Abdomen

Neurovascular Supply to the Abdomen

Abdominal Aorta

1) a direct continuation of the descending thoracic aorta
2) lies on the anterior surface of the bodies of the lumbar vertebrae
3) terminates near the L4 vertebra by dividing into left and right common iliac arteries
4) single midline branches
   a) celiac trunk
   b) superior mesenteric artery
   c) inferior mesenteric artery
   d) median sacral artery – descends into pelvis
5) paired branches
   a) inferior phrenic arteries – to diaphragm
   b) middle adrenal arteries – to adrenal glands
   c) renal arteries – to kidneys
   d) lumbar arteries – 4 pairs to the abdominal wall
   e) ovarian & testicular arteries

Clinical Note: 1) Abdominal aortic aneurysms (AAA) – common, present in about 5% of the U.S. population; incidence is actually increasing, which likely reflects an increase in the number of older individuals and the increasing use of improved diagnostic techniques. AAA have a propensity for rupture and, along with aortic dissection, is the 15th leading cause of death in the U.S.. 75% of AAA are asymptomatic and usually incidentally diagnosed during radiographic studies for other reasons or on routine physical exam where one palpates an epigastric or umbilical region mass with expansile pulsations.

Left & Right Common Iliac Arteries

1) terminal branches of the abdominal aorta
2) divide along the pelvic brim into
   a) external iliac arteries – continue into the thigh as femoral arteries
   b) internal iliac arteries – descend into pelvic cavity; principle blood supply to the pelvis

Inferior Vena Cava

1) venous return of some branches of the abdominal aorta
2) tributaries do not exactly match with branches of the abdominal aorta due to the hepatic portal system
3) originates at the level of the L5 vertebra by the union of the left and right common iliac veins
4) ascends on the right side of the aorta, traverses the diaphragm to enter the thorax

Lymphatics of the Abdomen

1) the lymphatic vessels of an organ accompany the blood vessels of the organ
2) major sets of lymph nodes in the abdomen
   a) peripheral nodes – located close to an organ or within the peritoneum (e.g. mesentery, mesocolons, etc.) associated with the organ
   b) preaortic lymph nodes

   i) located near the origins of the single midline arteries that arise from the abdominal aorta and regionally named according to those arteries, e.g. celiac lymph nodes, superior mesenteric lymph nodes, etc.
   ii) receive lymph from peripheral nodes
  c) lumbar lymph nodes
   i) located along the sides of the abdominal aorta and inferior vena cava
   ii) receive lymph from the organs supplied by the paired arteries that arise from the abdominal aorta, the muscles of the abdominal walls, and the common iliac lymph nodes.
   iii) many preaortic and lumbar nodes so intermingle near the aorta and inferior vena cava that it is difficult to distinguish one from the other
  d) common and external iliac lymph nodes – located along the blood vessels of the same name; receive lymph from the pelvis and lower limbs
3) preaortic and lumbar lymph nodes drain via large lymphatic ducts into the cisterna chyli
4) cisterna chyli
  a) a sac-like confluence of large lymphatic ducts on the right side of the L1 vertebral body
  b) receives all of the lymph from the body below the diaphragm
  c) the thoracic duct begins at the cisterna chyli, draining the lymph from it

Autonomics of the Abdomen

1) sensory receptors in abdominal viscera - two categories
  a) nociceptors
   i) receptors that respond to stimuli resulting from damaged tissue (e.g. the inflammation of an appendicitis) or that have the potential to damage (e.g. ischemia, over distention of a hollow organ)
   ii) stimulation is perceived as visceral pain
   iii) visceral pain
    (1) often dull and difficult to localize
    (2) may include referred pain - visceral pain that is perceived to arise from a somatic (skin, muscle, bone) area of the body; the somatic sensory nerves and the autonomic sensory nerves enter the same level of the spinal cord where they “cross signals”
    (3) carried primarily in sympathetic nerves
  b) physiologic receptors
   i) respond to innocuous (harmless) stimuli, e.g. changes in stretch or tension, blood pressure
   ii) monitor visceral functions and mediate normal visceral reflexes necessary to maintain homeostasis (stable internal environment)
   iii) carried primarily in parasympathetic nerves
  c) visceral sensory afferent fibers follow the routes of the visceral motor efferent fibers
2) target regions and cells of the abdomen
  a) sympathetics – innervate both the abdominal wall and abdominal viscera
  b) parasympathetics – innervate only abdominal viscera
  c) innervation to abdominal wall
   i) vascular smooth muscle
   ii) secretory cells of sweat glands
   iii) arrector pili of hair follicles (piloerection)
  d) innervation to abdominal viscera
   i) vascular and non-vascular smooth muscle
   ii) glandular secretory cells
3) sympathetic innervation – two sources

