Mohammad Rahimi-Gorji

Numerical Simulations of Pressurized Intraperitoneal Aerosol Chemotherapy (PIPAC): Effect of Inertial Impaction

Mohammad Rahimi-Gorji (1,2,3), Charlotte Debbaut (2,3), Ghader Ghorbaniasl (4), Wouter Willaert (1,3), Wim Ceelen (1,3)

(1) Experimental Surgery Lab, Department of Human Structure and Repair, Ghent University, Ghent, Belgium

(2) IBiTech – Biommeda, Ghent University, Ghent, Belgium

(3) CRIG – Cancer Research Institute Ghent, Ghent, Belgium

(4) Department of Mechanical Engineering, Vrije Universiteit Brussel (VUB), Brussels, Belgium

INTRODUCTION

Pressurized IntraPeritoneal Aerosol Chemotherapy (PIPAC) is a novel method to treat peritoneal metastases by intraperitoneal nebulization of chemotherapy. Homogeneous distribution of the resulting aerosol is hampered by inertial impaction of aerosol droplets, and by gravitational acceleration. Here, we used computational fluid dynamics (CFD) to simulate the effect of inertial impaction on spatial aerosol distribution during PIPAC.

METHODS

The peritoneal cavity was modelled as a box divided in 4 regions, corresponding to dorsal (1) to ventral (4) regions of the abdomen, with the nebulizer positioned on top (Fig.1a). After mesh generation, we simulated a CO_2 capnoperitoneum (1600 Pa) and nebulization of 20 mL of liquid (density 1071.9 kg/m^3, viscosity 4.875 mPa·s). Inertial impaction was expressed as the impaction parameter (IP), defined as IP=d^2*Q, with d=droplet diameter (µm) and Q=liquid flow rate (mL/s) [1]. Aerosol deposition was simulated using COMSOL Multiphysics considering different values of d (1 and 30 µm) and Q (0.31, 0.41, 0.50, 0.70 and 0.94 mL/s).

RESULTS

The results show preferential accumulation of the aerosol in the dorsal region (1) due to inertial impaction and gravity (Fig.1b), while the ventral region (4) remains unexposed. With increasing values of IP, aerosol deposition significantly increases in region 1 (opposite the nebulizer) due to inertial impaction.

CONCLUSION

Optimal aerosol distribution is obtained with a droplet diameter of 1 µm and flow rate of 0.7 mL/s. Transport of aerosol droplets is significantly affected by their size. With low flow rates, the effect of gravity is dominant, especially for heavy and large droplets.

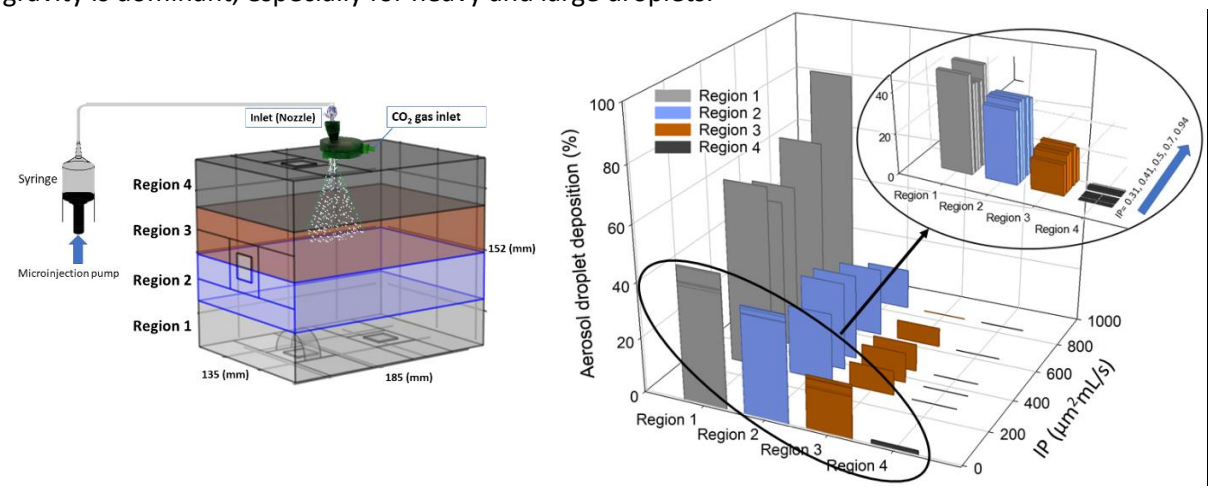

Fig. 1. (a) Box geometry, and (b) aerosol droplet deposition in the four box regions for different IP values using CFD.

[1] Cheng et al. Aerosol Sci. Technol. 31, 286–300 (1999).