

FUNCTIONAL ANATOMY

General Considerations

- There are two adrenal glands, one on either side, situated extraperitoneally at the upper pole of the kidney, hence also called 'suprarenal gland' (Fig. 8.5-1).
- These are also known as 'glands of emergency', as they secrete most vital hormones needed during an emergency.
- Normally, each gland weighs about 5 g and consists of two parts, the adrenal cortex and the medulla, which are absolutely distinct from each other structurally, functionally and developmentally (Fig. 8.5-1).
- The cortex (outer zone), makes up to 80–90% of the gland and is a source of the cortisol hormone.
- The medulla (inner zone), makes up 10–20% of the adrenal gland and is a source of the catecholamine hormones.
- Morphologically and physiologically, the fetal adrenal gland differs strikingly from that of the adult. The adrenal gland is larger at birth than it is during adulthood.

Development

Adrenal Cortex Adrenal cortex is a mesodermal derivative. During fetal life and in a newborn, the adrenal cortex comprises of the outer *neocortex* (15% in volume),

which is the progenitor of the adult cortex and the inner *fetal cortex* (85% in volume). The fetal cortex or fetal zone undergoes rapid involution during the first few months of extrauterine life and completely disappears by 3–12 months postpartum. At the same time, the thin outer zone of the neocortex enlarges and differentiates permanently into the three-layered adrenal cortex of the mature human. It is a nuclear receptor with a currently uncertain ligand steroidogenic factor-1 (SF-1), which is essential for the development of the adrenal cortex and expression of the enzymes and steroid hormone biosynthesis. It is axiomatic that all endocrine glands derived from the mesoderm synthesize and secrete steroid hormones.

Adrenal Medulla The adrenal medulla essentially represents an enlarged and specialized sympathetic ganglion derived from the neuroectodermal cells giving rise to sympathetic ganglia. The neural crest gives rise to neuroblasts, which eventually give rise to the autonomic postganglionic neurons, the adrenal medulla and the spinal ganglia. In early fetal life, the adrenal medulla contains only norepinephrine.

Histological Structure

Adrenal Cortex The adrenal gland is covered by a connective tissue capsule from which septa extend into the gland

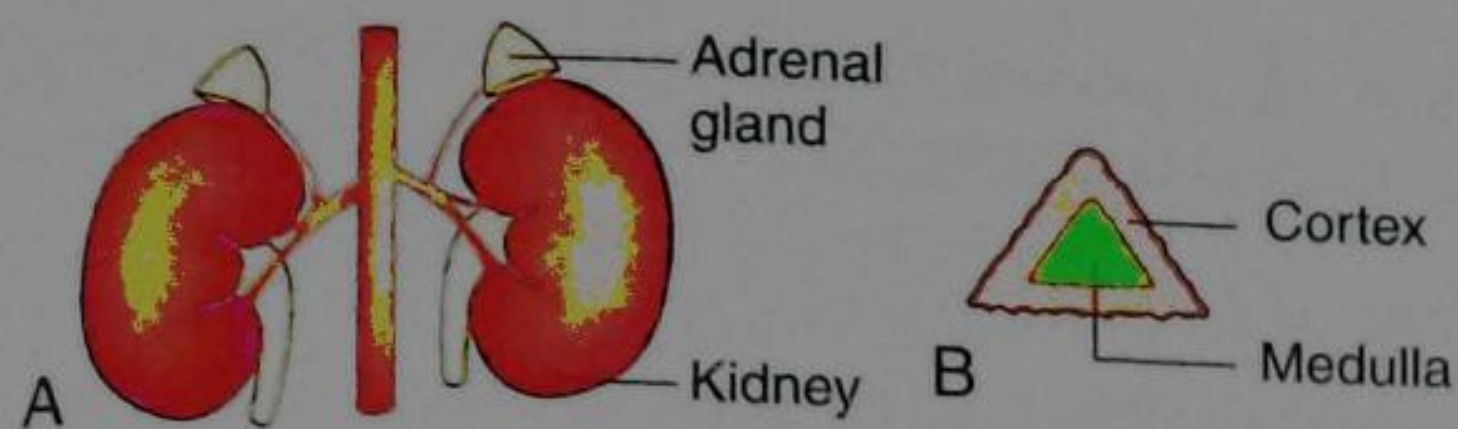


FIGURE 8.5-1 Location (A) and divisions (B) of adrenal glands.

substance. The mature human adrenal cortex consists of three distinct layers or zones of cells (Fig. 8.5-2).

