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# Use of In-Line Venous Oxygen Saturation to Predict Post Bypass Cardiac Output

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## Abstract

A series of 50 patients were studied to determine if post cardiopulmonary bypass (CPB) cardiac output (CO) could be predicted based upon in-line venous oxygen saturation (SvO<sub>2</sub>) values generated as CPB was being terminated. After rewarming, the arterial pump flow (APQ) was varied and resultant changes in SvO<sub>2</sub> recorded. At low flow (600 ml/min), just prior to terminating CPB, the SvO<sub>2</sub> was recorded and plotted on a linear graph generated from the previous data. The CO predicted by the low flow SvO<sub>2</sub> correlated well with post-CPB measurements of the CO. ( $r = 0.82$ ,  $p < .0001$ )

## Introduction

One of the most critical periods during cardiac surgery utilizing cardiopulmonary bypass (CPB) is the transition from CPB to termination of support from the heart-lung machine. Currently, assessment of cardiac function includes observing the ECG, arterial blood pressure, filling pressures and direct vision of the heart size and vigor. Post-bypass, the cardiac output (CO) is the most reliable measurement of cardiac function.<sup>1,2</sup> Therefore, any technique that reliably estimates CO is of clinical significance.

The relationship between cardiac output (or CPB blood flow) and mixed venous oxygen saturation (SvO<sub>2</sub>) has been described as linear.<sup>3,4</sup> Further-

more, accurate in-line monitoring of the venous saturation has been shown to be possible by using the Bentley OxySat Meter.<sup>5</sup> The present investigation was undertaken to determine if the relationship between on CPB SvO<sub>2</sub> and post CPB CO could be defined.

## Methods and Materials

Fifty concurrent adult patients undergoing CPB for a variety of cardiac surgical procedures served as the patient population for this study. All patients were fully anesthetized and paralyzed and all measurements were taken after the patient's temperature had been returned to normal (rectal temp.  $\geq 35^{\circ}\text{C}$ .)

The arterial pump flow (APQ) was varied between cardiac indices of 2.0 and 3.0 L/min/m<sup>2</sup> and the SvO<sub>2</sub><sup>a</sup> at the two flows was recorded approximately five minutes after the flow was changed. A linear graph of SvO<sub>2</sub> versus APQ was plotted. As CPB was being terminated by slowly reducing the APQ and elevating the left atrial pressure to between 10 and 18 mmHg, the APQ was held at 600 ml/min. The SvO<sub>2</sub> was noted and the CO estimated from the graph generated previously.

After CPB was terminated, the CO was determined by averaging three thermodilution<sup>b</sup> CO readings.<sup>6</sup> The thermodilution measurements were performed by the anesthesiologist who was not informed of the estimated CO. Linear regression analysis was used to determine correlation between the SvO<sub>2</sub> estimated COs and the thermodilution COs.

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a. Bentley OxySat Meter. American Bentley, Irvine, Ca. 92714

b. Edwards Cardiac Output Computer, American Edwards, Santa Ana CA 92705.

