Knowing Your Monitoring Equipment

THE PB3300 INTRAARTERIAL BLOOD GAS MONITORING SYSTEM

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ABSTRACT. Continuous intraarterial blood gas (IABG) monitoring is in clinical use both in the operating room and intensive care unit. This technology uses miniature, optically-based sensors that can be placed into a patient’s artery. The arterial blood gas values are transduced into an optical signal that is measured by a bedside monitor on which the values are displayed. In this paper, we describe the operating principles of the PB3300 Intra-Arterial Blood Gas Monitoring System (Puritan-Bennett Corporation, FOXS Division, Carlsbad, CA). Topics include the principles of fluorescent determinations of pH, PCO2, and PO2; the optical path of the PB3300; system calibration; dye layer geometry; and clinical operation. The accuracy, precision, and drift of the system measuring tonometered aqueous standards are reported. The following values were noted for eight sensors sending data to eight monitors: system bias and precisions of 0.00 ± 0.02 pH at a pH of 7.40, -2.5 ± 1.5 mm Hg PCO2 at a PCO2 of 40 mm Hg, and 3.3 ± 1.3 mm Hg PO2 at a PO2 of 80 mm Hg.


Arterial blood gas analysis has become an important tool in the diagnosis and management of critically ill patients since the advent of the modern blood gas analyzer in the late 1950s [1]. The oxygen and carbon dioxide tensions of arterial blood (Pao2 and Paco2), as well as the acid–base balance (pH) are key guideposts in the therapy of a patient’s oxygenation, ventilation, and cardiovascular and metabolic status. Until recently, clinicians have only been able to make intermittent measurements of the arterial oxygen and carbon dioxide gas tensions and blood pH using bench-top in vitro analyzers.

For nearly 20 years, researchers have been pursuing alternative methods of acquiring blood gas measurements. Much effort has gone into developing invasive systems that provide the physician with continuous blood gas measurements. In addition to eliminating the drawbacks of the conventional in vitro methods, continuous intraarterial blood gas monitoring systems may provide other benefits. No blood is taken from the patient, which benefits the patient and reduces exposure to blood for the caregiver and lowers the risk of nosocomial infection. Many technologies have been pursued, including electrochemical sensors [2–5]; field effect transistors gated by chemicals, enzymes, or ions [6–8]; gas chromatographs [9]; and mass spectrometers [10] with indwelling sampling catheters, optical reflectance [11], and fluorescence [12–16].

Many challenges face the developer of a continuous intraarterial monitoring system. The sensor must be miniaturized for intravascular use, while maintaining
stability and mechanical integrity. The sensor must also be small enough so that blood pressure fidelity is not compromised when the sensor occludes part of the lumen of the arterial catheter. Blood-contacting materials must be nonthrombogenic, biocompatible, and sterilizable. If the sensor is a single-use product, cost constraints and manufacturability also must be considered. Above all, the system must provide accurate and reliable information on arterial blood gas values.

A real-time, continuous blood gas monitoring system, the PB3300 Intra-Arterial Blood Gas Monitoring System (PB3300), has been developed and is being used clinically in the care of both surgical and medical critical care patients.

**SYSTEM DESCRIPTION**

The PB3300 system consists of the PB3300 monitor (Fig 1) and the PB-FOxS intraarterial sensor (Fig 2). The fundamental measurement technology uses oxygen and pH-sensitive optical fluorescent dyes immobilized at the tip of optical fibers housed in the sensor. The sensor contains three optical fibers—one for each of the three measured parameters, and a thermocouple for measuring temperature at the sensor tip (Fig 3). The three fibers differ primarily by the dye system used.

The microprocessor-controlled monitor contains a three-channel optical block. Each channel is dedicated to a single parameter and is coupled to the correspond-