Diabetologia (1983) 25: 120–122

Diabetologia

Short Communications

Blood Collection While Using a Continuous Glucose Analyzer Without Insertion of an Additional Venous Catheter

M. J. Castillo, A. J. Scheen, A. S. Luyckx and P. J. Lefèbvre

Division of Diabetes and Division of Clinical Pharmacology, Institute of Medicine, University of Liège, Liège, Belgium

Summary. A new method for continuous blood collection using the Biostator is described. Blood is withdrawn through the double lumen catheter by a tube installed in the optional channel of the infusion pump. The amount of blood withdrawn from the patient is slightly greater than that necessary for continuous glucose analysis; the excess blood can be collected into assay tubes. Blood collection is continuous and produces a sample of diluted heparinized blood. The volume of blood collected depends on the size of the tube used, i.e. for a tube with a lumen diameter of 0.020 inches, the mean (± SD) volume collected was 1.21 ± 0.07 ml/10 min ($n = 13$). The mean time interval between sampling and arrival at the glucose sensor by the double lumen catheter was 119 versus 108 s with the conventional method. The proposed modification does not affect blood glucose measurements (correlation coefficient compared with the reference method $r = 0.9572$; $n = 13$). To compensate for blood dilution, a dilution-factor depending on tubing diameter has to be calculated in each experiment.

Key words: Biostator, continuous blood collection.

Introduction

Use of the Biostator machine for the feed-back control of blood glucose levels requires the cannulation of two superficial veins [1–4]. This can be difficult in children and obese patients. If additional blood sampling is required, particularly in the context of research, a third cannulation may be necessary with its associated technical difficulties. An alternative way of obtaining intermittent blood samples is to disconnect the double lumen catheter which results in the interruption of feed-back control. We propose a method that allows continuous blood collection without insertion of a third catheter or disconnection of the double lumen catheter.

Material and Methods

The modifications are shown diagrammatically in Figure 1. All the tubing and needles which were used were supplied by Ames Division, Miles-Martin Laboratories, Elkhart, Indiana, USA, for use with the Biostator. In our system, as shown in Figure 1, the free end of the double lumen catheter (A) is mated to the lower part of a tube (sizes from 0.020 to 0.051 inches) connected to the optional channel of the infusion pump (B) thus ensuring continuous blood withdrawal. To the distal end of this tube, a short needle is mated (C). The amount of blood delivered to the female cone of the needle is a function of the inner diameter of the tube (Table 1) connected to the infusion pump and of the turning rate of the latter (7.8 revolutions/min). An overflow can thus be generated at (C) and may be collected, for instance by placing the system within a small funnel or even inside an assay tube (E). With such a system, blood flow to the analyzer through the line (D) is never interrupted. Figure 2 shows the final arrangement of the collecting system.

Results and Discussion

Table 1 shows the volume of blood collected with this system during an experiment in which tubes of various sizes were connected to the optional channel. In all cases, the analyzer pump tubing for channels 2 (blood) and 3 (diluent buffer) were 0.015 and 0.051 inches respectively. As can be seen, the volumes obtained were small, the small size of the double lumen catheter being the limiting factor. Due to variations in tubing diameter, the blood dilution factor has to be calculated for every experiment, by measuring the total amount of diluted blood collected during a given time and the amount of diluting solution delivered during the same period. In a series of nine experiments, we found the mean (± SD) calculated dilution factor to be 1.56 ± 0.18, not significantly different from the mean (± SD) measured dilution factor which was 1.51 ± 0.09. In experiments lasting

