

Arterial blood collection - part 1 of 2

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The collection of arterial specimens with glass syringes and immediate storage in iced water was the accepted industry standard for many years. Practice has changed over the past several years to blood gas sample collection in plastic syringes, likely due to the cost, safety and convenience of plastic.

This change in practice has led to a re-evaluation of the impact of the collection device, storage time and storage conditions on the acid-base, oxygen and carbon dioxide results. A comparison of the knowledge gained in the use of glass syringes as compared to plastic syringes and the resultant changes on the measured results is necessary to identify and control the potential for measurement error.

The arterial collection and analysis guidelines published by the Clinical and Laboratory Standards Institute (CLSI) provide specific recommendations regarding specimen collection devices, sample handling, specimen transport and storage conditions based on scientific studies. This two-part article will examine what we have learned

from the studies and how it might be applied in daily practice.

Part 1 of 2

Historically, the collection of arterial specimens has occurred with glass syringes and immediate storage in an ice slurry. Glass syringes provided a negligible change in diffusion between the air and blood, but there was still a progressive decrease in pO_2 and increase in pCO_2 caused by metabolism of the leukocytes and erythrocytes over time. Storage in an ice slurry to one degree centigrade provided a decrease in metabolic rate to approximately 10 % of the value at 37 degrees centigrade [1].

Practice has changed over the past several years to blood gas sample collection in plastic syringes as the standard, likely due to cost, safety and convenience. This change in practice has led to a re-evaluation of the impact of the collection device, storage time and storage conditions on the acid-base, oxygen and carbon dioxide results.

A comparison of the knowledge gained in the use of glass syringes compared to plastic syringes and the resultant changes on these measured results is necessary to identify and control the potential for error in result interpretation.

The arterial specimen collection and analysis guidelines published by the Clinical and Laboratory Standards Institute (CLSI) provide specific recommendations regarding specimen collection devices, sample handling, specimen transport and storage conditions based on scientific studies. Both CLSI documents, C-46; Blood Gas and pH Analysis and Related Measurements and H11-A4; Procedures for the Collection of Arterial Blood Specimens recommend that arterial specimens be collected in a plastic syringe, left at room temperature and analyzed within 30 minutes [2, 3].

Blood collected for special studies should be analyzed within 5 minutes. There are still situations in which a glass syringe should be selected as the collection device. This two-part article will examine what we have learned from the studies and how it might be applied in daily practice.

Several factors are important when evaluating the integrity of the arterial blood gas sample during the preanalytical stage. Substituting plastic syringes for glass syringes has required clinical and bench studies to evaluate the impact of syringe size, sample volumes, the effect of sample storage in ice water and the initial oxygen concentration in the sample.

Glass or plastic syringes

Plastic syringes have been shown to be significantly more permeable to both oxygen and carbon dioxide. Mahoney et al examined the changes in oxygen measurements when whole blood was stored in an iced plastic syringe or a glass syringe [4]. Blood gas samples have been stored on ice for many years to minimize leukocytic metabolism.

The cooling effect increases the solubility of oxygen in the plasma and increases the oxygen-hemoglobin affinity.

Polypropylene plastic syringes form a semipermeable barrier to atmospheric oxygen and other gases, whereas glass is an impermeable barrier to atmospheric gas pressures. This study reported minimal changes in pO_2 at lower values, but significant changes in pO_2 with an initial value of approximately 100 mmHg. A mean change of 8.4 mmHg was observed at 30 minutes, 9.6 at 60 minutes and 10.3 at 90 minutes.

These results are consistent with an earlier study by Scott *et al* [5]. There was little change noted at any level of pO_2 for samples stored in glass syringes and iced for 60 minutes. The carbon dioxide did not change significantly with collection device or storage temperature. The pO_2 did not change significantly when whole-blood samples collected in a plastic syringe were stored at ambient temperature for 30 minutes.

The authors concluded that samples collected in a plastic syringe should not be stored on ice.

The authors acknowledged that this may also impact preanalytical errors in specific conditions. When the hemoglobin concentration is decreased, the capacity for buffering oxygen may be reduced. Samples from individuals with extreme leukocytosis may also result in an incorrect diagnosis. Glass syringes may still be more appropriate in these specific conditions.

A 1992 German study compared the stability of blood gases, electrolytes and hemoglobin stored in ice water for 45 minutes in six different types of syringes (one glass syringe and five plastic syringes) [6].

Differences were observed among the plastic syringes as compared to the glass syringe. pO_2 changes were observed in the plastic syringes after 20 minutes. The authors concluded that samples collected in a plastic syringe should be analyzed within 15 minutes or a glass syringe should be used for sample collection.

Wu et al studied the source of errors in $pO_2(A-a)$ calculated from blood stored in plastic or glass syringes [7].

The authors examined the impact of time delays in sample analysis on blood gases, pH and base excess for specimens collected in plastic or glass syringes. The impact of the resultant errors on the calculation of the alveolar-to-arterial pO_2 difference was also evaluated.

Potential sources of error may include the syringe size due to the surface-to-volume ratio, the syringe wall thickness, initial blood gas tensions, the shape of the oxygen and carbon dioxide dissociation curves, and the effect of the Haldane and Bohr shifts as the blood gas tensions change.

The authors selected a 3-mL and a 5-mL plastic syringe. In addition, a 5-mL glass syringe was selected for comparison. Three different tonometered gas mixtures were collected and analyzed in each of the selected syringes. The specimens were stored on ice. Measurements were repeated on the same blood sample every hour for up to 6 hours. The authors reported several important findings from the study. Syringe size appeared to impact the rise in pO_2 with a sharper change in the 3-mL syringe versus the 5-mL syringe.

Although storage on ice reduces the rate of change in blood gas tensions and pH in glass syringes, the changes are not eliminated. Specimens collected and stored on ice in plastic syringes will actually increase the rate of rise in pO_2 . This occurs due to the combination of a decreased metabolic utilization of oxygen and a rise in the rate of diffusive transfer of oxygen into blood secondary to the decreased temperature.

The study revealed changes over time with both glass and plastic syringes. The impact of the error on $pO_2(A-a)$ moves in the same direction for both, but the magnitude of the error is greater in plastic syringes. The authors recommended storage at room temperature when specimens are collected in plastic syringes and immediate analysis of the specimen.

Each of the aforementioned studies found significant differences between the type of collection device, storage conditions and time to analysis. The consistent recommendation was analyzing specimens collected

in a plastic syringe in a 15-to-30-minute window. It is also important to consider special situations and when a specimen should be analyzed to decrease error in the measurement.

Part two will continue with collection devices, the impact of a high initial pO_2 , recent studies and current recommendations.

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