The Oxygenator Arterial Sampling Port: A Potential Source of Error

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During cardiopulmonary bypass (CPB) oxygen tension of the perfusate is measured periodically to verify performance of the oxygenator. To this end, bubble oxygenators have a sampling port for removing an aliquot of "arterialized" blood. In our hospital, specimens for analysis are sometimes drawn simultaneously from this port and from the patient's indwelling arterial catheter. We have been struck by the occasional appearance of a large gradient from oxygenator to patient for oxygen. It was never clear whether this discrepancy was laboratory error, a defect in the machine, or some previously undescribed venous admixing in the patient's circulation. This study was performed to determine if these observations represented a systematic rather than random occurrence and, if so, the cause.

**METHODS**

During a 6-week period, 55 patients undergoing elective coronary artery bypass operations requiring normothermic cardiopulmonary bypass were studied. Oxygenators used were the Cobe Optiflo II®, Bentley-BOS 10S®, and Harvey H-1700®. An additional sampling port was created in the arterial tubing between the roller head and the patient to serve as a definitive source for a sample of blood actually transmitted to the patient. During the time of CPB when the aorta was cross-clamped and the heart entirely excluded from the circulation, blood was simultaneously withdrawn from the standard oxygenator sampling port provided by the manufacturer, from the added inline arterial port, and from the patient's indwelling arterial catheter. Specimens were placed in ice and analyzed in random order for PO₂, and PCO₂, and pH at 37° C within 10 min on the same blood gas machine by the same technician. No corrections were made for temperature.

Two sets of samples were obtained from 44 of the 55 patients providing data for 99 separate comparisons. Statistical analyses were performed by an analysis of variance routine for a completely randomized design (simple randomized). When the analysis of variance tested significant at the 0.05 level, a Student's t test was performed to determine which of the three sample sites significantly differed from the others.

**RESULTS**

Each set of three samples drawn simultaneously was treated as one observation. The mean oxygen tensions for observations among the various oxygenators are presented in table 1. Carbon dioxide tension and pH were not different at the three sampling sites for the Cobe® or Bentley® oxygenators, while PCO₂ measured from the oxygenator port of the Harvey H-1700 was significantly lower (44 ± 4 mmHg) than that obtained from the inline sampling port (46 ± 5 mmHg) or patient artery (46 ± 5 mmHg). When the PO₂ values of the paired radial artery and pump arterial tubing samples for all oxygenators were compared, there was no significant difference (fig. 1). However, the plot of the oxy-

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<tr>
<th>Table 1. Oxygen Tension Values Obtained Simultaneously from the Three Sites during CPB with Three Different Oxygenators</th>
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<tbody>
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<td><strong>Patients</strong></td>
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<td>Cobe Optiflo II®</td>
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<td>Bentley-BOS 10S®</td>
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<td>Harvey H-1700®</td>
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* Reported as mean ± SD.
† Significantly different from oxygenator value at P < 0.001.
Fig. 1. Plot of paired observations for oxygen tension simultaneously sampled from the added inline sampling site and the patient's radial artery. The dashed line is the line of equality.

Fig. 2. Plot of 99 paired observations for oxygen tension simultaneously sampled from the added inline sampling site and the "arterial" sampling port of the oxygenator with regression lines for each oxygenator. The dashed line is the line of equality.

Oxygenator values versus those from the inline arterial tubing verifies a significant tendency of the Harvey® oxygenator specimen to overestimate the $P_{O_2}$ of the blood actually pumped to the patient (fig. 2).

DISCUSSION

Our data clearly show that with at least one bubble oxygenator, the Harvey H-1700®, there is a systematic error in blood gas values obtained from the sampling port provided by the manufacturer and that the error arises from incomplete mixing at the oxygenator sampling port rather than venous admixing in the patient.

A computer-assisted review of the literature and a personal solicitation of the companies involved failed to provide either verification of the representative accuracy of samples obtained from the oxygenator sampling port or a scientific investigation of the problem.

In terms of patient safety, blood gas values obtained from the sampling port provided in the Harvey® device are likely to be misleading in a potentially dangerous direction. Samples from this site typically provide higher oxygen tensions than the actual levels arriving in the patients, and in our series of 49 observations there were two instances where the blood received by the patient was less than fully saturated with a $P_{O_2}$ less than 100 mmHg, despite values obtained from the oxygenator to the contrary. Since patient management decisions are based on these values, this set of circumstances may be hazardous.

Although this discrepancy was not seen systematically with either of the other oxygenators, a tendency for the same type of error existed at physiologic oxygen tensions (fig. 2) and the potential for a unique problem with these or some other device remains a possibility. For this reason we urge that, with all bubble oxygenators, blood gas analysis be sampled from the patient's indwelling arterial catheter and that all management decisions be based on those values.