Welch Allyn
Blood Pressure Training
History, Physiology and Clinical Procedure
In This Lesson We’ll Cover:

- Terminology of Blood Pressure
- Functions of the Blood
- Arteries and Veins
- Hypo / Hypertension
- BP Measurement Technology
- History
- Non-Invasive BPM Today
- Auscultatory Method
- Oscillometric Method
- Invasive BPM Today
- Arterial
- Venous
Blood Pressure Basics

- Blood Pressure is the amount of blood pumped by the heart in relation to the size and condition of arteries.
- Measured by the force of blood on artery walls.
- Measured in millimetres of mercury (mmHg).

Factors Affecting Blood Pressure:
- Volume of water in the body.
- Salt content of the body.
- Condition of the kidneys, nervous system, and blood vessels (arteries and veins).
- Levels of various hormones in the body.
Arterial Vs. Venous Pressure

- Arteries take blood away from the heart.
- Arterial Pressure is the force exerted by the blood upon the walls of the arteries.
- Veins bring blood to the heart.
- Venous Pressure is the force exerted by the blood upon the walls of the veins.
- Blood Pressure Generally Refers to Arterial Pressure
Systole over Diastole

- BPM = Systolic Pressure over Diastolic Pressure
- 120/80 mmHg (Healthy Measurement)
- During Systolic Pressure, Ventricles Contract
- Blood Pressure is Highest During Systole
- During Diastolic Pressure, Ventricles Relax and Refill
- Blood Pressure is Lowest During Diastole

\[
\frac{120}{80} = \text{Systolic} \quad \text{Diastolic}
\]
Cardiac Cycle

- Complete Cycle of Heart Events
- Beginning of 1 Heart Beat to Beginning of Next

Systolic Pressure (SP)
- Highest Recorded Arterial Pressure Reading
- Occurs Near Beginning of Cardiac Cycle

Diastolic Pressure (DP)
- Lowest Recorded Arterial Pressure Reading
- Resting Phase of Cardiac Cycle
MAP and Pulse Pressure

- Mean Arterial Pressure (MAP)
  - Average Pressure Throughout Cardiac Cycle
  - \( \sim = DP + \frac{1}{3} (SP-DP) \)

- Pulse Pressure
  - Difference Between Maximum and Minimum Pressures Measured
  - \( = (SP-DP) \)
Summary on Part I

- Blood Pressure is the amount of blood pumped by the heart in relation to the size and condition of the arteries.
- Arteries carry blood from the heart, while veins carry blood to the heart.
- When we refer to blood pressure, we generally refer to arterial pressure.
- Blood pressure is written as systole over diastole.
- Four phases of the cardiac cycle include: Atrial Systole, Ventricular Systole, Early Diastole, Diastole
Anatomy and Physiology

- Functions of the blood
- Arteries
- Veins
- Cellular Respiration
- Hypertension
- Hypotension
Functions of the Blood

- Transports oxygen from lungs to all body cells.
- Transports all nourishment to cells, including monosaccharides, amino acids, fatty acids, glycerol, vitamins, mineral salts and water.
- Removes all waste products from tissues and cells and takes to appropriate organ for excretion or to the liver in preparation for excretion.
- Transports hormones and enzymes to target organs.
- Defends body by transporting white blood cells, antibodies and antitoxins.
- Prevents excessive loss of body fluid and cells by clotting.
- Maintains body temperature.
Blood and Plasma

Blood
- Highly Specialized Tissue
- Consisting of Several Types of Cells
- Cells are Suspended in a Fluid Medium called Plasma

Plasma
- Faintly Yellow Transparent Fluid
- 90% Water
- Floating in Plasma are Different Types of Cells
- Plasma Transports Various Dissolved Substances from One Part of the Body to Another
Floating in Plasma

**Nutrient Materials**
- Amino Acids, Glucose, Fatty Acids, Glycerol and Vitamins
- Absorbed from Digestive Tract

**Organic Waste Products**
- Urea, Uric Acid and Creatinine
- Produced by Protein Metabolism (formed in the liver and conveyed to the kidneys)

