

Gas Man derived compartmental vs Lerou physiological model for Desflurane

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Introduction

Hendrickx et al derived a classical three compartmental model with two covariate, cardiac output and body weight, from the physiological uptake model used by the Gas Man program (Med Man Simulations, Inc., Chestnut Hill, MA) [1].

We tested the predictive performance of the derived compartmental model vs the Lerou physiological model used by AnestAssist program (Palma Healthcare Systems LLC).

Methods

For the simulations we used the model covariates weight (Wt) and fixed cardiac output (CO) at 5 l/min (not usually clinically available), the ventilation in volume controlled mod with tidal volume (Vt), respiratory rate (RR), fresh gas flow (FGF), as ventilator settings, and vaporizer sevoflurane concentration (FD) as model inputs. Outputs of the model simulations are sevoflurane inspiratory (Fi), end-tidal (Fet) and effect site, brain, concentration (Fb).

For the compartmental model we calculated the inspiratory concentration (Fi) :
 $Fi = Fet + (FD - Fet) * FGF / (Vt * RR)$
 and the uptake (Ut) :
 $Ut = (Fi - Fet) * (Vt * RR)$

For calculation of the brain sevoflurane concentrations we added an effect site compartment with a $ke0 = 0.61 \text{ min}^{-1}$ to the compartmental model (Rehberg et al).

We run 1 hour simulations for a virtual 70kg patient, $Vt = 600 \text{ cc}$, $RR = 10 \text{ breath/min}$.

Washin, maintenance and washout Fet and Fb concentrations resulted for 3 different scenarios (S).

S1 : FGF=6l/min, FD=6% time=0 to 45min than FD=0% ;

S2 : FGF=2l/min, FD=6% time=0 to 45min than FD=0% ;

S3: FGF=6l/min FD=6% time=0 to 15 and FD=0% time=45 to 60 and FGF=2l/min FD=6% time=16 to 44min.

Results

High Fresh Gas Flow Scenario (S1)

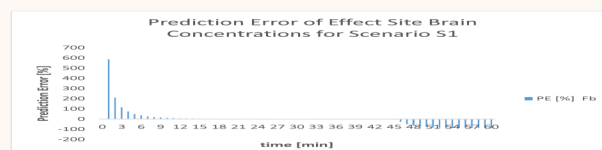
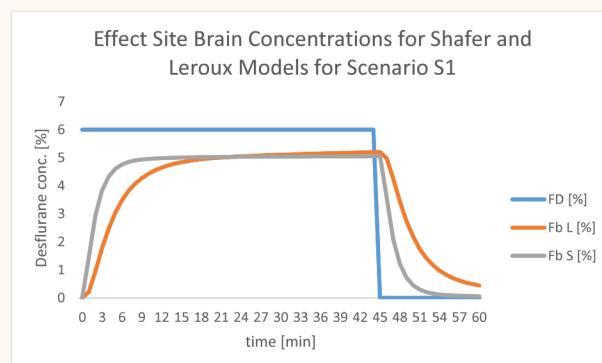


Fig.1 Calculated desflurane effect site concentrations for Shafer (FbS), Leroux (FbL) at set vapor concentrations (FD) and the prediction error (PE) for Scenario S1.

Low Fresh Gas Flow Scenario (S2)

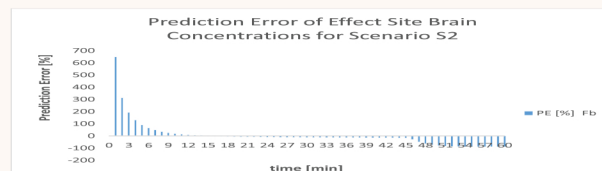
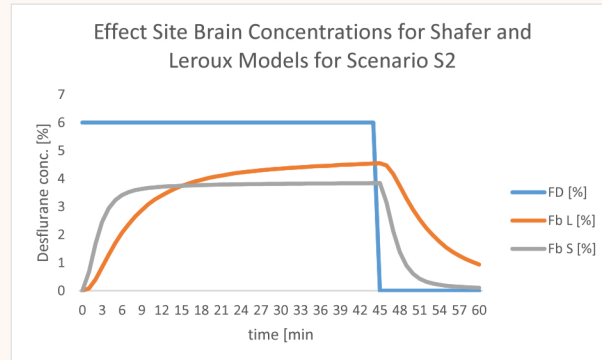


Fig.2 Calculated desflurane effect site concentrations for Shafer (FbS), Leroux (FbL) at set vapor concentrations (FD) and the prediction error (PE) for Scenario S2

High/Low/High Fresh Gas Flow Scenario (S3)

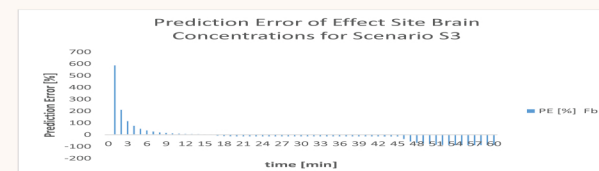
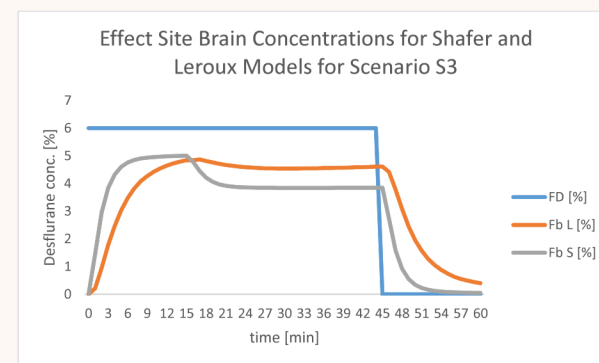


Fig.3 Calculated desflurane effect site concentrations for Shafer (FbS), Leroux (FbL) at set vapor concentrations (FD) and the prediction error (PE) for Scenario S3

We calculated the median prediction error (MPE) and median absolute prediction error (MAPE), as a measure for bias and accuracy, respectively, for the end tidal and brain concentrations, of the compartmental model vs the Lerou physiological model as reference.[2] (Table 1).

	Fet MDPE [%]	Fet MDAPE [%]	Fb MDPE [%]	Fb MDAPE [%]
Table 1				
Simulation 1				
Overall	-2	3	5	3
Washin	8	8	18	18
Maintenance	-2	2	-1	2
Washout	-87	87	-87	87
Simulation 2				
Overall	-13	15	4	15
Washin	13	13	31	31
Maintenance	-13	13	-13	13
Washout	-88	87	-87	87
Simulation 3				
Overall	-16	16	5	16
Washin	8	8	18	18
Maintenance	-16	16	-16	16
Washout	-89	88	-88	88

Conclusions

It appeared that it was a good estimation of the end tidal and brain desflurane concentrations of the compartmental vs the physiological model overall with an accuracy of <16%, negative bias for Fet and positive for Fb. However during washin it reached 13% for Fet and 31% for Fb with a positive bias and during washout 88% for Fet and Fb with a negative bias. The accuracy decreased with decreased FGF and more FD changes.

The acceptable approximation of the end tidal concentrations by the Gas Man derived compartmental model compared to the Lerou physiological model, that was previously clinically validated, is promising to its use in the study of volatile anesthetic agents.

References

- 1 Hendrickx et al. BMC Anesthesiology 2006, 6:7
- 2 Varvel et al. J Pharmacokinetic Biopharm 1992;20:63-94