The aorto-mesenteric angle and its elements: clinical and imaging features of vascular and gastrointestinal compression syndromes.

Poster No.: C-1800
Congress: ECR 2013
Type: Educational Exhibit
Keywords: Abdomen, Gastrointestinal tract, Kidney, CT-Angiography, Ultrasound-Colour Doppler, Digital radiography, Normal variants, Image compression, Image registration
DOI: 10.1594/ecr2013/C-1800

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR’s endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys’ fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Learning objectives

• To Highlight the importance of aortic-mesenteric compass as anatomical space where may lie both gastrointestinal and genitourinary pathology.
• To Review the regional anatomy and outline clinical syndromes resulting from anomalies and variations in embryological development, as also of the constitutional and postoperative changes that can affect this anatomic area.
• To describe with the radiographic appearance of the various syndromes and their clinical correlation
• To stand out advantages and disadvantages of each different imaging methods technique, with emphasis on key findings for diagnosis.
Background

MORPHOLOGICAL REVIEW:

The aortomesenterico compass (AMC) corresponds to a small sector of the upper retroperitoneum located at the first and second lumbar vertebra, where the superior mesenteric artery (SMA) originates from the aorta, approximately 1 cm below the celiac trunk, mesenteric vein usually is located at the upper right of the SMA.

Among the emergence of the SMA and the aorta forms an angle, looks like a compass has been referred as AMC. Fig. 1 on page 8 There are very important anatomical elements in this angle, from cranial to caudal comprise the left renal vein, uncinate process of the pancreas and third portion of the duodenum encompassed by retroperitoneal adipose tissue. Fig. 2 on page 8 Fig. 3 on page 9

Vascular development:

The SMA originates from vitelline arteries which are a group of vessels arising from the dorsal aortas on both sides of the yolk sac. Fig. 4 on page 10 The cups are attached in pairs (with fusion of the aortas) and, at the end of the fourth week of development persist as unilateral ventral remaining three branches of the aorta are the final celiac trunk and SMA and inferior mesenteric artery (IMA), the SMA is the limit anterosuperior of AMC.

The development of the venous system becomes a fully symmetrical fetal vascular network in a completely asymmetrical in adults. The veins subcardinal are ventral to the plane of the aorta and are responsible for draining the lower half of the fetus. While supracardinal veins, which are in a back plane with respect to the aorta, are responsible for the drainage of the upper segment.

Both systems are interconnected by a venous network that forms a necklace around the aorta. This network consists mainly of veins Intersubcardinales whose fusion and regression form two renal veins, a ventral and dorsal other regarding the aorta. The dorsal vein usually degenerates and forms the ventral renal vein, which is located in the most cranial of AMC. Fig. 5 on page 10

Development of the pancreas:

Pancreas is located in the anterior pararrenal retroperitoneal space. The pancreatic head is located adjacent to the duodenal frame to the right of the superior mesenteric vein, neck compass level, while the body and tail are localized to the left of SMA.
By the fourth week of gestation pancreatic buds are formed, one ventral (lower) and a dorsal (upper) topography of the junction between the middle and posterior intestine, gallbladder, bile duct and pancreas derived from ventral outline ventral (named hepatic diverticulum). The dorsal bud is the dorsal pancreatic precursor.

At the same time the developing ventral pancreas, gallbladder, and the biliary duct rotate clockwise with respect to the duodenum and and fuse to the dorsal pancreas in the retroperitoneum, the whole process takes place immediately to the right of CAS. Each pancreatic sketch presents his pancreatic ductal system.

At 7th week of gestation, approximately, the pancreatic conducts dorsal and ventral they fuse to level of the neck, habitually located to level of the AMC. Fig. 6 on page 11

**Intestinal development:**

During her 6ta and her 9na week of gestation, the rapid liver expansion and the gastrointestinal tract growth is not proportional development of the abdominal cavity, this disagreement in the relation contained-continent, leads the development of the herniation of the primitive intestine towards the celoma extraembrionario in the sector proximal of the umbilical cord, during this process it experiences a rotation of 90 ° in sense anti hourly, about the axis formed by the artery mesentérica top. During 10ma and 12va week, the average intestine suffers another rotation of 180 ° in the same direction and having recovered the relation contained-continent the intestine re-enters to the abdominal cavity. It is fixed by the retroperitoneo Fig. 7 on page 12

Finally, the duodenum realizes a rotation in the shape of "C" and the retroperitoneo is fixed, staying his third portion in the most caudal sector of the AMC and the transition duodenoyeyunal is fixed by means of Treitz's ligament, in left superolateral quadrant of the abdomen, the cecum fix to the retroperitoneo on the low right quadrant. Fig. 8 on page 13 Fig. 9 on page 14

**PHYSIOPATHOLOGICAL REVIEW:**

Several factors (embryological, constitutional, surgery, etc.) can reduce the aortomesenterico angle. Secondly cause compression of the LRV or the duodenum at AMC generating different symptoms and / or syndromes.

