Beyond point-of-care blood gas analysis

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‘True Point-of-Care Testing’ was the subject of discussion at the annual congress of The Association of Anaesthetists of Great Britain and Ireland (AAGBI). The seminar considered the challenges of maintaining control of patient physiology in the ICU.

GAVIN TROUGHTON provides an overview of the presentation.

At the recent AAGBI 2014 Annual Congress, Dr Tom Clutton-Brock, senior lecturer anaesthesia and intensive care medicine, University Hospital Birmingham, presented an industry seminar discussing ‘True Point-of-Care Testing’, focussing on the frequency of arterial blood sample testing ideally required and associated limitations — such as staff time involved, costs and blood conservation. It also considered how matters might change if these limitations were removed.

The importance of monitoring

Close monitoring of patients when in a critical care setting, such as in the intensive care unit (ICU) or when under anaesthesia in the operating theatre, is essential in order to best manage them. It would be impossible to manage extremely sick patients, without detailed real-time physiological monitoring where results have the potential to dictate an immediate or urgent response.

It is well understood that there are a number of key physiological variables, in cardiovascular, pulmonary and neurologic functions, that must be maintained within acceptable levels in order to keep a patient out of danger. What perhaps is less well understood is the concept of repeated small physiological insults. There is no doubt that healthy individuals can tolerate episodes of brief hypoxia very well with no long term effect at all. However, it may be the case that in sicker patients — often the very young and the very old — repeated insults physiologically may actually have an additive effect. This cumulative effect could potentially stimulate an inflammatory response and may affect cell recovery.

Although it is extremely challenging to do so, given the uncertainty of the long-term effects of repeated hypoxia episodes, when looking after desperately unwell patients it is advisable that vital signs should be maintained as near normal as possible. This is in order to ensure that no harm is done. To achieve this, monitoring devices play a vital role in a modern ICU setting. Without such devices, clinicians would not have the necessary information to care effectively for the critically ill, especially if patient status changes acutely and prompt intervention is required. This makes such devices essential for delivering treatment within the ICU.

Blood gas – a vital sign

Blood gases should actually be considered to be one of the vital signs, as it is an extremely widely used measurement and is the most commonly undertaken blood test in ICU and operating theatre settings. Analysis of arterial blood gases is central to the management of most critically ill patients, since the maintenance of tissue oxygenation, ventilation and acid-base status is a major concern for most ICUs. Life-threatening changes in these characteristics can occur suddenly and so rapid results are often needed for effective patient monitoring and treatment.

Blood pressure, cardiac output and tissue perfusion are all continuously monitored, however, immediate return of data and swift response to rapidly changing blood gases is just as essential in patient care. Strictly speaking blood gases are not monitored as such, since individual measurements are taken at discrete points in time. This is due to the absence of technology enabling clinicians to do otherwise. Therefore, blood gases (including pH, pO₂, pCO₂, lactate and calcium changes) are currently only measured intermittently and away from

Analysis of arterial blood gases is central to the management of most critically ill patients, since the maintenance of tissue oxygenation, ventilation and acid-base status is a major concern for most ICUs.
Using intermittent blood gas measurements to manage patient ventilation can be problematic, as patient management decisions could be based on out of date blood gas samples. Each patient having their own device either attached, or extremely close, to them.

There is a huge difference between having a measurement of blood gas, blood glucose or blood pressure actually in the patient’s bed space as opposed to taking a sample and then walking away from the patient for analysis, even if the analyser is based within the ICU or theatre. The time delay in taking the sample, moving away, making the measurement and returning is not insignificant, even if the analyser is near to the patient and not within a central laboratory. For vital signs that change rapidly this does not make a lot of sense and is not tolerated for blood pressure, but it is for blood gases due to the absence of an alternative.

An ideal scenario

There is certainly a very positive argument for the need for a patient dedicated blood gas analyser (BGA) in order to enable faster and more frequent measurements. However, modern BGAs are highly complex and, if anything, have actually been getting larger and not smaller with time as more parameters have been introduced. Furthermore, BGAs take time to calibrate, flush, sort the blood path and control temperature for example.

Therefore, in order for each patient to have their own BGA, this complicated analyser needs to be shrunken down to a chip, or sensor, that sits in series with the arterial line. Blood can then be drawn directly over that sensor to give immediate blood gas measurements without leaving the patient. It should not be underestimated what a significant technological challenge it is to actually shrink and convert a complex BGA in which all patient blood goes to waste to a chip-based system, where all blood is conserved and returned to the patient safely. However, this has been achieved by Sphere Medical (Cambridge, UK) which has researched, developed and is now manufacturing a highly specialised chip (Proxima Sensor).