1. **Zona glomerulosa**, constituting outer one-fifth of the cortex, is a small zone present under the capsule. It consists of cells that are arranged as inverted U-shaped formations, or acinus-like groups. It is the site of *aldosterone* and *corticosterone* synthesis. Aldosterone is the principal mineral corticoid of the human adrenal cortex.
2. **Zona fasciculata** is the widest zone forming middle three-fifths of the cortex. It is made up of cells that are arranged in two cells thick straight columns. Sinusoids intervene between the columns and cells appear clear or vacuolated in stained sections because of high lipid (cholesterol) content.
3. **Zona reticularis** forms the inner one-fifth of the cortex. It is made up of a network of compactly arranged cords of cells that branch and anastomose with each other to form a kind of network (hence the name zona reticularis). These cells contain fewer lipids.

Zona fasciculata and zona reticularis constitute a single functional unit where mainly cortisol (and some corticosterone) and androgen (dehydroepiandrosterone, i.e. DHEA) are synthesized.

Adrenal Medulla The adrenal medulla essentially represents an enlarged and specialized sympathetic ganglion. Histologically, it is made up of chromaffin cells, innervated by preganglionic sympathetic neurons.

Chromaffin Cells. The cells forming adrenal medulla show yellow granules in their cytoplasm (i.e. *chromaffin reaction*) and hence called chromaffin cells.

- These cells are columnar or polyhedral and are arranged in all groups or columns that are separated by wide sinusoids.

