A MINIATURE ARTIFICIAL KIDNEY FOR PERITONEAL DIALYSIS

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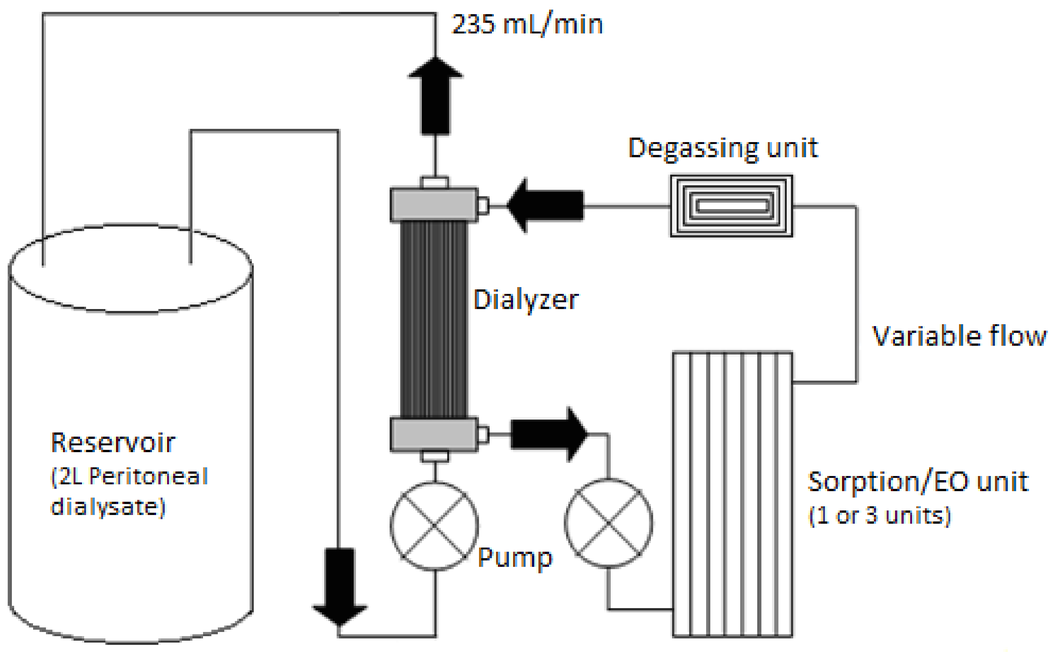
Background and objectives

A miniature artificial kidney for peritoneal dialysis is being developed based on the wearable artificial kidney developed within NEPHRON+ (EU FP7).
Concept: continuous regeneration of peritoneal dialysate will maintain a large plasma-dialysate concentration gradient, thereby enhancing blood purification while reducing the number of exchanges.

Aims:

- To study efficacy of urea, creatinine, K^+ and PO_4^{3-} removal as influenced by dialysate flow and number of sorption/electro-oxidation (EO) units.
- To study whether equilibration at physiological [Ca^{2+}], [Mg^{2+}], [HCO_3^-] and hypotonic [NaCl] can prevent Ca^{2+}, Mg^{2+} and HCO_3^- adsorption and Na^+ release, respectively.

Design and methods



- 2L Spent peritoneal dialysate (PD), containing [urea] 20.4±2.7mM, [creatinine] 0.6±0.1mM, [K^+] 3.1±0.2mM and [PO_4^{3-}] 1.1±0.2mM, was pumped over a dialyzer (235mL/min).
- 100mL Dialysate was recirculated counter-currently to PD at 20, 40 or 75 mL/min) over a sorption/EO unit for 180 min (N=3/flow rate). Subsequently, 3 units were applied (3x40 mL/min).
- Each unit contained:
  - -Polystyrene-divinylbenzene (90 g) for K^+ removal
  - -FeOOH (30 g) for PO_4^{3-} removal
  - -10 graphite electrodes (70 g, cumulative surface 585 cm^2); 3A with activated carbon (AC) (50 g) for organic waste removal (i.e. urea and creatinine)
- The sorption/EO unit was equilibrated with NaCl 95 mM, $NaHCO_3$ 25 mM, $CaCl_2$ 1.2 mM, $MgCl_2$ 0.45 mM.
- Every 30 min electrode polarity was inversed to avoid deposition.
- To simulate replenishment from the plasma compartment (in vivo) the estimated amount of removed urea, creatinine, K^+ and PO_4^{3-} was added to the reservoir at 60 and 120 min.

