Anatomy of the inguinal canal: Correlation with USG, CT and MRI

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Learning objectives

To review the anatomy of the inguinal canal.

To identify the structures of inguinal canal on CT and MRI.

To understand pathophysiology and imaging finding of common lesions of inguinal canal.

Background

In daily clinical practice, we often encounter various pathologic conditions of inguinal region. Diagnosis of inguinal lesions generally presented as a lump or mass, understanding of complex anatomy of this region and range of possible pathologic condition is essential. Accurate interpretation of images based on anatomical comprehension is key to successful diagnosis.

We reviews the anatomy of inguinal canal and describe the imaging findings of benign lesions, benign and malignant primary neoplasms and metastases with USG, CT and MRI images.

Imaging findings OR Procedure details

Normal anatomy of inguinal canal

The abdominal wall and the groin region are composed of several layers: skin, superficial fascia, subcutaneous fat, muscle groups, extraperitoneal fat, and peritoneum.

The muscles of the abdominal wall consist of the external and internal oblique, transversus abdominis, and rectus abdominis. (Fig. 1)
In the lower abdominal region, the three lateral muscle layers (external oblique, internal oblique, and transversus abdominis) form an aponeurosis extends toward midline. (Fig. 2)

The inguinal ligament is thickened lower border of the external oblique aponeurosis attached to anterior superior iliac spine and pubic tubercle, it forms floor of inguinal canal and its reflection forms a lacunar ligament. (Fig. 3) The superior wall is formed by the internal oblique and transversus abdominis muscles. The anterior wall of inguinal canal formed mainly by the aponeurosis of the external oblique and internal oblique muscles and the posterior wall is formed mainly by the transversalis fascia and conjoint tendon. (Fig. 4)

The inguinal canal has two openings, deep and superficial inguinal rings. The deep inguinal ring is anatomical defect in transversalis fascia. The superficial inguinal ring is triangular opening in the external oblique aponeurosis superior and lateral to pubic tubercle. (Fig. 5, 6, 7)

The inguinal canal runs medially from proxial to distal. Deep inguinal ring is identified at lateral end of inguinal canal and superficial inguinal ring is at the opposite end (Fig. 8)

The inguinal canal transmits the spermatic cord (including vas deferens, testicular vessels, genital branch of the genitofemoral nerve) to scrotum in male and transmits round ligament of the uterus and the ilioinguinal nerve to the labia majora (Fig. 9)

Three of each fascial layer provides another covering for the spermatic cord, there are three coverings of the cord from outer to inner: external spermatic fascia (derived from external oblique aponeurosis), cremaster muscle and fascia (derived from the internal oblique and transverse muscles) and internal spermatic fascia (derived from transverse fascia.

The vas deferens and the pampiniform plexus can be seen, the latter even better after intravenous contrast agent. (Fig. 10)

In females the round ligament can be seen coursing toward the labium (Fig. 11)

Herniation of normal anatomic structures
Hernia is a pathologic protrusion of beyond boundaries such as inguinal ligament and into the femoral canal, obturator foramen or abdominal wall (Spigelian hernia)

Usually develop from abnormalities the cause high intraabdominal pressure resulting in nonclosure of the processus vaginalis

Classified depending on whether medial or lateral to the inferior epigastric artery

Direct inguinal hernia

Direct inguinal hernia is protruded via specific anatomical region named 'Hasselbach's triangle'. Hasselbach's triangle is a potential weak point of abdominal wall bounded by the inguinal ligament, interior epigastric artery and conjoint tendon. The lateral margin of Hasselbach's triangle is the inferior. (Fig. 12, 13)epigastric artery. Direct inguinal hernia always originates medial to the inferior epigastric vessels. (Fig. 14, 15)

Indirect inguinal hernia

Indirect inguinal hernia protrudes to lateral to the inferior epigastric vessels. Herniated contents descends along the spermatic cord, course of the inguinal canal (Fig 16, 17.)

Amount of herniated contents range from focal herniation of small bowel or omentum to small and large bowel with mesentery or even other organs. Large mass-like lesions due to hernia can be seen. (Fig 18.)

Because inguinal canal is short and narrow structure, in some conditions herniated contents can be incarcerated or strangulated if it caught in a inguinal canal or ring. Delayed detection of strangulation is could be result in even infarction of herniated organ. (Fig 19.)

