HERNIAS OF THE GREATER OMENTUM THROUGH THE ANTERO-SUPERIOR ABDOMINAL WALL: AN EXTENSIVE PICTORIAL MDCT REVIEW WITH EMPHASIS ON TYPICAL ANATOMIC LANDMARKS. A PICTORIAL ESSAY*

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Thanks to its very high performances in term of spatial resolution, table speed and multiplanar reconstructions (MPR), 64-row MDCT today produces unrivalled high quality images of the entire abdominal wall (AW) during a single short breath hold. It appears thus particularly useful for the evaluation of AW hernias, allowing accurate identification of their contents, differentiation from other abdominal masses, planning of optimal surgical repair and detection of pre- or post-operative complications.

The greater omentum (GO) is another structure that can also be clearly identified, localized and characterized with 64-row MDCT. The identification of its numerous vessels, which predominantly have a vertical course, is the essential key for its delineation.

AW hernias implicating the GO are therefore exquisite situations that can also be optimally diagnosed by MDCT. The very high contrast provided by the mostly predominant fatty content of the GO offers a unique opportunity to clearly illustrate the classical anatomic landmarks of almost nearly each type of hernia of the antero-superior AW. The cases presented in this extensive pictorial review were collected in our department during a 5-year-period.

Key-words: Omentum - Hernia.

Thanks to its very high performances in term of spatial resolution, table speed and multiplanar reconstructions (MPR) 64-row MDCT today produces unrivalled high quality images of the entire abdominal wall (AW) during a single short breath hold (1). 64-row MDCT appears thus particularly useful for the evaluation of AW hernias, allowing accurate identification of their contents, differentiation from other abdominal masses, planning of optimal surgical repair and detection of pre- or postoperative complications.

The greater omentum (GO) is another structure that can also be clearly identified, localized and characterized with 64-row MDCT in all patients (2). The identification of its numerous vessels, which predominantly have a vertical course, is the essential key for its delineation.

AW hernias implicating the GO are therefore exquisite situations that can be optimally diagnosed by MDCT. The GO is not only perfectly identified but the very high contrast provided by its mostly predominant fat content offers a unique opportunity to clearly identify, illustrate and finally remember the anatomic landmarks of nearly each type of hernia of the anterior and superior AW.

Discussion

MDCT anatomy of the GO

The GO is a large free-hanging apron arising from the gastric greater curvature (GGC), crossing the transverse colon and descending in front of the hollow viscera (2-3). After a distance that usually ranges from 14 to 36 cm, it turns superiorly on itself to drape over the transverse colon and extend to the retroperitoneal pancreas. These descending and ascending portions usually fuse to form a four layer fatty apron. A persisting space continuous with the lesser sac sometimes separates the two sets of layers. The GO is composed of a trabecular connective tissue framework that carries arteries, veins, lymphatics and fat pads. Its arterial supply is determined by the right and left gastroepiploic arteries receiving their blood supply from the celiac trunk, the left one by the lineal artery and the right, a stronger one, from the gastroduodenal artery. Both arteries pass tortuously along the GGC and decrease in diameter by giving off gastric and epiploic arteries. 5 to 13 epiploic arteries originate from the right gastroepiploic artery and only one main epiploic artery emerges from the left. These vertical epiploic arteries descend mostly at right angles from the GGC and bifurcate close to the GO margin, where they eventually anastomose. The venous drainage parallels the arteries and empties into the portal system. The identification of this rich vascular network and particularly that of the essentially vertical epiploic vessels - particularly the veins which are generally twice as large as the arteries - constitutes the main landmark for current prompt identification of the GO during abdominal MDCT. These vessels may be clearly identified in 100% of patients (2).

Because the GO represents the most superficial fatty intraperitoneal apron, its free edge can be easily identified during scrupulous up and down cine view analysis of the abdomen. It is found just at the level where the fatty omental apron abruptly disappears allowing the intestines to lie directly beneath the AW.

The GO has considerable mobility and may move all around the peritoneal cavity. It functions as a visceral fixation and serves to shield an abnormality and limit its spread (3). However, it is also a common location for neoplastic intraperitoneal seeding and infectious processes because it is bathed in the peritoneal fluid (3).

