Catheter DT20190930

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This document describes models for describing the arterial input function (AIF) in vivo.

1. INTRODUCTION

The arterial input function (AIF) provides the boundary conditions for tracer kinetic problems. The boundaries are Gaussian surfaces across which tracers migrate by fluid mechanics and satisfy continuity equations. In general, the AIF cannot be directly measured for arbitrary volumes such as anatomical structures in vivo. The most common direct measurement obtains from cannulation and automated sampling of the radial artery. The cannulating catheters introduce additional delays and dispersions which require correction. There are also delays and dispersion that are discrepant between the AIF measured at the radial artery and AIFs which describe the internal carotid artery, basilar artery or distal arterioles. Consequently, a model of the AIF is always necessary. The classes *Catheter* in this package provide such models.

All source codes, testing codes, documentation and ancillary data are available at `https://github.com/jjleewustledu/mlswisstrace`. All Matlab codes are packaged as `mlswisstrace` unless indicated otherwise.

2. MATERIALS AND METHODS

Function `calibrateCatheter2` from class `TwiliteCatheterCalibration` describes how tabulated measurements, including bench-top hematocrit measurements, were passed to class `CatheterModel2` to estimate dispersion and delay characteristics of the catheter apparatus.

The phantom is shown in Figure 1. The catheter assembly is schematically described in Figure 2. Impulse-response trials comprised switching the inflow needle from the unlabelled reservoir to the ^{18}FDG-labelled reservoir with the most rapid possible manual switching so that the labelled impulse lasted 120.0 seconds. The impulse duration was much shorter than the half-life of ^{18}FDG and no attempt was made to adjust for tracer radiodecay.

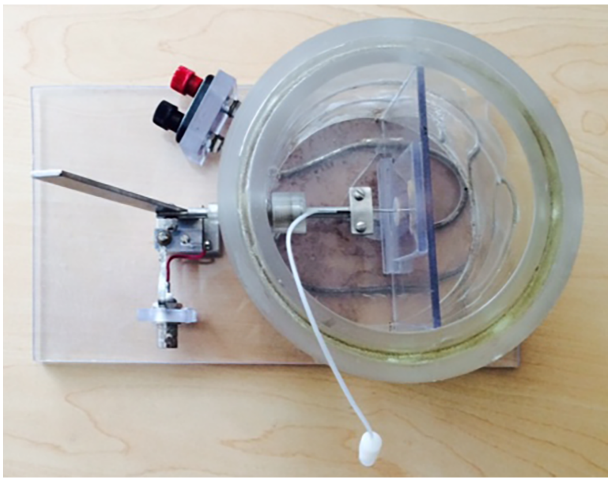

FIG. 1: Phantom courtesy of Abraham Z. Snyder. Following assembly with proximal extensions and valves, the estimated volume from blood supply to the edge of the Twilite detection zone was 1.50 mL.

3. DATA AND RESULTS

The final model comprised a generalized gamma distribution with polynomial adjustment and additional linear adjustments for fractional hematocrit:

$$K(t) \sim (t-t_0)^{\alpha} e^{-\beta(t-t_0)^p} \left[1 + \frac{w(t-t_0)}{1+wt_0}\right] \tag{1}$$

$$\alpha = 0.72507\,\mathrm{Hct} - 0.13201 \tag{2}$$

$$\beta = 0.59645\,\mathrm{Hct} + 0.69005 \tag{3}$$

$$p = -0.14628\,\mathrm{Hct} + 0.58306 \tag{4}$$

$$w = 0.040413\,\mathrm{Hct} + 1.2229 \tag{5}$$

$$t_0 = 9.87 \tag{6}$$

$$K(t) := \frac{K(t)}{\int dt' K(t')} \tag{7}$$

with $K(t) := 0$ for $t < t_0$.

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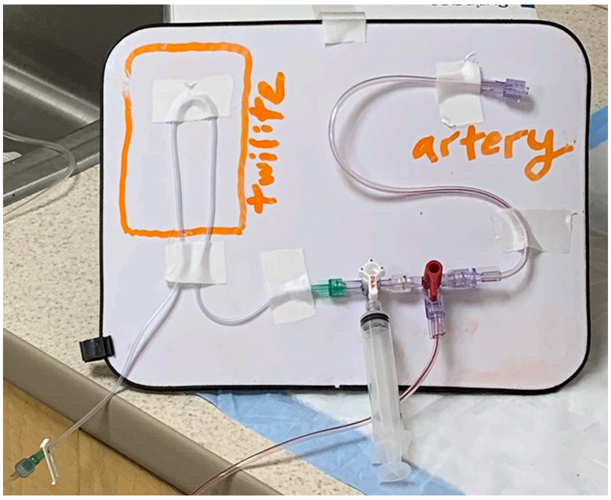

FIG. 2: The proximal extension and valves with 1.348 ml interior volume were packaged as pressure monitoring set REF C-PMS-2502-15-3.5 and REF G07943 (Cook Inc., Bloomington, IN). The microbore extension set had priming volume 0.642 mL and was packaged as REF V5424 (B. Braun Medical Inc., Bethlehem, PA). The Twilite probehead enclosed 20 cm (0.3 mL) of the microbore extension distal to 3 cm (0.04 mL) of tubing slack.

