**Respiratory**

**Alveolar Gas Equation**

\[ PA_{O_2} = FI_{O_2} \left( P_{ATM} - P_{H_2O} \right) - Pa_{CO_2} / RQ \]

- \( PA_{O_2} \) = Alveolar partial pressure of oxygen
- \( Pa_{CO_2} \) = Arterial partial pressure of CO2
- \( FI_{O_2} \) = Inspired O2
- \( P_{ATM} \) = Atmospheric pressure
- \( P_{H_2O} \) = Saturated vapor pressure
- \( RQ \) = Respiratory Quotient

**Dead Space (Bohr Equation)**

\[ \frac{V_D}{V_T} = \frac{P_{aCO_2} - P_{EO2}}{P_{aCO_2}} \]

- \( P_{aCO_2} \) = Arterial partial pressure of oxygen
- \( P_{EO2} \) = Partial pressure of CO2 from all expired gases

**Q’s**
- Respiratory Physiology: Q14
- Basic Pulmonary Physiology: Q7

**Shunt Equation**

\[ \frac{Q_{shunt}}{Q_{total}} = \frac{(Cc'_{O_2} - Ca_{O_2})}{(Cc'_{O_2} - C_{mVO_2})} \]

- \( Cc'_{O_2} \) = Post-capillary blood oxygen content (typically assumed to be the saturation of haemoglobin utilizing the PAO2 • haemoglobin concentration • 1.34)
- \( Ca_{O_2} \) = Arterial Hbsat • Hb • 1.34
- \( C_{mVO_2} \) = Mixed venous Hbsat • Hb • 1.34

**Q’s**
- Basic Pulmonary Physiology: Q17

**Ventilation/Perfusion Index (ratio)**

\[ VQI = \frac{(1 - Arterial Hbsat)}{(1 - Mixed Venous Hbsat)} \]

**Q’s**
- Basic Pulmonary Physiology: Q17

**Ohm’s Law**

Pressure Gradient = Air Flow • Airway Resistance

**Q’s**
- Basic Pulmonary Physiology: Q17
Airway Resistance for Laminar Flow (Poiseuille’s Law)

\[
\text{Laminar Flow Resistance} = \frac{(8 \cdot \text{Length} \cdot \text{Viscosity of gas})}{(\pi \cdot \text{Radius}^4)}
\]

Q’s  
Respiratory Physiology: Q7  
Basic Pulmonary Physiology: Q5

Law of LaPlace

\[
\text{Pressure} = \frac{2 \cdot \text{Wall Tension}}{\text{Radius}}
\]

Note: Wall thickness is typically not considered for alveoli

Q’s  
Basic Pulmonary Physiology: Q5

Reynold’s Number

\[
R = \frac{(\text{Velocity} \cdot \text{Density} \cdot \text{Diameter})}{\text{Viscosity}}
\]

>2000 consistent with turbulent flow

Q’s  
Respiratory Physiology: Q7  
Respiratory Physiology: Q8  
Basic Pulmonary Physiology: Q4

Time Constant

\[
\text{TC} = \text{Compliance} \cdot \text{Resistance}
\]

Q’s  
Basic Pulmonary Physiology: Q5

Static Compliance

\[
\text{Static compliance} = \frac{\text{Volume}}{\text{Pressure}} = \frac{\text{Tidal volume delivered}}{(\text{Plateau pressure} - \text{PEEP})}
\]

Q’s  
Basic Pulmonary Physiology: Q33

Dynamic Compliance

\[
\text{Dynamic compliance} = \frac{\text{Volume}}{\text{Pressure}} = \frac{\text{Tidal volume delivered}}{(\text{Peak pressure} - \text{PEEP})}
\]

Q’s  
Basic Pulmonary Physiology: Q33
Respiratory

Transpulmonary Pressure

Transpulmonary pressure  =  *Alveolar pressure – Pleural pressure*

Q’s  ICU: Advanced Cardiopulmonary: Q1

Transthoracic Pressure

Transthoracic pressure  =  *Pleural pressure – Atmospheric pressure*

Q’s  ICU: Advanced Cardiopulmonary: Q1

Predicted PaO2 by Age

Predicted PaO2  =  110-(age • 0.4)

Q’s  Special Situations: Q12  
Respiratory Physiology: Q6

Boyle’s Law

Pressure1 • Volume1  =  Pressure2 • Volume2

Q’s  Basic Cardiac Physiology: Q12
Respiratory

Henry’s Law

Partial Pressure = $k \cdot C$

$k = \text{Henry’s Law Constant}$

$C = \text{Concentration of dissolved gas}$

Ohm’s Law

Pressure = Cardiac Output $\cdot$ Resistance

Q’s

Cardiac Physiology: Q14

Henderson-Hasselbach

$pH = pK + \log[HCO_3^- (0.03 \cdot PaCO_2)]$
Cardiac

Myocardial Perfusion Pressure

MPP = Aortic diastolic pressure – LVEDP

Note: Notice that as opposed to the equation in the Respiratory Section, the equation is solved for wall tension

Q’s Cardiac Physiology: Q23

LaPlace Law

Tension = (Pressure • Radius)/(2 • Wall Thickness)

Note: Notice that as opposed to the equation in the Respiratory Section, the equation is solved for wall tension

Q’s Basic Cardiac Physiology: Q12

Poiseuille’s Law

Flow Rate = (\(\pi \cdot \text{Pressure} \cdot \text{radius}^4\))/(8 \cdot \text{viscosity} \cdot \text{length})

Note: Notice that as opposed to the equation in the Respiratory Section, the equation is solved for flow.