In a diagnosis of inguinal hernia, USG is the first choice. evaluation of inguinal region is best with oblique scanning between the easily identifiable bony landmarks of the anterior superior iliac spine and the pubic tubercle. other anatomical structures for sonographic
orientation are lateral margin of rectus abdominis muscle, iliac and femoral vessels and inferior epigastric artery.

USG allow differentiation between direct and indirect inguinal hernia by identifying the origin of the hernia. Hernial sac may be hard to seen on USG, especially when it is collapsed or not containing bowel or other structures. (Fig 20.)

Hernial contents can be hyperechoic due to fatty content or heterogeneous echoic with reverberation artifact due to air in bowel (Fig 21.)

When the inguinal hernia is suspected, the valsava maneuver if a critical component of the examination, because in many patients the hernia may be completely reduced at rest. Examination with standing position is also recommended.

Femoral hernia

originates below the inguinal ligament from the inferior aspect of the peritoneal cavity

lies in the femoral canal, medial to femoral vein

because of narrowness of femoral canal, more likely to become incarcerated

Cryptorchidism

common congenital anomaly at birth in term males. Testis can be found in any position along its usual course of descent. But 80% will be located in the inguinal region just outside the inguinal canal. Later risks associated with cryptorchidism include infertility and malignancy (Fig 22, 23)

CT finding

Isodense to soft tissue and contrast enhancement

Following the path of gonadal vessel confirms that the visualized structure represents either ovary of testicle.
MR finding
Low SI in T1WI, high SI in T2WI, homogeneous contrast enhancement

Hydrocele

fluid collection in the inguinal canal as a result of congenital nonclosure of the processus vaginalis. other causes include trauma, infection, or neoplasm.

2 types

1. communicating : communicates with the peritoneum at the inguinal ring (Fig 24.)

2. noncommunicating : encysted and no communication with peritoneum or tunica vaginalis(Fig 25.)

CT finding
fluid attenuation without contrast enhancement (fig 25.)

MR finding
low SI on T1WI, high SI on T2WI, do not enhance with contrast material. (Fig 26.)

Hematoma

Hematoma in inguinal canal can be occurred as a result of anticoagulation therapy, surgery, trauma or catheter insertion. Presents as swelling with pain or tenderness. Hematoma can be found with USG as a heterogeneous echoic mass without vascularity. (Fig 27.) At CT, acute hematoma shows increased density lesion in inguinal region (greater than 30 HU). (Fig 28.)

Varicocele
Varicocele is abnormal dilatation of the pampiniform plexus in the spermatic cord. Primary varicoceles are due to impaired drainage of the internal spermatic vein from incompetent valves. Secondary varicoceles results from increased pressure on the testicular vein produced by disease processes such as hydronephrosis, abdominal neoplasm and nutcracker syndrome.

At CT, varicoceles appear as a enhancing tubules in the inguinal canal. (Fig 29.)

Penile prosthesis

Penile prosthesis is inserted for erectile dysfunction occur from various causes, diabetes, surgery, trauma or smoking. Prosthesis consist of three components, reservoir, bulb and two cylinders. The reservoir is placed in the lower anterior pelvis, the bulb is placed in the scrotum and the cylinders ar placed in the penile shaft.(Fig. 30.)

Neoplasm

Schwannoma

Schwannoma is a benign slow-growing encapsulated tumors of nerve sheath. Most commonly seen in extremities. Commonly involves spinal and sympathetic nerve roots of head and neck, flexor surfaces of upper and lower limbs. Theriotically neurilemoma is eccentric and separable from normal nerve.

At CT, seen as a well defined non-homogeneous low density mass. At MRI, fusiform appearance in peripheral lesion. Low-signal (similar to muscle) on T1 weighted image and high signal (higher than fat) on T2 weighted image. May have fluid-fluid level due to hemorrhage. Strong enhancement is can be seen on Gadolinium contrast media administration. (fig 31.)

Chondrosarcoma

Chondrosarcoma is a cartilage-based tumor and is in a category of cancers called sarcomas. About 25% of primary bone cancers (meaning those which start in the bone) are chondrosarcomas. The most common bones for chondrosarcoma to grow are the pelvic and shoulder bones along with the superior regions of the arms and legs. CT is
helpful in defining the integrity of the cortex and distribution of calcification. MR imaging commonly demonstrate features suggesting chondrosarcoma with evidence of chondroid matrix and cortical destruction. MRI is also helpful in evaluating possible malignant degeneration of osteochondromas by allowing accurate measurements of the cartilage cap which should be less than 2 cm thick. (Fig 32.)

