IN VIVO UREA REMOVAL BY ELECTRO-OXIDATION IN A WEARABLE DIALYSIS DEVICE

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Introduction and Aims: In NEPHRON+, an EU consortium, a wearable dialysis device is being developed that can offer prolonged gradual dialysis. The concept is based on continuous regeneration of a small volume of dialysate. A major challenge is the removal of urea, since the daily urea production is very high and removal by adsorption has proved difficult. Electro-oxidation (EO) seems attractive since electrodes are durable, small and inexpensive. We achieved clinically relevant urea degradation in blood (9.5±1.0 mmol/h) in vitro using an EO unit in series with activated carbon (AC) for removal of chlorine by-products (Artif Organs; 2014; 998-1006). Here, we studied in vivo efficacy of urea removal by EO in a hemodialysis model in goats.

Methods: An EO-unit, containing 10 graphite electrodes (cumulative surface 585cm²), was incorporated in the dialysate circuit in series with activated carbon (AC; 25g/unit). The unit also contained sorbent beads for K+ and PO₄³⁻ removal (data not shown). Graphite electrodes (n=10, cumulative surface 585cm²) were used for electro-oxidation, 3 Ampère (A) was applied using 1 EO-unit (1x3A; N=7) or 2 EO-units in parallel (2x3A; N=7). Blood was pumped (110 mL/min) during 3 hours over a 0.2m² Polyflux dialyzer and dialysate was recirculated over the EO unit in counter current direction (40 mL/min for 1x3A; 2 x 40 mL/min and 2 x 70 mL/min for 2x3A). Healthy goats were instrumented with a central venous catheter. Unfractionated heparin was used for anticoagulation. Urea was infused to achieve higher urea concentrations closer to the uremic range. Urea removal was estimated from its extraction across the EO-unit(s).

Results: Urea removal and clearance were 8.4±1.5 mmol/h and 11.9±1.6 mL/min, respectively, using one EO unit (3A, dialysate flow 40 mL/min; Fig. 1A,B) and remained stable during consecutive hours. Use of two units in parallel doubled the removal of urea (17.0±1.8 mmol/h) and caused a 1.6-fold increase in urea clearance (19.3±3.7 mL/min). Increase of the dialysate flow to 70 mL/min per unit did not further increase urea removal (15.8±3.4 mmol). Urea removal was dependent on urea plasma concentrations (Fig. 1C) while there was no relation between urea concentration and clearance.

Conclusions: EO by graphite electrodes combined with AC shows promising urea removal in vivo. Further research aimed at increasing the efficacy and biocompatibility testing is warranted.