

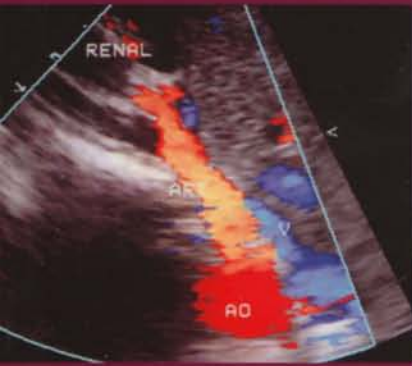
# DAVIES



# Vascular Technology

AN ILLUSTRATED REVIEW

FOURTH EDITION



3



## 1-2-3 Step Ultrasound Education & Test Preparation

### Step 1

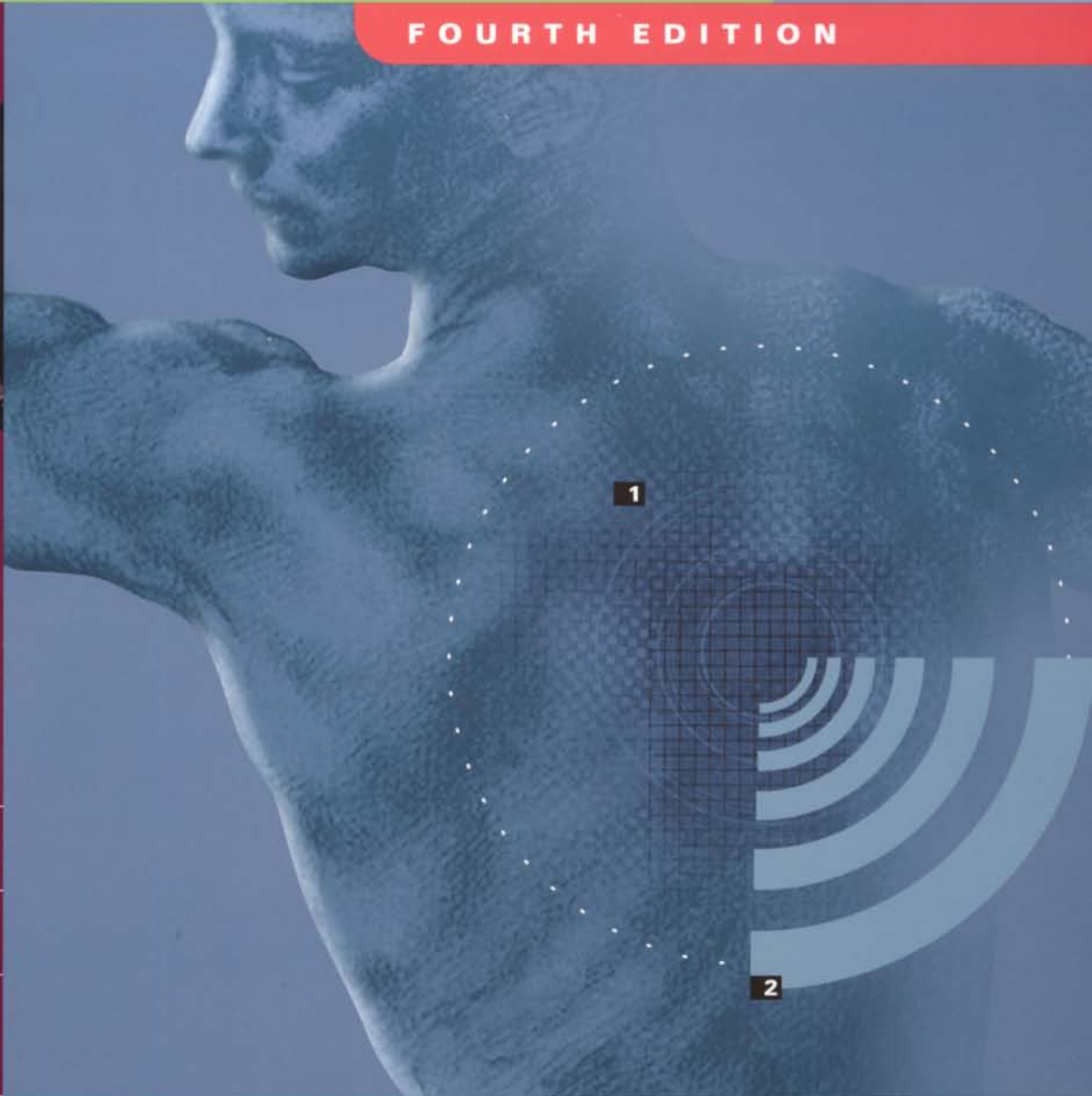
Review text

### Step 2

Mock examination

### Step 3

Q&A memory skills  
flashcard drill



SDMS-Approved  
Continuing Education Activity

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CLAUDIA RUMWELL

MICHAELNE McPHARLIN



# Vascular Technology

AN ILLUSTRATED REVIEW

FOURTH EDITION

**Claudia Rumwell, RN, RVT, FSVU | Michalene McPharlin, RN, RVT, FSVU**

For registry candidates, technologists in training, sonographers in cross-training, lab personnel, and interpreting physicians, here is the revised and expanded fourth edition of this very popular book. It began life as an illustrated review of everything a registry candidate needs to know to pass the Vascular Technology exam, topic by topic, in one volume. Written by nationally renowned authors, it quickly became *the* review for vascular candidates. It also became a standard text in diagnostic ultrasound programs across the country and a practical guide for vascular lab personnel. It is now perhaps the most widely read vascular reference in print. So we made it better. We expanded and updated the text, added many new illustrations and images, photo-documented physiologic exam techniques, published more case studies and angiograms, and included an integral application for continuing education credits with self-assessment quizzes, glossaries, and other new features. Registry candidates and students can combine this text with *Vascular Technology Review*, *Vascular Physics Review*, and *ScoreCards* for powerful 1-2-3 Step Ultrasound Education & Test Preparation.

