On-Line Clearance Monitoring: Haemodialysis Treatment and Patient's Benefit

Vlastimir Vlatkovic, Biljana Jakovljevic, Aleksandar Arezina
International Dialysis Center Banja Luka

Introduction

Constant striving to develop the quality of dialysis and improve the treatment successfulness has brought to development of various models of work and control. Regular measurements of delivery dialysis dose (DDo) today represent a condition sine qua non for improvement of treatment quality and correction of the prescribed haemodialysis dose. According to the nowadays widely accepted guidebooks and guidelines, it is required to perform the controls at least once a month (1-4). On-line modules allow the daily measurements in real time and at each haemodialysis session. Thus the haemodialysis control and quality is significantly improved (5-9). On the basis of such measured clinical results the possibilities are determined for quality improvement by means of new scientific and technological achievements (10-12).

On-line clearance monitoring principle

The need for simplifying the DDo measurements, as well as avoiding the mistakes that might occur due to application of complicated techniques, has led to designing DDo models that allow DDo measurements in real time. These models use the Kt/V index as a measuring unit for expressing DDo quantities. On-line monitors are added as modules to the haemodialysis devices and contain software by which the DDo measurements and calculations are performed. One of the on-line clearance monitoring (OCM) principles is based on the biosensor, which measures dialysibillity of the ions (that are in correlation with urea clearance). This allows a continuous measurement of the Kt/V index in real time (5). Change of dialysate conductivity (which occurs due to the changes of sodium concentration in the course of its passing through dialyser, where certain number of ions enters blood) is mathematically translated into the Kt/V index value, which represents the real value of DDo. Dialyser clearance value represents here its real in vivo value. Direct correlation of sodium clearance and urea molecule was clinically established. Sodium and urea have approximately the same molecular weight thus sodium plays the role of urea "surrogate" since its concentration can more easily be indirectly determined through changes of dialysate conductivity. In measurements, all the parameters that influence a dialysis treatment are taken into account. These are: effective blood flow and dialysate solution, effective time of dialysis, in vivo urea clearance, plasma sodium concentration and actual Kt/V index (5, 6). Measurement of dialysis solution conductivity is performed independently on two biosensors in regular intervals, and, adding the measured values a cumulative value of Kt/V index is obtained, representing the measured real DDo quantity.

Comparative monitoring of delivered dialysis dose

The research was performed in 2002. It was applied a concept of comparative measurement of DDo. Control of DDo was performed on daily basis by means of randomized use of OCM (out of the total of 17810 dialysis treatments performed, 5572 (31%) were checked by OCM application) calculation of daily average value of Kt/V index obtained by this method. Each month, before and after the first dialysis in the week, blood samples were taken for determining analysis by single-pool technique. Out of these samples, the values of urea were determined for calculation of urea reduction ration (URR) and single-pool Kt/V index and, on the basis of obtained results, anamnesis data and examination of patients the correction of the prescribed haemodialysis program was performed (change of dialyser, blood flow and therapy).

Urea reduction ratio describes the degree of urea reduction in the course of one dialysis treatment, which means that cumulative effect and duration of dialysis are not taken into account. Thus it is always important to mention haemodialysis frequency in a week. This index most simply and most reliably reflects the degree of small molecules reduction. Lower acceptable limit of such realized index is 65% and the prescribed one should be 70% (3). It was shown that this is the most sensitive assessment parameter, which was also in correlation with the other two - Kt/V index and OCM. In the beginning of the study, the average value was below acceptable limit as well as the value in the group of male patients. Female patients had acceptable value and it was on the lower limit. Generally, we can say that, from the prospective of this parameter, DDo was not enough, since only female patients had acceptable values. At the end of the study, the obtained values showed that the DDo was significantly higher and that the prescribed measures had a significant impact on its quality. URR values were significantly higher at the end of the study than in the beginning, $p<0,05$.

