UNIVERSITÀ DEGLI STUDI DI PADOVA

INTERNATIONAL CAE CONFERENCE
Vicenza, Italy | 2019, 28 - 29 October

Centre for Mechanics of Biological Materials

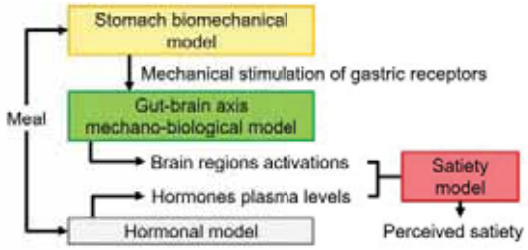
ANALYSIS OF BARIATRIC CONFIGURATIONS AFTER ENDOSCOPIC SURGERY: NOVEL APPROACHES

Claudia Salmaso*[1,2], Ilaria Toniolo[1,2], Pietro Da Roit[2], Chiara Giulia Fontanella[2,3], Emanuele Luigi Carniel[1,2]

[1] Department of Industrial Engineering, University of Padova, Padova, Italy
[2] Centre for Mechanics of Biological Materials, University of Padova, Padova, Italy
[3] Department of Civil, Environmental and Architectural Engineering, University of Padova, Padova, Italy

Research activities

- Bariatric surgery in the treatment of obesity is increasingly applied throughout the world and proved to be the most effective treatment in inducing excess weight loss. However, beyond the peri-surgical complications, other risks can compromise surgery success: weight regain, anatomic complications and micronutrient deficiencies [1].
- The goal is the development of engineering tools for the effectiveness assessment and the optimization of bariatric surgery. Computational analyses were performed considering different stomach conformations in order to compare laparoscopic and endoscopic currently–used techniques and to deepen their influence on the stomach functionality. Also, numerical investigations allowed to consider new possible scenarios regarding bariatric surgery mimicking novel endoscopic approaches.



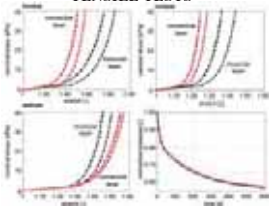
Materials and methods

Definition of the stomach biomechanical model

- Data analysis from histo-morphometric and mechanical investigations [2] on porcine tissues and definition of the fiber-reinforced hyperelastic constitutive formulation.
- Identification of constitutive parameters by the inverse analysis of tensile tests along circumferential and longitudinal directions on stomach samples from porcine tissues scraps [3].
- Development of the virtual solid model and FE discretization, considering fundus, corpus and antrum regions and connective and muscular layers.
- Reliability assessment of the stomach biomechanical model by the comparison of experimental and model results from membrane flexural tests and inflation tests.

HISTOLOGY

TENSILE TESTS



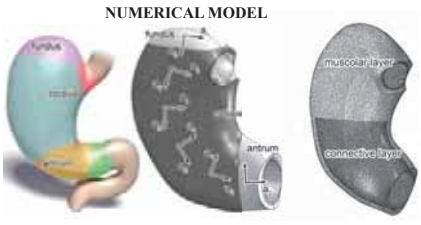
MEMBRANE FLEXURAL TESTS

INFLATION TESTS

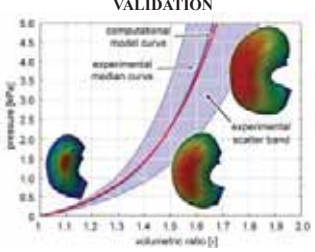
CONSTITUTIVE MODEL

$$\begin{cases} W(\mathbf{C}) = W_m(\mathbf{C}) + W_f^j(\mathbf{C}, \mathbf{a}_0^j) \\ W_m(\mathbf{C}) = -p(I_3^{1/2} - 1) + [C_1/\alpha_1]\{\exp[\alpha_1(I_1 - 3)] - 1\} \\ W_f^j(\mathbf{C}, \mathbf{a}_0^j) = [C_4^j/\alpha^{j2}]\{\exp[\alpha^j(I_4^j - 1)] - \alpha^j(I_4^j - 1) - 1\} \end{cases}$$

