**Computational modelling of cardiac control following myocardial infarction using an *in silico* patient cohort**

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# Model Parameters

*We would like to emphasize that many of these parameter values are from source material and are provided here for the readers’ convenience.*1–4 *Interested readers are recommended to review this paper for a detailed description of the model.* The model, created in the SIMULINK (R2023b) platform and associated MATLAB (R2023b) code are available on GitHub (https://github.com/Daniel-Baugh-Institute/CardiovascularControl/tree/main/Virtual\_patient\_cohorts).

1. S.1 Hemodynamic variables

|  |  |
| --- | --- |
| **Model parameters** | **Corresponding physiological parameter** |
|  | Intravascular pressure |
|  | Unstressed volume |
|  | Blood flow |
|  | Compliance |
|  | Inertance |
|  | Resistances |
|  | Flow out of right ventricle |
|  | Flow out of left ventricle |

Extended model parameter values for basal (healthy) state

1. S.2 Hemodynamic parameter values (vascular system)

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | **Reference** |
| Compliances (mL/mmHg) | | |
|  | 0.28 | 2 |
|  | 2.05 | 2 |
|  | 1.36 | 5 |
|  | 0.31 | 5 |
|  | 43.11 | 5 |
|  | 28.40 | 5 |
|  | 6.60 | 5 |
|  | 33 | 5 |
|  | 0.76 | 2 |
|  | 5.80 | 2 |
|  | 25.37 | 2 |
| Unstressed Volumes (mL) | | |
|  | 0 | 2 |
|  | 274.40 | 2 |
|  | 274.1 | 5 |
|  | 62.50 | 5 |
| \* | 1121 | 2 |
| \* | 1120 | 5 |
| \* | 255 | 5 |
| \* | 0 | 4 |
| \* | 0 | 2 |
| \* | 123 | 2 |
| \* | 120 | 2 |
| Hydraulic Resistances (mmHg\*s\*mL-1) | | |
|  | 0.06 | 2 |
| \* | 3.307 | 2 |
| \* | 1.725 | 5 |
| \* | 4.130 | 5 |
|  | 0.038 | 2 |
|  | 0.0197 | 5 |
|  | 0.0848 | 5 |
|  | 0.0054 | 5 |
|  | 0.0230 | 2 |
|  | 0.0894 | 2 |
|  | 0.0056 | 2 |
| Inertance (mmHg\*ml\*s-2) | | |
|  | 2.2e-4 | 2 |
|  | 1.8e-4 | 2 |

1. S.3 Hemodynamic parameters (left heart)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 19.23 | mL/mmHg | 2 |
|  | 25 | mL | 2 |
|  | 2.5e-3 | mmHg\*s\*mL-1 | 2 |
|  | 1.5 | mmHg | 2 |
|  | 0.014 | mL-1 | 2 |
|  | 16.77 | mL | 2 |
|  | 1.283 | mmHg/mL | 1 |
|  | 3.75e-4 | s/mL | 2 |

1. S.4 Activation function parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 0.075 | sec2 | 2 |
|  | 0.40 | sec | 2 |

1. S.5 Hemodynamic parameters (right heart)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 31.25 | mL/mmHg | 2 |
|  | 25 | mL | 2 |
|  | 2.5e-3 | mmHg\*s\*mL-1 | 2 |
|  | 1.5 | mmHg | 2 |
|  | 0.0110 | mL-1 | 2 |
|  | 40.8 | mL | 2 |
|  | 0.7570 | mmHg/mL | 1 |
|  | 1.4e-3 | s/mL | 2 |

1. S.6 Afferent input parameters (baroreceptors)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 92 | mmHg | 2 |
|  | 2.52 | Hz | 2 |
|  | 47.78 | Hz | 2 |
|  | 11.758\*\* | mmHg | 5 |
|  | 6.37 | sec | 2 |
|  | 2.076 | Sec | 2 |

1. S.7 Afferent input parameters (cardiopulmonary receptors)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 10.80 | mmHg | 5 |
|  | 20 | Hz | 2 |
|  | 1.43 | mmHg | 5 |
|  | 2 | sec | 5 |

1. S.8 Afferent input parameters (lung stretch receptors)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 23.291 | ν | 5 |
|  | 0.5 | sec | 5 |

1. S.9 Afferent firing frequency gains (to heart)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 1 | -- | 2 |
|  | 1.541 | -- | 1+ |
|  | 2 | -- | 5 |

+ Note: is multiplied by a gain factor of -1 in the Simulink model indicating the “inhibiting” effect lung stretch receptors have on the heart.

1. S.10 Afferent firing frequency gains (to peripheral circulation)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 1 | -- | 2 |
|  | 0.33 | -- | 3 |
|  | 2.5 | -- | 5 |

1. S.11 Afferent firing frequency gains (to unstressed volumes)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 1 | -- | 2 |
|  | 0 | -- | 5 |
|  | 0 | -- | 5 |

1. S.12 Efferent sympathetic outflow parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 16.11 | Hz | 2 |
|  | 2.1 | Hz | 2 |
|  | 2.66 | Hz | 2 |
|  | 0.0675 | Sec | 2 |

1. S.13 Effector function regulation (gains)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 0.695 | mmHg\*mL-1\*ν-1 | 2 |
|  | 0.653 | mmHg\*mL-1\*ν-1 | 2 |
|  | 2.81 | mmHg\*mL-1\*ν-1 | 5 |
|  | -265.4 | mL/ν | 2 |
|  | -107.5 | mL/ν | 5 |
|  | -25 | mL/ν | 5 |
|  | -0.13 | ν | 2 |
|  | 0.09 | ν | 2 |
|  | 0.103 | mmHg\*mL-1\*ν-1 | 1 |
|  | 0.205 | mmHg\*mL-1\*ν-1 | 1 |

