Useful Pharmacokinetic Equations

Symbols

D = dose
τ = dosing interval
CL = clearance
Vd = volume of distribution
k = elimination rate constant
k_a = absorption rate constant
F = fraction absorbed (bioavailability)
R_0 = infusion rate
T = duration of infusion

General

Elimination rate constant

$$k = \frac{CL}{Vd} = \frac{\ln\left(\frac{C_1}{C_2}\right)}{\left(t_2 - t_1\right)} = \frac{\ln C_1 - \ln C_2}{\left(t_2 - t_1\right)}$$

Half-life

$$t_{1/2} = \frac{0.693 \cdot Vd}{CL} = \frac{\ln(2)}{k} = \frac{0.693}{k}$$

Ideal Body Weight

$$IBW\left[kg\right] = 50_{males}\left(45_{females}\right) + 2.3 \cdot \left(inches > 60\right)$$

Creatinine Clearance [ml/min]

$$CL_{Creatinine} = \frac{\left(140 - age\left[years\right]\right) \cdot weight\left[kg\right]}{72_{males}(85_{females}) \cdot C_{Creatinine}\left[mg/dl\right]}$$

Intravenous bolus

Initial concentration

$$C_0 = \frac{D}{Vd}$$

Plasma concentration (single dose)

$$C = C_0 \cdot e^{-k \cdot t}$$

Plasma concentration (multiple dose)

$$C = \frac{C_0 \cdot e^{-k \cdot t}}{\left(1 - e^{-k \cdot \tau}\right)}$$

Peak (multiple dose)

$$C_{\max} = \frac{C_0}{\left(1 - e^{-k \cdot \tau}\right)}$$

Trough (multiple dose)

$$C_{\min} = \frac{C_0 \cdot e^{-k \cdot \tau}}{\left(1 - e^{-k \cdot \tau}\right)}$$

Average concentration (steady state)

$$\overline{C} = \frac{D}{CL \cdot \tau}$$

Loading Dose

$$LD = C \cdot Vd$$

Maintenance Dose

$$MD = C \cdot CL \cdot \tau$$

Oral administration

Plasma concentration (single dose)

$$C = \frac{F \cdot D \cdot k_a}{\left(k_a - k\right) \cdot Vd} \cdot \left(e^{-k \cdot t} - e^{-k_a \cdot t}\right)$$

Time of maximum concentration (single dose)

$$t_{\max} = \frac{\ln\left(\frac{k_a}{k}\right)}{\left(k_a - k\right)}$$

Plasma concentration (multiple dose)

$$C = \frac{F \cdot D \cdot k_a}{\left(k_a - k\right) \cdot Vd} \cdot \left(\frac{e^{-k \cdot t}}{\left(1 - e^{-k \cdot \tau}\right)} - \frac{e^{-k_a \cdot t}}{\left(1 - e^{-k_a \cdot \tau}\right)}\right)$$

Time of maximum concentration (multiple dose)

$$t_{\max} = \frac{\ln\left(\frac{k_a \cdot \left(1 - e^{-k \cdot \tau}\right)}{k \cdot \left(1 - e^{-k_a \cdot \tau}\right)}\right)}{\left(k_a - k\right)}$$

Average concentration (steady state)

$$\overline{C} = \frac{F \cdot D}{CL \cdot \tau}$$

Constant rate infusion

Plasma concentration (during infusion)

$$C = \frac{R_0}{CL} \cdot \left(1 - e^{-k \cdot t}\right)$$

Plasma concentration (steady state)

$$C = \frac{R_0}{CL}$$

Calculated clearance (Chiou equation)

$$CL = \frac{2 \cdot R_0}{\left(C_1 + C_2\right)} + \frac{2 \cdot Vd \cdot \left(C_1 - C_2\right)}{\left(C_1 + C_2\right) \cdot \left(t_2 - t_1\right)}$$

Short-term infusion

Peak (single dose)

$$C_{\max(1)} = \frac{D}{CL \cdot T} \cdot \left(1 - e^{-k \cdot T}\right)$$

Trough (single dose)

$$C_{\min(1)} = C_{\max(1)} \cdot e^{-k \cdot \left(\tau - T\right)}$$

Peak (multiple dose)

$$C_{\max} = \frac{D}{CL \cdot T} \cdot \frac{\left(1 - e^{-k \cdot T}\right)}{\left(1 - e^{-k \cdot \tau}\right)}$$

Trough (multiple dose)

$$C_{\min} = C_{\max} \cdot e^{-k \cdot \left(\tau - T\right)}$$

Calculated elimination rate constant

$$k = \frac{\ln\left(\frac{C^*_{\max}}{C^*_{\min}}\right)}{\Delta t}$$

with C_{max}^* = measured peak and C_{min}^* = measured trough,
measured over the time interval Δt

Calculated peak

$$C_{\max} = \frac{C^*_{\max}}{e^{-k \cdot t^*}}$$

with C_{max}^* = measured peak, measured at time t^* after the end of the infusion

Calculated trough

$$C_{\min} = C^*_{\min} \cdot e^{-k \cdot t^*}$$

with C_{min}^* = measured trough, measured at time t^* before the start of the next infusion

Calculated volume of distribution

$$Vd = \frac{D}{k \cdot T} \cdot \frac{\left(1 - e^{-k \cdot T}\right)}{\left(C_{\max} - C_{\min} \cdot e^{-k \cdot T}\right)}$$

Calculated recommended dosing interval

$$\tau = \frac{\ln\left(\frac{C_{\max(desired)}}{C_{\min(desired)}}\right)}{k} + T$$

Calculated recommended dose

$$D = C_{\max(desired)} \cdot k \cdot Vd \cdot T \cdot \frac{\left(1 - e^{-k \cdot \tau}\right)}{\left(1 - e^{-k \cdot T}\right)}$$

Physiological models

$$CL = \frac{f_u \cdot CL_{\text{int}} \cdot Q}{f_u \cdot CL_{\text{int}} + Q} = Q \cdot E$$

$$Vd = V_B + \frac{f_u}{f_{u,T}} \cdot V_T$$