CHAPTER 8

ANATOMICAL CONSIDERATIONS

CHAPTER OBJECTIVES

- Embalming injection and drainage sites
- Vessels used for arterial injection and drainage
- Vessel extents, linear and anatomical guides
- Relationship of arteries, veins, and surrounding anatomical structures
- Vessels of the body trunk cavities

It is essential that the embalmer possesses a sound understanding of and familiarity with the human body to efficiently approach and solve embalming problems. This chapter emphasizes those areas of anatomy most concerned with the embalming process. The orientation is strictly anatomical and space in the text is not consumed with considerations of the functional significance of any structure.

Before one can conceptualize the internal anatomy of the body, he or she must first be familiar with surface features and the manner in which they relate to underlying structures. A thorough knowledge of surface anatomy permits one not only to make appropriate skin incisions but also to anticipate which structures will appear when the incisions are made.

A portion of this chapter is devoted to the fundamentals of surface anatomy as it relates to underlying musculoskeletal and visceral structures. As a complete treatment of these topics is well beyond the scope of this text, this discussion is limited to those aspects of greatest importance to the embalmer.

All descriptions used throughout the text assume that the body is in the anatomical position: the subject is standing erect, the arms of the subject are at the sides with the palms of the hands facing the observer, the feet are together, and the subject is facing the observer.

The embalmer should have a detailed understanding of the blood vascular system. For each of the major vessels used in embalming, the anatomical guide, linear guide, and anatomical extent (limit) of each artery are given.

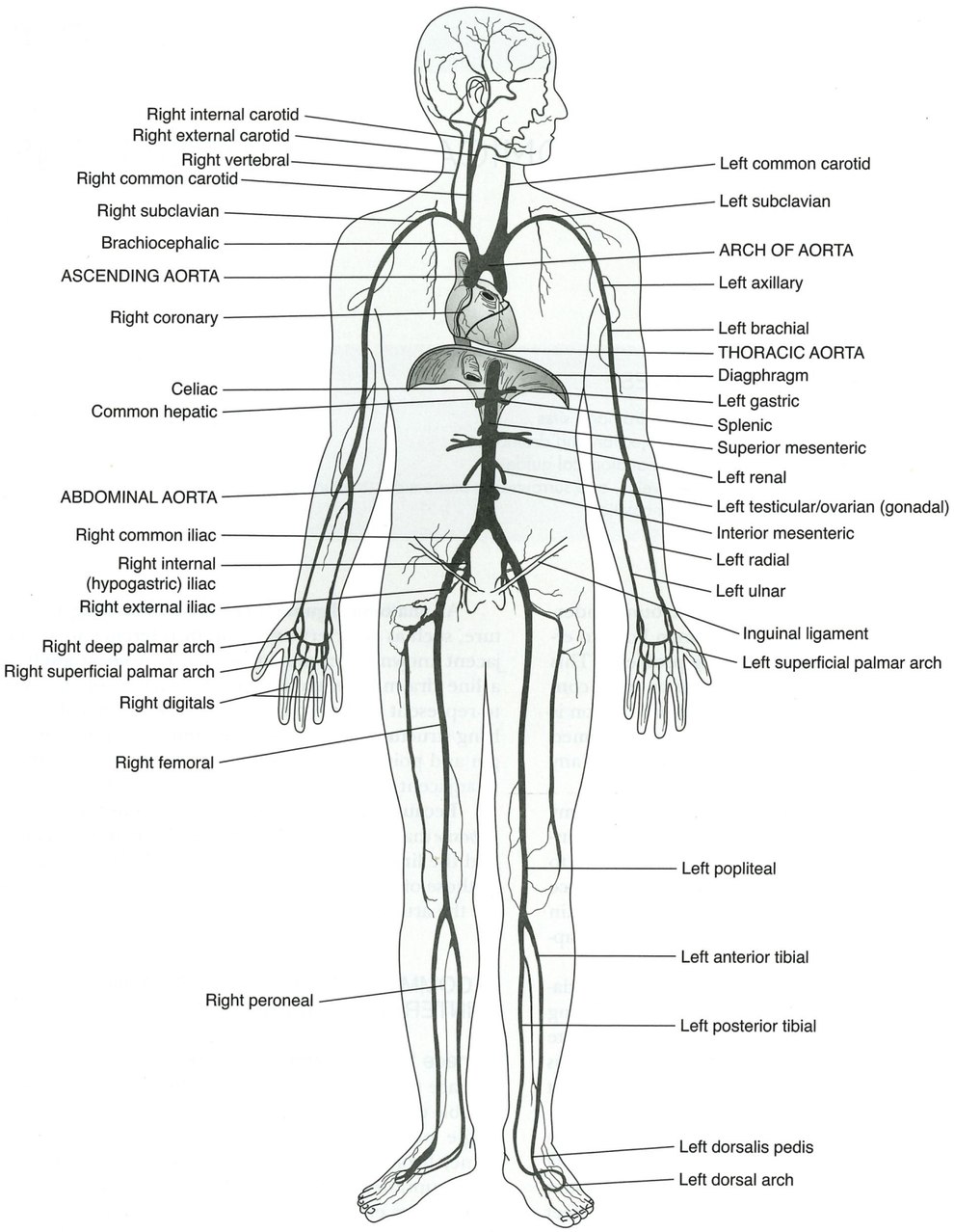
An **anatomical guide** is a method of locating a structure, such as an artery or a vein, by reference to an adjacent known or prominent structure. A **linear guide** is a line drawn or visualized on the surface of the skin to represent the approximate location of some deeper-lying structure. The **anatomical limit** is the point of origin and point of termination of a structure in relation to adjacent structures.

Because the blood in the veins flows in the *direction opposite* that of blood in the arteries, the anatomical limit and the linear guide for the veins would be the *opposite* of those of the respective artery. The anatomical guides for the arteries and the veins would be the same.

▶ COMMON CAROTID ARTERY AND INTERNAL JUGULAR VEIN

Surface Features and Landmarks

Surface features of the neck that the embalmer should be able to locate and describe are the clavicle, mandible, angle of the jaw, mastoid process of the temporal bone, hyoid bone, sternum, sternoclavicular articulation, suprasternal notch, and thyroid cartilage of the larynx. The embalmer should also be familiar with one muscle, the **sternocleidomastoid muscle (SCM).** In addition, the location of the external jugular vein should be recognized. Underlying the skin in this area is a thin, delicate cutaneous muscle (a muscle of facial expression) called the **platysma,** the presence of which is indicated by the shallow, transverse wrinkles of the neck.



Consider first the anterior triangle of the neck. Draw an imaginary line along the midline of the neck between the tip of the mandible and the sternum. Extend this line superiorly along the anterior border of the SCM and then anteriorly along the lower margin of the body of the mandible. These three lines and their anatomical parallels describe the **anterior triangle.** In the midline, one can palpate (feel), from above downward, the hyoid bone and the thyroid and cricoid cartilages. The external carotid artery and several of its branches are located in the anterior triangle. Here, these vessels are relatively superficial, being covered only by skin and subcutaneous tissue.

Anterior Triangle of the Neck

The skin over the anterior triangle is thin and underlaid by the thin, cutaneous platysma muscle. This muscle acts to alter the contour of the skin of the neck in much the same manner that the muscles of facial expression modify the appearance of the face. The significance of the muscle to the embalmer is that most structures of importance in the embalming process lie beneath the plane of this muscle. With the skin and platysma incised and reflected, the contents of the anterior triangle and the surrounding area are brought into view.

The SCM is a useful guide to the anterior triangle. Attached to the mastoid process of the temporal bone and the manubrium of the sternum, the muscle courses obliquely along the side of the neck. On the muscle surface, one can identify the external jugular vein together with some of its tributaries. The external jugular and the internal jugular veins cannot be confused because of the relationship of the former to the outer surface of the SCM.

Lying posterior and roughly parallel with the SCM muscle are the carotid sheath and its contents. The sheath is an investment of fascia that extends up into the neck and contains within it the common carotid (medial) artery, the internal jugular vein (lateral), and the vagus nerve (between the artery and the vein). The lower portion of the sheath is crossed anteriorly by the central tendon of the omohyoid muscle. Identification of this muscle can guide the embalmer to the underlying carotid sheath and provide confidence that the operation has not progressed too deep.

