BLOOD GAS ANALYSIS

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Much attention has been given to the accuracy and precision of blood gas analysers, and the majority of modern instruments are robust and produce accurate, reproducible results. However preanalytical factors can introduce errors which are many times greater than the analytical imprecision of the blood gas analyser, and which often lead to incorrect decisions on patient management being made.

Many modern blood gas analysers also provide values for plasma sodium, potassium, ionised calcium and haemoglobin which are also very susceptible to the effects of incorrect specimen preparation. The following is a summary of important sources of error and ways of minimising them.

ANTICOAGULANT

Effect – Dilution errors, addition or extraction of sodium, potassium and ionised calcium

Heparin is the preferred anticoagulant since EDTA or citrate will affect the pH and make simultaneous calcium and potassium measurement impossible. Liquid heparin mixes more easily with blood than dry heparin, but introduces a dilution error. Heparin solution of 500-1000 IU/mL is generally used to fill the syringe dead space, typically about 0.05 mL. Thus for a 1 mL arterial blood sample an overall dilution of around 5% can be expected. Plasma constituents which can easily pass into the red blood cells such as CO_2 will be reduced by about 5%. However since the dilution of the plasma component will be about 9%, plasma constituents which do not enter red blood cells easily will be more profoundly affected. Thus a normal plasma sodium result of 140 mmol/L will be reduced to 128 mmol/L, and normal ionised calcium of 1.20 mmol/L to 1.09 mmol/L. Blood pH is less affected by dilution as it is largely dependent on the ratio of dissolved CO_2 and plasma bicarbonate, which dilution does not greatly disturb.

Different heparin preparations contain variable amounts of calcium, potassium and sodium which can increase measured values. Heparin can also bind ions particularly calcium, reducing the amount available for measurement.

Solution

Where possible use purpose-made syringes containing the correct amount of dry heparin. This will avoid dilution errors, and use of 'balanced' heparin will neither add nor remove (bind) calcium, sodium or potassium ions.

INCORRECT BLOOD SAMPLING

Effect – Misleading pO_2, specimen dilution, clotted blood sample

Generally arterial blood samples are required, and steps should be taken to ensure the specimen is arterial not venous blood. Arterial blood will be lighter in colour, unless the patient is severely hypoxic, will fill the syringe more rapidly and will be pulsatile. Arterial blood sampling lines are frequently used in ICU patients and are kept from clotting by introduction of heparinised saline solution. Prior to drawing a blood gas specimen it is essential that the heparinised saline is completely withdrawn from the line into a separate syringe, so that undiluted blood can be drawn into the heparinised blood gas syringe. Provided this is done aseptically the mixture of heparinised saline and blood initially drawn off can be reintroduced to reduce unnecessary blood loss.

Rarely can introduction of air bubbles into the syringe during sampling be avoided. However it is important that bubbles are expelled immediately since if they are allowed to remain in contact with the blood the measured pO_2 will be increased. For example a 1% air bubble (0.01 mL in a 1mL specimen) allowed to equilibrate with the blood at 4°C will increase the pO_2 by 15%.

If the heparin is not completely mixed with the blood, part of the specimen may clot. This will be invisible to the user, but will block the blood gas analyser.

Solution

Use good quality syringes which do not allow air to leak in during sampling. Expel any air bubbles from the syringe immediately then mix well by inversion. (Do not leave the needle on the syringe as this is a potential health hazard).

SPECIMEN STORAGE

Effect – Low pH and pO_2, high potassium and pCO_2

Red and white blood cell metabolism continues in the syringe, increasing plasma potassium and pCO_2 and decreasing pH and pO_2. Ideally blood gas measurements should be done immediately, and analysis should not be delayed for more than 10 minutes if the specimen is kept at room temperature. If the delay before analysis is longer, metabolism can be slowed by storage of the specimen at 0-4°C in iced water for up to 30-40 minutes. Longer storage in polypropylene syringes leads to CO_2 loss through the syringe wall. Plasma potassium values rise during cold storage due to leakage from red blood cells at 0.1 - 0.4 mmol/L per hour.

Solution

Analyse samples immediately wherever possible.

INTRODUCTION OF BLOOD CLOT INTO THE BLOOD GAS ANALYSER

Effect – Inoperative blood gas analyser

The blood sample which is in the tip of the syringe will not be heparinised and therefore may contain a blood clot.

Solution

First, ensure the blood sample is mixed immediately after sampling. Secondly, before introducing the specimen to the blood gas analyser, a few drops of blood should be expelled into a piece of cotton wool.

RED CELL SEDIMENTATION

Effect – Erroneous haemoglobin, pH, pCO_2 and pO_2

Red blood cells settle out of the plasma rapidly, especially in critically ill patients. Therefore unless the specimen is mixed well a few seconds before the introduction into the blood gas analyser, measurements will be made on red cell rich or red cell poor blood (depending on which way up the specimen has been stored). This will profoundly affect the haemoglobin value and also lead to inaccurate pH, pCO_2 and pO_2 results.

Solution

Mix the blood sample well immediately before introduction into the blood gas analyser.

References

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VIOLENT INJECTION OF SAMPLE INTO BLOOD GAS ANALYSER

Effect – Falsely high potassium and pO_2 values

Where the specimen is injected into the analyser, this should be done gently, because undue pressure may cause haemolysis increasing plasma potassium results, and in some instruments may affect the pO_2 value.

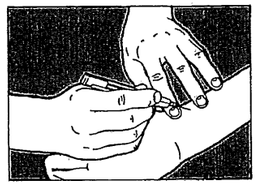

Fig. 1 Use a dry heparinised syringe or micro sampler to obtain an arterial blood sample.

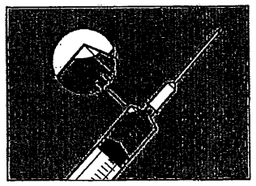

Fig. 2 Remove any air bubbles. Mix immediately after sampling. Store in iced water if delay >10 minutes.

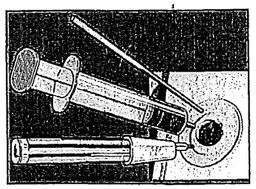

Fig. 3 Expel a few drops of blood, mix sample well and gently inject into analyser port.

Fig. 4 Keep a record of results for patient's notes. Repeat abnormal results, recheck quality control if necessary.

Contact the local laboratory to ensure you know how to use the instrument properly