

Role of platelets in blood–biomaterial interactions

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Abstract. Over 2 million cardiovascular procedures are performed annually in the United States. Every one of these procedures requires some period of contact with blood with several different biomaterials used in the manufacture of assist devices or implant devices. In view of the increasing importance of the biomaterials in clinical practice, it would be timely to review briefly physicochemical characterization as well as biological evaluations. Blood compatibility encompasses a variety of events associated with blood interaction with the biomaterials used in various procedures. Two separate coagulation mechanisms are involved (arterial and venous) depending upon the flow characteristics. At least three interacting factors modulate normal hemostasis and the pathogenesis of thromboembolic events. They are the state of activation of coagulation cascade, circulating levels of thrombin and fibrinogen and relative activity of platelets. In this overview we discuss the current concepts on the role of platelets in blood–biomaterial interactions.

When blood contacts a biomaterial surface a variety of blood components interact with the surface. Some of the key players in platelet activation on biomaterial surface include fibrinogen and von Willebrand factor. Currently available antiplatelet drugs effectively block aggregation and secretion induced by physiological agonists such as epinephrine, adenosine diphosphate and thromboxane in suspension. However, they do not prevent platelet interaction on biomaterial surfaces. Mechanisms involved in platelet activation in suspension and on surfaces as well as the pharmacology of newer antiplatelet drugs will be discussed.

Keywords. Platelet adhesion; protein adsorption; biomaterials; surface induced platelet activation; fibrinogen; platelet-surface receptors; antiplatelet drugs.

1. Introduction

The adhesion of circulating platelets at sites of injury on the vessel wall where subendothelium, in particular collagen, is exposed to the flowing blood, is known to be an important step in a sequence of events leading to the formation of a hemostatic plug (Mustard and Packham 1975). With the development of prosthetic devices and artificial organs, the study of platelet adhesion and thrombus formation on synthetic polymer surfaces has become very important in assessing the compatibility of biomaterials to blood. A clear understanding of the blood interactions with artificial surfaces would promote a better utilization of existing materials and the development of new materials with improved properties.

1.1 Contribution of platelets to thrombus formation

1.1a Platelet morphology, physiology and function: Platelets are the disc-shaped fragments of bone marrow megakaryocytes circulating in blood. They are about $250,000 \pm 80,000$ per μl . They have a life span of 8–10 days and play a critical role in the recognition of vascular injury, formation of effective hemostatic plugs, retraction of clots and wound healing. However, when hyperactive,

they can initiate events leading to clinical complications associated with cardiovascular and cerebrovascular diseases. Although completely nonsticky in the resting state, they become sticky with the slightest stimulation. The degree of activation depends on the strength of the stimulus and the type of signal generated by ligand–receptor interaction. Four well developed stages of activation are recognized: (i) development of stickiness, (ii) changes in cell shape, (iii) contraction and release of granule contents and (iv) irreversible aggregation.

Platelet plasma membranes contain transmembrane proteins as well as glycoproteins. Glycoproteins serve as the receptors for agonist/surface-mediated stimuli initiating platelet activation. Platelets contain integrin and nonintegrin domains in their plasma membranes. Integrins are transmembrane glycoproteins with α and β units coupled noncovalently (GPIIb–IIIa, GPIa–IIa, GPIc–IIa). They participate in both cell–cell and cell–matrix interactions. In addition, there are nonintegrin glycoprotein domains on platelets capable of interacting with acromolecules such as vWF and collagen (GPIV, GPIb).

1.1b Role of platelets in thrombosis: Circulating platelets rapidly adhere to the subendothelial matrix, become activated, adhere, spread, release the contents of various storage organelles and become cohesive, leading to

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The Role of Platelets in Blood-Biomaterial Interactions E Missirlis,J-L. Wautier,2012-12-06 Medicine and engineering work together towards solutions for biomedical problems The interactions of blood elements with artificial materials bags tubes artificial organs etc require many disciplines for its understanding Thus the effort presented in this book is the culmination of a genuine discussion on the problems arising in blood banks in hospitals in biomaterials development in experimental hemocompatibility testing when platelets interact with biomaterials Hematologists chemists biologists and engineers have tried to put their own point of view and to understand the point of view of the other disciplines The main themes that are presented in the discussion are Platelet collection storage and transfusion Hemostasis and anticoagulation Platelet and biomaterials extracorporeal circulation and implanted materials Hemorheological parameters Modulation of platelet function Biological tests for evaluating platelet biomaterial interactions LIST **Manual of Blood Platelets:**