## Other publications of interest

***Vascular Technology Review***, edited by Don Ridgway, RVT, and D.E. Strandness, Jr., MD. This completely revised edition illuminates the facts you need to know to pass the Vascular Technology specialty exam, hones your test-taking skills, and reveals your strengths and weaknesses by exam topic. Based on the ARDMS exam outline, it delivers nearly 600 Q&A items with explanations, references, and lots of images. 12 hours CME credit.



***Vascular Physics Review***, edited by Barton A. Bean, RVT. Here's the continuously updated vascular physics review candidates rely on. Approximately 500 illustrated question/answer/explanation items in registry format to simulate the exam so you can test yourself before taking the vascular physics exam. 7.5 hours CME credit.

***ScoreCards for Vascular Technology***, by Cindy Owen, RDMS, RVT, and D.E. Strandness, Jr., MD. This portable flip-card study system exercises your ability to think fast, recall key facts, and apply knowledge, wherever you are. And it's fun. More than 400 Q&A items keyed to the new registry outline, 50 image-based questions in the Image Gallery, explanations, and references. 7.5 hours CME.



***Vascular Anatomy and Physiology***, by Ann C. Belanger, RN, RVT. The perfect introduction to vascular anatomy and physiology for everyone who seeks a clear and simple presentation of the facts they must know, including hemodynamics. Highly recommended. 5 hours CME credit.

***Introduction to Vascular Scanning***, by Donald Ridgway, RVT. For novice scanners and for sonographers and echocardiographers cross-training in vascular ultrasound, here is the new and improved version of Don Ridgway's very popular, unabashedly practical, and famously unique guide to performing vascular studies—now with new chapters on the Doppler principle, those darn Doppler angles, and other vascular diagnostic modalities. 16 hours CME credit.



**CD-ROM Mock Exams.** New editions of these powerful and fun interactive wonders simulate the ARDMS exams and deliver content you can trust in Learn Mode or Test Mode: 600+ questions in registry format, answers, clear explanations, 100+ image-based questions, video demonstrations, references, tutorials, automatic performance analysis, and 15 hours CME credit. A snap to use.



**Claudia Rumwell, RN, RVT, FSVU**

Claudia Rumwell is editor of the *Vascular Laboratory Operations Manual* and the *Vascular Laboratory Policies & Procedures Manual on LabDisk*, recipient of SVU's distinguished service award, and a Fellow of the Society for Vascular Ultrasound. She has served as Technical/QA Director for the Oregon Health Sciences University Hospital/ Providence Health Systems Vascular Laboratory and lectures on registry preparation, provides consulting services, and continues to write in her spare time.



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# **Vascular Technology**

**AN ILLUSTRATED REVIEW**

New Fourth Edition

**CLAUDIA RUMWELL, RN, RVT, FSVU**

**MICHAELNE McPHARLIN, RN, RVT, FSVU**

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# Preface

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**N**ow in its fourth edition, this book remains concise, practical, and clinically oriented. Its purposes also remain the same:

- A text for sonographers and technologists in training (and cross training).
- A reference and guide for practicing technologists and sonographers.
- A resource for interpreting physicians and RPVI candidates.
- A very efficient and powerful means of preparing for the national registry examinations in vascular technology, which indeed was a primary goal of the first, second, and third editions.

In this fourth edition we have greatly expanded the content of our illustrated review. The text has been reorganized into chapters, some of them new and all of them updated and revised. There are many more figures as well. We have added and revised hundreds of images and illustrations to provide examples of normality, abnormality, and hemodynamics as they relate to physiologic Doppler and plethysmographic waveforms, duplex scanning, and color flow studies. We selected, annotated, and explain these new images to promote an understanding of not only the data acquisition process, but also the interpretation of findings.

Vascular diagnosis depends on a broad spectrum of diagnostic modalities and techniques. Like the first three editions, this fourth edition continues to explain these modalities and techniques in a concise, orderly manner, integrating a variety of elements—text, illustrations, photographs, radiographic findings, and self-assessment case-study questions. In so doing it addresses the topics on the ARDMS outline for the specialty examination in vascular technology, and also the CCI exam. In addition, it explains vascular-specific physical principles and also provides an excellent resource for those physicians taking the ARDMS physician interpretation (RPVI) exam.

The text clearly and systematically covers anatomy and hemodynamics, patient history, clinical manifestations, testing capabilities, limitations, physical principles, techniques, current diagnostic criteria, interpretation, therapeutic interventions, test validation, and related subtopics. For those whose familiarity with the nonimaging tests (physiologic studies) may be limited, it explains and illustrates them in great detail.

A complete questionnaire and exam at the end of the book make it possible to earn continuing medical education credit toward satisfaction of ARDMS, ICAVL, and other requirements for professional registration and facility accreditation.

We are very happy to offer this fourth edition to you. It is designed to provide a strong educational foundation upon which those with less experience can build and those with more experience can expand. *Vascular Technology* describes and explains how, why, and when imaging and nonimaging techniques are applied to the noninvasive diagnosis of vascular disease. It is our hope that this new edition will become a valuable tool for you in the years ahead.

Claudia Rumwell, RN, RVT, FSVU  
Portland, Oregon

Michalene McPharlin, RN, RVT, FSVU  
Detroit, Michigan

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# Arterial Evaluation

## PART I

---

GROSS ANATOMY

PHYSIOLOGY AND FLUID DYNAMICS

PATIENT HISTORY, MECHANISMS OF DISEASE, AND PHYSICAL EXAMINATION

DOPPLER WAVEFORM ANALYSIS IN THE EXTREMITIES

DOPPLER SEGMENTAL PRESSURES IN THE EXTREMITIES

LASER DOPPLER

PENILE PRESSURES, WAVEFORMS, AND DUPLEX ULTRASONOGRAPHY

PLETHYSMOGRAPHY IN THE EXTREMITIES

DIGITAL PRESSURES AND PLETHYSMOGRAPHY

TRANSCUTANEOUS OXIMETRY

DUPLEX SCANNING AND COLOR FLOW IMAGING OF THE EXTREMITIES

DUPLEX SCANNING AND COLOR FLOW IMAGING OF THE ABDOMINAL VESSELS

PREOPERATIVE MAPPING PROCEDURES

OTHER CONDITIONS

INVASIVE TESTS AND THERAPEUTIC INTERVENTION

# Gross Anatomy of the Central and Peripheral Arterial System

## CHAPTER 1

---

Aortic Arch

Upper Extremity Arteries

Thoracic and Abdominal Arteries

Lower Extremity Arteries

Microscopic Anatomy of the Arterial Wall

.....