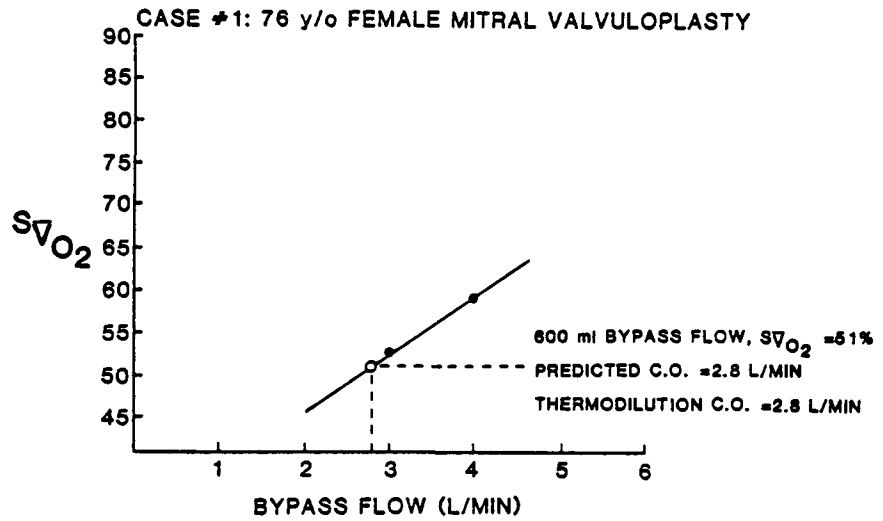


Figure 1A

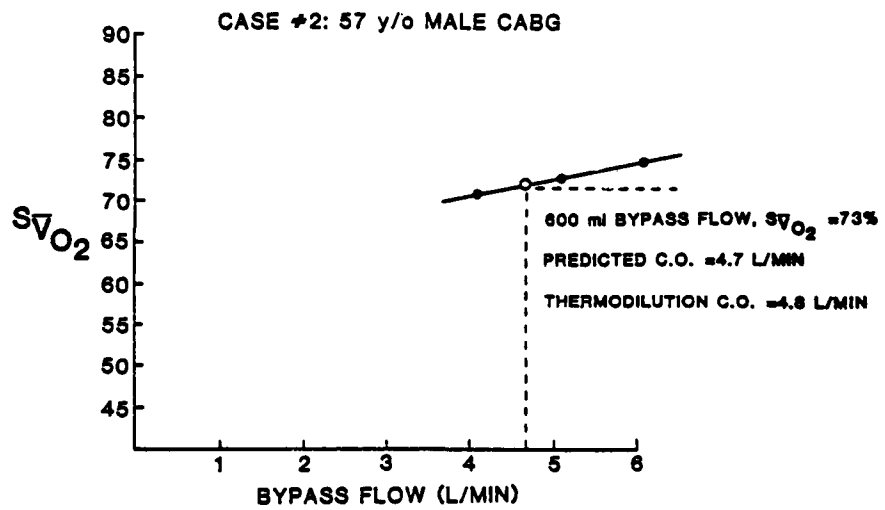


Figure 1B

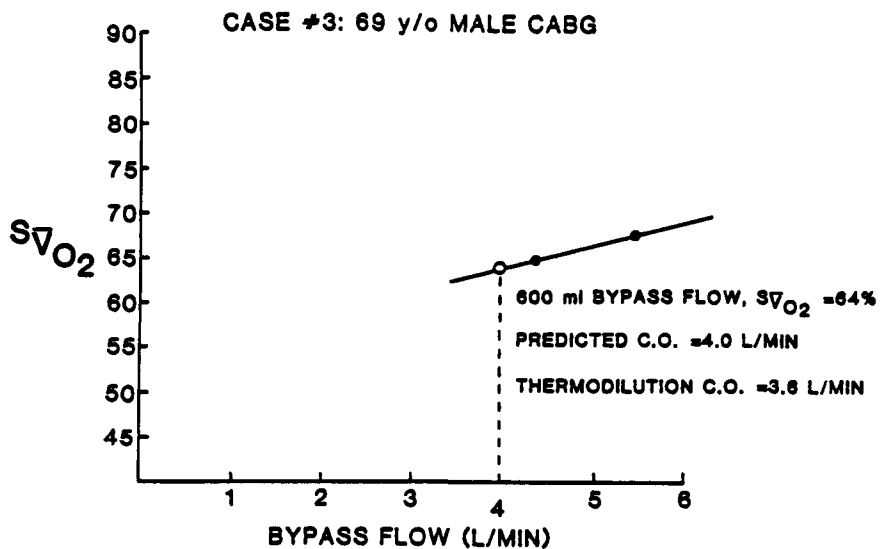


Figure 1C

**Figures 1A, 1B, 1C**

The SvO<sub>2</sub> was noted at varying bypass flows and a linear plot constructed (circus). As bypass flow was decreased to 600 ml/min, the oxygen saturation was noted (open circle) and the immediate post bypass cardiac output predicted. Thermodilution CO was then performed in triplicate by the anesthesiologist, who was unaware of the predicted CO. Baseline SvO<sub>2</sub> levels varied from patient to patient, but the relationship remained useful whether the baseline SvO<sub>2</sub> was (a) 50%, (b) 70%, or (c) 60%.

