Flow Dynamic Analysis by Contrast-Enhanced Imaging Techniques of Medium Cutoff Membrane Hemodialyzer

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BACKGROUND

The introduction of medium cutoff membrane has spurred new interest in potential improvements in medium- and long-term outcomes in patients undergoing chronic hemodialysis. **MCO** membrane presents increased solute permeability with improvement of molecular weight retention onset (MWRO) while maintaining cutoff values adequate to limit albumin losses. **MCO** membrane is utilized in a dialysis technique defined "expanded hemodialysis" that provides significant improvement in removal of large (PM > 25 and < 58 kDa) middle molecular weight solutes (LMM) responsible for symptoms and complications. While solute clearances, sieving coefficients, and hydraulic permeability have been extensively studied, flow dynamic characteristics of hollow fiber hemodialyzers utilizing such membranes have not been studied in detail. This information may be required to correctly prescribe **HDx** therapy and to optimize its operational parameters.

OBJECTIVE

To evaluate the flow dynamic and cross-filtration characteristics of the new **MCO** hemodialyzer (**Theranova** 400; Baxter, Deerfield, IL, USA), and aiming to gather specific information useful for the correct and safe delivery of expanded hemodialysis with the **MCO** membrane, specifically:

- Define the flow dynamic conditions inside the blood compartment and the flow distribution inside the dialysate compartment
- Define the hydraulic permeability and its sieving properties
- Analyze the segmental cross flow (direct filtration and backfiltration) along the length of the hollow fiber bundle

METHODOLOGY

Characteristics of Dialyzer Evaluated

The **Theranova** 400 dialyzer is a dialyzer designed specifically for **HDx** therapy with a surface area of 1.7 m^2. The membrane has an asymmetric 3-layer structure composed of polyarylethersulfone and polyvinylpyrrolidone blend, BPA free. It is characterized by uniform pore distribution and specific sieving properties: high MWRO and molecular weight cutoff (MWCO) value lower than albumin.

Study Techniques

Blood and dialysate flow distribution and internal transmembrane cross-filtration were studied with two separate imaging techniques: CT helical scanning and sequential and static scintigraphic imaging. Two different experimental setups were used in the CT imaging technique for blood and dialysate flow dynamic analysis. See Figures 1 and 2.

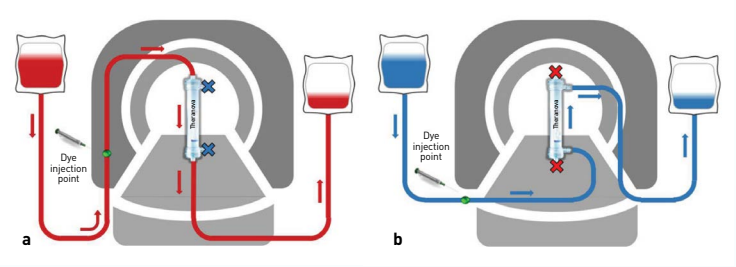

FIGURE 1. Schematic representation of the first experimental setup. The dialyzer was held in vertical position and placed in the middle of the gantry. Blood and dialysate compartments were analyzed separately. **a** Dye solution was injected in the blood inlet line, and flow was directed from the top to the bottom; the dialysate compartment was prefilled and sealed. **b** Dye solution was injected in the dialysate inlet line, and flow was directed from the bottom to the top; the blood compartment was prefilled and seal. Figure adapted from Lorenzin, et al.

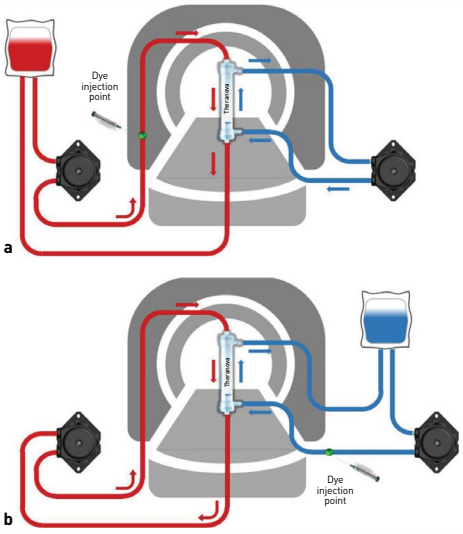

FIGURE 2. Schematic representation of the second experimental setup. The dialyzer was held in vertical position and placed in the middle of the gantry. Two peristaltic pumps flowed blood and dialysate in counter-current at 300 and 500 mL/min, respectively, and no net filtration. **a** Dye solution was injected in the blood inlet line, and flow was directed from the top to the bottom; the dialysate circulated in a closed loop. **b** Dye solution was injected in the dialysate inlet line, and flow was directed from the bottom to the top; blood circulated in a closed loop. Figure adapted from Lorenzin, et al.

A third analysis was conducted employing a scintigraphic method to assess the internal filtration/backfiltration. See Figure 3.

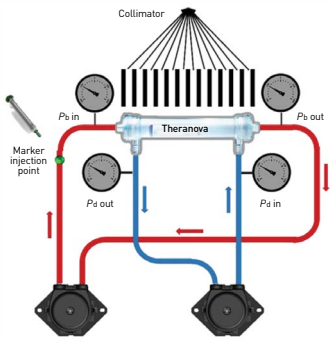

FIGURE 3. The scintigraphic experimental setup. Dialyzer was laid on the gamma camera. Blood (300 mL/min) and dialysate (500 mL/min) were circulated in a closed loop configuration ensuring zero net filtration. The tracer was injected in the blood line, upstream the inlet of the dialyzer. Pressures at inlet and outlet of the 2 compartments were monitored. Pb: pressure blood; Pd: pressure dialysate. Figure adapted from Lorenzin, et al.