

# PREVENTING PREANALYTICAL ERROR IN BLOOD GAS ANALYSIS

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Preanalytical sample handling is estimated to account for 75% of the error in blood gas analysis. The magnitude of this kind of error and its serious consequences should not be underestimated. Given the number of blood gas samples drawn and analyzed each day, it is inevitable that there will be wrong results reported. And a portion of those erroneous results will lead to inappropriate interventions and additional costs. In some cases blood gas errors, when taken in combination with critical illness and poor judgment, could result in serious nosocomial injury or death. Respiratory Therapists can reduce these potential risks by employing good sample handling and analysis technique. Awareness and education are keys to reduction of practices that can lead to preanalytical error.

My previous article focused on air contamination and post draw metabolic sample changes. Air contamination is easily remedied by immediately expelling air bubbles upon completion of draw. Preventing error from post draw metabolic changes is avoided by analyzing the sample within 15 minutes of its being drawn. A notable exception is samples that have high white cell counts (>100000 cells/mm<sup>3</sup>). Immediate analysis of leukocytotic sam-

ples helps avoid "leukocyte larceny", the depletion of O<sub>2</sub> in the sample by white cell metabolism.

Advancements in blood gas analyzers have lead to larger blood gas menus with the availability of electrolyte and metabolite analysis. Subsequently, dry and electrolyte balanced heparin products have become available in blood gas syringes. Liquid heparin, while waning in popularity, is still used in some labs. Liquid heparin is a weak acid and can contaminate a "short sample" Typically, a preheparinized syringe has 0.05 ml of liquid heparin. Empirically, one would assume a 5% dilution from liquid heparin in a 1.0 ml blood sample (0.05 ml heparin / 1.0 ml blood x 100%). However, this is not the case. Blood gas analyzers measure pH, oxygen and carbon dioxide and other analytes in plasma phase. Heparin only dilutes the plasma, and does not dilute the cellular component of blood. Thus, in a 1.0 ml sample, assuming a 45% hematocrit, the plasma phase is approximately 0.5 ml. The dilution error is actually 10% (0.05 ml heparin / 0.5 ml plasma x 100%). An even smaller blood sample of 0.5 ml would have a very significant liquid heparin dilution error of 20%.

The pH of liquid heparin is approximately 6.5. A 20% heparin dilution, as expected in a 0.5 ml blood sample, would likely have a significant pH error. Electrolyte values would also reflect significant dilution error in such a sample. Sodium is particularly affected, as liquid heparin is in the form of sodium heparin. The sodium from the heparin would be measured along with the plasma sodium, resulting in a high bias error. Hemoglobin and hematocrit values are reduced by heparin dilution. There appears to be very little pO<sub>2</sub> error from liquid heparin dilution, unless the sample pO<sub>2</sub> is very high. However, pCO<sub>2</sub> decreases can be significant. The difference is thought to arise from the higher liquid phase solubility of CO<sub>2</sub> when compared to that of O<sub>2</sub>. A 1% decrease in pCO<sub>2</sub> can be expected per 1% dilution error. A sample with a "real" pCO<sub>2</sub> 50mmHg would very likely analyze as 40mmHg if diluted 20% by liquid heparin. To avoid liquid heparin dilution errors, samples should be 2 ml or more. This

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is not an option for neonatal or pediatric units. In a NICU, it is common practice to use very small sample volumes. In neonatal applications, dilution errors from liquid heparin become an even greater preanalytic concern. Dry heparin products preclude the possibility of liquid heparin dilution errors, altogether. For blood gas analyzers with electrolyte capability, dry heparin offers another advantage. Liquid heparin is in the form of sodium heparin and will increase the value reported for sodium. Dry heparin is available as lithium heparin and has no affect on sodium analysis.

