ATLAS *of*
ENDOVASCULAR VENOUS SURGERY

SECOND EDITION

ATLAS *of* ENDOVASCULAR VENOUS SURGERY

Jose I. Almeida, MD, FACS

Founder, Miami Vein
Voluntary Professor of Surgery
Division of Vascular and Endovascular Surgery
University of Miami Miller School of Medicine
Miami, Florida

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1600 John F. Kennedy Blvd.
Ste 1600
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Senior Content Development Specialist: Joan Ryan
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Senior Project Manager: Daniel Fitzgerald
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To my loving wife of 25 years, Yvette Angela Almeida, who has raised our four children and managed the complex affairs of our family and my surgical practice. Without her, I would be a mess.

To my mother, Estrella Almeida, who instilled the traditional values of faith, family, and education, which I strive to maintain every day.

To my father, Jose Almeida, MD, who died on April 16, 2009. He served as the chief medical officer for the CIA-trained force of Cuban exiles whose unsuccessful attempt to overthrow the Cuban government of Fidel Castro is now known as the Bay of Pigs Invasion. After release from his 2-year incarceration as a political prisoner of Cuba, my father went on to train at the renowned Menninger School of Psychiatry in Topeka, Kansas. He practiced psychiatry in West Palm Beach, Florida, until he died at home from multiple sclerosis at the age of 75.

To the memory of Robert Zeppa, MD, Chairman of Surgery at the University of Miami–Jackson Memorial Hospital, under whom I received my general surgery residency training.

CONTRIBUTORS

Andrew M. Abi-Chaker, MD
Vascular Surgery Resident
Division of Vascular and Endovascular Surgery
University of Miami
Jackson Memorial Hospital
Miami, Florida
Venous Diagnostic Tools
Iliocaval and Femoral Venous Occlusive Disease

Ashley Nicole Adamovich, MD
Department of Radiology
University of South Florida
Tampa, Florida
Endovenous Management of Central and Upper Extremity Veins

Rima Ahmad, MD
Clinical Instructor
University of Vermont College of Medicine
Burlington, Vermont
Radiofrequency Thermal Ablation: Current Data

Jose I. Almeida, MD, FACS
Founder, Miami Vein
Voluntary Professor of Surgery
Division of Vascular and Endovascular Surgery
University of Miami Miller School of Medicine
Miami, Florida
Venous Anatomy
Venous Diagnostic Tools
Endovenous Thermal Ablation of Saphenous Reflux
Treatment of Perforating Veins
Treatment of Varicosed Tributary Veins
Endovenous Approach to Recurrent Varicose Veins
Thromboembolic Disease
Endothermal Heat-Induced Thrombosis
Iliocaval and Femoral Venous Occlusive Disease

Guilherme Dabus, MD, FAHA
Director, Fellowship
Neuroendovascular Surgery
Miami Cardiac & Vascular Institute
Miami, Florida
Venous Malformations

Michael C. Dalsing, MD
Professor Emeritus
Division of Vascular Surgery
Indiana University
Indianapolis, Indiana
Deep Venous Incompetence and Valve Repair

Alan M. Dietzek, MD, RPVI, FACS
Network Chief
Vascular & Endovascular Surgery
Western Connecticut Health Network
Linda and Stephen R. Cohen Chair in Vascular Surgery
Danbury Hospital
Clinical Professor of Surgery
University of Vermont College of Medicine
Burlington, Vermont
Radiofrequency Thermal Ablation: Current Data

Steve Elias, MD, FACS, FACPh
Director
Center for Vein Disease
Englewood Hospital and Medical Center
Englewood, New Jersey
Nonthermal Ablation of Saphenous Reflux

Mark J. Garcia, MD, MS, FSIR, FACR
Founder and Medical Director
EndoVascular Consultants
Wilmington, Delaware
Pharmacomechanical Thrombolysis

Monika Lecomte Gloviczki, MD, PhD
Research Fellow, Emeritus
Department of Internal Medicine and the Gonda Vascular Center
Mayo Clinic
Rochester, Minnesota
Evidence-Based Summary of Guidelines From the Society for Vascular Surgery and the American Venous Forum

Peter Gloviczki, MD, FACS
Joe M. and Ruth Roberts Professor and Chair, Emeritus
Division of Vascular and Endovascular Surgery
Mayo Clinic
Rochester, Minnesota
Pelvic Venous Disorders
Nutcracker Syndrome
Evidence-Based Summary of Guidelines From the Society for Vascular Surgery and the American Venous Forum