Morphology, Physiology and Pharmacology Gundu HR Rao,2018-11-30 Platelets are tiny blood cells that help the body form clots to stop bleeding Antiplatelet medications such as aspirin and clopidogrel are commonly used to thin the blood which limits clotting and reduces the risk of heart attack This book is a comprehensive guide to blood platelets for haematologists Beginning with discussion on platelet structure morphology function and physiology the next chapters cover the role of calcium in platelet activation and calcium modulation by cyclic nucleotides The following sections explain the pharmacology of antiplatelet drugs antiplatelet therapies aspirin resistance and the association of diabetes mellitus with major platelet dysfunction The book concludes with chapters on acute coronary problems interaction between endothelial cells and platelets and blood biocompatibility studies Authored by a Minneapolis based expert in the field the text is further enhanced by clinical photographs diagrams and tables Key points Comprehensive guide to blood platelets for haematologists Extensive coverage of antiplatelet drugs and resistance Recognised author from University of Minnesota Highly illustrated with clinical photographs diagrams and tables Hemocompatibility of Biomaterials for Clinical Applications Christopher Siedlecki,2018-03-05 Hemocompatibility of Biomaterials for Clinical Applications Blood Biomaterials Interactions summarizes the state of the art on this important subject The first part of the book reviews the latest research on blood composition and response mechanisms of coagulation test standards and methods Next the book assesses techniques for modifying biomaterial surfaces and developing coatings to improve hemocompatibility In the final sections users will find discussions on ways to improve the hemocompatibility of particular classes of biomaterials and a review of methods for improving medical devices Provides comprehensive information on the fundamentals of hemocompatibility and new technologies Combines research in the biomaterials field in a digestible format for clinical applications Provides a complete overview biomaterials in current use and test methods *An Introduction to Tissue-Biomaterial Interactions* Kay C. Dee,David A. Puleo,Rena Bizios,2003-03-31 An Introduction to Tissue Biomaterial Interactions acquaints an undergraduate audience with the

fundamental biological processes that influence these sophisticated cutting edge procedures Chapters one through three provide more detail about the molecular level events that happen at the tissue implant interface while chapters four through ten explore selected material biological and physiological consequences of these events The importance of the body s wound healing response is emphasized throughout Specific topics covered include Structure and properties of biomaterials Proteins Protein surface interactions Blood biomaterial interactions Inflammation and infection The immune system Biomaterial responses to implantation Biomaterial surface engineering Intimal hyperplasia and osseointegration as examples of tissue biomaterial interactions The text also provides extensive coverage of the three pertinent interfaces between the body and the biomaterial between the body and the living cells and between the cells and the biomaterial that are critical in the development of tissue engineered products that incorporate living cells within a biomaterial matrix Ideal for a one semester biomedical engineering course An Introduction to Tissue Biomaterial Interactions provides a solid framework for understanding today s and tomorrow s implantable biomedical devices

Handbook of Polyester Drug Delivery Systems M. N. V. Ravi Kumar, 2017-03-27 In the quest for innovative drug delivery systems attempting to meet the unmet needs in pharmaceutical space research has taken a much more complicated path that poses a significant challenge for translation Despite the progress made with novel materials polyesters still remain at the helm of drug delivery technologies This book provides a single source of reference of polyester drug delivery systems that covers a broad spectrum of materials design manufacturing techniques and applications

Subject Index of Current Research Grants and Contracts Administered by the National Heart, Lung and Blood Institute National Heart, Lung, and Blood Institute, 1979

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Biomaterials Surface Science Andreas Taubert, Joao F. Mano, José Carlos Rodríguez-Cabello, 2013-07-23 At the interface of biology chemistry and materials science this book provides an overview of this vibrant research field treating the seemingly distinct disciplines in a

unified way by adopting the common viewpoint of surface science The editors themselves prolific researchers have assembled here a team of top notch international scientists who read like a who's who of biomaterials science and engineering They cover topics ranging from micro and nanostructuring for imparting functionality in a top down manner to the bottom up fabrication of gradient surfaces by self assembly from interfaces between biomaterials and living matter to smart stimuli responsive surfaces and from cell and surface mechanics to the elucidation of cell chip interactions in biomedical devices As a result the book explains the complex interplay of cell behavior and the physics and materials science of artificial devices Of equal interest to young ambitious scientists as well as to experienced researchers

Handbook of Platelet Physiology and Pharmacology Gundu H.R. Rao, 2012-12-06 Handbook of Platelet Physiology and Pharmacology represents the first comprehensive work to review blood platelet biochemistry physiology pharmacology and function This edited volume provides up to date information on how platelets function the biochemical mechanisms that modulate their physiology and function as well as the pharmacology of platelet inhibitory drugs The book presents an excellent overview of biochemistry receptor biology signaling mechanisms calcium homeostasis molecular pathology and comparative physiology of platelets as well as the pharmacology of antiplatelet drugs and clinical trials Handbook of Platelet Physiology and Pharmacology will prove a useful reference for hematologists cell biologists biochemists pathologists and other researchers in the areas of cell biology pathobiology atherosclerosis thrombosis and biomedical engineering

