

CLOSED LOOP VS. ANESTHESIOLOGIST MANAGEMENT OF SIMULATED MASSIVE HEMORRHAGE

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Background: Dynamic predictors of fluid responsiveness like pulse pressure variation have made automated management of fluid resuscitation feasible. We present simulation data for a novel closed-loop fluid-management algorithm using pulse pressure variation (PPV) as the input variable. The performance of the closed loop was compared to the performance of anesthesiologists in managing a simulated hemorrhage.

Methods: Using a simulator which includes a PPV output, twenty practicing anesthesiology residents and faculty were asked to manage fluids and pressors for a one-hour simulated hemorrhage case of 2L blood loss over 20 minutes (group 1). One week later, they repeated the simulation, but this time fluids were secretly managed by the closed-loop system while practitioner fluid administrations were ignored and only the pressors were entered (group 2). The simulation was also run twenty times with only the closed-loop (group 3) and twenty times with no management (group 4).

Results: Simulated patient weight, height, heart rate (HR), mean arterial pressure (MAP), and cardiac output (CO) were similar at baseline. Once the hemorrhage began, the closed loop groups (2&3) intervened significantly earlier than the practitioners (group 1) and gave more fluid. The mean and final CO was higher in both closed-loop groups than in the practitioners group, and the coefficient of variance was lower. There was no difference in MAP between intervention groups, but all were significantly higher than the unmanaged group.

Conclusion: Our data demonstrate that closed-loop management of fluid resuscitation is feasible using our novel dynamic-parameter based algorithm and that this approach can be used to optimize cardiac output.

Table 1: Fluid Management: Practitioners vs. Closed-Loop

Group	(1) Anesthesiologist Managed	(2) Anesthesiologist Managed Pressors, Closed-loop Fluids	(3) Closed-loop Managed	(4) No Management
First Bolus (minutes)	21.5 ±5.6*	15.6 ±1.1	16.0 ±1.3	-
Total Fluid Given (ml)	1968 ±644*	2875 ±275	2675 ±244	-
Mean Arterial Pressure (mmHg)	76 ±4.2	79 ±2.0	79 ±1.1	61 ±6.9
Mean Cardiac Output During Case (L/min)	5.2 ±0.6*	5.8 ±0.2**	5.9 ±0.2**	3.8 ±0.4
Final Cardiac Output (L/min)	4.8 ±1.5*	5.6 ±0.5**	5.7 ±0.4**	1.7 ±0.9
Cardiac Output During Case, Coefficient of Variation (%)	36.7 ±23*	16.6 ±9**	16.3 ±8**	89 ±29

Data are reported as mean +/- standard deviation. * $p < 0.05$ vs. groups 2,3, and 4. ** $p < 0.05$ vs. groups 1 & 4.