If the sheath is incised, the upper portion of the internal jugular vein and the common carotid artery become visible. The vein lies lateral to and partially overlaps the artery. A few variable tributaries of the internal jugular vein may be seen crossing the carotid artery in this area. The vagus nerve (cranial nerve X) can be identified between and posterior to the two vessels within the sheath.

In the upper portion of the anterior triangle, the common carotid artery divides into internal and external carotid arteries and several branches of the latter

Figure 8–1. Linear and anatomical guides for the common carotid artery.

may be identified here. The internal carotid, of course, has no branches until it enters the cranium.

Common Carotid Artery

Linear Guide. Draw or visualize a line on the surface of the skin from a point over the respective sternoclavicular articulation to a point over the anterior surface of the base of the respective earlobes.

Anatomical Guide. The right and the left common carotid arteries are located posterior to the medial border of the SCM, on their respective sides of the neck (Fig. 8–1).

Anatomical Limit. The right common carotid begins at the level of the right sternoclavicular articulation and extends to the superior border of the thyroid cartilage. The left common carotid begins at the level of the second costal cartilage and extends to the superior border of the thyroid cartilage.

Origins. The right common carotid is a terminal branch of the brachiocephalic artery. The left common carotid is a branch off the arch of the aorta.

Branches. There are no branches of the right common carotid, except the terminal bifurcation into the right internal and external carotid arteries. The left common carotid also has no branches, except the terminal bifurcation into the left internal and external carotid arteries.

Branches of the Right and Left External Carotid Arteries. Ascending pharyngeal, superior thyroid, lingual, facial,* occipital, posterior auricular, maxillary, superficial temporal (Fig. 8–2; also see Fig. 9–4).

*To raise the facial artery for injection, the incision is made along the inferior border of the mandible just anterior to the angle of the jaw.

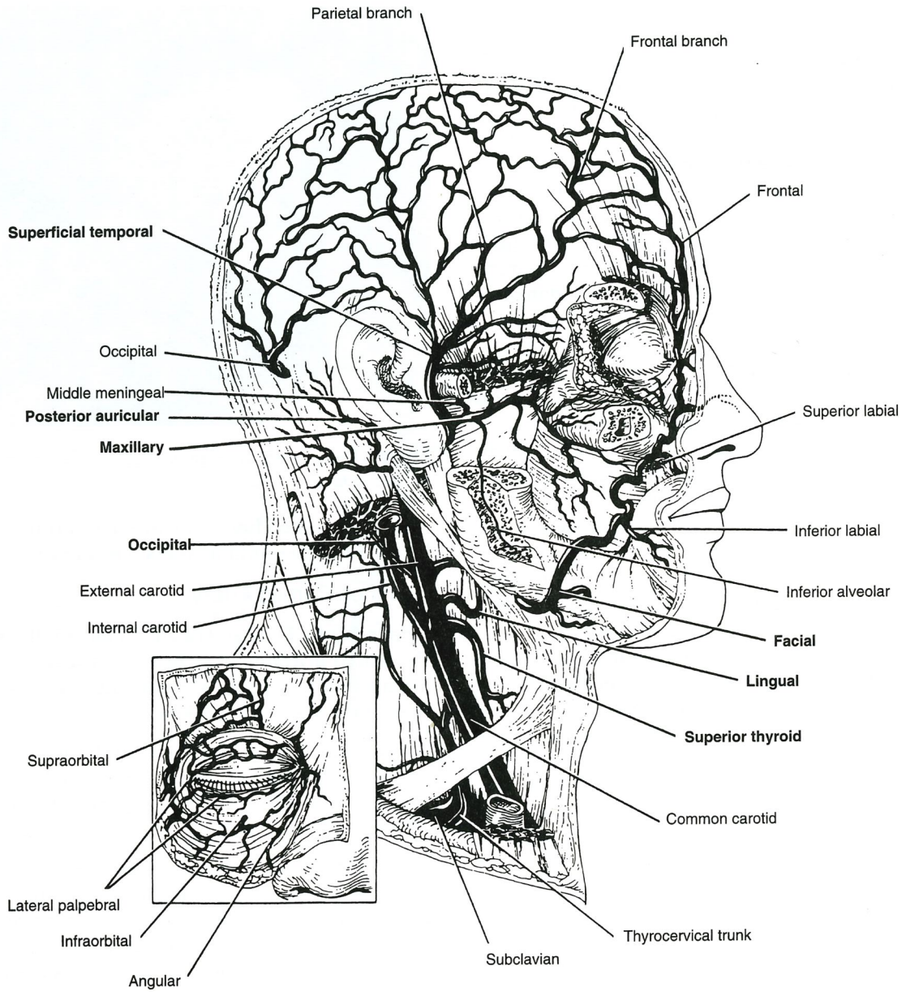


Figure 8–2. Cross-section of the head and the neck. Branches of the external carotid artery are shown in bold type.

Branches of the Right and Left Internal Carotid Arteries. Branches arising within the carotid canal, in addition to ophthalmic, anterior cerebral, middle cerebral, posterior communicating, and choroidal branches.

Relationship of the Common Carotid to the Internal Jugular Vein. The internal jugular vein lies lateral and superficial to the common carotid artery.

Contents of the Carotid Sheath. Internal jugular vein (lateral to artery), vagus nerve (between and posterior to artery and vein), common carotid artery (medial to vein) (Fig. 8–3).

▶ THE AXILLA—SURFACE ANATOMY

When the arm is extended (or abducted), conceptualization of the axilla is easy. Think of a truncated pyramid: four walls, a base, and an apex that has been made flat and parallel with the base. Surface landmarks of the axillary region are the ribs and intercostal muscles and the anterior and posterior axillary folds. The most obvious boundaries of the axilla are its anterior and posterior walls, which comprise the anterior and posterior axillary folds. The anterior fold can be identified by grasping (with one hand) the mass of tissue on the anterior surface of the axilla on the contralateral side of the body.

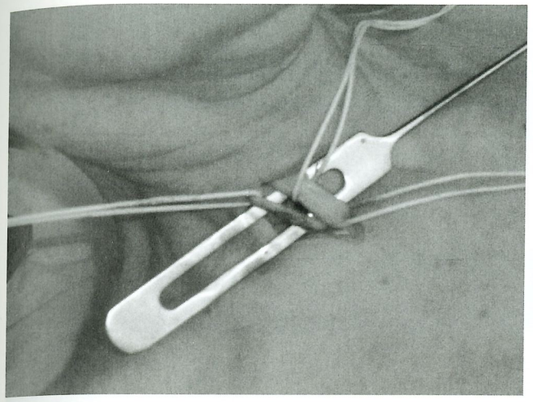


Figure 8–3. Right common carotid artery and internal jugular vein. The artery lies medial to the vein.

Most of the substance of this fold consists of the pectoralis, major muscle with contributions from the pectoralis minor, and the subclavius muscles.

The posterior axillary fold can be identified by grasping (with one hand) the tissue mass on the posterior side of the axilla on the contralateral side of the body. This fold consists of the latissimus dorsi, subscapularis, and teres major muscles. The medial axillary wall consists of ribs 2 through 6 and their intercostal muscles, covered externally by the serratus anterior muscle. The ribs can usually be palpated even if they are not visible on the chest surface.

The serratus anterior muscle also contributes to the medial wall but is visible as a surface feature only in lean, muscular subjects. The shaft of the humerus makes up a portion of the lateral wall, and although it cannot be seen, it is easily palpated.

The biceps brachii and coracobrachialis muscles also contribute to the lateral wall. The former is discernible in virtually all subjects, whereas the latter is clearly defined only in lean, muscular subjects. The apex of the axilla is an opening called the **cervicoaxillary canal,** which transmits structures from the neck into the arm and is bounded by three bony points of interest: the clavicle, the scapula, and the first rib. The cervicoaxillary canal is an important point of interest to the embalmer, particularly in autopsied bodies. Of the three landmarks that demarcate this canal, only the first rib is difficult to palpate. The base of the axilla is closed with dome-shaped fascia and skin on which the axillary hair is found.

Familiarity with the surface features of the axilla guides one to the important axillary contents, including the axillary artery and its six branches, the axillary vein, and the many elements of the brachial plexus. The axillary sheath invests the major structures that leave the neck and pass through the cervicoaxillary canal to enter the axilla. On opening the axillary sheath, the first structure encountered is the axillary vein. If the extremity is abducted, the vein comes to lie over the axillary artery and partially obscures it.

