Biomechanical study of abnormal uterine activity during a vaginal delivery using an electro-chemo-mechanical constitutive model

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During a normal vaginal delivery, the muscle cells propagate electrical signals throughout the uterine wall, which will result in a synchronized set of uterine contractions and resting stages [1]. An uncoordinated uterine activity may change the uterine contractions pattern and impact fetal and maternal health [2]. There are many uterine activity abnormalities identified by the specialists, such as precipitate labor, excessive frequency of contractions (tachysystole), excessive contraction duration, excessively short resting intervals, among others.

The main goal of this work is to investigate the maximum principal stress distribution and the collagen fibers stretch in the uterine tissue during a vaginal delivery with (i) a normal contraction pattern, (ii) excessively short resting intervals and (iii) excessively uterine high frequency (tachysystole).

A biomechanical model comprising a fetus and a uterus was developed and an electro-chemo-mechanical constitutive model that triggers uterine contractions was implemented and validated with literature findings. The normal contraction pattern was defined with a contraction time of 80s and a resting time of 60s, while for the excessively short resting interval the contraction time was maintained, and the resting stage was shortened to 20s. Finally, the tachysystole was characterized by a contraction time of 55s and a resting stage of 35s.

Generally, the excessively short resting intervals exhibit higher average maximum principal stresses during the contraction and resting stages, lower average fibers stretch values in the longitudinal direction, and higher stretch in the circumferential direction. This indicates that more intense uterine contractions will be created, which my interfere with the fetal oxygenation, since higher contractions tend to compress the uterine vessels. On the other side, the tachysystole exhibit generally lower stress values during the uterine contraction and higher stress values during the resting stages, higher stretch in the longitudinal direction and lower stretch in the circumferential direction. Once more, oxygenation deficiency may be detected, since the uterine muscle does not have time enough to rest, leading to higher stresses at the end of each resting interval.

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