The GO has anatomic variations (2). Some of these are related to sex and first concern the length and shape (2). The average length of the GO is very statistically significantly longer in females than in males, particularly his left portion.

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^{*} This pictorial review is respectfully and kindly dedicated to the memory of Professor Emeritus Pierre Bodart who was my Master of Radiology from 1983 to 1987 in the Cliniques Universitaires Saint-Luc (UCL), Brussels, Belgium.



Fig. 1. — Coronal (A, B), axial (C) MPR views and selected volume rendering view (d) of a very large hiatal hernia (HH). A 180° vertical volvulus of the stomach (white star) induces a secondary incarceration of a major portion of the GO. It is situated in front of the inverted antrum (black stars). The main gastroepiploic arcade is projected in the upper pole of the hernia (white arrow) and the right and left main lateral epiploic veins are clearly seen penetrating the neck of the hernia (black arrows).

As a result the GO could be expected being more frequently implicated in hypogastric or inguinal hernias in females.

Because of its mobility, length and the fact that it is the most superficial intraperitoneal structure the GO also represents an organ being massively exposed to herniation through the AW. When a hernia produces, the GO is the statistically most exposed structure to protrude first and for this reason it also plays a fundamental protective role for the gut.

Hiatal hernia (HH)

The common sliding (type 1) and the less common paraesophageal (types 2, 3 and 4) HHs are caused by a weakened or torn phrenoesophageal membrane (4). The GO is potentially commonly implicated in the paraesophageal types (particularly in the type 4) in which variable portions of the stomach herniate into the chest (the gastroesophageal junction classically remaining below the diaphragm). This situation predisposes to gastric volvulus or





Fig. 2. — Chest plain film (A), coronal (B), axial (C, D), sagittal (E) MPR views and selected VR view (F) of a very large omental paraesophageal hiatal hernia (HH). The gastroesophageal junction remains under the diaphragm (black arrow). A large portion of the transverse colon herniates within the posterior mediastinum (white arrow) together with a major portion of the GO (white star). Small black arrows delineate the diaphragmatic ring. Epiploic veins are clearly seen penetrating within the hernia.



Fig. 3. — Chest plain film (A), posterior coronal (B), axial (C) and anterior coronal (D) MPR views obtained in a 70 year old woman presenting with a major acquired diaphragmatic hernia (DH). The stomach and a great portion of the transverse portion and of the splenic flexure of the colon are herniated within the thorax through a 7 centimeter large diaphragmatic defect — black arrows on C) and dotted white line on D) -. Because anatomically inserted on these organs a major portion of the GO (white star) is concomitantly forced through the hernia constituting a major portion of the volume of the hernia.

torsion (5). Because it is firmly attached along the GGC, the GO is forced to follow the stomach into the thorax when a sufficiently great portion of its GGC migrates in the hernia (Fig. 1). In extensive cases the colon (especially its transverse portion) may secondarily – or primarily – (Fig. 2) accompany (6). Cases of iso-

lated paraesophageal intrathoracic herniations of the GO through the esophageal hiatus have also rarely been described (7-9). In these cases the differential diagnosis is that of mediastinal lipoma or liposarcoma. The identification of the herniating omental vessels represents the key of the diagnosis.

Non-hiatal diaphragmatic hernia (DH)

Most DHs have a traumatic origin (10-11). Traumatic diaphragmatic rupture is reportedly seen in 0.8%-5.8% of all blunt trauma cases, 2.5%-5% of abdominal blunt traumas and 1.5% of thoracic blunt traumas (10).



Fig. 4. — Axial (A), coronal (B), axial oblique (C), sagittal (F) MPR views and selective VR views (D, E) illustrating a rare case of right Morgagni-Larrey hernia (MH) of the GO (white star). Epiploic veins (white arrow) clearly protrude through a 25 × 33 mm right anterior paramedian diaphragmatic hiatus (C) to expand in the right cardiophrenic space. The ligamentum teres of the falciform ligament (black arrow) is forced through the hernia.

