A NOVEL METHOD FOR THE EXPERIMENTAL STUDY OF THE KINETICS OF UREMIC MARKERS DURING HEMODIALYSIS WITH OPTICAL SPECTRAL SENSORS

Vasilevsky A.M.*, Konoplev G.A.*, Stepanova O.S.*, Rubinsky A.V.**, Zemchenkov A.Ya.***, Gerasimchuk R.P.***, Frorip A.****

*Saint-Petersburg Electrotechnical University, Department of Quantum Electronics and Optoelectronic devices, Saint-Petersburg, Russia;
** First Pavlov State Medical University of St. Peterburg, Department of Physics, Mathematics and Informatics, Saint-Petersburg, Russia;
*** Mariinsky Hospital, Dialysis unit, Saint-Petersburg, Russia;
****LDIAMON AS, Tartu, Estonia

INTRODUCTION AND AIMS:

Generally accepted quantitative criteria of HD efficiency such as kt/V are based upon the kinetic modeling of uremic markers, mainly single-pool and double-pool models of urea kinetics. At the same time very few experimental methods are available for the study of uremic markers elimination during HD treatment. Most of them involve taking numerous (minimum 5-7) blood samples and total dialysate collection [1], which is impractical, time consuming and not well for patients. In our opinion a more useful approach to this problem is to monitor the concentration of basic uremic markers in effluent dialysate with special sensors connected to the outlet of a dialysis machine.

METHODS:

In this research we used a dual-wavelength optical spectral sensor (fig. 1) based on ultraviolet (UV) light-emitting diodes (wavelengths 262 and 287 nm) for online monitoring of uric acid (UA) concentration in effluent dialysate during HD. The sensor allows to measure the time profiles of UA concentration CUA(t) with extremely high temporal resolution (down to 5 sec). It should be noted UA was chosen as having the strongest UV absorption among low-molecular weight waste products, and we relied upon the fact that the kinetics of uric acid elimination during HD is similar to the kinetics of conventional uremic markers such as urea and creatinine.

