Blood Pressure Training
How This Program Works

Before We Get Started:

Welcome to Blood Pressure Training: History, Physiology and Clinical Procedure. In this workbook we will cover Terminology of Blood Pressure; Functions of the Blood; Arteries and Veins; Hypo / Hypertension; Blood Pressure Measurement Technology; History; Non-Invasive BPM Today; Auscultatory Method; Oscillometric Method, and Invasive Blood Pressure Measurement Today.

Measuring Blood Pressure is one of the most commonly performed diagnostic procedures. So it is important to have a clear understanding of what blood pressure is and how to measure it. The goal of this workbook is to provide you with a basic yet thorough understanding of non-invasive blood pressure measurement and exercises throughout are designed to help you comprehend and retain this information.
Welch Allyn
Blood Pressure Training

Course Directory

Part I Introduction........................................3
Part II Anatomy and Physiology.......................8
Part III Hypertension and Hypotension........23
Part IV Evolution of BPM Technology ....29
Part V Invasive Blood Pressure ...............42
Part I Introduction

Blood Pressure Basics (slide 3)

- Blood Pressure is the Amount of Blood Pumped by the heart in relation to size and condition of arteries.
- Measured by Force of Blood on Artery Walls
- Measured in Millimeters of Mercury (mmHg)
- Factors Affecting Blood Pressure:
  - Volume of Water in Body
  - Salt Content of Body
  - Condition of Kidneys, Nervous System and Blood Vessels (Arteries and Veins)
  - Levels of Various Hormones in Body

Arterial vs. Venous Pressure (slide 4)

- 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 wall of the veins.
- Blood Pressure Generally Refers to Arterial Pressure.
Systole over Diastole (slide 5)

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

\[
\begin{align*}
\frac{120}{80} &= \text{Systolic}\\
\text{Diastolic}
\end{align*}
\]

Cardiac Cycle (slide 6)

Cardiac Cycle

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

Systolic Pressure (SP)

- Highest Recorded Arterial Pressure Reading
- Occurs Near the Beginning of the Cardiac Cycle

Diastolic Pressure (DP)

- Lowest Recorded Arterial Pressure Reading
- Resting Phase of Cardiac Cycle
The Cardiac cycle is broken down into four phases.

Phase 1: Atrial systole

- It occurs when the atria is electrically stimulated and is denoted as the P-wave in an ECG
- This stimulation causes the atria to contract

Phase 2: Ventricular systole

- It occurs when the ventricles are electrically stimulated and is denoted as the QRS-wave segment in an ECG reading
- This stimulation causes the ventricles to contract. And it is here that we get our systolic pressure reading.

Phase 3: Early diastole

- It is when the heart begins to relax after its stimulation and is denoted at the T-wave in an ECG
- Here the ventricles relax

Phase 4: Diastole

- The heart finishes up its relaxation period. This moment is denoted as the TP-period in an ECG
- The diastolic pressure reading comes from the diastolic period of phases of the cardiac cycle.
MAP and Pulse Pressure (slide 7)

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

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

1) Give a brief but accurate definition of blood pressure in the space provided.

2) Circle the correct word in each bracketed section of the following statements.

   Arteries carry blood [to / from] the heart,
   while veins carry blood [to / from] the heart.

   When we refer to blood pressure, we generally refer to [arterial / venous] pressure.

3) How is a blood pressure measurement written?
   (a) Diastole over Systole
   (b) Systole over Diastole

4) Name 4 phases of the cardiac cycle.
Part II Anatomy and Physiology (Slide 8)

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

functions of the blood (slide 9)

- 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 cell by clotting.
- Maintains body temperature.
Blood and Plasma (slide 10)

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 (slide 11)

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 (slide 12)**
- Erythrocytes or Red Blood Cells – 45%
- Leucocytes or White Blood Cells – 1%
- Thrombocytes or Platelets - >1%
- Remaining 55% is Plasma
Erythrocytes (slide 13)

- 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 (slide 14)

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

Thrombocytes (slide 15)

