

Contents

1 Hemorheology and Hemodynamics	1
1.1 Historical Remarks	1
1.2 The Human Circulatory System	14
1.2.1 Systemic Circulation	14
1.2.2 Mathematical Models for Blood Flow Dynamics	17
1.3 Blood Rheology	38
1.3.1 Blood Components	38
1.3.2 Non-Newtonian Properties of Blood	40
1.3.3 Constitutive Models for Blood	44
1.4 Hemodynamics and Microcirculation	50
1.4.1 A New Approach to Modeling Microcirculation	50
1.4.2 The Microcirculation Model	52
1.5 Vasomotion	55
1.5.1 The Elusive Phenomenon of Vessel Oscillations	55
1.5.2 Arterioles	58
1.5.3 Venules	60
1.6 Atherosclerosis	62
1.6.1 The Pathogenesis of Atherosclerosis	63
1.6.2 Mathematical Modeling	64
References	67
2 Blood Coagulation	79
2.1 Introduction	79
2.2 Historical Remarks	81
2.3 Cells and Proteins Intervening in the Formation and Dissolution of Clots	88
2.3.1 Blood Cells and Coagulation	89
2.3.2 Platelets Regulators	94
2.3.3 The Coagulation Factors	95
2.3.4 Fibrinolysis Factors	100
2.3.5 Factors Inhibitors	101

2.4	The Cell-Based Model for Secondary Hemostasis	102
2.4.1	Secondary Hemostasis	103
2.4.2	Fibrinolysis	108
2.5	Bleeding Disorders	109
2.6	The 3-Pathway Cascade Model	117
2.7	Anticoagulant Drugs, Thrombolytic Drugs, Hemophilia Therapies	120
2.7.1	Anticoagulant Drugs	120
2.7.2	Thrombolytic Drugs	124
2.7.3	Hemophilia Therapies	124
2.8	Mathematical Models for Blood Coagulation	125
2.8.1	ODE's Models	126
2.8.2	PDE's Models	131
	References	146
3	Blood Filtration in Kidneys	159
3.1	Historical Remarks	159
3.2	General Structure of Kidneys	161
3.3	Calculating Glomerular Filtration Rate	165
3.4	The Steady Flow and the Glomerular Filtration Rate	168
	References	170
4	Extracorporeal Blood Ultrafiltration	171
4.1	Historical Remarks	171
4.2	The Hollow Fibers Dialyzer	174
4.2.1	General Description of the Apparatus	174
4.2.2	A Mathematical Model Based on the Upscaling Technique	177
4.2.3	Modeling the Device	179
4.2.4	Modeling the Body Reaction	190
4.2.5	Modeling the Evolution of Masses and Volumes	192
4.3	Numerical Simulations	196
4.4	Going Further	199
	References	201
5	Extracorporeal Blood Oxygenation	205
5.1	About Extracorporeal Blood Treatments	205
5.2	Gases in Blood	206
5.3	Historical Remarks	206
5.4	Mathematical Models	212
5.4.1	Heart-Lung Machine	212
5.4.2	ECMO	215
5.4.3	IMO	220
	References	222
6	Blood and Heat Transfer	227
6.1	Historical Remarks	227

6.2	The Bioheat Equation	231
6.3	Hyperthermia: General Characteristics and Historical Information	234
6.4	Mathematical Models	237
6.4.1	Hyperthermia	237
6.4.2	Assessing the Thermal Damage	241
6.4.3	Therapeutic Hypothermia	243
6.4.4	Laser Induced Thermal Therapy (LITT).....	245
6.5	Treatments by High Intensity Focused Ultrasound (HIFU)	250
	References	255
7	Thermal Ablative Procedures in the Treatment of Heart Arrhythmia	265
7.1	Physiological and Historical Notes	265
7.2	Importance of Mathematical Models	275
7.3	RF Ablation Models	278
7.4	Cryoablation Models	283
	References	287
8	Blood and Cancer	295
8.1	Historical Remarks	295
8.2	Hematopoiesis and Types of Blood Cancer	298
8.3	Mathematical Models	307
8.3.1	Hematopoiesis: Onset of Leukemic Disorders	307
8.3.2	Cyclic Leukemic Disorders	309
8.3.3	Treatment of Leukemic Disorders	313
8.3.4	Leukemia and the Immune Response	319
8.3.5	Bone Marrow/HSCs Transplantations	322
	References	324
	Index	331

Hemomath

The Mathematics of Blood

Fasano, A.; Sequeira, A.

2017, XVII, 340 p. 99 illus., 60 illus. in color., Hardcover

ISBN: 978-3-319-60512-8