The new CE marked disposable sensor contains a range of biological sensors and sits in series in the arterial line, with the blood pressure transducer, and is connected to an intuitive monitor located in the patient’s own bed space (Figure 1). This allows blood samples to be withdrawn, analysed just outside the body and then returned to the patient.

Performance of miniature BGA

The next questions to ask should be: does this new technology work? Does it measure what it says it measures? Does it do it with an acceptable bias and precision? All of which can be answered with ‘Yes’. The Proxima miniature in-line BGA has recently been the focus of a method comparison clinical study at the Queen Elizabeth Hospital, Birmingham. The observational method comparison each patient having their own device either attached, or extremely close, to them.

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A study fully met the primary end point to demonstrate excellent agreement between Proxima and the standard bench top blood gas analysers at the Queen Elizabeth Hospital, measuring various arterial blood parameters in a clinical setting.

A total of twenty intensive care unit patients with a range of clinical conditions, including trauma, head injury, post-surgical recovery and sepsis, were included in the study. Patients were connected to the Proxima system for up to three days during which as many as 33 blood gas measurements were obtained per device. Use of the new system was carried out by the clinical staff at the Queen Elizabeth Hospital who each underwent an initial 90 minute training programme.

Within the study, each time a patient’s blood was tested using the Proxima system, a concurrent sample was drawn and tested using the hospital’s standard bench top blood gas analyser. During the course of the study over 300 comparative measurements were taken across the system’s analyte range of pH, pCO₂, pO₂, haematocrit and K⁺, with each analyte showing excellent agreement with the reference bench top blood gas analyser (Roche Cobas b221).

**Indications for in-line BGA**

The benefits of immediate access to frequent blood gas analysis are clear when there is the potential for rapid and life-threatening changes to blood gas chemistry, such as during major cardiac, neuro and vascular surgery. Likewise, the critically ill patient, during septic shock or severe respiratory failure (SHRF) would certainly benefit from continuous, or semi-continuous, blood gas monitoring.

A further important consideration is how an in-line BGA could help with nursing dependency. An interesting scenario is found with Level 2 patients where there is normally one nurse for two patients on a cubic. Here the nurse is unable to leave the patients to undertake a BGA as this would unacceptably leave two critically ill patients with no nurse. Furthermore, in the case of Level 3 patients, where there is a 1:1 nurse to patient ratio, it would be necessary to temporarily convert the highly critical patient to a Level 2 if the nurse needs to undertake a BGA.

Such scenarios can prove problematic, particularly since blood gases are by far the most commonly used blood measurements in critical care, as previously discussed. Therefore, having blood gas measurements directly within the bed space means that a nurse can actually continue to look after two patients, or maintain a 1:1 ratio, while undertaking these important measurements. Consequently, this has the potential to decrease the nursing dependency of patients.

The opportunity to conserve blood has been previously discussed. Due to the fact that it is in-line, the Proxima System enables closed blood sampling as many times as needed. When a blood gas analysis is required, blood is simply withdrawn from the patient directly into the Proxima Sensor. Once analysis is completed, all blood is returned to the patient, meaning that there is no waste of patient blood at all. This is of course not only ideal for paediatric anaesthesia, but also for adults in ICU. Arterial blood sampling for laboratory investigations is a recognised source of blood loss in intensive care patients. Therefore, using an in-line BGA will eliminate blood wastage and in turn reduce the risk of hospital-acquired anaemia and the subsequent need for transfusions with associated patient risk and costs.

A further cost consideration is the fact that cost per sample using an in-line BGA is small. If a critical care patient is to undergo the relatively common invasive procedure of putting an arterial line on, why not attach a device that measures blood gases at the same time? Single use pressure transducers are commonly used now, so the obvious next step is to move into attaching a single-use blood gas analyser.

**Conclusion**

Frequent measurement of arterial blood samples is a key component in the effective management of patients in the critical care environment, particularly those that are unstable. Rapid return of data and swift response to changing blood gases is as essential in critical patient care as the continual measurement of blood pressure. Fast feedback and response via a dedicated in-line miniature blood gas analyser such as Proxima could have a real impact on efficiently stabilising patients or weaning them from mechanical ventilation.

**References:**


**About the Author**

Gavin Troughton is employed by Sphere Medical in the role of VP Business Development.

Dr Tom Clutton-Brock’s (senior lecturer anaesthesia and intensive care medicine, University Hospital Birmingham) AAGBI 2014 Annual Congress industry seminar presentation is available to view at: http://www.spheremedical.com/content/clinical-resources.