HAEMOPERFUSION MADE SAFE WITH SORBENT MEMBRANES

P S Malchesky, W Piatkiewicz, S Nakamoto, Y Nose

Cleveland Clinic Foundation, Departments of Artificial Organs and Hypertension and Nephrology, Cleveland, Ohio, USA

In the application of sorbent haemoperfusion, especially for chronic treatment, the system must be biocompatible, with no sorbent particle release, and be efficient in removing known toxic solutes without depleting essential solutes or blood components. Based upon the biochemical abnormalities generally seen in the disease state, a multi-sorbent system is required. With these criteria, the Enka (Wuppertal, West Germany) sorbent membranes were chosen and studied [1,2]. Evaluations of sorbent membranes include in vitro determination of equilibrium and kinetic sorption parameters [3-5]; the membranes were incorporated into devices which were investigated for in vitro sorption and fluid dynamic characteristics, particle release and using ex vivo perfusions, for biocompatibility.

Studies have been carried out with membranes containing activated charcoal and aluminium oxide. The solutes of particular interest have been the electrolytes, sodium, potassium, chloride, calcium and magnesium, and urea, creatinine, uric acid and dextrose. Studies indicate that sorption, which is of the Langmuir type for solutes studied, is a function of solute concentration. The isotherm is represented by a Freundlich-type relationship with n and K as Freundlich parameters. The presence of several solutes may affect the sorption of a single species (e.g., glucose at a concentration of 200 mg\% decreases the sorption of creatinine). Gamma irradiation (0.5-2.5 mrad) of the charcoal sorbent membrane had no effect on equilibrium isotherms for sorption of creatinine and uric acid.

Kinetic studies indicate that significant quantities of the solutes may be removed in practical treatment time periods. Evaluation of various types of charcoals and new sorbents indicates that efficiencies up to 3 times higher are possible. Less than 100 gm of sorbents would be required to remove known solutes, other than urea, removed in a standard dialysis in an adult. Low priming volume, low resistance device designs employing sorbent fibres (13-115 gm of sorbents), tested in vitro using 35.0 litre pools at flows of 200 ml/min, yielded 4-hr removal rates for creatinine, uric and inorganic phosphorous as high as 49, 58, and 40 mg/gm sorbent. Device analyses, when compared with
sorption parameters, indicate that fluid dynamics may be a major limiting resistance to mass transfer and demonstrates the importance of device design and flow geometry.

Particle release studies have revealed no release of sorbent from the membrane. Ex vivo studies on two calves and four dogs, with normal heparin dosage, have been tolerated well. There were no changes in serum electrolytes, enzymes or organ function tests. Transient changes in some haematological parameters, such as white blood cell and platelet counts and fibrinogen, were not related to the devices but, rather, to surgical procedures or animal condition. Employing the various structural forms of the sorbent membranes, such as sorbent and sorbent dialysing fibres, multifunctional device designs (sorption plus dialysis or sorption plus filtration) may be created. While sorbent membranes have direct application to renal failure treatment, as an adjunct to dialysis or for the regeneration of haemofiltrate and peritoneal dialysate fluid, they may also prove useful in exploring the treatment of non-renal metabolic disorders such as hepatic insufficiency, schizophrenia, and psoriasis.

References

4 Malchesky, PS and Nose, Y (1978) In Artificial Kidney, Artificial Liver and Artificial Cells, Ed. TMS Chang, Plenum, New York
5 Piatkiewicz, W, Malchesky, PS and Nose, Y (1977) Proc. ACEMB, 19, 392