Abstract

Reducing the rate of post-surgical infection is of great significance in the medical community. Airflow patterns are major contributors to an increased risk for infection within the surgical theater. The current state of modeling and present experimental work leave opportunity to improve upon modern practices and offer new insight to surgeons to ameliorate the problem. This thesis focused on both small-scale and full-scale experimental and computational work to monitor direct impacts from thermal plumes, relative humidity, vent blockage, and door-opening behaviors on the air flow in controlled air environments.

On the small scale, fume hoods provided testing conditions that verified direction of airflow, pressure differences, and allowed for a scale-up of computational methods. Air clearance was observed in every configuration of fume hood use, with various adverse events causing an immediate decrease in fume hood flow rate. The pressure gradient in the hood steadily increased from the inlet of the hood to the outlet or exhaust of the hood, as expected.

On the full scale, the operating room (OR) at Montefiore Hospital provided a basis for computational models, that were build using AutoCAD and Autodesk Inventor. They were then rendered in ANSYS, and provided a fluid environment for use in Fluent. Initial and boundary conditions from experimental data were compiled using the Testo dP 440 and Turbulence probe, and included inlet velocities of 24.6 ± 4.5 feet per minute (FPM), pressure differences from 2-12 Pa from the exhaust vents to the air inlet, and an average air temperature of 18 °C Steady state convergence confirmed unidirectional air clearance from the ceiling inlet to the two exhaust vents in the OR. Vent blockage did not allow for air clearance, causing air recirculation in the bulk of the room and stagnation in the corners of the room. Pressure remained constant and average air temperature increased by 0.07 °C (n = 200). Door opening studies of both the door leading to the patient hallway and the door leading to the OR staff room greatly disrupted air flow, displacing air from the intended direction to the space outside each door. The room depressurized within 1-2 seconds in each case, causing air to leave the patient door in the OR up to 208 ± 97 FPM in the case of unblocked air vents.

Computational convergence was verified by checking for conservation of mass, temperature stabilization, and pressure stabilization after green gauss node based of least-square cell-based methods.