

Supplementary Information for the manuscript:

“Evaluation of Fluid Resuscitation Control Algorithms via a Hardware-in-the-Loop Test Bed”

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- **Blood Pressure (BP) Waveform Generator**

The BP waveform is generated (Box B in Fig. 1) by adjusting a template BP pulse from a single cardiac cycle. The template pulse is normalized to 1000 samples length and 0 to 1 height. The pulse pressure (PP), diastolic pressure (P_{Dias}), and pulse-pulse interval (PP-Int) can then be set for each beat to scale the pulse to the current values. However, for this work, PP was fixed at 40 mmHg and P_{Dias} was initially set as the first MAP value output from the computational patient model minus one-third PP. MAP of the waveform was set by adjusting the offset of the waveform by the current value output from the computational patient model. P_{Dias} was then set as the previous value. To prevent step changes in the pressure waveform, differences between the previous and current value of P_{Dias} were linearly distributed over the tail of the pressure pulse [$Pulse(n) = Pulse(n) + ((P_{Dias}(M) - P_{Dias}(M-1))/400) \times Pulse(n)$, where n are the pulse shape samples from 601 to 1000 and M is the current pulse]. PP-Int was set from the current heart rate value and the pulse was linearly interpolated to match the length of the current interval.

- **Individual RMSE values for all three comparisons (i.e., HIL vs. in silico, HIL vs. in vivo, and in silico vs. in vivo)**

Table 1 Root mean square of error (RMSE) for hemodynamic measurements between the HIL system and in vivo data for individual subjects

Subject	BV (L)	CO (L/min)	MAP (mmHg)
1	0.07	0.46	9.05
2	0.09	1.41	16.95
3	0.06	0.85	6.68
4	0.06	0.48	5.52
5	0.05	0.47	6.78
6	0.09	0.39	6.02
7	0.07	0.48	9.61
8	0.15	0.56	9.74
9	0.11	0.44	9.31
Mean (SD)	0.08 (0.03)	0.62 (0.33)	8.85 (3.45)
Mean % (SD %)	4.29 % (2.08 %)	16.17 % (6.76 %)	11.57 % (3.69%)

Table 2 Root mean square of error (RMSE) for hemodynamic measurements between the HIL system and in silico data for individual subjects

Subject	BV (L)	CO (L/min)	MAP (mmHg)
1	0.03	0.25	3.57
2	0.06	1.04	12.63
3	0.01	0.13	1.47
4	0.01	0.03	0.12
5	0.03	0.11	0.57
6	0.03	0.11	0.97
7	0.01	0.39	4.33
8	0.06	0.31	4.56
9	0.05	0.21	1.20
Mean (SD)	0.03 (0.02)	0.28 (0.30)	3.27 (3.88)
Mean % (SD %)	1.72 % (1.34 %)	7.36 % (7.1 %)	4.12 % (4.64%)

Table 3 Root mean square of error (RMSE) for hemodynamic measurements between in silico and in vivo data for individual subjects

Subject	BV (L)	CO (L/min)	MAP (mmHg)
1	0.05	0.45	8.72
2	0.07	0.81	10.42
3	0.06	0.85	6.64
4	0.06	0.47	5.48
5	0.05	0.41	6.65
6	0.08	0.42	5.90
7	0.07	0.51	7.02
8	0.10	0.43	7.57
9	0.08	0.29	8.54
Mean (SD)	0.07 (0.02)	0.52 (0.19)	7.44 (1.56)
Mean % (SD %)	3.50 % (1.21 %)	13.51 % (3.22 %)	9.82 % (1.47%)

- Total amount of fluid infusion from PID and rule-based controller for each subject

Table 4 Total amount of fluid infused by the controllers for individual subjects

	PID (mL)	Rule-Based (mL)
Subject 1	687	403
Subject 2	384	260
Subject 3	1581	1103
Subject 4	1484	695
Subject 5	1177	842
Subject 6	1410	846
Subject 7	1423	892
Subject 8	889	378
Subject 9	399	261

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- Six different blood pressure artifact models added to the waveform