Immobilised Macromolecules: Application Potentials U.B. Sleytr, P. Messner, D. Pum, M. Sara, 2013-06-29 Immobilized functional biomolecules particularly enzymes are important tools in biotechnology biochemistry biochemical engineering biomedicine and biosensor research This book provides an introduction and overview of selected major areas of the science and technology of immobilized systems The chapters are intended as an introduction and overview to these interdisciplinary areas as well as a source of practical details and of new research trends This book will be useful for scientists technologists academics and students in direct and related fields

Indian Science Abstracts, 1999-11 **Biomaterials Science** Buddy D. Ratner, 2004-07-29 Completely revised and expanded update of the best selling classic text reference which defined an entire subject field

Encyclopedic Handbook of Biomaterials and Bioengineering: v. 1-2. Applications Donald Lee Wise, 1995

Adverse Reactions to Biomaterials: State of the Art in Biomaterial Risk Assessment, Immunomodulation and In Vitro Models for Biomaterial Testing Nihal Engin Vrana, Amir M. Ghaemmaghami, Pinar Zorlutuna, 2019-05-15 Adverse immune reactions to biomaterials are important bottlenecks for translation of novel biomaterials for clinical use Moreover recent advances in highthroughput biomaterial discovery and synthetic biology while providing exciting new avenues also significantly increases potential risks related to the in vivo reactions to these new materials For example the novel materials might have unintended biological activities due to their natural building blocks In this perspective biomaterial field needs i better understanding of cell biomaterial interactions at systems level ii development

of new analysis and testing tools for advanced risk assessment iii tools and technologies for modulating reactions to biomaterials and iv advanced in vitro models for understanding and testing of reactions to biomaterials In the following collection of articles you will find examples of such systems together with comprehensive reviews of current developments in in vitro model systems The collection also contains articles that elucidate the immune reaction to biomaterials in vitro and in vitro

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phenomena and mechanisms of biomaterials performance a whole chapter dedicated to the biomaterials industry itself including guidance on regulations standards and guidelines litigation and ethical issues to prepare students for industry informative glossaries of key terms engaging end of chapter exercises and up to date lists of recommended reading Drawing on the author's forty years experience in biomaterials this is an indispensable resource for students studying these lifesaving technological advances

Biomaterials Science William R Wagner, Shelly E. Sakiyama-Elbert, Guigen Zhang, Michael J. Yaszemski, 2020-05-23 The revised edition of the renowned and bestselling title is the most comprehensive single text on all aspects of biomaterials science from principles to applications Biomaterials Science fourth edition provides a balanced insightful approach to both the learning of the science and technology of biomaterials and acts as the key reference for practitioners who are involved in the applications of materials in medicine This new edition incorporates key updates to reflect the latest relevant research in the field particularly in the applications section which includes the latest in topics such as nanotechnology robotic implantation and biomaterials utilized in cancer research detection and therapy Other additions include regenerative engineering 3D printing personalized medicine and organs on a chip Translation from the lab to commercial products is emphasized with new content dedicated to medical device development global issues related to translation and issues of quality assurance and reimbursement In response to customer feedback the new edition also features consolidation of redundant material to ensure clarity and focus Biomaterials Science 4th edition is an important update to the best selling text vital to the biomaterials community The most comprehensive coverage of principles and applications of all classes of biomaterials Edited and contributed by the best known figures in the biomaterials field today fully endorsed and supported by the Society for Biomaterials Fully revised and updated to address issues of translation nanotechnology additive manufacturing organs on chip precision medicine and much more Online chapter exercises available for most chapters

Green Biorenewable Biocomposites Vijay Kumar Thakur, Michael R. Kessler, 2016-01-05 Keeping in mind the advantages of bio based materials this book focuses on the potential efficacy of different biocomposites procured from diverse natural resources and the preparation and processing of the biocomposites to be used for a variety of applications Each chapter gives an overview on a particular biocomposite material and its processing

Polyurethanes in Biomedical Applications Nina M. K. Lamba, 2017-10-19 Polyurethanes in Biomedical Applications studies the use of polyurethanes in implanted medical devices This analysis describes the concepts of polymer science the manufacture of polyurethanes and the biological responses to implant polyurethanes reflecting the developments in biomaterials science and the interdisciplinary nature of bioengineering

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