Evaluation of a simple method for minimizing iatrogenic blood loss from discard volumes in critically ill newborns and children

Abstract  
Objective: To validate a simple method avoiding discard volumes in pediatric patients with indwelling arterial and venous lines.  
Design: Zero-discarding was achieved by passive extracorporeal arteriovenous backflow via standard single pressure transducer equipment. We tested backflow distances (10, 20 and 30 cm beyond the sampling port), corresponding to withdrawal volumes of 0.6 ml, 0.8 ml and 1.0 ml, respectively, in comparison to conventional sampling with discard of 0.6 ml. With the backflow technique, the “withdrawal volume” was flushed back to the patient after sampling. We enrolled 120 patients who were allocated to either of the following paired sampling procedures: 10 cm versus conventional, 20 cm versus conventional, 30 cm versus conventional and two paired conventional samples. The order of the sampling was randomly allocated before obtaining the sample, in order to minimize contamination with the catheter flushing solution. It has been estimated that the volume of this discarded blood accounts for 24–30% of the total amount of blood withdrawn for diagnostic sampling [1, 4]. Some clinicians prefer to return the withdrawn deadspace volume to the patient. This practice, however, bears the potential risk of arterial embolism (air, clots) and contamination with infectious agents.  

Results: No appreciable difference was found for blood gases, hemoglobin, potassium and calcium between the backflow technique and conventional sampling. Sodium results and blood glucose showed a bias towards higher values with the backflow technique (mean difference, sodium, 0.9 mmol/l; glucose, mean difference 0.5 mmol/l, standard deviation 0.44 mmol/l).  
Conclusions: The backflow technique provides reliable results for blood gases and electrolytes. However, in patients at risk of hypoglycemia, the backflow method should not be used to monitor blood glucose levels.

Keywords  
Arterial blood sampling · Blood conserving · Invasive pressure monitoring · Pediatric, neonatal intensive care

Introduction

The measurement of blood gases, electrolytes and other blood compounds is a cornerstone of critical care. Indwelling arterial or central venous vascular catheters facilitate on-demand withdrawal of blood samples. In small infants, iatrogenic blood loss due to repetitive sampling may lead to anemia and may increase the need for blood transfusions, with its associated risk of adverse reactions and infections [1, 2, 3].

When blood is collected from indwelling catheters, a certain amount of blood is usually withdrawn and discarded before obtaining the sample, in order to minimize contamination with the catheter flushing solution. It has been estimated that the volume of this discarded blood accounts for 24–30% of the total amount of blood withdrawn for diagnostic sampling [1, 4]. Some clinicians prefer to return the withdrawn deadspace volume to the patient. This practice, however, bears the potential risk of arterial embolism (air, clots) and contamination with infectious agents.  

During the past decade, several measures aimed at minimizing iatrogenic blood loss have been introduced. These include the use of pediatric-sized laboratory col-
lections tubes, batching the requests for laboratory tests and monitoring the cumulative volume of blood taken from individual patients [1, 4, 5, 6, 7]. To reduce the need for erythrocyte transfusions, the application of recombinant human erythropoietin has been suggested [8, 9]. More recent strategies to minimize blood loss include the use of sensors and electromechanical devices to evaluate blood chemistries and arterial blood gases “in line” [10, 11, 12, 13, 14, 15, 16], and the use of blood-conserving arterial blood lines [17, 18, 19, 20, 21, 22, 23]. From the latter, only the blood required for diagnostic testing is withdrawn, while the volume usually discarded is returned to the patient.

These blood-conserving arterial blood sampling systems include a capacitive element and a volume-restricted reservoir for aspiration of blood from the patient. The use of these systems in neonatal and pediatric intensive care is hampered by the high volume which is drawn back into the system and the negative pressures generated by the system during aspiration. In our own unit the latter frequently led to temporary collapse of the artery vessel. Moreover, flushing the capacitive element free from remaining blood required large quantities of flushing solution, a particular disadvantage in infants with fluid restriction. These problems forced us to search for a simple method for the closed return of deadspace volumes.

The principle of withdrawing the usual discard volume via the arterial line for subsequent reinfusion can also be realized by means of a single transducer system for continuous arterial and intermittent central venous pressure measurement, which were originally proposed, in 1979, by Rhoads and Kariman and by Calisi and Welt in 1983 [24, 25]. In our unit, such a double-stopcock system is employed for continuous arterial blood pressure monitoring with intermittent readings of the central venous pressure. With this system extracorporeal passive arteriovenous blood flow from the arterial cannula to the central venous catheter can also be established (Fig. 1). This feature can be used to withdraw the required deadspace volume into the proximal arterial line by passive backflow. Subsequently, blood may be withdrawn from the arterial sampling port or stopcock. After completion of blood sampling, the discard volume is flushed back to the patient through the arterial cannula. The proposed method does not incur additional cost or waste.

The purpose of the present study was to compare systematically the results of the arterial backflow technique with the results obtained from the conventional, discarding procedure.

Material and methods

Patients and setting

We enrolled 120 critically ill newborns and children who were admitted to a 19-bed tertiary multidisciplinary intensive care unit. Patients were included when an arterial and a central venous catheter were present, and free flow of blood could be obtained from the arterial cannula for blood sampling. Premature infants were excluded, as well as patients with hemodynamic instability or patients receiving vasoactive drugs through the venous line used for the backflow technique. The study was approved by the institutional review board. The board waived the need for informed consent.