In this paper, a new method is presented that combines mechanical compliance effects with Poiseuille flow and push-out effects (“dead volume”) in one single mathematical framework for calculating dosing errors in multi-infusion set-ups” Konings et al (2017).

Abstract:

BACKGROUND: In this paper, a new method is presented that combines mechanical compliance effects with Poiseuille flow and push-out effects (“dead volume”) in one single mathematical framework for calculating dosing errors in multi-infusion set-ups. In contrast to existing numerical methods, our method produces explicit expressions that illustrate the mathematical dependencies of the dosing errors on hardware parameters and pump flow rate settings.

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METHODS: Our new approach uses the Z-transform to model the contents of the catheter, and after implementation in Mathematica (Wolfram), explicit expressions are produced automatically. Consistency of the resulting analytical expressions has been examined for limiting cases, and three types of in-vitro measurements have been performed to obtain a first experimental test of the validity of the theoretical results.

RESULTS: The relative contribution of various factors affecting the dosing errors, such as the Poiseuille flow profile, resistance and internal volume of the catheter, mechanical compliance of the syringes and the various pump flow rate settings, can now be discerned clearly in the structure of the expressions generated by our method. The in-vitro experiments showed a standard deviation between theory and experiment of 14% for the delay time in the catheter, and of 13% for the time duration of the dosing error bolus.

CONCLUSIONS: Our method provides insight and predictability in a large range of possible situations involving many variables and dependencies, which is potentially very useful for e.g. the development of a fast, bed-side tool ("calculator") that provides the clinician with a precise prediction of dosing errors and delay times interactively for many scenario's. The interactive nature of such a device has now been made feasible by the fact that, using our method, explicit expressions are available for these situations, as opposed to conventional time-consuming numerical simulations.

Full Text

Reference:

Konings, M.K., Snijder, R.A., Radermacher, J.H. and Timmerman, A.M. (2017) Analytical method for calculation of deviations from intended dosages during multi-infusion. Biomedical Engineering Online. 16(1), p.18.

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