Acute care testing at the point-of-care: now and in the future

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The field of point-of-care testing (POCT) is entering a period of rapid expansion. This expansion is being driven by new evidence for clinical effectiveness of POCT, and new technologies that allow consolidation of testing onto smaller platforms.

Technological improvements will also lead to increased accuracy for point-of-care tests, which will facilitate the transition of more central-lab testing to the bedside.

In this article I will review where we are today and where the field of POCT is heading in the next few years, particularly in the area of critical care.

State of the art

Adoption of POCT as a patient-care solution has been hampered by concerns over cost of testing, analytical accuracy of POCT solutions, data management and evidence for improved patient care outcomes when POCT is employed.

While cost and data management will not be covered in this review, there has been significant progress on both fronts.

The focus of this article will be on advances in defining the evidence for improved outcome with POCT, and advances in analytical accuracy driven by platform consolidation and new technologies.

NACB practice guidelines

In 2007 the National Academy of Clinical Biochemistry (NACB) released the final version of the practice guideline *"Evidence-based Practice for Point-of-Care Testing"* [1].

The document is broken down into 13 chapters, with each chapter reviewing evidence for the use of point of care in a given clinical area or for a given set of analytes (i.e. critical-care testing, infectious-disease testing, coagulation).

The strength of evidence for improved patient outcome was graded from A to C. A grade of "A" indicates that POC experts reviewed the available evidence and concluded that the use of POC testing improves important health outcomes.

Thus "A" is the strongest recommendation given by the committee.

A grade of "B" indicates that use should outweigh harm, or that there was at least fair evidence that important health outcomes could be improved through the use of POCT.

A grade of "C" indicates that harm outweighs use; that is a recommendation against the adoption of POCT.

A grade of "I" indicates that there is currently insufficient evidence to make a recommendation.

The chapter on critical care (Chapter 5) may be of most interest to readers of this article. The chapter evaluated evidence for point-of-care testing for arterial blood gas (ABG) analysis, glucose, lactate, magnesium, CO-oximetry, electrolytes and ionized calcium.

The clinical benefits of point-of-care (POC) ABG testing were evaluated in three different settings: the Intensive Care Unit (ICU), Emergency Department (ED) and cardiac surgery.

The authors found fair evidence (grade of "B") for POC ABG testing when used in the ICU.

The most compelling data on patient outcome with ABG testing in the ICU occurred in the setting of goal-directed therapy for the early detection and treatment of sepsis and shock [1].

POC ABG testing was effective in a randomized trial of patients presenting to an urban emergency department and admitted to the ICU with either sepsis or shock.

The study found that using POC methods to monitor blood gas and lactate reduced mortality compared to patients receiving conventional treatment [2].

Regarding POC relative to laboratory blood gas testing, the guidelines state that in some facilities POC blood gas analysis may offer little time savings compared to central-lab analysis of ABG.

In addition, there was no consensus reached on the cost-effectiveness of POC ABG testing (grade of "I") [1].

The cost-effectiveness of POC blood gas testing is likely dependent upon the existing laboratory structure and turnaround time within the facility. Specifically, a significant reduction in turnaround time [3] and elimination of laboratory staff [4] may be necessary to show the cost-effectiveness of POC blood gas analysis.

In facilities with STAT laboratories dedicated only to blood gas analysis, elimination of STAT laboratories in favor of POCT approaches may be cost-effective [4]. If ABG samples are currently analyzed in STAT or central labs that offer rapid turnaround time and perform many different tests (some not available on POCT platforms), then cost-effectiveness may be more difficult to demonstrate.

The guidelines concluded that evidence was only fair (grade of "B") for use of POC ABG in other patient-care areas such as the ED and cardiac surgery. In the ED the best evidence for improved patient outcomes with POC blood gas use was related to the early recognition of shock or metabolic acidosis using pCO$_2$ at the bedside.

Some institutions, however, have found that lactate (discussed below) may be as or more valuable for this purpose.

Glucose measurements

Glucose testing by POC received a grade of "A" because the use of POC testing has been associated with improved patient outcomes. For glucose it was noted that the implementation of tight glycemic control protocols that rely on POC glucose testing improves outcome for critically ill patients. POC glucose testing also allows the rapid detection of hypoglycemia in patients on insulin therapy and thus can reduce harm.

Glucose testing by POC was strongly endorsed by the authors because there was a demonstrated reduction in turnaround time for results; and in addition there was evidence that the reduced turnaround time lead to improved patient outcomes [1].

Although glucose measurement at the point of care was strongly endorsed by the NACB guidance document, glucose POCT for critically ill patients is not without controversy.

Two recent editorials raised questions about whether the current generation of handheld glucose meters is accurate enough for use in managing critically ill patients on tight glycemic control protocols [5, 6]. Studies examining the accuracy of POCT glucose measurement in this population have found that the use of blood gas analyzers results in improved accuracy compared to handheld glucose meters [7, 8], but the use of larger devices such as critical-care or blood gas analyzers may not be feasible in all environments.

Newer glucose-meter devices with improved accuracy have recently become available that may close the gap between the analytic performance of blood gas analyzers and handheld glucose meters [9].

The appropriate manner in which to monitor glucose concentrations for critically ill patients, and the degree of accuracy required for this patient population, will continue to be debated and studied in the coming years.

In the meantime institutions must weigh convenience, workflow, cost and quality considerations carefully when considering a POCT solution for glucose monitoring of critically ill patients.