### The Aortic Arch

The *aortic arch* has several branching vessels, which are shown in figure 1-1 on the following page and listed below:

**1** The *innominate/brachiocephalic artery*:

- Arises on the right only; it is the first branch off of the aortic arch.
- Divides into the right common carotid and subclavian arteries.

**2** The *left common carotid artery*:

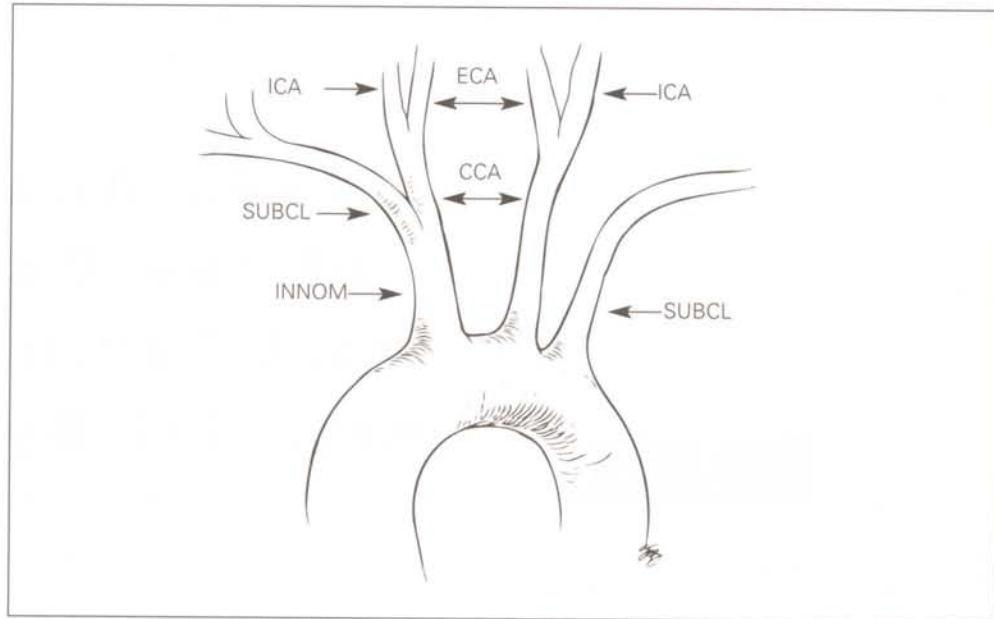
- Is the second branch off of the aortic arch.
- Terminates at the carotid bifurcation.

**3** The *left subclavian artery*:

- Is the third branch off of the aortic arch.
- Terminates at the thoracic outlet.