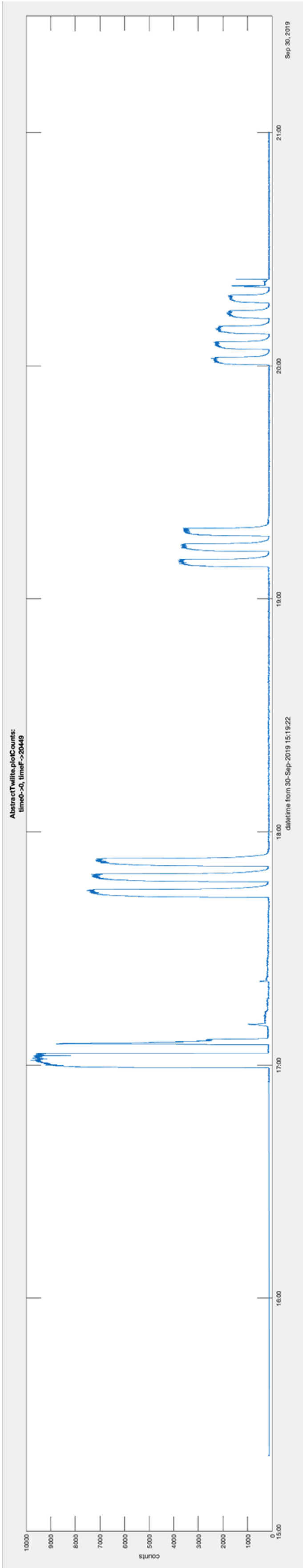

FIG. 3: Figures can be rotated using the angle command, see the TeX file for details. If a figure is to be placed after the main text use the “figure*” option to make it extend over two columns, see the LaTeX file for how this was done.

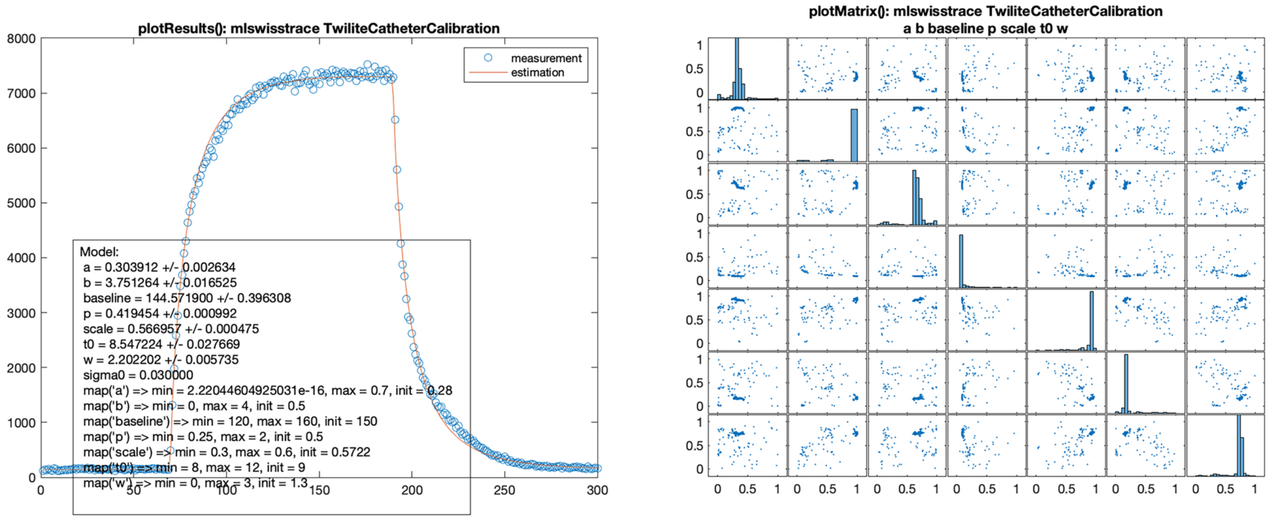

FIG. 4: Left panel shows emissions, model fit and best parameters. Right panel shows the covariance of distributions. Similar results were obtained for each of the trials of impulse-response.