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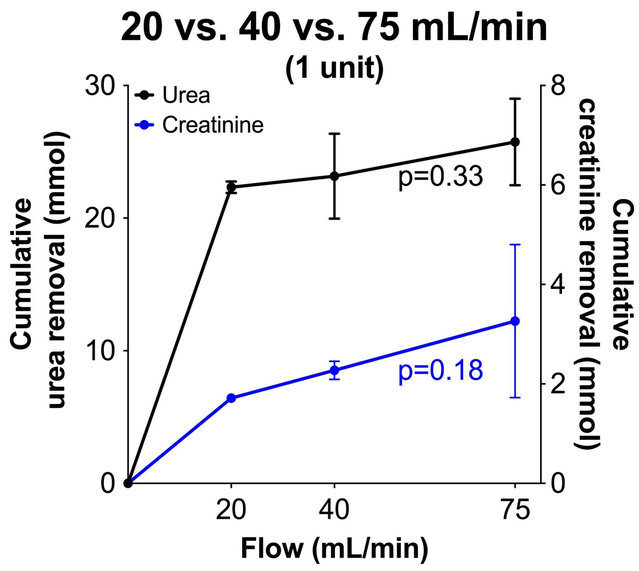
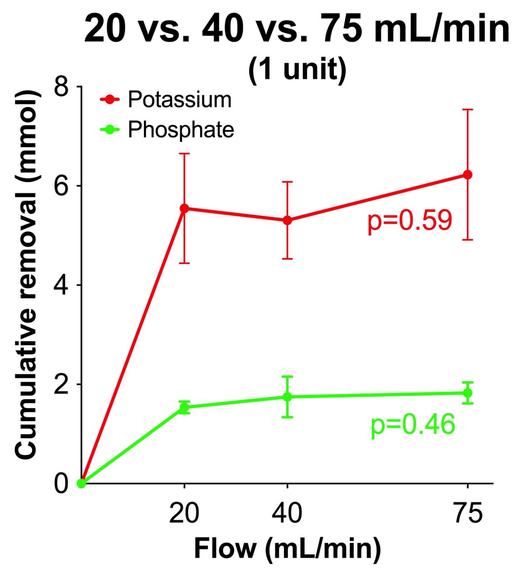
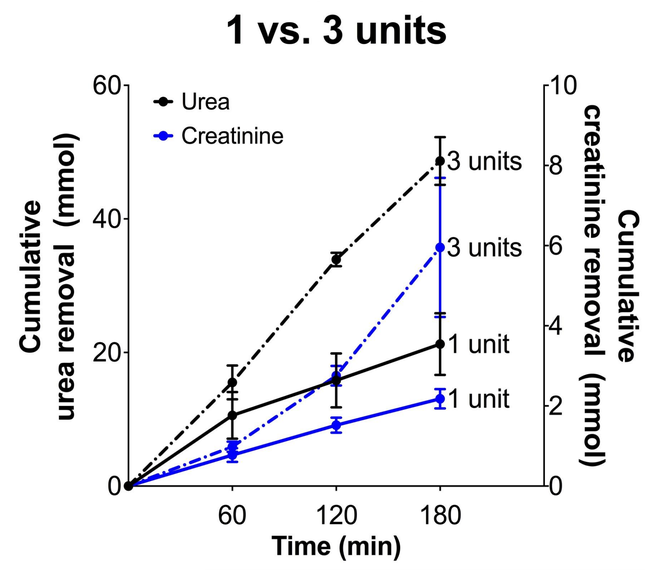
Results - I

Cumulative removal







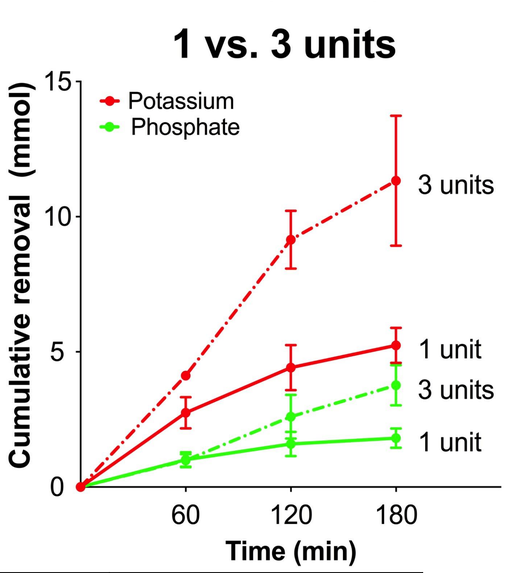


Table 1	Aver conc T=0 min (mM)	Aver conc T=180 min (mM)
[Ca^{2+}]	0.7±0.3	1.4±0.3
[Mg^{2+}]	0.5±0.1	0.7±0.2
[Na^+]	123.5±1	117.5±0.7

Results - II

- Equilibration at [Ca^{2+}] 1.2mM and [Mg^{2+}] 0.45mM prevented adsorption of these ions (Table 1).
- Equilibration at [Na^+] 120mM prevented Na^+ release.
- Bicarbonate release was 15.4±9.9 mmol when equilibrating at [HCO_3^-] 25mM (3 units).
- Glucose was removed primarily by saturable adsorption to activated carbon occurring within 60 min (21.1±4.5 mmol in the 1st hour vs. 0.5±1.1 mmol in the 3rd hour, p=0.01)
- Chlorine levels below maximum acceptable levels (AAMI standard)
- Ammonia/-um release: 0.016±0.05 mole / mole of urea

Conclusions

- Relevant removal of urea, creatinine, K^+ and PO_4^{3-} without Ca^{2+}, Mg^{2+}, HCO_3^- adsorption or Na^+ release.
- For application as a bedside device (8 hours/day) + 1 exchange per day, creatinine removal is sufficient with 3 sorption/EO units. Removal of urea needs to be increased with ~50% and that of potassium and phosphate with ~25%.
- Chlorine release complies with AAMI standards.
- Higher dialysate flow did not increase toxin removal.
- Slight ammonia/-um generation due to hydrolysis of urea.