Q’s Basic Cardiac Physiology: Q12
**Cardiac**

### Fick Principle

\[ \text{CO} = \frac{\text{VO}_2}{(\text{CaO}_2 - \text{CmvO}_2)} \]

- \( \text{CO} \) = Cardiac Output
- \( \text{VO}_2 \) = Oxygen consumption
- \( \text{CaO}_2 \) = Arterial content of oxygen
- \( \text{CmvO}_2 \) = Mixed venous content of oxygen

### Consumption of Oxygen (not including O2 dissolved in blood for simplicity)

\[ \text{VO}_2 = \text{Hb} \cdot (\text{Sata} - \text{Satmv}) \times 1.34 \cdot \text{CO} \]

*Rearranged:*

\[ \text{Satmv} = \text{Sata} - \left[ \frac{\text{VO}_2}{(\text{Hb} \cdot 1.34 \cdot \text{CO})} \right] \]

- \( \text{CO} \) = Cardiac Output
- \( \text{VO}_2 \) = Oxygen consumption
- \( \text{Sata} \) = Arterial saturation of haemoglobin
- \( \text{Satmv} \) = Mixed venous saturation of haemoglobin
- \( \text{Hb} \) = Haemoglobin

\[ \text{Q’s} \]

- ICU Principles: Q1
- ICU Principles: Q2
- ICU Principles: Q19
Cardiac

**Arterial Content of Oxygen**

\[ \text{CaO}_2 = [\text{Hb} \cdot \text{Sata} \cdot 1.34] + 0.003 \cdot \text{PaO}_2 \]

- \( \text{Sata} \) = Arterial saturation of haemoglobin
- \( \text{PaO}_2 \) = Partial pressure of oxygen in arterial blood

**Oxygen Delivery**

\[ \text{DO}_2 = \text{CaO}_2 \cdot \text{CO} \]

- \( \text{CaO}_2 \) = Arterial content of oxygen
- \( \text{CO} \) = Cardiac Output

**Elimination of CO2**

\[ \text{VCO}_2 = \text{Hb} \times \text{Sat} \text{mCO}_2 \cdot \text{CO} \]

- \( \text{Sat} \text{mCO}_2 \) = CO2 saturation in mixed venous blood

**Oxygen Extraction Ratio**

\[ \text{ER} = \frac{\text{VO}_2}{\text{DO}_2} \]

- \( \text{VO}_2 \) = Oxygen consumption
- \( \text{DO}_2 \) = Delivery of oxygen

**Respiratory Quotient**

\[ \text{RQ} = \frac{\text{VCO}_2}{\text{VO}_2} \]

- \( \text{VCO}_2 \) = Elimination of CO2
- \( \text{VO}_2 \) = Oxygen consumption

**Cardiac Output**

\[ \text{CO} = \text{Stroke Volume} \cdot \text{Heart Rate} \]
## Cardiac

### Stroke Volume

\[ SV = \text{End-diastolic volume} - \text{End-systolic volume} \]

**Q’s** Basic Cardiac Physiology: Q29

### Pulmonary Vascular Resistance

\[ PVR = \frac{\text{PAP-Wedge}}{\text{CO}} \times 80 \]

- **PAP** = Pulmonary Arterial Mean Pressure
- **CO** = Cardiac Output

**Q’s** ICU Principles: Q6

### Cardiac Index

\[ CI = \frac{\text{CO}}{\text{BSA}} \]

- **CO** = Cardiac Output
- **BSA** = Body Surface Area

**Q’s** Basic Cardiac Physiology: Q29

### Stroke Work

\[ SW = \text{Stroke volume} \times \text{mean arterial pressure} \]

**Q’s** Basic Cardiac Physiology: Q29

### Systemic Vascular Resistance

\[ SVR = \frac{\text{MAP-CVP}}{\text{CO}} \times 80 \]

- **MAP** = Mean Arterial Pressure
- **CVP** = Central Venous Pressure
- **CO** = Cardiac output

**Q’s** Basic Cardiac Physiology: Q13
Cardiac

**Starling Equation**

\[ Q = kA \times [(P_c - P_i) + \sigma(\pi_i - \pi_c)] \]

- \( Q \) = Net Fluid Filtration
- \( k \) = Capillary Filtration Coefficient (of water)
- \( A \) = Area of the Membrane
- \( \sigma \) = Reflection Coefficient (of albumin)
- \( P_c \) = Capillary Hydrostatic Pressure
- \( P_i \) = Interstitial Hydrostatic Pressure
- \( \pi_i \) = Interstitial Colloid Osmotic Pressure
- \( \pi_c \) = Capillary Colloid Osmotic Pressure.

