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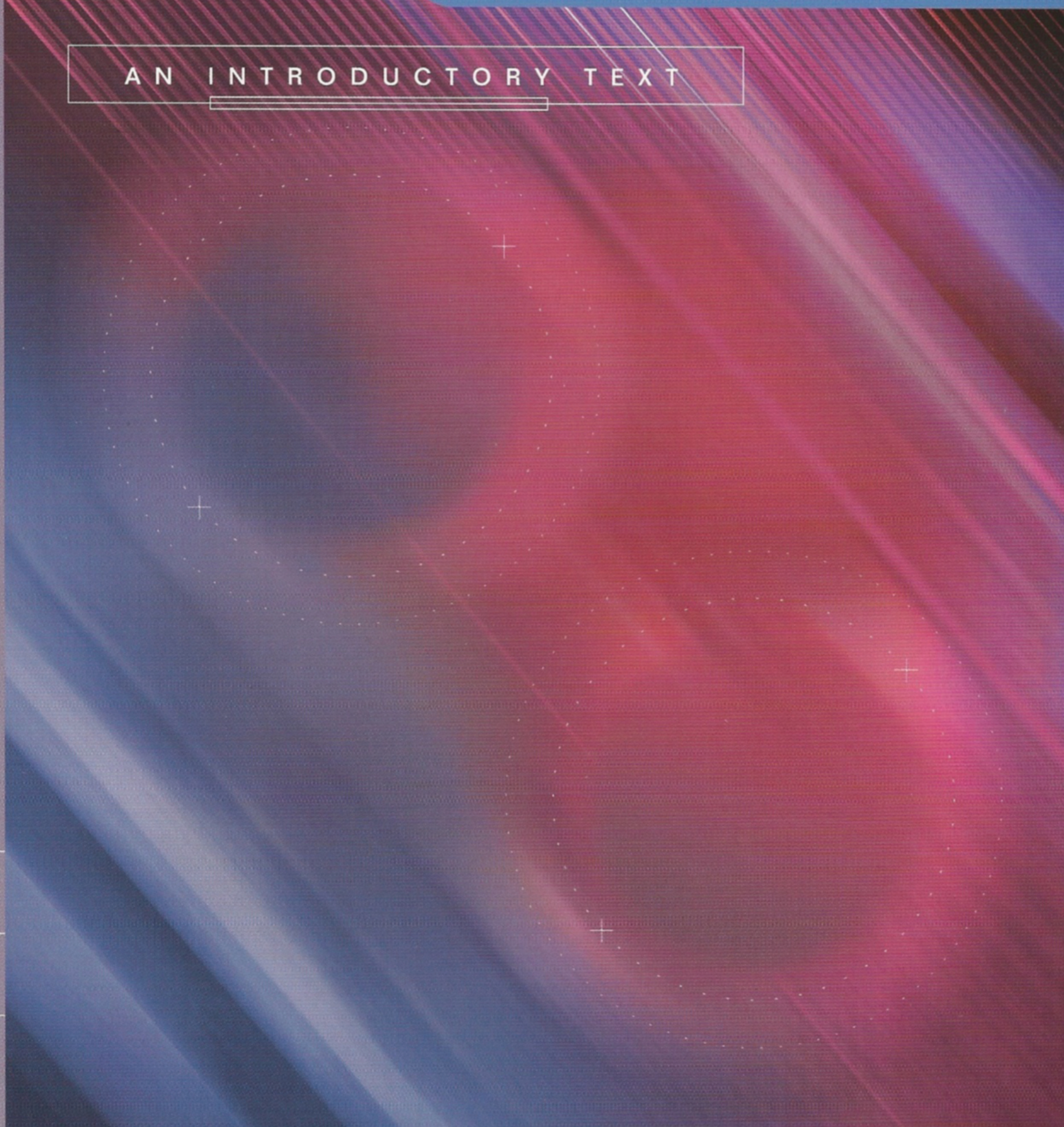
VASCULAR ANATOMY AND PHYSIOLOGY