The compression of the LRV increases venous pressure, causing hematuria and pelvic congestion. It is named "Nutcracker syndrome" or "Nutcracker phenomenon" depending on the presence or absence of clinical symptoms. Moreover compression of the third portion of the duodenum causes a sub-occlusion or proximal gastrointestinal obstruction known as "Wilkie Syndrome".
Variants or embryological faulty development of this "anatomical crossroads" lead to congenital pathology as annular pancreas and malrotation, both entities originate symptomatology variable expression but with the same clinical syndrome of total or partial bowel obstruction.

The syndromes mentioned have been described several years ago, and probably because of its low incidence to not be considered in the differential diagnosis. On the other hand, congenital malformations as a cause of intestinal obstruction in adults also are rare and usually not taken in mind when analyzing the studies. The ability of multiplanar and high resolution images of current method allows a detailed analysis of this anatomical crossroads, having carefully assessed, as well as related clinical support.

DISEASE DESCRIPTIONS:

Here we give a brief description of the possible causes, clinical presentation and main features of the Nutcracker phenomenon or syndrome, Wilkie syndrome, annular pancreas and intestinal malrotation.

**Nutcracker Syndrome (entrapment of the renal vein)**

The LRV compression resulting in its passage through the vascular angle formed between the aorta and the SMA, causing functional stenosis of it, its etiology is unknown and is characterized by the clinical presence of: hematuria, proteinuria, abdominal pain cramping. Also known as Syndrome entrapment of renal vein. Fig. 10 on page 15

The increased pressure in the LRV at the kidney output would result in collateral circulation to other territories, mainly gonadal vein, peripielic, pericalicial, periureteral, lumbar, paravaginal and periuterin plexuses. Venous dilatation and the imprint of the same within the urothelium could justify hematuria.

The prevalence of nutcracker syndrome is unknown. It usually occurs in young patients, healthy, more common in women of 3rd-4th decade (1), it is important to rule out other more common etiologies of hematuria: stones, infections, neoplasms.

**Posterior nutcracker syndrome**

It's due to compression of the LRV in retroartic location, between the aorta and spine, often associated with an abdominal aortic aneurysm. Clinically presents with intermittent pain lumbar hematuria and / or flank.

**SMA Syndrome or Wilkie Syndrome**
SMA syndrome is a rare cause of duodenal obstruction of vascular origin, as a result of compression of the third portion of the duodenum between the SMA (ahead) and the aorta or spine (behind), also known as Wilkie's syndrome.

The usual presentation is with gastric dilatation and associated with other conditions that facilitate the decrease of the aortomesenteric compass angle, such as conditions with marked loss of retroperitoneal fat as oncological processes or entities that lead to sudden drop weight or cachexia, or also relates to methods that determine dorsal hyperextension, particularly in the post-surgical correction of scoliosis (2).

Usually the presentation is oligosymptomatic but gastric distension may be so great that it can compress the IVC generating chest pain and pulmonary ventilation compromise and lead to respiratory failure and shock by immobilization of the diaphragm. Ischemic necrosis of the stomach can occur when intragastric pressure exceeds 20 cm H2O.

**Intestinal Malrotation**

Abnormal intestinal position in the peritoneal cavity, is a consequence of abnormality in the intestine rotational movement about the axis formed by the AMS and subsequent fixation of the midgut. The absence or fixing abnormality increased risk of intestinal obstruction. Acute or chronic volvulus and necrosis usually is presented as the only one finding but can associate to congenital heart disease (3 4 5)

It occurs in about 1 in 500 newborns (6), diagnosed in neonates and young infants, more than 75% of symptomatic cases occur in infants, because the symptoms occurs after birth, however, an important group are diagnosed in adulthood (6) and, often as an incidental finding on diagnostic methods such as CT (7).

The classic clinical manifestation in infants include bilious vomiting with or without distension abdominal duodenal bands associated with obstructive or volvulus. (8 9)

**Pancreas**

It is a rare congenital anomaly (10 11) in which the head of the pancreas completely encircles the duodenum, usually in its second portion. The ventral pancreatic rotation outline incomplete carries a segment of the pancreas surrounds the duodenum second portion. There are two types of annular pancreas: the extramural surrounding the ventral pancreatic duct into the duodenum to join the main line. The intramural where pancreatic tissue is intermingled with the muscle fibers of the duodenal wall and small ducts drain directly to (3).

Approximately half of the cases affect childhood with duodenal obstruction.