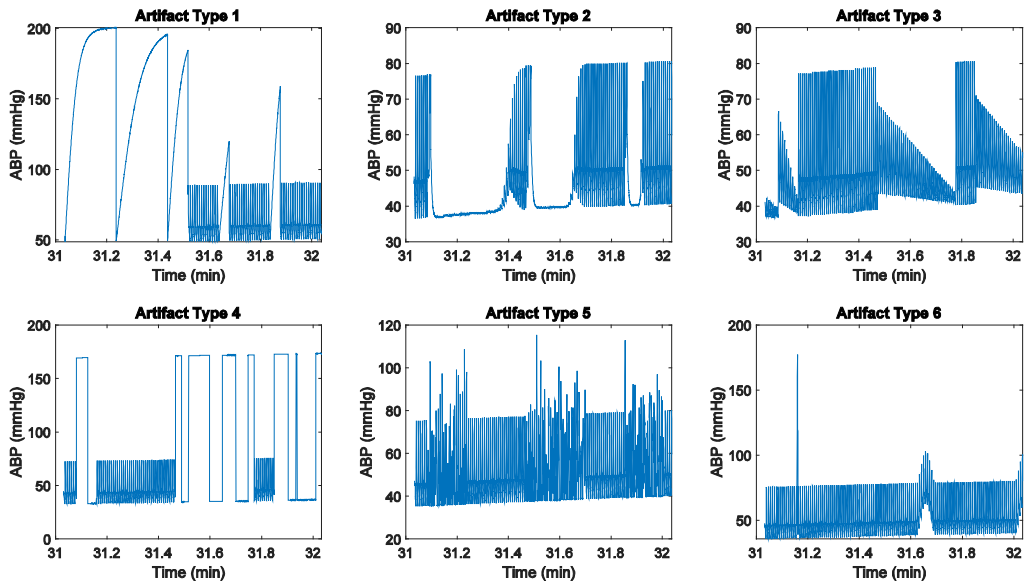


Figure 1 Arterial blood pressure combined with separate artifacts: Type 1: rapid saturation to some maximal BP (ExpBPmax), Type 2: rapid saturation to some BP minimum (ExpBPmin), Type 3: rapid saturation to the current mean BP (LinearAtt), Type 4: high amplitude square wave artifact (Square), Type 5: high frequency noise (HighFreq) and Type 6: highly transient impulse-like artifact (Sinc).

- Infusion and MAP responses for all experiments (in presence of different types of BP artifacts)