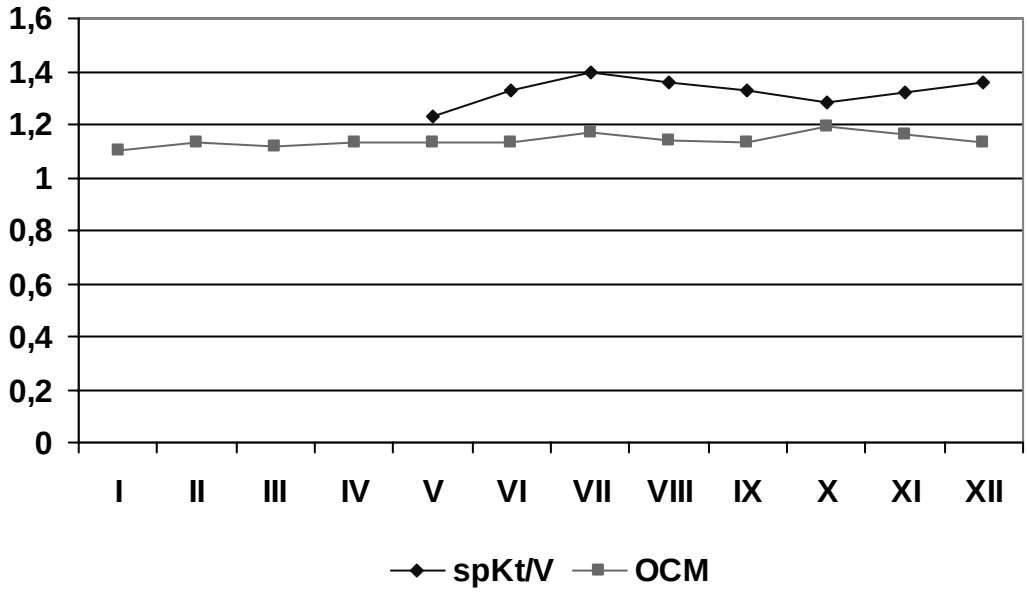
Another applied model for DDo measurements was Kt/V index for which the blood samples were taken by single-pool technique and it was calculated on the basis of Daugirdas'equation (1-3). Kinetic models such are single-pool and equilibrated Kt/V index require taking several blood samples before and after dialysis session. These technical details disallow a routine application of the

Correspondence to: Vlastimir Vlatkovic, Jovana Raskovica 55, Banja Luka 78000, Bosnia and Herzegovina
Tel: 38765668923, fax: 38751320760, e-mail: wlastimir@hotmail.com

method in every treatment. Various factors influence the Kt/V index value – membrane type, dialysate and blood flow, blood access quality, as well as cardiopulmonal and blood access recirculations (13 -15). On the other side, symptomatic arterial hypotension significantly influences the reduction of blood flow, dialysis time, appearance of dialyser microcoagulation and blood access problem thus DDo may vary from one session to another (5). It is why it should be emphasised that such calculated index, as well as URR, reflects DDo of only one dialysis, and that most often they are used as the indicators of the whole treatment adequacy, which could hypothetically be true only if each of the dialyses was absolutely identical, which is not possible. This index has also proved to be a sensitive assessment parameter and the values obtained in the beginning and at the end of the study significantly differ statistically, $p<0,05$.

Unlike the previous two models used for measuring DDo of one dialysis a month, OCM application allows unlimited number of repeated measurements in DDo real time. This way the influence of all the factors is monitored during the month and their cumulative effect obtained at the end of the month (13). That is why the Kt/V index values obtained by OCM differ from those obtained by standard technique. However, the value of such obtained index is not influenced by blood samples taking technique since the clearance matter is measured several times in the course of haemodialysis and the final result represents in vivo value in real time. With application of this method in some studies it was clearly established that many patients were significantly sub-dialysed (6). In this study the average Kt/V index values of obtained by OCM did not differ significantly in the beginning and at the end of the study, although they were slightly higher at the end. However, these values reflect the quality of dialysis profile more comprehensively since they are based on repeated measurements. Average values, obtained daily, allowed regular daily DDo controls and corrections of the prescribed haemodialysis in order to rectify these values. That is the reason for the URR and single pool Kt/V index parameters to be higher at the end of the research. It was confirmed by examination of the correlation of these parameters that was positive.