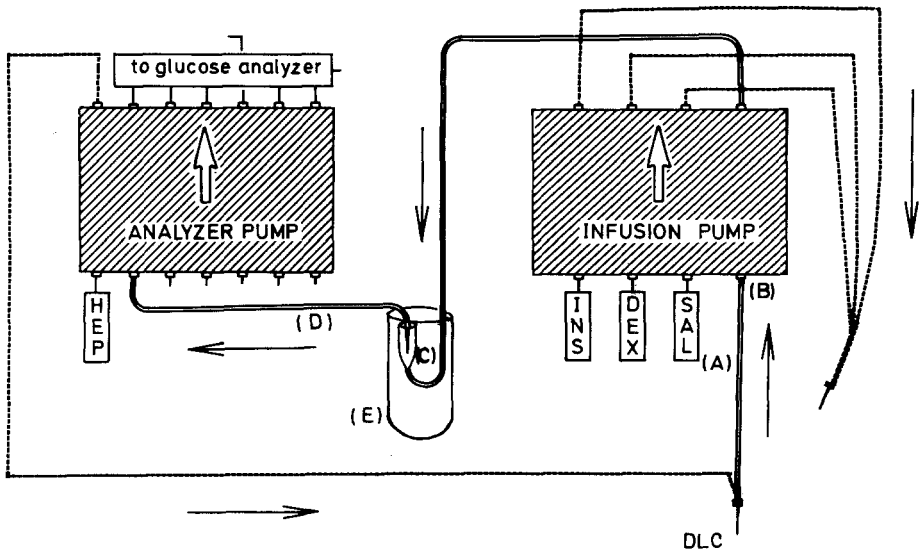

Fig. 1. Schematic representation of Biostator proposed modification to allow continuous blood collection. *A* = double lumen catheter; *B* = optional channel of the infusion pump; *C* = needle; *D* = line to glucose analyzer; *E* = assay tube for blood collection. *DLC* indicates the double lumen catheter. *HEP, INS, DEX, SAL* represent solutions of heparin, insulin, dextrose and saline, respectively

