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MODELING OF PULSE WAVES IN THE MARKED AREA OF THE RADIUS ARTERY

The topicality of the study of methods for diagnosing the cardiovascular system is due to the fact that its pathologies are the primary factors of mortality of the population all over the world. In order to identify the first signs of circulatory system diseases and their prevention, it is necessary to provide medical facilities with effective diagnostic techniques and automated systems capable of analyzing the state of the cardiovascular system (CS) and providing information on the presence / absence of its dysfunction. This will accelerate the procedure for diagnosis, improve the efficiency of medical diagnosis, develop measures to prevent circulatory system diseases.

In order to carry out pulse wave modeling, we will introduce restrictions on the age of a person, in particular, we will simulate pulsations for the age group of 20-22 without apparent pathologies from the CS.

General view of the mathematical equation of the pulse wave

$$p = p_a + p_0 \cdot cos\omega \ \ t - \frac{1}{v} \ \ + p_0' \cdot \ sin\omega'(t - \frac{1}{v} + \varphi') \ +$$
$$+1{,}5 \cdot p_0'' \cdot \ sin\omega''(t - \frac{1}{v} + \varphi'')$$

or taking into account $\omega'' = \omega' = \frac{\omega}{2} = 3{,}30$ and $p_0''^{\text{brachial}} \approx p_0'^{\text{brachial}}$

$$p = p_a + p_0 \cdot cos\omega \ \ t - \frac{1}{v} \ \ + 1{,}5 \cdot p_0 \cdot \ sin\frac{\omega}{2}(t - \frac{1}{v} + \varphi') \ +$$
$$+1{,}5 \cdot p_0 \cdot \ sin\frac{\omega}{2}(t - \frac{1}{v} + \varphi'')$$

where p_q is atmospheric pressure or pressure in the environment around the vessel,

p_0 is pulse wave amplitude,
$p_0'^{\text{brachial}}$ is amplitude of the dielectric wave,
$p_0''^{\text{brachial}}$ is amplitude of presystolic wave,
ω' is circular frequency of the dicrotic wave,
ω'' is circular frequency of the presistolic wave,
φ' is time delay between systolic and dicrotic components,
φ'' is delay in time between systolic and presystolic components,
v is speed of the pulse wave, m / s,
ω is circular frequency of oscillations,
t is time.

Taking into account the comments to the models that were developed earlier, for the 6 types of pulse, the mathematical equations will look like:

Type of signal "equal pulse"

$$p_{\mathrm{equal}} = 50 + 18{,}75 \cdot cos6{,}61 \cdot \ \ t - \frac{0{,}06}{6{,}8} \ \ + 28{,}13 \cdot \ sin3{,}30 \cdot (t - \frac{0{,}06}{6{,}8} + 0{,}12) \ \ +$$

$$+28{,}13 \cdot \ sin3{,}30 \cdot (t - \frac{0{,}06}{6{,}8} + 0{,}30) \ \ = 50 + 18{,}75 \cdot cos6{,}61 \cdot \ \ t - \frac{0{,}06}{6{,}8} \ \ +$$

$$+28{,}13 \cdot \ sin3{,}30 \cdot (t + 0{,}11) \ \ + 28{,}13 \cdot \ sin3.30 \cdot (t + 0{,}29)$$

Type of signal "uneven pulse"

$$p_{\mathrm{uneven}} = 50 + 18{,}75 \cdot cos6{,}61 \cdot \ \ t - \frac{0{,}06}{6{,}8} \ \ + 28{,}13 \cdot \ sin3{,}30 \cdot (t - \frac{0{,}06}{6{,}8} + 0{,}15) \ \ +$$

$$+28{,}13 \cdot \ sin3{,}30 \cdot (t - \frac{0{,}06}{6{,}8} + 0{,}22) \ \ = 50 \dots 55 + 18{,}75 \cdot cos6{,}61 \cdot \ \ t - 0{,}0088 \ \ +$$

$$+28{,}13 \cdot \ sin3{,}30 \cdot (t + 0{,}14) \ \ + 28{,}13 \cdot \ sin3{,}30 \cdot (t + 0{,}21)$$

Type of signal "high pulse"

$$p_{\mathrm{high}} = 60 + 18{,}75 \cdot cos6{,}61 \cdot \ \ t - \frac{0{,}06}{6{,}8} \ \ + 28{,}13 \cdot \ sin3{,}30 \cdot (t - \frac{0{,}06}{6{,}8} + 0{,}9) \ \ +$$

$$+28{,}13 \cdot \ sin3{,}30 \cdot (t - \frac{0{,}06}{6{,}8} + 0{,}32) \ \ = 60 + 22{,}5 \cdot cos6{,}61 \cdot \ \ t - 0{,}0088 \ \ +$$

$$+34{,}6 \cdot \ sin3{,}30 \cdot (t + 0{,}8) \ \ + 34{,}6 \cdot \ sin3.30 \cdot (t + 0{,}31)$$

Type of signal "low pulse"

$$p_{\mathrm{low}} = 45 + 9{,}4 \cdot cos6{,}61 \cdot \ \ t - \frac{0{,}06}{6{,}8} \ \ + 33{,}8 \cdot \ sin3{,}30 \cdot (t - \frac{0{,}06}{6{,}8} + 0{,}9) \ \ +$$

$$+33{,}8 \cdot \ sin3{,}30 \cdot (t - \frac{0{,}06}{6{,}8} + 0{,}2) \ \ = 45 + 9{,}4 \cdot cos6{,}61 \cdot \ \ t - 0{,}0088 \ \ +$$

$$+33{,}8 \cdot \ sin3{,}30 \cdot (t + 0{,}89) \ \ + 33.8 \cdot \ sin3.30 \cdot (t + 0{,}19)$$

Type of signal "fast pulse"

$$p_{\mathrm{fast}} = 75 + 43{,}13 \cdot cos6{,}61 \cdot \ \ t - \frac{0{,}06}{6{,}8} \ \ + 28{,}13 \cdot \ sin3{,}30 \cdot (t - \frac{0{,}06}{6{,}8} + 0{,}135) \ \ +$$

$$+33{,}8 \cdot \ sin3{,}30 \cdot (t - \frac{0{,}06}{6{,}8} + 0{,}06) \ \ = 75 + 43{,}13 \cdot cos6{,}61 \cdot \ \ t - 0{,}0088 \ \ +$$

$$+33{,}8 \cdot \ sin3{,}30 \cdot (t + 0{,}126) \ \ + 33{,}8 \cdot \ sin3.30 \cdot (t + 0{,}05)$$

Signal type "slow pulse"

$$p_{\mathrm{slow}} = 80 + 20{,}63 \cdot cos6{,}61 \cdot \ \ t - \frac{0{,}06}{6{,}8} \ \ + 16{,}88 \cdot \ sin3{,}30 \cdot (t - \frac{0{,}06}{6{,}8} + 0{,}075) \ \ +$$

$$+16{,}88 \cdot \ sin3{,}30 \cdot (t - \frac{0{,}06}{6{,}8} + 0{,}55) \ \ = 80 + 20{,}63 \cdot cos6{,}61 \cdot \ \ t - 0{,}0088 \ \ +$$

$$+16{,}88 \cdot \ sin3{,}30 \cdot (t + 0{,}066) \ \ + 16{,}88 \cdot \ sin3.30 \cdot (t + 0{,}0465)$$

The simulation will provide the opportunity to further create an expert system for diagnosing the state of the CS.