a) aortic plexus
   i) a continuous network of autonomic nerve fibers and ganglia overlying the abdominal aorta; extends from the aortic hiatus of the diaphragm to the pelvic brim
   ii) regionally subdivided based on the names of neighboring blood vessels that originate from the aorta, e.g. celiac plexus and celiac ganglia, superior mesenteric plexus and superior mesenteric ganglia, etc.
   iii) preganglionics into the plexus from:
      (1) thoracic splanchnic nerves - sympathetic input
      (2) lumbar splanchnic nerves - sympathetic input
      (3) vagus nerves - parasympathetic input
   iv) postganglionic sympathetics and preganglionic parasympathetics out of the plexus accompany the blood vessel branches of the aorta to their targets
b) lumbar sympathetic trunks
   i) continuous with the sympathetic trunks in the thorax and pelvis
   ii) lie on the sides of the lumbar vertebral bodies, usually 4 or 5 ganglia per side
   iii) send postganglionics to the lumbar plexus
   iv) lumbar splanchnic nerves – preganglionics passing through the lumbar sympathetic trunks to reach ganglia in the aortic plexus

4) parasympathetic innervation – two sources
   a) vagus nerves (CN X)
      i) join the aortic plexus from the vagal trunks that descend from the thorax on the esophagus
      ii) innervate the GI tract as far as the transverse colon
   b) sacral (S2-S4) part of the parasympathetic system
      i) ascend from the pelvis to innervate the descending and sigmoid colons
5) enteric nervous system
   a) a somewhat autonomous motor and sensory visceral system within the walls of the GI tract itself
   b) activity is influenced by the abdominal autonomics described above

Clinical Notes: 1) Celiac plexus block – injection of a local anesthetic (with or without an indwelling catheter for multiple injections) or a neurolytic compound (destroys nerve fibers) into the celiac plexus. Used for the relief of pain originating in abdominal viscera whose pain fibers pass through the celiac plexus portion of the aortic plexus. A common indication for the use of a celiac plexus block is pancreatic cancer, characterized by severe and unremitting pain that often does not respond well to narcotics.

Urinary System (Kidneys & Ureters)

Kidneys

1) location
   a) retroperitoneal
   b) lie obliquely on the posterior abdominal wall, i.e. anterior surface faces slightly laterally
      i) upper posterior surface is adjacent to the diaphragm (kidneys descend about 3 cm during deep inspiration)
      ii) lower posterior surface is adjacent to the psoas and quadratus lumborum muscles
   c) lie deep to the 11th and 12th ribs opposite the T12 to L3 vertebrae
   d) right kidney is slightly lower than the left; reflects the large right lobe of the liver
2) fat and fascia
   a) perirenal (perinephric) fat - mass of fat immediately surrounding each kidney
   b) renal fascia - fascial layer surrounding perirenal fat