Most ruptures occur in the posterolateral area of the left diaphragm, which is structurally weak. The right diaphragm is congenitally stronger and may also be protected by the liver. A review article found left sided ruptures in 68.8% of patients, compared to right sided ones in only 24.2%, bilateral in 1.5%, pericardial in 0.9%, and unclassified in 4.9% (12). The diaphragm may also be altered by age and/or by previous surgery especially of the left upper quadrant. Although most DHs are diagnosed and successfully repaired at the time of initial injury, the correct diagnosis can often be delayed because blunt traumatic DH is relatively uncommon, and because patients may remain asymptomatic

- sometimes for an extremely long time - or display various nonspecific Nevertheless symptoms. the diaphragm doesn't heal spontaneously and the diameter of the orifice will progressively increase allowing intrathoracic prolapse of larger amount of abdominal organs (11). Due to its great mobility and large anatomic insertion on the stomach the GO can largely prolapse within the hernia (Fig. 3).

Morgagni hernia (MH)

The anteromedial subcostosternal diaphragmatic MHs accounts for only 3% of all surgically treated diaphragmatic hernias (13-16). It produces through a defect described by both Morgagni and Larrey that is a triangular space caused by a failure of fusion between the musculofibrotendinous elements of the diaphragm that originate from the xiphisternum and the costal margin and insert on the central tendon of the diaphragm (14). This potential space is referred to as the foramen of Morgagni or the space of Larrey. The internal mammary artery - with its associated vein and lymphatics passes through this space, as it becomes the epigastric artery. Congenital MH often is considered as being only a pediatric condition. However there have been many case reports and small series of acquired MH involving adults. Nevertheless MH remains a rare entity among



Fig. 5. — Volume rendering view (A, B), axial (C), sagittal (D) and coronal (E) MPR views of a very proximal painful incarcerated epigastric hernia EH (white star) situated just below the xyphoid process. A portion of the GO is incarcerated and the result is an upper attraction of the main gastroepiploic vein (white arrow). The herniation produces through a very tiny orifice of about 1 cm in diameter (black arrow) and the protrusion of the GO induces a displacement of the ligamentum teres of the falciform ligament (small black arrows). Within the hernia the peritoneal omental inflammatory fat appears surrounded by another sheet of fat constituted by properitoneal fat (black asterisks).

adults with a prevalence of only 0,17%, a not well established natural history, a clinical presentation which may be confusing and no definitive management strategies. 70% of the patients are women. MH is far most common on the right (90% of cases) despite protection of the liver (13, 16-17). The defect has classically a

greater transverse than anteroposterior diameter (18) (Fig. 4). Almost any peritoneal abdominal organs may be found within a MH (13, 17) but the GO alone (31%) or accompanied by the colon (29%) represents the most common contents. The stomach (15%), small bowel (11%) and liver (4%) may also be found within the hernia sac (14). Those patients with a herniated stomach are considered potentially having serious symptoms when compared to others. Pregnancy, chronic cough, trauma, obesity, chronic constipation are common predisposing conditions cited in the literature (13, 16). Most MHs are usually asymptomatic



Fig. 6. – Sagittal (A) and coronal (B) MPR views and oblique volume rendering view (C) show two small superposed omental epigastric hernias (EH) (white arrows) producing through the linea alba in very obese female. The epiploic vessels are clearly identified.

and symptoms occur mainly in patients who have a hollow viscus included in the herniation (14, 16). In reality most hernias are discovered incidentally (19-21). Traditional teaching states that repair of MH is invariably indicated after diagnosis because the risk of incarceration or strangulation of abdominal organs. Even if the hernia sac appears to only contain the GO, repair is considered clearly indicated (13, 19, 22).