The six typical branches of the axillary artery are fairly consistent and the axillary artery is relatively large. Identification of the artery within the sheath may prove difficult because of the many nerves of the brachial plexus that surround and partially obscure the artery. There are three large nerve cords of the brachial plexus: medial, lateral, and posterior. They are grouped around the middle portion of the axillary artery in positions corresponding to their names.

Within the axilla, the nerve cords and some of the terminal branches form specific anatomical relationships with the axillary artery, making access to the artery sometimes awkward. These are large nerves in some cases, and care must be taken to avoid confusing elements of the plexus with the axillary artery. Careful inspection and the knowledge that the nerves surround the artery will remove any confusion. *Approach to the axilla is made through an incision along the midaxillary line.*

Axillary Artery

Linear Guide.. Draw or visualize a line on the surface of the skin from a point over or through the center of the base of the axillary space to a point over or through the center of the lateral border of the base of the axillary space. This line is parallel to the long axis of the abducted arm.

Anatomical Guide. The axillary artery is located just behind the medial border of the coracobrachialis muscle.

Anatomical Limit. The axillary artery extends from a point beginning at the lateral border of the first rib to the inferior border of the tendon of the teres major muscle (Fig. 8–4).

Origin. The axillary artery is a continuation of the subclavian artery.

Branches. Highest (supreme) thoracic artery, thoracoacromial artery, lateral thoracic artery, subscapular artery, anterior humeral circumflex artery, posterior humeral circumflex artery.

Relationship of the Axillary Artery to the Axillary Vein. The axillary artery is located lateral and deep to the axillary vein.

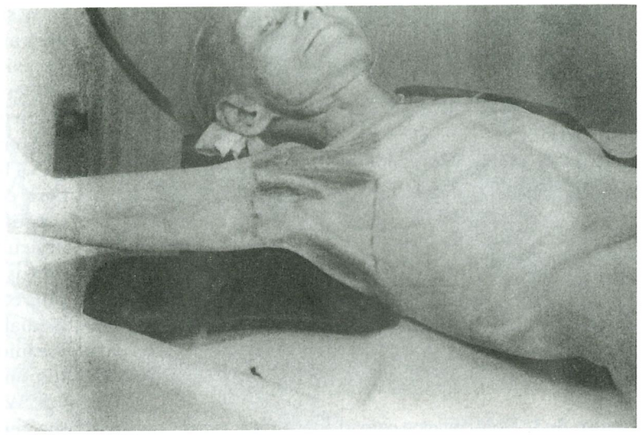


Figure 8–4. The axillary space is outlined and the location of the coracobrachialis muscle illustrated.

Incision for Raising the Axillary Vessels. The incision is made along the anterior margin of the hairline of the axilla with the arm abducted.

Brachial Artery

Linear Guide. Draw or visualize a line on the surface of the skin from a point over the center of the lateral border of the base of the axillary space to a point approximately 1 inch below and in front of the elbow joint.

Anatomical Guide. The brachial artery lies in the bicipital groove at the posterior margin of the medial border of the belly of the biceps brachii muscle.

Anatomical Limit. The brachial artery extends from a point beginning at the inferior border of the tendon of the teres major muscle to a point inferior to the antecubital fossa (Fig. 8–5).

Origin. The brachial artery is a continuation of the axillary artery.

Relationship of the Brachial Artery and the Basilic Vein. The accompanying basilic vein is located medial and superficial to the brachial artery.

Location of the Incision. The brachial artery is usually raised by an incision made along the upper one-third of the linear guide.

▶ DISTAL FOREARM

The distal forearm is the area in which the radial and ulnar arteries can be approached should they need to be raised for injection (Fig. 8–6). The radial artery lies on the lateral side of the forearm and the ulnar artery on

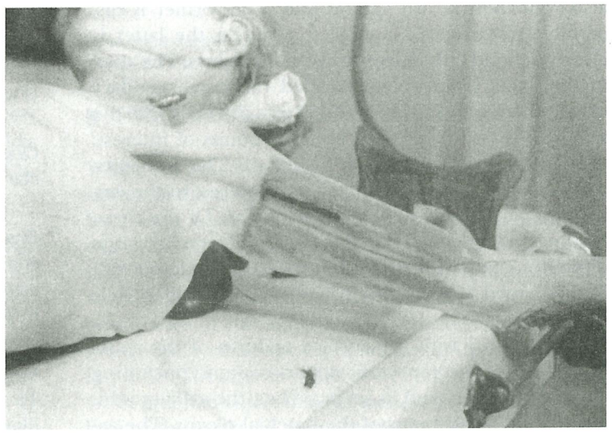


Figure 8–5. Linear guide, anatomical guide, and suggested incision location for the brachial artery.

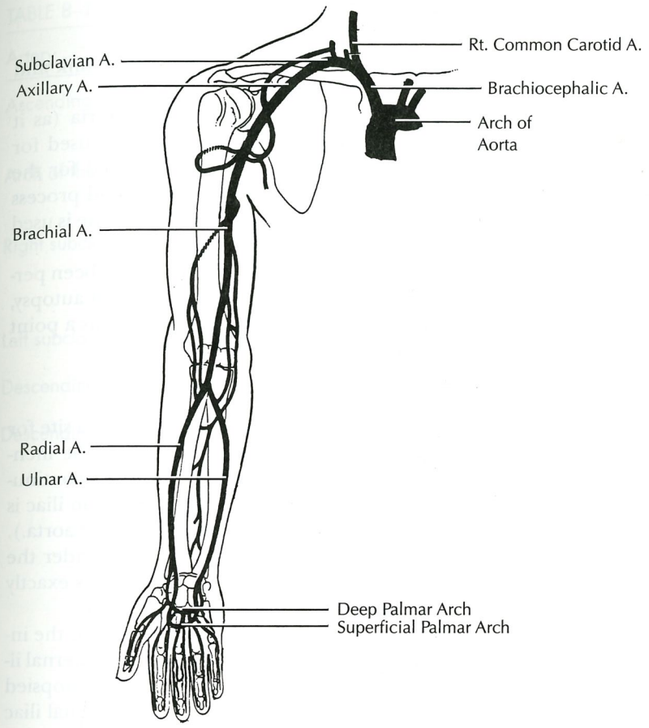


Figure 8–6. Arteries of the distal forearm.

the medial side. The distal forearm permits easy access to the radial artery. Surface features of importance here are the styloid process of the radius and the tendon of the flexor carpi radialis muscle. In the interval between these two structures lies the radial artery on the anterior surface of the styloid.

A pulse may be obtained here easily in the living subject. The styloid is the most distal and lateral bony structure in the forearm, and just medial to this, one can palpate the tendon of flexor carpi radialis. In the distal region, the fleshy bellies of the muscles tend to yield to long, usually well-defined tendons. Here, a layering of the musculature is evident. In the most superficial layer are four muscles, including the pronator teres, flexor carpi radialis, flexor carpi ulnaris, and palmaris longus. Only the tendon of the pronator teres does not reach the distal forearm.

The second layer consists of one muscle with four tendons, one each leading to digits 2 through 5. This muscle is the flexor digitorum superficialis. The three muscles in the deep group are the flexor digitorum profundus, the flexor pollicis longus, and the pronator quadratus. Of these three, only the pronator has no long tendon. Some of these tendons are useful guides to the radial and ulnar arteries.

Consider first the identification of the radial artery. An additional muscle, the brachioradialis, must be introduced here. This muscle is seen partially in the flexor compartment of the forearm. It is, nevertheless, an extensor muscle. In the proximal forearm, the radial artery is overlaid by the brachioradialis muscle but at no point is the artery crossed by this or any other muscle. This situation keeps the radial artery superficial and permits easy access to it at any point along its course in the forearm. In the middle and distal forearms, the radial artery lies medial to the brachioradialis and lateral to the flexor carpi radialis. Its course is described by a line drawn from the middle of the cubital fossa to the medial side of the radial styloid process. It is easiest to approach the artery with an incision in the distal two-thirds of the forearm along this line.

The ulnar artery is located on the medial side of the distal forearm. It lies between the tendon of the flexor carpi ulnaris muscle and the tendons of the flexor digitorum superficialis muscle. Here, it will always be found traveling with the ulnar nerve, with which it should not

be confused. Together with the venae comitantes, the nerve and artery will be found in a connective tissue sheath from which the vessels must be freed before beginning injection.

