Gefferie et al. Advances in Simulation

https://doi.org/10.1186/s41077-021-00184-y

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Correction to: An empirical model for educational simulation of cervical dilation in first stage labor



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(2021) 6:34

Correction to: Adv Simul 3:9 (2018) https://doi.org/10.1186/s41077-018-0068-3

Continuing work on a recently published empirical model for educational simulation of cervical dilation [1] resulted in identification of errors in the code implementing this model. Numerical values of three parameters and one state variable had to be updated to obtain the original simulation results with corrected code. The errors identified in the original code included incorrect assignment of the value of the parameter that governs the dilation increase due to pressure exerted by the fetus on the cervix, a discrete time step specified in hours with parameters using minutes as a time reference, numerical integration of a static equation, and unnecessary capping of the uterine contraction amplitude. In the MATLAB code listed in the appendix, these errors are corrected. To obtain the originally published simulation results for cervical dilation, three parameter values had to be adjusted, see Table 1.

On closer inspection, it was also found that the value of the parameter AFR₅₀ of 7.9 mU/min in [2] was incorrectly assigned to P₆, which is a concentration in mU/mL. In semi-steady state it can be derived from Eqs. (2, 3) of the original paper that the updated value listed in Table 1 corresponds to the concentration in steady state on an infusion of magnitude AFR₅₀ for the given pharmacokinetic parameters P₃ and P₄. The evolution of drug mass over time is given by the pharmacokinetic equation, Eq. (4) of the original paper. In semi-steady state, drug mass is proportional to infusion rate. This value is assigned to m (0) in Table 1. Simulation results for cervical dilation using corrected code and adjusted numerical values match the results presented in the original paper in good approximation. The conceptual model and all presented model equations stood up to this additional scrutiny.

The original article can be found online at https://doi.org/10.1186/s41077-018-0068-3.

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Table 1 Original and updated model parameters. See [1] for a detailed description of the individual parameters and references to numerical values

	original value	updated value	units
P ₁	0.740		mU/min
P ₂	50.0	1.70	mU/(min cm)
P ₃	0.0693		1/min
P_4	18,700		mL
P ₅	0.500		1/min
P ₆	7.90	0.00610	mU/mL
P ₇	1.11		dimensionless
P ₈	40.0		mm Hg
P ₉	40.0		mm Hg
P ₁₀	1.00×10^{-3}		cm/min
P ₁₁	1.90×10^{-2}	4.00×10^{-4}	cm/mm Hg
m(0)	273	59.0	mU
d(0)	2.0		cm

