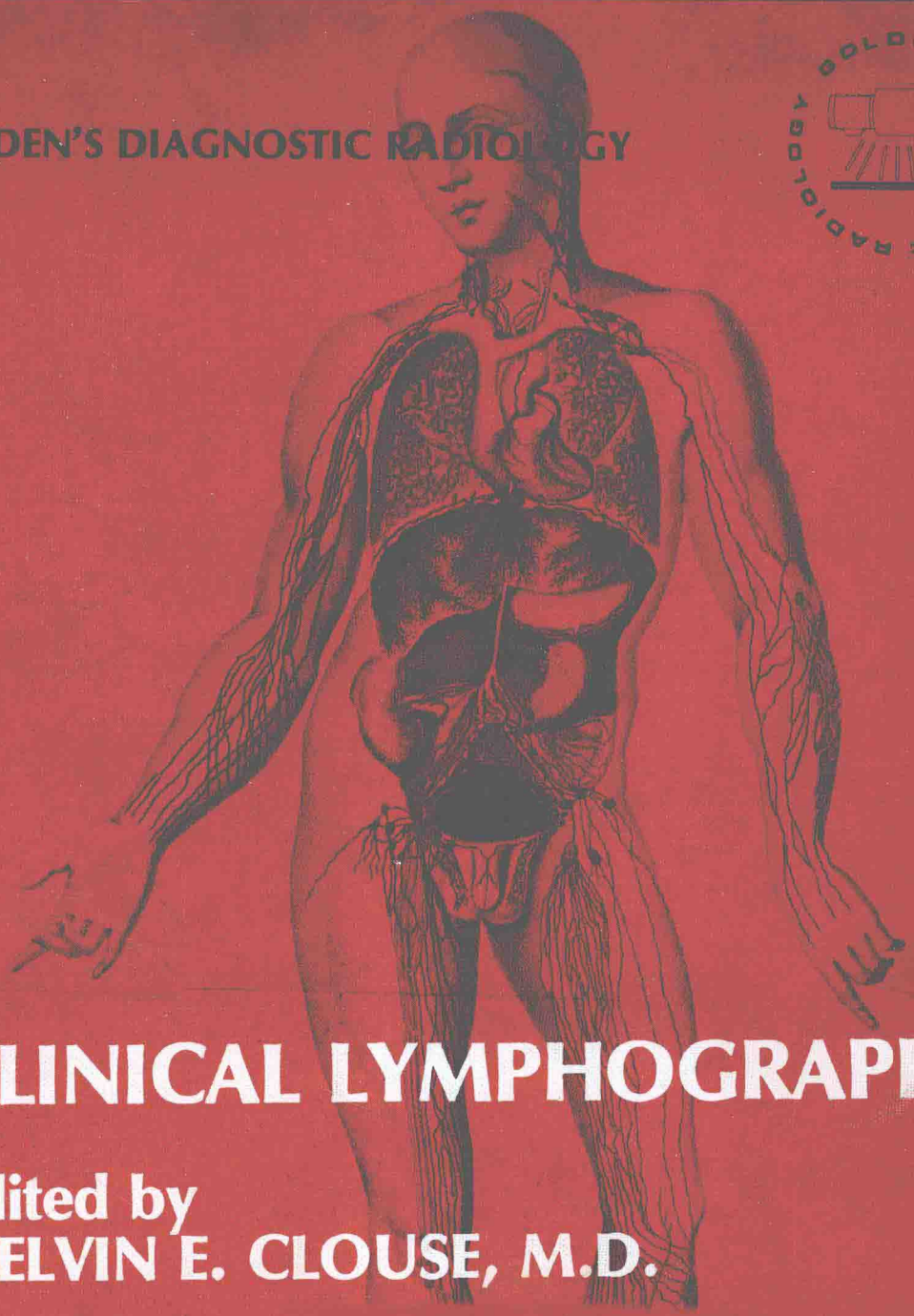
GOLDEN'S DIAGNOSTIC RADIOLOGY



# CLINICAL LYMPHOGRAPHY

edited by
MELVIN E. CLOUSE, M.D.

