Noninvasive measurement of blood pressure
Measurement of arterial pulse

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Arterial pulse

Definition:
- Arterial pulse is a peripheral expression of the heart’s mechanical activity perceived by palpating the arteries.
- It is the rhythmic expansion of arterial walls which is synchronous to ventricular systole.

In people with normal arterial elasticity and normal blood pressure, pulse wave spreads in arterial walls at a speed of:
- 3-5 m/s in normal aorta;
- 7-10 m/s in large arterial branches;
- 15-35 m/s in peripheral arteries.
Common arterial pulse sites:

- Temporal
- Carotid
- Brachial
- Radial
- Femoral
- Popliteal
- Pedal (dorsalis pedis, posterior tibialis artery)
MEASURING THE PULSE

Taking the Radial Pulse.

☐ Supporting the patient's arm and hand with the palm up, press the second and third finger of your dominant hand gently against the radius bone until you feel the contraction and expansion of the artery with each heartbeat.

☐ Do not use your thumb; it has a strong pulse of its own and you may be counting your own pulse.

☐ Count the pulsations for 30 seconds using a watch with a second hand or digital display to time yourself. Multiply the result by 2 to determine the pulse rate for 1 minute. If the pulse is abnormal, count for a full minute to get a more accurate reading.
MEASURING THE PULSE

- **Important:** The radial pulse palpation must be done bilaterally in the same time, because we have to check the synchronicity and the symmetry of the wave.

- The pulse rate may also be determined by the electronic vital signs monitor.
Arterial pulse curve recording

- The arterial pulse recorded centrally (ie. close to the heart) or at the periphery is called sphygmogram (central or peripheral sphygmogram).
- Mechanical devices (Marey) or photoelectric pletismography is used to record it.
- The shape of the arterial pulse curve is represented by 2 positive waves:
  - The first, higher one represents the systolic rise of blood pressure;
  - the second one, lower than the first one represents ventricular diastole, it is due to arterial wall elasticity.
Arterial pulse curve recording - sphygmogram
Different qualities of the arterial pulse

1. Frequency:
   - n- 60-90/min
   - value < 60 : bradycardia
   - value > 90 : tachycardia

2. Rhythm: interval between two consecutive pulsations
   - puls regularis;
   - puls irregularis = arrhythmia.

3. Velocity: the speed of the wave's advent and disappearance (puls celer, puls tardus).

4. Amplitude: magnitude of the pulse wave (puls magnus, puls parvus).

5. Tension: the force used to compress the artery completely - in order to obtain the disappearance of the pulse wave (puls durus, puls mollis)
Pathological aspects of the arterial pulse

- One abnormal pulse is called *pulsus alternans*. This is a regular pulse with alternation of beat amplitude every other beat. It is associated with severe left ventricular failure of any cause. These amplitude changes will be emphasized in a peripheral artery and may be easiest to detect in the femoral pulse.

- Severe aortic stenosis causes a small pulse known as *pulsus parvus et tardus*. It is a low-amplitude pulse with a delayed upstroke. This is best palpated on the carotid artery.
Pathological features of the arterial pulse

- Atrial Fibrillation causes an irregular pulse.
  - Not only the rate of the pulse will be irregular, but the pulse amplitude will also vary. This results from variable stroke volumes.
  - If the ventricular rate is rapid, some pulses may not be transmitted to the periphery. **Pulse deficit** refers to the difference between cardiac frequency and peripheral pulse frequency. Simultaneous auscultation of the heart and palpation of the radial pulse make it possible to detect it.
Noninvasive measurement of blood pressure

- **Definition**: Blood pressure is the force applied against the walls of the arteries, induced by the rhythmic contractile activity of the heart.

- The pressure is determined by the force and amount of blood pumped and the size and flexibility of the arteries.
## Parameters of arterial pressure

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Normal values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Systolic Blood Pressure (SBP)</strong></td>
<td>The maximal value of BP during cardiac systole, dependent on stroke volume</td>
<td>120-140 mmHg</td>
</tr>
<tr>
<td><strong>Diastolic Blood Pressure (DBP)</strong></td>
<td>The minimal value of BP during cardiac diastole, depends on arterial wall elasticity</td>
<td>70-90 mmHg</td>
</tr>
<tr>
<td><strong>Mean Arterial Pressure</strong></td>
<td>The average pressure throughout each cycle of the heartbeat</td>
<td>(SBP-DBP)/3 +DBP</td>
</tr>
<tr>
<td><strong>Pulse Pressure</strong></td>
<td>The difference between systolic and diastolic pressure, depends on stroke volume and arterial compliance</td>
<td>SBP-DBP (40-50 mmHg)</td>
</tr>
</tbody>
</table>
Noninvasive measurement of blood pressure
Clinical methods for measuring arterial pressure

Auscultatory method

- Material: sphygmomanometer and stethoscope
- Method:
  1. place the cuff of the sphygmomanometer around the upper arm
  2. place the stethoscope over the brachial artery
  3. inflate the cuff, when the cuff pressure is high enough to obstruct the artery (i.e. cuff pressure higher than systolic arterial pressure), no radial pulse can be felt and no sounds can be heard
  4. gradually reduce cuff pressure. When the pressure in the cuff falls bellow systolic pressure, blood flow through the artery restarts – tapping sounds in the brachial artery (KOROTKOFF sounds). When the first Korotkoff sounds are heard, the pressure level indicated by the manometer connected to the cuff is approximately equal to the systolic pressure.
  5. as the pressure in the cuff is lowered still more, the intensity of the sounds increases and then decreases. When the pressure in the cuff is lowered to the level that equals diastolic pressure, the sounds become muffled, than disappear completely.
Clinical methods for measuring arterial pressure

