Equations for Primary FRCA

Pharmacology

C: concentration
t: time

Bioavailability

$$Bioavailability = \frac{AUC_{ORAL}}{AUC_{IV}}$$

AUC: area under concentration – time curve

Exponential Function

$$\frac{dC}{dt} \propto C \quad \text{or} \quad \frac{dC}{dt} = K.C$$

$$e = 2.718 \quad \text{or} \quad \frac{1}{e} = 0.37$$

$$C = C_O.e^{-Kt}$$

(for a negative exponential relationship)
C_O is the concentration at t = 0
K: rate constant

Pharmacodynamics

D: free drug
R: unoccupied receptors
DR: drug occupied receptors
K_D: dissociation constant

$$K_D = \frac{[D][R]}{[DR]}$$

$$affinity = \frac{1}{K_D}$$

Enzyme Kinetics

$$V = \frac{V_{max}[S]}{K_m + [S]}$$

V: initial velocity
V_{max}: maximum initial velocity
K_m: concentration at which the initial velocity is half the maximal initial velocity
S: substrate

Pharmacokinetics

Cl: clearance
Vd: volume of distribution
τ: time constant
K: rate constant
D: dose

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

$$\tau = \frac{1}{K_{el}}$$

$$\tau = \frac{Vd}{Cl}$$

$$t_{\frac{1}{2}} = \tau \log_e 2$$

$$Loading\ dose = Vd.C_p$$
$$Maintenance\ dose = C_p.Cl$$

Three Compartment Model

$$C_p = A.e^{-\alpha t} + G.e^{-\gamma t} + B.e^{-\beta t}$$

A/α B/ β G/γ: kinetic constants

Physics and Measurement: Pressure & Fluids

Pressure

$$\Pr essure = \frac{force}{area}$$

$$Absolute\ pressure = gauge\ pressure + atmospheric\ pressure$$

Fluids

Q: flow
d: tube diameter
P: pressure
η: viscosity
l: length of tube
v: fluid velocity
p: density

Laminar flow. Hagen-Poiseuille Equation

$$\dot{Q} = \frac{\pi P d^4}{128 \eta l}$$

Reynolds Number

$$= \frac{vpd}{\eta}$$

Turbulent Flow

$$\dot{Q} \propto \sqrt{P}$$

$$\dot{Q} \propto \frac{1}{\sqrt{l}}$$

$$\dot{Q} \propto \frac{1}{\sqrt{p}}$$

Bernoulli's Equation

$$\frac{1}{2} pv^2 + P = K$$

P: potential energy

Physics and Measurement: Gas Laws

P: pressure V: volume T: temperature K: constant

Boyle's Law: $PV = K$

Charles' Law: $\frac{V}{T} = K$

3rd Law: $\frac{P}{T} = K$

$$\frac{PV}{T} = K$$
$$PV = nRT$$

n: number of moles
R: universal gas constant

Physics and Measurement: Electricity

V: potential difference (volts)
I: current (amps)
R: resistance (ohms)

$$V = IR$$

Power

$$Power\,(watts) = VI = I^2R$$

Charge

$$Q = amperes(A) \times \sec onds(s)$$

Q: charge (coulombs)

Capacitance

$$C = \frac{Q}{V}$$

C: capacitance (farads)

Defibrillator

$$Stored\ Energy = \frac{1}{2}CV^2 = \frac{1}{2}\mathrm{QV}$$

Resistors

Parallel: $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} \ldots$

Series: $R_T = R_1 + R_2 \ldots$

Wheatstone Bridge: $\frac{R_1}{R_2} = \frac{R_3}{R_4}$

Physics and Measurement: Other

Tension

T: tension
R: radius
P: pressure gradient

Tube: $P = \frac{T}{r}$

Sphere: $P = \frac{2T}{r}$

Work

Work done = force X distance

Unit of work= Nm

Humidity

$$Relative\ humidity = \frac{actual\ vapour\ pressure}{saturated\ vapour\ pressure}$$

Linear Function

$$y = Mx + C$$

M: gradient of a straight line
C: y axis intercept

Light

Lambert-Bouguer law

$$I = I_O e^{-ad}$$

I: transmitted light
I_O: incident light
a: extinction coefficient for the solution
d: thickness

Lambert-Beer law

$$Absorbance = \xi c d$$

ξ: molar extinction coefficient
c: molar concentration
d: thickness

Physics and Measurement: Statistics

$$Variance = SD^2 = \frac{\sum (x - \bar{x})^2}{n-1}$$

$$Standard\ Error\ of\ the\ Mean = \frac{SD}{\sqrt{n-1}}$$

SD: standard deviation

Physiology: cellular

Diffusion

$$Q = k_p \cdot \frac{A}{T} \cdot (C_1 - C_2)$$

Q: rate of diffusion
k_p: permeability constant → $permeability \propto \frac{solubility}{\sqrt{MW}}$
A: area of membrane
T: thickness of membrane