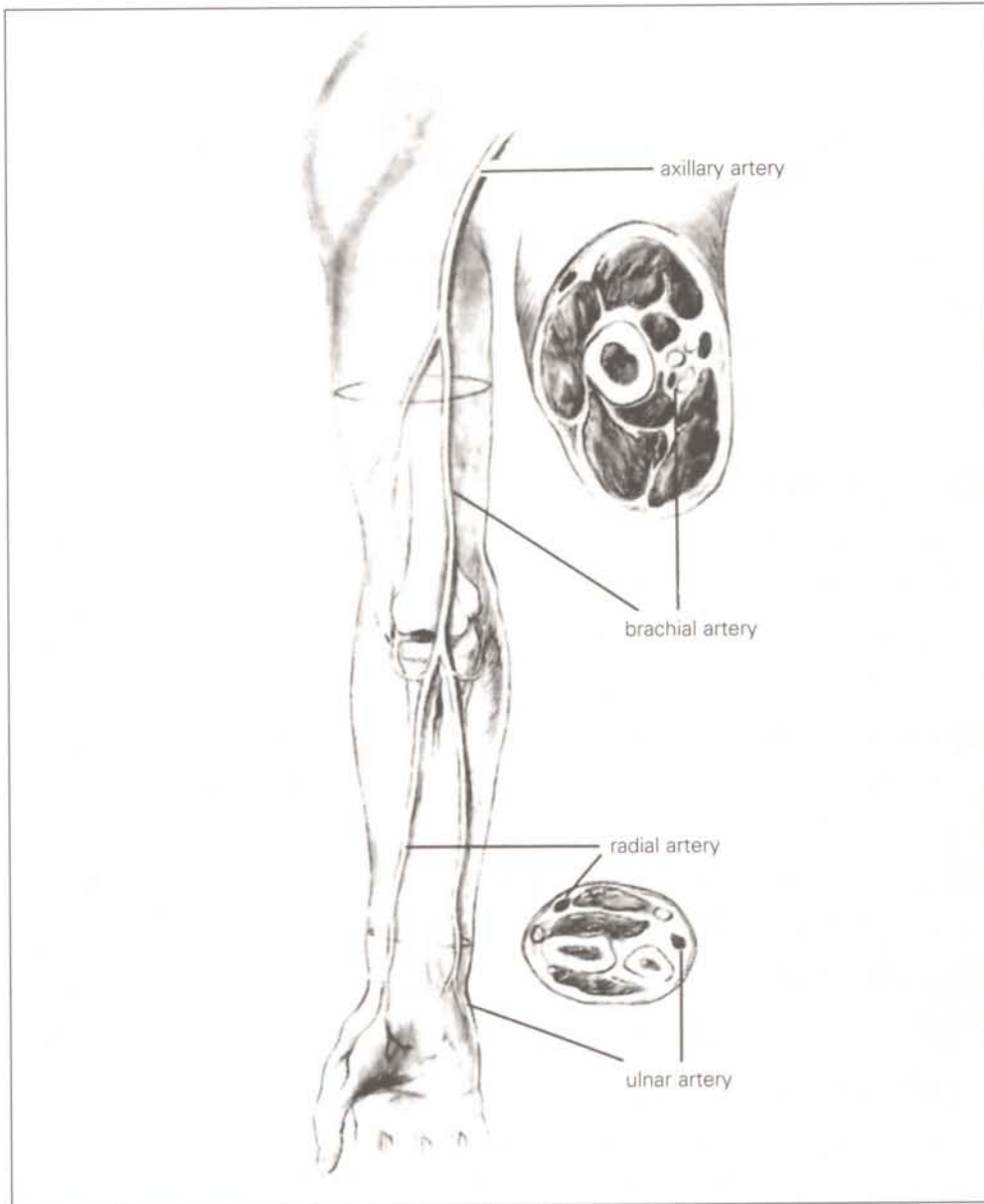
**Figure 1-1.**

The aortic arch and its branches. From Belanger AC: *Vascular Anatomy and Physiology: An Introductory Text*. Pasadena, Davies Publishing, 1999.



### Upper Extremity Arteries

- 1** The *subclavian artery* becomes the axillary as it travels along the shoulder to the upper arm:
  - It arches above the clavicle, in front of the apex of the lung and behind the scalenus anterior muscle.
  - It runs laterally and downward to the outer border of the first rib; there it becomes the axillary artery.
  - Its most important branches are the vertebral, thyrocervical, internal thoracic, and costocervical arteries.
- 2** The *axillary artery* becomes the brachial after giving off seven branches:
  - Superior artery
  - Thoracic artery
  - Thoracoacromial artery
  - Lateral thoracic artery
  - Subscapular artery
  - Anterior and posterior humeral artery
  - Thoracodorsal artery
- 3** The *brachial artery* (figure 1-2) courses down the upper arm, ending about 1 cm beyond the bend of the elbow where it divides into the radial and ulnar arteries.

**Figure 1-2.**

Major arteries of the upper extremity. From Salles-Cunha SX, Andros G: *Atlas of Duplex Ultrasonography: Essential Images of the Vascular System*. Pasadena, Appleton Davies, 1988.

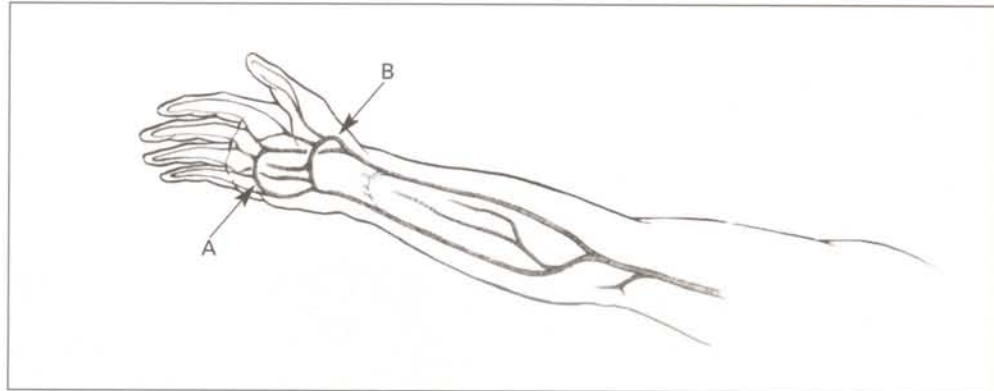
**Note:** The *antecubital fossa* is a triangular region located anterior to and below the elbow.

**4** The *radial artery* (figure 1-2):

- Originates from the brachial artery and travels down the lateral side of the forearm into the hand.
- Gives off a branch in the hand to form the superficial palmar arch and terminates in the deep palmar arch of the hand by joining the deep branch of the ulnar artery.

**Figure 1-3.**

The superficial palmar arch (A) and the deep palmar arch (B).



**5** The *ulnar artery* (figure 1-2):

- Originates from the brachial artery and travels down the medial side of the forearm into the hand.
- Gives off a deep palmar branch and then terminates in the superficial palmar arch.

**6** The *superficial palmar (volar) arch* (figure 1-3) consists of the distal portion of the ulnar artery, as it continues into the hand, and a branch of the radial artery.

**7** The *deep palmar (volar) arch* (figure 1-3) consists of the deep palmar branch of the ulnar artery and the distal portion of the radial artery.

**8** The *digital arteries*:

- Arise from the palmar arches.
- Extend into the fingers/toes.
- Divide into lateral and medial branches.

### The Thoracic and Abdominal Arteries

**1** The *ascending aorta*:

- Arises from the left ventricle.
- Has two branches, the right and left coronary arteries.

**2** The *aortic arch*, formed by the ascending aorta, gives off the three branches described above (the innominate, left common carotid, and left subclavian arteries).

