BMSN1601 – Anatomy

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| What is Cardiovascular System |

* Through Hemodynamics 🡪 Deeper understanding in Cardiovascular System
  + Hemodynamics = Study of Blood flow by physical methods
  + Visualization of Hemodynamics can be done by 3D MRI

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| Introduction to definition of CO, HR, SV, Q and BP |

* CO is Cardiac Output
  + Amount of blood pumped by **each ventricle** in **1 minute**
* HR is Heart Rate
  + Number of Heart beat in 1 minute
* SV is Stroke Volume
  + Volume of Blood Pumped out by **a ventricle** with each beat.
* Q is Blood Flow
  + Volume of blood flowing through a vessel, an organ or the entire circulation in each period
* BP is Blood Pressure
  + Force per unit area exerted on the wall of a blood vessel by its contained blood.
    - Like e.m.f 🡪 Provide Driving Force to the Blood
  + Unit: mmHg
  + Site of measurement: **brachial artery** (large arteries near the heart)

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| 💥 | Blood Flow is not equivalent to the Cardiac Output.  Blood Flow in the entire circulation per minute = Cardiac Output. |

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| Introduction to Blood Pressure |

* Difference in BP within vascular system 🡪 Driving force to blood 🡪 Blood Flows
  + From High Pressure to Low Pressure Area
  + Aorta (大動脈) 🡪 Arteries (動脈) 🡪 Arterioles (小動脈) 🡪 Capillaries (毛細血管)   
    🡪 Venules (小靜脈) 🡪 Veins (靜脈) 🡪 Venae Cava (大靜脈)
* Arterial Blood Pressure – Systolic Pressure
  + Arterial Pressure **during ventricular contraction**
* Arterial Blood Pressure – Diastolic Pressure
  + Arterial Pressure **during ventricular filling**
* Pulse Pressure
* Mean Arterial Pressure
  + Average arterial pressure during **a single cardiac cycle**.

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| 💦 | Examination Technique:  Systolic Pressure @ Highest Level in cardiac cycle  Diastolic Pressure @ Lowest Level in cardiac cycle |

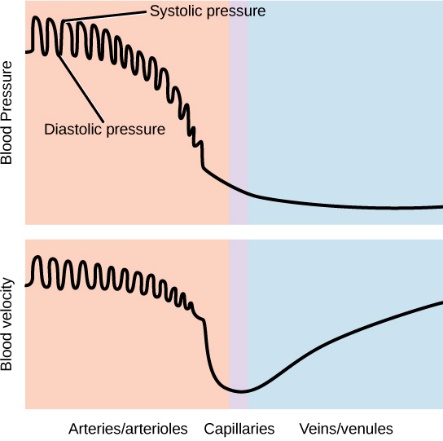
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| The Common Formula For Cardiovascular System |

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| Entire Circulation Formula: |
| #Blood circulation Formula:  #:The Formula is similar to the Ohm’s Law, where |
| Formula for velocity of Q:  \* The Formula is assume that there is no resistance in the blood vessel  \* Important Idea: Current in = Current Out, when there is no branches, the blood flow will always be the same |
| Poiseuille’s Law:  \* Regulation of blood vessel radius  \* is not subject to **significant short-term regulation**, in other word, t cannot  \* and not subject to **significant regulation** by body, where t cannot 0   |  |  | | --- | --- | | ❔ | * Do notice that the Blood Pressure decrease over the time   + From Aorta to Venae Cava * There is no change in the radius of blood vessel within the length L * Smaller the radius, Larger the Resistance, Smaller the speed.   + Do compare this relationship with the above formula , where the above formula omit the resistance. – For Detailed Information, Plz Refer to the next page | |

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| Poiseuille’s Law v.s. Q-v Formula |

* Poiseuille’s Law can only be applied when is not significant.
* Q-v Formula can only be applied when there is no resistance

*According to the Following Graph:*



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| * Do notice that the in Aorta (大動脈), Arteries (動脈) are significant.   + The formula cannot be applied because the heart keeps bumping bloods (keep doing work on the blood flow) to against the resistant.  🡪 The force acted by resistance on the blood flow is not constant (tends to zero). 🡪 The Q (Blood Flow) tends to be unchanged. 🡪 Thus, the velocity of fluid cannot be found by the Poiseuille’s Law * Q-v Formula should be applied in Aorta and Arteries, where the resistance is tends to zero due to the effect of bumping of heart. * That’s why the beginning of velocity of fluid is tends to unchanged.   **We have , Larger the radius, Lower the Velocity of Fluid.** |

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| * Do notice that the in each region of Arterioles, Capillaries and veins/venules **are not significant.** * However, it is far apart from the heart, **the resistance cannot be cancelled by the work done by heart**.   + The Resistance is significant & Lots of Branches 🡪 Thus, the **Q is not constant** and **Q-v formula cannot be applied.** * We should applied Poiseuille’s Law in those cases.   + We have: and * Region Arterioles & Capillaries   + **Smaller the Radius, Lower the Velocity of Fluid.** * Region Venules (小靜脈) ,Veins (靜脈) ,Venae Cava (大靜脈)   + **Larger the Radius, Higher the Velocity of Fluid.**   + The Blood Flow is gradually increased from Venules to Venae Cava. |