Auscultatory method
Clinical methods for measuring arterial pressure

Radial pulse method

- Material: sphygmomanometer
- Method:
  1. place the cuff of the sphygmomanometer around the upper arm
  2. feel the radial pulse before inflating the cuff
  3. raise the pressure in the cuff above the systolic level; no pulsation will be felt in the radial artery
  4. progressively reduce the pressure in the cuff, when the pressure reaches the systolic level a distinct radial pulse can be felt

Observation: this method estimates only the systolic blood pressure
Rules for a correct measurement of blood pressure

- Don't use caffeine, alcohol, or tobacco products 30 minutes before measuring your blood pressure.
- Rest for 3 to 5 minutes before measuring your blood pressure. Do not talk.
- Sit in a comfortable position, with your legs and ankles uncrossed and your back supported.
- Place your arm, raised to the level of your heart, on a table or a desk, and sit still.
- Wrap the correctly sized cuff smoothly and snugly around the upper part of your bare arm. The cuff should fit snugly, but there should be enough room for you to slip one fingertip under the cuff.
- Be certain that the bottom edge of the cuff is 2-3 cm above the crease of your elbow.
<table>
<thead>
<tr>
<th>Cuff denomination</th>
<th>Arm circumference (cm)</th>
<th>Cuff width (cm)</th>
<th>Bladder length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant</td>
<td>6-15</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Child</td>
<td>16-21</td>
<td>8</td>
<td>21</td>
</tr>
<tr>
<td>Small adult</td>
<td>22-26</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>Adult</td>
<td>27-34</td>
<td>13</td>
<td>30</td>
</tr>
<tr>
<td>Large adult</td>
<td>35-44</td>
<td>16</td>
<td>38</td>
</tr>
<tr>
<td>Thigh</td>
<td>45-52</td>
<td>20</td>
<td>42</td>
</tr>
</tbody>
</table>
## Classification of BP levels (BP measured in mmHg)

<table>
<thead>
<tr>
<th></th>
<th>Systolic BP</th>
<th>Diastolic BP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Optimal</strong></td>
<td>&lt;120</td>
<td>&lt;80</td>
</tr>
<tr>
<td><strong>Normal</strong></td>
<td>120-130</td>
<td>80-85</td>
</tr>
<tr>
<td><strong>High normal</strong></td>
<td>130-140</td>
<td>85-90</td>
</tr>
<tr>
<td><strong>Mild hypertension</strong></td>
<td>140-160</td>
<td>90-100</td>
</tr>
<tr>
<td><strong>Moderate hypertension</strong></td>
<td>160-180</td>
<td>100-110</td>
</tr>
<tr>
<td><strong>Severe hypertension</strong></td>
<td>&gt;180</td>
<td>&gt;110</td>
</tr>
</tbody>
</table>
White-coat hypertension

- For some patients, BP measurements taken in a doctor's office may show higher BP values than their usual BP.
- In up to 25% of patients, the office measurement is higher than their typical BP. This type of error is called white-coat hypertension (WCH) and can result from anxiety related to an examination by a health care professional.
- The misdiagnosis of hypertension for these patients can result in needless and possibly harmful medication.
- WCH can be reduced (but not eliminated) with automated BP measurements over 15 to 20 minutes in a quiet part of the office or clinic.
Ambulatory Blood Pressure Monitoring (ABPM)

- The recording is done at rest and in activity;
- Beginning usually before 10:00 a.m.
- Every 15 or 20 min during the day,
- Every 30 min at night,
- Daytime from: 07:00 to 22:00
- Night time from: 22:00 to 07:00
- Push button for manual measurement by the patient;
- Link to a computer, data transfer;
- Statistics and graphic presentation of data;
- SBP & DBP: maximum, minimum, mean for 24 hour, daytime, night time; heart rate.
Ambulatory Blood Pressure Monitoring (ABPM)
ABPM: indications

- to exclude white coat hypertension,
- to confirm diagnosis: borderline hypertension, elderly
- patients during pregnancy;
- to evaluate therapy,
- to confirm resistant hypertension,
- to identify nocturnal hypertension,
- to diagnose hypotension under antihypertensive medication,
- to diagnose paroxysmal hypertension;
- to confirm and evaluate autonomic dysfunction.
Ambulatory Blood Pressure Monitoring

- Systolic blood pressure
- Diastolic blood pressure
- Blood pressure threshold while awake: 140/90 mm Hg
- Blood pressure threshold while asleep: 120/80 mm Hg
Ambulatory Blood Pressure Monitoring
Ambulatory Blood Pressure Monitoring

- Each of the ABPM profiles is laid out as follows:
  - X axis: time (24 h)
  - Y axis: blood pressure (mm Hg)
  - The yellow line adjacent to the Y axis represents the blood pressure obtained for that patient.
  - The horizontal grey bars represent the accepted normal limits for systolic and diastolic blood pressure obtained by ABPM, including the nocturnal dip.
  - The vertical bars on the left of the profile represent the "white coat" window, when the effect of medical staff on blood pressure may still be evident.
  - The darker vertical band of shading represents night time. In most individuals blood pressure falls by 10 - 20% during the night.
Ambulatory Blood Pressure Monitoring

- This 24 h ABPM shows sustained hypertension with the absence of a nocturnal dip. Absence of a normal diurnal profile may be associated with increased risk of target organ damage.