The course of the ulnar artery is indicated by a line curving medially from the midpoint of the cubital fossa to the pisiform bone in the wrist. An incision along the distal one-third of this line permits access to the flexor carpi ulnaris muscle, which is then reflected medially to expose the ulnar artery.

Radial Artery

Linear Guide. Draw or visualize a line on the surface of the skin of the forearm from the center of the antecubital fossa to the center of the base of the index finger.

Anatomical Guide. The radial artery lies just lateral to the tendon of the flexor carpiradialis muscle and just medial to the tendon of the brachioradialis muscle.

Anatomical Limit. The radial artery extends from a point approximately 1 inch below and in front of the bend of the elbow to a point over the base of the thumb (thenar eminence).

Origin. The radial artery originates at the bifurcation of the brachial artery.

Relationship of the Radial Artery and the Vena Comitantes. Two small veins (venae comitantes) lie on either side of the artery. They may be helpful in locating the artery, for they generally contain some blood.

Ulnar Artery

Linear Guide. Draw or visualize a line on the surface of the skin from the center of the antecubital fossa on the forearm to a point between the fourth and fifth fingers.

Anatomical Guide. The ulnar artery lies just lateral to the tendon of the flexor carpi ulnaris muscle. (It lies between the tendons of the flexor carpi ulnaris and flexor digitorum superficialis.)

Anatomical Limit. The ulnar artery extends from a point approximately 1 inch below and in front of the bend of the elbow to a point over the pisiform bone (hypothenar eminence).

Origin. The ulnar artery originates at the bifurcation of the brachial artery.

Relationship of the Ulnar Artery to the Venae Comitantes. Two small veins (venae comitantes) lie on either side of the artery. They can be useful in locating the artery, for they generally contain some blood.

▶ ARTERIES OF THE BODY TRUNK

Table 8–1 outlines the arteries of the body trunk and their branches (Fig. 8–7).

In embalming infants, the ascending aorta (as it leaves the heart) or abdominal aorta can be used for injection points. A midsternal incision is used for the ascending aorta. An incision from the xiphoid process directed downward and to the left of the midline is used to raise the abdominal aorta.

In the adult, where partial autopsies have been performed or visceral organs are donated without autopsy, the abdominal or thoracic aorta can be used as a point of arterial injection.

External Iliac Artery and Vein

The use of the external iliac artery and vein as a site for arterial injection and blood drainage should be mentioned (Fig. 8–8). The external iliac artery is a continuation of the common iliac artery. (The common iliac is one of the terminal branches of the abdominal aorta.). The external iliac artery extends to a point under the center of the inguinal ligament. The artery lies exactly at this ligament lateral to the external iliac vein.

In the autopsied body, this artery is used for the injection of the lower extremities. Injecting the external iliac artery rather than the common iliac in the autopsied body eliminates the need to clamp off the internal iliac artery (which usually has been cut during the removal of the pelvic organs). In the unautopsied body, when the body is very obese, the femoral vessels are located very deep and are hard to work with; however, the external iliac artery, where it passes under the inguinal ligament, is quite superficial, and this can be a good location if there is a need to use this vessel in the unautopsied obese body.

Because insertion of an artery tube into the femoral artery (directed toward the upper area of the body) actually places the tip of the tube into the external iliac artery, the term *iliofemoral* is used by many embalmers to indicate the use of the vessels at a site near the inguinal ligament.

▶ INGUINAL REGION

The inguinal region is an area below the inguinal ligament in which the femoral vessels may be approached for injection and drainage. As a rule, the subcutaneous tissue in the thigh masks underlying soft tissue structures, so the embalmer must rely on bony landmarks in this area. Fortunately, the anterior superior spine of the ilium and pubic tubercle are easily identified. These two bony processes serve as attachments for the inguinal ligament. The positions of the underlying femoral vessels can be identified if the operator begins by placing the thumb of the left hand on the subject's right anterior superior iliac spine and the left middle finger on the subject's right pubic tubercle. If the operator's left index finger is now allowed to bisect the interval between his or her thumb and middle finger (i.e., bisect the inguinal ligament), the tip of the index finger will indicate the approximate position of the femoral vessels in the thigh. The procedure can be repeated on the subject's left side using the operator's right hand. The incision to raise the vessel can be made on the linear guide.

TABLE 8–1. ARTERIES OF THE BODY TRUNK

Artery	Description	Branches
Ascending aorta	Originates at the left ventricle; at its beginning, the aortic semilunar valve should close, thus creating the pathway for arterial solution distribution	Right coronary artery Left coronary artery
Arch of the aorta	Center of arterial solution distribution	Brachiocephalic artery Left common carotid artery Left subclavian artery
Right subclavian	Begins at the right sternoclavicular articulation and extends to the lateral border of the first rib; in the complete autopsy (with neck organs removed), the branches need to be clamped	Vertebral artery Internal thoracic artery Inferior thyroid
Left subclavian	Begins at the level of the left second costal cartilage and extends to the lateral border of the first rib	
Descending thoracic aorta		Its branches include nine pairs of thoracic intercostal arteries
Descending abdominal aorta	Extends from the diaphragm to the lower border of the fourth lumbar vertebra	Parietal Inferior phrenic Superior suprarenals Lumbar Middle sacral Visceral (unpaired) Celiac axis Superior mesenteric Inferior mesenteric Visceral (paired) Middle suprarenals Renals Internal spermatic (male), ovarian (female) Common iliacs (terminal)

▶ FEMORAL TRIANGLE

The inguinal ligament serves as the base for this triangle whose two sides consist of the medial border of the sartorius and the lateral border of the adductor longus muscles (Fig. 8–9). In addition to skin and subcutaneous tissue covering the triangle, the roof consists of a dense sheet of fascia, the fascia lata, which attaches firmly to the inguinal ligament and encircles the thigh. This roof must be incised to expose the boundaries and contents of the triangle.

Lying on the surface of the fascia lata is the great saphenous vein that has coursed up the medial aspect of the thigh all the way from the foot. The operator should not mistake the great saphenous for the femoral vein. This potential mistake can be avoided simply by remembering anatomic relationships. **If the vein in question is lying on the surface of the dense, white fascia lata and if the fascia lata has not yet been incised, then the vein must be the great saphenous or one of its tributaries.**

If the great saphenous is followed, it disappears through an opening in the fascia lata called the "fossa ovalis." This opening is not so glamorous, as some textbooks would have one believe. Rather, there is a hiatus in the fascia lata and the great saphenous insinuates itself through the fascia and empties directly into the femoral vein. So, it is clear that identification of the great saphenous will lead directly to the femoral vein near the base of the femoral triangle. Around the hiatus one is likely to encounter inguinal lymph nodes, which may have to be resected.

When the roof of the triangle is incised and reflected, the contents and borders come into view. The femoral vessels are contained within the femoral sheath,