Sarcoma

Soft tissue sarcomas are uncommon tumors. arise from the embryonic mesoderm. Genitourinary sarcomas are less than 5% of total sarcomas, spermatic cord is a common site. Usually presented as a palpable mass in the inguinal region or scrotum. At USG, usually seen as a mass with heterogeneous or low echogenicity in ingunal canal. At CT, sarcomas appear as enhancing masses with infiltration along the spermatic cord or inguinal canal. Imaging finding is nonspecific, usually required biopsy for definitive diagnosis. (Fig 33.)

Lymphoma

Inguinal lymph node is can be involved as a systemic manifestation of lymphoma. Gonadal and spermatic cord involvement is rare and imaging findings are nonspecific. At CT, enhancing solid mass can be seen at inguinal area, thickening of spermatic cord can be combined (Fig 34.)

Metastasis from melanoma

Melanoma is accounts for only 4% of all skin cancers, but it is the first cause of mortality in skin cancer. Metastasis to inguinal region is rare, but aggressive melanoma frequently presented as systemic metastases. At CT, metastasis appears as nonspecific enhancing soft tissue mass. (Fig 35.) Melanoma with metastasis to inguinal canal is considered stage IV disease on the basis of AJCC staging system.

Metastasis from penile cancer

Penile carcinoma is a rare disease in the western world, with an incidence of less than 1/100,000 men. More than 95% of malignant penile neoplasms are squamous cell
carcinomas. The pattern of dissemination is predominantly lymphogenic, as is common in squamous cell carcinomas. In penile carcinoma, the first draining lymph nodes are in the inguinal region. At CT and MRI, no specific imaging finding is known. Enhancing soft tissue mass with or without necrosis can be seen. (Fig. 36, 37)

Images for this section:

**Fig. 1:** Three layer of lower abdominal wall muscles from inner to outer - transversalis abdominis, internal oblique and external oblique muscles are seen. At the midline rectus abdominis muscles are also seen.
Fig. 2: Three layer of lower abdominal wall muscles and aponeurotic portion forming inguinal canal are seen. (Reprinted, from reference 1.)
**Fig. 3:** Borders of inguinal canal is seen on illustration - floor, anterior and posterior wall. Inguinal and lacunar ligaments consisting floor and posterior wall of inguinal canal are shown, respectively. (Reprinted, from reference 1.)
Fig. 4: Non-contrast enhanced axial CT image of 47yrs old healthy male. well visualization of anterior and posterior wall of left inguinal canal. note the spermatic cord and surrounding fatty tissue.
Fig. 5: a. contrast enhanced coronal image of 36 years old male. b. T2 weighted coronal image of 27 years old male. superficial (black arrow) and deep (white arrow) inguinal rings are well visualized.
**Fig. 6:** Nonenhanced axial image of 47 yrs old male. Two openings of inguinal canal at each end are well visualized.
**Fig. 7:** T2 weighted axial MR image of 27 years old male. Deep (a) and superficial (b) inguinal rings are well defined. (arrow)

**Fig. 8:** T2 weighted sagittal image of same person of Fig. 7, serial three images of inguinal canal are shown proximal to distal in order.
**Fig. 9:** Oblique sagittal image of inguinal canal. Fascial layers forming anterior (black arrow) and posterior (white arrow) walls and internal tubular and vascular structures are shown.
**Fig. 10:** Postcontrast CT image of 47 years old male. Inguinal canal, deep and superficial inguinal rings are well visualized. Internal venous plexus with contrast enhancement.

**Fig. 11:** Noncontrast enhanced CT image of 13 yrs old girl, round ligaments running along the course of inguinal canal are seen. Anterior and posterior wall of left inguinal canal are also identified.
**Fig. 12**: Illustration shows inside of abdominal wall; boundary of Hasselbach’s triangle is marked with dotted line. Note the deep inguinal ring at lateral aspect of inferior epigastric artery. (Reprinted, from reference 1.)
Fig. 13: Coronal reformation CT image of 36 years old healthy male showing lower abdominal wall. Three sides of Hasselbach’s triangle are well delineated. (black arrow: lateral margin of rectus abdominis, white arrow: inferior epigastric artery, striped arrow: conjoint tendon)
**Fig. 14:** Non-enhanced axial and coronal CT image showing direct inguinal hernia. Note the position of inferior epigastric artery lateral to hernia.

