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

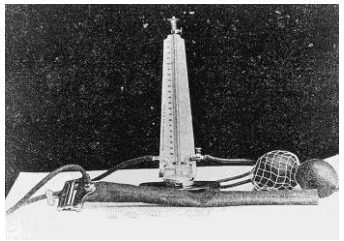
HYSTORY OF AUSCULTATORY METHOD

- 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

евич Коротков

- nowadays auscultatory method is the "golden standard"
  - Name of the method is "Riva-Rocci and Korotkoff"
  - essentially the same as described by Korotkoff

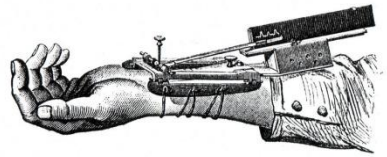


Non-invasive blood pressure measurements

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



Portable sphygmograph

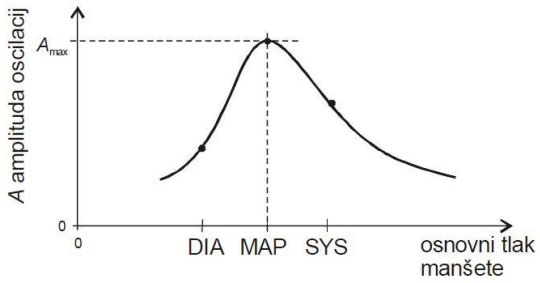


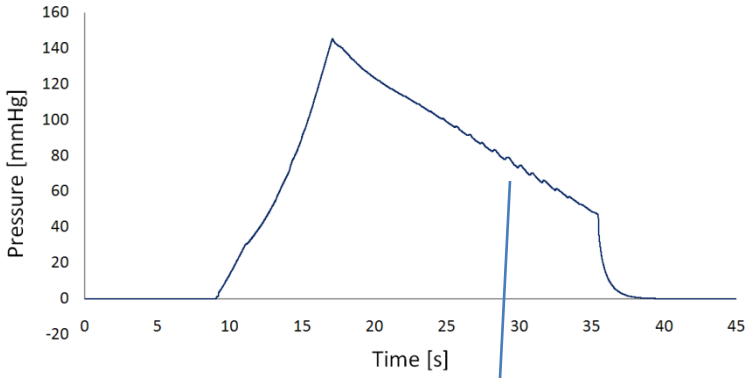
Figure 3. Pressure oscillations envelope versus the cuff pressure and characteristic parameters (DIA, SYS, MAP).

MAP mean arterial pressure
SYS systolic pressure
DIA diastolic pressure

Figure 3 from: G. Geršak, "Acquiring the oscillometric envelopes for non-invasive blood pressure measurements," Elektrotehniški vestnik, vol. 76, no. 3, pp. 97-102, 2009. In Slovenian.

Pressure pulses in the cuff

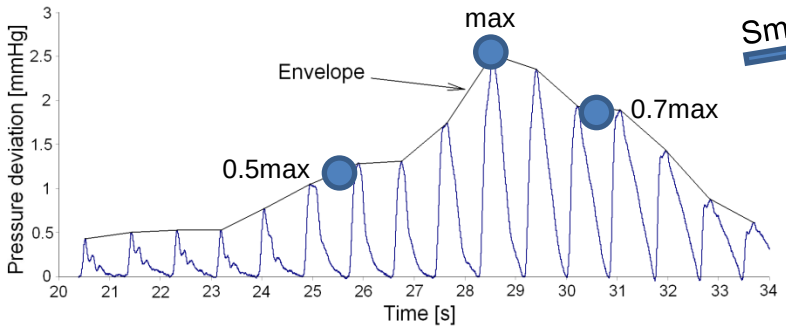
Automatic oscillometric measurement – details



Pressure in the cuff during the complete measurement cycle.

Automatic oscillometric device
(Omron M6, HEM-7001-E)

