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Polyethersulfone: Membranes for Multiple Clinical Applications

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Preface

The introduction of high permeability membranes still produces enthusiasm in the medical community that stems from the better performance and biocompatibility unattainable with low-flux (even of synthetic type) membranes. The introduction of high-flux membranes is therefore related to the need for improving clearance of middle and large molecules. Evidence is also accruing showing that the use of membranes with pore size and reduced negative charge may allow an increased albumin loss, albeit tolerable for the patient’s nutritional balance, with the advantage of removing albumin-bound toxins and even albumin molecules modified by the uremic microenvironment.

In more recent years, the scenario of both substituted cellulosic and synthetic membranes has greatly expanded. In the area of synthetic membranes, an increasing number of producers is able to offer synthetic membranes with protein permeability higher than that of conventional high permeability. Numerous authors have emphasized the possible advantage of a higher albumin loss particularly in relation to the possibility of eliminating uremic toxins bound to albumin. A controlled loss of albumin would enable the elimination of oxidized albumin, a target protein for oxidation processes in the body. The issue as to whether and to what extent the loss of albumin could be beneficial to the patient is still highly controversial due to the lack of randomized, controlled studies. Nevertheless, it represents a new challenge for nephrologists interested in the optimization of dialysis treatment. The understanding of how a high flux membrane works in in vitro and, even more importantly, in vivo conditions comes from the analysis of ‘conventional’ marker molecules such as vitamin B_{12} (1,200 Daltons), parathyroid hormone and its C- and N-terminal fragments.
(9,400 Daltons), $\beta_2$-microglobulin (11,800 Daltons), AGE-peptide (1,000 up to 5,000 Daltons) and expressed as sieving coefficients. Recent studies on the kinetics of albumin loss in highly convective-diffusive treatments such as predilutional hemodiafiltration have shown well that the loss of proteins occurs in the first hour of treatment and strikingly diminishes during the following hours.

The Bellco BLS series hemodialyzers now incorporate a new polymer that has been engineered in order to provide two innovative aspects: (1) hydraulic permeability to allow high convective transport, notwithstanding that the membrane has highly diffusive performances for all small solutes thanks to the reduced thickness of the membrane (30 $\mu$m), and (2) the introduction of PET in the bundle which produces almost complete absence of fouling due its balanced charge at the blood-surface interaction.

Thus, polyethersulfone may be fine tuned for different clinical applications. We have organized this issue in the series of *Contributions to Nephrology* into two parts in order to provide the reader with complete knowledge of the state-of-the-art of the new polymer. In the first paper dealing with ‘Polymer, membrane and filter characteristics’, Brandt and Wiese from Membrana, the manufacturer of the polymer, have summarized the physicochemical basis of this membrane and its particularly noteworthy applicability to the different clinical uses ranging from low- to high-permeability membranes and even to much higher porosities reaching the performances required for plasma filtration and plasma pheresis. The ultrastructural aspects of the low-, high- and very high-permeability membrane have been intensively studied by Ballestri et al., who help the reader to clearly identify the innovative morphologic features in comparison to other conventional membranes. Ronco et al. have elegantly provided evidence for the appropriate geometry of Bellco dialyzers incorporating the polyethersulfone membrane using an innovative imaging technique. Finally, Schindler et al. have tested the cytokine handling in in vitro experiments suggesting the advantage in cytokine removal using very high-permeability membranes. In the second part, ‘Clinical applications in extracorporeal treatment for renal failure’, David et al. have presented the results of studies on performances and albumin loss with the very high-permeability polyethersulfone (BLS8-series) used in post-dilutional hemodiafiltration. These authors have also tested a modified version with almost no loss of albumin in high-flux dialysis. In this context, using the modified version they have proved that using a well-tailored membrane one can achieve high $\beta_2$-microglobulin removal rates even in high-flux dialysis. Extensive studies on the performances and electrolyte fluxes across the polyethersulfone have been provided by Locatelli et al. and Di Filippo et al. Garibotto et al. have studied the amino acid losses with polyethersulfone and compared them with those observed with conventional
polysulfone. Despite increased permeability (and higher albumin loss), no significant differences were observed by these authors in the loss of amino acids. Sénécal et al. have investigated the effect of glucose infusion on the permeability of polyethersulfone suggesting a striking difference in regard to conventional polysulfone. The biocompatibility of high permeability (Bonomini et al.) and low permeability (Memoli et al.) is shown both throughout the analyses of conventional parameters as well as new indicators as suggested by Stefoni et al. These studies provide extensive information on the high biocompatibility of the whole polyethersulfone family of hemodialyzers. Memoli et al., however, clearly indicate the relevance of a high-microbiological quality of the dialysate. Potier et al. have looked at the heparinization and handling of high-permeability polyethersulfone providing relevant suggestions at the practical level. Pizzarelli et al. have provided clinical data on their 2-year experience with paired filtration hemodiafiltration, a newly proposed online technique that takes particular advantage of the high permeability of the membrane.

We, as guest editors, would like to thank all the contributors for providing original data, and Membrana and Bellco for their support. In closing, we hope the reader will receive complete information for ever better optimization of hemodialysis and for the ultimate benefit of our patients.

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