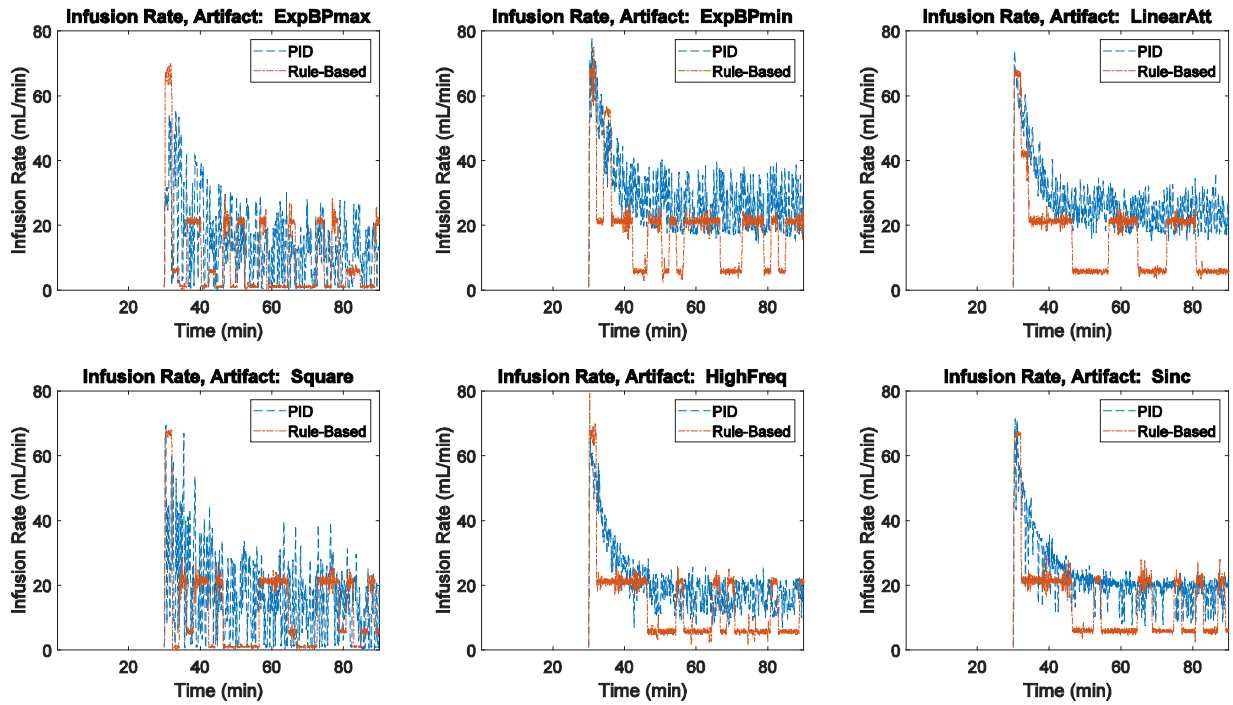


Figure 2 Infusion rate of controllers for different types of BP artifacts: ExpBPmax, ExpBPmin, LinearAtt, Square, HighFreq, and Sinc

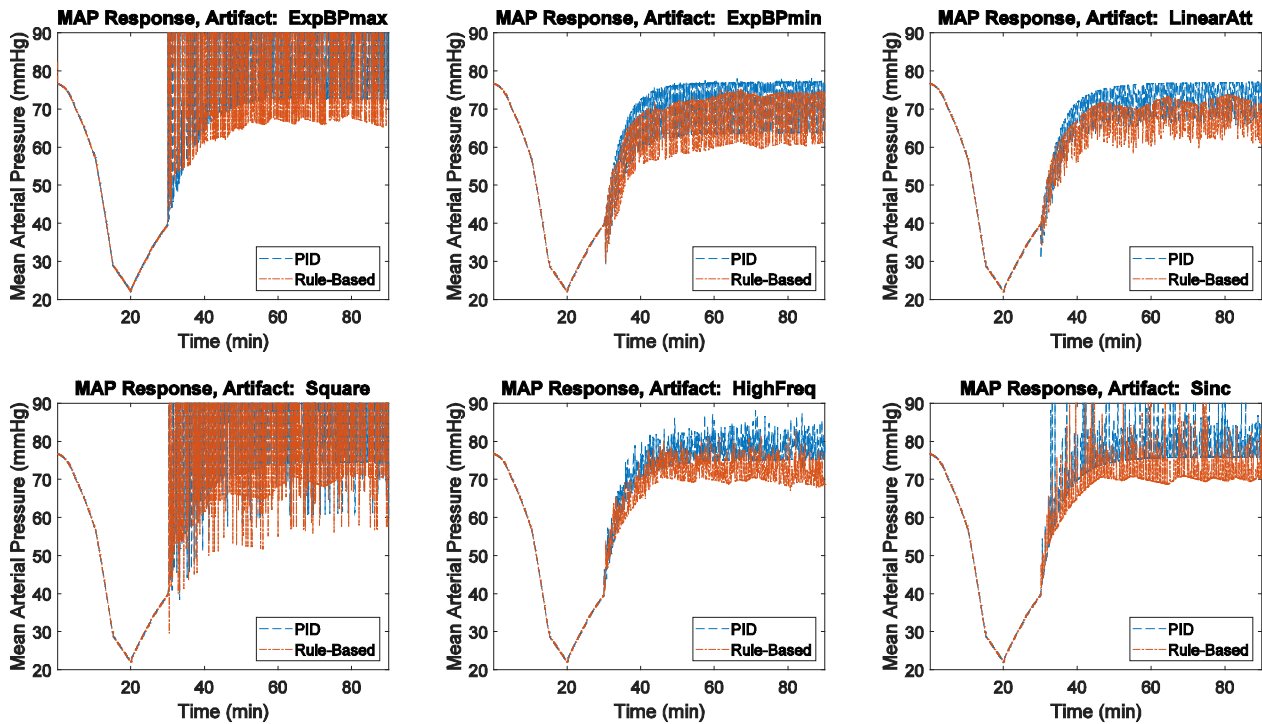


Figure 3 MAP response of controllers for different types of BP artifacts: ExpBPmax, ExpBPmin, LinearAtt, Square, HighFreq, and Sinc