NUMERICAL MODEL



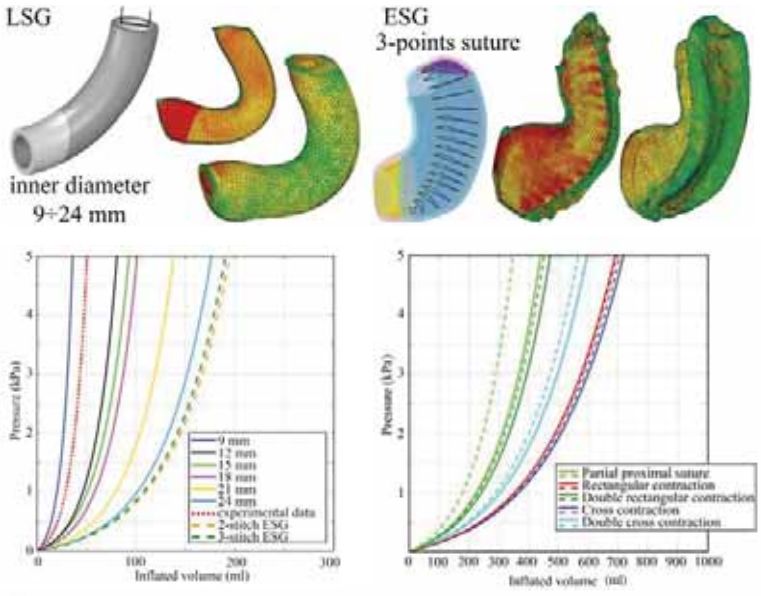
VALIDATION



Results

Comparison of currently used techniques

- Simulation of Laparoscopic Sleeve Gastrectomy (LSG) and Endoscopic Sleeve Gastroplasty (ESG) and comparison of their pressure-volume relationships: the diameter of LSG stomach conditions the strain states, also in the inner layer, and the strain distribution is less homogeneous in the walls of the ESG stomach.
- Great influence of bariatric surgery parameters on stomach mechanics, in particular on gastric structural stiffness and strain field conformation and intensity.



Tools for simulation of novel endoscopic approaches

- Computational tools are adopted to analyze hybrid procedures between the Adjustable Gastric Banding (AGB) and the LSG.
- These are preliminary engineering analyses to study differences between several suture patterns, with contraction of 50 and 75% of the wires. Fixation points are represented by wires.

Conclusion

Computational activities analyze stomach natural configuration and different post-surgical conformations. Considering the mechano-transduction capabilities of gastric receptors, it follows the relevance of the proposed computational procedures that allow evaluating the intensity and the conformation of stress and strain fields depending on stomach conformation and food intake [4]. The functional comparison between different surgical techniques provide additional data about the mechanism of operation, the reliability and effectiveness of the specific procedure. Finally, the in-silico models help reducing the amount of animal experiments replacing them with accurate simulations.

References

[1] S.J. Concors, B.L. Ecker, R. Maduka, A. Furukawa, S.E. Raper, D.D. Dempsey, N.N. Williams and K.R. Dumon, "Complications and Surveillance After Bariatric Surgery." Curr Treat Options Neurol, vol. 18, pp. 1–12, 2016; [2] E.L. Carniel, A. Frigo, C.G. Fontanella, G.M. De Benedictis, A. Rubini, L. Barp, G. Pluchino, B. Sabbadini, L. Polese, "A biomechanical approach to the analysis of methods and procedures of bariatric surgery", J Biomech, vol. 56, pp. 32-41, 2017; [3] Zhao, J., Liao, D., Chen, P., Kunwald, P., Gregersen, H., "Stomach stress and strain depend on location, direction and the layered structure.", J. Biomech, vol. 41, pp. 3441–3447, 2008; [4] S.C. Woods, "Gastrointestinal satiety signals I. An overview of gastrointestinal signals that influence food intake", Am J Physiol Gastrointest Liver Physiol, vol. 286, pp. 7-13, 2004.

***Corresponding author: Claudia Salmaso, University of Padova, Via Venezia 1 - 35131 Padova (Italy) – claudia.salmaso.1@phd.unipd.it**