**Fig. 15:** Axial and coronal CT image of 59 years old male. Direct inguinal hernia of urinary bladder via abdominal wall. Note the inferior epigastric artery at the lateral aspect of herniate bladder.
**Fig. 16:** Indirect inguinal hernia. Herniated bowel and omental fat in hernia sac is seen. Coronal image shows fluid containing bowel in inguinal canal.

**Fig. 17:** T2 weighted MR image of 20 years old male. Indirect inguinal hernia. Herniated fat along the inguinal canal is identified.

**Fig. 18:** Contrast enhanced CT image of 55yrs old male. Indirect inguinal hernia. Small bowel and mesentery are herniated. Note the valvular conniventus suggesting small bowel herniation.
Fig. 19: CT image of 80 years old female. Small bowel is herniated and strangulated at the left deep inguinal ring. Proximal small bowel dilatation due to obstruction is identified on coronal images. Gross photography of resected small bowel infarction.

Fig. 20: USG of 10 years old boy. hernial sac with internal fluid collection is well visualized.
Fig. 21: USG of 2 month old male infant. Heterogeneous echoic mass like lesion in hernial sac. Color doppler image shows blood flow suggesting vessels in herniated bowel.

Fig. 22: Contrast enhanced CT image of 25 years old male. enhancing nodular lesion in left inguinal canal. Postoperative pathologic diagnosis is cryptorchidism.
**Fig. 23:** USG and CT image of 2 years old boy. At USG, well defined heterogeneous echoic mass lesion is found in left inguinal canal. CT shown well defined cystic and solid mass in left inguinal canal. Postoperative diagnosis is hemorrhagic infarction of undescended testis.

**Fig. 24:** Inguinal USG of years old boy. Fluid collection in scrotal sac is communicated with peritoneal cavity.
**Fig. 25:** CT image of 39 years old male. Well defined cystic lesion is located in right inguinal canal. No communication is identified.

**Fig. 26:** T2 weighted MR image of 72 years old male. Well defined fluid collection in both scrotal sac. Low SI in T1 weighted image (not shown) and high SI in T2 weighted image suggested hydrocele.
**Fig. 27:** USG of 41 years old male. well circumscribed heterogeneous echoic mass in left inguinal canal is seen. Note the color doppler image visualized no vascularity in the mass.

**Fig. 28:** Contrast enhanced CT image of same person of Fig 27. After herniorrhaphy, palpable lump with tenderness is appeared. CT revealed postoperative hematoma in left inguinal area.

**Fig. 29:** Contrast enhanced CT image of 67 years old male. Enhancing tubular structures in both inguinal canal is seen.

**Fig. 30:** CT of 62 years old male. Tubing in right inguinal canal, pump in left scrotum and reservoir in lower anterior pelvis is seen in order.
**Fig. 31:** Contrast enhanced CT of 76 years old female. Well defined heterogeneous enhancing mass in left inguinal area. Postoperative diagnosis is schwannoma.

**Fig. 32:** CT of 54 years old male. Huge osteolytic mass compressing adjacent structures with destruction of right pubic bone. Internal necrotic portion is seen as low density. Final diagnosis is a chondrosarcoma.
Fig. 33: USG of 56 years old male. Well defined heterogeneous low echoic mass in right inguinal canal. Color doppler image shows internal vascularity. Final diagnosis is leiomyosarcoma.

Fig. 34: CT image of 83 years old female. Well defined enhancing soild mass in right inguinal area. Adjacent fascial thickening is identified. Pathologic diagnosis is diffuse large B cell lymphoma.
**Fig. 35:** 67 years old male with right sole melanoma and metastasis to right inguinal canal. Well circumscribed soft tissue masses in right inguinal canal are seen.

**Fig. 36:** Penile squamous cell carcinoma with right inguinal metastasis in 61 years old male. Well defined enhancing mass with internal necrosis is seen. Adjacent fascial thickening is also visualized.
Fig. 37: T2 weighted and contrast enhanced T1 weighted image of same patient in Fig 36. Metastatic lymph node with necrosis and surrounding soft tissue edema is seen.
Conclusion

Pathologic conditions with great diversity can be found in inguinal region. In evaluation of inguinal region, it is crucial being well understood about detailed anatomy. Because of its anatomical complexity consist of various structures. Combination of accurate image interpretation on the basis of anatomy and clinical history can make reach to the correct diagnosis. Imaging modality of first choice is USG, easily accessible and inexpensive, and feasible to differentiate between solid and cystic lesion. CT and MRI is can be used in further evaluation considering USG findings.

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References