Issam Kably, MD
Assistant Professor
Vascular and Interventional Radiology
University of Miami Miller School of Medicine
Miami, Florida
New Concepts in the Management of Pulmonary Embolus

Lowell S. Kabnick, MD
Associate Professor
Department of Surgery
Director of NYU Vein Center
New York University Langone Health
New York, New York
Laser Thermal Ablation: Current Data
Endothermal Heat-Induced Thrombosis

Manju Kalra, MBBS
Professor
Vascular and Endovascular Surgery
Mayo Clinic
Rochester, Minnesota
Nutcracker Syndrome

Robert L. Kistner, MD
Clinical Professor of Surgery
University of Hawaii
Honolulu, Hawaii
Deep Venous Incompetence and Valve Repair

Nicos Labropoulos, PhD, DIC, RVT
Professor of Surgery
Department of Surgery
Division of Vascular Surgery
Stony Brook University Medical Center
Stony Brook, New York
Venous Pathophysiology
Postthrombotic Syndrome

Timothy K. Liem, MD, MBA
Professor of Surgery
Knight Cardiovascular Institute
Oregon Health & Science University
Portland, Oregon
Thromboembolic Disease
Endovenous Placement of Inferior Vena Caval Filters

Edward G. Mackay, MD
Private Practice
Palm Harbor, Florida
Treatment of Spider Telangiectasias

Rafael D. Malgor, MD, FACS
Assistant Professor of Surgery
Eastern Virginia Medical School
Norfolk, Virginia
Venous Pathophysiology
Postthrombotic Syndrome

William Marston, MD
Chief
Division of Vascular Surgery
Professor
Department of Surgery
University of North Carolina School of Medicine
Chapel Hill, North Carolina
Venous Ulcers

Mark H. Meissner, MD, FACS
Professor of Venous and Lymphatic Disorders
Division of Vascular and Endovascular Surgery
University of Washington
Seattle, Washington
Pelvic Venous Disorders
Evidence-Based Summary of Guidelines From the Society for Vascular Surgery and the American Venous Forum

Marc A. Passman, MD
Professor
Division of Vascular Surgery and Endovascular Therapy
Department of Surgery
University of Alabama at Birmingham
Birmingham, Alabama
Severity Scoring and Outcomes Measurement

Constantino S. Peña, MD
Assistant Professor
Department of Radiology
University of South Florida
Tampa, Florida
Medical Director of Vascular Imaging
Baptist Cardiac and Vascular Institute
Miami, Florida
Endovenous Management of Central and Upper Extremity Veins
Venous Malformations

Seshadri Raju, MD, FACS
Vascular Surgeon
The Rane Center
Jackson, Mississippi
Venous Hemodynamics

Michele N. Richard, MD
Clinical Instructor
University of Vermont College of Medicine
Burlington, Vermont
Radiofrequency Thermal Ablation: Current Data

Mikel Sadek, MD
Assistant Professor
Department of Surgery
Chief
Vascular Surgery
Bellevue Hospital
New York University Langone Health
New York, New York
Laser Thermal Ablation: Current Data
Endothermal Heat-Induced Thrombosis

Jason Thomas Salsamendi, MD
Associate Professor
Vascular and Interventional Radiology
University of Miami Miller School of Medicine
Miami, Florida
New Concepts in the Management of Pulmonary Embolus

Priscila Gisselle Sanchez Aguirre, MD
Division of Vascular and Endovascular Surgery
Leonard M. Miller School of Medicine
University of Miami
Miami, Florida
Venous Diagnostic Tools
Iliocaval and Femoral Venous Occlusive Disease

Jan M. Sloves, RVT, RCS, FASE
Technical Director of Vascular Imaging
Mount Sinai Beth Israel-Mount Sinai Health System
New York, New York
Venous Diagnostic Tools

FOREWORD

Advances in the field of endovascular venous surgery created the stimulus for a second edition of this material under the editorship of Jose Almeida following the enthusiastic reception of the first edition in 2011. This field is undergoing rapid development in breadth and depth for both diagnosis and treatment of venous disease. These changes include new techniques and refinements of established procedures that are best expressed by the visual display afforded in the atlas format. The presentations allow the practitioner to grasp subtleties that are often poorly appreciated through descriptive formats limited to the written word.

The need for this atlas presentation is dictated by the requirement for accuracy in transmitting critical details of technique that are best understood by a visual presentation to supplement the written word. Just as we understand that the training of the surgeon requires clinical experience in addition to academic understanding, so there is the need for visual understanding of the technical steps that are the key to performing successful procedures in open and minimally invasive endovascular surgery. The strength of the atlas is that it displays technical procedures in visual steps, and in many instances there are videos with audio to link the key steps into a full presentation of the procedure. The picture supplemented by the written explanation provides the nearest thing to the real-time experience of watching or participating in a technical operation.

