

Automated Titration of Vasopressor Infusion

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Background: Automated titration of vasoactive medications is not a novel concept, but it may be a concept that is due for reexamination for intensive care unit settings. Blood pressure management in critical care often requires a vasopressor support that is usually hand titrated by a bedside provider in response to clinical need. Hypotension risks ischemia due to inadequate perfusion pressure, while high drip rates risk ischemia of the viscera and digits. Even a simple self-titrating system could provide significant clinical benefit over hand titration in terms of provider workload and infusion accuracy.

Methods: We developed an automated infusion controller using a PID closed-loop which informs a rules-based decision engine. The controller is “allowed” to titrate infusion rate within preset guardrails (upper and lower limits). The objective of the controller is not tight continuous control, but rather loose adaptivity that is nevertheless better than hand titration that might occur every 30 to 60 minutes in practice. The controller was experimented with using a previously developed hemodynamic simulator. The controller was set to manage mean arterial pressure (MAP) in two settings: 1) Steady MAP from 40-80, in which the simulated patient was stable and had no hemodynamic perturbations; 2) Highly variable MAP, in which the simulated patient was wildly unstable and fluctuated at random. Both scenarios were also run without management as “controls”. Each simulation also had a random ‘infusion delay’ set from 5 to 60 seconds to simulate lag time from tubing length.

Results: 250 trials were run in each of the four conditions. In the steady MAP condition, the MAP in the unmanaged group was 56.2 ± 9.3 , and patients spent 79% of case time outside of the target MAP zone of 65-75. In the managed group, MAP was 70.8 ± 4.4 and patients spent 9.4% of case time outside of the target range. In the variable MAP condition, the unmanaged group had an MAP of 56.2 ± 12.2 and spent 80% of case time outside of target range. The managed group had an MAP of 71.2 ± 6 and spent 29% of time outside of the target range.

Conclusion: This initial feasibility study showed that our hybrid controller is capable of managing a vasopressor infusion to control blood pressure. The data is currently being reviewed to better understand the limitations of the controller and the conditions under which oscillations occur (present in 10% of the managed cases). Following this we plan to undertake a control-engineering approach to tuning the controller and optimizing its performance.