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Edited by

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GOLDEN'S DIAGNOSTIC RADIOLOGY

# Section 7:
# CLINICAL LYMPHOGRAPHY

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DEDICATED

to

Robert D. Moreton, M.D.
Laurence L. Robbins, M.D.
Mr. Robert D. Lowry

Who have always given excellent advice and whose support over the years has made this book possible.

# Foreword

It is with great enthusiasm that I welcome the formation and publication of this book. As a clinician critically interested in the status of the lymph nodes and lymphatics, I have found the lymphogram a valuable asset albeit sometimes a confusing one. Interpretations of abnormalities in the lymph node architecture vary from center to center and are quite different for different diseases. This book has an excellent description of the history of studies of the lymphatics and lymph nodes. The technique of doing conventional contrast lymphography, the problems of interpretation, as well as careful review of the lymphographic findings in carcinoma and lymphoma are presented and illustrated. These will be of value, not only to the skilled diagnostic radiologist, but to the radiation, medical, and surgical oncologists dealing with these patients. These alone would be enough to justify this book. The radiation oncologist and the surgeon find lymphography useful because not only can it be used to diagnose abnormalities but it also locates the abnormalities within the patient, making them available for surgical excision or treatment by radiation. With accurate beam localization it is quite important for us to understand the location of the lymph nodes and the pattern of lymphatic drainage. The book describes in detail the normal anatomy and embryology so that these patterns can be evaluated with their anatomic variations. The book would not be complete without a discussion of the complications of lymphography. The role of radionuclide lymphangiography and the exciting experimental technique of using immunospecific radionuclide immunoglobulins for lymphography are presented for comparison with conventional techniques.

It is a great privilege to introduce this book as it is an excellent review of the history and development of lymphographic techniques, their current status, and prospects for the future.

Samuel Hellman, M.D.
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Harvard Medical School
Boston, Massachusetts

# Preface

During the past 20 years diagnostic roentgenology has undergone an incredible evolution in techniques for imaging normal and abnormal anatomy. The evolution has progressed from the conventional techniques of body imaging to the use of sophisticated contrast media and equipment.

The development of lymphography is but one of the new techniques of diagnostic radiology. Study of the lymphatic system on a routine clinical basis was made possible with the startling publication by Dr. John B. Kinmonth, a British surgeon at St. Thomas Hospital, London, in 1952. The initial studies with water-soluble contrast media were of limited clinical use. The introduction of oily contrast media made lymphography applicable to the study of a large number of diseases of the lymphatic system and has produced an enormous amount of literature on the subject.

This book has been written primarily for those performing lymphography in a busy radiology department, for practicing surgeons, residents, and the oncologist. The format lends itself to easy and rapid reference beginning with history, normal anatomy, technique, interpretation, abnormal lymphatics, benign lymph node disease, lymphoma, carcinoma, complications, radionuclide studies, and immunospecific lymphography. Each chapter is accompanied by a reference list that includes the major contributors on the subject material. Harrison has written a detailed anatomic and lymphographic chapter on anatomy of the lymphatic system. The technique of pedal lymphography described in the text has proven over the years to be the least complicated and makes the most efficient use of the lymphographer's time without the need of specialized instruments.

The technique of percutaneous lymph node aspiration biopsy is also described. The more complicated techniques of cervical, testicular, and mammary lymphography have been omitted because they are time-consuming and complicated and because the diagnostic results have limited value. The importance of general interpretation of the lymphogram merits a separate chapter.

Chapter 3 is not intended as a complete reference text on the physiology of the lymphatic system but is a brief review of the formation, function, and circulation of lymph. The chapter on "Abnormal Lymphatics" by O'Donnell, a vascular surgeon, is an especially good, concise review of the lymphedemas, both congenital and acquired, describing the current clinical and surgical techniques of management. It is an up-to-date review of the subject for surgical residents and practicing surgeons as well as the radiologist.

