

Of Time and Temperature, Plastic and Glass: Specimen Handling in the Blood-Gas Laboratory

Mr McGuire: I want to say just one word to you.

Just one word.

Benjamin: Yes, sir.

Mr McGuire: Are you listening?

Benjamin: Yes, I am.

Mr McGuire: Plastics.

The Graduate, 1967

Character actor Walter Burke spoke his famous line about “plastics” just about the time that syringes made of plastic were being widely introduced to the medical marketplace. Plastics have taken hold in just about every aspect of modern life, including health care. Plastics equate to disposability, a characteristic that makes them valuable for eliminating cross-contamination in almost every area of the hospital and clinic. Intravenous bottles have become intravenous bags, and glass syringes have become just syringes, almost always plastic.

However, there is at least one medical use in which plastic does not have an advantage over glass, and that is for storage of whole blood to be used for blood-gas analysis. Almost as soon as plastic syringes appeared in hospitals, differences in blood-gas tensions of O₂ and CO₂ were observed with specimens collected in plastic versus glass syringes.¹ For over 30 years, investigators have described the effects of gas diffusion through the walls of plastic syringes.²⁻⁵ The P_{O₂} of blood stored in a glass syringe decreases slightly over time, primarily as a result of continuing cellular metabolism. Room-air blood-gas specimens drawn and stored in plastic syringes show the opposite pattern: the P_{O₂} increases, despite ongoing metabolism in erythrocytes and their kin.⁶ The degree of difference is largely a result of the differences in gas partial pressures between the sample and the environment. Samples with P_{O₂} values in the normal range tend to show P_{O₂} increases, whereas samples with high P_{O₂} values (eg, in shunt studies) decrease toward the ambient partial pressure of O₂. Notably, these differences can be clinically important if the blood-gas analysis is delayed. The P_{CO₂} displays similar but smaller differences between plastic and glass syringes, and in the opposite direction.

The traditional technique for reducing the effects of cell metabolism in blood-gas samples has been to place the

specimen in an ice-water bath. This works remarkably well for specimens in glass syringes; the changes in blood-gas tension in samples kept on ice for an hour or longer are clinically insignificant. The deleterious changes in gas tension observed in plastic syringes seem to be exaggerated when those same syringes are placed in a cooling bath.⁷ There are several explanations for this phenomenon. The solubility of oxygen almost doubles when the specimen is cooled from 37°C to 4°C. Hemoglobin’s affinity for O₂ increases with cooling even more dramatically, with a marked leftward shift of the dissociation curve. The combined effects of increased solubility and increased hemoglobin affinity enhance the influx of O₂ through the walls of the plastic syringe. When the specimen is warmed back to 37°C in the blood-gas analyzer, these effects reverse, releasing O₂ into solution and causing a falsely increased P_{O₂} measurement.

SEE THE ORIGINAL STUDY ON PAGE 732

In this issue of RESPIRATORY CARE, Knowles and colleagues revisit the problem of blood-gas specimen collection and storage.⁸ They used an innovative technique to simulate arterial blood specimens that have a *known* P_{O₂} and P_{CO₂}. This is a somewhat different technique than previous investigators have used, and it allowed for specimens stored in glass or plastic, both cooled and at ambient temperature, to be compared to “expected” values. Their results not only show the expected differences, they give us a perspective on how large those differences can be under well-controlled conditions. An analysis delay of 30 min for specimens collected in plastic syringes can result in P_{O₂} overestimates of ≥ 10%, with blood that has an oxygen tension in the normal range. Although Knowles et al looked at only “normal” P_{O₂} and P_{CO₂} levels, their methods could be used to evaluate the effects on blood gases in the critical ranges used for titrating O₂ therapy (50–60 mm Hg) or evaluating intrapulmonary shunt (200–600 mm Hg).⁹ Knowles et al provide an excellent discussion of the factors that affect blood gases drawn in plastic versus glass syringes.

The current guidelines for storage and handling of arterial-blood specimens for blood-gas analysis are fairly consistent. The Clinical and Laboratory Standards Institute (formerly the National Committee for Clinical Laboratory Standards) permits collection in plastic syringes if the specimen is to be analyzed within 30 min, and specifically states: "Do not cool the specimen."¹⁰ If analysis will be delayed more than 30 min, glass syringes and coolant immersion are recommended. The American Thoracic Society Pulmonary Function Laboratory Management and Procedure Manual¹¹ and the American Association for Respiratory Care (AARC) Clinical Practice Guidelines¹² reiterate the recommendations and warnings that blood gas specimens in plastic syringes may yield inaccurate results, particularly if analysis is delayed. My cursory review of the vendors listed under "syringes" in the AARC 2005 Buyers Guide found only one (of 15) advertising the availability of a glass syringe.

The effect of specimen handling (a pre-analytical variable), in regard to the type of syringe used and whether it is cooled, should be considered in relation to other sources of inaccuracy in blood-gas analysis (analytical variables). For example, the standard deviation for controls with a P_{O_2} near 100 mm Hg might be in the range of 1–3 mm Hg (with a well-maintained instrument). Manufacturers' package inserts for commercially available controls (Bayer RapidQC, Radiometer Qualicheck3+) list control ranges with 2 SD equal to 7–9 mm Hg, when the mean P_{O_2} is near 100 mm Hg. Similarly, proficiency-testing specimens with mean P_{O_2} values near 100 mm Hg shows SD values of 7–8 mm Hg across a wide variety of instruments and laboratories.¹³ The errors observed with a plastic syringe immersed in ice water equal or exceed the limits used to evaluate precision or accuracy of blood-gas analysis. The bottom line: these are *not* insignificant errors.

Plastics are here to stay, and plastic syringes are a fact of medical care. So if you must use them, analyze the specimen promptly and hold the ice!

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