Dr. Almeida has chosen recognized experts to join him in detailing the intricacies of successful technique in the various fields of endovascular procedures. The range of subjects covers the active endovascular field at this time, making it safe to predict this atlas will address a basic need for those who are working in the endovascular field.

Robert L. Kistner, MD

PREFACE

This book was conceived as a well-illustrated technical guide for the endovascular surgical management of venous diseases. This second edition of the *Atlas of Endovascular Venous Surgery* builds on the first edition; it remains a text atlas, but I hope that it will eventually grow into an authoritative reference for venous disease. Currently, the best evidence-based reference of venous disorders is the *Handbook of Venous Disorders: Guidelines of the American Venous Forum,* edited by Peter Gloviczki, MD. This second edition of the *Atlas of Endovascular Venous Surgery* should serve as a nice companion to the *Handbook of Venous Disorders* because it beautifully illustrates the technical aspects of endovenous vascular surgery through full-color illustrations, photographs, and radiologic (ultrasound, fluoroscopy, contrast venography, and cross-sectional) images. We are pleased that the current book is bundled as a print and Web version. It also contains video presentations.

This second edition includes five brand new chapters covering venous hemodynamics, new concepts in the management of pulmonary embolus, endothermal heat-induced thrombosis, deep venous incompetence and valve repair, and nutcracker syndrome. It features significant updates throughout, including new devices in the management of thromboembolic disease, aggressive techniques for recanalizing iliofemoral venous occlusions, new nomenclature and endovascular approach to the treatment of pelvic venous disorders, new nonthermal devices for saphenous vein ablation, new stents for treatment of iliac vein obstruction, new devices for clot management, and endovascular and open repair of deep vein obstruction and reflux.

All this work would not have been possible without the excellent contributions of the coauthors—all world-renowned experts—who prepared many of the chapters that make up this book.

A special recognition goes to the beautiful artistic renderings prepared by Tiffany Davanzo. Her illustrations really make the technical details of the procedures self-explanatory.

Finally, we appreciate the assistance of many individuals at Elsevier, especially Joan Ryan the Senior Content Development Specialist. Their efforts, combined with those of many other copyeditors, artists, and printers, helped to assemble this final product.

Jose I. Almeida, MD, FACS

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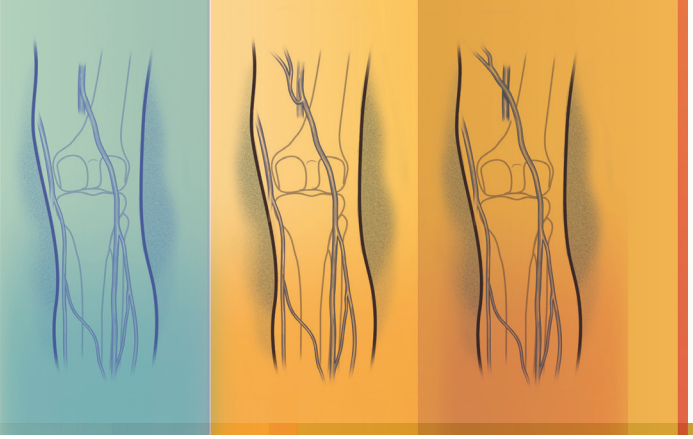


CHAPTER 1

Venous Anatomy

Jose I. Almeida

HISTORICAL BACKGROUND

Chronic venous diseases include a spectrum of clinical findings ranging from spider telangiectasias and varicose veins to debilitating venous ulceration. Varicose veins without skin changes are present in about 20% of the general population, and they are slightly more frequent in women.

References to varicose veins are found in early Egyptian and Greek writings and confirm that venous disease was recognized in ancient times. A votive tablet in the National Museum in Athens showing a man holding an enlarged leg with a varicose vein is frequently featured in many historical writings regarding venous disease.

The venous system originates at the capillary level and progressively increases in size as the conduits move proximally toward the heart. The venules are the smallest structures, and the vena cava is the largest. It is critical that all endovascular venous surgeons understand the anatomic relationships between the thoracic, abdominal, and extremity venous systems, especially from the anatomic standpoint (Fig. 1.1). Veins of the lower extremities are the most germane to this book and are divided into three systems: deep, superficial, and perforating. Lower extremity veins are located in two compartments: deep and superficial. The deep compartment is bounded by the muscular fascia. The superficial compartment is bounded below by the muscular fascia and above by the dermis. The term *perforating veins* is reserved for veins that perforate the muscular fascia and connect superficial veins with deep veins. The term *communicating veins* is used to describe veins that connect with other veins of the same compartment.