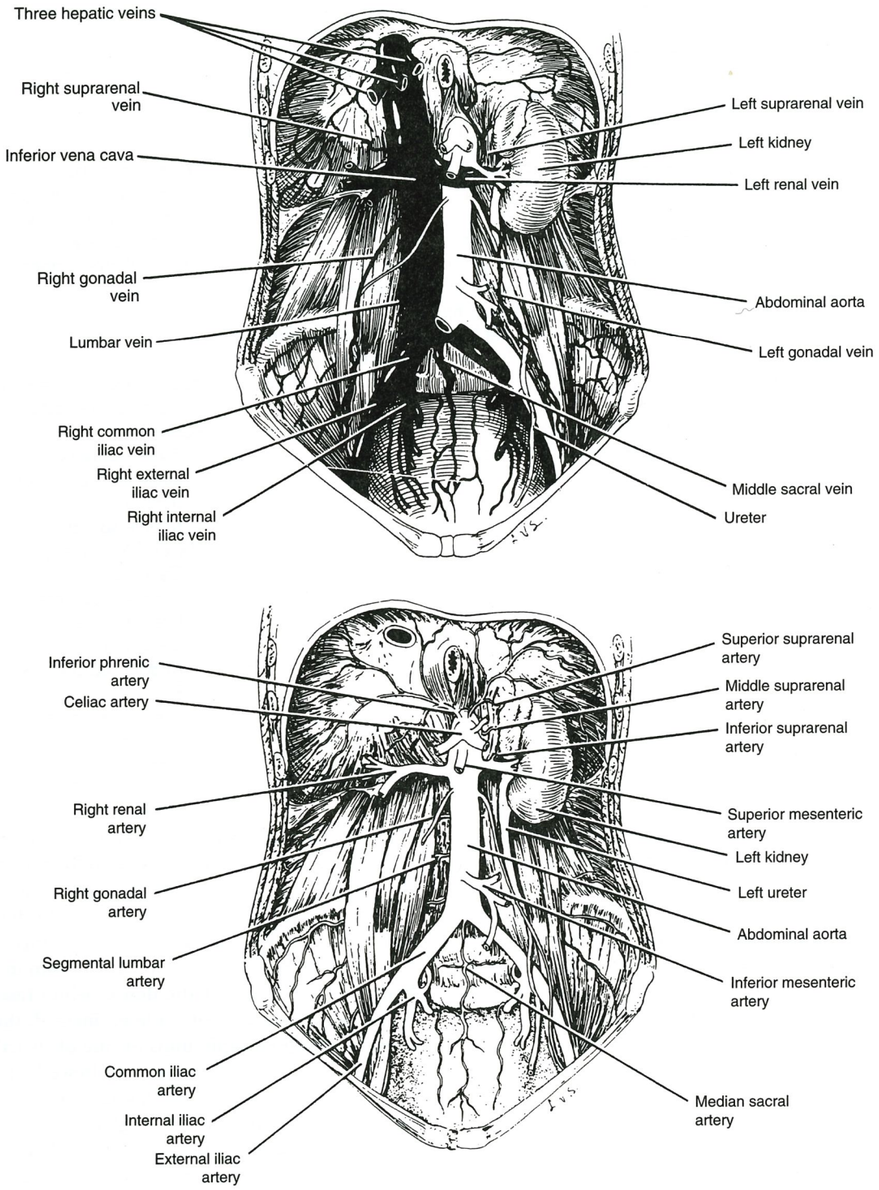


Figure 8–7. Arteries and veins of the body trunk.

which is a continuation into the thigh of abdominal wall and pelvic fascias. The sheath is subdivided into three compartments which, from lateral to medial, contain the femoral artery, femoral vein, and lymphatic vessels and nodes. The most medial compartment is designated the femoral canal and is the site of femoral hernias. Therefore, a femoral hernia is always situated medial to the femoral vein. This relationship is an important one to remember if preparing a subject whose inguinal region is distorted (such as with a hernia).

To gain access to the femoral vessels, open each of the other two compartments separately. An incision

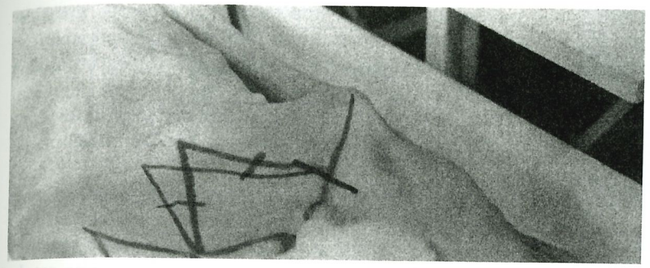


Figure 8–8. Incision location for left external iliac vessels. The linear guides are also shown.

in the sheath over each vessel will cause the artery and vein to be delivered easily. At the base of the triangle, the artery lies slightly anterior and lateral to the femoral vein and its position may be identified at the midpoint of the inguinal ligament. The vessels are best approached 1 to 2 inches from the base of the triangle, where they lie side by side and are easily accessible.

As the vessels approach the apex of the triangle, their relationship shifts to an anteroposterior one so that the femoral artery, femoral vein, deep femoral vein, and deep femoral artery lie one in front of the other, making access to most of them somewhat difficult.

The most lateral structure at the base of the femoral triangle is the femoral nerve, which lies outside the femoral sheath. This very substantial nerve and its many branches should not be confused with the adjacent femoral artery because the nerve lies without the sheath.

The floor of the triangle is entirely muscular and different authors consider that either two or three muscles constitute the floor. Laterally, the iliopsoas muscle emerges beneath the inguinal ligament. Just medial to this lies the pectineus muscle. Certainly, these two muscles contribute to the floor of the triangle. The disagreement comes about as a result of whether the medial or lateral border of the adductor longus muscle is considered to be the medial boundary of the triangle. The distinction is academic but in this text the adductor longus is treated as part of the floor for the following reason. The triangle is easily visualized in terms of the number 3. There are three borders: the inguinal ligament, the sartorius muscle, and the adductor longus muscle. Basically, three structures are contained within the triangle: the femoral nerve, the femoral artery, and the femoral vein. Each of these has branches or tributaries, but three major structures are present. Finally, if the adductor longus is considered to be a part of the floor, there are three muscles in the floor: the iliopsoas, the pectineus, and the adductor longus.

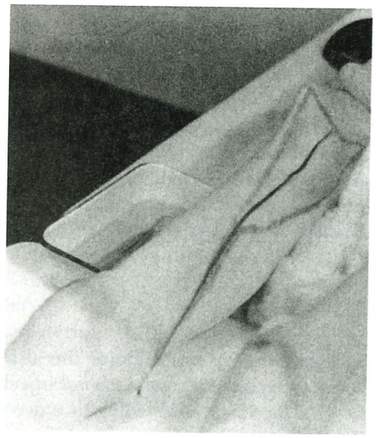


Figure 8–9. Femoral triangle showing the linear guide for the femoral vessels.

At the apex of the femoral triangle, the femoral vessels, but not the femoral nerve, enter the subsartorial or adductor canal. Recognizing the relationships of the femoral artery and vein at the triangle apex facilitates the understanding of the anatomical relationships of these vessels after they emerge from the adductor canal and enter the popliteal fossa or space.

Femoral Artery

Linear Guide. Draw or visualize a line on the surface of the skin of the thigh from the center of the inguinal ligament to the center of the medial prominence of the knee (medial condyle of the femur).

Anatomical Guide. The femoral artery passes through the center of the femoral triangle and is bounded laterally by the sartorius muscle (its medial border) and medially by the adductor longus muscle.

Anatomical Limit. The femoral artery extends from a point behind the center of the inguinal ligament to the opening in the adductor magnus muscle (Fig. 8–10).

Origin. The femoral artery is a continuation of the external iliac artery.

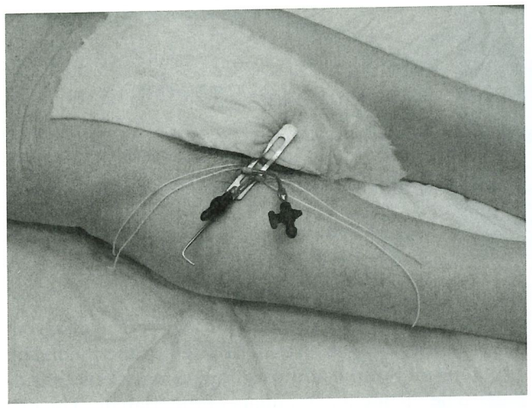


Figure 8–10. Right femoral artery with arterial tubes.

Branches. Superficial epigastric, superficial circumflex iliac, external pudendal, profunda femoris.

Relationship of the Femoral Artery and Vein. The femoral artery lies lateral and superficial to the femoral vein.

Popliteal Fossa

On the posterior aspect of the knee, two sets of tendons and two fleshy muscle heads can be identified. This describes the popliteal fossa as a trapezoid and can be subdivided into an upper femoral and a lower tibial triangle.

The femoral triangle (not to be confused with the femoral triangle in the inguinal region) is bounded laterally by the long and short heads of the biceps femoris and medially by the tendons of the semimembranosus and semitendinosus muscles. The tibial triangle is limited medially and laterally by the diverging medial and lateral fleshy heads of the gastrocnemius muscle and, to a lesser extent, by the plantaris muscle laterally. The base of each triangle is an imaginary line drawn through the middle of the joint. These surface landmarks serve as guides to the underlying popliteal vessels within the boundaries of the space.

