An empirical model for educational simulation of cervical effacement and dilation during first stage labor

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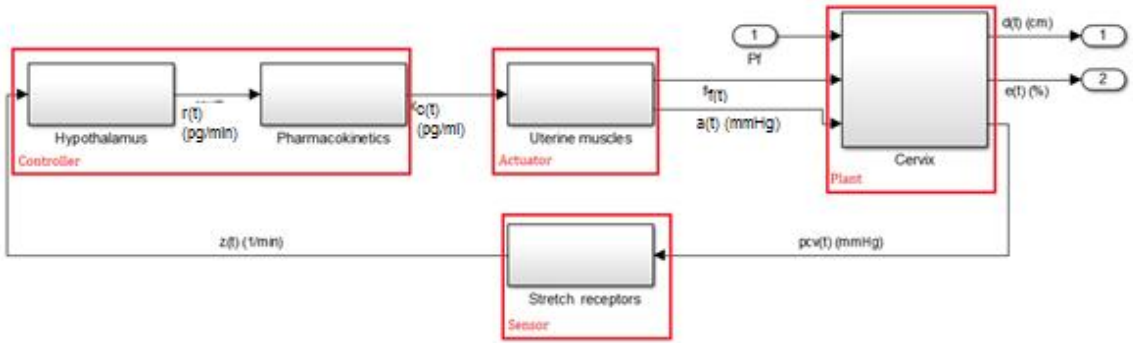
Introduction. Several models for educational simulation of labor and delivery are published in the literature [1,2] and incorporated into a commercially available training simulator [3], but do not include a model for the clinically relevant indicators: cervical effacement and dilation. Here we present such a model for the primagravida in normal and preterm labor.

Methods. Figure 1, below, shows the conceptual model, including feedback from cervical stretch receptors to oxytocin production in the hypothalamus, oxytocin pharmacokinetics, oxytocin effect on uterine contractions, and cervical effacement and dilation.

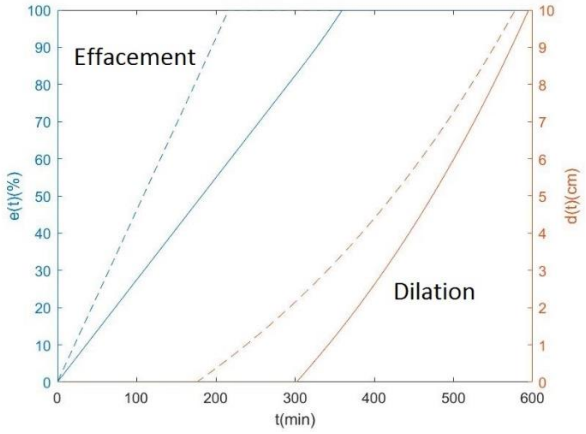


The full model will be presented at the conference; here we describe the mathematical model of the cervix, consisting of the following equations:

$$\dot{e}(t) = P_1 f(t) + P_2 a(t) + P_3 \qquad sd(t) = u\left(e(t) - P_4\right) \qquad \dot{d}(t) = sd(t)\left(P_5 f(t) + P_6 a(t) + P_7\right)$$

with r(t) oxytocin production rate, c(t) oxytocin concentration, frequency and amplitude of uterine contractions f(t) and a(t), effacement e(t), trigger from effacement to start of dilation sd(t), and dilation d(t), respectively. u(x) is the unit step function. Parameter values reflecting normal and preterm labor were established to meet effacement and dilation profiles described in the literature.

Results. Figure 2, to the right, shows effacement and dilation simulation results for the normal (continuous lines) and preterm (dashed lines) primagravida.



Conclusion. The presented model correctly reflects effacement and dilation during first stage labor in the primagravida (formal validation results will be presented) and can easily be adapted to reflect cervical insufficiency. It represents a meaningful expansion of the capabilities of medical training simulators.

References

[1] Bastos LF, van Meurs W, Ayres-de-Campos D: A model for educational simulation of the evolution of uterine contractions during labor, Comput Methods Programs Biomed. 2012 Aug;107(2):242-7.
[2] Lobo MF, Bastos LF, van Meurs WL, Ayres-de-Campos D: A model for educational simulation of the effect of oxytocin on uterine contractions, Med Eng Phys. 2013; 35: 524-531 [Epub ahead of print: Jul 24 2012].
[3] http://caehealthcare.com/eng/patient-simulators/maternal-fetal-childbirth-simulator, Jan. 12, 2017.