Epigastric hernias (EH)

EH is caused by a defect in the linea alba between the xiphoid process and the umbilicus (Fig. 5),

and it usually occurs just superior to the umbilicus (23-26). During cadaver studies, the linea alba has been found having a varying make-up: in 30% of cases it is constituted by the confluence of only one anterior and only one posterior rectus sheath layer; in 10% only one anterior and three posterior layers are concerned and finally in 60% of cases there are three anterior and three posterior layers that constitute the linea alba. Moreover the decussation that constitutes the linea alba has a low tensile strength with a low density of collagen fibers. This variability in the already generally weak fascia is undoubtedly one of the factors determining spontaneous ventral hernias. EH occur in 3 to 5% of the population and are most likely to affect men 20 to 50 years of age. 20 to 30% of patients have multiples defects. Most patients are asymptomatic but the hernia may become incarcerated and painful. Generally, properitoneal fat, blood vessels or the GO (Fig. 6 & 7) protrude through the defect (27). Sometimes hollow viscera may also protrude especially in patients in which the GO has a prehepatic configuration (Fig. 8). Hernia producing in the linea alba below the umbilicus are hypogastric ventral hernias and are much less common (24).



Fig. 7. – Axial (A) and sagittal (C) volume rendering views and coronal (B) and sagittal (D) MPR views illustrating a series of four superposed omental epigastric hernias producing through centrimetric orifices of the linea alba in a very obese female.

Umbilical hernia (UH)

UHs are usually congenital and result from incomplete closure of the AW after ligation of the umbilical cord (15, 27). Closure of the umbilical stump involves circumferential granulation tissue formation which results in fusion of skin, single fascial layer and peritoneum, a process leading to complete closure by 4 years of age in the majority of cases. UHs that persist are usually small and rarely demonstrate incarceration.

Acquired UHs – developing after the normal closure of the umbilical ring – account for 4% of all hernias

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Fig. 8. — Sagittal (A) and coronal (B) MPR views illustrating another case of multiple epigastric hernias (EHs). In this case the multiple superposed EHs (white star) contain intestinal loops with a permanent risk of incarceration and occlusion. The GO is constitutionally permanently developed in a right supra and pre-hepatic position — a situation found in about 30% of males — and doesn't play its classical midline protective role. A selected volume rendering view (C) confirms the prehepatic development of the GO (black arrows).



Fig. 9. — : Sagittal (A) and axial (B) MPR views and volume rendering (C, D) views of an enormous umbilical hernia (UH) exclusively constituted by more than 50% of the GO: the GO is globally concentrated on the midline of the abdomen (white arrows) and massively herniates in the UH (white star).

and are more common in women (24, 27-28). They usually occur secondary to obesity (Fig. 9), multiple pregnancies, intraabdomianal masses, liver failure, and a weak abdominal wall (29). They may become large and strangulation is more common (Fig. 10).

Rectus sheath hernia (RSH)

Superior to the arcuate line are classically found the strong complete rectus sheaths, which are continuous structures housing the rectus muscle and the epigastric vessels (30). At this level the rectus sheath is classically composed by a central splitting of the aponeurosis of the internal oblique muscle inclosing the rectus muscle itself (1). This aponeurotic complex is anteriorly covered by the aponeurosis of external oblique muscle and posteriorly by that of transverse abdominis muscle. Thoracic and intercostal perforating vessels can enter the posterior sheath only at the costal margin (25). As a rule spontaneous RSHs producing above the arcuate line appear exceedingly rare (Fig. 11). Only about 8 cases have been reported (30, 31). The pathophysiology of spontaneous RSH is not well understood. A combination of thinner posterior aponeurotic components and defects due to posterior perforating vessels or nerves (i.e., intercostal nerves and the transition of internal thoracic to superior epigastric arteries) could contribute to these rare interstitial RSH (26, 31).

Linea arcuata hernia (LAH)

LAH is a rather recently described and peculiar type of interstitial parietal hernia of the AW which consists of a generally asymptomatic ascending protrusion of intraperitoneal structures under the linea arcuata (LA) or arcuate line of Douglas (1, 32). In most cases this type of hernia appears fortuitously demonstrated during abdominal CT obtained for various other pathological conditions



Fig. 10. — Axial (A) and sagittal (B) MPR views illustrating a case of inflammatory necrotic umbilical hernia (black star). Volume rendering view (C) of the GO vasculature (black arrows) clearly demonstrates the convergence and incarceration of epiploic vessels (white arrow).



