JECT. 2007;39:311–312
The Journal of The American Society of Extra-Corporeal Technology

A "Virtual" Blood Gas Electrode for Use During Cardiopulmonary Bypass

Andrew Pybus, FANZCA; Richard Morris, FANZCA; Jacqui Jacobs, CCP

St George Private Hospital, Sydney, Australia

Presented at the Perfusion Downunder Meeting, Hayman Island, Queensland, Australia, August 9–11, 2007.

INTRODUCTION

We describe the development of a "virtual" blood gas electrode system intended for use during cardiopulmonary bypass (CPB). The electrode functions in real time and predicts the patient's arterial and mixed venous blood gas results every 500 ms. It takes as its primary inputs the settings of the heart-lung machine (FiO_2, sweep gas rate, pump flow) and the patient's hematocrit and metabolic rate. The electrode system incorporates integrated computer models of the oxygenator in use during the case and the patient's arterial, venous, and tissue pools. The architecture of the model is a development of that described by Dickinson (1) and is shown schematically in Figure 1.

Author for correspondence: Andrew Pybus, dpybus@bigpond.net.au

EVALUATION

The electrode is currently being validated in vitro against existing physio-logical computer models and in vivo using a Terumo CDI 500 (Terumo Cardiovascular Systems Corp., Ann Arbor, MI) blood gas analyzer (Figure 2). Preliminary results suggest that the performance of modern, hollow fiber artificial lungs is remarkably consistent and is amenable to modeling as described by Riley and Cournand (2).

OTHER APPLICATIONS

The electrode has other possible applications in perfusion practice. These include evaluation of therapeutic

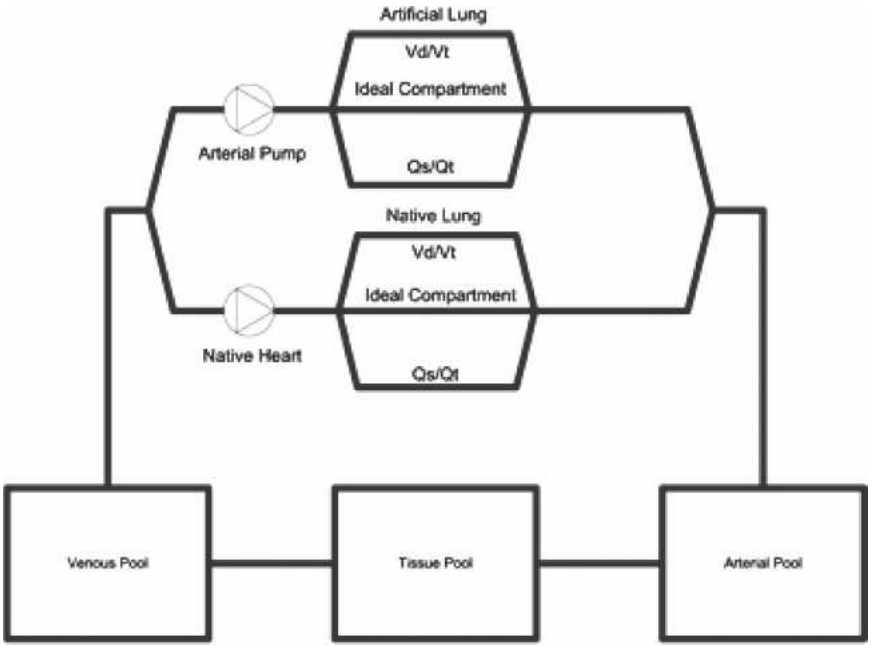

Figure 1. Virtual blood gas electrode system architecture.

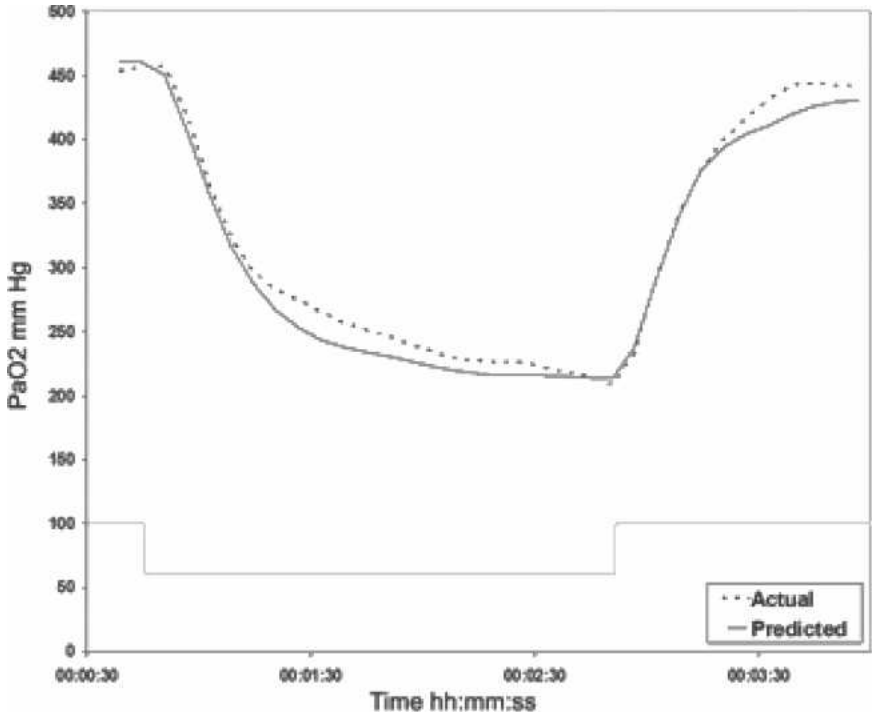

Figure 2. An example of a real-time prediction of PaO_2. In a patient on stable CPB at 32°C the effect of reducing the inspired oxygen concentration from 100%–61% has been demonstrated. The PaO_2 measured by an inline CDI 500 (dotted line) has been compared with the PaO_2 prediction of the virtual electrode (solid line). During the period of exposure to the lower FiO_2, note how the PaO_2 falls from about 460 mmHg to about 230 mmHg in both cases.

strategies, use in simulation systems, use in intelligent alarm systems, and evaluation of new products or techniques.

During the course of the presentation, examples of the evaluation of therapeutic strategies (such as the impact of different degrees of hypothermia on the survivability of arrest) will be examined. The use of the electrode in a software implementation of a veno-venous extracorporeal membrane oxygenation (ECMO) simulation system will also be demonstrated.

REFERENCES

1. Dickinson CJ. A Computer Model of Human Respiration. MTP Press, Lancaster, England, 1977.
2. Riley RL, Cournand A. "Ideal" alveolar air and the analysis of ventilation-perfusion relationships in the lungs. J Appl Physiol. 1949;1: 825–47.