**3** The *descending thoracic aorta* extends downward from the aortic arch to just above the diaphragm (figure 1-4).

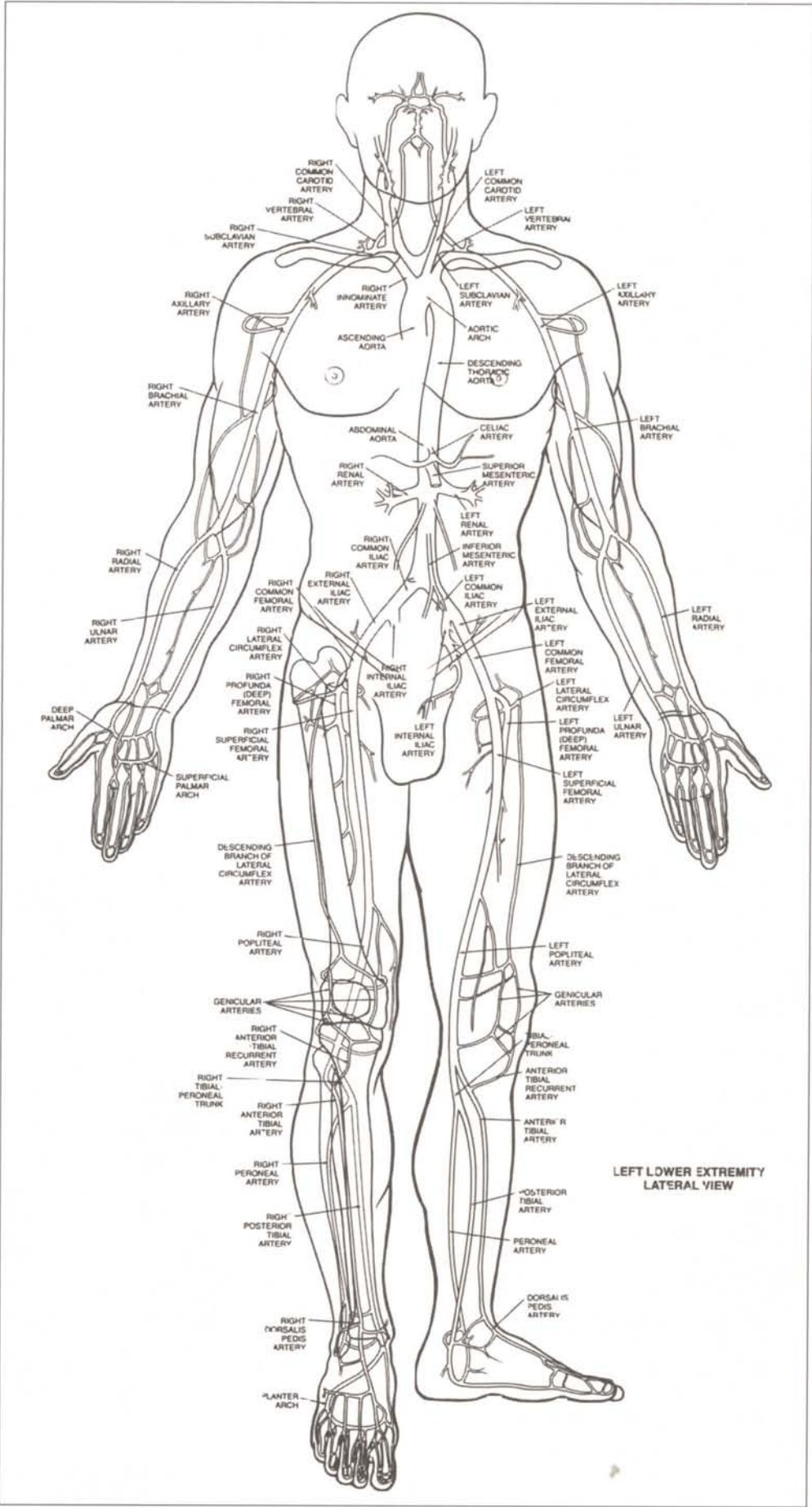
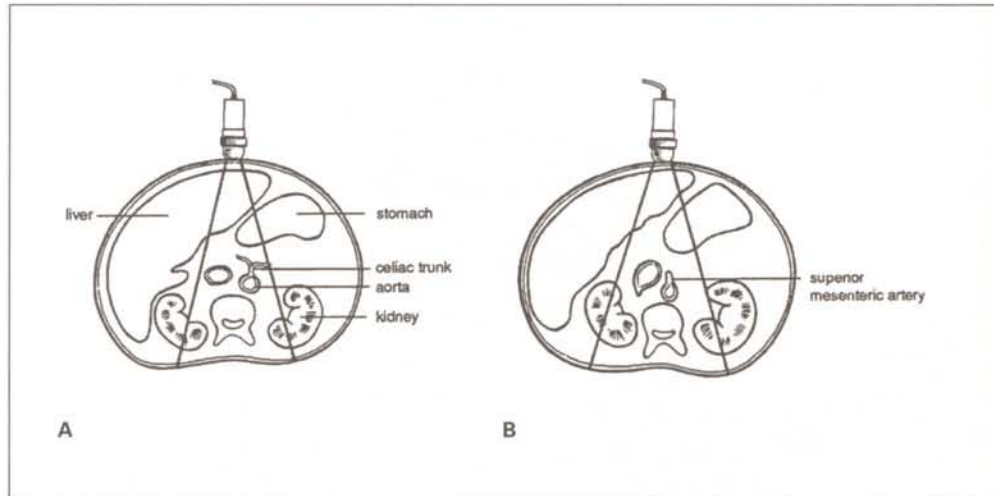


Figure 1-4. Arterial circulatory system. Courtesy of MedaSonics.

**Figure 1-5.**

Transverse views of (A) the proximal aorta at the level of the celiac trunk and (B) the proximal aorta at the level of the superior mesenteric artery. From Ridgway DP: *Introduction to Vascular Scanning*, 3rd edition. Pasadena, Davies Publishing, 2004.

