

Malposition of Blood Sampling Catheter in the Polystan Oxygenators

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Introduction

In both clinical and experimental perfusions with Polystan* VT 2000 and VT 5000 (Rygg-Kyvsgaard) oxygenators, areas of desaturated blood have been observed in the defoamer and arterial reservoir. The suspicion arose that the arterial blood samples extracted from the arterial reservoir near or in the desaturated areas (see Diagram 1) might provide a false indication of the blood gas tensions reaching the patient and thus lead to inappropriate management decisions. The aim of the present investigation has been to analyze this phenomenon in detail.

Methods

The pO_2 , pCO_2 and pH in blood samples taken from the oxygenator reservoir sampling catheter have been compared with samples taken from the arterial line filter in the clinical perfusions or from a 3-way stopcock inserted in the arterial line during experimental perfusions. Samples were taken only during total bypass.

The blood samples were analyzed with Radiometer** microelectrode equipment. In perfusions where hypothermia was employed blood sample analysis was corrected to $37^\circ C$.⁵

High correlation existed between pO_2 , pCO_2 , and pH values in simultaneously extracted blood samples

from the arterial line filter and a 3-way stopcock inserted in the extracorporeal arterial line in seven sample pairs from a single ninety-minute experimental perfusion. Oxygen tension variation of ± 5 mm Hg, carbon dioxide variation of ± 3 mm Hg, and pH variation of ± 0.03 were observed. Thereafter the arterial line filter was used to extract blood samples in the clinical perfusions.

In addition, high correlation was demonstrated between blood sample values for the above mentioned parameters between the arterial line and the aorta in seven paired comparisons from another 90-minute experimental perfusion. Oxygen tension variation of ± 4 mm Hg, carbon dioxide variation of ± 2 mm Hg,

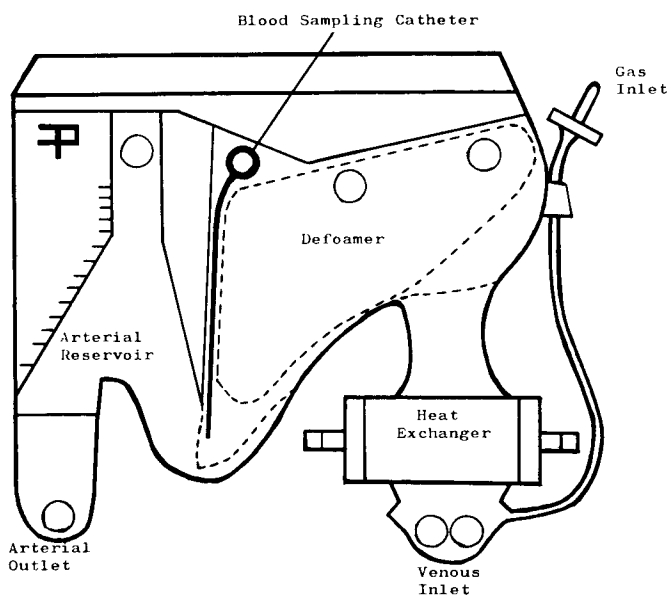


DIAGRAM 1. Schematic diagram of Polystan oxygenator showing the position of the blood sampling catheter.