The place of lymphography for benign diseases of the lymph node has not been clearly established, but the importance of differentiating benign from malignant disease is stressed. Lukes has written an excellent review of the classification of lymphomas for the clinician and radiologist. The chapter on "Lymphography in Lymphoma" by Hessel, Adams, and Abrams is especially clear and concise. Wallace and Jing present their vast experience with lymphography in carcinoma from the M. D. Anderson Hospital in Chapter 9, describing in detail its usefulness in staging and management of solid tumors especially in the genitourinary tract.

A review of the complications and method of management is presented in Chapter 10. Potsaid and McKusick in Chapter 11 review the use of radionuclide lymphography dealing extensively with gallium-67.

The chapter by Order on immunospecific radionuclide lymphography must be considered investigational. It has been included because of its exciting potential. Dr. Order presents a review of tumor antigenicity and possible uses of immunospecific reagents, the method of direct immunospecific lymphography—its diagnostic and therapeutic potential.

MELVIN E. CLOUSE, M.D.

# Acknowledgments

The problem of acknowledgement is always difficult because so many have helped in the final product. I would like to thank Miss Ruth M. Sullivan and Mrs. Marian K. Arnoff of the Horrax Library at the New England Deaconess Hospital for obtaining a large number of reference articles and all of the staff at the Countway Library, especially Mr. Richard Wolfe, the rare book librarian, and his assistants, Mrs. Grinne Blakeslee and Mrs. Hulda Newell, for retrieving the reference books of early anatomists used in preparing Chapter 1.

The secretaries at the New England Deaconess Hospital, especially Mrs. Margo Wyner, were most helpful throughout in typing the original manuscripts. I also want to thank Sally Ann Edwards and Katherine Arnoldi for editorial assistance and final typing. Without their help the book could never have been finished on schedule. Mr. Stanley M. Bennett, Chief of the Photography Department at the Massachusetts General Hospital, and Ms. Kathleen Grady, the Photographic Assistant, were very helpful in preparing the illustrative material.

I am especially grateful and want to thank each of the contributors for their work and diligence in preparing chapters of such high quality on schedule.

M.E.C.

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# Contents

# 1

# *History*

MELVIN E. CLOUSE, M.D.

Hippocrates' description of white blood and Aristotle's description of structures containing colorless fluid make it probable that lymph and lymph vessels were observed by the Alexandrian School in ancient times. These descriptions were lost with the decline in learning during the Middle Ages but were rediscovered in late Renaissance. According to Cruikshank (1786), a student of Hunter and the personal physician of Samuel Johnson, a Roman anatomist named Eustachius discovered the thoracic duct in a horse and described it in his treatis, *De Vena Fin Pari*, in 1563. He called the thoracic duct the vena Alba thoracica.

The glory of discovering the lymphatic vessels belongs to Gasparo Asellius, Professor of Anatomy and Surgery at Pavia, who on July 23, 1622, vivisected a well fed dog before members of the Order of Physicians to observe the recurrent nerve (Fig. 1.1). According to Drinker (1942), as an afterthought he decided to observe diaphragmatic motion. On opening the abdominal cavity and pulling the stomach aside, which he noted to be full, he was astonished by small white vessels in the mesentery along with the intestine. Asellius at first thought them to be nerves, but when real nerves were seen, he incised one and observed chyle rush out. He performed the same experiment on a dog whose stomach was empty and could not demonstrate these vessels. They were observed again when the experiment was repeated on another well fed dog. Asellius called them the vasa lactea and ascribed their function to absorbing chyle from the intestines and transporting it to the liver to be mixed into the blood stream.

Asellius' discovery was completely submerged for some time by Harvey's publication, *An Anatomical Disquisition on the Motion of the Heart and Blood in Animals*, in 1628. Even at the peak of his career, however, Harvey did not believe in the existence of Asellius' lymphatics or their function.

Asellius' book, *De Lactibus sive Lacteis Venis*, which contains his excellent diagrams of the mesenteric lymphatics and lymph nodes, was not only the first book on the lymphatic system but the first to have anatomic drawings in color.