   c) pararenal fat - mass of fat outside the renal fascia
3) external features
   a) bean-shaped, flattened anteroposterior
   b) anterior and posterior surfaces
   c) medial and lateral borders
   d) superior and inferior poles
   e) renal hilus (hilum) – a slit-like space on the medial border through which neurovascular structures enter and exit; "doorway" to the renal sinus
4) internal features
   a) renal sinus – fat-filled cavity deep to the hilus where blood vessels branch and the urine collecting system coalesces
   b) renal cortex
      i) outer region containing glomeruli and tubules that contribute to urine formation
      ii) extends into medulla as renal columns
   c) renal medulla
      i) inner region organized into renal pyramids (apex of a pyramid, called renal papilla, points toward renal sinus; base parallels the surface of the kidney below the cortex)
      ii) consists of filtration/absorption ducts (alter the composition of urine) and collecting ducts (transport final urine product to the apex of a pyramid)
5) blood supply
   a) renal arteries
      i) paired branches of the abdominal aorta - arise high up, between L1 and L2
      ii) divide outside and within the renal hilus into segmental arteries (usually five)
         (1) segmental arteries - end arteries supplying individual segments (regions) of the kidney
      iii) arterial patterns commonly vary
         (1) supernumerary renal arteries
            (a) typically originate from the aorta above or below the renal arteries; less commonly arise from other vessels such as the common iliac artery
            (b) typically pass through the hilus into the renal sinus
            (c) present in about 20% of individuals
            (d) polar arteries - supernumerary arteries that bypass the hilus and renal sinus and directly enter the superior or inferior pole of a kidney
   b) renal veins – tributaries of the inferior vena cava
6) lymphatics – drain to lumbar lymph nodes
7) functions
   a) excretion of metabolic end products, e.g. urea, uric acid
   b) excretion of toxins and drugs
   c) maintenance of extracellular fluid volumes and composition, e.g. regulates water and electrolyte content of blood
   d) production of enzymes and hormones with systemic actions, e.g. renin, erythropoietin

Ureters

1) thick-walled muscular ducts whose peristaltic contractions transport urine from the kidneys to the urinary bladder
2) descend retroperitoneally over the psoas major muscles to the pelvic brim
   a) at pelvic brim pass anterior to the common iliac blood vessels or the bifurcation of the common iliac vessels - important surgical landmark in efforts to locate the ureters
3) parts of the urine transport system
   a) minor calyx (pl. calyces) – trumpet-shaped collecting duct that surrounds the renal papilla of one or two renal pyramids

   b) 2 to 4 minor calyces unite in the renal sinus to form a major calyx
   c) 2 to 4 major calyces unite in the renal sinus to form the funnel-shaped renal pelvis (considered upper expanded end of a ureter)
   d) narrow end of the renal pelvis is continuous with the proximal end of the ureter proper (part distal to the renal pelvis) at the ureteropelvic junction
4) three anatomical constrictions of the ureter
   a) ureteropelvic junction
   b) at the crossing of the pelvic brim
   c) at passage through the wall of the urinary bladder
5) peristaltic contractions of the urine transport system
   a) pacemaker sites
      i) spontaneously active smooth muscle in the wall of each minor calyx
      ii) wave of contraction is propagated toward the ureteropelvic junction (away from kidney parenchyma) and spreads to other minor calyces to initiate their contraction
      iii) pacemaker site for successive contractions moves among different minor calyces
   b) peristaltic contraction of the ureter – the wave of contraction initiated in a minor calyx only spreads to the ureter proper when a threshold volume of urine resides within the renal pelvis; hence ureteropelvic junction acts as a "gatekeeper"
6) blood supply – varies along its length, i.e. branches of renal, gonadal, and vesicular (bladder) arteries

Clinical Notes; 1) Urinary Stone Disease – a disorder characterized by the presence of urinary calculi (syn. kidney stones) at any point in the urinary collecting system; the third most common affliction of the urinary tract (1st is urinary tract infections, 2nd is pathologic conditions affecting the prostate gland) affecting about 5% of the U.S. population with a recurrence rate as high as 50% within 5 years of the initial diagnosis. The most common type of stone consists of calcium-based crystalline components embedded among an organic matrix. The typical pain of a kidney stone reflects blockage of the ureter with accumulation of urine behind the blockage, resulting in over distention of the wall of the ureter that results in muscular spasms of the wall and pain. Small stones capable of passing down the ureter usually have difficulty passing through the three anatomical constrictions of the ureter. 2) Removal of kidney stones – the most common approaches include a) natural passage of the stone, b) percutaneous (performed through the skin) lithotripsy in which focused shock or sound waves are used to break the stones into smaller pieces that can be passed in the urine, and c) endoscopic removal in which a fiberoptic instrument (called a uteroscope) with an attachment device that can grasp the stone is inserted through the urethra and bladder into the ureter or renal pelvis.

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