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| ❗ | There is no direct relationship between velocity of blood, blood pressure and blood flow. |

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| Blood Vessel – Laminar Flow & Turbulent Flow |

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| Laminar Flow |
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| * Requirement:   + Fluid flows in layers parallel to vessel wall   + Without disruption between layers * #Characteristic:   + **The layer of fluid in contact with the wall has lower velocity**   + **The layer of fluid that moves along the axis of the tube has maximal velocity**   #: This can be explained by the resistance act on the layer of fluid in contact with the wall |

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| Problematic: Turbulent flow | |
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| * Requirement:   + Irregular Movement * Characteristic:   + Q is decreased 🡪 Heart Need to Bump more vigorously 🡪 Great Work load   + v is decreased | |

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| Some Example to demonstrate the importance of Hemodynamics |

图示

描述已自动生成

* Hypertension / Hypotension
* Stroke
* Aneurysms 🡪 Enlargement of an artery 🡪 Thin artery wall. 🡪 Risk of Apoplexy (内出血) / Intracranial bleed (腦出血)

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| Introduction to Respiratory System |

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| Upper Tract | * **Filter & humidify incoming air** | **Nose** |
| **Pharynx** |
| Frontal Sinus |
| Sphenoidal Sinus |
| Nasal Cavity |
| Internal Nares |
| Lower Tract | * + **Delicate conduction passages**  (精緻的傳導通道)   + **Gas Exchange – Refer to Respiratory Zone** | **Larynx** |
| **Trachea** |
| **Bronchi** |
| **Lung** |
| Bronchioles |
| Diaphragm |
| Alveoli |

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| Zone in Respiratory System |

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| **Conducting Zone**   * Provide Rigid conduits for air to reach Respiratory Zone | | | | | |
| Nose | Pharynx | Frontal Sinus | Sphenoidal Sinus | Nasal Cavity | Internal Nares |
| Larynx | | Trachea | | Bronchi | |

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| **Respiratory Zone**   * Site of Gas Exchange | | | |
| Bronchioles | Alveolar Ducts | Alveoli | Alveolar Sac |

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| **Respiratory muscle**   * Promote ventilation |
| Diaphragm |

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| Terms used in Respiratory System |

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| * Respiratory System   + To supply the body with O2   + To dispose of CO2 * Pulmonary ventilation   + Movement of air into & out lungs * Transportation   + Transport of CO2 and O2: Lung & Blood | * External Respiration   + Gas Exchange (GE): lung & blood * Internal Respiration   + GE: systemic blood vessels & tissues * Inspiration (inhalation)   + Air flows into the lungs * Expiration (exhalation)   + Gases exit the lungs |

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| Gas Law & Atmospheric Pressure & Unit for Pressure |

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| * 1 mmHg = Pressure generated by a column of mercury 1mm high * Atmospheric Pressure = 760 mmHg |
| * Delton’s Law   + Formula:   + By this formula, we can calculate the partial pressure by specific gas molecule * Fick’s Law of Diffusion   + Formula:     - k: Diffusion Constant (Solubility of Gas & Temperature)     - A: Area for gas exchange     - : difference in partial pressure of gas on either side     - D: Thickness of barrier to diffusion * Boyle’s Law / Ideal Gas Law   + Formula: , where k is constant |

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| Introduction to Pressure and Respiratory System (Inhalation) |

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| 🌹 | Important Note:   * Intrapulmonary Pressure Always equalizes itself with atmospheric pressure eventually * The Surface Tension = -1 \* Intrapleural Pressure (Pressure within the pleural cavity)   + Where the surface tension is the collapsing pressure of lungs. * **Intrapulmonary Pressure is always higher than Intrapleural pressure** |

* The Diaphragm contracts (變高)  
  🡪 Thoracic cavity increase 🡪 Intrapulmonary Pressure (Pressure within alveoli) Decrease
* The Rib Cage elevation (變肥)  
  🡪 Thoracic cavity increase 🡪 Intrapulmonary Pressure Decrease
* Intrapulmonary Pressure < 1atm / 760mmHg 🡪 Air Flows in

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| Mechanism of Exhalation |

* The Diaphragm relaxes (變矮)  
  🡪 Thoracic Cavity increase 🡪 Intrapulmonary Pressure Increase
* The Rib Cage Lowering (變瘦)  
  🡪 Thoracic Cavity Increase 🡪 Intrapulmonary Pressure Increase
* Intrapulmonary Pressure > 1atm/ 760mmHg 🡪 Air Flow out.