The vein wall is composed of three layers: intima, media, and adventitia. Notably, the muscular tunica media is much thinner in a vein than in a pressurized artery. Venous valves are an extension of the intimal layer, have a bicuspid structure, and support unidirectional flow (Fig. 1.2).

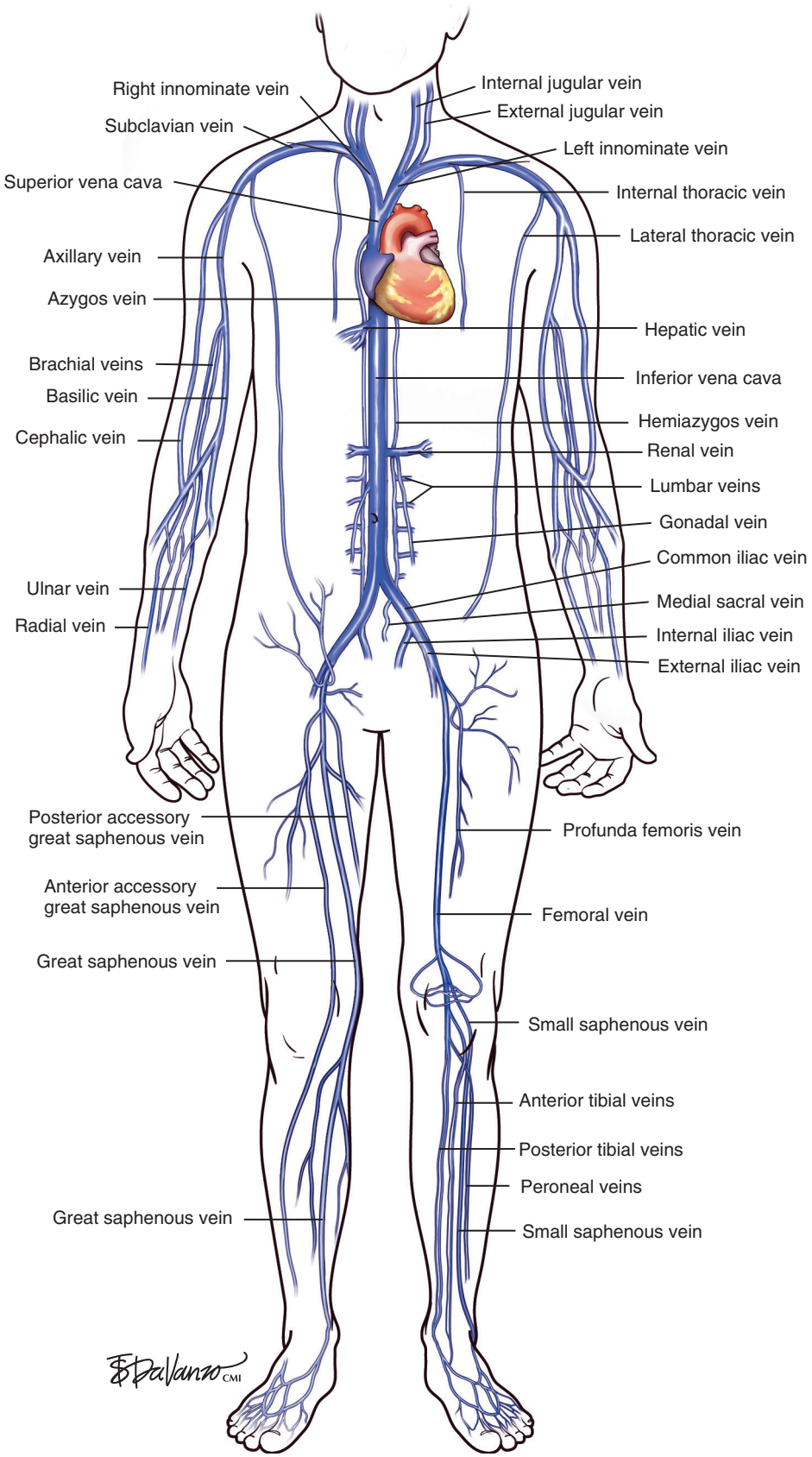
Abstract

Anatomic variation is the norm within the venous system because there are many options for the venous channels to develop and flow. Sources of venous hypertension must be investigated to determine the appropriate treatment. One should be familiar with the anatomy of the great saphenous vein (GSV), anterior accessory saphenous vein (AASV), posterior accessory saphenous vein (PASV), posterior thigh circumflex veins (PTCVs), small saphenous vein (SSV), vein of Giacomini, and perforating veins of the thigh and calf if truncal ablation treatment is under consideration. Deep venous disease treatment is also developing rapidly; therefore, a detailed understanding of deep compartment anatomy is required. It is important to understand which anatomic segments are more prone to reflux or obstruction—most of this can be sorted out with duplex ultrasound imaging. Vena cava therapy continues to expand for congenital, primary, and secondary disease indications and, therefore, knowledge of anatomic variants and collateral flow patterns becomes paramount for successful patient care. This chapter provides pictures with written supplementation of venous anatomy.

