the electrode by erythrocytes and proteins. This is best prevented by separating the electrodes and electrolyte from the sample with a membrane permeable to oxygen (Clark, 1956). A typical electrode assembly of this type is shown in figure 3.

**Measurement of signal.** The current passed by the electrode may be measured with a mirror galvanometer but this is rather inconvenient. A more suitable method is to measure the potential difference across a resistance in the circuit. This will indicate the current by Ohm's law. Apparatus used for measurement of pH is suitable for this purpose.

**Cuvette.** The design of the cuvette is of the greatest importance since the response of the electrode is dependent on temperature, flow and pressure. At a given \( P_O \) the current passed by the electrode is increased by 4–10 per cent per °C.
Polarograms obtained when the electrolyte at the surface of the cathode is equilibrated with gas mixtures of different oxygen content. The background current at zero Po\textsubscript{2} is higher than usual. Inset is shown the circuit used in this experiment. V is a voltmeter indicating the polarizing voltage (mV). G is a mirror galvanometer measuring the current passed (\( \mu \text{A} \)).

A typical polarographic electrode assembly for the measurement of Po\textsubscript{2} of gas mixtures or blood. The sample is separated from the electrolyte by a polyethylene membrane.
It is, therefore, essential to control the temperature as carefully as possible and certainly to within $\pm 0.1^\circ C$. This may be done either by immersing the cuvette in a thermostatically controlled water bath or by perfusing it with water at constant temperature. The output (current) is almost independent of small variations in the flow of a gas through the cuvette. It is, however, markedly dependent upon flow of liquids and falls rapidly when flow ceases. This is due to local depletion of oxygen in the boundary layer of liquid next to the membrane—a result of the consumption of oxygen at the cathode. Constant readings may be obtained by vigorous stirring of liquids, either by a magnetically rotated rod (Bishop and Pincock, 1958) or with a directly driven rotating paddle (Severinghaus and Bradley, 1958). Stirring is an unwelcome complication and interest is presently focused on less permeable membranes and micro-electrodes of low oxygen consumption (and consequently low current output) which do not appear to need stirring (Polgar and Forster, 1960; Staub, 1961). Once the need for stirring is removed the design of the cuvette is considerably simplified and the electrode may be mounted in the end of a cardiac catheter (Kreuzer and Nessler, 1958) or within the lumen of an intra-arterial needle (Said et al., 1961). With the Clark type of micro-electrode, blood even when stirred gives an output 3–7 per cent less than that of water of the same $P_f$2. Water in turn usually gives a smaller signal than gas of the same $P_f$2. The Clark cell is little affected by moderate increases in pressure but gives a surge of current with transient falls of pressure such as may occur during the transfer of a liquid from a syringe into the cuvette. This is presumably due to momentary lifting of the membrane away from the surface of the platinum electrode. The cuvette must, therefore, be designed to keep the membrane firmly applied to the tip of the electrode. Figure 4 shows a suitable cuvette which is similar to that described by Bishop and Pincock (1958).

**Response time.** The response of the electrode is not a simple exponential and continues to change slightly for a considerable time. The first rapid phase of response is 90 per cent complete within about 10 seconds with a polyethylene membrane. Since drift is a major limitation of accuracy, it is necessary to compromise and it may be preferable to take all readings 30 seconds after introduction of a sample.

**Calibration.** Since gas, water and blood at the same $P_f$2 do not usually give the same output, it is theoretically desirable to calibrate with an aliquot of the patient's blood equilibrated with a gas of known $P_f$2 (Severinghaus and Bradley, 1958). Others prefer to calibrate with water equilibrated with gas of known $P_f$2 (air is suitable) and to make allowance for the previously mea-
sured difference in output between blood and water (Bishop, 1960). The most convenient method of calibration would be the use of a gas (such as air) of known Po$_2$. However, this presents considerable difficulty at the present time.

Influence of other substances. The output of a blood oxygen polarograph is not entirely uninfluenced by the Pco$_2$ of the sample. The effect is, however, very small and may be overcome by the use of the appropriate tension of carbon dioxide in the calibrating gas mixture. There is no evidence that the polarograph when used for measurement of Po$_2$ is influenced by anaesthetic agents. The background current is identical with nitrogen, carbon dioxide and nitrous oxide.

Accuracy. The accuracy of a method of measurement of blood gas tension can be assessed only by determinations on blood which has previously been equilibrated with gas mixtures of known tensions. The results of forty-eight such studies by Nunn and Caselle (unpublished) show a random error which appears to depend upon the actual Po$_2$. It is, therefore, best expressed as a coefficient of variation which is 5 per cent of the actual Po$_2$. Polgar and Forster (1958) and Bishop (1961) have reported a somewhat smaller scatter of results.

Scope. In three respects the polarographic method of determination of Po$_2$ would appear ideal for the conditions of anaesthesia. Firstly, it is uninfluenced by the presence of anaesthetic agents. Secondly, it may be used throughout the range of Po$_2$ encountered in anaesthetic practice (including high pressure oxygen). Thirdly, the results are immediately available.

