

PREVENTING PREANALYTICAL ERROR IN BLOOD GAS ANALYSIS

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In case you haven't noticed, error prevention and improved safety in healthcare delivery are major targets for hospitals. The genesis of this zeal for improved quality lies from the convergence of a number of interconnected factors. Certainly, the notoriety and frequency of high profile malpractice incidents, such as deaths from mismatched organ or blood typing has pushed hospitals to reduce errors. There have been numerous publications in the popular press, along with very disturbing studies in medical literature that have indicted the unacceptably high error rate in hospitals. Malpractice rates and public scrutiny have also risen to unprecedented levels. JCAHO and other regulatory agencies have sharpened their guidelines for and monitoring of safety and error prevention practices. Beyond these pressures to reduce errors in healthcare, providing safe and effective healthcare should be the goal of everyone providing healthcare.

The provision of accurate and reliable blood gas results is crucial for care of the most vulnerable and critically ill patients. Due to the severe and acute nature of the illnesses that many of our patients are afflicted with, it becomes even more important to prevent error. There is simply no margin of error in the care of these patients. This is the final article of a three part series (March/April and July/August 2006) on preventing preanalytical error in blood gas analysis. As previously stated, approximately 75% of errors in blood gas analysis arise from preanalytical factors. Understanding and preventing these errors has the potential to help achieve the avowed goals of making

healthcare safer and more effective. There is some "low hanging fruit" in blood gas error prevention. Expelling residual air quickly and immediate sample analysis have been noted as the most effective means of reducing preanalytical error.

Fortunately, these are well known and hopefully, widely practiced preventive procedures.

In this final installment, some less widely known considerations and error preventive practices will be discussed. Venous admixture, inadvertent dilution of an arterial sample with venous blood, can significantly alter blood gas results. A 10% venous volume addition to an arterial sample can cause a 25% drop in PO₂. Most commonly, venous admixture occurs when attempting sampling from the femoral artery.

In a situation that requires femoral sampling such as a code or hypotensive crisis, it is not as likely to get the "syringe flash" or rapid filling of the blood gas syringe. It is more difficult to assess the source of the blood as arterial, venous or a "mix". Additionally, the proximity of the femoral vein and the presence of femoral arteries that are anterior to the vein in some patients, increases the likelihood sampling venous arterial mix. To further complicate the matter, it is simply impossible to predict magnitude of error from admixture. Additionally, these are the patients on whom pulse oximetry measurements are not likely to be obtainable or reliable. In femoral sampling, unless the sample is obviously arterial, the reported PO₂ may seem to indicate that oxygenation status is worse than it really is. Fortunately, in the patient who is in a condition that dictates femoral sampling, short-term inadvertent overaggressive oxygen therapy will have little or no untoward consequences. The pH and PCO₂ will also be erroneous as well, with values that are more acidic and hypercarbic than those from a true arterial sample. Careful consideration must be given to the patient's clinical condition when evaluating acid base and oxygenation status from a femoral sample.

Venous admixture in arterial samples can occur when sampling from the radial artery as well. Again, it is impossible to predict the magnitude of the error from venous admixture. The error depends on the venous volume and PO₂ differential of venous blood compared to the arterial volume and PaO₂. It should be noted that venous blood returning from the skin may have a value 60 mmHg or higher. As a consequence, the result of venous admixture can be very subtle. It can become very difficult to determine if changes in blood gas values are due to changes in clinical condition or from errors in blood gas sampling. Careful and observant sampling technique, clinical assessment and pulse oximetry can be very useful when evaluating a sample for the presence of venous admixture. An example of this type of subtle error that might result in a life change could be on the patient who is being evaluated for home oxygen. Consider the consequences of a sample contaminated by admixture being reported with a PO₂ of 50 mmHg, when the "real" PO₂ is 58 mmHg. It is likely that the patient would be sent home with oxygen with subsequent inconveniences and costs.

The practice of temperature adjustment of blood gas results is somewhat controversial. The problem with temperature adjustment

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or correction is not so much in applying the corrections, as analyzers can provide corrections automatically. The issue is that normal value ranges are at 37°C. Temperature corrected values should not be evaluated with eutermic normal ranges. Reporting temperature adjusted norms and temperature adjusted results would be a logistical nightmare, not to mention the fact that normal ranges have not been validated for hypothermia and hyperthermia. For example, the significantly hypothermic patient has lower oxygen consumption. What PO₂ value is considered hypoxemic at 34°C, at 32°C? Other practical considerations arise with temperature adjustment of blood gases. When was the temperature taken, was the temperature oral, axillary, skin surface or rectal? Body temperatures are site variable. Because of these considerations most authors recommend against temperature correction of blood gas results for most applications.