In 1651 Pecquet described the thoracic duct and the cisterna chyli (Fig. 1.2). He found the cisterna chyli while performing an autopsy on a well fed dog and observed white fluid after removal of the heart. He first thought it pus but after careful dissection found the thoracic duct. Almost simultaneously, van Horne, Professor of Anatomy at Leiden in 1652, also described the thoracic duct.

In 1652–1653 Thomas Bartholin and Olaf Rudbeck assembled the known parts of the lymphatic system and recognized them as a system (Fig. 1.3). Bartholin was the first investigator to use the term lymphatic. The chyle vessels discovered by Asellius had been thought to convey food substances to the liver, but when Bartholin ligated the portal tracts, he observed dilated lymphatics above the ligature and collapsed lymphatics below. At the same time he observed the thoracic duct, its inflow into the large veins, and the cisterna chyli. Immediately after his work was published, it became known that Rudbeck had presented essentially the same material before the Queen of Sweden at Uppsala prior to Bartholin's publication. Because of this, a violent argument erupted with each accusing the other of plagiarism. It is probable that each investigator working independently made the same discovery.

Anatomists until the time of Anton Nuck in 1685 considered the lymphatic vessels to have only one coat—the intima (Fig. 1.4). Nuck demonstrated a second fibrous coat in the thoracic