SAMPLING, HANDLING, STORAGE AND TEMPERATURE

The most careful estimation of blood Po$_2$ is useless if the sample is not representative or if its Po$_2$ is changed during handling or storage. A large discrepancy will be introduced if Po$_2$ is measured at a temperature appreciably different from that of the patient.

Sampling. Arterial puncture may be carried out with almost any type of hollow needle. For repeated sampling a stilette may be passed or a flexible intra-arterial catheter may be passed over a solid nylon director. The brachial and radial arteries are equally suitable for puncture and it is exceedingly rare to hear of any complication. The femoral artery is rather easier to puncture and the site may be used in an emergency when it is not possible to enter the arteries of the arm.

Arterial puncture requires careful localization of the artery, followed by a slow steady advance of the needle: the movement required is quite different from the intermittent jerky advance of the needle in venepuncture. There is seldom any doubt when the artery is entered, as blood passes through the needle with considerable force. When the needle is withdrawn, firm pressure should be applied and maintained for 5 minutes by the clock. At the end of that time the site should be very carefully inspected for signs of haematoma formation, in which event the pressure should be continued for as long as is necessary.

In the unconscious patient the gas tensions of the arterial blood should not be altered by arterial puncture. With conscious patients this is not so and it is advisable to perform the puncture, leave the needle stiletted for several minutes and then sample after the patient has settled. Especially with high oxygen tensions, it is important that the sample be drawn without entraining air bubbles. Arterial puncture is far easier in this respect than venepuncture, since no suction is required.

Venous blood may give a reasonable indication of the arterial Pco$_2$ since the mean arteriovenous difference of Pco$_2$ is only 6 mm Hg. In the case of oxygen, however, the mean arteriovenous difference is ten times as great and the venous blood cannot, therefore, give a very good indication of the arterial Po$_2$. On the other hand, the venous Po$_2$ is an excellent index of the adequacy of arterial oxygenation and bloodflow in relation to the oxygen uptake of that part of the body from whose venous drainage the blood is sampled. In view of the wide difference in venous Po$_2$ in different part of the body (15–70 mm Hg), the significance of the level is lost if there is any doubt concerning the area of drainage of a venous sample.

Handling. Particularly with high and low Po$_2$, the sample must be carefully kept from contact with the air. The blood should be drawn directly into a syringe whose deadspace is filled with anticoagulant. The syringe should then be detached from the needle and the hub either plugged or
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apply a correction factor for the difference in temperatures at an angle of about 15° to prevent accidental aspiration of air.

Storage. The oxygen consumption of whole blood is sufficiently rapid to cause a fall in $P_{O_2}$ of about 3 mm Hg/min when fully saturated blood is stored at 38°C. The rate may be substantially reduced by cooling, and is almost zero at 0°C. However, it is important to warm blood stored in ice before it is introduced into a thermostatically controlled electrode assembly. Blood sediments rapidly in a syringe and this may be prevented by rolling. Mixing is aided by including mercury or a ball-bearing in the syringe. Particularly in the case of blood of high $P_{O_2}$, much of the most satisfactory solution is to analyze the blood as soon as possible after sampling.

Temperature. Changes in temperature alter the $P_{O_2}$ of a blood sample by about 6 per cent per °C (Bradley, Stupfel and Severinghaus, 1956). Thus it is usually necessary to measure the patient's temperature at the time of sampling and then to apply a correction factor for the difference in temperature between the patient and that at which the $P_{O_2}$ is actually determined.

When the electrode temperature difference is more than a few degrees Centigrade, the correction factor is very large and probably not reliable. During routine anaesthesia, body temperatures frequently fall to 33°C and, therefore, 36°C is a more suitable temperature for running an electrode (or bubble equilibration bath) than the conventional 38°C. With a body temperature of 27–33°C, it is advisable to drop the electrode temperature, and the author has found it convenient to switch off the heating element of the water bath during induced hypothermia. In profound hypothermia the accuracy of $P_{O_2}$ determination would be limited primarily by temperature gradients within the patient's body.

END-TIDAL AND REBREATHED SAMPLES

End-tidal samples are of limited value as an indication of the arterial $P_{O_2}$, since the arterial $P_{O_2}$ is normally at least 8 mm Hg below the (ideal) alveolar $P_{O_2}$. Furthermore, during anaesthesia the alveolar $P_{O_2}$ will in turn be significantly below the end-tidal $P_{O_2}$ for the same reasons that the alveolar $P_{CO_2}$ is above the end-tidal $P_{CO_2}$ (Nunn and Hill, 1959). Nevertheless, the end-tidal $P_{O_2}$ might be of some value as an indication of the approximate state of oxygenation. It will certainly be above the arterial $P_{O_2}$, and a low value will, therefore, indicate defective oxygenation. The rebreathing method of determination of $P_{CO_2}$ cannot be applied in the case of oxygen because of the large arteriovenous $P_{O_2}$ difference. Equilibration at the mixed venous $P_{O_2}$ would, furthermore, result in dangerous hypoxia.

REFERENCES