Fig. 11. — Rectus sheath hernia (RSH): sagittal (A), axial oblique (B) and coronal oblique (D) MPR views of an exceptionally rare right interstitial hernia of the right portion GO (white star) through a defect (black arrow) of the posterior aponeurosis (white arrow) of the rectus muscle (black star) above the level of the arcuate line. The orifice of the hernia is in oval shape. Volume rendering (C) perfectly identify the GO thanks to its typical epiploic vessels (small white stars).

(Fig. 12). Three grades (G1 to G3) of LAH have been described (1, 32): G1 is a single delineation of the LA due to a minimal bulging of intraperitoneal fat (generally the GO), G2 represents a minimal but more substantial real herniation of fat and/or intestinal loops under the LA and G3 represents clearly prominent hernias of abdominal structures (essentially the GO and/or intestinal loops) (Fig. 12). G2 and G3 have an combined incidence of only 1,42% and most cases remain asymptomatic (1). There is a major male prevalence (M:F sex ratio 12,5:1) and patients older than 71 years represent 76% of patients (1). Up to now, only 4 cases of surgically treated LAH have been reported: one was treated with laparoscopic mesh repair, two with open mesch repair and more recently one with laparoscopic without mesh repair (32-34).



Fig. 12. -2 cases of linea arcuata hernia (LAH) : coronal (A) and sagittal (B) MPR and axial (C) views of a typical right interstitial hernia of the GO (white star) under the arcuate line of Douglas (black arrow). The omental nature of the herniating process is clearly confirmed by the identification of the protruding epiploic veins. Axial (E), coronal (D) and sagittal (F) MPR views of another typical left case. The semeiology is exactly the same.

Spigelian hernia (SH)

SH is considered rather rare affecting less than 1% of the population with hernia defects (35-36). It classically develops under the level of the arcuate line of Douglas or Linea Arcuata (LA). Under this LA, all three aponeurosis of the lateral abdominal muscles do not more equally distribute anteriorly and posteriorely around the rectus muscle to constitute a firm circumferential sheath but abruptly pass exclusively anteriorly to the muscle, thus creating a weakness of the posterior rectus sheath. The LA corresponds to the brutal anatomic concave ending of the transverse abdominis and posterior sheet of internal oblique aponeu-

rosis on the posterior side of the rectus muscle sheath (35). This weakness is amplified by the fact that, at this level, the internal oblique and transverse muscles do not more constitute solid muscular bands but only fascias or thin musculo-aponeurotic bands separated by fascias and running in a parallel instead of perpendicular way. 95% of SH produce through these slitting defects (Fig. 13). Transversally this area of weakness is situated between the rectus muscle and the lateral abdominal muscles on a curvilinear vertical line called the line of Spiegel (35-36).

SH mostly affects a population in the fifth and sixth decades of life and usually occurs on abdominal walls that have undergone traumas or previous surgical operations. It is usually localised on the right side (36). SHs are usually identified once there is pain or obstruction from incarceration (37). Presentation and symptoms are variable and related to the nature of the incarcerating structure. Moreover SH are also clinically difficult to diagnose because a typical mass is not always palpable. Diagnosis is thus notoriously difficult and CT is the imaging modality of choice (27). It is reported that only 50% of all SHs are diagnosed in the preoperative period (37). These difficulties make it all the more important to determine whether repair of incidentally identified SHs is justifiable and under what circumstances one should proceed with repair.



Fig. 13. — Spigelian interstitial hernia (SH) implicating the right inferior angle of the GO (white star) : axial (A), sagittal oblique (B) and coronal oblique (C) views of the right inferior abdominal wall demonstrate a large orifice producing through the conjoint aponeurosis of the transverse and internal oblique muscles (black arrows). Selective VR views (D, E) of the GO perfectly illustrate long right epiploic veins (white arrows) protruding through the well delineated oval orifice. The herniated process remains recovered by the distended aponeurosis of the great oblique muscle (white arrowhead). Black star = Rectus muscle.