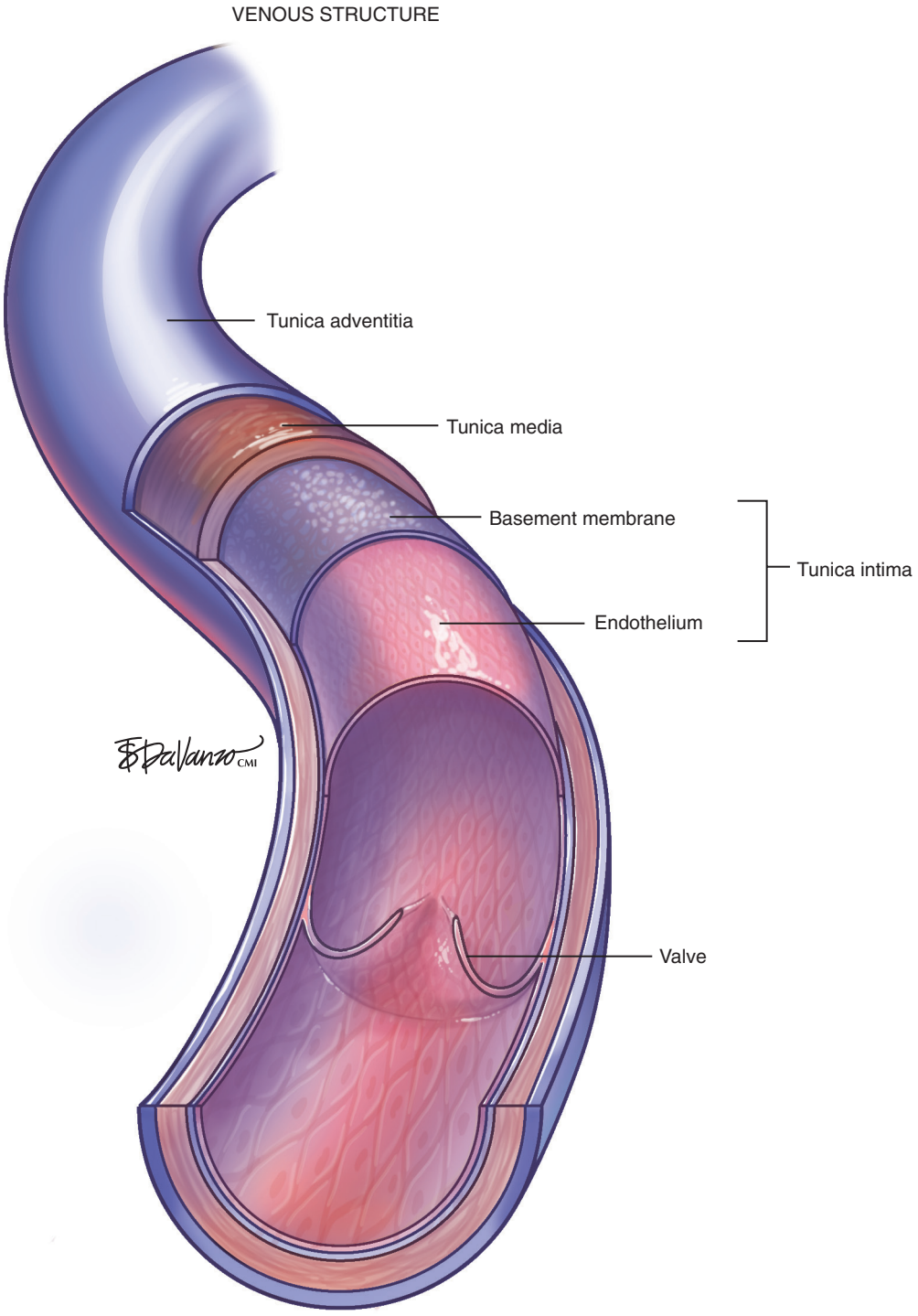
Keywords

great saphenous vein
small saphenous vein
anterior accessory saphenous vein
common femoral vein
femoral vein
profunda femoris vein
anterior and posterior thigh circumflex veins