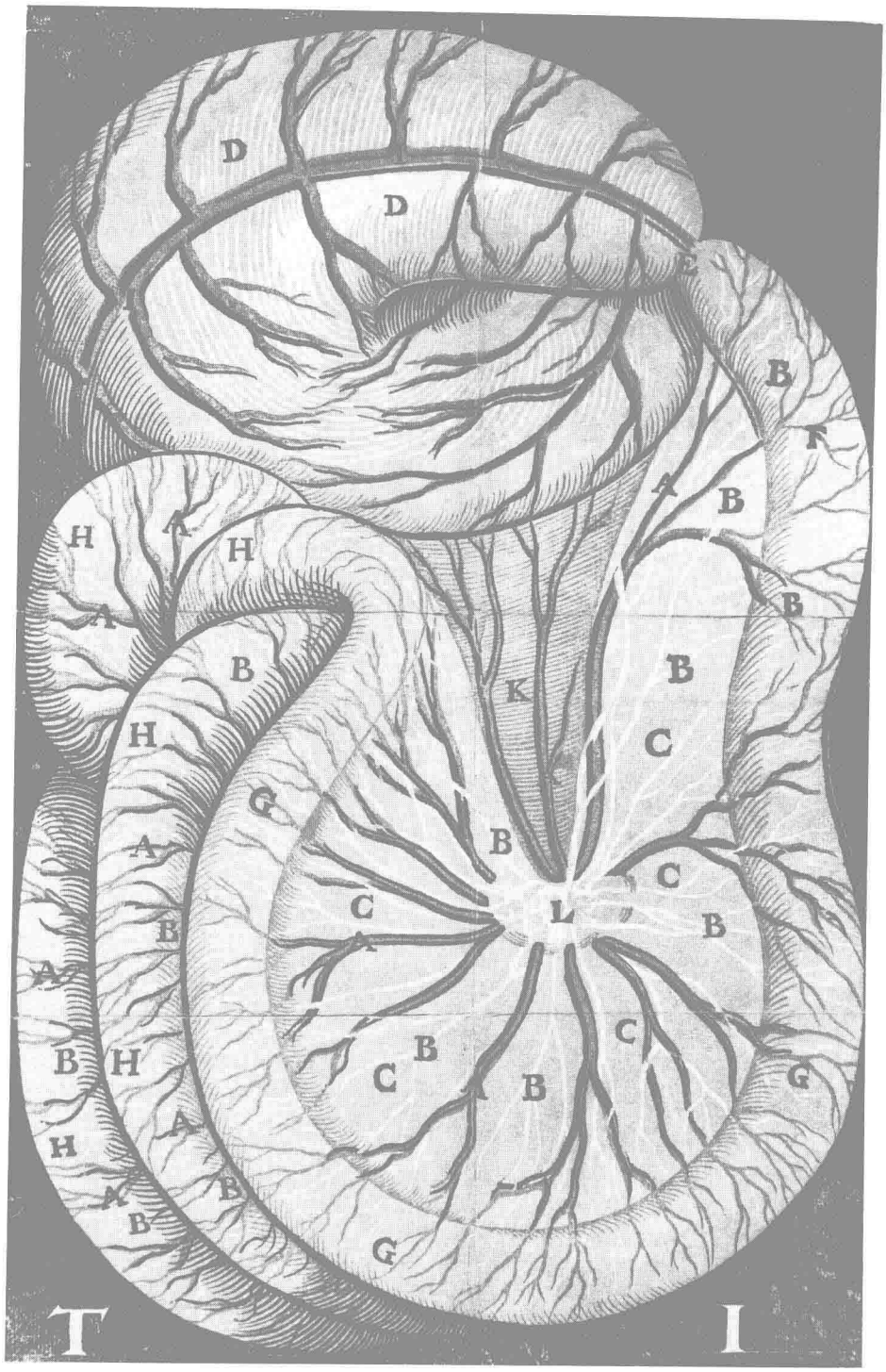


FIG. 1.1. MESENTERIC LYMPHATIC VESSELS (B VENAE LACTEAE)
(From Gasparo Asellius: *De Lactibus sine Lacteis Venis*. Mediolani, apud Io B. Bidellium, 1627.)

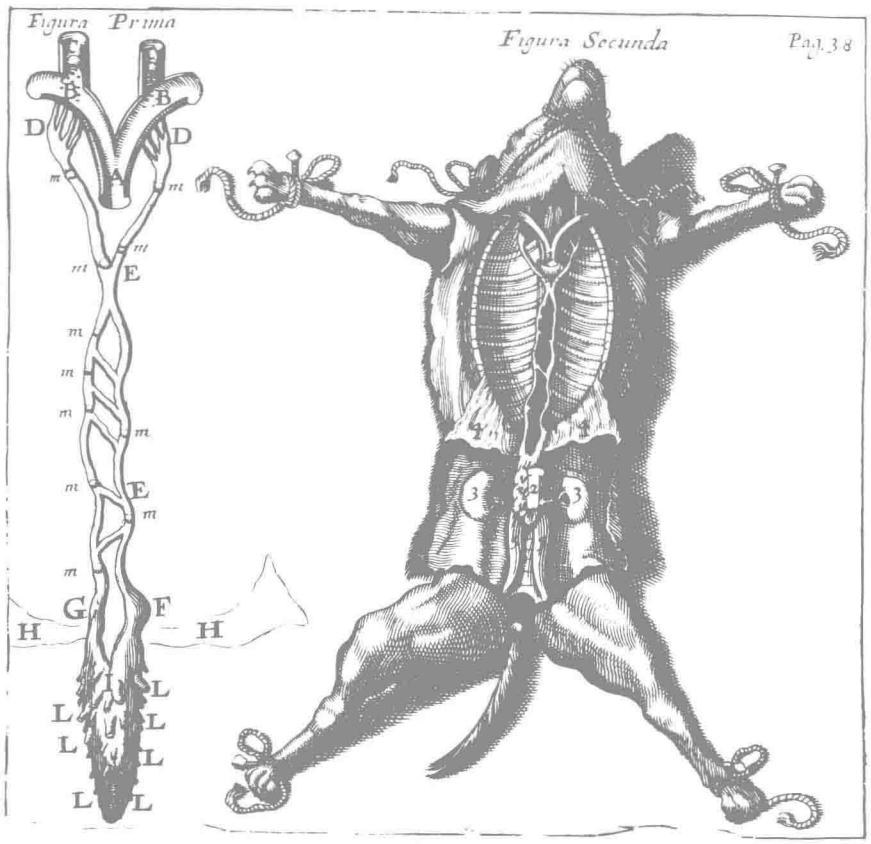


FIG. 1.2. FROM BOOK BY JEAN PECQUET, DISCOVERER OF THE THORACIC DUCT AND CISTERNA CHYLI
(From *Experimenta Nova Anatomica quibus Incognitum Chyli Receptaculum, et ab eo per Thoracem in Ramos usque Subclavis Vasa Lactea Deteguntur*. Paris, 1651, p. 38.)