The muscular boards of this fossa are overlaid by a roof of deep fascia, subcutaneous tissue, and skin. Intrusion into this space provides access to the popliteal vessels for injection and drainage. After recognizing and dispatching minor vascular and nervous branches external to the deep fascia, the fascia is incised to gain access to the vessels. The major contents of the space include the tibial and peroneal nerves (from the sciatic) and their branches, the popliteal vein and its tributaries, the popliteal artery and its branches, and a good deal of fat and lymphatic tissue.

As the space is approached posteriorly, the first structures to be encountered are the tibial and peroneal nerves. The tibial nerve is the larger of the two and is located directly in the midline. The common peroneal nerve, on the other hand, leaves the sciatic nerve at about midthigh and courses down the lateral aspect of the popliteal space.

With the tibial nerve retracted, the popliteal vein comes into view, lying superficial (posterior) to the *popliteal artery, which is the deepest (most anterior) structure in the fossa.* Remember that this relationship was established as these vessels entered the adductor canal. The vessels are bound together by connective tissue, which must be loosened and reflected to gain access to the vessels. Several branches and tributaries of the vessels are also found in the fossa, but these need not be identified by name here.

Deep (anterior) to the popliteal artery, the floor of the fossa is formed by the lower end of the femur and a portion of the capsule surrounding the knee joint.

Linear Guide. Draw or visualize a line on the surface of the skin from the center of the superior border of the popliteal space parallel to the long axis of the lower extremity to the center of the inferior border of the popliteal space.

Anatomical Guide. The popliteal vessels are located between the popliteal surface of the femur and the oblique popliteal ligament.

Anatomical Limit. The popliteal artery extends from a point beginning at the opening of the adductor magnus muscle to the lower border of the popliteus muscle.

Origin. The popliteal artery is a continuation of the femoral artery.

Branches. There are five pairs of genicular arteries, and five muscular branches.

Relationship of the Popliteal Artery and Vein. The vein lies posterior and medial to the artery. Because of the location of these vessels, the vein can also be described as lying superficial to the artery.

▶ DISTAL LEG

In the distal leg, the superficiality of the anterior tibial artery makes it easily accessible as an injection site. The popliteal artery ends by dividing into two terminal branches: the anterior tibial artery and the posterior tibial artery. The branches begin at the lower border of the popliteus muscle. In the distal portion of the leg, the arteries become superficial and can be used as points of injection for the foot. Injection could also be made toward the head to embalm the distal leg and thigh (Fig. 8–11).

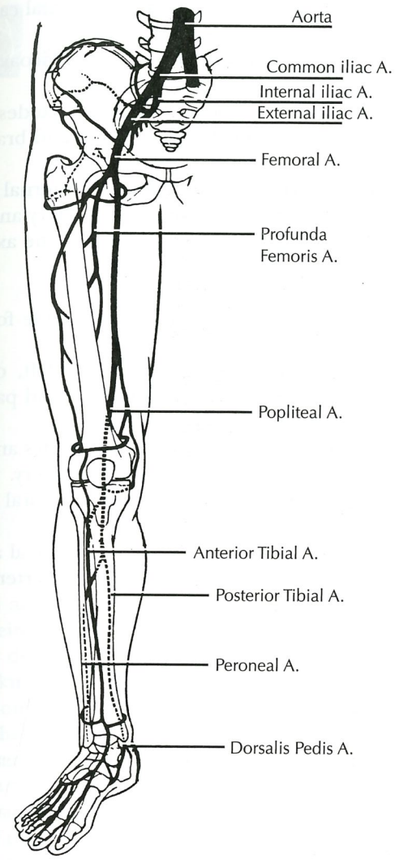


Figure 8–11. Arteries of the distal leg.

The anterior tibial artery is the smaller of the terminal branches of the popliteal artery. As it approaches the distal portion of the leg, it becomes very superficial. It can be raised by making an incision just above the ankle, just lateral to the crest of the tibia. In front of the ankle joint, the anterior tibial artery now becomes the dorsalis pedis artery.

The posterior tibial artery is also one of the terminal branches of the popliteal artery and passes posteriorly and medially down the leg. In the area between the medial malleolus and the calcaneus bone, the artery can be raised by the embalmer for injection of the foot. The artery terminates by dividing into the medial and lateral plantar arteries.

Anterior and Posterior Tibial Arteries

Linear Guide. Anterior Tibial Artery: Draw or visualize a line from the lateral border of the patella to the anterior surface of the ankle joint. *Posterior Tibial Artery:* Draw or visualize a line on the surface of the skin from the center of the popliteal space to a point midway between the medial malleolus and the calcaneus bone.

Anatomical Guide. Anterior Tibial Artery: The anterior tibial vessels are located in a groove between the tibialis anterior muscle and the tendon of the extensor hallucis longus muscle. *Posterior Tibial Artery:* The posterior tibial vessels are located between the posterior border of the tibia and the calcaneus tendon.

Anatomical Limit. Anterior Tibial Artery: The anterior tibial artery extends from a point beginning at the inferior border of the popliteus muscle to a point in front of the middle of the ankle joint on the respective sides. *Posterior Tibial Artery:* The posterior tibial artery extends from a point beginning at the inferior border of the popliteus muscle to a point over and between the medial malleolus and the calcaneus of the respective foot.

Branches and Tributaries of the Vessels. Anterior Tibial Vessels, Posterior Tibial Vessels: right and left peroneal branches, right and left dorsalis pedis arteries.

▶ FOOT

Tendons passing onto the dorsum of the foot from the leg pass posterior to and are restrained by two thickenings of fascia, the superior and inferior extensor retinacula, which lie anterior to the ankle. In addition, the anterior tibial artery and the deep peroneal nerve also pass deep to these retinacula. Only inconsequential superficial nerves and veins lie superficial to these retinacula.

Skin on the dorsum of the foot is thin and loosely applied. The subcutaneous tissue permits easy visualization of the venous network, which is so prominent here.

Tendons of two extrinsic muscles of the foot, the extensor hallucis longus and the extensor digitorum longus, are easily identified as they pass to the great toe and digits 2 through 5, respectively. The dorsalis pedis artery is situated in the interosseous spaces between the tendon of extensor hallucis longus and the first tendon of extensor digitorum longus as it passes to the second digit. An incision made from a point midway between the medial and lateral malleoli to the interosseous space will provide access to the dorsalis pedis artery.

Linear Guide (Dorsalis Pedis Artery). Draw or visualize a line from the center of the anterior surface of the ankle joint to a point between the first and second toes.

▶ CONCLUSIONS

The anatomy of several potential injection sites has been considered. More than just vascular anatomy has been presented with the hope that complete familiarity with the anatomy of these regions will facilitate the work of the practitioner. Being aware of the anatomy peripheral to the blood vessels at an injection site and having a solid command of anatomical relationships in these areas should make the embalmer more comfortable with and more confident in his or her operations.

▶ CONCEPTS FOR STUDY AND DISCUSSION

1. Describe the anatomical position.
2. Define anatomical guide, linear guide, and anatomical limit.
3. Give the anatomical limits of the right and the left common carotid arteries.
4. Give the linear guide and the anatomical guide for the common carotid artery.
5. Give the anatomical guide for the facial artery.
6. List the eight branches of the external carotid artery and the areas they supply.
7. Give the bony boundaries of the cervicoaxillary canal.
8. Give the linear and anatomical guides and anatomical limits for the axillary and brachial arteries.
9. Describe the relationship of the internal jugular vein to the common carotid artery and the relationship of the axillary vein to the axillary artery.
10. Give the extent of the axillary artery.
11. Give the linear and anatomical guide for the radial and ulnar arteries.
12. List the branches, from right to left, of the arch of the aorta and the visceral and parietal branches of the abdominal aorta.
13. Give the anatomical and linear guides and the anatomical limits for the femoral artery.
14. Describe the relationship of the femoral artery to the femoral vein.
15. Give the linear guides for the popliteal artery, anterior tibial artery, posterior tibial artery, and dorsalis pedis artery.

CHAPTER **9**

EMBALMING VESSEL SITES AND SELECTIONS

CHAPTER OBJECTIVES

- Selection of vessels for injection
- Selection of vessels for drainage
- Suggested techniques for raising vessels
- Vascular injection procedures

There are several anatomical locations where arteries and veins may be elevated for the arterial embalming of the dead human body. One of the major objectives of making a preembalming analysis of the body is the selection of vessels to employ for injection and drainage.