Incarceration and strangulation with occlusive syndrome is reported in as many as 24% of these hernias. This high percentage of complications is essentially due to a generally small size of their orifice (0,5 to 2 cm). SHs always contain a peritoneal sac, rarely exceed a diameter more than 2 or 3 cm and remain covered by the aponeurosis of the external oblique (Fig. 13).

The GO (Fig. 13), small bowel, sigmoid colon or caecum are the most implicated organs but cases implicating a strangulated appendix, the gallbladder, an ovary or a testis, the round ligament or the fallopian tube, the stomach, the Meckel's diverticulum, an uterine fibroma or endometric nodules, and epiploic appendage have also rarely been reported (35-36).



Fig. 14. — Association of indirect inguinal (IIH) and incisional (IH) omental hernias: coronal oblique and sagittal oblique MPR views of the anterolateral abdominal wall of an old man presenting clinically with a parietal mass: an IIH of the GO (black star) coexists with an omental IH of another portion of the GO (white star) and producing through an old Mc Burney scar. The long elongated epiploic veins which are running just under the anterior abdominal wall are clearly protruding through the orifices and unequivo-cally identify the GO nature of the herniated fat tissue.

Incisional (IH), trocar and drain site hernia (TSH)

IHs are iatrogenic and occur in a weak area in the abdominal wall after abdominal surgery (27, 38). Infection of the wound or obesity are major etiologic factors. They may manifest anywhere in the abdominal wall and are more commonly encountered in association with vertical than with transverse incisions. They may also be peristomal. IH commonly manifests in the first year after surgery, although a small percentage may be clinically occult. Their reported prevalence ranges from 0.5% to 13,9% for most abdominal surgeries but may be as high as 41% after aortic surgery. Typically properitoneal fat or the GO protrudes first through the hernia defect (Fig. 14). If IH is left untreated, bowel loops may be incorporated and become incarcerated or strangulated.

Laparoscopic surgery has quickly developed, becoming in some cases the gold standard procedure as the preferred mode of access to the peritoneal cavity (39-40). Despite the minimal invasiveness, some laparoscopic procedures-related complications can be directly attributed to abdominal access with laparoscopic trocars. The postoperative port-site hernia formation, which is defined as the development of a hernia at the canula insertion site, is one of them. TSH is a rare but potentially dangerous complication of laparoscopic surgery ranging from early small omental herniations (Fig. 15) to delayed hernia formation with or without bowel entrapment. The incidence of TSH has been shown to be 0,65% to 2,8% and an incidence of 1,5 to 1,8% would be reasonably standard (41-42). TSHs are classified into 3 types (27, 40) : the "early onsettype" that occurs immediately after the operation (within two weeks), with a small-bowel obstruction frequently developing, the "late-onset type" that occurs several months after surgery, mostly with local abdominal bulging with no small bowel obstruction and the "special type" indicating dehiscence of the whole abdominal wall with protrusion of the intestine and other tissue (eg, greater omentum).

TSHs with facial defects of 10 mm or larger should be closed, including



Fig. 15. – 2 cases of omental "trocar" hernias (TH): sagittal (A), axial (B) and oblique (C) MPR views in a case of symptomatic painful omental TH (white arrow) through a "trocar site" of the right upper quadrant (recent cholecystectomy). Ultrasound (D), axial (E) and oblique (F) CT views in another case of small omental hernia (black arrow) through a very small "trocar" site of the right upper quadrant (post- cholecystectomy).



Fig. 16. — CT anatomy of the inguinal area: these two coronal MDCT views (A, B) obtained in a 60 year old patient presenting with a left mild indirect inguinal hernia (IIH) illustrate the classical anatomic landmarks of the inguinal area. The femoral area (1) — where a femoral hernia may produce medially to the femoral vessels (white arrowhead) — is separated from the inguinal area by the inguinal ligament (B, open arrow). The epigastric vessels (A, black arrow) — contained in the external umbilical fold separating the medial from the external inguinal fossa — represent the landmarks between the anatomic sites where direct (internal inguinal fossa =2) and indirect (external inguinal fossa = 3) hernias may produce. Rectus muscle = white star. Internal oblique muscle = white arrow.

the peritoneum. Opinions vary if a 5-mm trocar site defect should be closed. The main pathogenesis appears not related to host factors but rather to technical factors: eg, a large trocar size and stretching of the port site.