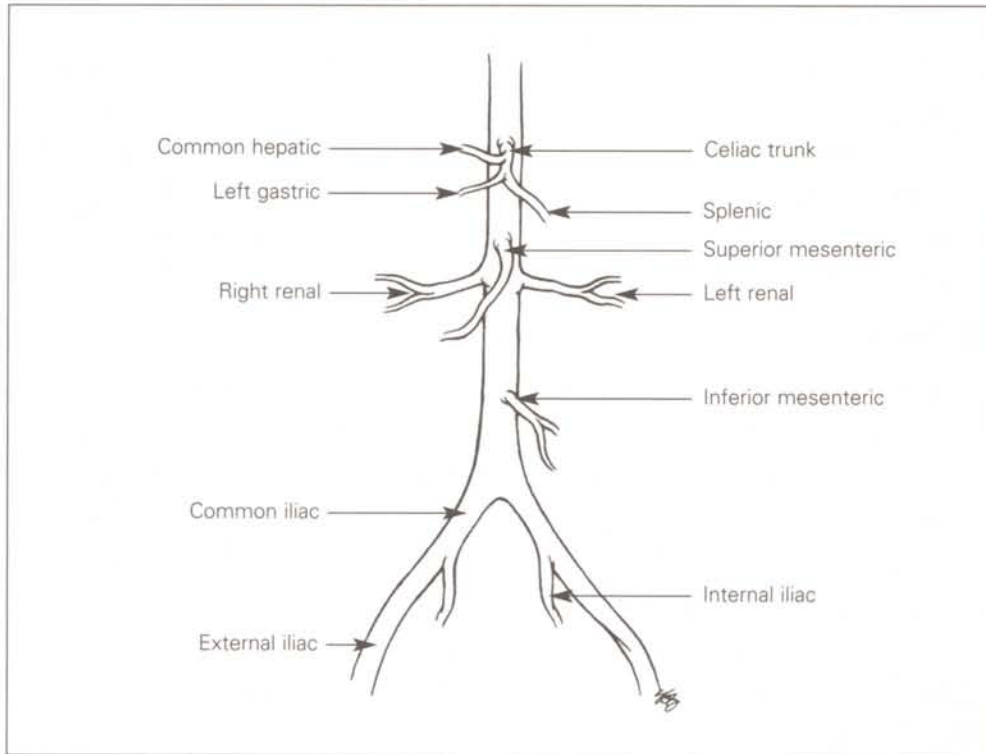


**4** The major *visceral branches of the abdominal aorta* are:

- The *celiac artery* (figures 1-4, 1-5A, and 1-6), which feeds the stomach, liver, pancreas, duodenum, and spleen, and which branches into the *left gastric, splenic, and common hepatic arteries*.
- The *superior mesenteric artery* (figures 1-4, 1-5B, and 1-6), which feeds the small intestine, cecum, ascending colon, and part of the transverse colon. Commonly abbreviated "SMA," the superior mesenteric artery is located approximately 1 cm distal to the celiac artery. The SMA and celiac artery occasionally share a common trunk.
- The *renal arteries* (figures 1-4 and 1-6), which supply blood to the kidneys, suprarenal glands, and ureters. Multiple renal arteries are not uncommon bilaterally. A landmark for locating the left renal artery is the left renal vein, which crosses the aorta anteriorly and is positioned superior to the artery. After the right renal artery branches off the aorta, it courses underneath the inferior vena cava (IVC).
- The *inferior mesenteric artery* (figures 1-4 and 1-6), which supplies the left half of the transverse colon, the descending, iliac, and sigmoid colon, and part of the rectum. It arises from the distal abdominal aorta approximately 3–4 cm above the aortic bifurcation and can act as a collateral connection.

**5** The major *parietal branches of the abdominal aorta* are:

- The *inferior phrenic artery*
- The *lumbar arteries*
- The *middle sacral artery*

**Figure 1-6.**

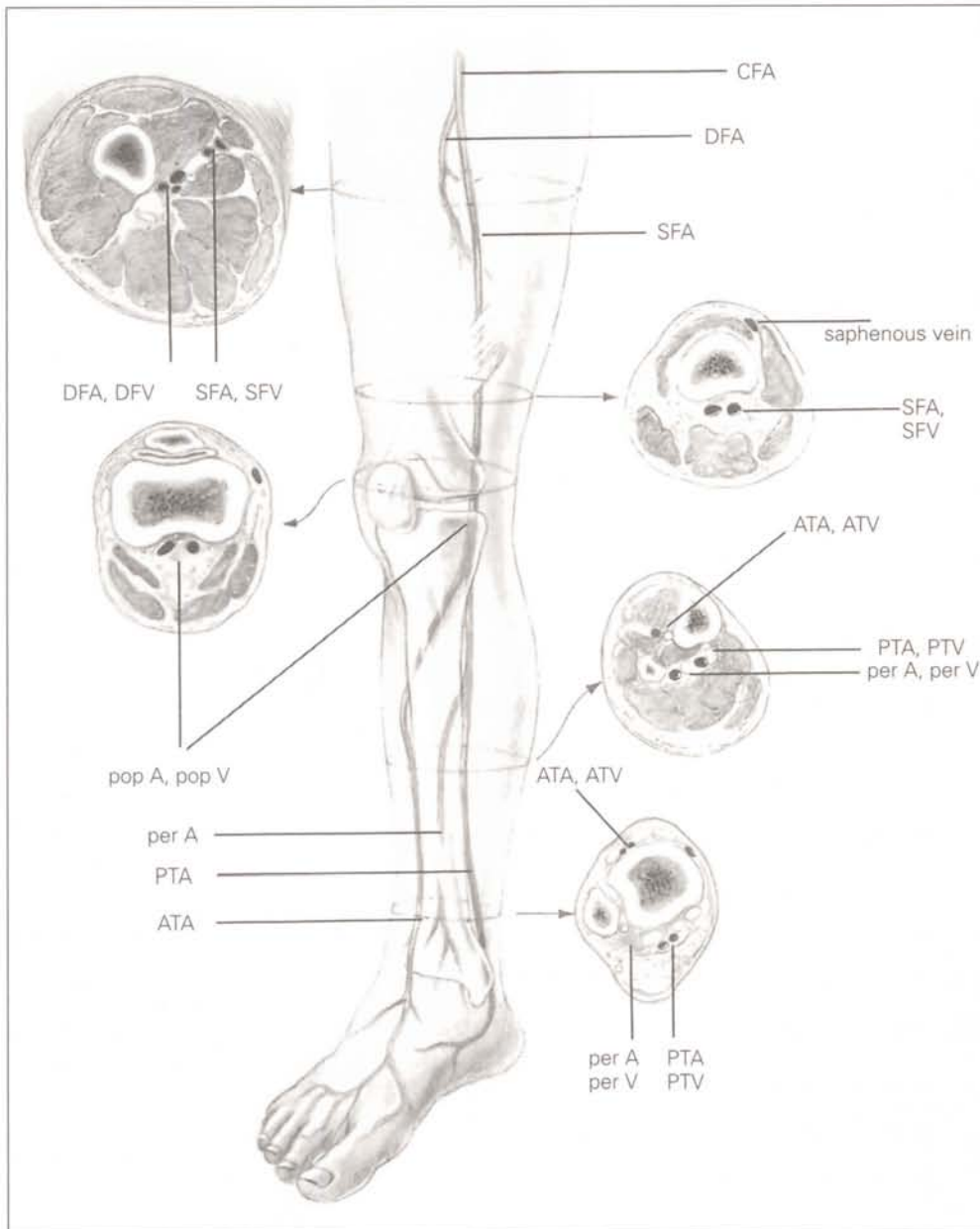
The abdominal aorta and branch vessels.

