Bentley Gas-STAT: Our Clinical Experience

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Abstract

An on-line, real-time blood gas monitoring system will provide the perfusionist with an accurate trend of the ever-changing pH fluctuation and gas exchange.

With very little adaptation to our perfusion circuit using the Bentley, Gas-STAT Device, we are now able to monitor the arterial and venous pH, pCO₂, PO₂, as well as the blood temperature.

Its ease of calibration and initial battery life of 14 hours allows continuous monitoring over a prolonged bypass time. This added parameter enables the perfusionist to respond to the immediate needs of the patient.

As a result we are able to anticipate potentially hazardous events that can occur unexpectedly at any time. Equipment fatigue, such as membrane failure, can be diagnosed with absolute certainty, and therefore, a perfusion catastrophe can be averted.

Introduction

Milwaukee Heart Surgery Associates of Milwaukee, Wisconsin, performing cardiac surgery at St. Mary's Hospital, elected to evaluate the Bentley Gas-STAT Monitoring System.

Materials and Methods

The Bentley Gas-STAT Monitoring System provides continuous, on-line, real-time, blood gas monitoring of arterial and venous pH, pCO₂, PO₂, and temperature. Each value is an average of four data points which is updated every six seconds.

The system operates on the principle of fiberoptic fluorescence. It functions as a microprocessor-based monitor which couples via two fiberoptic cables to the disposable Gas-STAT cells and optical fluorescence-based sensors. Light pulses, originating from a flash lamp similar to one used in photography, are passed through an optical filter so only pulses of a specific color are transmitted down the fiberoptic bundles to the sensors which are inserted into the outflow line of the oxygenator prior to the arterial filter. Another sensor is inserted into the venous return line should venous gases be desired.

The sensors contain fluorescent chemicals which emit light in response to the stimulating pulses. The intensity of this emitted light depends upon the concentration of oxygen, carbon dioxide, and hydrogen ions passing through the gas and ion permeable membrane of the Gas-STAT cell which separate the sensing chemicals from the blood. The light emitted by the fluorescent sensors is returned to the monitor through receiving optical fibers in the fiberoptic bundle.

A detection filter isolates the specific colors of interest from the returning light spectrum for measurement by a light detector. The detector output signal is converted by the microprocessor circuitry and the monitor displays a numerical readout in millimeters of mercury or pH units. Blood temperature is also displayed using a thermistor located in the sensor.

The sensors must be calibrated prior to insertion using Bentley's Gas-STAT Calibration Device. It is specifically designed for rapid automated calibration utilizing two-point tonometry. The device is designed so two Gas-STAT sensors may be calibrated at the same time.

The monitor itself is preprogrammed for the given partial pressures of the gases in the cylinders that fit into the calibration device.

Results

The accuracy of the Bentley Gas-STAT Monitoring System has ranged from 3–7% when compared to the hospital laboratory. It was felt while accuracy was an important feature of the unit, accurate trending was imperative.

When arterial and venous gases are monitored we can determine not only the true status of the patient by the venous gases but can also monitor the perfor-
performance of our oxygenator by simply observing the arterial blood gas values. Should the oxygenating system begin to fail, the drop in arterial pO₂ is almost immediate and the buildup of arterial pCO₂ is almost just as immediate.

By continuously observing the pH value we are able to determine acidosis or alkalosis and respond with the appropriate treatment. Bearing in mind that these are real-time values with the option of temperature correction. We are able to observe the effects of "hypothermia" on the patient. The benefit of a device such as this is limitless.

The monitor can be securely mounted to the mast of any heart-lung machine commercially available and because of the compactness of the unit itself, poses no problem or creates no obstruction on the console or tubing circuitry. Because of the size and weight of the Fiber Optic cables and Fiber Optic Cable Connectors, we must emphasize cautious placement of the sensor if used in the arterial line as it may lead to possible kinking. Because of our particular system, which is fairly universal, we have not seen this but are obligated to recognize this possibility as a potential hazard.