Groin hernias

Groin hernias may be divided into two main categories: inguinal hernia (IH) and femoral hernia (FH). IHs are the most common and are subdivided into direct (DIH) and indirect (IIH) types. The ring of IH and the ring of FH are located above and below the inguinal ligament, respectively (43).

a) Landmarks

The inguinal ligament of Poupart, which represents the folded-up lower border of the external obligue muscle, constitutes the floor of the inguinal canal. It joins the anterosuperior iliac spine to the pubic tubercle (44-45). Just lateral to this tubercle a V-shaped gap in the external oblique aponeurosis forms the external inguinal ring. The transverse abdominis and internal oblique muscles joint medially to form the conjoint tendon that has a free edge arching over the spermatic cord and round ligament before attaching to the pectineal line. Thus this tendon conjoint forms the posterior wall and roof of the inguinal canal. The inferior epigastric artery (IEA) lies on the surface of the tendon conjoint immediately medial to the spermatic cord and defines the medial border of the inguinal internal ring. Medially to the IEA is the important triangle of Hesselbach formed by the IEA laterally, the lateral border of the rectus muscle medially and the inguinal ligament inferiorly.

MDCT produces images of the inguinal region with detail not available with previous generations of CT (44). When multiplanar reconstructions are performed in the sagittal, coronal and axial plane 100% identification of the key anatomic structures can be achieved (Fig. 16).

For the evaluation of groin hernias, physical examination is most important in clinical practice, although it is sometimes difficult to distinguish FHs from IHs. CT has recently been proved being useful to make this differential diagnosis (43, 46). The demonstration of a compression of the femoral vein by the hernia sac is common in FH (46). Additionally the relationship between the hernia sac



Fig. 17. — Giant indirect inguinal hernia (IIH) : axial (A, B), curvilinear sagittal (C) MPR views and Volume Rendering view (D) of a giant IIH of the GO (white star). The calcified spermatic artery is identified at the internal border of the hernia. Long epiploic veins (black arrows) can be followed from the hernia to the greater curvature of the stomach.

and pubic tubercle on CT images represents another key to the differentiation of FHs from IHs (Fig. 16). If the hernia sac is located lateral and posterior to the horizontal line drawn from the pubic tubercle, the probability of a FH is high (43, 46). If the hernia is anterior to this line it is more likely an IH.

b) Inguinal Hernias (IHs)

Among groin hernia, IH is undoubtedly the commonest hernia type and accounts for 75% of abdominal wall hernias with a lifetime risk of 27% in man and 3% in women (24, 47-48). IH is at risk of irreducibility or incarceration, which may result in strangulation and obstruction (47). However unlike with FH, strangulation is rare with an estimated lifetime risk of strangulation of 0.27% for an 18 year old man and 0.03% for a 72 year old man (49).

IHs are classically classified as direct (DIH) or indirect (IIH) depending on whether the hernia sac bulges

Fig. 18. — Another case of incarcerated indirect inguinal hernia (IIH) of the GO: A,B: curvilinear coronal MPR CT views and C,D: selected ultrasound pictures. An elongated inflammatory fatty omental mass passes through the inguinal canal (white arrow). Ascitic fluid is trapped below the hernia (black star) and the long epiploic veins are typically attracted to the inguinal area (black arrow). This attraction induces an unusual angulation of the main gastroepiploic arcade (white star).





Fig. 19. — Incarcerated indirect inguinal hernia (IIH): Right sagittal inguino-scrotal ultrasound view (A) and corresponding curvilinear sagittal oblique MPR CT view (B) illustrate an inflammatory incarcerated omental IIH (white arrow). The long epiploic veins of the GO are clearly identified and the incarceration induces an attraction of the gastric antrum to the hypogastric area (black star); white star = right testis surrounded by reactive fluid.

directly through the posterior wall of the inguinal canal (DIH) or passes through the internal inguinal ring alongside the spermatic cord, following the coursing of the inguinal canal itself (IIH) (24).

