GUIDANCE FOR MANAGING PATIENTS USING POCT RESULTS: APPENDIX 1: Blood Gas Analysers: Radiometer ABL90 Flex Plus

Blood gas, electrolytes, metabolites and oximetry

Samples:

- Arterial, venous or capillary specimens must be collected anaerobically (avoiding the introduction of air bubbles) into balanced heparin syringes/capillaries. ALL air bubbles must be eliminated prior to mixing.
- Mix first by inversion immediately after phlebotomy, and secondly on the device auto-mixer directly before analysis. Do not transfer blood from one container to another prior to analysis.
- Blood gas analysis on samples collected into vacuum collection tubes are likely to give inaccurate results and should not be performed.
- For accurate results, samples should be run as soon as possible and within 15 minutes for syringes, 5 minutes for capillaries.

High or low results

The blood gas analyser gives biological reference intervals and clinical decision limits for its tests, with a traceable evidence base to the literature. The reference intervals and clinical decision limits are shown on the device screen or print out, and in the EPR.

A full list of these reference intervals and clinical decision limits is published as an appendix to this document.

Sometimes results are outside the measuring range of the analyser and the device produces an error in the results place. This is indicated as ****. On the device and the printout, it will indicate that the result is outside of the measuring range and what the upper or lower limit is. This can occur for any test in the profile, but is particularly worth highlighting (due to previous incidents) for pCO_2 (the top of the measuring range is 14.9kPa) and with glucose (the top of the measuring range is 47mmol/L). If this happens **for glucose a laboratory sample must be sent to get the absolute glucose value** for the patient.

Blood gases (pH, pCO_2, pO_2, HCO_3):

The introduction of any air into the sample and significant delay in running the sample can severely affect results, making them inaccurate.

Due to limitations of the device, a paediatric reference range for pO_2 in arterial samples for the first hour of life cannot be reported, but is given below:

	Neonatal age	Arterial reference range
pO2 (kPa)	<= 30 mins	4.1 – 11.3
	<= 1 hour	7.3 – 10.6
	Adult reference range (applicable after 1h post-partum)	11.0 – 14.4

Source: Rifai, N. Tietz textbook of laboratory medicine. Seventh edition. Edited by R.W.K. Chiu and I. Young. Elsevier.

Electrolytes (Na, K, iCa):

Sodium (Na) results performed on the POCT analyser may differ from the central laboratory. The difference is slight, and variable, averaging around +3mmol/L across the clinical range of results, and is likely due to methodological differences.

POCT results differ significantly from central laboratory results if the patient has abnormally high levels of blood lipids or total protein. In these instances, the POCT result will be higher than the laboratory result and is more accurate as it is a "direct" measurement. The laboratory performs an "indirect" measurement.

Potassium (K): Serum samples sent to the laboratory are expected to give higher K results compared to whole blood samples processed on a blood gas analyser, due to release of potassium from cells during normal clotting of the serum sample. The mean difference according to local data is 0.2 - 0.3mmol/L higher in the lab, for samples taken in the same blood draw. This difference is exacerbated by delays in laboratory processing, lab sample exposure to cold air temperatures, and in patients with extremely elevated levels of platelets or WBCs.

The POCT K result is likely to be the more accurate unless there is significant haemolysis (see below).

Does haemolysis affect K results on BGA?
The blood gas analyser does not measure or record haemolysis (the measure of burst red blood cells). However, as samples are tested quickly and not subjected to centrifugation like lab samples, the extent of haemolysis is reduced and likely not significantly cause a falsely-raised K. Extreme care must be taken to avoid haemolysis of samples during the phlebotomy episode, by following established SOPs for correct venepuncture technique.

The possibility of haemolysis impacting on POCT electrolyte test results must always be considered, particularly if the blood draw was difficult.

Ionised calcium (iCa) is measured and reported by the POCT analyser, which is the physiologically-active fraction of calcium in circulation, and not affected by the serum protein concentration. The laboratory measures total calcium, which is affected by serum protein concentration, so an adjusted

calcium result is additionally reported, which accounts for abnormal serum albumin levels. When there are normal levels of serum protein and albumin, and normal acid-base status, ionised calcium levels are approximately half the value of total adjusted calcium levels. Adjusted calcium and ionised calcium must not be confused or compared.

Does haemolysis affect the ionised calcium result? Yes, **haemolysis can have a significant impact on ionised calcium** levels, causing a decrease.