Adults with annular pancreas usually do not have other associated congenital anomalies. This disease has a prevalence of one in 12,000 to 15,000 people and one in 70 patients
with Down syndrome (4 5 10 11), one review (12) states that 103 cases of annular pancreas is a condition seen in neonates and in adults between the third and sixth decades of life. Approximately 50% of patients are symptomatic. In neonates manifests as gastrointestinal obstruction. In adults, can be expressed as symptoms of peptic ulcer, duodenal obstruction (10% of cases) or pancreatitis (13 14).
Figure 1: Analogy between the morphology of a normal compass and aortomesentérico angle: a) Compass device, the arrows point both branches b) 3D reconstruction. Normal mesenteric profile view. SMA: superior mesenteric artery. Ao: aorta

Fig. 1

© Diagnostico por Imágenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
Figure 2: Vascular and digestive crossroads: a) MDCT reconstruction maximum intensity projection (MIP) sagittal view of the Aorta mesenteric compass b) schematic comparison colors. Aorta (red) superior mesenteric artery SMA (pink) left renal vein (blue) third duodenal portion (green), pancreas (yellow), dorsal vertebra (gray). AMS: Superior mesenteric artery. LRV: left renal vein. Ao: Aorta.

Fig. 2

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR

Figure 3: Vascular and digestive crossroads: a) MDCT reconstruction maximum intensity projection (MIP) caudal view of Aorta mesenteric compass b) schematic comparison colors. Aorta (red) Superior mesenteric artery (pink) left renal vein (blue). AMS: Superior mesenteric artery. LRV: left renal vein. Ao: Aorta. LRV: left renal vein

Fig. 3
Figure 4: Vascular development. Arcos circulatory of embryo at 4 weeks. The AMS originates from vitelline arteries which are a group of vessels arising from the dorsal aortas on both sides of the yolk sac.

Fig. 4

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
Figure 5: Vascular development. Schematic drawing of the development of the venous system. Anastomosing subcardinal veins. (red)

Fig. 5

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
**Figure 6**: Development of the pancreas: Embryological development of normal pancreas and annular pancreas. A. Picture of the embryological development of the pancreas with the ventral and dorsal pancreatic sketches. Note the blue arrow showing the normal rotation of the ventral outline and green arrow showing malrotation. B normal pancreas. C annular pancreas normal.

**Fig. 6**

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
Fig. 7

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
Figure 8: **Ligament of Treitz** a) Normal b) Variant ligament of short Treitz or high insertion of the angle duodenojejunal. The length of the black arrow marks the distance between the angle duodenojejunal and the ostium of the artery mesentérica, the short ligament provokes ascent of the duodenum towards the angle between the aorta and the SMA, that the ascent carried the 3er portion of the duodenum

**Fig. 8**

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
Figure 9: Ascent of the duodenum: a) Normal b) Duodenal ascent (arrow) for short ligament of treitz, where the compass angle is small size and is more easily to generates compression of the third portion of the duodenum. C) TCMD Reconstruction sagittal of the AMC in which is observed the compression of both structures. Distinguishes itself in blue color the renal left vein and in green the 3th duodenal portion. LVR: left renal vein.

Fig. 9

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR

Figure 10: A. The diagram illustrates the normal opening and the reduction of the aortomesenteric compass causing LRV vascular compression (arrow). B and C. TCMD 3D Sagittal reconstruction show normal in B and patological in C. LRV: left renal vein. SMA: Superior mesenteric Artery
Fig. 10

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
Imaging findings OR Procedure details

TECHNICAL DESCRIPTION

The diagnostic methods usually used in the assessment of the described pathology comprise barium contrast studies particularly Small Bowel Follow Through, Doppler ultrasound (US), CT (computed tomography), MR (magnetic resonance) and DSA (Digital Substraction Angiography).

SMALL BOWEL FOLLOW THROUGH

Is performed by getting the patient to ingest 400-600 ml of barium suspensión (Gastropaque) of approximately 50% weight/volumen, with radiographs taken at timed intervals as it progresses through the jejunum and ileum. The length of time it takes to complete the exam depends on the time it takes for the barium to pass through the small intestine. The barium filled loops are examined fluoroscopically, and compression is applied at intervals, particularly when the distal ileum is outlined with barium.

DOPPLER ULTRASOUND

US was performed with the patient supine with an Mylab 70x Vision, Escote. In the transverse plane, anteropostenor (AP) diameter and peak velocity (PV) were measured at two points in the LRV, one at the lateral portion of the LRV near the hilum and the other where the LRV courses between the aorta and the SMA. Doppler angle was kept at less than 60°, and wall filters were set at minimum (100 Hz). When Doppler spectra were obtained in the lateral portion of the LRV 2-4-mm sample volume was used; however, a sample volume of 4-10 mm was used when Doppler spectra were obtained in the aortomesenteric angle to cover the movement of the LRV between the pulsating aorta and SMA. We found very helpfull to use de "semi sitting Fowler" position To reduce the stomach air and artifice that occurs when compressing the ultrasound transducer.

