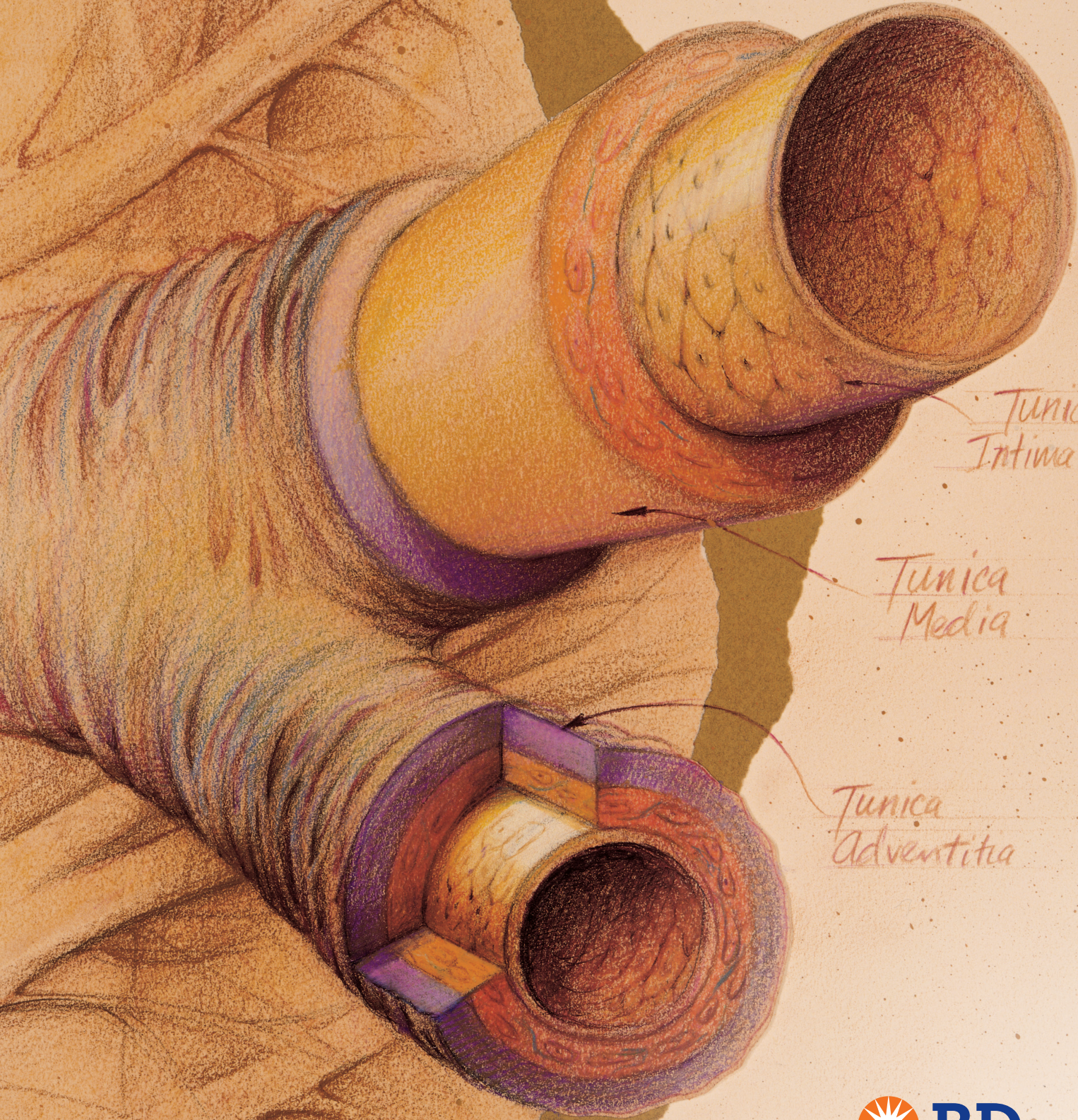


# Layers of the Vein

Better Care, Better Outcomes



*Tunica  
Intima*

*Tunica  
Media*

*Tunica  
Adventitia*



Helping all people  
live healthy lives

# Layers of the Vein

A knowledge of vein wall anatomy and physiology is necessary in understanding the potential complications of IV therapy.