- Small Cells
- 300,000 thrombocytes per milliliter of blood
- Involved in Blood Clotting
- Several Factors Activate Platelets
- Can Deplete Rapidly
- Dysfunction from Aspirin
Blood Groups (slide 16)

4 Main Blood Groups:

- Group A 42%
- Group B 8%
- Group AB 4%
- Group O 46%

All figures above for Caucasians

The diagram illustrates compatibility of the four blood groups with O being the
Circulatory System / Cardiovascular System (slide 17)

2 Main Parts:

- Blood Circulatory System
  - Heart and Blood Vessels
- Lymphatic System
  - Lymph Nodes and Lymph Vessels

Blood Vessels (slide 18)

- Arteries (blood from heart)
  - Arterioles
    - Capillaries
      - Destination
      - Capillaries
    - Venules
  - Veins (blood to heart)
Arteries (slide 19)

- 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 - more Elastic Tissue and less Muscle
    - In Smaller Arterioles Tunica Media - almost all Smooth Muscle
Veins (slide 20)

- 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 (slide 21)

<table>
<thead>
<tr>
<th>Arteries</th>
<th>Veins</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pressure Blood</td>
<td>Low Pressure Blood</td>
</tr>
<tr>
<td>Blood Flow Away from Heart</td>
<td>Blood Flow Towards Heart</td>
</tr>
<tr>
<td>Mainly Oxygenated Blood</td>
<td>Mainly De-Oxygenated Blood</td>
</tr>
<tr>
<td>Thick Walls</td>
<td>Thin Walls</td>
</tr>
<tr>
<td>No Valves</td>
<td>Valves</td>
</tr>
</tbody>
</table>
**Nervous Control (slide 22)**

- 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 (slide 23)**

- Internal/Cell Respiration - the interchange of gases between the blood and the cells of the body.
- Oxygen from the arteries diffuses through the arterial end of the capillary wall into the tissue fluid then into the cell through its semipermeable wall
- Carbon dioxide, a waste product of cell metabolism, diffuses into the blood towards the venous end of the capillary.
What is Normal Blood Pressure? (slide 24)

- 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 (slide 25)

BP Influenced by:

- Physical Activity
- Anxiety
- Pain
- Environmental Factors (Temperature)
- Psychological Factors (Mood)
- Can Vary Between Right and Left Arm
Hydrostatic Effect (slide 26)

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

Pathological Variability of Arterial Pressure (slide 27)

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

1) Give a breakdown by percentage of the cellular content of blood.
   Erythrocytes ___ %
   Leucocytes ___ %
   Thrombocytes ___ %
   Plasma ___ %

2) Finish filling in the letters and circles to represent the compatibility of the four blood groups.

3) What three tissue layers comprise both arteries and veins?

   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________
4) Why do some veins have valves?


5) Define cellular respiration.


6) What is considered a normal BP for healthy adults?

____ / _____
Part III Hypertension and Hypotension

**Hypertension (slide 28)**

- 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

**Secondary Hypertension (slide 29)**

- Adrenal Gland Tumours
- Cushing's Syndrome
- Renal Disorders
- Medications, Drugs or Other Chemicals
- Haemolytic-Uraemic Syndrome
- Schönlein-Henoch Purpura
Symptoms of Hypertension (slide 30)

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

Complications of Hypertension (slide 30)

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

Treatment of Hypertension (slide 31)

Medications

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

Lifestyle changes including

- Weight Loss
- Exercise
Hypotension (slide 32)

- 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

Other Causes of Hypotension (slide 33)

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

Symptoms of Hypotension (slide 34)

- Blurry vision
- Confusion
- Dizziness
- Syncope
- Light-headedness
- Sleepiness
- Weakness
Treatment of Hypotension (slide 34)

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

1) What does a patients have if SP is consistently greater than 140 mmHg DP is consistently lower than 90 mmHg
   a) Hypotension
   b) Hypertension
   c) Pre-Hypertension

2) What does a patient have if SP is consistently lower than 90 mmHg DP is consistently lower than 60 mmHg
   a) Hypotension
   b) Hypertension
   c) Pre-Hypertension

3) What are three causes of secondary Hypertension?