duct of horses. Cruikshank in 1790 demonstrated a muscular coat as well as the intima in large lymphatics, but he could not demonstrate a muscular wall in smaller lymphatics.

According to Cruikshank the vasa vasorum in the lymphatic wall was described by William Hunter in 1762, who also noted contraction of the lymphatic vessels in response to irritation but could not demonstrate nerve innervation. Wrisberg in 1808 and Cruikshank in 1786 observed nerves in the vicinity of lymphatic vessels but could not demonstrate direct nerve innervation of the thoracic duct. It was not until 1925 that nervous innervation of the lymphatics was properly demonstrated by Lawrentjew. Dissecting cats and dogs, he described a periadventitial plexus of small ganglia surrounding the thoracic duct. Fibers from the intercostal and vagus nerves entered the thoracic duct. Branches from the lesser splanchnic nerve also supplied fibers to the lower thoracic duct and cisterna chyli.

Valves in the lymphatic vessels were almost certainly observed by Bartholin and Rudbeck, but Frederick Ruysch (1638–1731) is considered—if not their discoveror—then the best demonstrator of the valves (Fig. 1.5).

Lymph nodes were seen by Herophilus, who noted certain veins in the mesentery that terminated in glandular bodies. These same glands were noted by Asellius, who thought them part of the pancreas because the lymph vessels were thought to pass through the pancreas on their way to the liver. For this reason they were labelled *pancreas Asellii* in *De Lacticus sive Lacteis Venis*. It was not until 1863 that His demonstrated them to be an integral part of the lymphatic system. In fact His' original description of the internal architecture and blood supply to the lymph nodes was so accurate that it has not changed.

Accurate demonstration of the course and interconnection of the lymphatic vessels was made possible by Anton Nuck in 1692. Using a time-consuming technique of injecting mercury into the lymphatics, he succeeded in visualizing practically the entire lymphatic system. It was from Nuck's technique that Mascagni in 1787

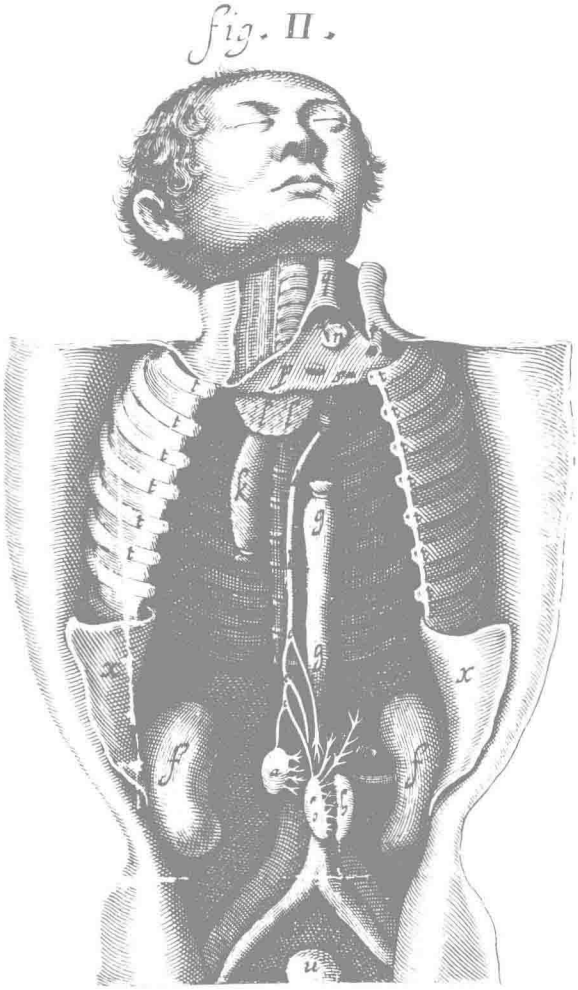


FIG. 1.3. HUMAN CISTERNA CHYLI AND THORACIC DUCTS (From *The Anatomical History of Thomas Bartholinus of the Lacteal Vein of the Thorax*. London, 1673.)