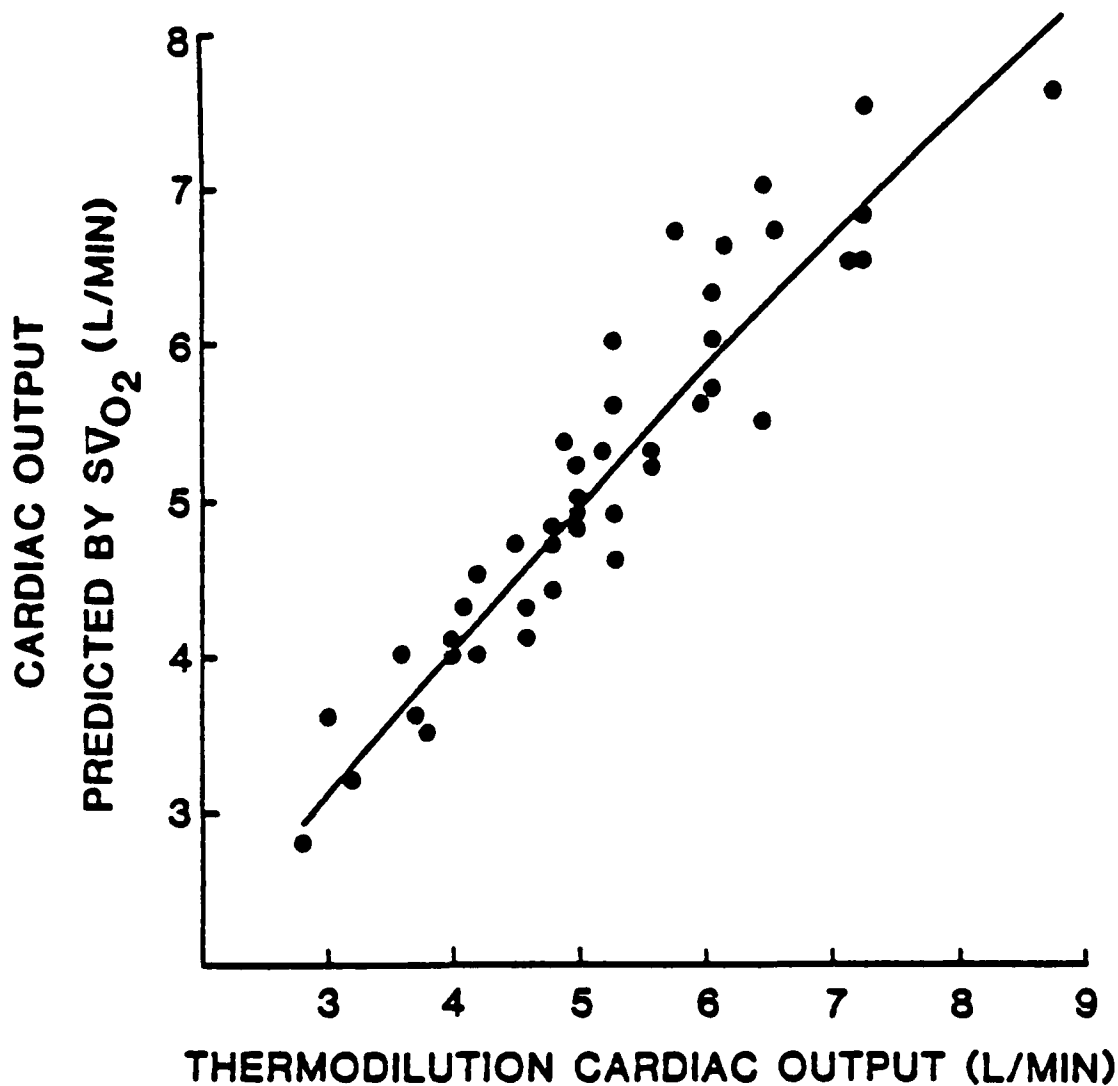


FIGURE 2. There was close correlation between predicted cardiac output and thermodilution cardiac output in 50 patients ( $r = .82$ ,  $p < .0001$ ).

## Results

Examples of the linear graphs generated during three procedures on patients with differing  $SvO_2$ s and the subsequently generated estimates of CO are shown in Figure 1a, 1b and 1c. The correlation between  $SvO_2$  estimated CO and thermodilution CO from all fifty trials is shown in Figure 2. There was an excellent correlation coefficient ( $r = .82$ ,  $p < .0001$ ).

## Discussion

The value of in-line monitoring of the  $SvO_2$  has

been demonstrated in previous studies.<sup>7,8</sup> This study demonstrates an additional function for the OxySat meter. Our current technique for terminating bypass includes slowly reducing the pump flow while reporting the flow, arterial blood pressure, left atrial pressure, central venous pressure and the  $SvO_2$ . If the  $SvO_2$  predicts a post-bypass cardiac index of  $2.0L/min/m^2$ , bypass is terminated. However, if the  $SvO_2$  falls and predicts a post bypass cardiac index of less than  $1.5L/min/m^2$ , bypass is reinstated with flows between  $2.0$  and  $3.0L/min/m^2$  for 15 to 30 additional minutes. If the  $SvO_2$  predicted CO remains below  $2.0L/min/m^2$

during a second weaning attempt, intra-aortic balloon support is instituted.

This technique has been especially useful in patients who exhibit low radial artery pressure but stable SvO<sub>2</sub> as bypass is terminated. We have observed that this may be due to either extremely low peripheral vascular resistance or to the existence of a pressure gradient between the central aorta and the radial artery pressure monitoring site. In both cases, if the SvO<sub>2</sub> value predicts an adequate post bypass CO, the cardiac output will be satisfactory upon termination of bypass.

A question may be raised concerning the use of an in-line sensor to monitor mixed venous return values. Cannulation technique may alter the value obtained especially as bypass flow is reduced.<sup>9</sup> This series of patients did include patients with both single venous cannulation with a two-stage cannula and patients in whom both cavae were separately cannulated. The SvO<sub>2</sub> displayed by the OxySat meter was predictive of the CO in both cannulation techniques.

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