## Tunica Intima

### Characteristics

The tunica intima is the inner layer of the vein and consists of a smooth, elastic endothelial lining. This surface allows for an uninterrupted flow of blood cells through the vein.

The endothelial lining has several different functions, one of which is its immunologic properties that cause it to recognize foreign bodies within the vein.

Damage to the endothelial lining or introduction of foreign material initiates an inflammatory response. Complications that may develop from damage to the tunica intima include:

- **Phlebitis.** Phlebitis is an inflammation of the intimal lining. This response involves the release of chemical mediators from the damaged cells that initiate the inflammatory response. Phlebitis is progressive in nature and if not appropriately managed can seriously affect patient outcome.
- **Thrombus.** The development of a blood clot is another potential result of injury to the tunica intima. If roughening occurs on the endothelial layer, platelet aggregation (clumping of cells) occurs, which stimulates thrombus formation.

Injury to the endothelial lining can be mechanical, chemical or bacterial in nature.

**Mechanical damage** is the actual tearing away of the endothelial lining. This can happen during a traumatic insertion or by excessive motion of the IV catheter from frequent manipulations or inadequate securement. This causes roughening of the surface within the vein wall and allows platelet aggregation to occur.

**Chemical damage** to the endothelial lining can be a result of administering irritating medications and solutions. Skin prepping agents that are not allowed to completely dry prior to venipuncture are also irritating to the tunica intima. This allows the skin prep to be dragged into the vein along with the IV catheter.

Normal serum pH is 7.35 – 7.45. Medications and solutions outside this range can irritate the endothelial lining. A pH of 7.0 is neutral and is less irritating to the vein.

**The pH of some commonly given IV medications include:**

Dilantin	10.0 – 12.3
Heparin	5.0 – 7.5
Potassium Chloride	4.0 – 8.0
IV Solutions	3.5 – 6.2

Isotonic solutions have an osmolality of 250 to 375 mOsm/kg. Solutions that are not in this range are either hypo- or hypertonic and are irritating to the tunica intima.

- **Hypotonic solutions** are less than 250 mOsm/kg. Hypotonic fluids hydrate cells while depleting the circulatory system. They cause fluids to shift out of the blood vessels and into the cells and interstitial spaces. 2.5% Dextrose and 0.45% NS are hypotonic solutions.
- **Isotonic solutions** are equal to 250 to 375 mOsm/kg. Solutions within this range are similar to normal body fluids and well tolerated by the tunica intima. Isotonic solutions are used to expand intravascular volume following acute losses. D5W, 0.9% NS and Lactated Ringers are isotonic.
- **Hypertonic solutions** are greater than 375 mOsm/kg. Solutions in this range shift fluid from interstitial spaces into the plasma. Hypertonic solutions are irritating to the tunica intima and require a large vein for adequate hemodilution. D5LR, D5NS and glucose solutions over 10% are hypertonic.

**Bacterial** introduction into the vein is related to contamination of the IV site or IV catheter during or after the venipuncture procedure.

### Practice Considerations

Use the smallest gauge and shortest catheter length appropriate for therapy to reduce trauma to the tunica intima.

IV sites on the extremities should be chosen from most distal to proximal. This avoids infusion of medications through a previously traumatized area and preserves the veins for future venipuncture sites.

Avoid placement in areas of flexion and extension.

Allow prepping agents to completely air dry prior to venipuncture.

Provide maximum stabilization of the catheter hub to prevent excessive movement of the cannula to reduce irritation to the intima.

Use catheter materials that are biocompatible and have low thrombogenicity.