Where ν = spikes/s (i.e. Hz)

1. S.14 Effector function (time constants)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 2 | sec | 2 |
|  | 2 | sec | 2 |
|  | 2 | sec | 5 |
|  | 5 | sec | 2 |
|  | 5 | sec | 5 |
|  | 5 | sec | 5 |
|  | 2 | sec | 2 |
|  | 0.2 | sec | 2 |
|  | 2 | sec | 1 |
|  | 0.2 | sec | 1 |

1. S.15 Effector function (constants)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 2.49 | mmHg\*s\*mL-1 | 2 |
|  | 0.78 | mmHg\*s\*mL-1 | 2 |
|  | 4.13 | mmHg\*s\*mL-1 | 5 |
|  | 1435.4 | mL | 2 |
|  | 1247 | mL | 5 |
|  | 290 | mL | 4 |
|  | 0.58 | sec | 2 |

1. S.16 Basal-Respiration

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 1.6 | sec | 4 |
|  | 4.0 | sec | 4 |
|  | 1.4 | sec | 4 |
|  | -9 | mmHg | 5 |
|  | -4 | mmHg | 5 |

**Parasympathetic (vagal) outflow**

1. S.17 Neuronal subtype parameters (baroreceptor-input subtype)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 0.30 | Hz | 1 |
|  | 21.50 | Hz | 1 |
|  | 37.07 | Hz | 1 |
|  | 21.00 | Hz | 1 |

1. S.18 Neuronal subtype parameters (cardiopulmonary receptor-input subtype)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 0.45\*\*\* | Hz | 1 |
|  | 28.33\*\*\* | Hz | 1 |
|  | 10.20\*\*\* | Hz | 1 |
|  | 7.00 | Hz | 1 |

1. S.19 Neuronal subtype parameters (lung-stretch receptor input subtype)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 2.75 | Hz | 1 |
|  | 31.57 | Hz | 1 |
|  | 11.13 | Hz | 1 |
|  | 2.00 | Hz | 1 |

Table S.20 Nucleus ambiguus neuronal population parameters (heart rate)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 4.88 | Hz | 1 |
|  | 15.78 | Hz | 1 |
|  | 59.83 | Hz | 1 |
|  | 23.00 | Hz | 1 |

1. S.21 Nucleus ambiguus neuronal population parameters (contractility)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 0.61 | Hz | 1 |
|  | 11.00 | Hz | 1 |
|  | 12.81 | Hz | 1 |
|  | 7.00 | Hz | 1 |

1. S.22 Dorsal motor nucleus neuronal population (contractility)

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 2.59 | Hz | 1 |
|  | 6.66 | Hz | 1 |
|  | 42.91 | Hz | 1 |
|  | 33.5 | Hz | 1 |

1. S.23 NTS subtype gains to NA and DMV

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 1.0 | -- | 1 |
|  | 1.0 | -- | 1 |
|  | 1.0 | -- | 1 |
|  | 0.0 | -- | 1 |
|  | 1.0 | -- | 1 |
|  | 1.0 | -- | 1 |

1. S.24 Respiratory sinus arrhythmia gating

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 0.5 | -- | Estimated |

1. S.25 RR interval elongation due to vagal firing

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 2.0 | -- | Estimated5 |
|  | 1.9 | -- | Estimated5 |
|  | 0.01 | -- | Estimated5 |
|  | 0.07 | -- | Estimated5 |
|  | 0.3 | -- | Estimated5 |
|  | 0.3 | -- | Estimated5 |
|  | 0.6 | -- | Estimated5 |

1. S.26 Principal neurons that receive nucleus ambiguus inputs neuronal population

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 1.69 | Hz | Estimated |
|  | 7.33 | Hz | Estimated |
|  | 13.81 | Hz | Estimated |
|  | 3.23 | Hz | Estimated |

1. S.27 Principal neurons that receive dorsal motor nucleus inputs neuronal population

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 2.42 | Hz | Estimated |
|  | 17.72 | Hz | Estimated |
|  | 14.18 | Hz | Estimated |
|  | 13.36 | Hz | Estimated |
|  | 0.3 | s | Estimated6 |

1. S.28 Local circuit neurons

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | **Units** | **Reference** |
|  | 1.99 | Hz | Estimated |
|  | 18.38 | Hz | Estimated |
|  | 521.22 | Hz | Estimated |
|  | 3.00 | Hz | Estimated |
|  | 2.66 | -- | Estimated |
|  | 5.64 | -- | Estimated |
|  | 0.07 | -- | Estimated |
|  | 3.33 | -- | Estimated |

\* These parameter values can also be calculated from the model equations.

\*\* This parameter value was corrected from Park et al. (2020) after cross-checking with Table 1 and Equation (A7) in Magosso et al. (2002).1,7

\*\*\* Alternate parameter values used in Park et al. (2020).1 As explained in the main text, the model is highly non-linear and the available experimental data are measurements of overall cardiac function and electrophysiological behavior in response to a stimulus. Thus, the use of multiple sigmoidal functions to represent the dynamic behavior of neuronal subpopulations raises the possibility of over-parametrization. Therefore, several distinct sets of parameter values could produce similar predicted cardiovascular system behaviors. In fact, previous experiments analyzing transcriptomic profiles of single neurons in the brainstem and ICN have shown that neurons exist in multiple functional states that may be described by these distinct sets of parameter values.8,9 Thus, these parameter values are an alternative set of parameter values identified in Park et al. (2020) that describe a plausible functional state of the neuronal group.1

# References

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