Prima Journal of Integrated Studies
ISSN (E): 3054-338X
Volume 01, Issue 05, May, 2026
Website: https://researchiapress.com

BIOMECHANICAL PROPERTIES OF BLOOD FLOW AND IMPACT ON THE CARDIOVASCULAR SYSTEM

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Abstract

In progress blood of the flow main biomechanical features , including viscosity , Poiseuille Reynolds 's law turbulence criteria and vein of the wall elasticity in detail seeing Blood is released . of the flow disorders with related cardiological pathologies and their prevent to take methods analysis will be done.

Keywords : biomechanics , blood flow , viscosity , rheology , artery , Reynolds number , atherosclerosis , cardiovascular vein system , hemodynamics.

Introduction

Heart and blood vein diseases (STDs) today on the day world along death and disability main from the reasons one is considered . World health storage According to the World Health Organization (WHO), according to , every year approximately 17.9 million people heart and blood vein from diseases death it will , this and all 32 percent of deaths organization does [1]. This of diseases big part blood of the flow biomechanical disorders — that is blood movement physicist laws and hemodynamic of parameters change with directly Atherosclerosis , hypertension , aneurysm and stenosis such as of diseases pathogenesis understanding for blood of the flow mechanic features study is necessary [2]. Medicine and engineering of sciences at the intersection located biomechanics field last ten in years intense is developing . Calculation hydrodynamics (CFD) and medicine visualization methods merger blood vein inside stream structure in vivo study opportunity is giving [3].

Blood rheological properties – blood simple liquid not , maybe non - Newtonian viscosity liquid is considered . Its viscosity shift depends on shear rate at low speeds high , high at speeds This feature is low . erythrocytes plasticity and aggregated ability with is marked [4]

Blood dynamic viscosity (η) is large veins for approximately 0.003–0.004 Pa·s what organization Hematocrit level (of erythrocytes) blood in size (partial) viscosity directly impact does : hematocrit from 45% to 60% If it increases , viscosity two equally increase possible [4].

Poiseul law and blood of the flow main parameters . Cylindrical laminar flow in a vessel for Poiseul law as follows is expressed as :

$$\mathbf{Q = (p \cdot r^4 \cdot D\ P) / (8 \cdot \eta \cdot L)}$$

Here : Q is the volume stream speed , r — vessel radius , Δ P — pressure difference , η — viscosity , L — vessel length . This from the formula It seems that the current speed vein radius fourth at the level It depends . Therefore for vein 2 times the diameter decreases , the resistance is 16 times increases [5].

This situation clinical point of view from the point of view very important: atherosclerotic plaque (vessel) on the wall cholesterol due to the sum of vein narrowness of the space blood flow sharp reduces and the heart more power spending to work forced does this and eventually heart hypertrophy and to the shortage take arrival possible [5].

Reynolds number and turbulent flow Whether the flow is laminar or turbulent assessment The Reynolds number (Re) is used for :

$$\mathbf{Re = (\rho\ v\ D) / \eta}$$

Here : ρ — blood density (~1060 kg/m³), v — average stream speed , D — vessel diameter . If Re < 2100 — laminar flow , if Re > 4000 — turbulent flow .

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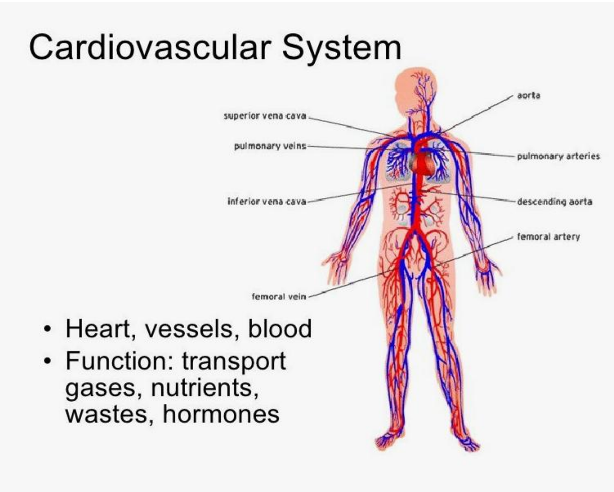
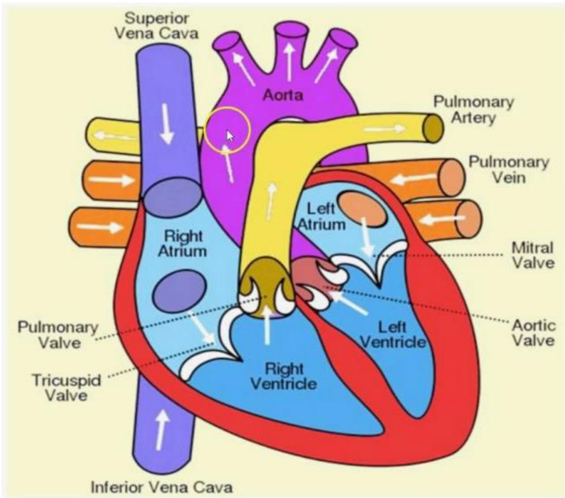
Physiological under the circumstances Re in the aorta is between 1000–2000 is systematic blood rotation mainly in laminar mode works [6].
Turbulent flow endothelial cells mechanic injures , inflammation mediators activates and atherosclerotic plaque harvest to be for conditions creates . Aortic bifurcation and coronary arteries turn points turbulence typical places is [6].