and Cruikshank in 1790 demonstrated the lymphatic topography in all parts of the body (Fig. 1.6). Gerota in 1896 introduced a new analytical technique using Prussian blue paint dissolved in turpentine and ether. On the basis of this improved technique, Jossifow in 1930 and Rouvièr in 1932 published books on the complete lymphatic system.

William Hunter was probably the first to appreciate the functional significance of the lymphatic system. He demonstrated absorption of chyle from the intestinal tract into the lymphatics. In a lecture published posthumously in 1784, he stated that lymphatic vessels all over the body (whether from the skin, lining of body cavities, or intestinal tracts) were the absorbing vessels and together with the thoracic duct transported chyle to the blood vascular system.

The mechanism of lymph formation was elusive. It was generally believed until 1850 that lymph passed from the blood stream into lymphatic vessels by direct communication through thin tubules—the vasa serosa. The chief architects of the vasa serosa theory were Boerhaave (1738, 1742) and Vieussens (1705), who demonstrated canaliculi between blood vessels and the lymphatics. These were later shown to be artifacts of their primitive histologic techniques.

Virchow in 1858 contested the vasa serosa theory for lymph formation but believed there were communications through intercellular canaliculi. Von Recklinghausen in 1862 opposed the intercanalicular theory but thought the communication was direct through very small lymphatics and blood vessels. Ludwig's theory, more nearly correct, was based on simple filtration of fluid and molecular substances caused by intravascular pressure (blood pressure). Heidenhain criticized Ludwig's simple filtration theory because certain substances increased lymphatic flow. The vasa serosa theory was not abandoned, however, until after Schwann discovered the cell as the basic form of living substances within the body.

In 1894 Starling proved these theories incorrect. Starling's theory was that the blood capillary endothelium is a semipermeable membrane that is permeable to water and crystalloids but impermeable to proteins. Hydrostatic pressure in the arterial limb of the capillary induces filtration of water and crystalloids into the interstitial space. As the hydrostatic pressure in the venous limb diminishes, the plasma osmotic pressure becomes the driving force for resorption of crystalloids and water. The proteins cannot be absorbed into the blood through the semipermeable membrane (the capillary endothelium) but are absorbed by the lymphatics.

The anatomic basis for absorption of fluid and large molecules into the initial lymphatics (lymphatic capillaries) has been demonstrated by Leak and Burke (1966) and Casley-Smith (1972). Using electron microscopy these authors have demonstrated "open" junctions between the lymphatic endothelial cells for passage of fluid and large molecules. Smaller molecules may pass directly through the endothelial cell membrane into the lymphatic lumen (Figs. 1.7 and 1.8). The lymphatic endothelial cells are anchored by small fibrils to the surrounding connective tissues.

Although there have been many investigators in the field of lymphology, Cecil K. Drinker, Professor of Physiology at the Harvard School of Public Health, must be considered the father of modern lymphology because of his extensive ob-