VENOUS SYSTEM OVERVIEW



■ **Fig. 1.1**

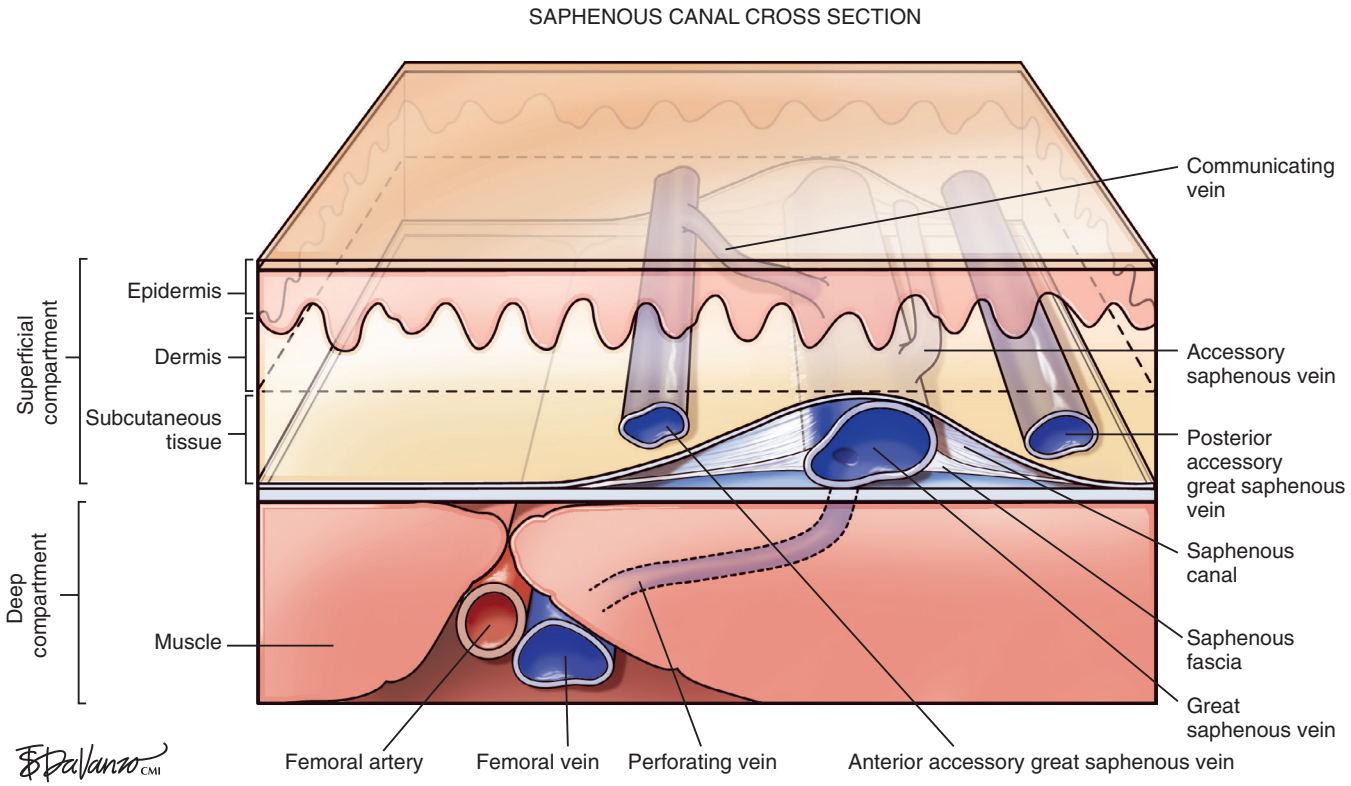

VENOUS STRUCTURE
Tunica adventitia
Tunica media
Basement membrane
Tunica intima
Endothelium
Valve

