THE PARAQUAT ADSORPTION PATTERN AND HEMODYNAMIC PROPERTIES OF CHARCOAL COLUMN IN HEMOPERFUSION

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INTRODUCTION

Hemoperfusion is a therapy for the drug intoxicated patients using the activated charcoal column. Although studies on the charcoal adsorption in the industrial field are active, in medical applications, quantitative prescription is not available. More quantitative standard on the hemoperfusion prescription is required. In this study, hemodynamic analysis on the hemoperfusion was quantitatively performed with a mathematical model of the paraquat adsorption was represented.

METHODS
HEMODYNAMIC MODEL

The paraquat adsorption in the charcoal column was simulated by solving the chemical reaction equation and mass balance equation simultaneously. The chemical reaction of adsorption was defined as the finite-rate reaction and stoichiometric coefficient and rate exponent were obtained from animal experiment. Langmuir model was used to fit the animal experiment data and calculate the parameters required to predict the absorption kinetics

Blood flow rate of 120 m/min was given as an inlet boundary condition and venous pressure of 10mmHg condition was set for the far enough from the column outlet. Darcy's law was used to model the porous media of the activated carbon and experimentally determined the porosity and flow resistance in the porous media.

To estimate the paraquat adsorption, the amount of paraquat absorbed and the time required for the adsorbent to take up half as much parauat as it will at equilibrium. Mass flux distribution was also calculated by dividing the charcoal column into three parts from central region to peripheral region.

A commercial computer-aided design software package, GAMBIT 2.0 (Fluent, Inc.), was used to generate the two dimensional axisymmetric geometry and computational surface mesh of the charcoal column (Figure). A commercial CFD code, FLUENT6 (Flunet, Inc.) was used to discretize and solve the mass and momentum equations governing fluid flow through the porous media

ANIMAL EXPERIMENT

For Six dogs (Body Weight = 30 kg), 50 cc diluted paraquat solution was injected in intravenous injection. The paraquat level an hour after injection was 61.8 mg/L. Hemoperfusions were started one hour after injection for four hours and blood was sampled at 30, 60,120, 180, 240 min from arterial line. Blood flow rate was maintained at 120 mL/min and pumped with peristaltic roller pump (Gambro AK95). The Adsorption Charcoal Column used was ASRORBA 300C (Gambro). The paraquat concentration analysis of the blood samples were entrusted to Inha University Hospital.
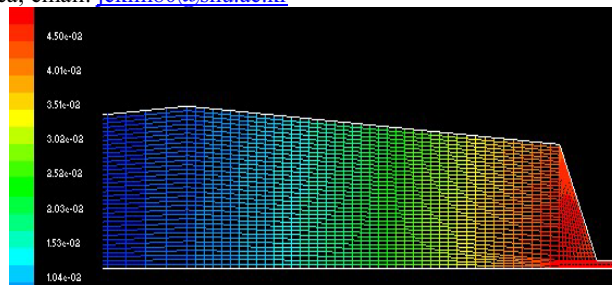

Figure: Praquat concentration distribution in the charcoal column.

RESULTS AND DISCUSSION

The peristaltic roller pump generated sine wave like mass flow with pressure drop about 15 – 20 mmHg. The charcoal column surface mesh was dissected in radial direction into three parts to assess the flow distribution. As shown in Figure, the concentration of the toxin is higher in the central region than that of peripheral region. This phenomenon is due to the mass flux inequality per unit volume. The mass flux ratio calculated per unit charcoal volume in each dissected part was 1: 1.7: 5.3 implying that 65% more influx was passed through the central region of the column and might lead to decrease in adsorption efficiency. At the interface of the porous media and blood inlet, secondary flow was observed, which possibly results in the risk of thrombosis formation in clinical application and this is an important factor in the life of charcoal column. The amount of paraquat absorbed during the hemoperfusion was 2.976g and the time required for the adsorbent to take up half as much parauat as it will at equilibrium was16.5 min implying the strong electrostatic interaction between negatively charged surface and paraquat cation.

CONCLUSIONS

This simulation may be helpful to determine the quantitative prescription of hemoperfusion dose for the drug intoxicated patients. And more optimized flow pattern and geometry of the charcoal column are required to maximize the paraquat adsorption efficiency in the activated carbon.

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