Metabolites: Glucose, lactate, *urea and *creatinine (*where available)

Glucose and lactate can be measured on arterial, venous or capillary specimens collected into syringes/capillaries containing balanced heparin. Immediate analysis of these samples means that glycolysis inhibitors (i.e. fluoride oxalate found in the labs grey topped tube) are not required to prevent sample degradation. More accurate glucose and lactate results can be generated at the point of care than by sending specimens to the laboratory because they are analysed more quickly with less opportunity for degradation.

In cases of severe hypotension, dehydration or peripheral circulatory failure, and for unconscious patients, measurements from capillary blood may be misleading for certain analytes, such as glucose, and must not be used in these circumstances. An arterial or venous specimen must be used instead.

Please note that the upper reference limits quoted for **glucose and lactate** are considered to be CLINICAL DECISION LIMITS rather than biological reference intervals or "normal ranges" i.e. a flagged glucose or lactate result should be a trigger for action by the reviewing clinician, and a result within the range may not be normal for that patient at that time.

The laboratory and POCT **creatinine** tests both use enzymatic methodologies and compare very well on most patient samples, but due to the use of different enzymes they will be subject to different interferences. The enzyme cascade (creatininase + creatinase + sarcosine oxidase) used in the Radiometer ABL90 POCT creatinine is subject to less endogenous or exogenous interferences than the laboratory test (creatininase + sarcosine oxidase), in particular this has been demonstrated for samples with high levels of lipids, which falsely lower lab creatinine results but has minimal impact the ABL90 creatinine result. Both the lab and the POCT creatinine tests are traceable to the reference method (IDMS) mandated by NICE NG203 for CKD-EPI (2009) eGFR calculation.

eGFR results are not yet reported on the blood gas analysers, but the spreadsheet provided as an appendix uses a locally-validated calculator for 2009 CKD-EPI eGFR equation (the same as is used in the Biochemistry Laboratory), and as recommended by NICE for adults (NG203, Chronic Kidney Disease: assessment and management).
Please note that online calculators may not use the NICE-recommended equation and should be avoided.

Haemoglobin

Total Hb results are produced by the blood gas analyser but if the sample tested is not well mixed, or contains clots, the Hb result may be grossly inaccurate. The POC result can be falsely high or falsely low if poorly mixed.

Calculated results

The following results are calculated by the blood gas analyser, and therefore only reported if the tests it requires for the calculation are successfully reported.

Actual Base excess cBase(B) = (1 - 0.014*tHb)(HCO3-(P) - 24.8 + (1.43*tHb + 7.7)(pH-7.4))

Standard Bicarbonate $HCO3^{-}(P,st) = 24.47 + 0.919 \times Z + Z \times a' \times (Z - 8)$

Where: $a' = 4.04 \times 10\text{-}3 + 4.25 \times 10\text{-}4 \times ctHb$

$Z = Base(B) - 0.3062 \times tHb \times (1 - sO2)$

Anion Gap Anion Gapc = $Na^{+} - Cl^{-} - HCO_3^{-}$

Haematocrit Hctc = $0.04939 \times tHb$

Maternity and neonatal testing

The devices are able to run test profiles for **cord blood venous, cord blood arterial** and **fetal scalp** samples. Users are shown how to indicate the sample is one of these types during training. They should not be running one of these samples as a venous or arterial sample as it will provide inappropriate reference ranges and record the result in EPR alongside the true venous/arterial samples potentially causing confusion in trending.

Co-oximetry in neonates: O_2 saturation, oxy-, carboxy-, met- and deoxyhaemoglobin.

Due to limitations of the device, oximetry parameters cannot be corrected for the presence of fetal haemoglobin (HbF – not a reported parameter) based on age alone. Therefore, there is a risk that in babies aged 0-3 months with a fraction of HbF <20% of total haemoglobin, the accuracy of sO2, FO2Hb, FMetHb, FCOHb and FHHb may be affected.
Where HbF is >20% of the total Hb, the blood gas analysers will adjust the oximetry results to compensate for the high HbF.

Fluid samples

Fluid pH is highly unstable and if measurement is required it is recommended to do so on a POCT blood gas analyser.
The ABL90 Flex Plus gas machine is not CE- or UKCA-marked for pleural fluid pH testing. However, results from another NHS Trust suggest it is able to produce accurate results in comparison to other

CE-marked methods. The company has stated it is in active progress of CE-marking this method for pleural fluid pH.
Therefore interpretation of the pleural fluid pH result should be carried out with caution and the following sample collection procedure should be followed to stabilise the samples:

- Collect in a safePICO heparinised syringe/aspirator, the lid placed on, and the air expelled from the syringe as quickly as possible.
- The sample should then be slowly mixed to move the heparin pad up and down the sample to minimise clots, and run on the POCT machine within 15min.

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