The proper selection of vessels should produce the most satisfactory results. This selection is based on various intrinsic and extrinsic factors. Embalming analysis is not simply a preembalming evaluation. During injection of the body, it may become necessary to select other vessels for injection and drainage. Analysis is necessary throughout the entire process.

▶ VASCULAR INJECTION PROCEDURES

One-Point Injection

An artery and a vein at one location are used for injection and drainage (e.g., injection from the right common carotid artery and drainage from the right internal jugular vein, or injection from the right femoral artery and drainage from the right femoral vein).

Split Injection

The injection is made in an artery at one location and the drainage occurs from a vein at another location (e.g., injection of the right common carotid artery and drainage from the right femoral vein, or injection from the right femoral artery and drainage from the right internal jugular vein).

Restricted Cervical Injection

Both right and left common carotid arteries are raised; tubes are placed into each of the arteries and directed toward the head. A tube is inserted toward the trunk of the body, either in the right or the left artery. The inferior portion of the other artery is tied off. Drainage is generally taken from the right internal jugular vein. Some embalmers prefer to open and drain from both the right and the left internal jugular veins if the face is badly discolored. During downward injection (toward the trunk), the arterial tubes directed toward the head **remain open**.

Multipoint Injection

Multipoint injection is vascular injection from two or more arteries (e.g., injection is begun from the right femoral artery but the embalming solution does not distribute to the left leg or the left arm; subsequently, the left femoral and the left brachial arteries are raised and injected.)

Six-Point Injection (Sectional Embalming)

In the unautopsied body, six arteries are raised that will separately inject the head and the limbs, for example, each "section" or body "region": right and left common carotid arteries, right and left axillary (or brachial) arteries, and right and left femoral (or external iliac) arteries. Drainage can be taken from each location or from one location such as the right internal jugular vein. The body trunk can be embalmed by injection of any one of these six arteries **toward the trunk**.

With the unautopsied body, this can become a 12-point injection for the tube at each location can be turned and injection made toward the trunk of the body. This can be beneficial with bodies where arterial injection to the tissues of the trunk of the body was poor; a good example would be bodies which exhibit early decomposition.

In the autopsied body, a six-point injection may include injection of the right and left common carotid arteries to embalm the head, right and left subclavian (axillary or brachial) arteries to embalm the upper extremity, and right and left common iliac (external iliac or femoral) arteries to embalm the lower extremity.

▶ VESSEL SELECTION

Two of the most important objectives in making the embalming analysis of the body are the selection of an artery (or arteries) for injection of arterial solution and the selection of a vein for drainage.

In the **unautopsied** body, the arteries most frequently used for embalming are the common carotid, femoral, and the axillary arteries. Because of the value of using an accompanying vein for drainage, the **femoral** and the **common carotid** vessels are preferred to the axillary artery.

Once injection of the body is begun, the embalmer needs to continually ask two questions:

1. What areas of body **are** receiving arterial solution? What areas of body **are not** receiving arterial solution?
2. Has an area received sufficient arterial solution?

There needs to be constant **observation → evaluation → implementation → results.** This four-step method is used during the embalming analysis **before**, **during**, and **after** arterial injection.

Example: If a one-point or a restricted cervical injection plan is used by the embalmer after a sufficient quantity of arterial solution has been injected (perhaps 1 gallon), the embalmer must evaluate what areas of the body **are** receiving arterial solution and what areas **are not** receiving arterial solution. Various embalming techniques can be used in an attempt to stimulate the flow of the solution into the body areas where the solution is lacking. Once the embalmer is satisfied that all body regions have sufficient arterial solution, those areas where there is insufficient solution can be separately injected by multipoint embalming. With multipoint embalming, an evaluation must also be made; if the preservative is not reaching all areas of a body region, perhaps more distant arteries can be raised and injected (e.g., the axillary artery may have been raised to inject the right arm; if solution is not entering the hand, the radial or ulnar artery can be raised and injected). After multipoint injection, an evaluation must again be made. If there is still insufficient solution in an area, supplemental methods of embalming (e.g., hypodermic or surface compresses) must be used.

A similar protocol of working from major arteries that supply large regions, to smaller arteries that supply localized body areas, and finally the possible use of supplemental embalming treatments, is utilized in the embalming of the **autopsied** body.

To summarize, a pattern of vessel selection, injection, and observation is as follows:

- Select artery for injection of the body and a vein for drainage
- Inject
- Observe and evaluate
- If an area does not have enough arterial solution, raise an artery that directly supplies that area
- Inject from this second artery
- Observe and evaluate
- If needed, use supplemental embalming treatments, hypodermic and surface compresses or gels

General Considerations

Most embalmers are right-handed and find working on the right side of the body much easier. If the internal jugular vein is to be used for drainage, the right internal jugular vein leads directly into the right atrium of the heart; drainage instruments are much easier and more effective when inserted into the right internal jugular vein. Selecting the left common carotid or left femoral vessels for one-point injection sites would afford the same advantages.

Selection of an injection site and vascular injection procedure involves two criteria: (1) factors concerning the vessels and (2) general body conditions.

Situations in which it may be necessary to locate severed or cut portions of arteries to inject arterial solution include (1) bodies where extensive autopsies have been performed, (2) bodies where partial autopsies have been performed, (3) bodies from which one or more organs and/or tissues for transplantation have been removed, and, (4) bodies with traumatic injuries.

Arteries, veins, and nerves tend to be grouped together in their routes through the body. It is essential that the embalmer be able to distinguish between these structures (Table 9–1).

Nerves have a silvery appearance and, when examined with the naked eye, show striations along their surface. When cut, they have no lumen or opening and

TABLE 9–1. COMPARISON OF ARTERIES, VEINS, AND NERVES

Artery	Vein	Nerve
Lumen	Lumen	Solid structure
Creamy white	Bluish when filled with blood	Silvery white
Thick walls are demonstrated when artery is rolled between two fingers; edges of the artery are easily felt	When vein is rolled between two fingers, walls collapse and edges are not felt	Solid structure is demonstrated when nerve is rolled between two fingers
Vasa vasorum may be seen on surface	Vasa vasorum not visible	Vasa vasorum not visible
Remains open when cut	Collapses when cut	Solid when cut; ends tend to fray
Generally empty of blood	Generally some blood or clotted material present	No blood present

their cut edges take on a frayed appearance similar to the frayed cut ends of a rope.

Veins are thinner than arteries. They contain valves, which arteries do not, but like arteries, when cut they do have an opening or lumen. When their sides are cut, veins collapse, creating a funnel effect.

Arteries have very thick walls as compared with healthy veins. Arteries are creamy white in appearance, and often, small vessels called the **vasa vasorum** can be seen over the artery surface (especially in arteries exhibiting arteriosclerosis). The most distinguishing feature of an artery is that if it is cut, **the lumen remains open** and very pronounced. The walls of the artery, unlike those of the vein, do not collapse. The common carotid arteries are quite elastic and can easily be stretched after dissection and cleaning. The femoral arteries are more muscular and not as elastic as the carotids.

It is most important that the embalmer should be familiar with the location of arteries in relationship to their accompanying veins.

▶ SELECTING AN ARTERY AS AN INJECTION POINT

The selection of an artery or arteries for embalming is based on conditions of the individual artery and conditions of the body with respect to these questions:

1. How superficial or deep is the artery?
2. What structures surround the artery?
3. How close to the aorta is the artery?
4. What is the diametric size of the artery?
5. Can the body be positioned properly if this artery is used?
6. Will incisions for the artery be on an exposed body area?
7. Can drainage be taken from the vein which accompanies the artery?
8. If arterial clotting is present, in what direction will these clots be moved during injection?
9. How much arteriosclerosis is present in the artery at the injection site?

Other factors governing the selection of an artery or arteries for injection include the following:

1. Age of the deceased
2. Sex of the individual with respect to the type of clothing which will be worn
3. Weight
4. Fat distribution
5. Disfigurations present (e.g., arthritic conditions, tumors, or scar tissue)
6. Diseases present
7. Edema, localized or generalized
8. Location of obstructions or congestion, possibly creating discolorations or a lack of preservative solution flow to a body region
9. Trauma present from mutilation, accident, or surgery
10. Vascular interruptions from organ and/or tissue donation
11. Medicolegal requirements with regard to autopsies; preparation for medical schools; preparation for international shipping; preparation under military contracts; requirements of a coroner or medical examiner.
12. Cause of death
13. Manner of death

In addition to these variables, two nonvariable guidelines must be considered: (1) Prepare each body with the assumption that the body is dead from an infectious and contagious disease; (2) prepare each body with the assumption that final disposition and viewing will be delayed.

