Reliable Glucose Monitoring by ex-vivo Blood Micro-dialysis and Infrared Spectrometry for Patients in Critical Care

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Background
Blood glucose monitoring has been realised by biosensors in combination with micro-dialysis, using either intravascularly or subcutaneously implanted catheters. Another alternative is ex-vivo micro-dialysis of continuously sampled heparinized whole blood available from ICU patients. However, a drawback are variable recovery rates, which can be observed for all devices. Infrared spectrometry has been suggested for multi-analyte detection and quantification, since also other clinically relevant analytes besides glucose can be simultaneously determined and that are important, e.g., for patients under intensive care [1–3].

Experimental

Fig. 1 Schematics of the fluidics setup for heparinized whole blood dialysis and dialysate analysis (left: scheme of flow-through μ-dialyzer)

Fig. 2 Glucose concentration profiles of a type 1 diabetic subject monitored spectrometrically, using an extracorporeal whole blood dialysis (A) and dialysis recovery rates using the perfusate marker of acetate (B).

Dialysates were measured under stable flow-rates, and simultaneous multi-component analysis was carried out by infrared spectrometry. Extensive ex-vivo measurements confirmed the theoretical nonlinear relationship between the relative dialysate marker concentration

\[ R_{\text{analyte,perf}} / R_{\text{analyte,sample}} = 1 - \left( \frac{C_{\text{sample}}}{C_{\text{perfusate}}} \right) \]

and recovery rates of the analyte of interest when using acetate, while for mannitol a nearly linear dependency exists. Exemplary results are shown in Figs. 3A and B.

Conclusions

The combination of micro-dialysis with infrared spectrometry provides a calibration-free assay for accurate continuous glucose monitoring, as reference spectra of dialysate components can be a priori allocated. Using such a system, blood glucose concentration values can be reliably and continuously monitored. These measurements can be considered as the gold standard in glycemic control of critically ill patients.

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References