The Circulation Model

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WindKessel Model

https://www.youtube.com/watch?v=bTFCnuh9lDM

Single Compartment WindKessel Model

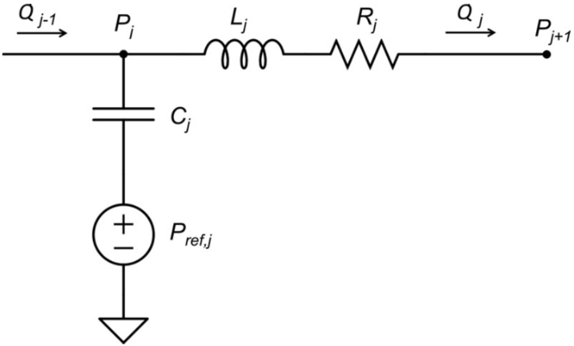

Fig. 3. Single-compartment, windkessel-type model. Q, outgoing blood flow rate; R, resistance; C, compliance; L, inertance; j, j + 1, j − 1, compartment index; P_{ref}, extravascular pressure reference (atmospheric pressure or P_{pl}, depending on the location of j).

Hydraulic Resistance

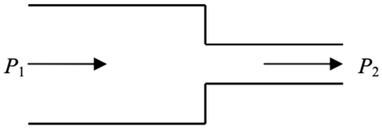

Figure: Hydraulic Resistance

Schematic diagram of cardiovascular system

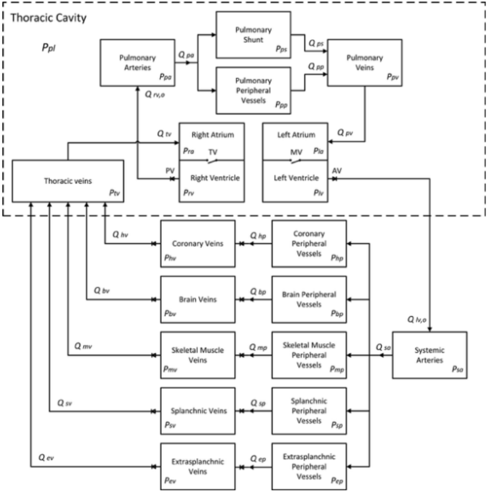

Fig. 2. Schematic diagram of the cardiovascular system model. P, pressure; Q, blood flow; MV, mitral valve; AV, aortic valve; TV, tricuspid valve; PV, pulmonary valve. Subscripts: la, left atrium; lv, left ventricle; lv, o, left-ventricle output; sa, systemic arteries; sp, splanchnic peripheral compartment; sv, splanchnic veins; ep, extrasplanchnic peripheral compartment; ev, extrasplanchnic veins; mp, skeletal muscle peripheral compartment; mv, skeletal muscle veins; bp, brain peripheral compartment; bv, brain veins; hp, coronary peripheral compartment; hv, coronary veins; tv, thoracic veins; ra, right atrium; rv, right ventricle; rv, o, right-ventricle output; pa, pulmonary artery; pp, pulmonary peripheral circulation; ps, pulmonary shunt; pv, pulmonary veins; pl, pleural space.

Auxilary Equations

$$C_{sa} \cdot \frac{dP_{sa}}{dt} = Q_{lv,o} - Q_{sa} \tag{A1}$$

$$L_{sa} \cdot \frac{dQ_{sa}}{dt} = P_{sa} - P_{ep} - R_{sa} \cdot Q_{sa} \tag{A2}$$

$$V_{sa} = C_{sa} \cdot P_{sa} + V_{u,sa} \tag{A3}$$

$$C_{p,eq} \cdot \frac{dP_{ep}}{dt} = Q_{sa} - \sum_j Q_{jp} \tag{A4}$$

$$P_{ep} = P_{sp} = P_{mp} = P_{bp} = P_{hp} \tag{A5}$$

Equation of Pressure and Flow

$$V_j = \underbrace{C_j \cdot P_{tm,j}}_{V_{e,j}} + V_{u,j} \tag{1}$$

PV Relationship of Thoracic Vein Compartment

$$P_{tm,tv} = \begin{cases} D_1 + K_1 \cdot (V_{tv} - V_{u,tv}) - \psi & V_{tv} \geq V_{u,tv} \\ D_2 + K_2 \cdot e^{\frac{V_{tv}}{V_{tv,min}}} - \psi & V_{tv} < V_{u,tv} \end{cases} \tag{2}$$

$$\text{with } \psi = K_{xp} \Big/ \left(e^{\frac{V_{tv}}{K_{xv}}} - 1 \right)$$

Resistance of Thoracic Vein Compartment

$$R_{tv} = K_R \cdot \left(\frac{V_{tv,max}}{V_{tv}} \right)^2 + R_{tv,0} \qquad (3)$$

The resistance of the thoracic veins compartment varies as a function of the volume.

Assumption

Gravity on the cardiovascular system has not been taken into account.

P_{atm} has been assumed to be **Zero**

The End