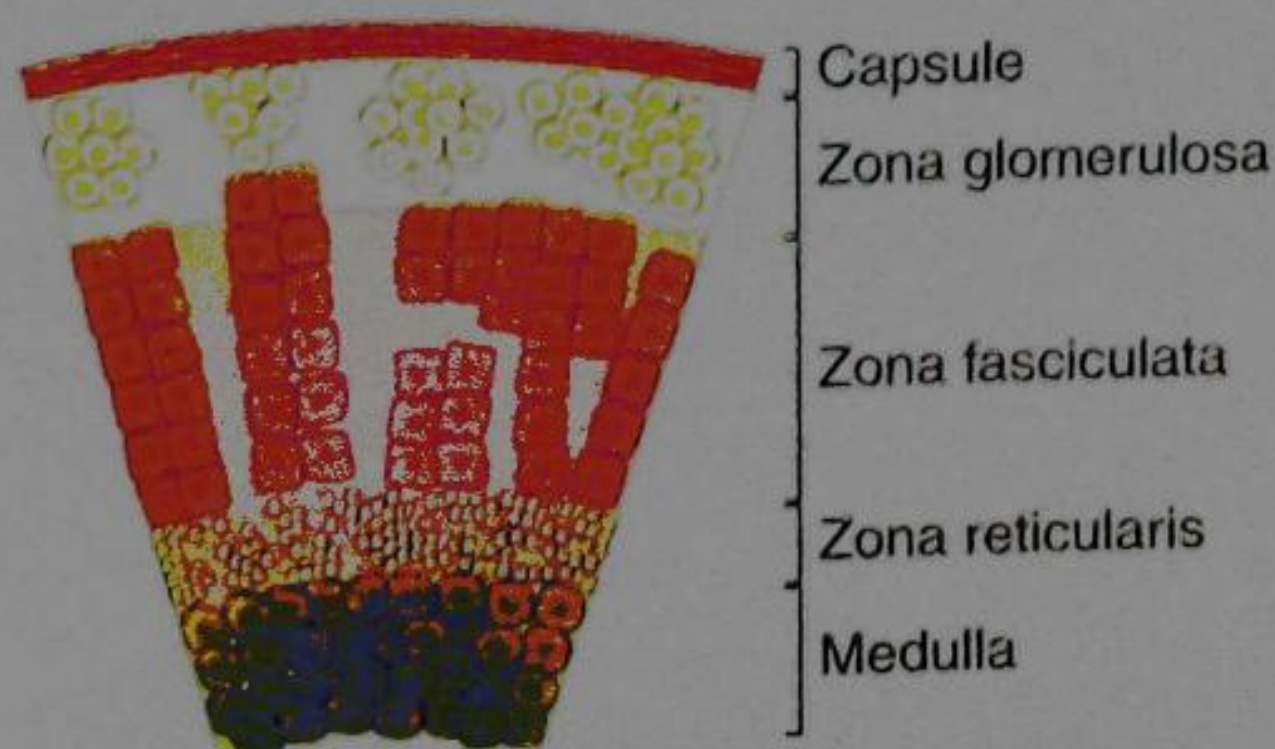


FIGURE 8.5-2 Histological structure of adrenal gland.

- Functionally, these cells are considered to be modified postganglionic neurons, which do not have axons.
- There are two types of adrenomedullary chromaffin cells, one type of cells constitute 80% of the total cells and synthesize epinephrine (adrenaline), and the second type (remaining 20%) cells synthesize norepinephrine (noradrenaline).
- The epinephrine and norepinephrine is largely stored in the subcellular particles called *chromaffin granules*. These granules are osmophilic, electron dense, membrane-bound vesicles. In addition to the catecholamines, the chromaffin granules also contain proteins, lipids and adenine nucleotides (mainly ATP). One of the proteins localized in the particulate fraction is the enzyme, *dopamine β-hydroxylase*. Soluble acidic proteins found in the granules are called chromogranins.
- The adrenal medulla is now included in the APUD (amine precursor uptake and decarboxylation) cell system or the so-called *diffuse neuroendocrine system*.

Nerve Endings, present in the adrenal medulla, are the *cholinergic preganglionic* sympathetic fibres that synapse directly on chromaffin cells. These fibres traverse the splanchnic nerve and are myelinated (type B) secretomotor fibres emanating mainly from the lower thoracic segments (T₅ and T₉) of the ipsilateral intermediolateral grey column of the spinal cord (Fig. 8.5-3).

Blood Supply (Fig. 8.5-4)

Arterial Blood Supply. The adrenal glands have one of the body's highest rates of blood flow per gram of tissue. The arterial blood to the gland reaches the outer capsule from the superior suprarenal artery (a branch of the inferior phrenic artery), middle suprarenal artery (a branch of the abdominal aorta) and the inferior suprarenal artery (a branch of the renal artery). The arterial blood enters sinusoidal capillaries in the cortex and then drains into medullary veins, which supply blood to the medulla and thus form a *portal system*. This arrangement of portal circulation exposes the medulla to relatively high concentrations of corticosteroids from

