# Imaging diagnosis of the inguinal canal

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Learning objectives

Our purpose is to:

1. Describe the anatomy of the inguinal canal (IC) and its embryological origin.
2. Emphasize the role of ultrasound examination as the initial imaging modality.
3. Review the pathological processes of the inguinal canal to make an accurate differential diagnosis with the entities can be found in that location.
Background

Embryologic Development of the IC

A basic understanding of the embryologic development and detailed anatomy of the processus vaginalis in its formation of the inguinal canal, plays an essential role in establishing the diagnosis.

The inguinal canal develop in the female embryo as well as in the male. There are two structures that have major roles in the development of the IC: processus vaginalis (PV), an evagination of the parietal peritoneum, and the gubernaculum, a fibromascular ligament.

The gubernaculum arises in the course of the 7th week of the embryonic development which extend down both sides of the abdomen. The superior aspect is attached to the inferior pole of the developing gonad, testis in males, the uterus and ovaries in females. In females, the cranial section of the gubernaculum becomes the ovarian ligament, and the caudal section becomes the round ligament of the uterus. The round ligament, attaches to the internal aspect of the labioscrotal folds, the future scrotum or labia majora. The gubernaculum allows the gonads to descend.

As the gonads are descending, an evagination of the parietal peritoneum herniated through the anterior abdominal wall ventral to the gubernaculum, forming the processus vaginalis. Extensions of the layers of the abdominal wall accompany the PV and form the walls of the IC. The craneal portion of the PV usually closes at or just before birth, and obliteration proceeds gradually in a downward direction.

Normal Anatomy of the IC

The IC is a tubular, narrow, diagonal passage in the lower anterior abdominal wall measuring approximately 4cm in length. The posterior wall of the canal is formed by the muscle, aponeurosis and fascia of transversus abdominis and also part of the internal oblique. The anterior wall is formed from the fascia of the external oblique muscle.

The IC has two openings: the deep and superficial inguinal rings. The deep inguinal ring is an oval gap in the transversalis fascia and lies 1cm superior to the inguinal ligament and lateral to the inferior epigastric vessels. The superficial inguinal ring is a triangular opening in the aponeurosis of the external oblique muscle.

Imaging of the IC
**US**

B-mode and color Doppler ultrasound (US) remains the initial imaging modality of choice. US is the most practical and rapid method of obtaining images and provides an excellent opportunity of real-time dynamic examination, important in the diagnosis of hernias and varicocele. We usually perform the US exploration with high-frequency transducers (10-12 MHz), comparing with the contralateral side.

**CT and MRI**

Occasionally, we will have to complete with computed tomography (CT) or magnetic resonance imaging (MRI), specially in imaging of deeper structures and to evaluate a larger area or the abdominal extension.
Findings and procedure details

Pathology associated with increased abdominal pressure

- Direct inguinal hernias
- Varicocele

Direct inguinal hernia (Fig 1)

Direct hernias account for 25% of all inguinal hernias. They result from protrusion of abdominal viscera through a weakness of the posterior wall of the inguinal canal, medial to the inferior epigastric vessels, through the Hesselbach’s triangle. Direct hernias are generally acquired and increase in incidence with age, as a result in either increased intra-abdominal pressure, chronic obstructive pulmonary disease, ascites, peritoneal dialysis, coughing... (Fig 3)

Hernias are not always painful, they can be found incidentally. The hernia sac can contain different intra-abdominal structures such as mesenteric fat, the small bowel, the colon, the urinary bladder, ovaries, the appendix and ureters. (Fig 2 and Fig 24)

US is the first-line imaging modality for evaluation of hernias, identifying the hernia neck and its relationship to the inferior epigastric vessels. Color or power Doppler imaging is used in inguinal hernia to evaluate perfusion of the hernia sac contents. During the exploration the patient should be positioned supine, having the patient stand upright and using provocative maneuvers as Valsalva to determine movement of the hernia contents.

Varicocele (Fig 5 and Fig 6)

Varicocele is a pathological enlargement of the pampiniform plexus of veins, a network of many small veins found in the male spermatic cord and can be classified as primary or secondary. Most varicoceles are primary and result from incompetent or congenitally absent valves in the testicular vein. The left testicle is affected much more commonly (85%) than the right. Secondary varicoceles result from increased pressure in the testicular vein. Right-sided varicoceles should prompt consideration of an intraabdominal or retroperitoneal mass.

Most patients with varicocele are asymptomatic. Other patients may palpate a scrotal thickening above the testis or complain of dull pain in the scrotum or groin. Varicocele is considered the most common cause of male infertility.
US is the most commonly performed imaging modality. The measurement of the diameter of the veins in the pampiniform plexus (>2-3mm), the assessment of potential reflux and the flow reversal with the Valsalva maneuver should be reported. US based varicocele grades:

1. Normal: relaxed state 2 mm / during Valsalva 2.7mm
2. Small: relaxed state 2.5-4mm / during Valsalva increased 1mm
3. Moderate: relaxed state 4-5mm / Valsalva increased > 1.2mm
4. Large: relaxed state >5mm / Valsalva increased >1.5mm

Congenital abnormalities of the processus vaginalis

- Indirect hernias
- Hydrocele
- Cysts of the canal of Nuck

Indirect inguinal hernia protrudes lateral to the epigastric vessels, descending along the spermatic cord, course of the IC.