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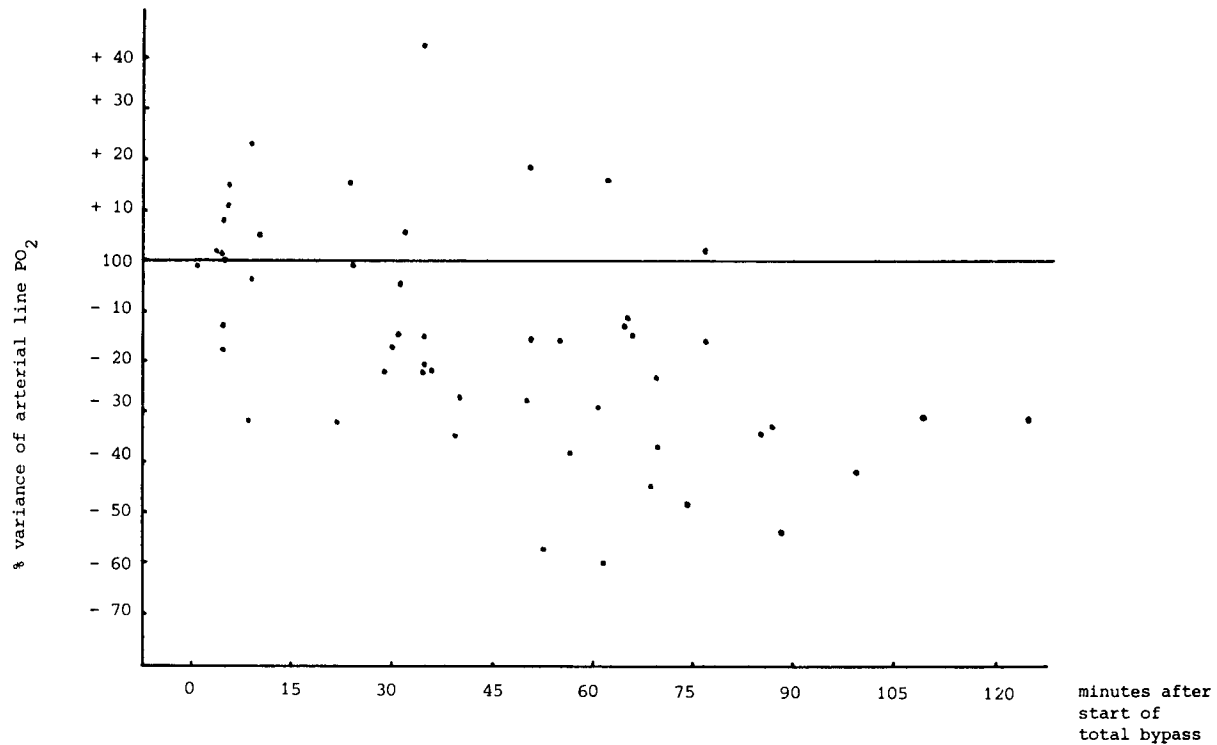


FIGURE 1. Arterial line blood pO₂ shown as percentage of blood sampling catheter pO₂ (set to 100%) in thirteen clinical perfusions.

and pH variation of ± 0.03 were observed.

Each perfusion was monitored with the results from the blood sampling catheter in the oxygenator. Results from the arterial line were not revealed until after the perfusion's conclusion.

The circuit used in both clinical and experimental perfusions consisted of the Polystan heart-lung machine with Verticlude roller pumps, Polystan VT 2000 or VT 5000 oxygenators, silicone rubber tubing, Polystan cardiotomy reservoir, Swank*** cardiotomy filter and the Pall Ultipor**** arterial filter (omitted in the experimental perfusions). Heparinization was controlled by measuring the active clotting time using the Hemochron***** system and the coagulation time was maintained above 480 seconds.

The experimental material consisted of six dogs with a bodyweight from 20 to 25 kg. The perfusions were done under normothermic conditions using Polystan VT 2000 oxygenators. The clinical subjects consisted

of thirteen adult patients. All patients were perfused using the VT 5000 oxygenator. Normothermia was employed in nine cases, and hypothermia (30°-32°C) was induced in the remaining four cases.

Results

The data were analyzed using the Student's T test. The results for the thirteen clinical perfusions are depicted in Fig. 1. The arterial filter blood pO₂ is shown as a percentage of the blood sampling catheter value which is set to 100%. Large discrepancies between sampling ports exist in almost all sample comparisons with a range from -60.4% to +42.2%.

Fig. 2 illustrates the results from the six experimental perfusions in a manner equivalent to that employed for Fig. 1 and here, too, large discrepancies are seen (from -66% to +37%). The difference between pO₂ values taken from the oxygenator and the arterial line are highly significant ($p < 0.05$).

Fig. 3 illustrates three clinical perfusions where the absolute oxygen tensions from the blood sampling catheter are compared with the arterial line filter oxygen tensions. Discrepancies as great as 139 mm Hg are observed.