Lactate measurements

Lactate was the other critical-care analyte to receive an "A" recommendation based upon evidence of improved turnaround time and improved patient outcome. The most compelling data supporting the use of point-of-care lactate again comes out of studies examining the rapid detection and treatment of sepsis and shock [1].

Recognition and treatment of sepsis has become both a priority and a quality indicator for some healthcare systems.

One recent study found that patient outcomes were improved when POC lactate measurement was used to support goal-directed therapy to keep lactate levels below set thresholds, compared to historical controls that did not use POC lactate or goal-directed therapy [10].

Because many laboratories struggle with rapid turnaround time for lactate measurement, and because more institutions are focusing on sepsis outcomes, demand for POC lactate measurement is likely to increase.

In contrast to glucose measurement, analysis of lactate at the point of care is less problematic.

One recent study compared two central-laboratory (plasma-based) lactate assays to three whole-blood lactate assays. Most whole-blood lactate assays agree well with the laboratory reference method up to ~6 mmol/L, and this allowed the correct clinical classification of almost all patients with most devices [11].

The methods studied included both blood gas analyzers and handheld devices; thus there does not appear to be an analytic limitation to the use of lactate at the point of care for clinical decision making.

Creatinine measurements

Although the NACB guidelines found that evidence for improved outcomes in critical-care settings was not good for POC creatinine (grade of "C"), the authors of this section also note that evidence is fair (grade of "B") for the use of POC creatinine in settings (mostly procedural areas) where rapid therapeutic decisions about dosing of contrast agents or other drugs must be made.

Many medical centers are now focusing on preventing contrast-induced nephropathy (CIN), temporary or permanent kidney damage caused by contrast agents

in patients at risk of renal damage. For this reason rapid turnaround time for creatinine measurement may be desired in hospital procedural areas.

However, accuracy of creatinine assays used at the point of care is another area where more data is needed. Most radiology guidelines recommend screening patients for CIN risk using the estimated glomerular filtration rate (eGFR). Because small changes in creatinine can result in significant changes to eGFR, some laboratory experts have cautioned that bias and interference in current laboratory creatinine methods may limit the ability to accurately report eGFR [12].

The problem is further compounded with point-of-care creatinine measurement, which is subject to even greater amounts of bias than central-laboratory measurement [13]. Close examination of the accuracy and precision of point-of-care creatinine methods, along with studies examining the efficacy of screening for CIN risk using point-of-care creatinine/eGFR, are needed in order to understand the utility of POC creatinine for risk evaluation of CIN.

One such study comparing multiple whole blood creatinine devices for CIN risk prediction has recently been completed but has not yet been published. This study found significant differences between different whole blood creatinine devices used for CIN risk prediction [14].

Similar to glucose and lactate, the combination of improved analytic accuracy and evidence for improved outcome will drive the transition from central-laboratory to point of-care creatinine.

Consolidation of testing platforms

Consolidation of testing platforms, driven by increasing evidence for improved patient-care outcomes for analytes such as glucose, lactate and creatinine, and the desire to use a single platform in multiple patient-care settings, is another important trend in POCT.

In general, platform consolidation has occurred in one of two ways: the conversion of central-laboratory blood gas analyzers into POC critical-care devices through the use of disposable multitest, multiassay cartridges, and in contrast the addition of more tests to handheld devices that rely on singe-use cartridges.

Multiple vendors have introduced devices that can perform tests such as ABG, CO-oximetry and critical-care analytes on a single platform. These devices generally perform multiple tests on a multiuse disposable cartridge, which must be changed every few days or weeks. As a class of devices these offer blood gas with CO-oximetry, and along with CO-oximetry an optically measured hemoglobin.

Depending on the particular device glucose, lactate and/or creatinine may also be available. Some also offer a total bilirubin measurement for neonatal testing.

These devices may also offer onboard quality control (QC) and various forms of automated function checks and QC tracking to simplify regulatory compliance and potentially improve the testing quality.

The disadvantage of these devices is that they are not as portable as handheld single-use devices, and operation may be more complicated compared to handheld devices.

The other trend has been the addition of more analytes to handheld devices that rely on a single-use cartridge, meaning that each cartridge, reagent or strip is used one time and discarded. Some of these offer basic blood gas analysis with a subset of critical-care analytes, most often creatinine and lactate, or less commonly offer CO-oximetry using a handheld device.

Those devices that do not perform CO-oximetry (most in this class) rely on a conductivity-based hematocrit measurement rather than an optical hemoglobin measurement for the measurement of the hemoglobin content of whole blood.

This distinction is important mainly for one patient population, i.e. patients on cardiopulmonary bypass procedures.

In patients with low hematocrit who have received prime fluids used for cardiac bypass circuits, conductivity-based measurement of hematocrit may produce clinically unacceptable results. This was observed in one recent study [15] and is likely a limitation of most technologies that use conductivity to measure hematocrit.

The use of an optically measured hemoglobin (CO-oximetry) may be a better option for measuring hemoglobin content during bypass.

Conclusion

In the near future POCT for critically ill patients will likely continue to evolve around consolidation of testing platforms, concentrating on analytes that have been shown to improve outcome in critically ill patients.

Technical advances will allow more accurate measurement of analytes that have traditionally challenged POCT platforms, such as glucose, hemoglobin/hematocrit, cardiac markers and creatinine.

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