■ Fig. 1.2

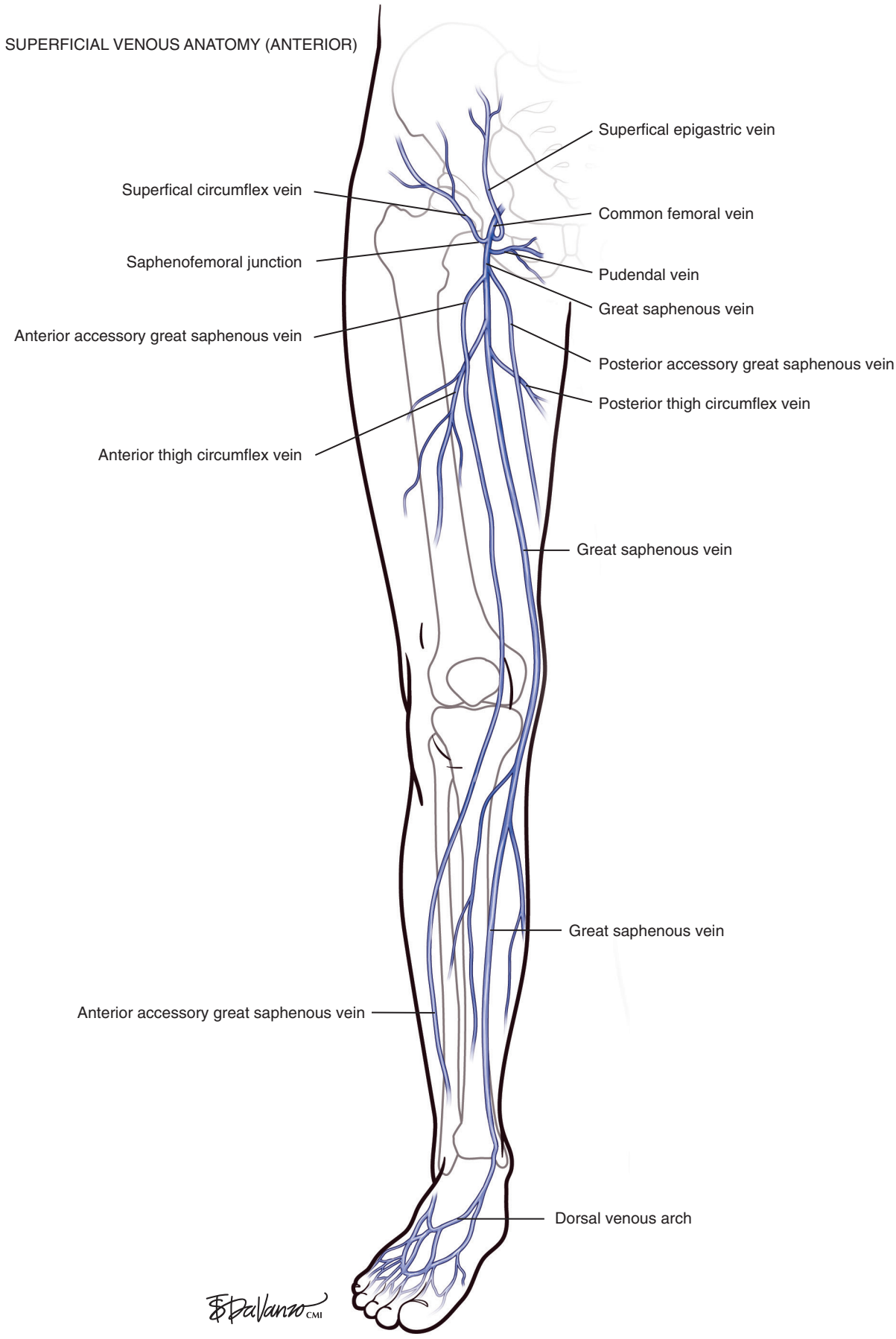
Surgeons who perform thermal or chemical ablation therapy of the great saphenous vein (GSV) and its related structures must have a good understanding of the saphenous canal. The importance of the saphenous canal in relation to B-mode ultrasound anatomy is detailed in Chapter 4. A cross section of the saphenous canal (Fig. 1.3) depicts many of the critical relationships referable to GSV treatment; the most important is how it courses atop the muscular fascia in a quasi-envelope called the *saphenous fascia*. The saphenous fascia is the portion of the membranous layer of the subcutaneous tissue that overlies the saphenous veins. Veins coursing parallel to the saphenous canal are termed *accessory veins*; those coursing oblique to the canal are called *circumflex veins*. Compressible structures superficial to the muscular fascia are potential targets for treatment, but treating those structures deep to the muscular fascia may lead to a disastrous outcome. Noncompressible structures generally represent major arteries. Perforating veins must pierce the muscular fascia as they drain blood from the superficial to deep systems.

As diagnostic and therapeutic options for venous disorders expanded, the nomenclature proposed in 2002 by the International Interdisciplinary Committee[1] required revision. The nomenclature was extended and further refined,[2] taking into account recent improvements in ultrasound and clinical surgical anatomy. The term *great saphenous vein* should be used instead of terms such as *long saphenous vein, greater saphenous vein,* or *internal saphenous vein*. The LSV abbreviation, used to describe both the *long saphenous vein* and *lesser saphenous vein*, was clearly problematic. For this reason, these terms have been eliminated. Similarly, the term *small saphenous vein,* abbreviated as SSV, should be used instead of the terms *short, external*, or *lesser saphenous vein*.