Figure 1. spKt/V and OCM average values



The presentation on figure 1 shows the average values in the month of examination of single pool Kt/V index and OCM Kt/V index. Each value of the single pool Kt/V index represents an average value obtained for all the patients for one monitored haemodialysis, while the OCM Kt/V index represents an average value obtained for all the patients for several dialysis sessions. This means that such obtained values represent a more severe criterion for DDo assessment.

Conclusion

While the accepted measurement methods (such are single pool Kt/V index and URR determination) bring some unsolved problems in calculation (16) whose final value is influence even by the way of taking blood samples for determining the urea concentration, OCM allows attractive DDo measurements in real time. The risk of the patients being sub-dialysed is always present. Along with that, the prescribed dialysis dose is, most often, the lowest needed one thus any inconsistency with the prescribed value leads to lower delivered dose. Therefore, it is recommended for

the prescribed dose to be higher than the one to be achieved (3). In order to obtain the same results of Kt/V index application with single pool technique or URR, it would be necessary to take new blood samples at each haemodialysis, which is difficult and uncomfortable. On the other side, OCM technique application allows the insight into each individual dialysis treatment and a maximum individualisation and treatment effect are thus achieved.

References

1. Levy J, Morgan J. Brown E. Dialysis adequacy. In Oxford handbook of dialysis; 154-162. Oxford University Press, 2001.
2. Gotch F. Urea kinetic modeling to guide hemodialysis therapy in adults. In Dialysis therapy, Section I, 117-125. Hanley & Belfus. Inc. Philadelphia, 2002.
3. The EBPG group on haemodialysis. European best practice guidelines for haemodialysis (Part 1). Nephrol Dial Transplant. Vol 17. Suppl 7. 2002.
4. Fink J.C, Zhan M, Blahut S.A. et al. Measuring the efficacy of a quality improvement program in dialysis adequacy with changes in center effects. J Am Soc Nephrol. 2002; 13: 2338-2344.
5. Kuhlman U, Goldau R, Samadi N. et al. Accuracy and safety of online clearens monitoring based on conductivity variation. Nephrol Dial Transplant. 2001; 16: 1053-1058.
6. Basham L.M, Agar J.W.M. Time spent on dialysis: the paramount consideration in dialysis adequacy? A new application for the BioStat 1000 on-line urea monitor. Dial Transplant. Vol 26. No 11. 1997; 739-748.
7. Santoro A, Tetta C, Mandolofo S. et al. On-line urea kinetics in haemodiafiltration. Nephrol Dial Transplant. 1996; 11: 1084-1092.
8. Mclntyre C, Lambie S. H, Taal M. W. et al. Assessment of haemodialysis adequacy by ionic dialisance: intra-patient variability of delivered treatment. Nephrol Dial Transplant. Vol 18. No 3. 2003; 559-562.
9. Chauveau P, Naret C, Puget J. et al. Adequacy of hemodialysis and nutrition in maintenance haemodialysis patients: clinical evaluation of a new online urea monitor.Nephrol Dial Transplant. Vol 11. Issue 8. 1996; 1568-1573.
10. Kliger A.S. Improving the quality of care in dialysis facilities: a model for accountability. Dial Transplantation. Vol 29. No 5. 2000; 276-279.
11. Fishbane S, Johnson D. The process owner in quality improvement. Dial Transplantation. Vol 27. No 9. 1998; 550-552.
12. Wright L.F, Francisco S.M, Warmath A. et al. Improving outcomes for maintenance hemodialyisis patients by using continuous quality improvement. Dial Transplant. Vol 25. No 6. June 1996; 346.
13. Kooman J.P, van der Sande F.M, Leunissen M.L. Kt/V: finding the tree within the woods. Nephrol Dial Transplant. 2001; 16: 1749-1752.
14. Geddes C.C, Traynor J, Walbaum D. et al. A new method of post-dialysis blood urea sampling: the "stop dialysate flow' method. Nephrol Dial Tranplant. 2000; 15: 517-523.
15. De Palma J.R, Pittard J. Dialysis dose (Part I). Dial Transplant. 2001; 252-261.
16. Wang A Y-M, Sea M.M-M, Ip R. et al. Independent effects of residual renal function and dialysis adequacy on actual dietary protein, calorie, and other nutrient intake in patients on continuous ambulatory peritoneal dialysis. J Am Soc Nephrol. 2001; 12: 2450-2457.