*** Pioneer Filters, Inc., 4650 S.W. Pacific Ave, Beaverton, Oregon, 97005.

**** Pall Biomedical Products Corp., Glen Cove, N.Y., 11542.

***** International Technidyne Corp., 138 Forrest Street, Metuchen, N.J., 08840.

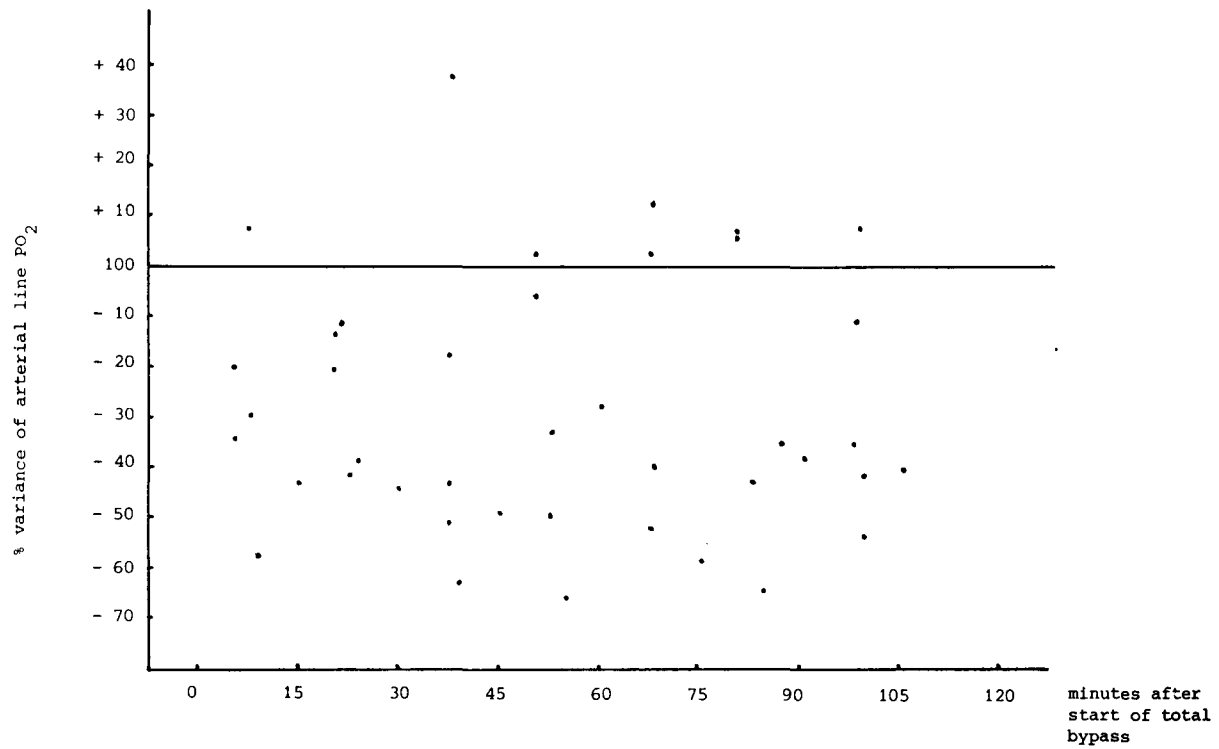


FIGURE 2. Arterial line blood pO₂ shown as percentage of blood sampling catheter pO₂ (set to 100%) in six experimental perfusions.