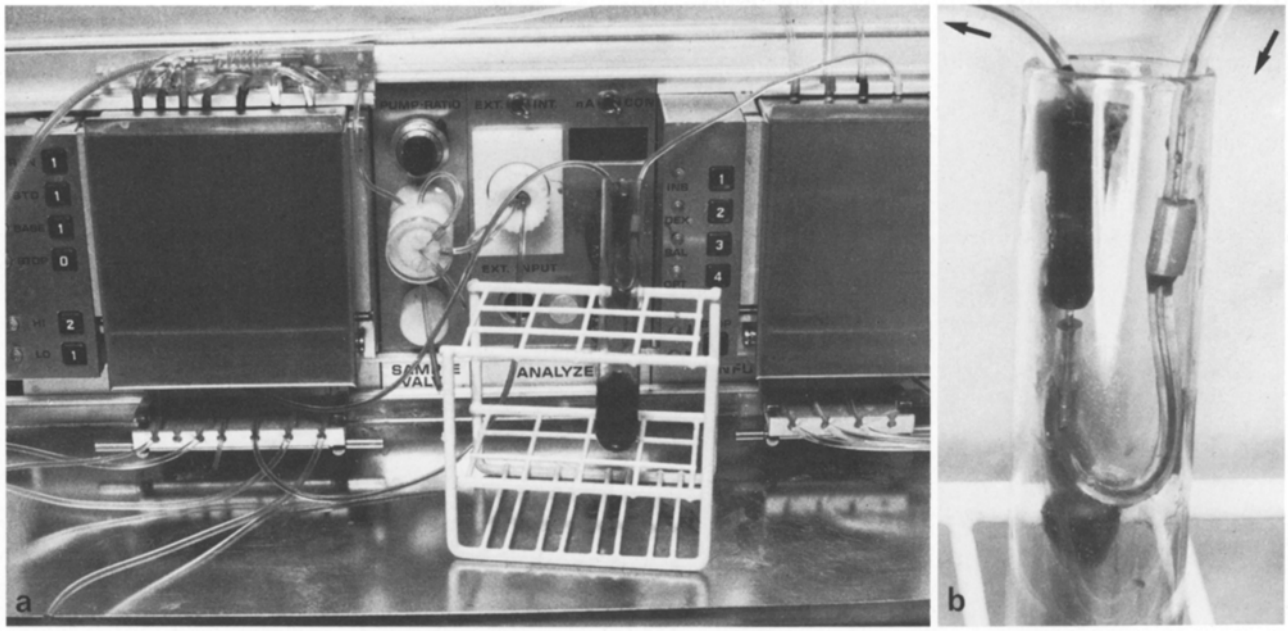

Fig. 2. **a** Arrangement of the collecting device on the Biostator; **b** detail of the system corresponding to item *C, D* and *E* in Fig. 1

Table 1. Volume of blood collected and dilution factors using differing tube diameters

	Speed of analyzer pump	Size of tube connected to optional channel (inches)			
		0.020	0.030	0.040	0.051
Blood volume (ml/10 min)	High	1.34	3.54	6.54	8.04
	Low	1.65	3.85	6.85	8.35
Blood dilution factor	High	1/1.49	1/1.18	1/1.10	1/1.08
	Low	1/1.21	1/1.09	1/1.05	1/1.04

The volumes and the dilution factor will vary from day to day and should be measured for each experiment. Analyzer pump tubing for channel 2 (blood) was always 0.015 inches

a longer time, calculation of the dilution factor should be performed at the beginning and at the end of the experiment. Therefore, data presented in Table 1 are merely examples and represent volume values obtained in one representative experiment.

With this system, the approximately eleven times blood dilution for glucose measurement is maintained, but precise adjustment of pump ratio by the usual method is necessary. The accuracy of the system regarding blood glucose determination is not altered. We found a correlation coefficient of $r = 0.9572$ ($n = 13$) between glucose values given by the Biostator as used with the proposed modification and the reference method (Technicon autoanalyzer using hexokinase). The mean time interval between sampling by the double lumen catheter

and the glucose measurement is 119 s in our modification versus 108 s in the conventional method. This difference should have little, if any, effect on the feed-back response. Other factors affecting the signal for feed-back are the time and volume in which the blood is mixed in the cone of the needle (C, Fig. 1). Since the maximum mixing time is 88 s and the mixing volume is 0.132 ml, the signal for feed-back reflects an actual glycaemic value and not an integrated one.

So far we have used this modified system more than 25 times, always using a 0.020 inch tube connected to the optional channel and the rest of the apparatus as indicated. We collect blood for periods of 10–30 min to measure insulin and C-peptide. The system can be useful in metabolic or glucose clamp studies or during the infusion of various substances. Special problems inherent in the proposed modification are the relatively small volume of blood collected, the fact that values are integrated over a certain period of time, thus potentially missing acute peak values, and the necessity of calculations to compensate for blood dilution.

References

1. Hepp KD, Kerner W, Pfeiffer EF (Eds) (1979) Feedback-controlled and preprogrammed insulin infusion in diabetes mellitus. Horm Metab Res Suppl. Series 8
2. Verdonk CA, Rizza RA, Westland RE, Nelson RL, Gerich JE, Service FJ (1980) Glucose clamping using the Biostator GCIIS. Horm Metab Res 12: 133–135
3. Home PD, Massi-Benedetti M, Shepherd GAA, Hanning I, Alberti KGMM, Owens DR (1982) A comparison of the activity and disposal of semi-synthetic human insulin and porcine insulin in normal man by the glucose clamp technique. Diabetologia 22: 41–45
4. Valenta LJ, Elias AN, Grossman M, Tanner SM, Friis R (1982) A new test of peripheral insulin sensitivity in vivo using artificial beta cell. Life Sci 30: 867–873

Received: 13 August 1982
and in revised form: 11 May 1983

Professor P. Lefèbvre
Institut de Médecine
Hôpital de Bavière
Boulevard de la Constitution, 66
B-4020 Liège, Belgium