Original Article
Presented at the AmSECT 30th International Conference
March 13-16, 1992, Washington, D.C.

Clinical Evaluation of a New Saturation/Hematocrit Monitor

Mark F. Miller, MS, CCP, Jeff Luckenbach, BS, CCP, Chao Chen, PhD
Deborah Heart and Lung Center, Browns Mills, NJ

Keywords: cardiopulmonary bypass, in-line monitoring, hematocrit, venous oxygen saturation

Abstract

The purpose of this study was to evaluate the utility of the Cobe SAT/HCT Monitor, an in-line device which continuously displays hematocrit and venous oxygen saturation. A fiber optic cable was used to connect the monitor to a "window" on the blood inlet of a venous reservoir (Cobe CML). Sixty venous blood samples were drawn from 20 patients undergoing cardiopulmonary bypass. Statistical correlations were performed comparing monitor readings with controls measured by an IL 482 co-oximeter and a TRIAC centrifuge. Results showed a high degree of correlation between the monitor and control values for both venous saturation (r = .96) and for hematocrit (r = .94). Although this device has some minor deficiencies, it is a useful tool which enables the perfusionist to monitor two important components of oxygen consumption.

Introduction

Rubsamen (1) argues that in-line monitoring devices for use during cardiopulmonary bypass are not only essential, but inevitable. But in-line monitoring of arterial and venous blood gases, hematocrit (Hct) and electrolytes may increase the cost and complexity of an already costly and complex procedure. Perhaps there exists a compromise, in which one or two important parameters can be monitored continuously, and discrete samples can be drawn for the remaining values. A rationale for continuously monitoring venous oxygen saturation (SvO_2) and Hct (or hemoglobin) involves examination of the Fick (2) equation:

VO_2 = CO X A-VO_2 Difference
where:
VO_2 is oxygen consumption,
CO is the cardiac output and
A-VO_2 Difference is the arterio-venous oxygen content difference

Address correspondence to:
Mark F. Miller
529 Regenhard Ave.
Moorestown, NJ 08057

Recall that A-VO_2 difference contains the parameters SaO_2 (arterial oxygen saturation), SvO_2 and hemoglobin. If one is willing to assume that SaO_2 equals about 100%, then a venous saturation/hematocrit monitor adds the necessary parameters for continuous monitoring of oxygen consumption. Cobe Cardiovascular Inc. has recently developed an in-line "satcrit" monitor to be used during cardiopulmonary bypass (CPB). This device continuously displays SvO_2 and Hct during bypass. A fiber optic cable connects the monitor to a "window" on the venous inlet of the Cobe CML Excel oxygenator. Although the SvO_2 function is precalibrated, the Hct function cannot be calibrated until after initiating CPB. After going on bypass, the perfusionist presses the "store" button while drawing a blood sample. Upon receipt of the hematocrit result from that sample, the "recall" button is pressed, and the monitor is calibrated by entering the known hematocrit.

The purpose of this study was to evaluate the utility of the Cobe SAT/HCT Monitor when used clinically, and in accordance with the manufacturer's instructions.

Materials and Methods

Approval was obtained from the Institutional Review Board for this study. The subjects included 20 adult patients who underwent cardiopulmonary bypass with hypothermia.

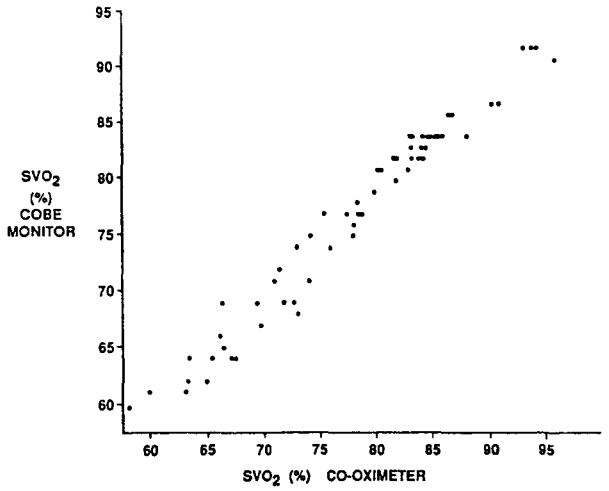

Figure 1.
Venous oxygen saturation (SvO_2) readings from the Cobe SAT/HCT monitor versus control values from the IL 482 co-oximeter. r = 0.96