**Hormones**
- Chemical Substances Formed by Glands
- Pass Directly into Blood and Transported to Target Organ

**Enzymes**
- Proteins Act as Catalysts to Chemical reactions (without being used up themselves)

**Antibodies and Antitoxins**
- Protective Substances Made of Complex Proteins
- Produced by Plasma Cells in Lymph Glands and Spleen

**Gases**
- Oxygen, Carbon Dioxide and Nitrogen
- Dissolve in Plasma and Transported via Erythrocytes (in plasma)
Cellular Content of blood

- Erythrocytes or Red Blood Cells – 45%
- Leucocytes or White Blood Cells – 1%
- Thrombocytes or Platelets - >1%
- Remaining 55% is Plasma
Erythrocytes

- Erythrocytes Give Blood Color
- Erythropoiesis is the Process of Forming Red Blood Cells
  - Form in Red Bone Marrow in Extremities of Long Bones
  - Form in Layers of Compact Bone like Sternum and Vertebrae
- Two Lines of Development to a Mature Erythrocyte
  - Erythrocyte Itself
  - Hemoglobin which Transports Oxygen
- Survive for 120 Days after Maturity
- 7 Days to Mature
- Women Usually Have a Smaller Normal Erythrocyte Count
Leucocytes

- Function is to Fight Disease
- Cell Size is > Erythrocytes
- Number < Erythrocytes
- Divided into 2 Main Groups
- Granular (75% of WBC)
  - Neutrophils
  - Eosinophils
  - Basophils
- Nongranular
  - Lymphocytes
  - Monocytes
Thrombocytes

- Small Cells
- 300,000/ml
- Involved in Blood Clotting
- Several Factors Activate Platelets
- Can Deplete Rapidly
- Dysfunction from Aspirin
Blood Groups

4 Main Blood Groups:
- Group A – 42%
- Group B – 8%
- Group AB – 4%
- Group O – 46%

Compatibility

All figures above for Caucasians
Circulatory System

Circulatory or Cardiovascular System

2 Main Parts:

- Blood Circulatory System
  - Heart and Blood Vessels

- Lymphatic System
  - Lymph Nodes and Lymph Vessels
Blood Vessels

- Arteries (blood from heart)
  - Arterioles
    - Capillaries
      - Destination
    - Capillaries
  - Venules
- Veins (blood to heart)
Arteries

- Transport Blood Away from Heart
- Arteries Vary in Size but all have Same Structure
- Consist of 3 Tissue Layers
  - Tunica Adventitia – Fibrous Outer Layer
  - Tunica Media – Smooth, Elastic Muscular Middle Layer
  - Tunica Intima – Epithelium and Lumen (Inner Layer)
    - In Large Arteries Tunica Media Has More Elastic Tissue and Less Muscle
    - In Smaller Arterioles Tunica Media Is Almost All Smooth Muscle
Veins

- Transport Blood to Heart
- Consist of 3 Tissue Layers
  - Tunica Adventitia
  - Tunica Media
  - Tunica Intima
- Venous Walls are Thinner than Arterial Walls (with less muscle and elastic tissue)
- Valves Stop Back Flow of Blood
- Valves Diminish Hydrostatic Pressure Below Heart
Arteries and Veins

**Arteries**
- High Pressure Blood
- Blood Flow Away from Heart
- Mainly Oxygenated Blood
- Thick Walls
- No Valves

**Veins**
- Low Pressure Blood
- Blood Flow Towards Heart
- Mainly De-Oxygenated Blood
- Thin Walls
- Valves
Nervous Control

- Veins and Arteries are Powered by Nerves from the Autonomic Nervous System
- Nerves Change the Calibre of the Vessels Controlling Amount of Blood Circulating
- Changes in Calibre Result from Contraction or Relaxation of the Blood Vessel’s Muscular Wall
- Small and Medium Vessels are Easier to Control (They have more muscle than elastic tissue.)
- Larger Vessels, Aorta, are More Difficult to Control (They are more elastic and have less muscle tissue.)
Cell Respiration

Interchange of Gases Between Blood and Cells of the Body
What is Normal Blood Pressure?