Congenital hernias are usually IIHs – protrusion through a patent processus vaginalis – and the hernia content includes bowel loops, omental fat or peritoneal fluid (24, 38, 45). Fluid may become encysted. They classically produce in the lateral umbilical fold thus laterally to the inferior epigastric vessels. They have a course along the inguinal canal toward the scrotum or labia and run at an angle (Fig. 16-19) to the peritoneal fossa rather than extending directly inferiorly like DIHs (38). In addition, the neck of the hernia tends to be narrow as it passes through the internal inguinal ring.

DIHs are generally believed to be acquired (38). They are unusual in women. They occur as a generalized bulge through an area of potential



Fig. 20. — Direct type of inguinal hernia (DIH): axial (A, D, E), coronal (B) and sagittal (C) MPR views illustrate a typical right DIH of the GO (white star). The hernia produces at the level of the medial inguinal fossa through an orifice (black arrow) located medially to the epigastric ascending vessels (white arrow) — contained in the lateral umbilical fold. The protruding epiploic vessels are clearly delineated (grey arrow). The obliterated umbilical artery which is contained in the medial umbilical fold and represents the inner border of the medial inguinal fossa (white arrowheads) is partially forced through the medial margin of the hernia. Within the hernia the peritoneal omental fat appears surrounded by another sheet of fat constituted by properitoneal fat (black asterisk). Black arrowheads represent the spermatic cord. Another DIH is visible on the left and only contains properitoneal fat (black star).



Fig. 21. — Another typical direct inguinal hernia (DIH) of the GO illustrated by a series of axial view (A), a coronal MPR view (B) and a selective volume rendering view (C). The vertically descending epiploic veins (black arrows) of the GO typically converge to herniate through the abdominal wall (white arrow) at the level of the medial inguinal fossa. The epigastric vessels classically remain outside the direct hernia (small white arrows).

weakness called the Hesselbach triangle in the posterior wall of the inguinal canal (Fig. 16) (38). The clinical symptoms are undistinguishable from those of IIHs and groin pain is the primary symptom. Unlike IIHs incarceration is uncommon in DIH because they are characterized by a broad neck (38). They occur medial to the lateral umbilical fold. There are two types of DIHs: one extends inferiorly from the medial umbilical fossa (Figs. 20 & 21) and the other extends inferiorly from the supravesical fossa (38). It is not uncommon to find synchronous DIHs and IIHs in a patient, either unilaterally or contralaterally.

c) Femoral hernia (FH)

In adult FHs (Fig. 22) are much less common, occur more commonly in females and account for between 5,3 to 8,2% of all groin hernias (38, 44-45, 50). They are relatively rare in children (less than 1% of all pediatric groin hernias) (50). They are thought to be congenital arising from a defect in the attachment of the transverse fascia of the pubis (45). They protrude through the femoral canal medial to the femoral vein in the potential empty space and posterior to the inguinal ligament. Clinically apparent FHs may be reducible, irreducible, incarcerated or strangulated (50). The hernia is initially quite small, internal and asymptomatic because it is contained within the femoral canal. However, it can be enlarged by passing through the saphenous opening into the subcutaneous tissue of the thigh. Incarceration or strangulation has been reported to occur in 15-20% of the hernias at this stage. The protruded viscus undergoes strangulation and necrosis more often in FH than in other hernias due to the narrower opening of the former. The majority of incarcerated and all strangulated FHs are considered to be surgical emergencies.



Fig. 22. — Typical femoral hernia (FH) of a right portion of the GO: axial (A, B), coronal oblique and sagittal oblique (C, D) MPR views illustrate an herniation of a portion of the GO (white star) typically producing under the inguinal arcade (small white arrows) at the level of the internal angle of the scarpa's triangle (white arrow), just internally to the femoral vessels. On the axial (A) view the hernia typically produces below a horizontal line drawn from the pubic tubercule (black arrowhead). Pectineus muscle (black star). The vertically descending epiploic veins (black arrows) of the GO typically converge to the herniation.

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