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Point of Care Testing Error in the ICU

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Background

Point-of-care testing (POCT) first arose in the 1970s, as self-calibrating blood gas measurement machines moved from the central lab to the ICU. Quality control factors, then as now, dictated operation by trained personnel. Sources of error reported in the literature are varied. Operator incompetence, nonadherence to procedures, and use of uncontrolled reagents or equipment are common issues.1 Analysis-stage error can arise from expired test strips in glucose meters2, plasma versus whole-blood samples in ABG analysis3, and plasma osmolality in hematocrit measurements.4 These errors are amplified through incoherent regulation, rapid result availability, and immediate clinical implications of the results.5 We discuss POCT error in the context of two clinical cases.

High-Flow POCT ABG Device Function2

- POCT ABG uses microfabricated electrodes of thin metal oxide films and an array of electrochemical sensors on silicon microchips. Each cartridge contains a calibrant solution with known concentration of each analyte. By comparing the sensors’ response to the sample with that of the calibrant, the concentration of each analyte in the sample is calculated.
- Na, K, Cl, pH, iCa, pCO2 are all measured via ion-selective electrode potentiometry. Concentrations are calculated via Nernst equation using the measured potential.
- pO2 is measured amperometrically. Oxygen permeates through a gas-permeable membrane from the blood sample into an internal electrolyte solution where it is reduced at the cathode. The oxygen reduction current is proportional to the dissolved oxygen concentration.
- O2 saturation, HCO3, and hemoglobin are calculated values.

POCT ABG Accuracy

- O2 saturation is estimated from measured pH, pO2, and hemoglobin utilizing empiric equations. These calculated estimates have been found to vary as much as 6% saturation from measured values6.
- Self-calibrating cartridges automatically control all functions of the testing cycle including fluid movement within the cartridge, calibrator, and continuous quality monitoring. i-STAT analyzer automatically performs a quality check using an internal electronic simulator every 8 hours.
- Linear testing is performed periodically comparing POCT devices with central machines based on institutional policy.
- PO2 measurements are particularly sensitive to temperature error. The temperature corrected pH, pCO2, and pO2 are calculated using complex algorithms.
- Exposing the sample to air allows CO2 to escape which causes pCO2 to decrease and pH to increase. This causes HCO3 and total CO2 to be under-estimated.

Case Reports

Patient 1: 46 y/o admitted for peritonitis who underwent abdominal washout and resection of perforated bowel. SICU course significant for septic shock and difficulty with ventilator weaning. On several POCT ABGs drawn over a few days at different arterial sites, discrepancy was noted between pulse oximetry (SpO2) values and oxygen lab values (pO2 and SaO2) obtained from POCT ABG (figure 1). At the time care was delivered, the assumption was made that oxygenation as measured by pulse oximetry was less accurate than POCT ABG values, as we rarely have suspicion of ABG values but commonly experience spurious pulse oximetry values. An investigation of potential causes of a falsely elevated SpO2 was undertaken (figure 2). This failed to reveal any reasonable explanation for the discrepancy between SpO2 and the POCT ABG pO2 values. On the 5th day described here, inconsistencies in patient 2’s POCT ABG and SpO2 were noted. After demonstrating the discrepancy on simultaneous draws from patient 2, patient 1’s care was focused on SpO2 values and POCT ABGs were no longer used (figure 3).

Patient 2: 59 y/o maintained on a ventilator in the ICU with a forklift encounter with a forklift. On Hb3 serial POCT ABGs showed pCO2 in the 50-60 mmHg range while SpO2 remained at 100% (figure 4). This apparent discrepancy in oxygenation values raised suspicion for error. Potential errors of SpO2 were eliminated as in figure 2. Because of high suspicion for erroneous POCT ABG values, a single ABG draw was tested simultaneously on several different POCT machines and central laboratory testing, demonstrating a notable difference in oxygenation values between the POCT and central lab, but consistency among the POCT (figure 5). This procedure was repeated with yet another POCT machine and again showed a large discrepancy in oxygenation. At this point oxygen intervention algorithms were made to patient 1 and patient 2 based on pulse oximetry values. Central lab was used for repeat ABGs as necessary.

Discussion

In the two cases discussed here, POCT error led to an inappropriately aggressive course of respiratory support. These errors increased the risk of oxygen free-radical tissue damage because of high FiO2, created a risk of barotrauma and hemodynamic instability with elevated PEEP, and prolonged exposure to intubation and thus increased the risk of ventilator-associated pneumonia. Additionally, a blood transfusion was given per surviving sepsis guidelines based on SpO2.<70% measured during the time of other suspect measurements. In both cases the recognition of error allowed alternative measurements to be preferred and changed the direction of care.

This error was reported to our lab and appropriately investigated. All suspect samples came from the same lot number of ABG cartridges. Further investigation was unable to consistently demonstrate a pattern of errors within a particular lot number, particular POCT devices, or specific operators. Quality control showed the devices in the ICU to be accurate. Cartridges of the suspicious lot number were removed from use.

The serial and low-volume nature of the work makes pattern recognition very difficult, a recognized weakness of POCT versus central lab testing. Detecting POCT errors is typically a matter of using clinical judgment if the values are in question. However, in the patients’ presentation, and, perhaps more importantly, planned quality control measures such as operator training, device maintenance, and periodic sample comparison with central lab values.

References


Figure 1. ABGs for patient 1 over several days.

Figure 2. Enlargement of potential sources of pulse oximetry error for patient 1 and patient 2.

Figure 3. Patient 1 Care Before and After Recognition of POCT Errors

Case based on POCT

Care based after recognition of error

ARDS diagnosis

ARDS diagnosis removed immediately on basis of central lab ABG

FiO2 selection for goal pO2 >60 mmHg (based on protocol)

FiO2 selection for goal pO2 >60 mmHg

PEEP selection by ARDS protocol

PEEP weaned for goal SpO2 >88%

Blood transfused based on POCT SpO2 (per surviving sepsis guidelines)

SpO2 checked only with central lab, no transfusions given based on these values

Figure 4. POCT ABG draw for patient 2. SpO2 is calculated by lab device. 24 hr intervals between draws. Note discrepancy between POCT ABG values and pulse oximetry. The patient was raised suspicion for a POCT ABG error.

Figure 5. Samples sent at two points in time demonstrate internal consistency of POCT and discrepancy between ABG and SpO2. Differences are apparent between POCT and central laboratory ABG (pO2) values, despite the rest of the ABG values corresponding. This difference is clinically significant for ventilator management.

Figure 6. Patient 2 Care Before and After Recognition of POCT Errors

Care based on POCT

Care based on central lab (testing and SpO2)

ARDS diagnosis

ARDS diagnosis removed

FiO2 selection for goal pO2 >160 mmHg

FiO2 selection for goal pO2 >160 mmHg

PEEP 30-40

PEEP

Figure 7. Serial and low-volume nature of the work makes pattern recognition very difficult, a recognized weakness of POCT versus central lab testing. Detecting POCT errors is typically a matter of using clinical judgment if the values are in question. However, in the patients’ presentation, and, perhaps more importantly, planned quality control measures such as operator training, device maintenance, and periodic sample comparison with central lab values.

Abbreviations

POCT: point-of-care testing

SaO2: arterial blood oxygen saturation

FiO2: fraction of inspired oxygen

SpO2: Pulse oximetry oxygen saturation