- Impossible to Precisely Categorize
- 120/80 Considered Normal for Healthy Adults
- Systolic Pressure 140mmHg or Below
- Diastolic Pressure 90mmHg or Below
Variability of Blood Pressure

BP Influenced by:
- Physical Activity
- Anxiety
- Pain
- Environmental Factors (Temperature)
- Psychological Factors (Mood)
- Can Vary Between Right and Left Arm
Hydrostatic Effect

- Hydrostatic Pressure: Static Pressure of Liquid
- Effected by Gravity
- Heart Level (Mid Right Atrium): Reference Point
- Clinical Pressure Measurements

Venous Pressure

-40
-20
0
80
mmHg

Mean Arterial Pressure

50
70
90
170
mmHg
Pathological Variability of Arterial Pressure

- Cardiac Dysrhythmias Produce Beat-to-Beat Variation in Pulse Pressure
- Marked Respiratory Variation (up to 50 mmHg) Restrict Normal Cardiac Filling (Pulsus Paradoxus)
- Mechanical Ventilation Cyclic Changes of Systolic Arterial and Pulse Pressure in Hypovolemic Patients
Summary of Part II

- The following is a cellular breakdown of blood’s content by percentage:
  - Erythrocytes (RBC) 45%
  - Leucocytes (WBC) 1%
  - Thrombocytes (clotting) >1%
  - Plasma 55%

- The four blood groups are O, A, B, and AB. O is the most compatible type, and AB is the least compatible type.

- The 3 tissue layers that comprise arteries and veins are
  - Tunica Adventitia – Fibrous Outer Layer
  - Tunica Media – Smooth, Elastic Muscular Middle Layer
  - Tunica Intima

- Some veins have valves to stop the backflow of blood.

- Cellular respiration refers to the interchange of gases between the blood and the cells of the body.

- A normal BP for healthy adults is 120/80.
Hypertension

- SP Consistently > 140mmHg
- DP Consistently > 90mmHg
- Caused by Genetics, Environment, Diet, etc.

- Pre-Hypertension:
  - Systolic between 120–139
  - Diastolic between 80–89
  - On Multiple Readings
Hypertension

Secondary Hypertension
- Adrenal Gland Tumours
- Cushing’s Syndrome
- Renal Disorders
- Medications, Drugs or Other Chemicals
- Haemolytic-Uraemic Syndrome
- Schönlein-Henoch Purpura
## Hypertension

### Symptoms
- Headache
- Tiredness
- Confusion
- Vision Changes
- Angina Like Pain
- Heart Failure
- Haematuria
- Epistaxis
- Tinnitus
- Irregular Heart Beat

### Complications
- Hypertensive Heart Disease
- Heart Attacks
- Congestive Heart Failure
- Arteriosclerosis
- Aortic Dissection
- Renal Failure
- Stroke
- Brain Damage
- Blindness
Hypertension

Treatment

- Medications
  - Diuretics
  - Beta-Blockers
  - Calcium Channel Blockers
  - Angiotensin-Converting Enzymes (ACE) Inhibitors
  - Others

- Lifestyle changes including
  - Weight Loss
  - Exercise
Hypotension

- SP Consistently < 90 mmHg
- DP Consistently < 60 mmHg
- 3 Main Types
  - Orthostatic Hypotension
    - Sudden Change in Body Position, Usually from Lying Down to Standing Up
  - Neurally Mediated Hypotension (NMH)
    - When Standing for Long Time (usually in children and young adults)
  - Severe Hypotension
    - Brought On by Shock
Hypotension

Other Causes

- Medications, Drugs, Alcohol
- Dehydration
- Heart Failure, Heart Attack
- Arrhythmias
- Syncope (Fainting)
- Advanced Diabetes
- Shock (including Anaphylaxis, Hypovolaemia, MI, Sepsis, etc.)
Hypotension

Symptoms
- Blurry vision
- Confusion
- Dizziness
- Syncope
- Light-headedness
- Sleepiness
- Weakness

Treatment
- Severe Hypotension
  - Emergency Treatment
- Orthostatic Hypotension
  - Medication Review
- NMH
  - Avoid Triggers
  - Add Extra Fluids or Salt to Diet
Summary of Part III

- A person whose systolic pressure is consistently >140 and whose diastolic pressure is consistently <90 mmHg probably has hypertension.

- A person whose systolic pressure is consistently <90 and whose diastolic pressure is consistently <60 mmHg probably has hypotension.