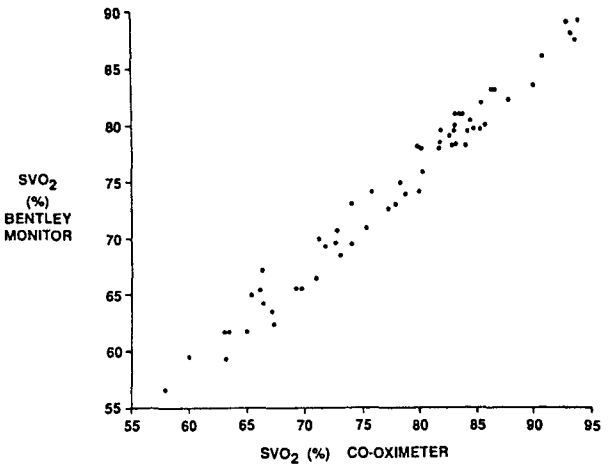

Figure 2.
Venous oxygen saturation (SvO_2) readings from the Bentley OxySat monitor versus control values from the IL 482 co-oximeter. r = 0.97

All patients were determined to have a body surface area of 1.90 meters squared or greater (standard procedure for using the Cobe Excel oxygenator[a] at Deborah Heart and Lung Center).

For each patient, blood samples were drawn at three different intervals during CPB. The first sample was drawn within ten minutes after going on bypass, the second sample was taken during hypothermia, and the third sample was drawn just prior to terminating CPB. For each sample, a control value was recorded for both hematocrit and for SvO_2. Controls for Hct were determined using capillary tubes and a TRIAC centrifuge[b]. Controls for SvO_2 were measured with an IL 482 co-oximeter[c]. While the blood samples were being drawn, readings were recorded from the Cobe SAT/HCT monitor[a] for SvO_2 and Hct (the first sample from each patient was used to calibrate the Hct function and, thus, was not included in the Hct data).

In order to aid in the evaluation of the Cobe monitor a Bentley OxySat[d] sensor was inserted into the venous line of each perfusion circuit. The OxySat is an in-line SvO_2 monitor that has been evaluated (3,4) and has been used clinically for several years (5). The SvO_2 was recorded from the OxySat at the same intervals as data was taken from the SAT/HCT. The data set was entered into a computer and analyzed by the SAS system[e].

The means of the experimental values and of the control values for each patient were first determined, then Spearman correlation coefficients (r) were computed.

Results

All the correlation coefficients were significantly different from zero ($p < 0.001$). A scattergram (Figure 1) depicts a positive correlation ($r = 0.96$) between the SvO_2 readings from the SAT/HCT monitor and controls from the co-oximeter. Figure 2 demonstrates a positive relationship between the SvO_2 readings from the OxySat and the co-oximeter ($r = 0.97$). Figure 3 shows a positive correlation between the hematocrit readings from the SAT/HCT and the control values of the centrifuge ($r = 0.94$). For SvO_2 there is a statistically significant ($p < .01$) bias with both the Cobe SAT/HCT and the Bentley OxySat. The mean bias (monitor minus co-oximeter) is -.94% for the SAT/HCT. The mean bias for the OxySat is -3.3%. The Hct function of the SAT/HCT has no significant bias.

