arterial blood gases

O2 content & capacity

General:
- methods to measure oxygen content and capacity include:
(i) volumetric method
(ii) blood haemolysis
(iii) galvanic cell
(iv) calorimetric method

Volumetric method:
- has been used whereby the gases dissolved in a blood sample were liberated using lactic acid and vacuum extraction & the volume measured at a fixed atmospheric pressure
- technically difficult, time consuming and now rarely used

Haemolysis:
- a small sample of blood is added to a large volume (50ml) of potassium ferricyanide solution which haemolyses red cells and drives oxygen into solution
- by measuring the PO2 before and after adding the blood and knowing the solubility of oxygen in the solution, it is possible to calculate the oxygen content of the original sample

Galvanic cell system:
- oxygen content measurement is possible using a direct reading galvanic cell system. Here a carrier gas consisting of 1% carbon monoxide, 2% hydrogen & 97% nitrogen is passed over a palladium catalyst and bubbled through a haemolysed blood sample.
- the liberated oxygen is reduced at a carbon cathode which gives rise to four electrons per molecule of oxygen with the current proportional to the amount of oxygen in the sample

Calorimetric method:
- requires a 10ml sample of whole blood to be injected anaerobically into a sealed curvette containing an alkaline catachl solution and the change in absorbency at 511nm is measured
- from this a blank of fully reduced Hb has to be subtracted and this is obtained by injecting a similar volume of sample into an identical curvette containing 0.1M sodium hydroxide

preanalytic errors

Pre-analytic

Exposure to air bubbles, with oxygen diffusing in or out according to the tension gradient.
Contamination with line flush solution, prevented if the discard volume is 2–3 times the internal volume of cannula and tubing.
Extreme leukocytosis causing pseudohypoxaemia by excessive *in vitro* oxygen consumption.
Iced storage in polypropylene syringes (rather than glass) causing artefactual PaO_2 elevations. Cold increases plasma oxygen solubility, and the semi-permeability of the plastic allows oxygen ingress.[18]

analytic errors

Analytic

Inter-analyser variability is significant, with 7–8% measurement variation on the same sample.
Inadequate blood heparinization, allowing protein deposition on the electrodes.
Significant non-linearity of the Clark electrode when PO_2 >150 mmHg.
Maintenance of electrode temperature within narrow limits (37 ± 0.1°C) is critical. PO_2 changes by 7% for every degree Celsius temperature change.

Interference by nitrous oxide and halothane is minimal, provided the polarizing voltage of the electrode does not exceed 600 mV.
Quality control materials such as aqueous, perfluorocarbon and bovine haemoglobin solutions are used for convenience, but tonometry is the primary reference method.
Arterial blood gas tensions fluctuate constantly even in stable patients. Intermittent blood gas analysis provides only a snapshot of a continuously changing variable.

serum measurement of oxygen tension

General
- can be measured using:
(i) oxygen electrode
(ii) transcutaneous electrodes
(iii) fluorescence-based blood gas analysis
(iv) ion-selective electrodes

Oxygen electrode (Clarke's electrode)
- consists of a platinum wire normally 2mm in diameter embedded in a rough surfaced glass rod which is immersed in a phosphate buffer which is stabilised by KCl & contained in an outer sachet
- at the end of the outer end of the jacket is a membrane which is usually polyethylene or polypropylene each of which is permeable to oxygen (polyethylene allows faster O2 diffusion making the system more sensitive but less stable)
- a polarising voltage of 600-800mV is applied to the platinum wire & as oxygen diffuses through the membrane electro-oxidoreduction occurs at the cathode & corresponding oxidation occurs at the Ag-AgCl anode. Thus a half cell is set up and current is generated.
- miniature electrodes have been set-up for continuous intravascular monitoring; however, they are subject to build-up of fibrin which alters electrode sensitivity

Transcutanous electrodes:
- allow monitoring non-invasively & are particularly used in neonates & infants
- the electrodes are based on similar principles to those used in blood gas analysers but also incorporate a heating element.
- the electrode is attached to the skin to form an airtight seal using a contact liquid & the area is heated to 43 degrees. At this temperature the blood flow to the skin increases and the capillary oxygen diffuses through the skin allowing measurement.
- problems include:
(i) surgical diathermy causing skin electrode overheating
(ii) values are generally lower than those from arterial specimens
(iii) electrode reads low with severe hypertension & microcirculatory perfusion failure

Fluorescence-based blood gas analysis:
- depends on light from a pulsed xenon lamp being selectively filtered at 410, 460 & 385nm for respective measurement of pH, pCO2 & pO2
- pO2 measurement utilises an oxygen quenchable dye dissolved in silicone attached directly to the end of the sensor fibre. The dye is excited at 385nm & the decrease in light emitted at 515nm is directly proportional to the oxygen tension

Ion selective or pH electrode
- utilises a glass membrane the composition of which is tailored selectively to allow hydrogen ions to pass throught thus produceing an electromotive force.
- the most commonly used electrode systems are those which are selective for sodium, potassium & calcium
- the magnitude of the electromagnetic force is based on the Nerst equation