Prior calibration, to a lesser extent, may be a possible concern in that the procedure requires twenty minutes. As the perfusionist is assembling the circuit the sensors can be calibrating because of the automated system so by the time the operator has set up the pump, the calibration of the sensors should be complete. This time time factor has posed no problem or inconvenience. Should an emergency arise, in vivo calibration can be accomplished during the pump run by calibrating the Gas-STAT to the known Lab results.

**Discussion**

The system is not perfect or without minor flaws but it has been our experience that the Bentley Gas-STAT System fulfills a need in perfusion and ultimate care of the patient while on bypass. If proper calibration and technique is observed accurate trending of real-time blood gas values can be obtained with a high degree of certainty. The information and data this unit has to offer allows our group a unique margin of safety that up until now did not exist.

In a research environment, the Gas-STAT's value is unparalleled because of the immediate trending capabilities and acquisition of data.

**References**


**Questions from the Audience**

*Question—Bob Carto:* You said you have an accuracy of 3 to 7%. We also have had some problems with some of the membrane oxygenators. I'd like to ask, what is the cost to the institution for arterial-venous probe?

*Answer:* I can't tell you what it is right now, because we have gone to a completely computerized system. We've discovered that not only does it cost more with the computerized system, but it takes longer with the computerized system. We want 24 hour availability of blood gas results, and the hours between midnight and 5:00 a.m. are when we do some of our best cardiac surgery. We know there are people in the lab, because the lights are on, they don't answer their phones, and we don't get our blood gas results. If we get them, they are 20 minutes late and totally meaningless at that particular point in time. The delivery of the blood samples, many times is lost within the bowels of the pneumatic tube system of the hospital, because the blood gas laboratory is not geographically located within the operating room. So we have a very serious time factor here. From the time the blood gases are drawn, picked up by the monitor tech, sent through the pneumatic tube system, sitting on the counter down in the lab, waiting for the computer tech to run the samples, it can range between 20 and 25 minutes. So a time factor as well as cost was considered. Our pump runs are very, very long—seven eight and nine hour ones in Milwaukee. You can imagine how much it would cost to do an arterial and venous panel and we like to draw them on an hourly basis. Subsequently, we know every six seconds what the status of the patient is with this unit. So we have saved the patient a lot of money and we have made a lot of enemies in the lab as a result of it.

*Question—Scott Garavet:* Have you found a long lag time in the results, especially when rewarming?

*Answer:* No. Because of the inline thermostat and temperature monitoring system of the cell itself, the results keep up with the change in the temperature gradient. We notice that there is a normal physiological response to the increase or decrease of the temperature, both on the arterial side and the venous side.
**Question (Unknown):** Are the Gas-STAT results your only documentation, or do you use the lab results too?

**Answer:** We draw a baseline blood gas sample 15 minutes after we’re on and we check the calibration of our unit with the known blood gas samples. If they are very far off, then we can in vivo calibrate. Normally, we do not have to do this. As far as legal documentation, the only legal documentation we have is what the perfusionists record on the perfusion record. There is a printer available with this unit, but we do not have it. The printer will give us documented blood gas value. As it samples, you can program it for 5 or 10 minutes, or whatever you prefer. But we do not have that at our institution.

**Question—Bob Corte:** When you connect your cable to your sensor in the venous line you can do that when the pump is off, or you can have a clamp on. How about when you connect your sensor on the arterial line?

**Answer:** What we generally do is to recirculate our volume when we’re setting up in the morning. After we finish recirculating, we shut the pump down and then put our sensors in line. Then we re-establish our recirculation, and we’re able to view the acidity or the alkali value of our solution. You cannot insert these sensors in line, if there is any pressure, or you pump while they are running—or you’ll just blow that membrane.

**Question—Bob Corte:** With the arterial line with some oxygenators, when you shut them off, you sort of suck some air in it. Do you have some difficulties, debubbling the oxygenator afterward?

**Answer:** We have seen no problem in this area.