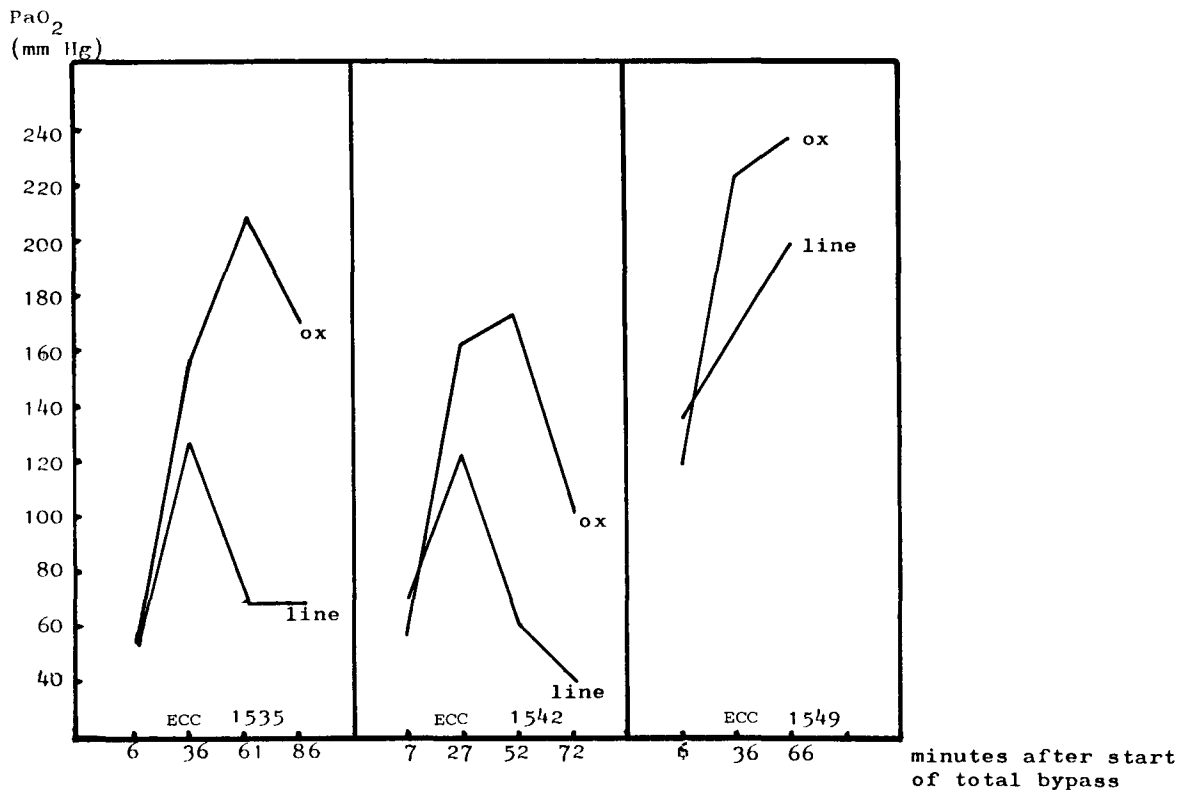


FIGURE 3. Comparisons of absolute oxygen tensions from blood sampling catheter (ox) and arterial line filter (line) in three clinical perfusions.