**Q’s**

- Basic Cardiac Physiology: Q30

**Cerebral Perfusion Pressure**

\[ \text{CPP} = \text{MAP} - \text{ICP} \]

- \( \text{MAP} \) = Mean arterial pressure
- \( \text{ICP} \) = Intracranial pressure

**Q’s**

- Clinical Neurophysiology: Q2
- Clinical Neurophysiology: Q3

**Perfusion Pressure**

\[ \text{PP} = \text{MAP} - \text{Venous Pressure} \]

**Allowable Blood Loss**

\[ \text{ABL} = \text{EBV} \times [(\text{Hb} - \text{Minimum allowable Hb})/\text{Hb}] \]

- \( \text{EBV} \) = Estimated Blood Volume
Pharmacology

It is important to understand the concepts of pharmacokinetics, but few equations need to be memorized. Memorizing complex clearance and half-life equations, accounting for peripheral compartments are very low yield...just understand the concept.

Volume of Distribution

VD = Dose / Concentration

Q’s
- Basic Pharmacology: Anesthesia Adjuncts Q1
- Basic Pharmacology: Anesthesia Adjuncts Q2
- Basic Pharmacology: Induction Agents Q12

Half Life

Half-life = Volume of distribution / Rate of clearance

Q’s
- Basic Pharmacology: Anesthesia Adjuncts Q1
- Basic Pharmacology: Anesthesia Adjuncts Q2
- Basic Pharmacology: Induction Agents Q12

Clearance

Clearance = dose / area under time concentration curve
Clearance = (Urine concentration • Urine flow) / Plasma concentration

Q’s
- Basic Pharmacology: Anesthesia Adjuncts Q1
- Basic Pharmacology: Anesthesia Adjuncts Q2
- Basic Pharmacology: Induction Agents Q12
# Pharmacology

## Opioid Conversions

<table>
<thead>
<tr>
<th>Drug</th>
<th>IV</th>
<th>Oral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphine</td>
<td>10 mg</td>
<td>30 mg</td>
</tr>
<tr>
<td>Hydromorphone</td>
<td>1.5 mg</td>
<td>7.5 mg</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>100 mcg</td>
<td>N/A</td>
</tr>
<tr>
<td>Codeine</td>
<td>N/A</td>
<td>200 mg</td>
</tr>
<tr>
<td>Hydrocodone</td>
<td>N/A</td>
<td>30 mg</td>
</tr>
<tr>
<td>Oxycodone</td>
<td>N/A</td>
<td>20-30 mg</td>
</tr>
</tbody>
</table>
Equipment

### Endotracheal Size (for children)

Size = 4 + (Age/4)

### Endotracheal Depth

Depth = 12 + (Age/2), or 3 • ETT size

Q’s Pediatrics: Q4

### Gas Tanks (E)

<table>
<thead>
<tr>
<th>Gas</th>
<th>Volume</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>625 L (US)</td>
<td>2200 psig</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>1590 L</td>
<td>745 psig</td>
</tr>
</tbody>
</table>

Q’s Equipment: Q1
Equipment: Q2
Statistics

### Incidence & Prevalence

\[ \text{Incidence} = \frac{\text{Number of occurrences}}{\text{Sum of person-time at risk}} \]

\[ \text{Prevalence} = \frac{\text{Number of cases}}{\text{Number of individuals sampled}} \]

### Measure of Effect

\[ \text{Absolute measure of effect} = \text{Rate Difference} = \frac{\text{Rate of risk exposed}}{\text{Rate of risk not exposed}} \]

\[ \text{Relative measure of effect} = \text{Rate Ratio} = \frac{\text{Rate of risk exposed}}{\text{Rate of risk not exposed}} \]
# Statistics

## Disease Screening

<table>
<thead>
<tr>
<th></th>
<th>Has Disease</th>
<th>No Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Positive Test</strong></td>
<td>True Positive (TP)</td>
<td>False Positive (FP)</td>
</tr>
<tr>
<td><strong>Negative Test</strong></td>
<td>False Negative (FN)</td>
<td>True Negative (TN)</td>
</tr>
</tbody>
</table>

\[
\text{Sensitivity} = \frac{TP}{TP + FN} \\
\text{Specificity} = \frac{TN}{TN + FP} \\
\text{Positive Predictive Value} = \frac{TP}{TP + FP} \\
\text{Negative Predictive Value} = \frac{TN}{TN + FN}
\]

Q’s
- Statistics: Q17
- Statistics: Q18
## Statistics

### Disease Screening

<table>
<thead>
<tr>
<th></th>
<th>Has Disease</th>
<th>No Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Not Exposed</td>
<td>C</td>
<td>D</td>
</tr>
</tbody>
</table>

**Odds Ratio** = \( \frac{AD}{BC} \)

**Relative Risk** = \( \frac{\frac{A}{(A+B)}}{\frac{C}{(C+D)}} \)

### Number needed to Treat

**NNT** = \( \frac{1}{ARR} \)

**ARR** = Absolute Risk Reduction = Control event rate – Experimental event rate