Discussion

We found the Cobe SAT/HCT monitor to be a useful and accurate tool for monitoring oxygen transfer. The SvO_2 values correlated extremely well with the controls. The "mean bias" reported above merely indicates that the SAT/HCT consistently reads an SvO_2 that is about one point low. The Bentley monitor,

a Cobe Cardiovascular Inc., Lakewood, CO 80215
b Becton Dickinson & Co., Rutherford, NJ 07070
c Instrumentation Laboratories, Lexington, MA
d Baxter Bentley Laboratories, Irvine, CA 94013
e SAS Institute, Cary, NC 27512

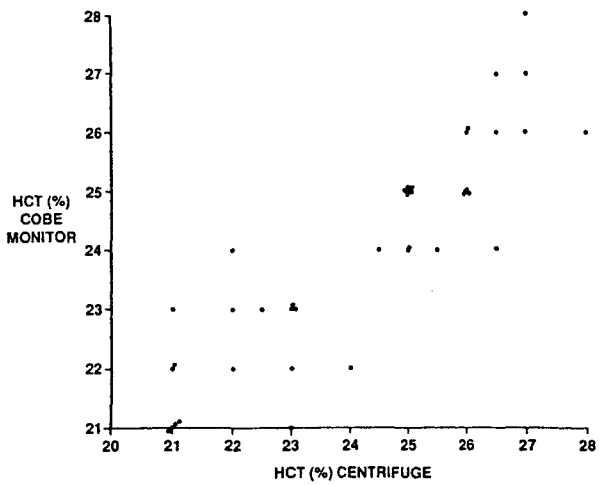

Figure 3.
Hematocrit (Hct) readings from the Cobe SAT/HCT monitor versus control values from the TRIAC centrifuge. r = 0.94

which continues to be used clinically in many institutions, reads about three points low, on the average.

Hematocrit values were consistent with Cobe's claims of accuracy (plus or minus one Hct %). We found in-line Hct to be most helpful in instances where it was necessary to add large amounts of volume in a short span of time. The absence of a pre-calibration capability for Hct is a minor deficiency. If the perfusionist has neither the time nor the inclination to calibrate the Hct function, monitoring in- line SvO_2 alone is valuable. For example, if the SvO_2 is low, such as 50%, tissue extraction of oxygen is relatively high, resulting in possible hypoxia and lactic acidosis (7). The perfusionist could immediately employ strategies to increase oxygen transfer, reduce oxygen consumption, or some combination of both. If low SvO_2 persists, a point may be reached where the oxygenator cannot fully saturate the hemoglobin. Arterial oxygen saturation then begins to drop, and a vicious cycle of hypoxia may ensue. In summary, the Cobe SAT/HCT monitor is a useful tool which enables the perfusionist to monitor two important components of oxygen consumption.

References

1. Rubsamen DS. Continuous blood gas monitoring - How soon will it be the standard of care? J Cardiothorac Anesth. 1990;4:1-4.
2. Yang S, Bentivoglio L, Maranhao V, Goldberg H. From cardiac catheterization data to hemodynamic parameters. Philadelphia: F.A. Davis Company; 1988:43-46.
3. Vurek GC, Kolobow T, Pegram SE, Friauf WS. Oxygen saturation monitor for extracorporeal circulation applications. Med Instrum. 1973;7:262-267.
4. Iatridis A, Heinemann S, DeRocher R, Osborn J. Continuous monitoring of blood oxygen saturation during extracorporeal circulation. J Extra-Corp Tech. 1981;13:233-236.
5. Eisiminger R, Fried M, Lindemann D, Kovach S, Ziga AM, Schmidt K. Use of in-line venous oxygen saturation to predict post bypass cardiac output. J Extra-Corp Tech. 1984;16:47-50.
6. Swan H, Sanchez M, Tyndall M, Koch C. Quality control of perfusion: monitoring venous blood oxygen tension to prevent hypoxic acidosis. J Thorac Cardiovasc Surg 1990;99:868-72.
7. Kandel G, Aberman A. Mixed venous oxygen saturation - Its role in the assessment of the critically ill patient. Arch Intern Med. 1983;143:1400-1402.