From Belanger AC: *Vascular Anatomy and Physiology: An Introductory Text*. Pasadena, Davies Publishing, 1999.

- 6** The *terminal branches of the abdominal aorta* are the right and left common iliac arteries—the distalmost branches of the aorta carrying blood to the pelvis, abdominal wall, and lower limbs (figures 1-4 and 1-6).

### The Lower Extremity Arteries

- 1** The common iliac arteries (figures 1-4 and 1-6) divide into the internal (hypogastric) and external iliac arteries at the level of the lumbosacral junction about 5 cm from their origin:
- The *internal iliac (hypogastric) arteries* are 3–4 cm in length. They descend into the pelvis, each dividing into two vessels—*anterior and posterior*—at the upper margin of the greater sciatic foramen. The internal iliac artery and its branches are highly variable. Specific branches provide arterial inflow to regions such as the pelvic wall, gluteal muscle, pelvic viscera, thigh, and perineum. Some of these branches anastomose with other arterial branches and can provide collateral flow when necessary.
  - The *external iliac arteries* are essentially continuations of the corresponding common iliac artery. In the adult they are larger than the internal iliac artery. The external iliac artery travels in a lateral and inferior direction along the medial side of the psoas major muscle. When it passes underneath the inguinal ligament, the external iliac becomes the

**Figure 1-7.**

Arteries of the lower extremities: common femoral (CFA), superficial femoral (SFA), deep femoral (DFA), popliteal (pop A), anterior tibial (ATA), posterior tibial (PTA), and peroneal arteries (per A). Adjacent veins (SFV, DFV, pop V, ATV, PTV, per V) are noted in cross section. From Salles-Cunha SX, Andros G: *Atlas of Duplex Ultrasonography*. Pasadena, Appleton Davies, 1988.

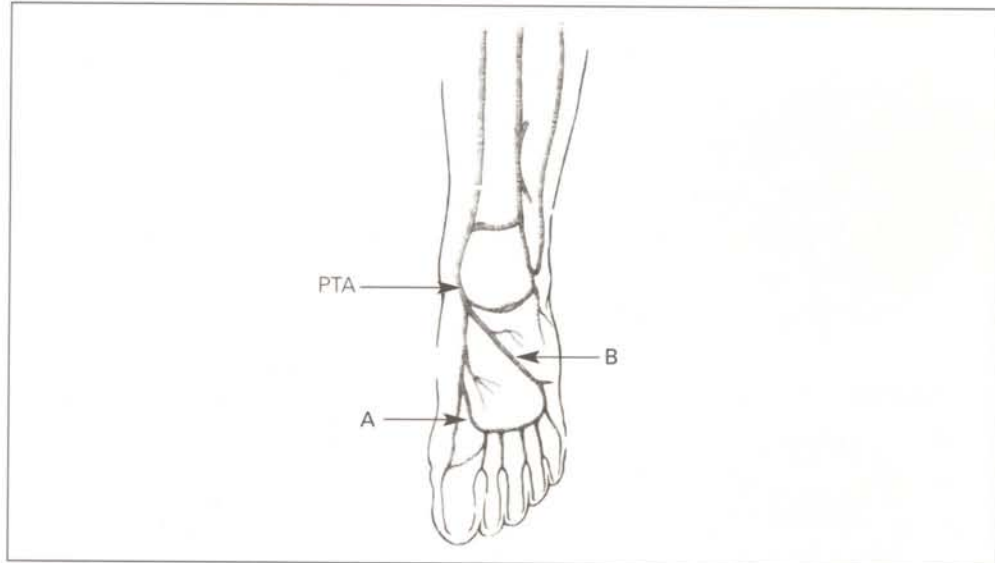
the deep plantar arteries. The deep plantar artery penetrates into the sole of the foot, uniting with the lateral plantar artery to complete the plantar arch of the foot. (See figures 1-4 and 1-8.)

##### **5** The *tibioperoneal trunk*:

- The second branch of the distal popliteal artery, the tibioperoneal trunk quickly gives rise to the posterior tibial and peroneal arteries.
- This short segment has also been called the proximal portion of the posterior tibial artery.

**Figure 1-8.**

Plantar arch (A) and the lateral plantar artery (B).



**6** The *posterior tibial artery*:

- Extends obliquely down the posterior and medial side of the leg. It is commonly referred to as one of two branches of the tibioperoneal trunk (a short segment between the anterior tibial branch and this region where the posterior tibial [PTA] and peroneal arteries develop) as shown in figures 1-4 and 1-7.
- Divides into the medial and lateral plantar arteries in the foot, below the medial malleolus, to supply the sole of the foot.