With respect to size (diameter) of an artery, of the four choices for an injection point, the common carotid artery is the largest, because it is nearest to the heart. The femoral (or external iliac) is the second in size, and the axillary artery is the smallest in diameter. Any artery could be used as an injection site to inject the entire body, but the use of a small vessel such as the radial or ulnar to embalm the entire body allows for a very slow rate of flow of arterial solution. It could also be difficult to build sufficient pressure in the arterial system to properly distribute and diffuse the arterial solution. The larger, more elastic arteries such as the common carotid

and the femoral allow for use of the higher pressures and greater rates of flow necessary to achieve uniform distribution of the arterial solution.

As for the accessibility of the artery, deep-seated vessels within the thorax or the abdomen are very difficult to use for injection of the adult body. In infants and children, these vessels can be considered, for they are easier to reach. In the unautopsied adult body, vessels near the surface of the skin and with few branches can easily be raised to the surface of the incision. The common carotid arteries do not have branches (except their terminals) and can easily be raised to the skin surface. Likewise, the femoral arteries and the external iliac arteries (at the inguinal ligament) are not held tightly in position by large numbers of branches.

The accompanying vein is one of the most important factors in selecting an injection site. Can this vein be used for drainage? The common carotid artery is accompanied by the large internal jugular vein. On the right side of the neck, this vein leads directly into the right atrium of the heart, and the right atrium is the center of drainage. The femoral artery is also accompanied by a large vein that may be used for drainage.

The size of the artery, its accessibility, and, finally, the possibility of draining from the accompanying vein must be considered in selecting an artery for injection. As previously stated, in the unautopsied adult body, this choice is among four vessels: (1) the common carotid artery, (2) the right and left common carotid arteries, (3) the femoral artery (or external iliac if raised at the inguinal ligament), and (4) the axillary artery (or brachial artery).

The second group of factors used in the selection of vessels for an injection site includes these body conditions:

1. Age of the body
   a. In the infant, additional vessels may be considered for injection such as the ascending aorta or the abdominal aorta.
   b. With respect to infants, the size of the artery may be the factor that determines which vessel can be used. The common carotid is the largest. A set of small infant arterial tubes should always be available.
   c. In the elderly, many times the femoral vessel is found to be sclerotic; the common carotid artery is rarely found to exhibit arteriosclerosis.
2. Weight of the body
   a. In obese bodies, the femoral artery is found quite deep in the upper thigh. Its depth should not preclude its possible use. If the vessel must be raised, it should be raised at the inguinal ligament, or the external iliac artery can be used. At this location, the vessel is the most superficial.
   b. Drainage is also a factor to consider with obese bodies. The internal jugular vein affords the best clearing of the body, especially the tissues of the face. Keep in mind that the weight of the viscera in heavy bodies provides resistance to the flow of arterial solution as well as resistance to drainage.
   c. In obese bodies, large quantities of arterial solution are needed to adequately preserve the body. To avoid distension of facial tissues, it is best to select the right and the left common carotid arteries, which would be raised at the start of embalming.

      The best approach to embalming obese bodies is to raise both the right and left common carotid arteries (restricted cervical injection) and use the right internal jugular vein for drainage. In this manner, large volumes (often of a strong solution) can be injected into the trunk areas without overinjecting the head and the face. Restricted cervical injection allows the use of higher injection pressures and greater rates of flow.
   d. With very thin bodies, care should be taken to minimize any destruction of the sternocleidomastoid muscle of the neck. All other factors taken into consideration, use of the femoral vessels, if possible, might prove advantageous in the preparation of these bodies.
3. Disease conditions
   a. A condition such as arthritis may necessitate the avoidance of certain body areas; legs can be in the fetal position in the elderly or in bodies that have suffered from certain brain tumors, making use of the femoral vessel quite difficult (see Fig. 11–8).
   b. A goiter condition in the neck may make use of the carotid artery and the jugular vein difficult, because the vessels will be pushed out of their normal location.
   c. Tumors or swollen lymph nodes in the neck, groin, or axillary area should be avoided for injection.
   d. Burned tissues should be avoided if possible; leakage will be a problem and suturing will be difficult.
   e. When edema is present in an area such as the upper thigh, raising a vessel should be avoided in this area; closure (suturing) may be difficult and leakage a problem. When edema is generalized (anasarca), large quantities of arterial solution must be injected. Here, it would be best to use restricted cervical injection, raising both the right and left common carotid arteries. This allows the embalmer to inject large quantities of arterial solution. Many times, these arterial solutions are very strong. The restricted cervical injection allows the use of large amounts of fluid to saturate other body areas without overinjecting the face. A separate, milder solution can then be used for injection of the head.
   f. A **ruptured aortic aneurysm** often dictates that additional arteries may need to be injected. Often, some circulation can be established in these conditions. In the majority, there is direct loss of all arterial fluid to the abdominal cavity, necessitating six-point injection of the body and treatment of the trunk walls, buttocks, and shoulders by hypodermic embalming.
   g. When **scar tissue** is seen in a location where a vessel is to be raised (such as the upper inguinal area), no doubt, surgery has been performed. Scar tissue beneath the skin can be very difficult to work within raising vessels, and it may be wise, if possible, to use another vessel.
   h. **Gangrene,** particularly in the lower extremities, indicates that the deceased suffered from a poor blood supply into the affected limb(s) or the presence of a clot in an artery or a vein. Most often, that poor blood supply is the result of arteriosclerosis. For example, if the foot or lower leg evidences gangrene, or a recent amputation has occurred, the femoral vessel should be avoided as the primary injection point. Use of the carotid arteries is advised, because generally, little arteriosclerosis is associated with these vessels.
4. Interruption of the vascular system
   a. *Mutilation or trauma:* Traumatic death can result in severed arteries. These conditions must be individually evaluated by the embalmer; arteries exposed as a result of the trauma may be considered as sites for injection. Also, standard points of injection such as the common carotid can be used and the severed arteries clamped during arterial injection. Secondary points of injection will, no doubt, be required.
   b. *Ulcerations:* Ruptured vessels can be the result of ulcerations. If this occurs in the stomach, there will be a great loss of blood during the agonal period. If sufficient arterial solution is lost during injection, the embalmer must select multipoints of injection to treat those areas of the body not reached by arterial solution.

When arterial solution is evidenced in purge from the mouth or the nose during arterial injection and there is still blood drainage, continue to inject arterial solution and evaluate the distribution of the solution.

When arterial solution is evidenced in purge from the nose or the mouth during arterial injection and there is no blood drainage, it would be wise to discontinue injection, evaluate the distribution of solution, and sectionally treat, by arterial injection, those areas not reached by sufficient arterial solution.

   c. *Autopsies:* Partial autopsies must be evaluated by the embalmer as to the selection of arteries for injection. For example, if the viscera were removed only from the **abdominal cavity,** the portions of the body above the diaphragm could be embalmed by (1) injecting from the thoracic aorta upward and (2) injecting from the right common carotid and ligating the thoracic aorta. Even after a complete autopsy, there can be a choice of vessels depending on the lengths of vessels left by the dissecting pathologist. For example, the subclavian artery or perhaps the axillary artery can be used to inject the arm. If the external iliac arteries have been cut under the inguinal ligament, the femoral vessels may have to be injected. In some autopsies, the entire arch of the aorta may be present and most of the upper areas of the body can be injected from the branches of the arch.
   d. *Organ and tissue donation:* There needs to be a careful evaluation of the arterial system when organs or tissues have been recovered for transplant. Disruption of the arterial system by organ or tissue removal will often require multipoint arterial injection and extensive use of surface and hypodermic embalming treatments.
   e. Ruptured aortic aneurysm (see above).
5. Clotting

   If an embalmer feels that clots may be present in the arterial system, particularly in the aorta, the femoral artery should **not** be used as the starting point for injection. The best choice in this situation is to begin the injection of the arterial solution from the common carotid, because if any coagula do break loose, it is better that this material be directed toward the legs. If the femoral artery is used, the coagula could be pushed up into the common carotid arteries or the axillary vessels. These arteries supply body areas that will