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Physiological modeling of trace gas exhalation kinetics: a non-invasive window to the body

Exhaled breath contains a plethora of volatile organic compounds (VOCs), resulting from normal metabolic activity as well as from specific pathological disorders. These trace gases can be detected and quantified at concentrations down to the parts-per-billion (ppb) level and hold great promise for medical diagnosis, therapeutic monitoring, and general assessments of physiological function. In particular, exhaled breath can nowadays be measured *on-line*, thus rendering VOC analysis as an optimal choice for gaining continuous and *non-invasive* information on the current metabolic and physiological state of an individual.

The success of using breath VOC concentration profiles for estimating endogenous processes will mainly hinge on the availability of valid mechanistic descriptions for the observable exhalation kinetics of the compound under scrutiny. Within this context, we focus on *real-time* measurements of VOCs during distinct physiological states, e.g., rest, exercise, and sleep [1,2].

An experimental setup for correlating breath-by-breath analyses using proton transfer reaction mass spectrometry (PTR-MS) with the behavior of major hemodynamic and respiratory variables will be presented. Building on the phenomenological findings from studies of normal volunteers, a novel compartmental modeling framework capturing the physiological flow of two prototypic VOCs, isoprene and acetone, is developed and validated [3,4].

Furthermore, several powerful concepts for system and parameter identification will be outlined, including qualitative system analysis, *a priori* identifiability, and numerical schemes based on multiple shooting.

The results discussed are intended as a first step towards employing breath gas analysis as a tool for examining exhalation, storage, transport, and biotransformation processes associated with volatile organic compounds *in vivo*.

References

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