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Study on the Effectiveness and Safety of Specially Designed Porous Hollow Carbon Spheres for Adsorbing Large Molecular Toxins in Uremia

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Objectives : With the prolongation of dialysis vintage, the accumulation of middle-molecular uremic toxins contributes to the high incidence of cardiovascular diseases. The development of new dialysis or adsorption materials, the exploration of novel toxin clearance techniques with improved biocompatibility, and more efficient and selective removal of middle-molecular toxins are essential. These approaches aim to reduce uremic complications, enhance the quality of life for patients, and extend their life expectancy.

Methods : The study employs independently developed nano-sized porous carbon composite microspheres with high efficiency in adsorbing middle-molecular toxins in uremia. Using the extrusion spherization method, millimeter-sized macroscopic carbon-based composite microspheres suitable for clinical use are constructed. Based on the characteristics of middle-molecular toxins such as parathyroid hormone (PTH), β 2-microglobulin (β 2-MG), interleukin-6 (IL-6), tumor necrosis factor- α (TNF- α), the macroscopic carbon-based composite microsphere's pore size and structure are regulated to efficiently adsorb the corresponding middle-molecular toxins. The efficacy of toxin adsorption is validated in vitro using serum from uremic patients.

Results : 1. The porous carbon composite microspheres demonstrated efficient removal rates of 94.75% for PTH and 98.33% for β 2-MG within 5-10 minutes. Additionally, they achieved removal rates of 60.55% for TNF- α and 39.96% for IL-6 within 60 minutes, reaching adsorption equilibrium. 2. Porous charcoal microspheres/charcoal extrusion-spherization composite microspheres, prepared using the extrusion spherization method, exhibited removal rates of 95.43% for PTH and 97.53% for β 2-MG. The removal rates for IL-6 and TNF- α were 2.87 and 7.58 times higher compared to a commercial large-pore resin. 3. Porous charcoal microspheres/charcoal extrusion-spherization composite microspheres exhibited excellent blood compatibility, with no significant differences in blood routine and coagulation parameters compared to a commercially available adsorbent.

Conclusions : The novel nano-sized carbon-based composite microspheres demonstrate high efficiency and selectivity in adsorbing PTH, β 2-MG, TNF- α , and IL-6. Simultaneously, they exhibit excellent blood compatibility, offering the potential to reduce complications in uremic patients.