Connective Tissues in Arterial and Pulmonary Disease

Edited by
Thomas F. McDonald
A. Bleakley Chandler

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Thomas F. McDonald, Ph.D.
Professor of Anatomy
Associate Dean for Basic Sciences
Medical College of Georgia

A. Bleakley Chandler, M.D.
Professor of Pathology
Chairman, Department of Pathology
Medical College of Georgia

With 66 Figures

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Thomas F. McDonald, Ph.D.
Associate Dean for Basic Sciences
School of Medicine
Medical College of Georgia
Augusta, Georgia 30912, U.S.A.

A. Bleakley Chandler, M.D.
Chairman, Department of Pathology
School of Medicine
Medical College of Georgia
Augusta, Georgia 30912, U.S.A.

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Connective Tissues in Arterial and Pulmonary Disease

Participants: Seated, left to right: Drs. Rosenquist, Glagov, Puchtler, Foster, Oegema; standing, left to right: Drs. Rhodes, Kramsch, Turino, Caulfield, Snider, Schiebler

Preface

The processes of distention and recoil have an essential role in the functions of arteries and lungs. In both organ systems, these processes involve to a great extent the connective tissues, in particular the manner in which the extracellular materials are arranged to afford such movements. This book concerns the microenvironment of the connective tissues in the walls of arteries and the stroma of lungs.

Proteoglycans, collagen, and elastic fibers and their interrelationships are discussed by eight scientists who are established researchers in this area. Their reports include important findings on how this microenvironment is altered in diseases such as atherosclerosis, emphysema, and pulmonary fibrosis. The concepts developed result from studies at the biochemical, macromolecular, ultrastructural, and light microscopic levels. Taken collectively, the reports focus attention upon the role of the connective tissues in arterial and lung distensibility and how alterations in the connective tissues result in the loss of this function.

Medical researchers and physicians interested in arterial or lung functions or diseases will find the scientific approaches and findings of the authors innovative and provocative. Students of stereologic morphometry will be particularly interested in the quantitative studies of cells and fibers in arterial walls; histologists and pathologists will find the chapter on histochemical staining interesting from both a scientific and historic viewpoint.

The papers were presented at the Symposium on Connective Tissues in Arterial and Pulmonary Disease conducted in honor of Dr. Holde Puchtler, October 15, 1980, in Augusta, Georgia. Since the discussions following presentation of the papers were informative and often illuminating, they have been edited and included here.

Thomas F. McDonald
A. Bleakley Chandler

Acknowledgments

This Symposium was held in Augusta, Georgia, in conjunction with the 20th annual meeting of the Southern Society of Anatomists and was sponsored by the Department of Pathology, Medical College of Georgia.

The Organizing Committee consisted of Thomas F. McDonald, Chairman; Dale E. Bockman, President, Southern Society of Anatomists; A. Bleakley Chandler, Faye Sweat Waldrop, Linda L. Vacca, David A. Welter, J. Robert Teabeaut II, and Benjamin O. Spurlock. The endorsement and support of the officers and members of the Southern Society of Anatomists are especially appreciated. Many others contributed to the success of this Symposium, including Eric Weiss, D. Greer Falls, Mark B. Barrett, Louise M. Markwalter, Marie F. Hiller, W. Thomas Broome, J. Michael Barrett, Fannie M. Mitchell, Heidi L. Valenzuela, Frank H. Gearhart, W. Clay Adamson, Susan N. Meloan, Octavia Garlington, Julie G. Guillebeau, Stanley R. Leida, Deborah I. Pomeroy, Delmar R. Staecker, Alex H. Vaughn, Dale W. Sickles, Gurkirpal S. Sohal, and Patricia O'Meara, all on the staff and faculty of the Medical College of Georgia.

The generous contributions of all those participants who made this Symposium so successful through their formal presentations and lively, productive discussions are gratefully acknowledged.

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Authors and Discussants

Sergio E. Bustos-Valdes, Ph.D., Department of Dental Biochemistry, Medical College of Georgia, Augusta, Georgia 30912, U.S.A.

James B. Caulfield, M.D., Department of Pathology, University of South Carolina, School of Medicine, Columbia, South Carolina 29208, U.S.A.

A. Bleakley Chandler, M.D., Department of Pathology, Medical College of Georgia, Augusta, Georgia 30912, U.S.A.

Ronald R. Cowden, Ph.D., Department of Basic Sciences, East Tennessee State University College of Medicine, Johnson City, Tennessee 37601, U.S.A.

Tukaram V. Darnule, Ph.D., Department of Medicine, Columbia University College of Physicians and Surgeons, New York, New York 10032, U.S.A.

Judith A. Foster, Ph.D., Department of Biochemistry, University of Georgia, Athens, Georgia 30602, U.S.A.

Rogers M. Fred III, B.S., Department of Zoology, University of Georgia, Athens, Georgia 30602, U.S.A.

