Tight Glycemic Control Models for Critically Ill Patients in Intensive Care Units

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Abstract

Critically ill patients often present stress-induced hyperglycemia and low insulin sensitivity [1]. Recent studies have shown that high blood glucose (BG) levels are linked to worsened patient outcomes and increased mortality [2, 3]. Tight glycemic control (TGC) aims at reducing BG levels taking into account inter-patient variability, evolving physiological patient conditions and minimizing hypoglycemic risks. Clinical protocols are used to specify insulin and nutrition rates and BG measurement time interval during control. This research compares different protocols to determine the best one to use at the CHU of Liege.

Keyword: modeling of physiological systems

1 Method

We compare three protocols: Glucontrol B, Targeted and STAR controllers. Glucontrol B is a Belgian protocol following an experimental sliding scale and aiming BG to be between 140 and 180 mg/dL. The BG measurement frequency can also vary from 1-4 hours. The Targeted and STAR controllers are adaptive, model-based predictive controllers designed for Christchurch, NZ with a BG target value of 90 mg/dL that specify hourly measurement. STAR uses a stochastic model accounting for hour-to-hour patient variability. Controller performance was tested in virtual trials using Glucontrol retrospective clinical data and the glucose-insulin model. STAR was adapted to Belgian ICU requirements to create STAR-Belgium.

2 Results

Initial results show better performance for the Targeted and STAR controllers. However, they can be aggressive increasing the risk of hypoglycemia (BG < 40 mg/dL). To improve the STAR controller, we allow the nutrition rate to be increased when BG is low and no insulin has been given, and also limit the insulin rate change per intervention. For better comparison, the target is changed to 144 mg/dL using 2 hourly measurements when the patient is glycemically stable.

The resulting controller, STAR-Belgium, has the lowest percent of hypoglycemic events and provides the tightest control around its BG target illustrated by the steeper BG CDF in Figure 1 and in Table 1.

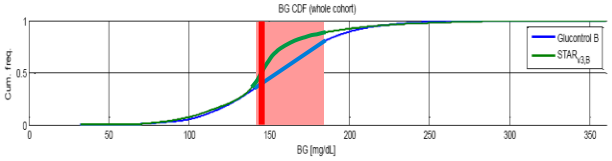

Figure 1 - Comparison of BG CDF for Glucontrol B (blue line) and STAR-Belgium (green line) controllers, for whole cohort

% BG	Glucontrol B	STAR	STAR-Belgium
< 40 mg/dL	0.054	0.062	0.020
> 180 mg/dL	24.1	6.8	12.9
in 140-180 mg/dL	42.4	8.5	50.1
in 120-160 mg/dL	39.33	67.96	58.43

Table 1 – Virtual trial results: whole cohort statistics

3 Conclusion

The STAR-Belgium controller is the best clinical protocol for TGC in this study. We have shown it is highly effective and safe. Pilot trials are currently underway to assess its control performance in real clinical conditions.

References

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