

# CLOSED LOOP VS. ANESTHESIOLOGIST FLUID ADMINISTRATION DURING SIMULATED MASSIVE HEMORRHAGE USING STROKE VOLUME, HEART RATE, AND MEAN ARTERIAL PRESSURE

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**Background:** In a previous publication (1) closed-loop fluid management was studied in-silico using pulse-pressure variation (PPV) as a monitored system output. One limitation of this work was the fact that both the simulator and controller utilized the same PPV dataset, creating a possible bias. Additionally, PPV cannot be used in all patients, so a system dependent on PPV would be limited in scope. In this study, we compared the performance of a group of anesthesia providers in managing a simulated hemorrhage to closed-loop (LIR™) fluid-management using stroke volume (SV), heart rate (HR), and mean-arterial pressure (MAP) alone.

**Methods:** Using a simulator previously described elsewhere (1), a 90-minute simulated hemorrhage protocol was run which included a 1200mL blood loss over 30 minutes. Twenty practicing anesthesiology providers (residents and faculty) were asked to manage this scenario by providing fluids and vasopressor medication at their discretion (group 1). The simulation program was also run twenty times with the closed-loop algorithm managing fluids (group 2) and an additional twenty times with no intervention (group 3).

**Results:** Simulated patient weight, height, HR, MAP, and CO were similar at baseline. The closed-loop group received slightly more fluid than the anesthesiologist group. The mean SV, MAP, CO, and final CO was higher in the closed-loop group than in the practitioners group, and the variance was lower

**Discussion:** Despite the roughly similar volumes of fluid given, the closed-loop outperformed the practitioners primarily because the fluid was given earlier in the protocol and SV optimized before the hemorrhage began, whereas practitioners tended to resuscitate well but only after significant hemodynamic change indicated the need. Overall, these data support the usability of this algorithm in clinical settings where PPV is not available or applicable.

**Table 1: Fluid Management: Practitioners vs. Closed-Loop (LIR™)**

	Group		
	(1) Anesthesiologist Managed	(2) Closed-loop Managed	(3) No Management
<b>Total Fluid Given (mL)</b>	1907 ± 366	2172 ± 323*	0 ± 0**
<b>Mean arterial pressure (mmHg)</b>	77.3 ± 7.9	86.2 ± 1.1*	57.0 ± 25.8**
<b>Heart rate (beats per minute)</b>	86.2 ± 15.6	75.6 ± 3.8*	141.4 ± 53.2**
<b>Mean SV (mL)</b>	47.9 ± 17.2	76.2 ± 5.6*	31.4 ± 26.9**
<b>Mean CO (L/min)</b>	3.9 ± 1.2	5.7 ± 0.2*	3.1 ± 2.1**
<b>Final CO (L/min)</b>	4.3 ± 1.1	5.8 ± 0.8*	0.8 ± 0.1**

Data are reported as mean ± standard deviation. \* P<0.05 compared to group 1; \*\*P<0.05 compared to groups 1&2.

## References

1. Rinehart, J., et al., Evaluation of a novel closed-loop fluid administration system based on dynamic predictors of fluid responsiveness: an in-silico simulation study. Crit Care, 2011. 15(6): p. R278.