Follow manufacturers' recommendations for appropriate reconstitution and dilution of medications. To further reduce risk of irritation:

- Inspect fluids prior to administration for visible particulate matter.
- Use appropriately sized in-line filter to reduce the risk of infusing particulate matter such as undissolved drug, glass or bacteria.
- Use single-use flush solutions to reduce the risk of bacterial contamination.

The vein wall consists of three layers and each has very specific characteristics and considerations involved in the introduction of IV catheters and the administration of IV fluids.

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Placement of a central venous access device should be considered for infusion of hypertonic solutions.

The rate of infusion may contribute to irritation.

- A large vein with a slow administration rate permits greater dilution of the drug with the circulating blood.
- A small vein with a slow administration rate prolongs contact of the solution due to inadequate dilution.

Prolonged duration of the infusion increases the risk of complications. This requires frequent monitoring of the IV site to assess for early development of complications.

### Elderly Population Tunica Intima Changes

The endothelial lining becomes thickened and less smooth, increasing the risk of platelet aggregation and thrombus formation.

The vein lumen becomes smaller as a result of this thickening and may affect the ability to successfully thread the catheter.

Thickening of the intimal layer slows perfusion.

There is development of small spidery collateral veins to compensate for decreased perfusion in the larger veins.

### Pediatric Population Tunica Intima Differences

The vein lumen is much smaller in pediatric patients.

The intimal lining increases in fragility with the degree of prematurity.

The vein fragility increases the potential of infiltration.

## Tunica Media

### Characteristics

The middle layer of the vein wall consists of muscle and elastic tissue. This layer is thick and comprises the bulk of the vein. The nerve fibers that control vasoconstriction, vasodilation, and that maintain muscle tone are also in the tunica media.

Stimulation of this layer by infusion of cold or irritating medications can cause venospasm. Venospasm can also occur in a patient who is anxious, making the venipuncture difficult.

Patients may also feel pain during the venipuncture when the needle penetrates this layer.

### Practice Considerations

Avoid infusion of cold solutions to reduce the chance of vasospasm. Prior to infusion, IV solutions should be warmed to room temperature.

If venospasm does occur, apply heat above the IV site to help reduce spasm.

Reduce patient anxiety by providing a supportive atmosphere.

### Elderly Population Tunica Media Changes

Elastin fibers become frayed, fragmented and brittle. This affects the ability of the vein to dilate and constrict. The loss of elasticity may cause difficulty with optimal vein dilation and leaking at the IV site.

Muscle fibers are replaced with collagen, fatty plaque and calcium deposits. This makes the vein hard and more difficult to access.

Venipuncture success may be increased in the elderly by not applying a tourniquet to avoid overdilatation and “blowing” of the vein during venipuncture.

Remove the tourniquet immediately following venipuncture to avoid increased vascular pressure that may stretch the venipuncture site and cause leaking at the insertion site.

## Tunica Adventitia

### Characteristics

The outer layer of the vein consists of connective tissue. The adventitia provides support and protection for the vein. Also contained in this layer are vessels that supply nutrients to the vein.

### Practice Considerations

This is the layer where a “pop” might be felt during venipuncture.

A hematoma may form at the insertion site if one of the nutrient vessels is nicked during venipuncture.

### Elderly Population Tunica Adventitia Changes

The veins become tortuous requiring good skin traction to straighten the vein for catheter insertion and advancement. It may be necessary to do a one-handed insertion while maintaining adequate skin traction with the opposite hand.

