ADEQUACY OF HAEMODIALYSIS

Hoque MF[1], Fakir MAH[2]

Haemodialysis remains the major modality of renal replacement therapy. Since 1970s the drive for shorter dialysis time with high urea clearance rates has led to the development of high-efficiency haemodialysis. In 1990s, certain biocompatible features and the desire to remove amyloidogenic (B2-microglobulin) led to the popularity of high-flux dialysis. During 1990s, the use of high-efficiency and high-flux membranes steadily increased and use of conventional membrane declined[1]. In 1994, a survey by the Centers for Disease Control showed that high-flux dialysis was used in 45% and high-efficiency dialysis in 51% of dialysis centers in United States[1]. Despite the increasing use of these new haemodialysis modalities the clinical risks and benefits of high-performance therapies are not well defined. In the literature published over the past 10 years the definitions of high-efficiency and high-flux dialysis have been confusing. Currently, treatment quantity is not only defined by time but also by dialyzer characteristics, i.e., blood and dialysate flow rates. In the past, when the efficiency of dialysis and blood flow rates tended to be low, treatment quantity was satisfactorily defined by time. Today, however, treatment time is not a useful expression of treatment quantity because efficiency per unit time is highly variable. The dialyzer mass transfer-area coefficient characterizes the permeability of the mass transfer barrier between the blood and dialysate path-ways of a haemodialyzer. Increasing the blood or dialysate flow rate decreases the thickness of the respective stagnant fluid layer[2].

Accurate prediction of dialyzer urea clearance during haemodialysis is essential when prescribing therapy using urea kinetic modeling[1,2]. Small solute removal is primarily obtained by diffusion. Convection represents an additional mechanism that is mostly important for larger molecules[3,4]. The efficiency of a haemodialyzer is therefore dependent on its ability to facilitate the diffusion process[5,6]. Diffusion is affected by blood and dialysate flow rates, temperature, surface area of the dialyzer, and thickness of the membrane. Assuming all other factors are constant, the diffusion process is basically dependent on the concentration gradient between blood and dialysate[7]. This is strongly affected by the blood and dialysate flow rates and by the distribution of the countercurrent flows in their relative compartments. It is evident that any possible mismatch between blood and dialysate flow distributions can create a significant reduction in the efficiency of the filter[7]. The dialyzer mass transfer area coefficient for urea, KoA, is a measure of dialyzer efficiency in clearing urea and solutes of similar molecular weight[1]. The KoA is the maximum theoretical clearance of the dialyzer in milliliters per minute for a given solute at infinite blood and dialysate flow rates. For any given membrane, KoA will be proportional to the surface area of the membrane in the dialyzer, although there is a drop-off in the gain in KoA as membrane surface area becomes very large[1]. Dialyzers with KoA values less than 500 mL/min should be used only for "low-efficiency" dialysis of for small patients. Dialyzers with KoA values of 500-700 mL/min represent moderate-effieiency dialyzers, useful for routine therapy. Dialyzers with KoA values greater than 700 mL/min are used for "high-efficiency" dialysis, in a large size patient when a 4 hour dialysis session is not adequate. In practice, whereas the KoA of a dialyzer does not change at various blood flow rates, the KoA does increase substantially when dialysate flow rate is increased from 500 to 800 mL/min[8,9]. This apparent increase in the surface area of the dialyzer at high dialysate flow rate is probably due to better penetration of the dialysate into the hollow-fiber bundle, resulting in an expansion of the dialyzer effective surface area and increasing in dialysis efficiency[10].

References

1. Daugirdas JT. Chronic haemodialysis prescription: a urea kinetic approach. In: Daugirdas JT. Ing TS, editors. Handbook of dialysis. 2nd ed. Boston: Little Brown. 1994.p. 92-120.
2. Sargepnt JA, Gotch FA. Principles and biophysics of dialysis. In: Jacobs C, Kjellstrand CM, Koch KM, Winchester JF, editors. Replacement of Renal Function by Dialysis. 4th ed. Dordrecht: Kiuwer Academic, 1996.p. 34-102.
3. Galach M, Ciechanowska A, Sabalinska S, Waniewski J, Wojcicki J, Werynskis A. Impact of convective transport on dialyzer clearance. J Artif Organs 2003; 6(1):42-8.
4. Locatelli F, Manzoni C, Di Filippo S. The importance of convective transport. Kidney Int 2002; 61:115-20.
5. Jaffrin MY, Ding LH, Laurent JM. Simultaneous convective and diffusive mass transfers in haemodialyzer. ASME J Biomech Eng 1990; 112:212-9.
6. Sigdell JE. Calculation of combined diffusive and convective mass transfer. Int Artif Organs 1982; 5:361-72.
7. Vander Velde C, Leonard EF. Theoretical assessment of the effect of flow maldistributions on the mass transfer efficiency of artificial organs. Med Biol Eng Cpmput 1985; 23:224-9.
8. Clard WR, Shinaberger JH. Effect of Dialysateside Mass Transfer Resistance on Small Solute Removal in Haemodialysis. Blood Purif 2000; 27:260-3.
9. Leypoldt JK. Effect of Increasing Dialysate Flow Rate on KoA and Dialyzer Urea Clearance. Semin Dial 1998; 11(3):195-6.
10. Leypoldt JK, Cheung AK. Increases in mass transfer area coefficients and urea Kt/V witk increasing dialysate flow rate are greater for high-flux dialyzers. Am J Kidney Dis 2001; 38:575-9.

---

1. Brig Gen Md Fazlul Hoque MBBS, FCPS, Chief Physician, Combined Military Hospital (CMH), Dhaka; 2. Col Md Amzad Hossain Fakir MBBS, FCPS, FCPS(Pak), FRCP(I) Classified Specialist in Medicine (Nephrology), CMH, Dhaka.