Additional pressure sensor inserted here



Smoothing the envelope

Small amount of the signal is used

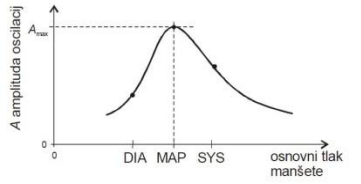
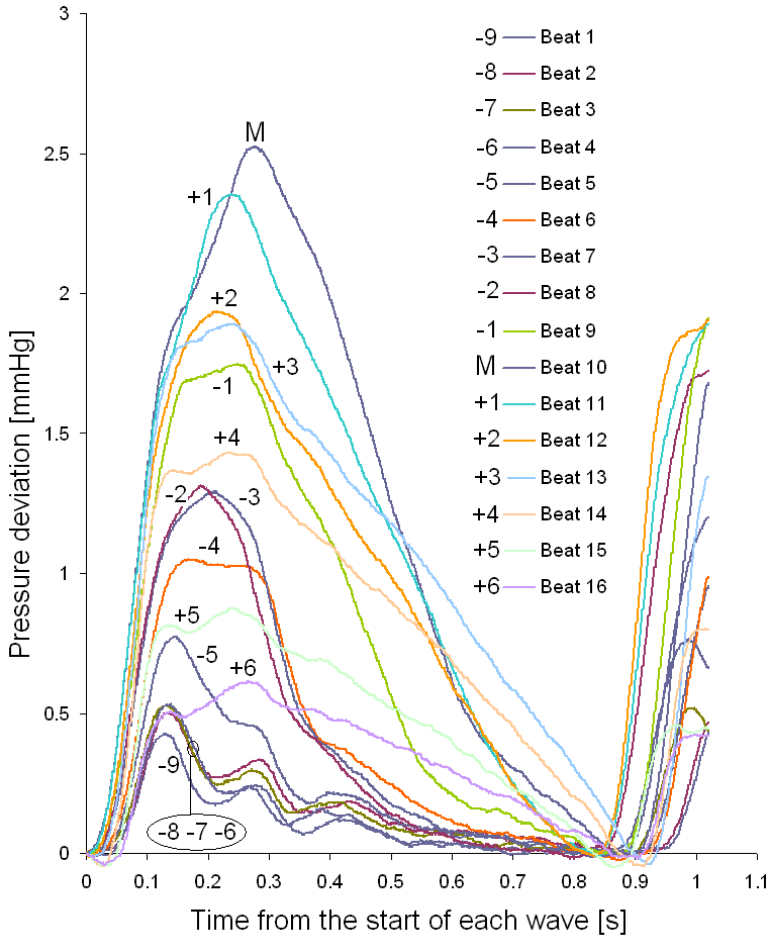


Figure 3. Pressure oscillations envelope versus the cuff pressure and characteristic parameters (DIA, SYS, MAP).

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)



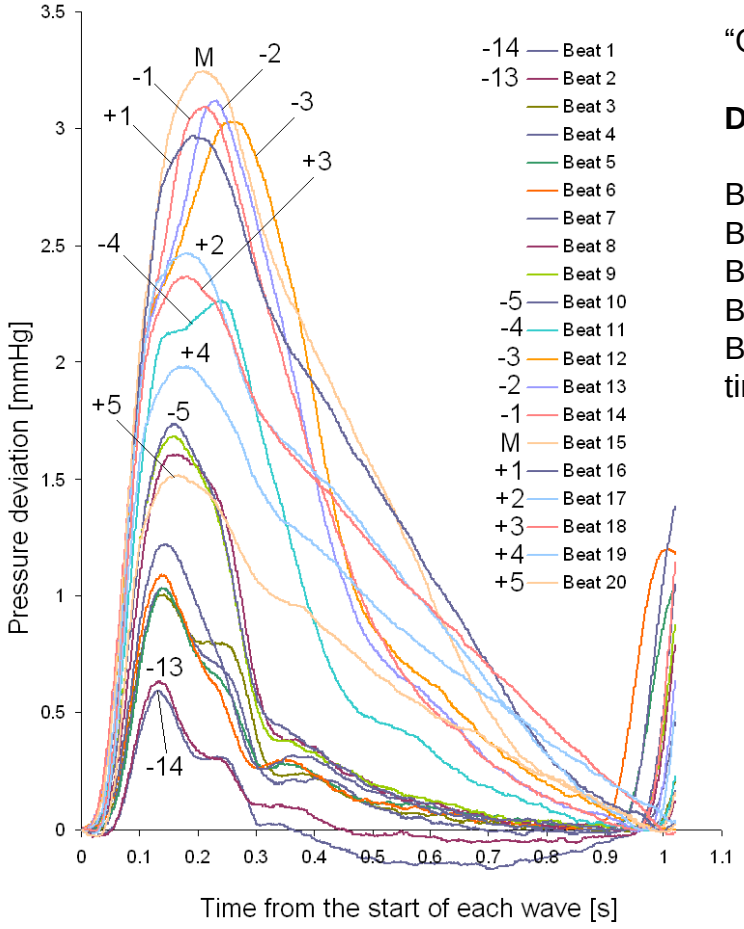
Subject with normal blood pressure

"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: wave with max amplitude, 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

Morphology of the pressure pulses (2/2)

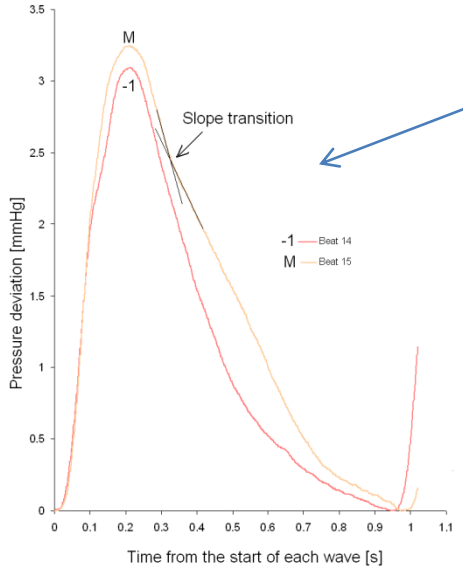


Subject with high blood pressure

"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 distintion 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