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Appendix

Corrected and verified Matlab code

	;		
888			888
		de implementation	666
	Cervical d	ilation model	**
888			888
888		Willem van Meurs	66
888		Consultant	888
888		Dec. 2020	666
888			રુ સ સ
%%% Verified by Lex	van Loon	and Hans Zwart Jan. 2021	888
%%% and by Silvano	Gefferie	April 2021	888
		-	888
*****		*****	68888
8			
<pre>% Algorithm implici % Symbols as in Gef</pre>			
\$ \${\$;	\$	68888
8			
clear			
8			
% DEFINITION OF SIM	ULATION T	IME	
ę			
% t=(n-1)*T Discre %	ete time n	also serves as Matlab vect	or ind
tmin=0.0;	% min		
tmax=1050.0;	% min		
T=1;		ation step size (min)	
N=round((tmax-tmin)	/T)+1;		
<pre>for n=1:N</pre>			
t(n) = (n-1) *T;			
end			
8			
<pre>% NUMERICAL VALUES %</pre>	MODEL PAR	AMETERS	
P1=0.740;	∛ mU/min		
P2=1.70;	≈ mU/(mi	n cm)	
P3=0.0693;	% 1/min		
P4=18700;	% mL		
P5=0.500;	% 1/min		
P6=0.00610;	% mU/mL		
P7=1.11;	% dimens	ionless	
P8=40.0;	% mm Hq		
P9=40.0;	% mm Hq		
P10=1.00*10^-3;	% cm/min		
P11=4.00*10^-4;	% cm/mm		
- %		2	
% STATE VARIABLE IN	ITIALIZAT	ION	
8			
m=59.0;	% mU		
d=2.00;	% cm		
% %			
% RUN-TIME EQUATION	IS		
%			
for n=1:N			
r=P1+P2*d;			
	r;	% m(n+1)	
nm=(1-P3*T)*m+T* c=m/P4;	r;	% m(n+1)	
nm=(1-P3*T)*m+T* c=m/P4;			
nm=(1-P3*T)*m+T* c=m/P4; s=c^P7/(P6^P7+c'		% m(n+1) % sigmoid	
nm=(1-P3*T)*m+T* c=m/P4; s=c^P7/(P6^P7+c^ f=P5*s;			
nm=(1-P3*T)*m+T* c=m/P4; s=c^P7/(P6^P7+c^ f=P5*s; a=P8+P9*s;	P7);	% sigmoid	
<pre>nm=(1-P3*T)*m+T* c=m/P4; s=c^P7/(P6^P7+c^ f=P5*s; a=P8+P9*s; nd=d+T*(P10+P11*</pre>	P7); f*a);	<pre>% sigmoid % d(n+1)</pre>	
<pre>nm=(1-P3*T)*m+T* c=m/P4; s=c^P7/(P6^P7+c' f=P5*s; a=P8+P9*s; nd=d+T*(P10+P11* if nd>10.0</pre>	P7); f*a);	% sigmoid	
<pre>nm=(1-P3*T)*m+T* c=m/P4; s=c^P7/(P6^P7+c' f=P5*s; a=P8+P9*s; nd=d+T*(P10+P11* if nd>10.0 nd=10.0;</pre>	P7); f*a);	<pre>% sigmoid % d(n+1)</pre>	
<pre>nm=(1-P3*T)*m+T* c=m/P4; s=c^P7/(P6^P7+c' f=P5*s; a=P8+P9*s; nd=d+T*(P10+P11* if nd>10.0 nd=10.0; end</pre>	P7); f*a);	<pre>% sigmoid % d(n+1)</pre>	
<pre>nm=(1-P3*T)*m+T* c=m/P4; s=c^P7/(P6^P7+c' f=P5*s; a=P8+P9*s; nd=d+T*(P10+P11* if nd>10.0</pre>	P7); f*a);	<pre>% sigmoid % d(n+1)</pre>	
<pre>nm=(1-P3*T)*m+T* c=m/P4; s=c^P7/(P6^P7+c' f=P5*s; a=P8+P9*s; nd=d+T*(P10+P11* if nd>10.0</pre>	P7); f*a);	<pre>% sigmoid % d(n+1)</pre>	
<pre>nm=(1-P3*T) *m+T* c=m/P4; s=c^P7/(P6^P7+c' f=P5*s; a=P8+P9*s; nd=d4T*(P10+P11* if nd>10.0 nd=10.0; end output(n)=d; m=nm; d=nd;</pre>	P7); f*a);	<pre>% sigmoid % d(n+1)</pre>	
<pre>nm=(1-P3*T) *m+T* c=m/P4; s=c^P7/(P6^P7+c' f=P5*s; a=P8+P9*s; nd=d+T*(P10+P11* if nd>10.0 nd=10.0; end output(n)=d; m=nm; d=nd; end</pre>	P7); f*a);	<pre>% sigmoid % d(n+1)</pre>	
<pre>nm=(1-P3*T)*m+T* c=m/P4; s=c^P7/(E6^P7+c' f=P5*s; a=P8+P9*s; nd=d+T*(P10+P11* if nd>10.0 nd=10.0; end output(n)=d; m=nm; d=nd; end %</pre>	P7); f*a);	<pre>% sigmoid % d(n+1)</pre>	
<pre>nm=(1-P3*T) *m+T* c=m/P4; s=c^P7/(P6^P7+c' f=P5*s; a=P8+P9*s; nd=d+T*(P10+P11* if nd>10.0 nd=10.0; end output(n)=d; m=nm; d=nd; end % GRAPHICAL OUTPUT</pre>	P7); f*a);	<pre>% sigmoid % d(n+1)</pre>	
<pre>nm=(1-P3*T)*m+T* c=m/P4; s=c^P7/(P6^P7+c' f=P5*s; a=P8+P9*s; nd=d+T*(P10+P11* if nd>10.0; end output(n)=d; m=nm; d=nd; end % GRAPHICAL OUTPUT %</pre>	P7); f*a);	<pre>% sigmoid % d(n+1)</pre>	
<pre>nm=(1-P3*T)*m+T* c=m/P4; s=c^P7/(E6^P7+c' f=P5*s; a=P8+P9*s; nd=d+T*(P10+P11* if nd>10.0 nd=10.0; end output(n)=d; m=nm; d=nd; end % GRAPHICAL OUTPUT % figure(1)</pre>	P7); f*a);	<pre>% sigmoid % d(n+1)</pre>	
<pre>nm=(1-P3*T) *m+T* c=m/P4; s=c^P7/(P6^P7+c' f=P5*s; a=P8+P9*s; nd=d+T*(P10+P11* if nd>10.0 nd=10.0; end output(n)=d; m=nm; d=nd; end % GRAPHICAL OUTPUT % figure(1) plot(t,output)</pre>	P7); f*a);	<pre>% sigmoid % d(n+1)</pre>	
<pre>nm=(1-P3*T) *m+T' c=m/P4; s=c^P7/(P6^P7+c' f=P5*s; a=P8+P9*s; nd=d+T*(P10+P11* if nd>10.0</pre>	P7); f*a);	<pre>% sigmoid % d(n+1)</pre>	
<pre>nm=(1-P3*T) *m+T' c=m/P4; s=c^P7/(P6^P7+c' f=P5*s; a=P8+P9*s; nd=d+T*(P10+P11' if nd>10.0 md=10.0; end output(n)=d; m=nn; d=nd; end % % GRAPHICAL OUTPUT % figure(1) plot(t,output) axis([tmin tmax 2 1] grid on</pre>	P7); f*a); 0])	<pre>% sigmoid % d(n+1)</pre>	
<pre>nm=(1-P3*T) *m+T' c=m/P4; s=c^P7/(P6^P7+c' f=P5*s; a=P8+P9*s; nd=d+T*(P10+P11* if nd>10.0</pre>	<pre>P7); f*a); 0])</pre>	<pre>% sigmoid % d(n+1)</pre>	

Acknowledgements

The authors thank Eva Kleinveld and Lex van Loon for their help in identifying and correcting the programming errors.

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Published online: 01 October 2021

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