A second source of dilution errors is from arterial or venous line contamination. Solutions that are used to keep arterial or venous lines patent are significantly different from blood. These solutions not only alter pH, pCO<sub>2</sub>, and pO<sub>2</sub>, but will also change electrolyte and metabolite results. To avoid dilution errors, an adequate amount of waste fluid must be removed from the line prior to the analytic sample draw. A study published in *Critical Care Medicine* in 2003 indicated that discarding 5.5 X line deadspace yielded results with very little dilutional bias. However, as a practice, removing that much blood for frequent blood gas determinations could be detrimental to the patient. On the other hand, removing a discard volume equal to line deadspace is not a good practice either. In the same study, this method yielded results with averages biases of -0.02 pH, -3.7mmHg pCO<sub>2</sub>, + 5.0mmHg pO<sub>2</sub>, +4.5mEq Na and -0.7mEq K. Errors of this magnitude are considered unacceptable. For clinically insignificant bias, the study recommended discard volume at two times the line deadspace. Most commercial line sets specify line deadspace volume. Unfortunately, not all hospitals standardize arterial line sets, which requires extra vigilance and awareness on the part of the RT staff. It should also be noted that arterial and Swan-Ganz catheters have differing deadspace volumes from that of arterial lines. Consistent and adequate waste (2X line deadspace) removal can significantly reduce preanalytic dilution errors. Samples drawn from pulmonary artery catheters (PAC) are subject to error if samples are withdrawn too quickly or drawn from a catheter that has been advanced too far. In the case in which a PAC is too far advanced, the catheter may be inadvertently placed in the "wedge" position. Instead of drawing a sample from the venous right side of the heart, a wedged catheter sample would reflect the arterialized values of the left heart. In nearly simultaneously drawn samples, arterial and inadvertently wedged PAC samples values were reported as pH 7.31, pCO<sub>2</sub> 35 and PO<sub>2</sub> 51 for the arterial sample and pH 7.38, pCO<sub>2</sub> 32 and pO<sub>2</sub> 128 from the wedged PAC sample. These results were obviously in error. Why would the sample from the PAC sample look more "arterialized" than the arterial sample? In this instance, the PAC was wedged in an area of the lung with a high V/Q ratio, which yielded a pO<sub>2</sub> value that was much higher than the arterial pO<sub>2</sub>. Arterial blood gas values reflect gas exchange from all areas of the lung, including shunt units. Arterial samples always have lower pH and PO<sub>2</sub> and higher PCO<sub>2</sub> than samples drawn from high V/Q areas of the lung. The PAC was withdrawn to the appropriate position and repeat sample was drawn. The resultant values were more consistent with pulmonary arterial results (pH 7.26, pCO<sub>2</sub> 41 and pO<sub>2</sub> 31). Rapid withdrawal of PAC samples can cause similar errors, albeit not as pronounced, by diluting the venous blood with arterialized blood. PAC errors are avoided by checking proper catheter placement and by slow sample withdrawal.

Preanalytical error is avoidable through awareness and precaution. Other sources of error are not widely known, however. We will explore those in future articles.

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and payment for equipment and services delivered in a timely fashion. So before someone says, "it's not my area," please, let us work together. Webster's New World Dictionary defines the term partner as "a person who takes part in some activity common with another or other associates or as one or two or more persons engaged in the same business enterprise and sharing its profits and risks." Are hospitals and home care providers true partners based on this definition? Whether they like it or not, they are.

Hospitals need to have patients discharged to free-up needed beds and home care providers are more than willingly to accept these patients for home care services, provided they qualify. How else is either party going to stay in business. It would be a sorry day if there were only a few home companies to call on. Would these few be able to adequately care for the home care needs of an aging population? Where would all of these patients go? If not home; then perhaps long-term care would be the only option. Hospitals need to partner with home care and visa versa in a meaningful and open relationship. Besides the two scenarios presented in this article, there are other areas where hospitals and home care can work together. Reducing the "frequent flyer" pattern for many COPD patients is another instance where hospital and home care can work more closely together to effect a positive change.

It seems logical that the onus is on home care to communicate to healthcare providers working in a variety of settings the current and always changing qualifying criteria for home care equipment and/or services. However, it is equally important that these facilities are open to and will welcome their partners in patient care by making their RT, PT/OT, case management and nursing staffs available to home care personnel in order to learn about new products, services and related criteria. Technology has advanced the level of care that can now be afforded patients, whether they are cared for in the hospital, skilled nursing facility, rehab center or home. We all need to be aware of what's new for our patients. After all, quality patient care is our bailiwick. We are all in this together but do we truly believe this and are we willing to put it into practice for the sake of who we care for?