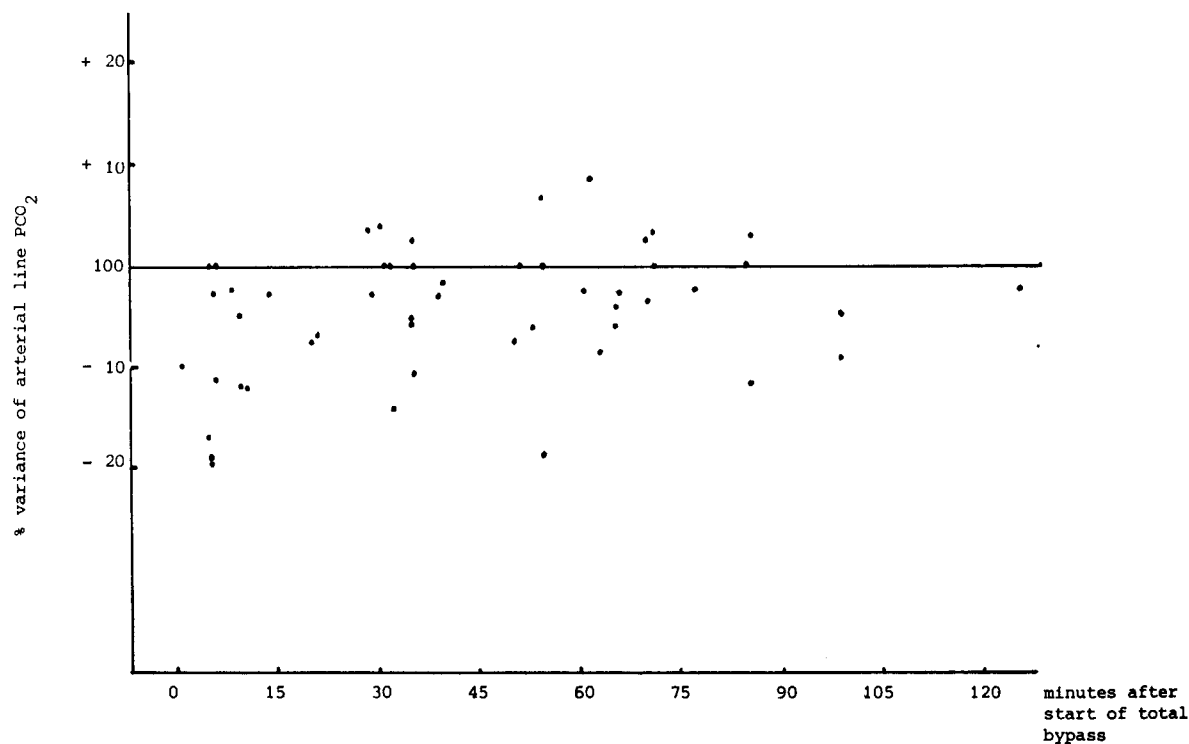


FIGURE 4. Arterial line blood pCO₂ shown as percentage of blood sampling catheter pCO₂ (set to 100%) in thirteen clinical perfusions.

Carbon dioxide tensions in the blood from the oxygenator sampling catheter and the arterial line were also compared and here, too, differences existed (Fig. 4). These are smaller than differences in pO₂ but greater than can be explained by gas analysis instrument sensitivity (98%).⁶ The range of discrepancy was from -19.4% to +8.3% for this parameter. However, this is not statistically significant.

Possible discrepancy in pH between arterial line and sampling catheter blood was investigated and pH variation of ±0.02 was observed, which is not statistically significant.

Blood flow and oxygenator arterial reservoir level were recorded each time a paired blood sample was taken, but no correlation could be established between these variables and the magnitude of the observed pO₂ and pCO₂ discrepancies. Nor could a relationship between normothermia or hypothermia and the observed results be established.

Discussion

Fig. 1 illustrates that, in most instances, great differences exist between blood values from the arterial reservoir sampling catheter and the true arterial blood

value. Fig. 3 illustrates that if the perfusionist attempts to maintain pO₂ in the range of 100 to 150 mm Hg based on arterial reservoir sampling catheter blood gas analysis, the patient could be receiving arterial blood with O₂ tensions below 70 mm Hg. For example, in one clinical perfusion the blood sampling catheter pO₂ was 123 mm Hg while the patient was actually receiving blood with a pO₂ value of 63 mm Hg.

The great difference between pO₂ from the blood sampling catheter and the arterial line is probably due to incomplete oxygenation of the blood at the catheter tip. The manufacturer reports that 40% of the oxygenation process occurs in the defoamer.¹ In fact, areas of desaturated blood in both defoamer and arterial blood reservoir have been observed on numerous occasions supporting this explanation.

The fact that there exist such large discrepancies between blood gas tensions obtained from the manufacturer's sampling catheter and the arterial line makes the use of the sampling catheter not only unprecise and misleading but potentially dangerous. Perfusionists using Polystan oxygenators should base their perfusions on blood sample gas analysis from the arterial line or the patient's arterial blood.

Finally, reports of Polystan oxygenators with blood sampling catheters in their present location must be reevaluated, especially those studies which deal with blood-to-gas flow ratios.¹⁻⁴

Summary

Statistically significant discrepancies in pO_2 have been demonstrated in comparisons of simultaneously drawn blood samples from the blood sampling catheter and the arterial line in Polystan VT 2000 and VT 5000 oxygenators during clinical and experimental perfusions. These results indicate that the blood sampling catheter, located in the arterial reservoir where the blood is not yet thoroughly mixed, is malpositioned.

Patients are in danger of receiving blood with abnormally low pO_2 despite normal oxygen tension in

blood extracted from the blood sampling catheter. Perfusionists using Polystan oxygenators should base their perfusion management on blood gas analysis from the arterial line or the patient's arterial blood.

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