AN INTRODUCTORY TEXT



1-2-3 Step Ultrasound Education

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ANN C. BELANGER, RN, RVT

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VASCULAR ANATOMY AND PHYSIOLOGY

AN INTRODUCTORY TEXT

ANN C. BELANGER, RN, RVT

Here is the perfect introduction to vascular anatomy and physiology for students, vascular and radiology technologists, sonographers, nurses, and others who seek a clear and simple presentation of the facts they must know to pass their certification examinations and to discharge their daily clinical responsibilities. There is a wealth of information on standard anatomic terminology, micro anatomy, gross anatomy, the cardiopulmonary and systemic circulations, and arterial and venous hemodynamics. All of it is presented with the clarity, simplicity, and practicality that are the hallmarks of Ms. Belanger's style. Clinical implications are always emphasized: How, where, and why do you palpate a pulse? What exactly is an anteroposterior view? A midsagittal section? What does one do with a transducer in order to move it medially or cephalad? How does Poiseuille's law help us understand blood flow data? What happens when the carotid sinus is massaged? Why? Coverage of these and a multitude of other topics includes terminology, micro anatomy and physiology of the blood vessels, gross anatomy and physiology of the cardiopulmonary and peripheral circulations, characteristics of arterial blood flow, energy concepts, arterial pressure and flow, mechanisms of control, venous pressure and flow, and the venous valves and leg muscles. This large-format manual contains reviews at the end of each chapter, self-assessment quizzes at the end of the book, a bibliography, and a detailed index.

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ANN C. BELANGER, RN, RVT

Foreward by
Victor M. Bernhard, MD

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CHAPTER

12

Venous Pressure and Flow

The first characteristic we associated with arterial flow was pulsatility. At that time we said that the direct influence of the pulsing heart on the venous system is minimal. Most veins do not pulsate, but there are two full and one partial exception to that rule. Because of their relationship to the heart, the internal jugular vein and the subclavian vein are normally pulsatile. The axillary vein is sometimes pulsatile and sometimes not, depending on the individual. Pulsatility in the axillary vein is not considered abnormal, but, rather, an individual variation.

If nonpulsatility is normal in all but the great veins, is some characteristic of flow typical of veins? Yes. The characteristic of flow typical of veins is phasicity.

PHASICITY

The term *phasicity*, in reference to the venous system, refers to the ebb and flow that occurs in normal veins in response to respiration. All deep veins normally exhibit phasicity, even those that are somewhat pulsatile. If you were listening to (auscultating) the internal jugular vein, for instance, you would expect to hear a sound that was both pulsatile and phasic. Respiration has this ebb/flow influence because unlike the strong-walled arteries, veins are collapsible (see Chapter 3).

The two phases of respiration are *inspiration* (breathing in) and *expiration* (breathing out). The way in which the blood moves in phase with respiration differs according to the part of the body affected and the position in which the body is placed. As an example, we can look at venous return from the lower limbs in an upright body.

Venous Return from the Lower Extremities

When a body is standing upright, breathing produces pressure gradients that influence the movement of venous blood. As the lungs fill with air during inspiration, the thoracic cavity expands. When the thorax expands, the diaphragm drops; consequently the abdominal cavity becomes smaller. The veins located within the chest and abdomen are affected by these changes in pressure.

As the thoracic cavity gets larger, pressure within it decreases, and pressure within the right atrium and the thoracic portion of the vena cava is also reduced. At the same time, the abdominal cavity is getting smaller, raising the pressure within the abdomen and the abdominal veins. You have already learned that fluids move from areas of high pressure to areas of low pressure, so you can deduce that during inspiration, more venous blood from the lower body will move into the thoracic area, which has the lower pressure.

With expiration, the process reverses itself. When the lungs expel air, the thoracic cavity becomes smaller and the abdominal cavity grows larger. Now the intraabdominal pressure is lower than the intrathoracic pressure, and less blood will move from the veins of the lower extremities into the veins of the chest.