Seymour Glagov, M.D., Department of Pathology, University of Chicago, Chicago, Illinois 60637, U.S.A.

Joseph Grande, Ph.D., Department of Pathology, University of Chicago, Chicago, Illinois 60637, U.S.A.

Stephen Keller, Ph.D., Department of Pathology, Columbia University College of Physicians and Surgeons, New York, New York 10032, U.S.A.

Dieter M. Kramsch, M.D., Department of Medicine and Biochemistry, Boston University Medical Center, Boston, Massachusetts 02118, U.S.A.

Ines Mandl, Ph.D., Department of Obstetrics and Gynecology, Columbia University College of Physicians and Surgeons, New York, New York 10032, U.S.A.

Thomas F. McDonald, Ph.D., Department of Anatomy, Medical College of Georgia, Augusta, Georgia 30912, U.S.A.

Susan N. Meloan, Department of Pathology, Medical College of Georgia, Augusta, Georgia 30912, U.S.A.

William H. Moretz, M.D., President, Medical College of Georgia, Augusta, Georgia 30912, U.S.A.

Theodore R. Oegema, Jr., Ph.D., Department of Orthopedic Surgery, University of Minnesota, Minneapolis, Minnesota 55455, U.S.A.

Harry B. O'Rear, M.D., Vice Chancellor for Health Affairs, University System of Georgia, Atlanta, Georgia 30334, U.S.A., and former President, Medical College of Georgia, Augusta, Georgia, U.S.A.

Mohamed M. Osman, D.V.M., Department of Medicine, Columbia University College of Physicians and Surgeons, New York, New York 10032, U.S.A.

Holde Puchtler, M.D., Department of Pathology, Medical College of Georgia, Augusta, Georgia 30912, U.S.A.

R. Kent Rhodes, Ph.D., Department of Biochemistry and Institute of Dental Research, University of Alabama, Birmingham, Alabama 35294, U.S.A.

Celeste B. Rich, M.S., Department of Biochemistry, University of Georgia, Athens, Georgia 30602, U.S.A.

Thomas H. Rosenquist, Ph.D., Department of Anatomy, Medical College of Georgia, Augusta, Georgia 30912, U.S.A.

Theodore H. Schiebler, M.D., The Anatomical Institute, University of Würzburg, Würzburg, Federal Republic of Germany

Gordon L. Snider, M.D., Department of Medicine, Boston University School of Medicine, Boston, Massachusetts 02118, U.S.A.

Gerard M. Turino, M.D., Department of Medicine, Columbia University College of Physicians and Surgeons, New York, New York 10032, U.S.A.

Draga Vesselinovitch, D.V.M., Department of Pathology, University of Chicago, Chicago, Illinois 60637, U.S.A.

Faye Sweat Waldrop, Department of Pathology, Medical College of Georgia, Augusta, Georgia 30912, U.S.A.

Shiu Yeh Yu, Ph.D., Department of Pathology, St. Louis University School of Medicine, St. Louis, Missouri 63125, U.S.A.

Christopher K. Zarins, M.D., Department of Surgery, University of Chicago, Chicago, Illinois 60637, U.S.A.

Contents

Part II
Connective Tissues in Pulmonary Disease
Thomas H. Rosenquist, Chairman

Part III
Holde Puchtler: An Appreciation

Part I
Connective Tissues in Arterial Disease

JAMES B. CAULFIELD, *Chairman*

Introduction

JAMES B. CAULFIELD

The presence of connective tissue throughout many phyla has been well demonstrated for many years (Homgren E [1907] Ueber die Trophospongien der quersteiften Muskelfasern nebst Bemerkungen über den allgemeinen Bau dieser Fasern. Arch Mikr Anat 71: 165-247). Early workers tended to use heavy metal impregnation techniques which outline in exquisite detail some of the fibrillar components of connective tissue. This reaction seemed to be more dependent upon the size of the fibrils than upon their chemical composition. The heavy metal approach was supplemented by tinctorial dyes, with the color variations empirically determined rather than being predetermined by specific chemical reactions defined by the investigator. These procedures, when augmented by polarizing optics and reasonably specific enzyme digestion techniques, allowed further identification and definition of the function of some of the extracellular components (Bairati A, [1937] Struttura e proprietà fisiche del sarcolemma della fibra muscolare striata. Z Zellforsch 27: 100-124; Banus PJ, Chur BM, Wayland H [1969] On the mechanical behavior of elastic animal tissue. Trans Soc Rheology 13: 83-102).

A more complete understanding of the disposition of connective tissue requires careful identification of the components and development of specific techniques for localizing and quantitating these materials in tissue. The results can then be related to the physical properties of the various materials present, and an idea of the relationship of connective tissue to specific organ function can be synthesized.