   ______________________________________________________
   ______________________________________________________
   ______________________________________________________
4) Draw lines to connect the three main types of Hypotension with the appropriate treatment.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe Hypotension</td>
<td>Avoid appropriate triggers.</td>
</tr>
<tr>
<td>Neurally Mediated Hypotension (NMH)</td>
<td>Emergency Treatment</td>
</tr>
<tr>
<td>Orthostatic Hypotension</td>
<td>Medication Review</td>
</tr>
</tbody>
</table>
Part IV Evolution of BPM Technology (slide 35)

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

History of Blood Pressure Measure (slide 36-37)

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

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 of the Mercury Sphygmomanometer 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
Blood Pressure Measure Today (slide 38)

- 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 (slide 39)

<table>
<thead>
<tr>
<th>Non-Invasive</th>
<th>Invasive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine Examinations and Monitoring</td>
<td>Restricted to Hospitals</td>
</tr>
<tr>
<td>Indirect Method (External)</td>
<td>Direct Method (Internal)</td>
</tr>
<tr>
<td>Requires Less Expertise</td>
<td>Generally Performed by Anesthesiologist or Surgeon</td>
</tr>
<tr>
<td>Less Accurate than Invasive Measure</td>
<td>More Accurate than Non-Invasive</td>
</tr>
<tr>
<td>Simple and Quick</td>
<td>Requires Close Supervision</td>
</tr>
<tr>
<td>No Complications, Less Pain</td>
<td></td>
</tr>
</tbody>
</table>
Non-Invasive Blood Pressure (NIBP) Uses (slide 40)

- 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
- When Invasive Arterial Pressure Monitoring is NOT Required
- To Compare with Invasive Pressure Readings

Arterial Pressure (slide 41)

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 (slide 42)

**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.
Auscultatory Technique (slide 43)

- Manual Method
- Use Microphone (Stethoscope) to 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 (slide 44)
Auscultation BPM Steps (slide 45)

- 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 (slide 46)

- 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 (auscultatory method) (slide 47)

- 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 (slide 48)

- 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 (slide 49)
Oscillometric Method (slide 50)

- 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 Quiz on Part IV

1) Who initially distinguished systolic and diastolic blood pressures by identifying sounds at different phases of cuff inflation and deflation?

2) Correctly complete the sentences below by drawing lines from the words on the left to the corresponding words on the right.

Non-Invasive Blood Pressure measures

Invasive Blood Pressure measures

arterial pressure directly with a cannula needle.

Oclusion of the brachial artery with an inflatable cuff.

3) What is the name of the artery shown in the diagram below?
4) The Auscultatory Method, or manual NIBP Method, requires attention to accuracy. Put the steps involved in taking blood pressure using the Auscultatory Method in the correct order by writing the appropriate (1–5) next to each statement below.

_____ Records results.
_____ Place a stethoscope over the patient’s brachial artery (distal to the cuff).
_____ Inflate the cuff to occlude the brachial artery.
_____ Wrap the cuff around the patient’s upper arm.
_____ Listen for the Korotkoff’s sounds as the cuff deflates.

5) Circle True or False
Using the correct cuff size helps ensure accuracy of blood pressure measurement.

6) The statements below describe the (circle one) Auscultatory Method or Oscillometric Method of NOBP.

• Automatic Method of Measuring Blood Pressure
• Senses Pressure Changes in Cuff
• Uses Algorithm to Calculate Systolic and Diastolic Values
• Measures Mean Arterial Pressure
• Estimates Systolic and Diastolic Pressure
• Easy to use
Part V Invasive Blood Pressure Measurement

Advantages of Direct Arterial Pressure (slide 51)

- 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 Measure Setup (Slide 52)
Summary Quiz on Part V

1) List two advantages of taking direct arterial blood pressure.

2) Write the terms below that correctly name numbers 1–5 in the diagram.
Congratulations!
You’ve Successfully
Completed
Blood Pressure Training

Notes:

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