IN SILICO DEVELOPMENT OF PATIENT-SPECIFIC BARIATRIC SURGERY

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Introduction

Endoscopic Sleeve Gastrectomy (ESG) is an emerging surgical procedure of Bariatric Surgery (BS) that treats people with morbid obesity. ESG is safe, feasible, repeatable, and reversible. The volume of the stomach is reduced by approximately 70% through the plication of the greater curvature [1], [2]. ESG patients reported better results respect to other BS procedures in gastrointestinal symptoms, Quality-of-Life score and comorbidities remission [3], [4]. However, the current outcomes are limited due to the retrospective nature of the studies and short-term follow-up. The computational analysis was addressed to BS in the last years by means of a patient-specific approach [5]. The goal is to improve the precision, safety and outcomes of BS through a customized intervention planning and forecast of success. This study was aimed to develop in silico simulation of the ESG starting from a pre-surgical Magnetic Resonance (MR) of ten bariatric patients submitted to ESG. The results were compared to the actual ESG configuration obtained from a 6-months after ESG MR of the same patients.

Materials and Methods

From MRs performed on ten bariatric patients before and six-months after ESG (Fig. 1), the volume of empty stomach was processed to generate a virtual solid model composed by a double layer. The finite element discretisation was performed with hexahedral elements. The ESG sutures were created by means of wire features, to which a displacement connector was imposed. Each computational analysis was performed defining a fluid cavity and increasing the volume in a step time of 1 s by means of Abaqus 2020.

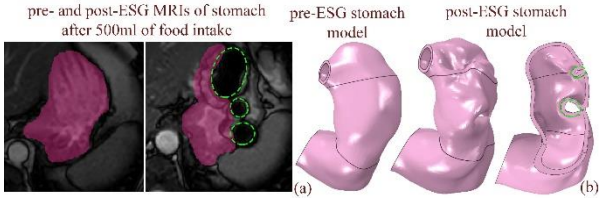

Figure 1: Patient-specific MRIs pre- and post- ESG (dashed green lines identify invaginations due to sutures) and stomach models.

Results and Discussion

The post-ESG volumetric capacities obtained after the closure of the wires were compared to the actual post-ESG volumes segmented in MRIs, finding an average discrepancy of maximum 30ml (over 200ml). The elongation strain and pressure-volume behaviour of the pre- and post-ESG stomach of patient 1 (Fig. 2) after the ingestion of 400ml showed a different pattern distribution and mechanical response, revealing a higher pressurisation in post-ESG models.

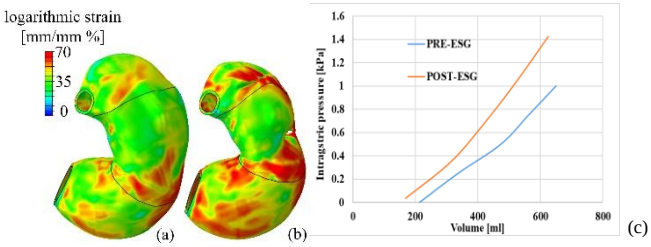

Figure 2: Colormaps (a and b) and pressure-volume behaviour (c) of pre- (a) and post-ESG (b) patient-specific stomach models.

Conclusions

The use of computational clinical tools could be a turning point in addressing the main issues related to BS. In fact, a patient-specific approach can improve the gastric solicitation of the stomach, which is crucial in weight loss and its maintenance because of the presence of chemo-mechanical receptors that perceive stimuli and send electric impulses to the brain, activating the brain regions of satiety. The final goal is the exploitation of a vast cohort of ESG-patients for the training and validation of an algorithm that will automatically detect the sutures' location, starting from a pre-surgical MRI. This procedure could be used as a planning tool that will identify the optimal patient-specific surgery design by proposing different sutures patterns and forecasting the success rate of BS.

References

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Acknowledgements

This work was supported by MIUR, FISR 2019, Project n° FISR2019_03221, titled CECOMES: CEntro di studi sperimentali e COmputazionali per la ModElliStica applicata alla chirurgia and by DICEA, BIRD 2022, titled Computational gastric biomechanics to improve bariatric surgery procedures with a patient-specific approach.