Morphological Changes of Pressure Pulses in Oscillometric Non-Invasive Blood Pressure Measurements

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Scope

- Non-invasive blood pressure measurements
  - auscultatory method
  - oscillometric method
- Pressure pulses in the cuff
- Morphology of the pressure pulses
- Conclusions
Non-invasive blood pressure measurements

**HYSTORY OF AUSCULTATORY METHOD**

- **Scipione Riva-Rocci (1863-1937)**
  - Italian internist and pediatrician
  - method (1896): cuff and mercury sphygmomanometer
  - palpation of radial pulse (systolic pressure)

- **Nikolai Sergeyevich Korotkoff (1874-1920)**
  - Russian surgeon
  - technique was reported in less than a page (1905)
  - listening with stethoscope to the artery just below the Riva-Rocci’s cuff
  - systolic and diastolic pressure

- Nowadays auscultatory method is the “golden standard”
  - Name of the method is “Riva-Rocci and Korotkoff”
  - essentially the same as described by Korotkoff
Non-invasive blood pressure measurements

**OSCILLOMETRIC METHOD**

- Étienne-Jules Marey (1830-1904)
  - French physiologist (studied blood circulation, heart beats, …)
  - method introduced in 1876
  - arm was placed in compression chamber
  - amplitude of pressure pulsations varied with pressure in chamber

- Automatic measurements
  - auscultatory method – difficulties with sound processing
  - oscillometric method – widely used

MAP mean arterial pressure
SYS systolic pressure
DIA diastolic pressure

Pressure pulses in the cuff

Automatic oscillometric measurement – details

Pressure in the cuff during the complete measurement cycle.

Raw oscillometric signal - deviations from the down-sloping deflation pressure.

Example (empirically derived values)
- MAP = pressure at max envelope amplitude
- SYS = pressure at 0.5*max env. amplitude
- DIA = pressure at 0.7*max env. amplitude
Morphology of the pressure pulses (1/2)

**Subject with normal blood pressure**

“Omron” values: SBP = 93 mmHg, DBP = 62 mmHg

**Description of morphology of successive pulse waves**

Beats -9, -8, -7, -6: 3 distinct waves

Beat -5: 3 distinct waves (first with higher amplitude)

Beat -4: 3 waves where the first 2 waves are fused

Beats -3, -2: single peak wave with fast down-slope

Beat -1: single peak wave modulated by 3 waves, fast down-slope

Beat M: single peak wave modulated by 3 waves, fast down-slope

Beat +1: lower down-slope than M

Beats +2, +3, +4, +5, +6: similar morphologies with progressively lower amplitudes and down-slope constants

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**Graph**

- Time from the start of each wave [s]
- Pressure deviation [mmHg]

Graph showing various wave forms with labels from -9 to +6.
Morphology of the pressure pulses (2/2)

**Subject with high blood pressure**

“Omron” values: SBP = 144 mmHg, DBP = 90 mmHg

**Description of morphology of successive pulse waves**

Beats -14, -13: 3 distinct waves
Beat -12 … -5: fast down-slope portion
Beat -4 … -1: down-slope portion needs progressively more time to the baseline
Beats -3, -2, -1, +1: amplitudes are nearly the same as pulse M
Beats -1, M: significant distinction between pulses (beat M have slope transition at time 0.32 s, but beat -1 has no such transition)
Conclusions

- Morphology of pressure pulses has additional information
  - Pulses before the pulse M and after it have different morphologies
  - Distinct 3 waves are present at high cuff pressure
  - Positions of these waves depend on subject (pulse wave velocity)
  - In case of similar amplitudes the morphology discriminate the pulses

- Using additional information in the morphology can result in
  - better accuracy of SBP and DBP values
  - pulse wave velocity measurements
  - arterial compliance measurements (elasticity)

- It is not worth throwing away the information by smoothing the signals