A hydrocele is an abnormal serous fluid collection between the visceral and parietal layers of the tunica vaginalis and/or along the spermatic cord, associated most of the cases with a patent processus vaginalis. There are two major types:

1. Communicating: there is a communication between the peritoneal cavity and scrotum due to complete patency of the PV.
2. Noncommunicating: there are two subtypes; encysted and funicular. In the first one fluid is trapped in the remnant of the PV and does not communicate with the peritoneal cavity or scrotum. In the second one, the fluid collection communicates with the peritoneal cavity but it does not communicate with the scrotum.

On US, hydrocele appears as an anechoid fluid collection and avascular on Doppler color study. Evaluation for possible extension of fluid into the peritoneum and scrotum can help determine the correct variant of hydrocele. In patients with increased intra-abdominal pressure, the PV may reopen and permit extension of intra-abdominal fluid into the scrotum. This is the most frequent cause of acquired communicating hydrocele. (Fig 4)

Hydrocele of the canal of Nuck is a condition caused by a failure of complete obliteration of the canal of Nuck (patent PV). It is classified in three types:

1. Type I: The most common. No communication with peritoneal cavity.
2. Type II: Direct communication with the peritoneal cavity.
3. Type III: The inguinal ring constricts the hydrocele like a belt, so that a part is communicating and a part is enclosed, giving this the name of "hourglass type". (Fig 8)
Postoperative complications after hernia repair

- Hematomas
- Seromas
- Abscesses
- Granulomas
- Recurrence

Seroma or hematoma in the IC is a common complication after laparoscopic or open hernia repair. The incidence ranges from 5% to 25%. Other common causes of hematomas in the IC include trauma, anticoagulation therapy, catheter insertion,... On US, hematoma can be found as heterogeneous echoic mass with no vascularity.

An abscess usually develops more than 30 days after the surgery and associated peripheral hyperemia on Doppler US examination with echogenic foci. (Fig 9, Fig 10, Fig 11 and Fig 12)

Abnormalities in the spermatic cord

- Cyst of the spermatic cord (Fig 13)
- Torsion
- Inflammatory disorders (funiculitis, sarcoidosis, tuberculosis). (Fig 19, Fig 20 and Fig 21)
- Infectious disease

Testicular torsion is a twisting of the spermatic cord and its contents and is a surgical emergency. The age distribution is bimodal, with one peak in the neonatal period and the second peak around puberty. On US, "whirlpool sign" can be observed, an abrupt change in the course of the spermatic cord with a spiral twist at the external inguinal ring in the scrotal sac. (Fig 14)

Funiculitis, or vasitis, is the inflammation of the spermatic cord and often occurs along with epididymitis. Patients present with painful inguinal mass. On US examination, cord structures appear thickened and echogenic with increased vascularity in color Doppler. (Fig 15)

Neoplastic diseases of the spermatic cord

- Benign (lipoma, hemangioma, leiomyoma, lymphangioma, cystoadenoma)
- Malignant masses (leiomyosarcoma, liposarcoma, lymphoma, rhabdomyosarcoma and metastases)
Primary tumors may arise from any component structures of the IC: connective tissue, fat, muscle, blood vessels and lymphoid tissue.

(Fig 16, Fig 17 and Fig 18).

**Pathology in the pediatric population**

- **Undescended testes**

Term such as undescended testis or cryptorchidism describe a testis that is not normally located at the bottom of the scrotum. Occurs up to 30% of premature infants and can be unilateral (90% of the cases) or bilateral (10% of the cases).

Correct localisation of the testes is essential because surgical management varies on location. The descent may be arrested at any level along the path from the retroperitoneum to the scrotum, however, up to 80% of individuals with this condition have testes in the IC. This condition may be associated with some complications, such as testicular malignancy, subfertility, torsion and inguinal hernia. On US examination, most of the testes are hypoechoic; however they may be hyperechoic with "eggshell calcifications". (Fig 22)

**Prosthesis**

Penile implants are a surgical placed device to assist with erectile dysfunction and include two penile cylinders, a pump within the scrotum and a reservoir located in the prevesical space. (Fig 23)
Fig. 1: Inguinal hernia after Valsalva maneuver.

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Fig. 2: Bladder herniation into inguinal canal

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Fig. 3: Incidental asymptomatic bilateral inguinal hernia

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**Fig. 4:** Ascites from gastric adenocarcinoma communicating with IC.

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Fig. 5: Left Varicocele

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Fig. 6: Grade III varicocele due to testicular mass.

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Fig. 7: Right hydrocele in neonate with no communication with IC.

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Fig. 8: Cyst of the canal of Nuck.

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Fig. 9: Patient with previous inguinal hernia repair. On US organized hematoma.

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Fig. 10: Inguinal abscess.

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Fig. 11: Sperm granuloma after vasectomy treatment.

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**Fig. 12:** Same patient as Fig 11.

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Fig. 13: Cyst of the spermatic cord.

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Fig. 14: Torsion of the spermatic cord.

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**Fig. 15:** Funiculitis.

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Fig. 16: Inguinal cord lipoma (hyperintense T1 and hypointense STIR).

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Fig. 17: Liposarcoma of the spermatic cord.

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Fig. 18: Leiomyoma of the spermatic cord.

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Fig. 19: Sarcoidosis presenting with spermatic cord affectation.

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Fig. 20: Paratesticular mass with thickening of spermatic cord. Biopsy confirmed granulomatous necrotizing vasculitis.

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Fig. 21: Testicular and IC affectation by tuberculosis.

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Fig. 22: Undescended testes in the IC.

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**Fig. 23:** Penile prosthesis with material at the IC.

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Fig. 24: Amyand’s hernia: inguinal hernia with acute appendicitis.

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Conclusion

We describe a variety of pathologies observed in the inguinal canal. The correct interpretation will allow an adequate management.
References