CLOSED-LOOP MANAGEMENT OF FLUID ADMINISTRATION USING DYNAMIC PREDICTORS OF FLUID RESPONSIVENESS

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Introduction: Closed-loop management has been successfully demonstrated for many clinical applications but has been limited in fluid resuscitation due to the absence of reliable predictors of fluid responsiveness. We present simulation data for a novel closed-loop fluid-management algorithm using pulse pressure variation (PPV) as the input variable.

Methods: Using a software simulator which includes an idealized PPV output, three groups of simulations were run using a random set of baseline variables for each run. These baseline variables included weight, height, and hemodynamic parameters. The groups were massive hemorrhage (2,000 ml of blood loss over 20 minutes), steady hemorrhage (1,500 ml over 1.5 hours), and small hemorrhage (500 ml over 1.5 hours). For each group two sets of simulations were performed: twenty were run without the closed-loop, and twenty with the closed-loop algorithm managing fluid resuscitation. Both groups received a 120ml/hour baseline infusion of lactated ringers.

Results: Conditions across all groups were similar at baseline. In the massive and steady hemorrhage groups, there was a significant difference between the control and the closed-loop managed sets in heart rate, mean arterial pressure, and cardiac output throughout the case and at the end of the simulation (Table 1). There was no significant difference between sets in the small hemorrhage group. The closed-loop usually administered fluid before clinical evidence of hemorrhage was apparent.

Discussion: The data from this study demonstrate that our novel algorithm functions well in an idealized testing environment. Future studies will focus on comparison of the algorithm to human management and then animal studies.

Table 1: Final hemodynamic parameters in simulated hemorrhage groups between the no intervention set and the Closed-loop managed set.

	No Intervention (n=20)	Closed-Loop Management (n=20)	p-Value*
Massive Hemorrhage			
Fluid Given (ml)	300 ± 0	1869 ± 50	
HR (bpm)	141 ± 29	72 ± 9	< 0.001
MAP (mmHg)	59 ± 26	91 ± 6	<0.001
CO (l/min)	3.2 ± 1.8	6.7 ± 0.9	<0.001
Moderate Hemorrhage			
Fluid Given (ml)	300 ± 0	1543 ± 54	
HR (bpm)	119 ± 32	73 ± 9	< 0.001
MAP (mmHg)	76 ± 10	88 ± 7	<0.005
CO (l/min)	5.0 ± 1.1	6.9 ± 0.8	<0.001
Slow Hemorrhage			
Fluid Given (ml)	300 ± 0	653 ± 44	
HR (bpm)	77 ± 10	72 ± 9	0.08
MAP (mmHg)	85 ± 7	87 ± 8.8	0.30
CO (l/min)	6.6 ± 1.0	6.5 ± 1.0	0.73

Data are presented as mean ± SD. HR = heart rate, MAP = mean arterial pressure, CO = cardiac output.