Fluid Dynamic Analysis of the Multi-Lumen Thoracic Catheter

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Abstract

INTRODUCTION: Current thoracic catheters are used in many surgical procedures to drain material from the space between the lungs and the chest wall, also known as the pleural space, but are often plagued with complications such as patient pain, infection, and clogging. The Multi-Lumen Thoracic Catheter (MLTC) incorporates multiple lumen within the wall of the catheter to allow for an array of new functionalities. These lumen provide the physician with easy access to the pleural space with which they may administer various materials to the patient such as anesthetics to deal with any pain, antibiotics to treat any infections, and anti-clotting agents to increase the efficacy of material drainage.

USE OF COMSOL MULTIPHYSICS: The MLTC design optimization studies and comparative analyses with standard thoracic catheters will be performed using the COMSOL Multiphysics® software. The standard catheter and the MLTC CAD models will be constructed in Simulink®, and using COMSOL Multiphysics software with LiveLink™ feature, will be imported into COMSOL for fluid dynamics analysis. The MLTC's lumen diameters and terminations points will be adjusted to determine the final design. Laminar flow studies will be conducted on each of the designs to ensure that there is maximum drainage through the catheter and through each of the additional lumen. By analyzing the flow rates and pressure drops across the catheter, we may examine how the MLTC compares to the existing thoracic catheters.

RESULTS: It is expected that the use of Simulink® through the LiveLink™ feature will dramatically reduce the time needed to simulate all of the prospective design options. It is also anticipated that even with the added functionality of the additional lumen, the flow rates and pressure profiles of the MLTC will prove to be as effective, or more so, at draining material from the pleural space as the standard catheters.

CONCLUSION: The Multi-Lumen Thoracic Catheter has the potential to dramatically reduce the occurrence of patient pain, infection, and occluded catheters. These factors can not only increase patient comfort, but they can also prevent the need to replace clogged catheters and cause increased hospital stays. This analysis will justify the use of these novel catheters as they will not only provide a variety of additional functions, but their drainage efficacy is comparative to that of a standard thoracic catheter.