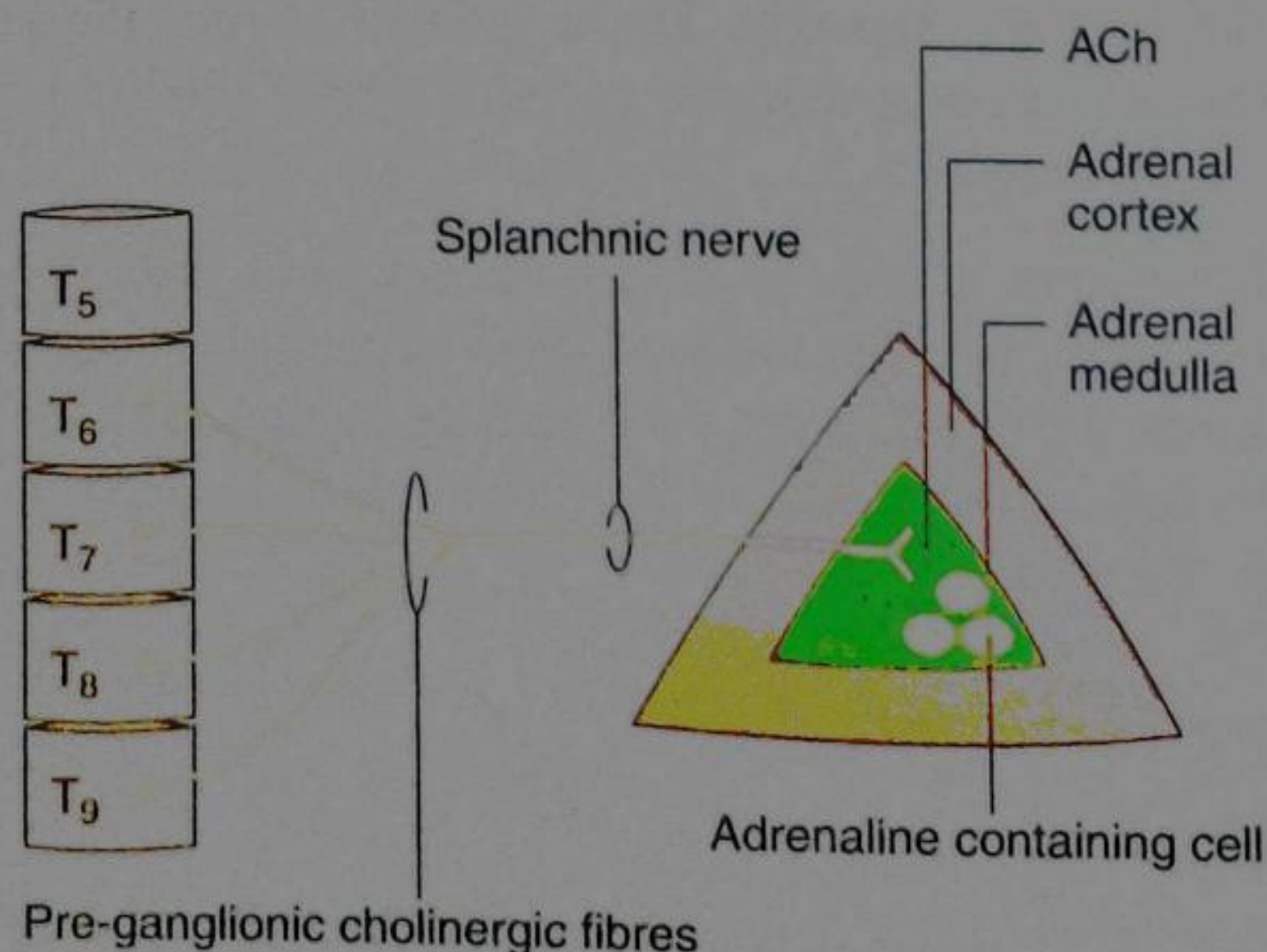


FIGURE 8.5-3 Preganglionic sympathetic fibres synapsing directly on chromaffin cells in the adrenal medulla.

- ① Superior suprarenal artery
- ② Middle suprarenal artery
- ③ Inferior suprarenal artery
- ④ Suprarenal vein
- ⑤ Sinusoidal capillaries in adrenal cortex
- ⑥ Medullary veins supplying medulla (forms portal vascular system)