A growing number of blood gas labs are offering electrolytes along with blood gases. The preanalytic error in electrolyte analysis from inadequate line waste clearance was previously discussed in part two of this series. Another significant source of electrolyte error is from sample hemolysis. Intracellular potassium is approximately 23 times higher than plasma potassium. As a consequence, hemolysis will result in spuriously elevated potassium. In contrast, ionized calcium decreases with hemolysis as intracellular calcium is only about one thousandth of extracellular Ca levels. Hemolysis is usually not a concern in whole blood testing but can occur in several situations. Storing samples in ice water slurry can increase friability of RBCs. Over-vigorous mixing of iced samples can subsequently cause hemolysis and spurious values for K and ionized Ca. Withdrawing arterial or venous samples too rapidly or active aspiration through a small needle can also cause hemolysis.

The most serious and potentially most deleterious error is sample/patient misidentification. There is no such thing as the "right" results on the wrong patient. Diligence and careful practices can avoid misidentification. The practice of using two forms of ID (name, med record number and/or DOB) along with bar code labeled syringes can significantly reduce identification errors.

Hopefully, these three articles have given readers a better appreciation of sources and possible consequences of preanalytic error. The following practices will reduce preanalytical error potential: 1) identify the patient positively, 2) avoid air in the sample, 3) avoid analysis delay, 4) mix well but gently 5) when drawing from a line remove 2x deadspace prior to sampling.



"I've lived a full life. I've been divorced, audited, sued and indicted"

involve a pre-determined 72-hour, 10-day, 30-day, and 3, 6, 9, and 12-month schedule with specific goals and tasks for each set increment. Each patient follow-up must be well documented in the patient file so that it can be effectively evaluated with any issues of non-compliance or troubleshooting being addressed.

When interviewing pre-existing CPAP/Bi-Level patients, 54% commented that they had their accessory equipment (mask, hose, headgear) for the same length of time as their actual machine, 43% of the same patients commented they had never been contacted after the initial fitting from the DME company that originally visited them. Also of the previous 43% of patients, 100% commented their machine pressure had never been tested for two to four years.

Q: How do I find affordable equipment for my patient?

Most vendors will work with a sleep facility that has integrated DME. Since both facilities are in need of this equipment, it is in the vendors' best interest to give the best price possible to continue to supply both facilities. The primary vendors are very competitive and will be very good at creating purchase options. Contracting vendor agreements are very popular in attempting to achieve the desired cost per unit required to be profitable in the sleep DME market.

Q: What type of compliance program is necessary for quality patient care?

After the initial fitting the patient can be entered into an equipment compliance program. Of course it can be offered with the patient option to opt out if so desired which would then make them responsible for the re-order of supplies when the need arises. The compliance program would ensure that the patient receives supplies at the manufacturer recommended specification for replacement, giving them the benefit of proper fitting comfortable equipment.

The initial follow-up within 72 hours of the sleep DME service is done to record any issue that the patient may be experiencing with pressures, interface fit, and any additional general questions on education, warranty, adjustment and operation of equipment.

At the 10 day follow-up, the technician will verify with the patient the cleaning procedure, education issues, and compliance, hours used, number of nights per week, and any issues with interface fit, pressure, comfort, and machine adjustments. The 30-day follow-up requires the same parameters conveyed in the 10 day.

Starting with the 90-day follow-up the equipment compliance program will begin, and subjective information will be recorded from the patient in compliance data logs. At this time the patient will make visit arrangements to have compliance data downloaded from their equipment. This information is sent to the physician for review. The data transfer process is repeated every 90 days for the first year.

At the 6 and 9 month follow-up the patient will cover subjective information, any issues with equipment and replacement of supplies. All issues will be addressed with the patient.

The 12-month follow-up includes supply re-orders and subjective information from the patient. A notification is sent to the sleep facility/physician that the patient needs to be scheduled for a one-year re-titration to prove efficacy and necessity of therapeutic treatment. This can be especially useful in cases where a patient has a significant weight gain/loss or some other change that would require a change in current treatment to insure it remains effective.

Should you provide both sleep diagnostic and DME services? There is not a simple answer but it is worth your business evaluation.

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