The first session of this symposium approaches a number of these problems with respect to the arterial wall. Clearly, connective tissue is a complex of fibrillar and nonfibrillar compo-

nents. The chemistry and structure of two of these components, proteoglycans and collagen, are covered in the first and fourth papers. The new information does not yet tend to simplify the problems of understanding the form and function of vascular connective tissue; rather it clearly indicates the complexity built into vessel walls. Utilizing morphometric techniques, the second paper points the way to identifying and quantitating the components, both cellular and matrical, of the aortic wall. The third paper, utilizing many of the techniques derived from basic chemistry and morphometry, approaches a major problem in the Western world, atherosclerosis.

The contributions of Dr. Holde Puchtler to the basic question of identifying and localizing the connective tissue components are presented in the final paper of this symposium. Morphometry requires precise identification, which Dr. Puchtler's histochemical techniques provide on a scale that permits sampling of large amounts of tissue. This is important in examining normal tissue and crucial to investigating the abnormal. The symposium emphasized the need to combine various techniques in order to work with and eventually understand the role of connective tissue.

Structure and Function of Aorta Proteoglycan

THEODORE R. OEGEMA, JR.

Ever since the extracellular matrix was first viewed through early microscopes, the matrix has been the subject of much speculation and its components the bearers of such fanciful names as amorphous ground substance. In recent years, major strides have been made in the development of methods to study the matrix. They include new techniques for exploring the biochemistry of two major components of the matrix, collagen and proteoglycan; advances in methods for culturing cells from these tissues; and new staining and other microscopic procedures for viewing the tissue and localizing the components. This multidiscipline approach is now in the process of revolutionizing the understanding of connective tissue structure and metabolism. This discussion outlines the current status of a study of proteoglycan structure and speculates on possible relationships to function in aorta.

PROTEOGLYCAN STRUCTURES

Proteoglycans are covalent complexes of protein and glycosaminoglycans. Although Morner isolated glycosaminoglycans from aorta as early as 1895, the major structural features of the molecules were not worked out until the 1950's by Meyer and others (Rodén and Horowitz 1978). The subtle features such as the

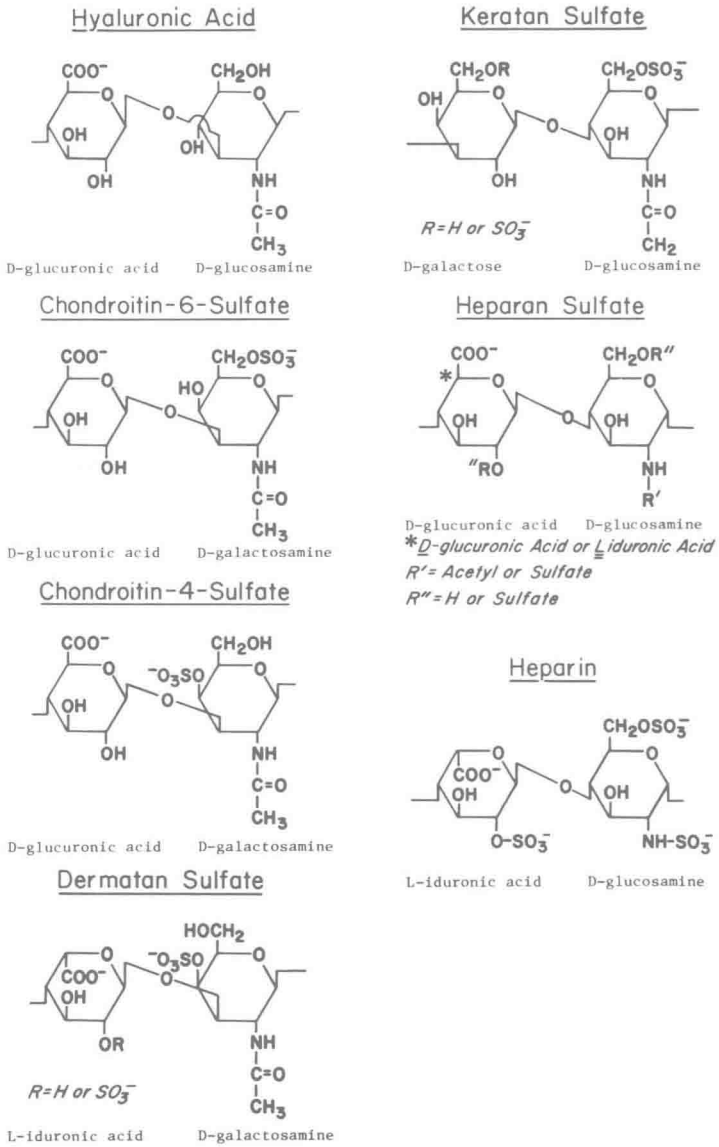

FIG. 1. Structure of repeating units of glycosaminoglycans.

antithrombin active sequence of heparin are still under investigation (Laurent et al. 1978; Danielsson and Bjole 1978). Figure 1 shows the generalized repeating structure for the glycosamino-