Subcutaneous administration of long-acting insulin analogues are often employed in multiple daily injection (MDI) therapy of type 1 diabetes (T1D) to cover patient’s basal insulin needs. Among these, insulin glargine 100 U/mL (Gla-100) and 300 U/mL (Gla-300) are formulations indicated for once daily subcutaneous administration in MDI therapy of T1D. Some models of subcutaneous insulin absorption of insulin glargine have already been proposed but were not assessed under controlled experimental conditions for both formulations. The aim here is to develop a model of subcutaneous absorption of both Gla-100 and Gla-300 formulations in T1D.

BACKGROUND AND AIM

DATABASE & PROTOCOL

Subjects
A total of 54 T1D subjects from 2 different datasets:
- Dataset 1: N=24 (age 43±10 y, body weight 79±10 kg, BMI 25±2 kg/m²)
- Dataset 2: N=30 (age 43±10 y, body weight 79±12 kg, BMI 25±3 kg/m²)

Protocol
- Dataset 1: a randomized, 4-sequence, cross-over, double-blind, dose-response euglycaemic clamp study of single-dose subcutaneous administration of 0.4, 0.6 and 0.9 U/kg Gla-300 and 0.4 U/kg Gla-100 (NCT01195454) [1].
- Dataset 2: a randomized, cross-over, double-blind, two-treatment, two-period, two-sequence in two parallel cohorts euglycaemic clamp study after 8-day once-daily subcutaneous administration of 0.4 (cohort 1) or 0.6 (cohort 2) U/kg Gla-300 in one treatment vs. 0.4 U/kg Gla-100 in the other (NCT01349855) [2].

Plasma insulin concentrations were measured for 36 h using a validated radioimmunoassay (LLOQ: 5.02 µU/mL).

METHODS

Model:
The subcutaneous absorption of Gla-100 and Gla-300 is described as a two-compartment model coupled with a single compartment for plasma insulin kinetics [3].

Identification strategy:
- Model parameters are estimated with a Bayesian Maximum a Posteriori identification technique since the model is a non-uniquely a priori identifiable.
- Measurement error on insulin concentration is assumed to be uncorrelated, Gaussian, with zero mean and variance defined in [4], while values at insulin concentration below LLOQ are fixed to zero with infinite variance.

REFERENCES:
2. Becker R. et al., New insulin glargine 300 Units ml−1 provides a more even activity profile and prolonged glycemic control at steady state compared with insulin glargine 100 Units ml−1, Diabetes Care, 38(4): 637-643, 2015.

RESULTS

Data vs. Model prediction:

Weighted residuals:

Model parameters of subcutaneous absorption:

CONCLUSIONS

- A new model of subcutaneous insulin absorption of Gla-100 and Gla-300 is developed describing the gradual dissolution from the precipitate to soluble state for both insulin formulations.
- The model well predicts the data and provides precise parameter estimates characterizing the different rates of subcutaneous absorption into plasma between Gla-100 and Gla-300 formulations.
- The model will be then incorporated into the UVA/Padova T1D Simulator together with the joint parameter distribution. This will open the door to perform in silico clinical trials for testing novel up-titration and insulin glargine switching rules.

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