Background & Objectives

Glycaemic control (GC) to improve outcomes in intensive care patients has been proven difficult to achieve safely, yielding significant glycaemic variability and hypoglycaemia.

STAR is a model-based GC protocol using a stochastic model to forecast distributions of likely future changes in insulin sensitivity (SI), based on its current value. This is used to determine likely future blood glucose (BG) levels for a given intervention, enabling optimal dosing (Figure 1).

This study investigates a novel 3D model capable to predict likely future distribution of SI using both current SI and its prior variability (%ΔSI).

Methods

Metabolic data from 3 clinical ICU cohorts totalling 819 episodes and 68269 hours of treatment under STAR and SPRINT protocols are used in this study (Table 1).

Insulin sensitivity (SI) is hourly identified from clinical BG and insulin data. SI variability (%ΔSI) is defined as the hour-to-hour percentage change in SI:

\[ %\Delta SI = 100 \times \frac{SI_{t+1} - SI_t}{SI_t} \]

Data triplets (%ΔSI, SI_t, SI_{t+1}) are created and grouped together in bins of size %ΔSI = 10% and SI_t = 0.5e-4.

The 5th, 50th, and 95th percentile of SI_{t+1} are determined for each bin where data density is high enough (>100 triplets).

The new model is compared to the previous stochastic model by
- Comparing their 90% CI prediction range and the percentage change in their prediction widths
- Assessing their predictive power, computing median [IQR] per-patient percentage prediction of SI within the 5th-95th and 25th-75th percentile ranges of model predictions.

Results

Results show the previous model is over-conservative for %ΔSI within an absolute 25% change (Figure 2).

The percentage change in the 90% CI width in this region is reduced by ≈25-40%. Conversely, non-conservative regions are also identified, with 90% CI width increased up to ≈80% (Figure 3).

As shown in Table 2 and Figure 4, the predictive power is similar for both model (60.3% [47.8%, 71.5%] vs. 51.2 [42.9%, 59.2%]) within 25th-75th and 93.6% [85.7%, 97.3%] vs. 90.7% [84.4%, 94.6%] within 5th-95th range.

Conclusions

The new 3D model achieved similar predictive power as the previous model, while reducing the 5-95th percentile prediction range for more than 77% of the data. If the over-conservative regions allows more aggressive dosing for stable patient, under-conservative regions identify potential risks from over-aggressive treatment for more variable patients.

These outcomes improve both performance and safety, and thus patient outcomes.