

3-24-2012

Point of Care Testing Error in the ICU

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Repository Citation

Petrinec, Nicholas; Huning, Bree; and Watson, Nicholas C., "Point of Care Testing Error in the ICU" (2012). *Anesthesiology and Perioperative Medicine Publications*. 118.

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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 measurements⁴. These errors are amplified through incoherent regulation, rapid result availability, and immediate clinical implications of the results¹. We discuss POCT error in the context of two clinical cases.

How Does POCT ABG Device Function?⁵

- 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, i-Ca, 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, calibration, 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 yo F 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 oxygenation lab values (paO₂ 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 paO₂ 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).

Day of draw	pH	pCO ₂	paO ₂ (SaO ₂)	SpO ₂	FIo ₂
1 (POCT)	7.40	42	58 (90%)	96%	0.60
2 (POCT)	7.48	36	46 (85%)	94%	0.60
3 (POCT)	7.46	40	61 (92%)	97%	0.60
4 (POCT)	7.56	29	62 (95%)	99%	0.65
5 (central lab)	7.48	32	175 (99%)	99%	0.65

Figure 1. ABGs for patient 1 over several days. SaO₂ is calculated by lab device. SpO₂ is pulse oximetry reading. Note discrepancy between pulse oximetry and POCT ABG values.

Potential source of error – How source was ruled out	
•Motion - finger held motionless	
•High ambient light - probe finger wrapped in opaque material	
•Penumbra effect - probe positioned correctly	
•Dyshemoglobinemia - no history, no meds to cause this	
•Nail polish - none	
•Dark pigmented skin - very light complexion	
•Hct <24% - Hct >27%	
•SpO ₂ error is +/- 3% when value is >70% per Philips manual ⁷	

Figure 2. Exoneration 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

Care based on POCT	Care after recognition of error
ARDS diagnosis	ARDS diagnosis removed immediately on basis of central lab ABG
FIo ₂ selection for goal paO ₂ >60 mmHg (based on protocol)	FIo ₂ selection for goal SpO ₂ >88%
PEEP selection by ARDS protocol	PEEP weaned for goal SpO ₂ >88%
Ventilator weaning non-existent. Patient could not meet criteria for spontaneous breathing trial.	FIo ₂ and PEEP changed in 1 day to meet criteria for spontaneous breathing trial, extubated 3 days after POCT no longer utilized
Blood transfused based on POCT ScVO ₂ (per surviving sepsis guidelines)	ScVO ₂ checked only with central lab, no transfusions given based on these values

pH	paCO ₂	paO ₂ (SaO ₂)	SpO ₂	FIo ₂
7.29	58	53 (82%)	100%	0.6
7.31	55	58 (86%)	100%	0.6
7.30	60	55 (84%)	100%	0.6

Figure 4. POCT ABG draws for patient 2. SaO₂ is calculated by lab device. 2-hour intervals between draws. Note discrepancy between POCT ABG values and pulse oximetry. This pattern raised suspicion for a POCT error.

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

Care based on POCT	Care based on central lab testing and SpO ₂
ARDS diagnosis	ARDS diagnosis removed
FIo ₂ >0.6	FIo ₂ weaned immediately to 0.5; 0.4 next day
PEEP 10-14	PEEP 5
Escalating ventilator settings	Met criteria for spontaneous breathing trial, extubated 4d later

Test Type	pH	paCO ₂	paO ₂ (SaO ₂)	SpO ₂	FIo ₂	
Sample 1	POCT	7.28	62	86 (95%)	100%	0.7
	POCT	7.29	61	84 (94%)	100%	0.7
	Central	7.31	60	170 (99%)	100%	0.7
Sample 2	POCT	7.34	55	94 (97%)	100%	0.7
	Central	7.34	55	135 (99%)	100%	0.7

Figure 5. Samples sent at two points in time demonstrate internal consistency of POCT and discrepancy between POCT and SpO₂. Differences are apparent between POCT and central laboratory ABG paO₂ values, despite the rest of the ABG values corresponding. This difference is clinically significant for ventilator management.

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 ScVO₂ <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 conclusion was that a consistent operator error such as not allowing cartridges to come to room temperature or simply sporadic cartridge malfunctions within the lot number was responsible.

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 discordance with the patient's presentation, and, perhaps more importantly, planned quality control measures such as operator training, device maintenance, and periodic sample comparison with central lab values.

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Abbreviations

POCT point of care testing	SaO ₂ arterial blood oxygen saturation	PEEP positive end-expiratory pressure
ABG arterial blood gas	Hct hematocrit	FIo ₂ fraction of inspired oxygen
Yo Year old	ARDS acute respiratory distress syndrome	ScVO ₂ central venous oxygen saturation
SpO ₂ Pulse oximeter saturation		