## Valves

### Characteristics

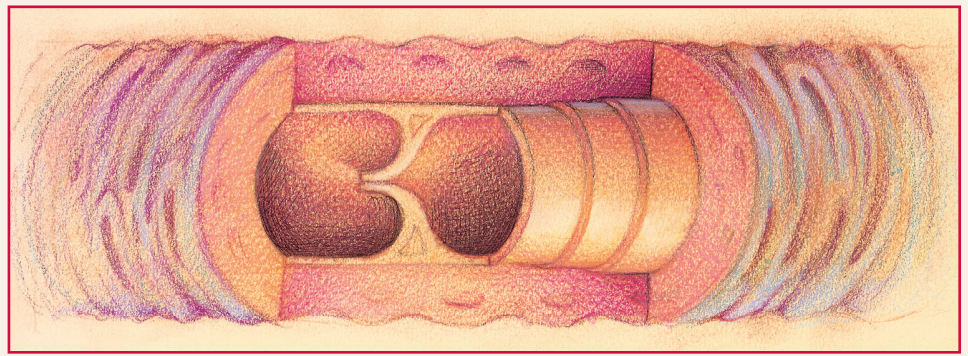
Valves are structures within the lumen of the veins that are formed by the endothelial lining of the tunica intima. They are a system of half-moon shaped flaps that are arranged in pairs. Valves are predominantly found in the large veins of the extremities.

The valves function to keep blood flowing upward to the heart by opening and closing like a “trapdoor.” The opening and closing of the valves is facilitated by contraction of the large muscles in the extremities.

Valves present as bumps along the course of the vein and also occur at bifurcations (areas where two veins join). There are no valves in the veins of the head and neck.

### Practice Considerations

Assess vein prior to venipuncture and avoid placing catheter near a valve. Valves may prevent the successful advancement of the catheter.



Damage to the valve during venipuncture may result in tearing of the endothelial lining and increases the risk of thrombus development.

If difficulty is met while advancing the catheter, some common techniques practiced include:

- Have patient open and close fist, if insertion is not in hand.
- Flush with fluid while attempting to advance catheter.
- Float cannula in with a running IV.

It is important to remember the clinical implications of damage to the valve and avoid them when possible.

Valves may negatively affect the ability to withdraw blood from the IV device.

Placement of the IV catheter tip within a valve may decrease IV flow rates.

### Elderly Population Valve Changes

Valves become dysfunctional and hardened, leading to venous pooling.

## Artery vs. Vein Anatomy

### Characteristics

Arteries do not have valves. The pressure within the artery keeps blood moving in the appropriate direction, and arterial flow is downward with gravity as opposed to the upward flow of blood in the veins.

Structural changes in arterial walls that accommodate increased pressures include:

- The muscle layer in the tunica media is stronger.
- The arteries will not collapse like veins.
- The tunica adventitia is thicker.

For protection, arteries are much deeper than veins and are surrounded by nerve endings that make arterial puncture painful.

Arteries are pulsatile.

### Use of Artery vs. Vein

Radiology for arteriograms.

Blood pressure monitoring in Critical Care Units.

Arterial blood gases.

Chemotherapy, e.g., hepatic artery.

Arteriospasm is a serious potential complication from infusion of medication into an artery. Each artery supplies oxygen-rich blood to a specific area. Tissue hypoxia as a result of arteriospasm may lead to tissue necrosis and gangrene. Care must be given to avoid inadvertent cannulation of an artery for routine intravenous therapy.

### Key Points to Therapy Management

Use strict aseptic technique.

Allow prepping agents to completely air dry prior to venipuncture.

Use the smallest gauge and shortest catheter length appropriate for therapy.

Assess vein prior to venipuncture to avoid placing the catheter near a valve or into an artery.

IV sites on the extremities should be chosen from most distal to proximal. This avoids infusion of solutions through a previously traumatized area of vein and preserves veins for future venipuncture sites.

Provide maximum stabilization of catheter hub to prevent excessive manipulation and movement of the IV catheter.

Avoid infusion of cold medications to reduce potential of venospasm.

Follow manufacturers' recommendations for appropriate reconstitution and dilution of medications.

Filter IV solutions and medications as required by institutional policy.

Frequently monitor IV site for early signs of irritation, i.e., redness, tenderness or swelling.

Immediately change IV site upon any sign or symptom of complication.

Provide atmosphere supportive of reduction in patient anxiety regarding venipuncture procedure.

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