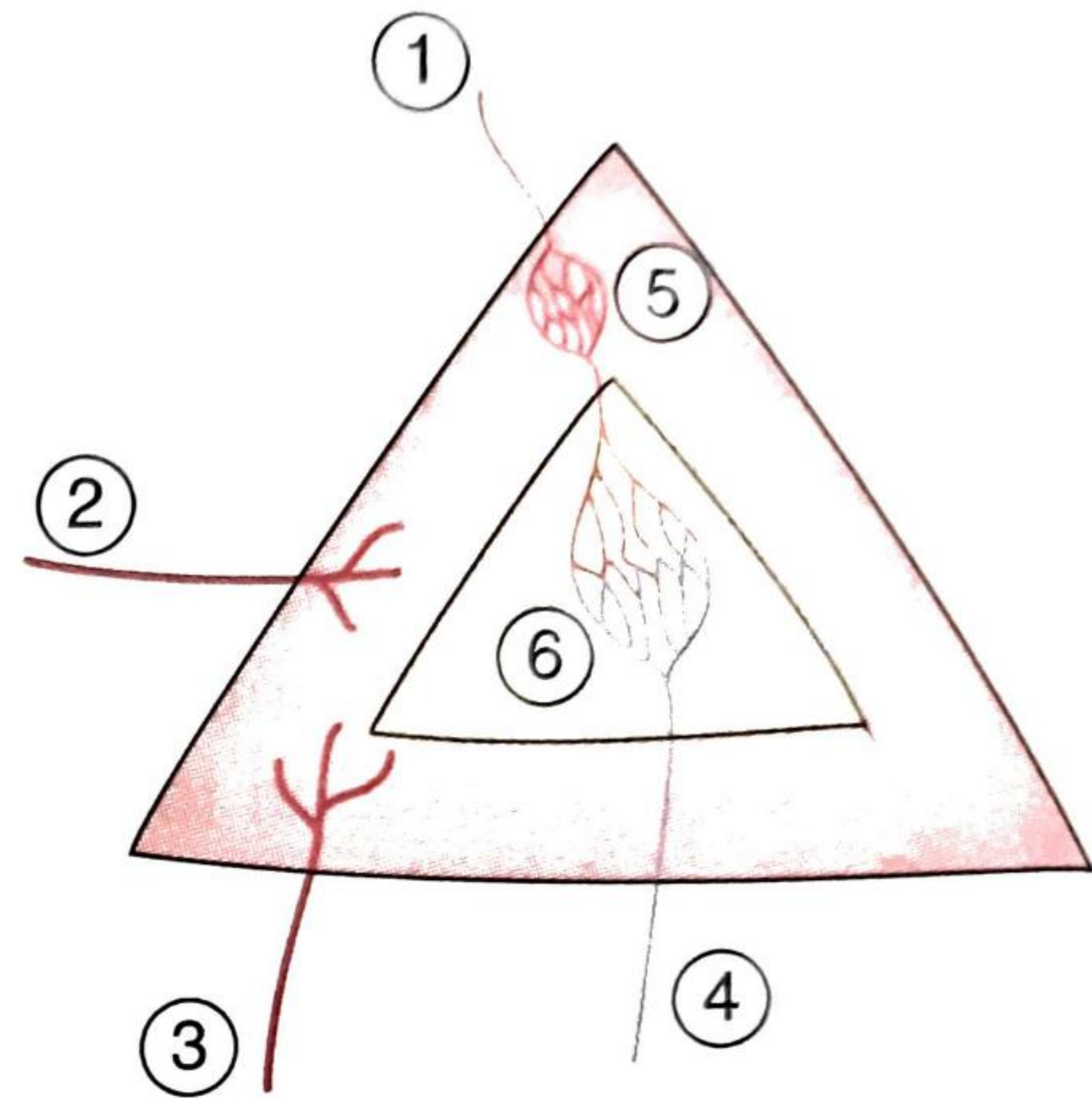


FIGURE 8.5-4 Schematic diagram showing arterial blood supply and venous drainage of adrenal gland. The portal vascular system which exposes the medulla to high concentration constitutes a functional connection between the cortex and medulla.

the cortex. As most of the blood perfusing the medulla is derived from the portal system it is, therefore, partly deoxygenated. There also exists a direct arterial blood supply to the medulla via the *medullary arteries*, which traverse the cortex.

Venous Drainage. The venous blood drains via single central vein, which passes along the longitudinal axis of the gland. The right suprarenal vein drains into the inferior vena cava and left suprarenal vein into the left renal vein.