The GSV originates at the medial foot and receives deep pedal tributaries as it courses to the medial malleolus. From the medial ankle, the GSV ascends anteromedially within the calf and continues a medial course to the knee and into the thigh. The termination point of the GSV into the common femoral vein is a confluence called the *saphenofemoral junction* (SFJ) (Fig. 1.4).



■ **Fig. 1.3**


SUPERFICIAL VENOUS ANATOMY (ANTERIOR)
Superfical epigastric vein
Superfical circumflex vein
Common femoral vein
Saphenofemoral junction
Pudendal vein
Great saphenous vein
Anterior accessory great saphenous vein
Posterior accessory great saphenous vein
Posterior thigh circumflex vein
Anterior thigh circumflex vein
Great saphenous vein
Great saphenous vein
Anterior accessory great saphenous vein
Dorsal venous arch

■ **Fig. 1.4**

The terminal valve of the GSV is located within the junction itself. A subterminal valve can often be identified approximately 1 cm distal to the terminal valve. From the upper calf to the groin, the GSV is usually contained within the saphenous compartment. Visualization of this fascial envelope is an important landmark in identifying the GSV with duplex ultrasound. The saphenous compartment is bounded superficially by a hyperechoic saphenous fascia and deeply by the muscular fascia of the limb.

At the groin, the GSV drains blood from the external pudendal, superficial epigastric, and external circumflex iliac veins just before it enters the common femoral vein confluence. As in all human anatomy, variations are crucial to recognize, to guide the correct diagnosis and treatment. Historically, the GSV has been reported to be duplicated in the thigh in as many as 20% of subjects. However, recent examinations have demonstrated that true duplication, with two veins within one saphenous compartment, occurs in less than 1% of cases. Large extrafascial veins, which are termed *accessory saphenous veins*, can run parallel to the GSV and take on the characteristics of duplicated veins.

The accessory saphenous veins are venous segments that ascend in a plane parallel to the saphenous veins. They may be anterior, posterior, or superficial to the main trunk. The term *anterior accessory great saphenous vein* describes any venous segment ascending parallel to the GSV and located anteriorly, both in the leg and in the thigh. The term *posterior accessory great saphenous vein* (PAGSV) is consistent with any venous segment ascending parallel to the GSV and located posteriorly, both in the leg and in the thigh. The leg segment corresponds to the popular terms *Leonardo's vein* or *posterior arch vein*. The term *superficial accessory great saphenous vein* is considered to be any venous segment ascending parallel to the GSV and located just superficial to the saphenous fascia, both in the leg and in the thigh.

Circumflex veins, by definition, drain into the GSV from an oblique direction. The posterior thigh circumflex vein is present in virtually every case; however, the anterior thigh circumflex vein is less common.

The SSV originates in the lateral foot and passes posterolaterally in the lower calf. The SSV lies above the deep fascia in the midline as it reaches the upper calf, where it pierces the two heads of the gastrocnemius muscle and courses cephalad until it enters the popliteal space. In approximately two-thirds of patients, the SSV drains entirely into the popliteal vein just above the knee at the saphenopopliteal junction (SPJ). In as many as one-third of patients, the cranial extension of the SSV drains into a posterior medial tributary of the GSV or directly into the GSV (vein of Giacomini) or into the femoral vein via a thigh perforating vein.

In variant drainage, a standard SPJ may or may not be present. The SSV is truly duplicated in 4% of cases; most often, this is segmental and primarily involves the midportion of the vein (Fig. 1.5).

SUPERFICIAL VENOUS ANATOMY (POSTERIOR)

■ **Fig. 1.5**

PERFORATING VEINS

Identifying perforating veins based on the original descriptions of investigators (i.e., Cockett, Sherman, Dodd) is falling into disfavor. Descriptive terms based on topography, which designate the anatomic location, have become the contemporary approach. Perforating veins pass through defects in the deep fascia to connect deep and superficial veins of the calf or thigh. Venous valves prevent reflux of blood from the deep veins into the superficial system. Perforating veins may connect the GSV to the deep system at the femoral, posterior tibial, gastrocnemius, and soleal vein levels. Located between the ankle and the knee are perforating veins, formerly known as Cockett perforators, that connect the posterior tibial venous system with the PAGSV of the calf (also known as the posterior arch vein) (Fig. 1.6).