- Secondary hypertension is when hypertension is caused by another disorder such as: Adrenal Gland Tumours, Cushing’s Syndrome, Renal Disorders, Medications, Drugs or Other Chemicals, Haemolytic-Uraemic Syndrome, Schönlein-Henoch Purpura.

- There are 3 main types of hypotension.
  - Severe hypotension, brought on by shock, requires emergency treatment.
  - Neurally Mediated Hypotension (NMH) is typically treated by modifying a patient’s medication.
  - Orthostatic hypotension can be avoided by avoiding what triggers it, or by adding extra salts or fluids to diet.
Measuring Blood Pressure

- Evolution of BPM Technology
- Non-Invasive Vs Invasive
- 2 NIBP Methods
  - Auscultatory Method
    - Importance of Cuff Size
  - Oscillometric Method
- IBP – Direct Arterial Pressure
History of BPM

- 1733 – Reverend Stephen Hales Inserts Long Glass Tube Upright into Horse’s Artery
  - Pumping Action of Heart Generates Pressure Raising Blood Level in Tube
- 1847 – Carl Ludwig Records Human Blood Pressure with Kymograph (Wave Writer in Greek)
  - Inserts Catheter Directly into Artery Using U-shaped Manometer Tube with Ivory Float, Rod and Quill Attached
- 1855 – Karl Vierordt Uses Inflatable Cuff Around Arm to Pressurize Arterial Pulse
- 1860 – Etienne Jules Mary Invents Sphygmograph
  - Accurate for Pulse Not Blood Pressure
  - Provides First Clinical Device Yielding Successful Pulse Measurement
History of BPM

- 1881 – Samuel Siegfried Karl Ritter von Basch Invents Sphygmomanometer
  - Water-Filled Bag Connected to Manometer
  - Feels Pulse on Skin Above Artery
- 1896 – Scipione Riva-Rocci Develops Mercury Sphygmomanometer (Inflatable Cuff Over Upper Arm)
- 1901 – Harvey Cushing Brings Riva-Ricci’s Design to U.S.
  - Today Mercury Devices are Still Perceived as Most Accurate in Manual Market
- 1905 – Nikolai Korotkoff Distinguishes Systolic and Diastolic Blood Pressures with Sounds at Different Phases of Cuff Inflation and Deflation
  - Use of Stethoscope for Korotkoff Sounds Makes Auscultatory Method Standard Practice
BPM Today

- Non-Invasive Measurement
- Measure Occlusion of Brachial Artery
  - Auscultatory Method
  - Oscillometric Method
- Invasive Measure
  - Direct Measurement of Arterial Pressure
    - Placing Cannula Needle in Artery
Non-Invasive Vs. Invasive

Non-Invasive
- Routine Examinations and Monitoring
- Indirect Method (External)
- Requires Less Expertise
- Less Accurate than Invasive Measure
- Simple and Quick
- No Complications, Less Pain

Invasive
- Restricted to Hospitals
- Direct Method (Internal)
- Generally Performed by Anesthesiologist or Surgeon
- More Accurate than Non-Invasive
- Requires Very Close Supervision
NIBP Uses

- Non-Invasive Blood Pressure (NIBP)
- Oldest Monitoring Parameter (along with Temperature and Pulse)
- Evaluates General Well-Being of Patient
- Standard Monitoring Parameter
  - Patients under Local, Regional or General Anesthesia
  - Operating Room (OP)
  - Recovery Rooms and Post Anesthesia Care Unit (PACU)
- When Invasive Arterial Pressure Monitoring is NOT Required
- To Compare with Invasive Pressure Readings
Arterial Pressure

- Brachial Artery
- Major Blood Vessel
- Upper Arm (both arms)
- Bifurcates Just Past Elbow
- When Occluded
  Pulse of BA
  Can be Felt and Measured
Auscultation Vs. Oscillation Methods

- **Auscultation**\(^*\) (aw-skūl-tay-shōn)  
  \(n.\) the process of listening, usually with a stethoscope, to sounds produced by movement of gas or liquid within the body, as an aid to diagnosis.

- **Oscillation**\(^*\)  
  (oss-I-lay-shōn)  
  \(n.\) a regular side-to-side movement; vibration.

