PRESENTING AUTHOR'S NAME & RESEARCH TITLE

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Toward Characterizing Failure of Colorectal Anastomosis Using Finite Element Models (FEM) Validated by Ex-Vivo Experiments

PURPOSE/BACKGROUND

In colorectal surgery, an anastomosis involves connecting the proximal and distal ends of the remaining intestine with sutures or staples. Approximately 600,000 patients undergo colorectal surgery every year in the United States alone. One of the most common post-operative complications of colorectal surgery is leak of intestinal contents from the anastomosis - an issue with an occurrence rate of up to 30% according to some studies. In addition to the impact on patients' morbidity, mortality, and quality of life, anastomotic leaks place a tremendous financial burden on the healthcare system. While studies have examined the multiple pre, intra, and post-operative factors associated with anastomotic leaks, few researchers have examined how the mechanical integrity of the anastomosis could lead to anastomotic leaks. The overall aim of this project is to develop reproducible ex-vivo and finite element models (FEM) that can understand, predict, and eventually prevent failure of colorectal anastomoses. In the first phase of the project, porcine colon mechanical properties were attained to provide an accurate finite element model of colorectal tissues. Currently, ex-vivo testing is being conducted on porcine colorectal sections to compare end-to-side and end-to-end colonic anastomoses. Finally, we plan to develop a finite element modeling approach to simulate these two types of anastomoses. This project has the potential to change the way colorectal surgery is practiced, to save lives, and to create a significant economic impact.

MATERIALS & METHODS

Freshly harvested porcine samples were tested in two different experiments: uniaxial tensile testing and stapled anastomosis burst testing. In the uniaxial testing, rectangular sections of the colon walls were tested in two orientations, axial and tangential, with the goal of understanding the orthotropic behavior of the colorectal tissues. A combination of load cell and video camera images were used to determine the stress-strain relationships in each orientation. These results were incorporated in finite element models (FEM) which simulated the experiments.

In the burst testing, porcine colon specimens were stapled with end-to-end and end-to-side methods using Ethicon 21mm circular staplers. Specimens were tested in a tank filled with temperature-controlled water to simulate the internal pressure and temperature of the body, and were inflated using a peristaltic air pump with a flow rate of 50mL/minute. The reactive force and pressure were measured using a load cell and pressure transducer respectively. Two video cameras were used to record the experiment and monitor for leakage of air from the anastomosis, indicating anastomotic failure.

RESULTS

Using the uniaxial specimen testing data, stress-strain characteristics were determined for both tissue orientations. It was found out that Mooney-Rivlin 5^{th} order hyperelastic models could present the tensile data accurately. These models were used in finite element simulations. Comparison of experimental and simulation results showed that the proposed model predicted experimental results with seven percent difference. Preliminary results indicated that out of the seven pigs tested so far, the end-to-side technique held higher pressure than end-to-end.

DISCUSSION/CONCLUSION

Experiments have yielded parameters that will be used to create predictive constitutive colorectal anastomosis finite element models. Uniaxial testing results confirm observations of other researchers that the colorectal tissue is an orthotropic material with significantly stronger characteristics in the tangential direction.

Preliminary inflation results do indicate that a trend can be seen where end-to-side anastomosis can withstand more pressure than end to end anastomosis. Further work must be done to understand the causes of this difference. Findings of this project may change the way colorectal surgery is practiced and positively impact patient care.