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| Pulmonary Function Test – Spirometer |

* Spirometer: Measure the **volume & rate** of air during inhalation & exhalation

1. A hollow bell is inverted over water
2. Bell is displaced as patient breathes into a connecting mouthpiece
3. A graph is plotted on a rotating drum

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| Concept of Homeostasis |

* Homeostasis = The Maintenance of a stable **internal** environment in the body
  + Internal Environment = Surrounds each living cells in the body / ECF
    - ECF = Interstitial Fluid + Blood Plasma

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| 🥩 | ICF: Intracellular Fluid / ECF: Extracellular fluid   * Cells undergo most vital biochemical reactions in ICF. * Substances are moved between ICF and ECF.   Interstitial Fluid: Lies between the cells  Blood Plasma: Liquid Matrix of Blood |

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| Properties of the internal environment |

表格

描述已自动生成

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| Physical Properties | Blood Pressure |
| Volume of ECF / Blood |
| Body Core Temperature |
| Chemical Properties | ECF, Concentration of ions |
| pH Level of Blood |
| Blood Glucose Level |
| Blood O2 and CO2 level |

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| Summary of Function of Organ System |

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| Nervous and endocrine systems | * Regulate body functions. |
| Integumentary system | * Forms a protective boundary around the body * Regulates body temperature |
| Musculoskeletal system | * provides support and body movement * Produces blood cells (Bone marrow) |
| Circulatory / Cardiovascular system | * Distributes materials by pumping blood |
| Respiratory system | Exchanging materials between the internal and external environment:   * Oxygen & Carbon dioxide |
| Digestive system | Exchanging materials between the internal and external environment:   * Nutrients & Water |
| Urinary system | Exchanging materials between the internal and external environment:   * Water and Waste |

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| Detailed Summary of Function of Organ System |

图形用户界面, 文本, 应用程序, 电子邮件

描述已自动生成

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| Fluctuation & Imbalance of Homeostasis |

图形用户界面

描述已自动生成

* Variables stay within a narrow range at all time
* Variables may change quite significantly throughout the day.

🡪 **If these variables become higher or lower than normal range, body acts to restore them to a “set point”**

* Some disease can be caused by **Imbalance of Homeostasis**
  + *Diabetes*
  + *Hypertension or Hypotension* （高血壓、低血壓）
* The disease involve failure of more than one organ system 🡪 It can be lethal.

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| Homeostatic control system - Sensors |

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| **Sensors** |
| * Body has several sensors to monitor regulated variable  |  |  |  | | --- | --- | --- | | *Sensory Cell* | Thermoreceptor | Monitor the absolute/relative change in temperature. | | Baroreceptor | Monitor the blood pressure | | Chemoreceptors | Monitor the O2 and CO2 and Blood pH value | | Osmoreceptors | Monitor the **Osmotic pressure**   * Detect Hypertonic / Hypotonic | | *Cellular Component* | Cell surface receptors |  | | Enzymes |  |      * Then, The Sensors are sending signals to Control Center / Integrating Center |

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| Homeostatic control system – Control Center |

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| Control Center / Integrating Center |
| * The Control Center (CC) integrate **Signals from Sensors** * Then, CC use *electrical signals,**chemical signals*   (Usually both signals send to the effector 🡪 Maintain the homeostasis)   |  |  | | --- | --- | | Common Type of Chemical Signals | | | Neurotransmitter | Neuron or effector cell in close proximity to (靠近) site of neurotransmitter release | | Endocrine agent (hormone) | Target cells in distant places in the body | | Paracrine agent | Target cells in close proximity to site of release of paracrine agent | | Autocrine agent | **Autocrine agent acts on the same cell** that secreted the agent | |

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| Homeostatic control system – Effectors |

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| Effectors |
| * Effectors are the organs/tissues that determine the regulated variable   + Liver, Adipose tissue, Skeletal Muscle 🡪 Blood Glucose Level   + Kidney, Blood Vessel 🡪 Blood Volume and osmolarity |

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| Control mechanism -- Neural mechanism & [Endocrine / Neuroendocrine mechanisms] |

* Neural Mechanism
  + Sensory cells send signal to the central nervous system (CNS) via afferent neural (sensory neurons)
  + CNS send signal to effector via efferent neural (motor neurons)
  + Signal Transmitted are in the form of:
    - Neurotransmitters
    - electrical signal (action potentials 電勢 ).
* Endocrine mechanism
  + Change in regulated variable 🡪 Stimulate endocrine gland 🡪 Secrete Hormones 🡪 Circulation
    - Through Circulation, hormone reach the target cells / tissues
* Neuroendocrine Mechanism
  + Endocrine Gland Receive signal from efferent neural pathway
    - Secrete Hormones 🡪 Circulation 🡪 Hormone Reach Target Cell/ Tissues

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| ⛅ | Neural Mechanism v.s. Endocrine/Neuroendocrine Mechanism   |  |  |  |  | | --- | --- | --- | --- | |  | Speed | Specificity | Duration of Action | | Neural | Immediate response | Localized Effects | Usually very short | | Endocrine  Neuroendocrine | Slower than neural | Global Effect | Last Longer than neural | |

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| Negative Feedback Loop |