MEASUREMENTS AND MODELING OF THE DESCENDING COLON

[1]M. Higa, [1]Y. Luo, [2]T. Okuyama, [3]Y. Shiraishi, [2]T. Takagi, [3]T. Yambe
[1]Biomedical Engineering Research Organization, Tohoku University
[2]Institute of Fluid Science, Tohoku University
[3]Institute of Developing, Aging and Cancer, Tohoku University
email: masaru@tubero.tohoku.ac.jp

INTRODUCTION

Stress-strain data obtained from animal and human tissue have several applications including medical diagnosis, assisting in surgical instrument design and the production of realistic computer-based simulators for training in minimal access surgery. Up to the present time, about gastrointestinal organs, some researchers have reported the extensive investigations. The common problem of the methods employed in these works, however, has been the extirpation of the organs from the experimental animals or human, so-called in vitro experiment. The object of this study is to determine the passive mechanical properties of large intestine under the condition in vivo. Experiments to determine the mechanical properties are to be performed on intact living organs.

METHODS

1. In vivo indentation experiments

Experiments were performed in the descending colons of a female goat under general anesthesia. Through an incision in the skin the large intestine were laterally exposed. A supporting plate of the indentation test was inserted into it through the incision on the intestinal wall, preserving the neurovascular supply. The indenter was cylindrical and flat-ended in ϕ1 mm, and applied to the tissue perpendicularly. Three indentation rate were chosen; 0.02, 0.5, and 5 mm/s. Load values and indent depth were measured at each experiment. The thicknesses of layers were also measured.

2. Finite element analysis

The biomechanics of compression behavior of descending colon was analyzed using a 3-dimensional finite element (FE) model. FE model consists of 3861 hexahedral and wedge shaped iso-parametric elements (Figure 1). The indenter was assumed to be a rigid body. The dimensions of the model and boundary conditions were assumed to be one of the representative model of the in vivo experiment. Descending colon was assumed to be incompressibility and homogeneous. Mechanical properties of descending colon were calculated as a inverse problem. The commercial FE software package ANSYS (Cybernet Systems, Co., LTD) was applied for analysis.

RESULTS AND DISCUSSION

The relation between indentation depths and load values is shown in Figure 2. These curves are results of in vivo experiment. The influence of the heartbeat and the respiration

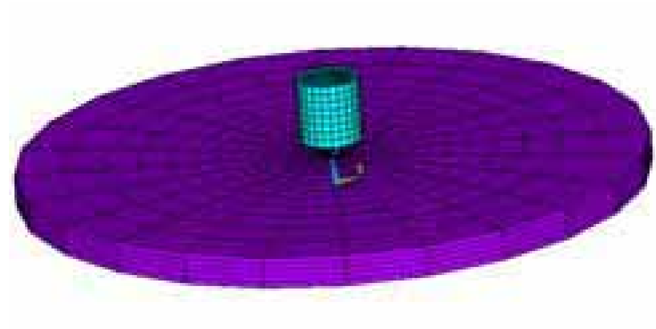

Figure 1: FE model of intestinal wall and rigid indenter

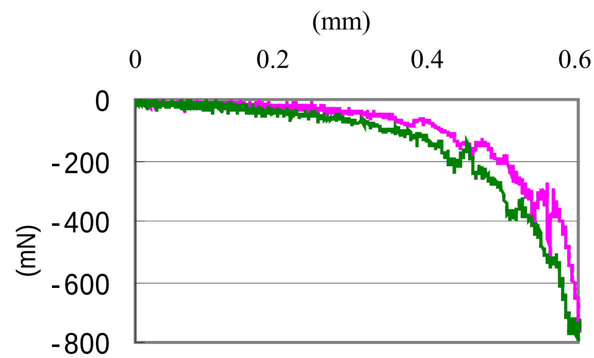

Figure 2: Results of in vivo experiments

is apparent. Values of elastic modulus were derived from these curves using Heyes' formula [1]. Average value of elastic modulus was 99.93 kPa. This value was same as the elastic modulus of the spleen [2] approximately. Elastic modulus derived from FE analysis was nearly consistent with the result of in vivo experiment. As a conclusion, the elastic modulus of descending colon was measured by in vivo indentation tests and the results of experiments were validated by FE analysis.

REFERENCES

1. Heyes W., et al., A mathematical analysis for indentation tests of articular cartilage, *J. Biomechanics*, 1972, **5**, pp541-551.
2. Carter F. J., et al., Measurement and modeling of the compliance of human and porcine organs, *Medical Image Analysis*, 2001, **5**, pp231-236.