EVALUATION OF THE LOCAL STIFFNESS OF THE ABDOMINAL WALL DURING PHYSIOLOGICAL ACTIVITIES

Florence Podwojewski[1], Doris Tran[1], Alexandre Cogan[1], Mélanie Otténio[1], Philippe Beillas[1], Frédéric Turquier[2], David Voirin[3], David Mitton[1]

[1] Université de Lyon, F-69622, Lyon - IFSTTAR, LBMC, UMR_T9406, Université Lyon 1, France ; [2] COVIDIEN, France ; [3] Clinique de Chirurgie Digestive et de l'Urgence, Hôpital Michallon, CHU de Grenoble, France

Introduction

Data on the biomechanical behaviour of the global abdominal wall are limited. Some studies report data on the *ex vivo* mechanical response of the abdominal wall [Junge, 2001; Podwojewski, 2012]. But, these studies do not consider the physiological boundary conditions and the muscle activity. A few studies interested in the *in vivo* abdominal wall measured the deformations [Szymczak, 2012], the local stiffness [Van Ramshorst, 2011] or the internal geometry depending on the muscle activity [Brown, 2010]. No study measured at the same time all these parameters on a same subject. Thus, the aim of our study was to develop an experimental protocol to collect all these data on the same subjects for various physiological activities.

Methods

In vivo experiments were performed on 11 volunteers (3 females, 8 males), aged between 40 and 62 years with a mean BMI of 23.6 kg/m^2 (range 21-29.4 kg/m^2) (ethical committee approval B110676-90). Subjects in a sitting position were asked to perform different physiological activities: stay at rest, resist a pullback load by contracting their muscles, and perform the Valsalva manoeuvre. During these activities, video cameras were used to record the motion of the external surface of the abdominal wall. Displacements of the abdominal wall were calculated using the correlation software Vic3D. Ultrasound, elastography and EMG measurements were also performed. For each activity, a controlled load was applied to the abdominal wall with the ultrasound probe at three locations: on the linea alba, on the rectus muscle and on the lateral muscles. During this loading, the displacement of the probe and the applied force were measured to evaluate the local stiffness of the abdominal wall. Measurements at rest and during the Valsalva manoeuvre were repeated in 7 volunteers to evaluate reproducibility by calculating coefficients of variation (CV). Only the results of the local stiffness will be displayed in this abstract.

Results

The local stiffness increased with the physiological activity and reached on average six times the stiffness at rest (Table1). At rest, the local stiffness was greater in the lateral region (lateral muscles) than in the anterior region (linea alba and rectus muscle) of the abdominal wall (respectively 0.97 vs 0.54 N/mm). The difference of stiffness between these two regions was significant ($p = 0.02$) at rest but no significant during the Valsalva manoeuvre. Mean CV of repeated measurements was 26.8% at rest and 38.5% for the Valsalva manoeuvre.

	Rest (N/mm)	Pullback load (N/mm)	Valsalva (N/mm)
Mean	0.49	0.69	2.15
SD	0.13	0.43	1.44

Table 1: Local stiffness measured on the linea alba.

Discussion

The present results of local stiffness are of the same order of magnitude as the values found by Van Ramshorst (2011). Greater variability between subjects was observed during activities with muscle contraction. This difference can be explained by differences in physical conditions between subjects. The use of these data combined with geometrical features and EMG data are ongoing to assess the performances of subject-specific finite element models under physiological boundary conditions.

References

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