Glass syringes are better than plastic for preserving arterial blood gas for oxygen partial pressure determination: an explanation based on nanomaterial composition

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Blood gas analysis is a basic and useful laboratory test for the critical care of patients (Wiwanitkit 1999; Barthwal 2004). Arterial blood gas analysis is an essential investigation for assessing clinical oxygenation and acid-base status in critically ill patients (Wiwanitkit 1999; Barthwal 2004), providing information about ventilation, oxygenation, and acid-base status, the three closely interrelated physiological parameters that maintain pH homeostasis. The correct interpretation and application of arterial blood gas analysis requires knowledge of basic applied physiology in relation to these parameters (Wiwanitkit 1999; Barthwal 2004). Quality control of blood gas analysis is therefore important. In general, this quality control should follow the basic principles of good laboratory practice, namely, pre-analytical, focusing on proper specimen collection, handling, and transportation; analytical, focusing on internal quality control and external quality assessment; and post-analytical, comprising good validation and interpretation (Wiwanitkit 1999).

An important source of aberrations in blood gas analysis results are errors in the pre-analytical phase (Mollard 2000). Several deficiencies in pre-analytical variables in blood gas analysis have been identified, most of which are caused by negligence and which are easily corrected (Ancic and Munoz 1997). Specific requirements for storage and transport of specimens for blood gas analysis have been proposed (Burnett et al 1994). Delay in analysis can decrease oxygen partial pressure (PO_2) and increase carbon dioxide partial pressure (PCO_2) because of the metabolism of blood cells. Ice preservation is recommended; however, there is no reason to keep arterial blood in ice if the blood gas analysis is done within 30 minutes (Liss and Payne 1993). The effect of syringe material on collected blood in general clinical chemistry has also been reported, including the diffusion of chemicals across the tube (Hilty et al 1969; Scott et al 1971). For blood gas analysis, the classical method requires a glass syringe; however, the new plastic syringes have been developed to address the increasing problems of blood-borne transmitted diseases (Evers et al 1972).

Some reports indicate that glass syringes are superior to plastic syringes in preserving samples, especially for PO_2 determination (Pretto and Rochford 1994; Deane et al 2004). However, there has been no specific explanation for this observation. Here, an explanation is attempted based on nanomaterial composition.

First, the size of the O_2 molecule was calculated based on the chemical-bonding principle (Goldberg 1989). The size of one O_2 molecule can be calculated by size of one O_2 molecule = 2 x (O^{2-} ion size) + (O-O bond length).

This equals 0.346 ([2 x 0.280] + 0.066) nm.

Then the pore size and pore density of the glass material (polymer of silicon dioxide, molecular weight = 28.09) and plastic (polypropylene, polymer of propylene, molecular weight = 132.16) were estimated. The pore size of glass and plastic material is equal

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to about 3–50 nm (pore radius = 1.5–25 nm) (Kin et al 1997) and 200–450 nm (pore radius = 100–225 nm) (Kin et al 1997), respectively. The pore densities of glass and plastic materials are equal to about 4×10^6 pores/cm^2 (Diem and Lentner 1971; Kin et al 1997) and 2×10^8 pores/cm^2 (Diem and Lentner 1971; Kin et al 1997), respectively. Therefore, the overall areas allowing diffusion, calculated by pore density $\times \pi \times$ (pore radius)^2, are estimated as 3×10^{-7}–8×10^{-5} cm^2/cm^2 of glass and 6×10^{-2}–3×10^{-1} cm^2/cm^2 of plastic, respectively.

At controlled temperature and other environmental factors, O_2 seems to have a greater chance (4–150 times) to diffuse across plastic than glass, which could be a good explanation why a glass syringe can better preserve oxygen in a blood sample for blood gas analysis.

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