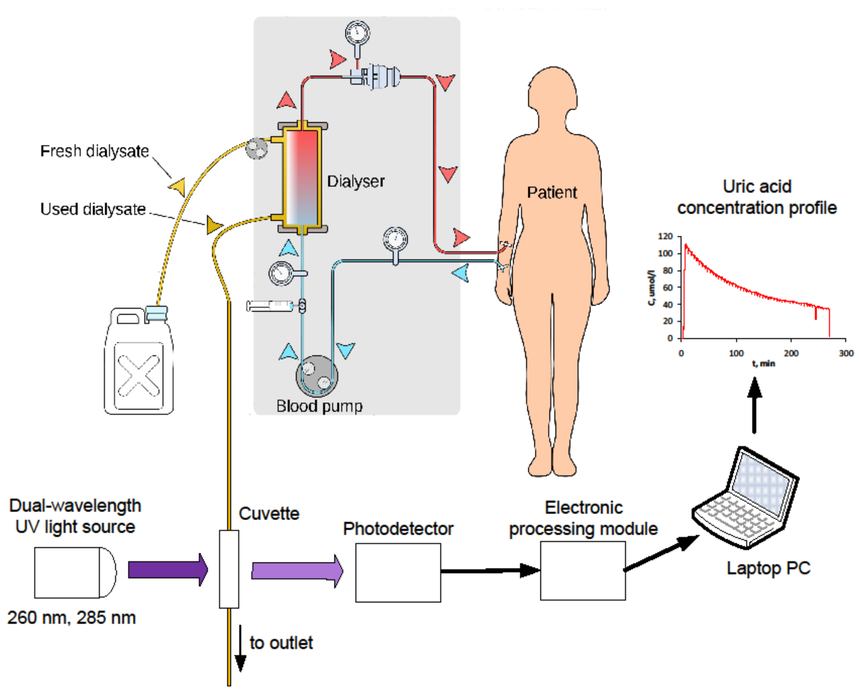

Fig. 1. Schematic representation of the optical sensor for HD on-line monitoring

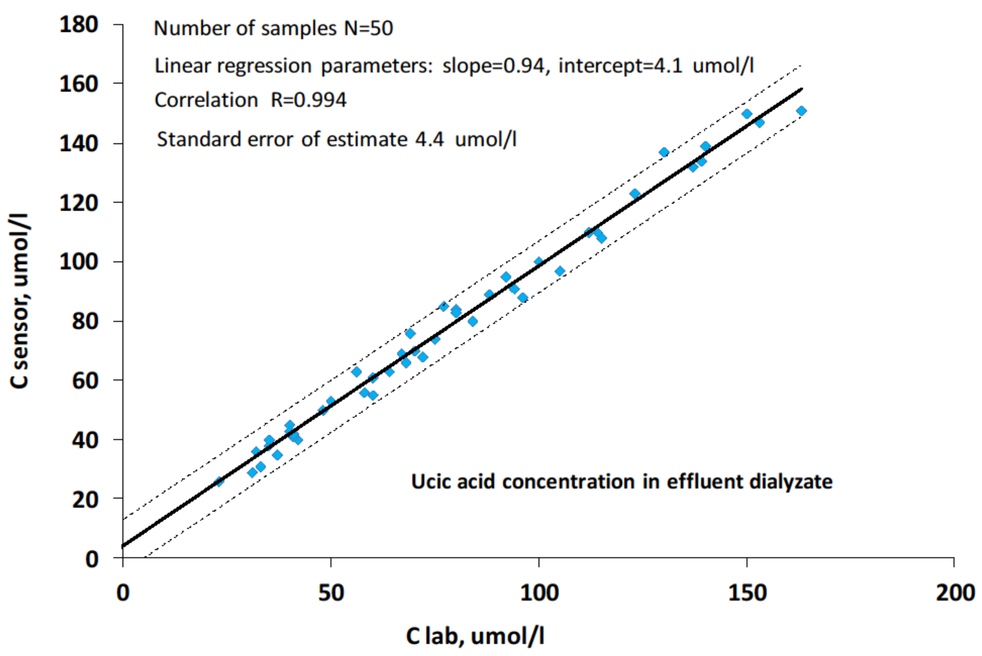

Fig. 2. The scatter diagram for uric acid concentration in the effluent dialysate samples measured with the optical sensor (C sensor) and with the automated biochemical analyzer "Beckman Coulter AU680"

RESULTS:

The time profiles of UA concentration were measured for the group of 10 patients with the help of the sensor. For validation the samples of effluent dialysate were taken at 0, 30, 60, 150 and 240 min of HD sessions and lab tests for UA were carried out. Statistical analysis using Bland-Altman method [1] showed a good agreement between the results obtained with the sensor and with the automated biochemical analyzer "Beckman Coulter AU680"(fig. 2); the relative error of determination was less than 10%.

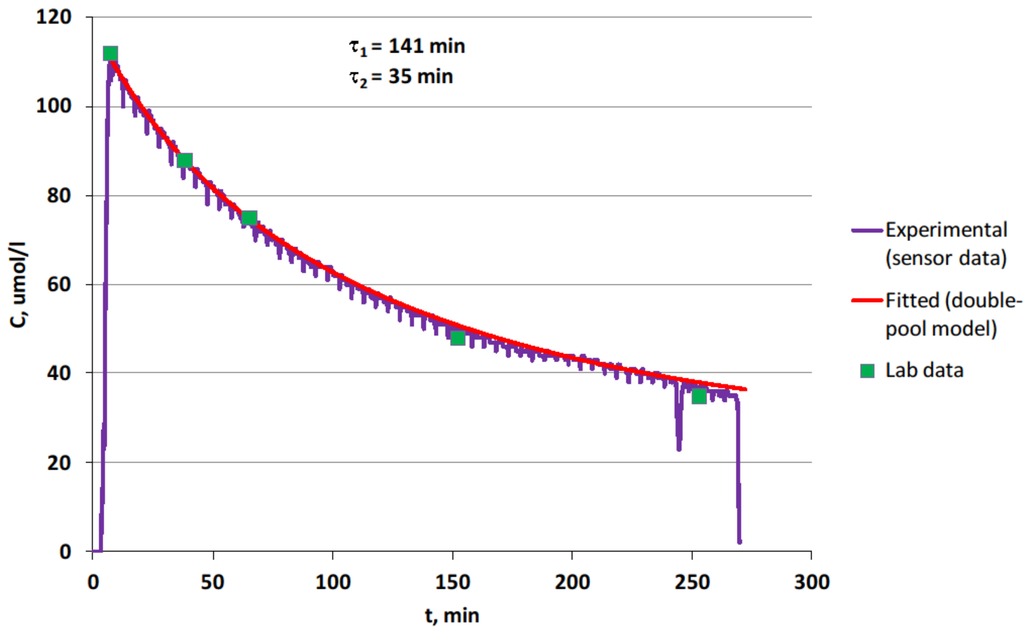

Fig. 3. The time profile of UA concentration in effluent dialysate measured with the help of the dual-wavelength sensor, results of the lab tests for UA and curve fitting according to the double-pool model for one of the patients (patient #4 in table 1)

Table 1. The values of the time constants in the double-pool model for the group of ten patients

Patient #	τ_1	τ_2
1	145	7
2	157	18
3	108	9
4	**141**	**35**
5	128	24
6	98	5
7	156	20
8	158	23
9	136	12
10	89	5

For all patients the concentration curves were fitted according to the double-pool model by the function $C_{UA}(t)=A_1 \cdot \exp(-t/\tau_1)+ A2 \cdot \exp(-t/\tau_2)+A_3$ and according to the single-pool model. In all cases the double-pool model gave much better approximation of the experimental data (fig. 3) .

The constant τ_1 that reflects the transfer of low-molecular weight substances through the membrane was in the 90…150 min interval for different patients; the constant τ_2 that reflects the intercompartment transfer was in the 5…35 min interval (table 1) . These values correspond well with the results reported by other researchers using conventional methods [2]. All constants, including A_3 that defines UA generation rate, were calculated from the sensor data, no additional blood samples were needed.

CONCLUSIONS:

The presented method and the optical sensor have been proved to be simple, safe, comparatively low-cost and very effective to study the kinetics of UA. Uremic markers other than UA could also be investigated using this approach provided a different set of working wavelengths and a corresponding spectral algorithm are used.

REFERENCES:

1. Bland J.M. Statistical methods for assessing agreement between two methods of clinical measurement. The Lancet. 1986; 8: 307-310.
2. Burgelman M., Vanholder R., Fostierx H., Ringoir S. Estimation of parameters in a two-pool urea kinetic model for hemodialysis. Med. Eng. Phys. 1997; 19: 69-76.

DOI: 10.3252/pso.eu.51era.2014
Poster presented at: 51 ERA-EDTA CONGRESS AMSTERDAM 2014
PosterSessionOnline.com