\(^*\)Mini dictionary for nurses, Oxford University Press 1991
Auscultatory Technique

- Manual Method
- Use Microphone (Stethoscope) Detect Korotkoff or “K” Sounds
- Gauge Measures Pressure Changes in Cuff
- Measures SP and DP
- Estimates MAP
- Less Convenient than Oscillometric Technique
- Sensitive to Microphone Placement or Human Hearing
Auscultatory Equipment
Auscultation BPM Steps

- Position Patient
- Apply Cuff (Upper Arm)
- Inflate Cuff (Occludes Brachial Artery)
- Place Stethoscope Over Brachial Artery (Distal to Cuff)
- As Cuff Deflates, Listen for Phases of Korotkoff Sounds
- Record Results
Korotkoff’s Sounds

- Phase I
  Sharp Thud
  Start of SP

- Phase II
  Blowing
  or Swishing Sound

- Phase III
  Softer Thud

- Phase IV
  Softer Blowing Sound
  That Disappears

- Phase V
  Silence

- Debate on Whether Phase IV, Phase V
  or Combination Best Represents DP
Ensuring Accuracy

- Use Correct Cuff Size
- Expel Air from Cuff Before Measurement
- Do Not Place Cuff on Same Extremity As Infusion Line (Impedes IV Flow)
- Apply Cuff Snugly Around Upper Arm (2.5cm above elbow joint)
- Test by Inserting 2 Fingers Under Cuff
- Place Artery Marker on Cuff Over Brachial Artery
- Arm Must be Supported and Level with Heart
- Ensure No Tight Clothing Constricts Arm
- Check Hose Connections to Cuff and Monitor (Sphygmomanometer)
- Movement Impedes NIBP Readings
- Instruct Patient to Lie/Sit Still During Measurement
Oscillometric Technique

- Oscillations Caused by Arterial Pressure Pulse
- Automatic Method
- Senses Pressure Changes in Cuff
- Uses Algorithm to Calculate Systolic and Diastolic Values
- Not Direct Measurement of BP
- Measures MAP
- Estimates SP and DP
- Easy to use

Oscillometric Equipment
Oscillometric Method

- Position Patient
- Apply Cuff (Upper Arm)
- Inflate Cuff (Occludes Brachial Artery)
- As Cuff Deflates Pressure Data is Recorded (Automatically)
- Over Time Pressure Data Looks Like Waveform
Summary of Part IV

- In 1905 Nikolai Korotkoff distinguished systolic and diastolic blood pressures by identifying sounds now known as Korotkoff sounds at different phases of cuff inflation and deflation.
- NIBP measure occlusion of the brachial artery with an inflatable cuff, while IBP measures arterial pressure directly with a cannula needle.
- The following are the steps for performing the Auscultatory Method, or manual NIBP method, of taking a blood pressure measurement.
  1. Position Patient
  2. Apply Cuff (Upper Arm)
  3. Inflate Cuff (Occludes Brachial Artery)
  4. Place Stethoscope Over Brachial Artery (Distal to Cuff)
  5. As Cuff Deflates Listen for Phases of Korotkoff Sounds
  6. Record Results
- Oscillometric method measures Oscillations caused by the arterial pressure pulse.
Invasive Blood Pressure Measurement

Advantages of Direct Arterial Pressure

- BPM Continuously Available (Patient in Critical Condition)
- Hemodynamic Consequences of Arrhythmias Readily Observed (Fast Atrial Fibrillation, Multiple Premature Beats)
- Arterial Tracing is Irreplaceable Guide of Fluid (Transfusion Therapy in Major Surgeries)
- Repeated Blood Samples Readily Obtained (Blood Gas Analysis)
Invasive Blood Pressure Measurement

1 - Monitor
2 - Fluid Back
3 - Fluid Back
4 - Flushing Set and Transducer
5 - Specific Cable

Definitely need some feedback on this slide.
Summary of Part IV

- Some important advantages of taking direct arterial blood pressure are that the BPM is continuously available, the hemodynamic consequences of arrhythmias can be readily observed, the arterial tracing is an irreplaceable guide of fluid, and repeated blood samples are also readily obtainable.

- A monitor, a fluid back, a flushing set and transducer, and a special cable are items necessary for a proper IBP measure set up.
Congratulations!
You’ve Successfully Completed
Blood Pressure Training
By Welch Allyn