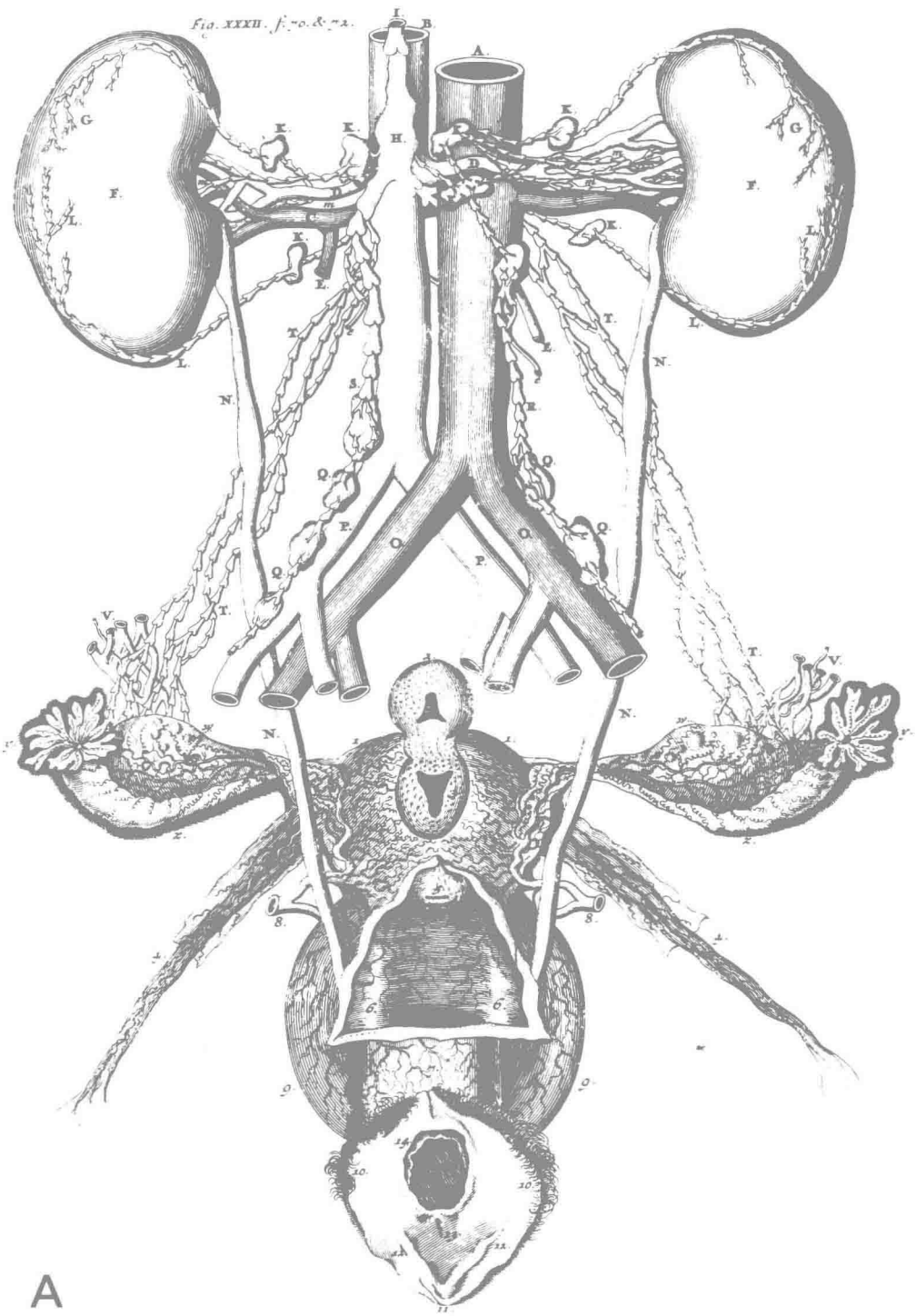


FIG. 1.4*A*. LYMPHATICS OF THE RENAL AND REPRODUCTIVE SYSTEMS
(From Anton Nuck: *Adenographia Curiosa et Uteri Foeminei Anatome Nova*. Lugd. B., 1692.)

servations and studies on the formation of lymph, its content, and changes in disease states (Drinker, 1942).

The concept of radiographic visualization of the lymphatics was published 35 years after Roentgen's discovery of x-rays. In 1930 and 1931 Funaoka from Japan and Carvalho of Portugal performed lymphography by injecting Thoro-