However, as we said at the outset, the position of the body influences the effects of respiration on venous flow. Consider what happens to venous flow in your lower extremities when you are supine (lying on your back).

Even when you are supine, you expand your chest when you inhale. But now the space in which your chest can expand is limited by the surface on which you are lying. When you fill your lungs with air, they push your posterior thorax against this surface, compressing the vena cava so that blood cannot enter it. Venous flow from the lower extremities will diminish. When you exhale, you release the compression on the vena cava, allowing blood from the lower extremities to enter it once more. So, when you are lying down, respiration has an effect opposite to what occurs when you are standing up.

Venous Return from the Upper Extremities

Respiration also affects venous return from the upper extremities, but to a lesser extent than it affects the lower body. Again, phasicity in the upper-extremity veins also can vary according to circumstances. If you are listening to a brachial vein, for instance, inspiration may produce either a reduced sound or an increased sound. If the lowered, or negative, intrathoracic pressure causes more blood to move from the brachial vein to the subclavian, sound from the brachial vein will increase. Sometimes, however, expansion of the lungs on inspiration will physically compress the subclavian vein. When this happens, less venous blood will move from the chest into the arms, and sound in the brachial vein will diminish.

The importance of all this is that you should be able to detect phasic changes in all the deep veins in relationship to breathing.

HYDROSTATIC PRESSURE

In Chapter 10 you learned a little about hydrostatic pressure in relation to arterial physiology. The principles discussed there also apply to venous hemodynamics. As you have just learned, changes in pressure in various parts of the body partially determine the movement of arterial blood. Changes in pressure within different veins also influence the movement of venous blood. So does the relationship between different types of pressure and energy, specifically hydrostatic pressure.

As stated earlier, *hydrostatic pressure* is the pressure exerted by fluid within a closed system. The equation we used for

$$HP = \rho g h$$

HP = hydrostatic pressure
ρ = specific gravity of the blood
g = acceleration due to gravity
h = height above a specified reference point

determining hydrostatic pressure is:

To review briefly: We said that the hydrostatic pressure in the vessel, together with the muscular contraction of the heart and the static filling pressure of the blood, determined the intravascular pressure. The static filling pressure has a negligible effect. The muscular contraction of the heart (which can also be called dynamic pressure) chiefly affects the arterial system, not the venous. That leaves hydrostatic pressure as the primary factor in determining intravascular pressure within the venous circulation.

Hydrostatic pressure varies with position. For instance, when you are lying down, there is virtually no hydrostatic pressure in your legs, since they are at the same level as the right atrium, which has a pressure of around zero. But when you stand up, the situation changes drastically. When you are upright, the veins of the lower extremity represent a long tube or column of fluid. The hydrostatic pressure in that tube is considerable.

As an example: Say that in a 6-foot person who is supine the venous pressure at the level of the ankle is about 10 mmHg. When that person stands up, the ankle venous pressure rises to 112 mmHg. As this occcurs, the veins of the legs dilate to accept the blood that is pooling in them. In fact, it is estimated that about 250 mL of blood shifts to the legs when a person who is lying down stands up.

In Chapter 13, we will discuss the mechanisms that interact to move this venous blood out of the legs, back to the heart, then out again into the arterial system.

CHAPTER REVIEW

- Phasicity—the ebb and flow of blood that occurs in response to respiration—is a flow characteristic common to all deep veins.
- Pulsatility is abnormal in veins, with the exception of the internal jugular and subclavian veins and, in some individuals, the axillary vein. (To be normal, these veins should also exhibit phasicity.)
- When the body is supine, inspiration decreases the flow of venous blood out of the lower extremities; expiration increases venous return to the heart.
- When the body is in the standing position, inspiration increases venous return to the heart; expiration decreases it.
- Hydrostatic pressure—the pressure exerted by fluid within a closed system—varies with position.