

Useful Pharmacokinetic Equations

Symbols

D = dose
 τ = dosing interval
CL = clearance
Vd = volume of distribution
 k_e = elimination rate constant
 k_a = absorption rate constant
F = fraction absorbed (bioavailability)
 K_0 = infusion rate
T = duration of infusion
C = plasma concentration

General

Elimination rate constant

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

Half-life

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

Intravenous bolus

Initial concentration

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

Plasma concentration (single dose)

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

Plasma concentration (multiple dose)

$$C = \frac{C_0 \cdot e^{-k_e \cdot t}}{(1 - e^{-k_e \cdot t})}$$

Peak (multiple dose)

$$C_{\max} = \frac{C_0}{(1 - e^{-k_e \cdot t})}$$

Trough (multiple dose)

$$C_{\min} = \frac{C_0 \cdot e^{-k_e \cdot t}}{(1 - e^{-k_e \cdot t})}$$

Average concentration (steady state)

$$\bar{C}_{p_{ss}} = \frac{D}{CL \cdot t}$$

Oral administration

Plasma concentration (single dose)

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

Time of maximum concentration (single dose)

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

Plasma concentration (multiple dose)

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

Time of maximum concentration (multiple dose)

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

Average concentration (steady state)

$$\bar{C} = \frac{F \cdot D}{CL \cdot t}$$

Constant rate infusion

Plasma concentration (during infusion)

$$C = \frac{k_0}{CL} \cdot (1 - e^{-k_e \cdot t})$$

Plasma concentration (steady state)

$$C = \frac{k_0}{CL}$$

Calculated clearance (Chiou equation)

$$CL = \frac{2 \cdot k_0}{(C_1 + C_2)} + \frac{2 \cdot Vd \cdot (C_1 - C_2)}{(C_1 + C_2) \cdot (t_2 - t_1)}$$

Short-term infusion

Peak (single dose)

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

Trough (single dose)

$$C_{\min(1)} = C_{\max(1)} \cdot e^{-k_e \cdot (t-T)}$$

Peak (multiple dose)

$$C_{\max} = \frac{D}{CL \cdot T} \cdot \frac{(1 - e^{-k_e \cdot T})}{(1 - e^{-k_e \cdot t})}$$

Trough (multiple dose)

$$C_{\min} = C_{\max} \cdot e^{-k_e \cdot (t-T)}$$

Calculated elimination rate constant

$$k_e = \frac{\ln\left(\frac{C_{\max}^*}{C_{\min}^*}\right)}{\Delta t}$$

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

Calculated peak

$$C_{\max}^* = \frac{C_{\max}^*}{e^{-k_e \cdot t^*}}$$

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

Calculated trough

$$C_{\min}^* = C_{\min}^* \cdot e^{-k_e \cdot t^*}$$

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

Calculated volume of distribution

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

Calculated recommended dosing interval

$$t = \frac{\ln\left(\frac{C_{\max(\text{desired})}}{C_{\min(\text{desired})}}\right)}{k_e} + T$$

Calculated recommended dose

$$D = C_{\max(\text{desired})} \cdot k_e \cdot V \cdot T \cdot \frac{(1 - e^{-k_e \cdot t})}{(1 - e^{-k_e \cdot T})}$$

Two-Compartment-Body Model

$$C = a \cdot e^{-at} + b \cdot e^{-bt}$$

$$AUC_{\infty} = a / a + b / b$$

$$Vd_{\text{area}} > Vd_{\text{ss}} > Vc$$

Creatinine Clearance

$$CL_{\text{creat}} (\text{male}) = \frac{(140 - \text{age}) \cdot \text{weight}}{72 \cdot Cp_{\text{creat}}}$$

$$CL_{\text{creat}} (\text{female}) = \frac{(140 - \text{age}) \cdot \text{weight}}{85 \cdot Cp_{\text{creat}}}$$

With weight in kg, age in years, creatinine plasma conc. in mg/dl and CL_{creat} in ml/min