$C_1 - C_2$: concentration gradient

Total Blood Volume (V_{BL})

$$\frac{V_{PL} \times 100}{(100 - Hct)}$$

V_{PL}: volume plasma
Hct: haematocrit

Measurement of Fluid Compartments

$$volume\ of\ compartment = \frac{mass\ of\ indicator}{concentration\ in\ compartment}$$

Osmotic Pressure (van't Hoff equation)

$$\pi = RTC$$

π: osmotic pressure
R: universal gas constant
T: absolute temperature
C: osmolality (mosm/kg H_2O)

Plasma Osmolality

$$Plasma\ Osmolality\ (mosm/kg\ H_2O) = 2 \times [Na] + [glucose] + [urea]$$

Gibbs-Donnan

$$[cation]_A \times [anion]_A = [cation]_B \times [anion]_B$$

Nernst Equation

For example, sodium:

$$capillary\ wall\ potential\ (mV) = \frac{RT}{FZ_{Na}} \times \log_e \frac{[Na]_{\text{int}}}{[Na]_C}$$

R: universal gas constant
T: absolute temperature
F: Faraday constant
Z: valency
Int: interstitial   c: capillary

Starling Forces

$$Pressure\ Gradient = (P_C + \pi_{Int}) - (P_{Int} + \pi_C)$$
$$Rate\ of\ \ Filtration = K \cdot (P_C + \pi_{Int}) - (P_{Int} + \pi_C)$$

π: colloid osmotic pressure
P: hydrostatic pressure
Int: interstitial   c: capillary

Physiology: Cardiac

SV: stroke volume
CO: cardiac output
SVR: systemic vascular resistance (dynes.s/cm^5)
BP: blood pressure (mmHg)
MAP: mean arterial blood pressure
HR: heart rate
CVP: central venous pressure (mmHg)

Stroke Volume

$$SV = EDV - ESV$$
$$Ejection\ Fraction = \frac{SV}{EDV}$$

EDV: end diastolic volume
ESV: end systolic volume

Cardiac Output

$$CO = HR \times SV$$
$$Cardiac\ Index = \frac{CO}{BSA}$$

BSA: body surface area

Systemic Vascular Resistance

$$SVR = \frac{MAP - CVP}{CO} \times 80$$

Mean Arterial Blood Pressure

$$MAP - CVP = CO \times SVR$$

QT interval corrected (QT_c)

$$QT_c = \frac{QT}{\sqrt{R-R}}$$

R-R: interval between two consecutive R waves

Fick Method

$$CO = \frac{\dot{V}O_2}{(CaO_2 - CvO_2)}$$

VO_2: oxygen uptake
CaO_2: oxygen content of arterial blood
CvO_2: oxygen content of venous blood

Physiology: Respiratory

$\dot{V}$: volume of gas per unit time
V: volume of gas
D: dead space
C: content
P: pressure or partial pressure

Ventilation

$$V_T = V_A + V_D$$

$$\dot{V}_A = \frac{\dot{V}CO_2}{PACO_2} \times K$$

Bohr equation

$$\frac{V_D}{V_T} = \frac{PACO_2 - PECO_2}{PACO_2}$$

(for physiological dead space)

Alveolar Gas Equation

$$PAO_2 = PIO_2 - \frac{PACO_2}{R}$$

R: respiratory quotient → $R = \frac{\dot{V}CO_2}{\dot{V}O_2}$

Venous to Arterial Shunt

$$\frac{\dot{Q}_S}{\dot{Q}_T} = \frac{Cco_2 - Cao_2}{Cco_2 - Cvo_2}$$

Q: volume of blood per unit time
S: shunt T: total c: end capillary

Compliance

$$compliance = \frac{\Delta V}{\Delta P}$$

$$\frac{1}{C_R} = \frac{1}{C_L} + \frac{1}{C_W}$$

C_R: respiratory system compliance
C_L: lung compliance
C_W: wall compliance

Oxygen Content

$$Content\ (ml\ O_2 / g\ Hb) = (1.39 \times [Hb] \times \frac{\%sat}{100}) + (0.023 \times Po_2)$$

Po_2: partial pressure in kPa

Physiology: Other

Clearance

$$C_x = \frac{U_x V}{P_x}$$

C_x: clearance of x (ml/min)
U_x: urine concentration of x
P_x: plasma concentration of x
V: urine flow (ml/min)

pK

$$pK = -\log K$$

$$k = \frac{[H^+][A^-]}{[HA]}$$

Henderson-Hasselbach

$$pH = pK + \log \frac{[conjugate\ base]}{[acid]}$$

$$pH = pK + \log \frac{[HCO_3^-]}{[H_2CO_3]}$$

$$pH = pK + \log \frac{[HCO_3^-]}{0.23 \times Pco_2}$$

Cerebral Perfusion Pressure

$$CPP = MAP - (ICP + CVP)$$