TEL +44 (0) 7758742358

E info@fts-engineeringanswers.com

www.ftsengineeringanswers.com

Focus on Bio Medical Applications

Using Simulation to Optimize Design and Provide Insight

FTS Engineering Answers is regularly asked to investigate how to optimize medical devices, to provide insight into the patient specific conditions or to help and improve the understanding of medical procedures. Here, three examples of such studies are provided: optimizing the design of a asthma inhaler and spacer; a demonstration of taking a patient CT Scan and using this as basis of an investigation of the blood flow through the carotid arteries; and an investigation of cornea grafts following DMEK surgery.

Device Optimization

Metered dose inhalers (MDIs) are widely used for the treatment of lung diseases, such as asthma. The delivery of the drug to the lung can be as low as 5% of the metered dose. In order to maximize the dose, a patient needs to inhale at the same time as actuating the inhaler, which can be difficult. Spacers have been developed to solve these drawbacks, and increase drug delivery to the lungs. However, there continues to be significant room for improvement.

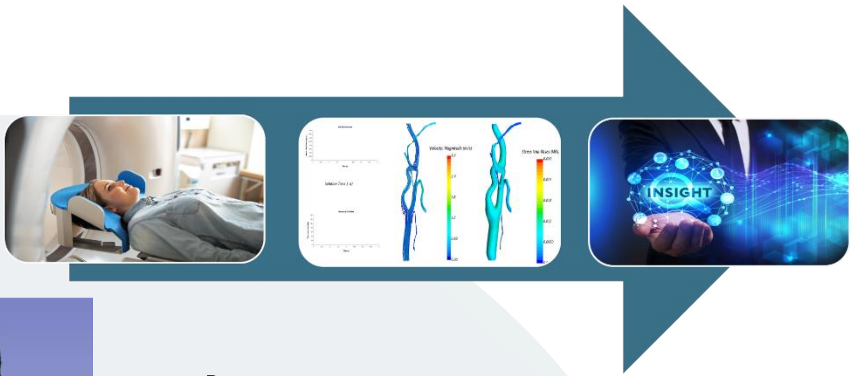
FTS Engineering Answers has been investigating the parameters of most influence of drug delivery (the atomized droplet size distribution and the spacer geometry) using transient, multiphase CFD simulations.

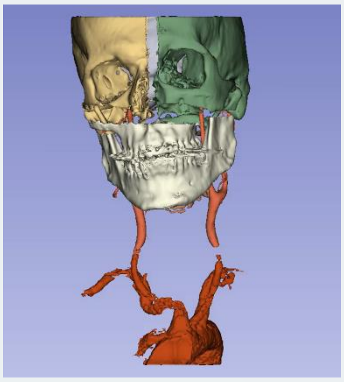
The majority of the mass of the metered dose is an accelerant, typically HFA134, which provides the energy to atomize the spray. Detailed properties of the accelerant and the drug as well as multiphase heat and mass transfer are required in order to capture these physics correctly.

These physics are combined with detailed geometrical models of a range of spacer devices and design options (position of vents, valve position and design etc.) to quantify the effect of each change on the drug delivery.

Processing of CT and MRI Scans

The objective of the study was to demonstrate the process of taking a Medical Scan (either CT or MRI) extracting physical parts of the scan (in this case the carotid arteries) and carry out a simulation with that geometry.



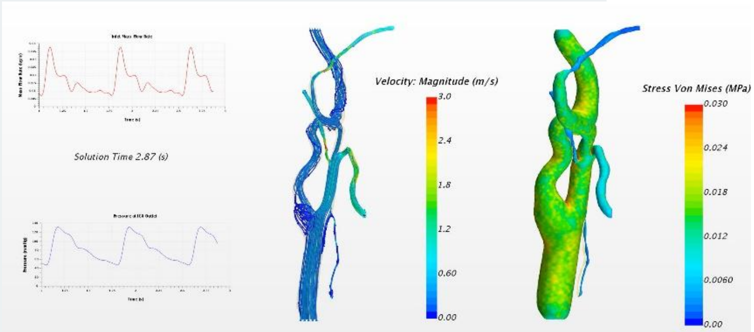


Process

Using an open source tool (3D Slicer), the CT Scan was segmented to extract the carotid arteries. The segmented carotid arteries are then imported into STAR-CCM+ as stl files.

Simulation

A Fluid Structure Interaction Simulation is then set up within STAR-CCM+. Appropriate boundary conditions are applied. A pulse flow rate at the inlet and a series of windkessel models at the outlets. Material properties are applied to the artery walls, and a pseudo "neck" is added around the artery to give the damping effect the neck does in reality.



Investigation of cornea graft failure following DMEK surgery

One option for corneal transplants is DMEK (Descemet Membrane Endothelial Keratoplasty). The procedure is outlined [here](#). As described, once the replacement cornea is unrolled and positioned in the anterior chamber of the eye, SF_6 or Air is injected below the cornea graft to push it up to the graft site. SF_6 or Air is then left in the chamber until it is naturally replaced by the aqueous fluid of the eye. This takes a few days.

During the recovery period the patient is instructed to lie down for longer periods especially in the immediate period after surgery. Following this period the patient is allowed to move freely. It is known that some grafts peel away from the graft site, and the surgery must be repeated.

FTS Engineering Answers worked with Moorfields Eye Hospital to investigate the problem using CFD.

We helped to show that the presence of both liquid and gas in the anterior chamber during the motion, as a patient moves from horizontal to vertical, may causes a force that effectively drags the cornea graft off the graft site. Removing the air/gas reduces or eliminates the force. This work led to changes in surgical procedure.