

UNCERTAINTY ANALYSIS OF INSULIN DOSES FROM BOLUS CALCULATORS



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Introduction

Accurate calculation of insulin boluses is a challenge for people with diabetes (PWD), even with a hybrid closed loop artificial pancreas pump (1)(2). The objective is to quantify errors of insulin bolus calculators as a function of patient uncertainties in insulin to carb ratio (ICR), correction factor (CF) and estimated meal carbs (CHO).

$$\text{calcBolus} = \frac{\text{CHO}}{\text{ICR}} + \frac{(\text{BG}_{\text{current}} - \text{BG}_{\text{target}})}{\text{CF}}$$

where ICR, CHO and CF are patient specified.

One study(6) showed 67% meals' CHO contents were accurately counted. The estimated CHO was considered accurate if it was within 20% of an experienced clinical dietician's counting. Underestimation and overestimation of CHO result in postprandial hyperglycemia and hypoglycemia, respectively.

Whatever the method of insulin delivery, a fundamental component of training in intensive insulin therapy requires participants to be adept at handling numbers in order for them to understand the nuances of glucose monitoring and to calculate appropriate and safe insulin doses (7)

Materials and Methods

An uncertainty analysis was performed on the calculator bolus, given selected % uncertainties of input parameters CHO, ICR and CF. Doses were characterized as +/- %error = $(\text{calcBolus} - \text{idealBolus}) \times 100 / \text{idealBolus}$, where calcBolus is from the calculator and idealBolus is the dose assuming perfect ICR, CHO and CF.

$$\text{calcBolusError} = \frac{(\text{calcBolus} - \text{idealBolus}) \times 100}{\text{idealBolus}}$$

The ICR and CF inputs were initialized at 12g/U and 50mg/dL/U respectively. Meal size estimates ranged from 10 to 100g, and (BG_{current} - BG_{target}) ranged from 50 to 300mg/dL.

Errors were applied to CHO, ICR and CF in 0.05% increments. The error ranges were between +/- 10%, 20%, 30% and 40%. The bolus calculator insulin dose was calculated for all combinations of CHO, ICR, CF and BG ranges values and errors. The bolus calculator dose was compared with the ideal bolus.

Results

With ICR, CHO and CF errors set at +/-10%, 20%, and 30%, the calcBolus %error ranges were [-17%, 20%] (SD 0.17), [-32%,47%] (SD 0.13), and [-44%, 80%] (SD 0.19) respectively. See figure 1.

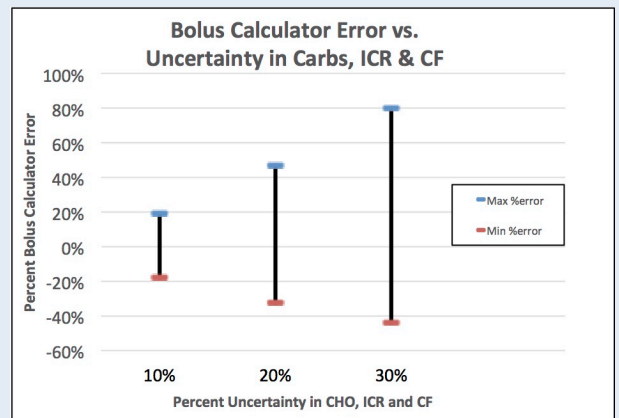


Figure 1

The maximum percentage errors occurred when CHO was the highest value(100g) and BG_{current} - BG_{target} was the smallest (50mg/dL).

A sensitivity analysis showed that for the 20% uncertainty case, when CHO, ICR and CF were individually set to zero the %error went down to [-20%,20%](SD 0.10), [-20%,24%](SD 0.10) and [-29%,44%](SD 0.11) respectively.

Therefore an accurate bolus calculator dose is more sensitive to accuracy of the meal carbs (CHO) estimate and the insulin to carbs ratio (ICR) than to the correction factor (CF).

Conclusions

More research is needed to help PWD make better estimates of CHO, ICR and CF. Auto tuning(8) of ICR and CF is a possibility.

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