**7** The *peroneal artery*:

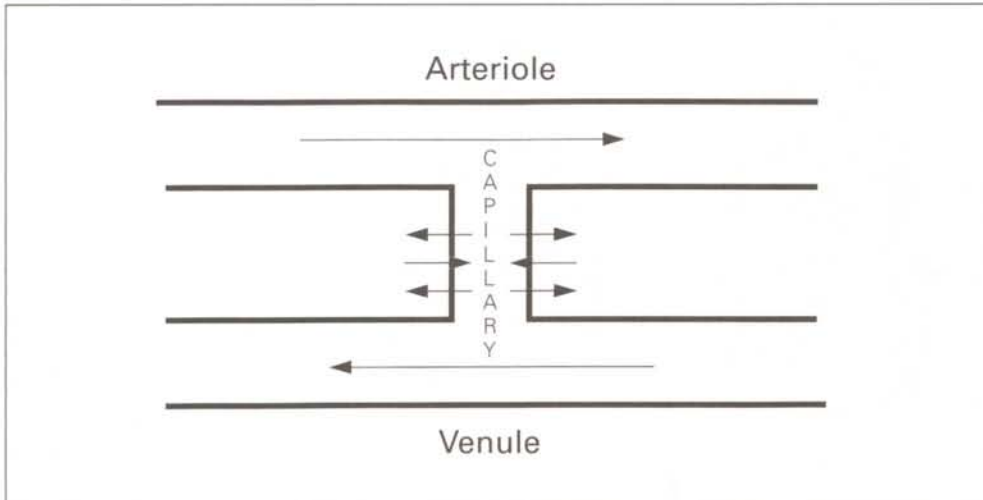
- Arises at the distal end of the tibioperoneal trunk, along with the posterior tibial artery.
- Passes toward the fibula and travels down the medial side of that bone to supply structures in the lateral side of the leg and in the calcaneal region of the foot. (See figures 1-4 and 1-7.)

**8** The *digital arteries*:

The *plantar arch*, which consists of the deep plantar artery (branch of the dorsalis pedis artery) and the lateral plantar artery (branch of the posterior tibial artery), and the dorsal metatarsal arteries distribute blood into the digits. (See figures 1-4 and 1-8.)

**9** The *capillaries*:

- Are vessels of the microcirculation.
- Are not much more than a millimeter long.

**Figure 1-9.**

Vessels of the microcirculation, where nutrients and waste products are exchanged between blood and tissue.

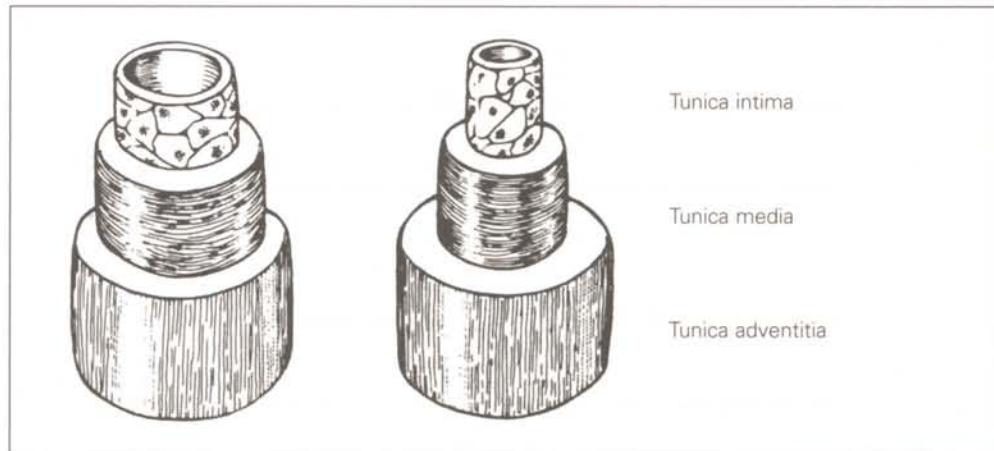
- Are 8–10 microns in diameter (about the same as a red blood cell).
- Flow quality is steady with low flow velocity.
- Have walls that consist of endothelial cells, forming a layer one cell thick.
- Form vast networks with a total surface area of about 1.5 acres or 6,000 square meters.
- Are supplied by the arteries, which transport gases, nutrients, and other essential substances to the capillary beds. Arteries progressively decrease in size from the aorta (largest) to the arterioles (smallest). Arterioles, which are considered to be resistance vessels, help to regulate blood flow by contracting and relaxing.
- Constitute a most vital part of the circulatory system. It is through the walls of the capillaries that nutrients and waste products are exchanged between tissue and blood to maintain the constancy of the internal environment (figure 1-9). It has been said that all other circulatory system organs exist only to serve the capillary beds.

### Microscopic Anatomy of the Arterial Wall

- 1** The function of the artery is to transport blood—and the gases, nutrients, and other essential substances it contains—away from the heart and out to the tissues.
- 2** Anatomy:
  - The *tunica intima*, the innermost layer of the arterial wall, is thin and consists of a surface layer of smooth endothelium over a base membrane and connective tissue.

**Figure 1-10.**

The three layers of the arterial wall. From Belanger AC: *Vascular Anatomy and Physiology: An Introductory Text*. Pasadena, Davies Publishing, 1999.



- The *tunica media*, the intermediate layer of the arterial wall, is thicker and composed of smooth muscle and connective tissue, largely of the elastic type. These components are usually arranged in a circular pattern.
- The *tunica externa* (or *adventitia*) is the outer layer of the arterial wall. It is somewhat thinner than the media and contains white fibrous connective tissue and, at times, a few smooth muscle fibers, all arranged longitudinally. The adventitial layer usually contains the vasa vasorum, tiny vessels that carry blood to the walls of the larger arteries.
- These three coats of the arteries may be separated by internal and external elastic membranes. (See figure 1-10.)