Vein of the wall elasticity and wave spread . Arteries — only passive pipe not, maybe asset elastic structures . Vein wall collagen and elastin fibers consists of is pulsating blood flow leveling (Windkessel effect) function This function performs heart your work efficiency increases and distal tissues continuous blood delivery gives [7].
Vein elasticity indicator — impulse wave spread speed (Pulse Wave Velocity, PWV). Healthy in person PWV in the aorta 5–7 m/s, age and atherosclerotic in patients and up to 12–15 m/s rise possible . PWV 's increase in arterial stiffness marker cardiovascular the danger in evaluation independent forecast indicator is [7].
On the wall cutter Wall Shear Stress . cutter stress (WSS — Wall Shear Stress) vessel wall to the surface blood flow by applicable tangential power is :

$$\tau = \eta\ (dv/dr)$$

Normal physiological WSS is in the range of 1–7 Pa. is endothelial cells for protection Low WSS (<0.4 Pa) is a sign of atherosclerotic plaque to develop inclined in the regions High WSS (> 40 Pa) — aneurysm to the formation and vein of the wall to injury take arrival possible [8]

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Diagnostic methods Blood of the flow biomechanical violations determination for modern in medicine following methods applies to :

– Doppler ultrasound blood test of the flow speed and real -time route measurement opportunity gives . Vein stenosis , thrombosis and arteriovenous fistula in determining is used [9];

– 4D flow MRI (4D Flow MRI) — three measurable stream structure time according to visualization to do . Aorta and kidney In vivo measurement of WSS in arteries for gold standard is [10];

– Calculation hydrodynamics (CFD) — patient CT/MRI data based on vein inside the flow mathematician Modeling . Surgery intervention before the danger in evaluation wide is used [11];

– Impulse wave speed measurement (PWV) — arterial hardness evaluation simple and cheap method is cardiological screen for convenient [7].

Clinical and therapeutic approaches . Antihypertensive Therapy : ACE inhibitors and sartan group preparations vein tone down , on the wall cutter voltage to normalize help gives [12];

– Statins : blood lipoproteins reduce with one in line endothelial function restores and WSS normalization contribution addictive [12];

– Stenting and cylinder angioplasty : vessel lumen expanded , Poiseuil to the law appropriate stream speed restored (r^4 correlation because of small change gives great results) [13];

– Aerobic physical Exercises : regular walking , swimming and bicycle driving arterial elasticity increases PWV reduces and endothelial WSS sensor it is well - known [14];

– Diet control : salt consumption reduce omega- 3 fatty acids multiplied diet blood viscosity reduces and rheological indicators improves [14].

Engineering and technological solutions . Biomechanical to principles based medical devices working exit field intense is developing . Artificial heart ventricle LVADs (Loss-of- Life Devices) Poiseuille and Bernoulli laws based on designed blood of the flow hemodynamic parameters to optimize intended [15].

Bioengineering vein dentures working on the way out endothelial to cells suitable incoming WSS range provision solution doer role plays . Last 3D printing research release technology using individually tailored to the patient stents create opportunity shows [15].

Conclusion

This in the article blood of the flow main biomechanical properties — rheological parameters , Poiseuille law , Reynolds number , vessel elasticity and on the wall cutter voltage — systematic accordingly seeing These parameters are every one heart and blood vein normal and pathological circumstances in understanding important role plays .

Received information this shows that atherosclerosis , hypertension and aneurysm such as of diseases pathogenesis blood of the flow biomechanical disorders with integral is related to . Poiseuille to the law according to , vein diameter small change stream against fourth level impact to show blood vein diseases early in stages of determination clinical importance further increases .

Modern diagnostics methods (4D Flow MRI, CFD modeling , PWV measurement) biomechanical indicators in vivo assessment opportunity is giving . Therapeutic approaches and not only the disease medicine with treatment , but also arterial elasticity to increase aimed at physical activity and diet also your recommendations inside to receive necessary .

In the future artificial intellect algorithms and medical visualization merger blood of the flow biomechanical analysis clinical of practice inseparable to the part to convert this is expected and cardiovascular of diseases prevent in receiving new opportunities opens .

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