CT ENTEROGRAPHY

Patients were instructed to drink 1200 mL of a 3% manitol solution during 45
minutes before undergoing (ie, 300-mL aliquots of the solution at 45, 30, 15, and 0 minutes before the scanning). CT enterography was performed by using a 64-detector row CT scanner (Aquilion, Tochiba). After acquisition without contrast, subjects received 150 mL of ioversol (Optiray 340) intravenously at a rate of 3 mL/sec by using an automatic power injector. The acquisitions were made at 30 seg, 60 seg and 3 minutes after the injection of contrast.

**MR ENTEROGRAPHY**

Enterography techniques require the ingestion of 1350-1500ml of oral contrast (manitol) that fills the stomach and the small bowel. The procedure starts about 40 minutes after the ingestion of oral contrast material.

The MR was performed with a RM SCANNER Magnetom Avanto Siemens 1.5 Tesla. The sequences used were: Coronal T2 SSFSE, Axial T2 SSFSE, Coronal 2D FIESTA, Axial2D FIESTA Fat Sat, Axial LAVA BH. And after the injection of venous contrast: COR LAVA BH MP, Axial LAVA BH (90 seconds after injection and covering the entire abdomen), Coronal 3D-MRCP upper and lower (done for bowel, not for bile ducts).

**CT ANGIOGRAPHY**

The protocol uses dual-phase imaging, with data obtained without contrast and at 25 and 60 seconds after the injection of 120 mL of ioversol (Optiray 340) at a rate of 3 mL/sec. Scan parameters are a 1.25-mm scan width reconstructed at 1-mm intervals for multidetector CT and a 3-mm scan width reconstructed at 1-mm intervals for single-detector CT. After data acquisition, the images are sent over the hospital imaging network to the workstation, and three-dimensional images selected from both phases of the data acquisition are generated

**MR ANGIOGRAPHY**

MR angiographic examination consists of axial fast spin-echo MR imaging through the region of interest. This is useful for the evaluation of abdominal organs and can help determine landmarks to be included in the 3D volume. A timing bolus is then injected and an appropriate scan delay determined. We acquire a precontrast 3D data set, which serves as a #nal check that the volume has been positioned correctly and also tests the patient's breath-holding ability. Contrast material is administered (0.15-0.2 mmol/kg at 2 mL/sec), and the arterial-phase breath-hold sequence is performed, followed immediately by two additional acquisitions with minimal intersequence delay. A #nal post-MR angiography axial fat-saturated spoiled gradient-echo sequence is performed to help visualize infarcts and parenchymal lesions

**DSA**
High-quality digital subtraction angiography images were acquired using a 38-cm field of view and an image matrix of 1,024 x 1,024 pixels (Philips Integris V5000 Series). A 4-French pigtail catheter was introduced transfemorally using the Seldinger technique, and its tip was positioned in the abdominal aorta above the level of the renal arteries between T12 and L1. An aortogram was obtained in the anteroposterior projection by injecting 30 mL of nonionic 300 mg I/mL contrast agent at a rate of 15 mL/sec. Subsequently, all renal arteries were projected after selective catheterization with a 4-French Cobra 2 catheter and the amount of contrast agent and the rate of administration were adjusted appropriately for the size of the vessel. After 7 min, a urogram was obtained.

For the venography a 5-French pigtail catheter was introduced transyugulary. Its tip was positioned in the inferior cava vein. The administration of contrast material allows to evaluate both renal veins.

**IMAGINE FINDINGS:**

Diagnostic methods provide relevant information but no definitive, for the diagnosis of this entities.

**NUTCRACKER SYNDROME**

**Doppler ultrasound** is a helpful method for the diagnosis of NS and should be the first study requested suspicion thereof. It is safe, noninvasive, and allows dynamic measurements with valsalva maneuvers and changes in patient position. Fig. 11 on page 25

Anteroposterior diameter is measured, in this position, two points in the narrowest area at the junction of the aorta with the mesenteric artery and the distal portion of the IVC. A diameter less than 1.5 mm diameter is a stenosis. When measured between 1.5 mm and 2.5 mm is borderline lesion, its normal when measured over 2.5 mm. (15) The non-light display of the left renal vein and the absence of differentiation of the wall thereof between the aorta and the SMA refers vein occlusion. This method also allows to measure the flow velocity and the diameter renal vein at the porta vein level and across the junction of the superior mesenteric artery. It is generally accepted that the flow rate at this level should exceed 100 cm / sec for diagnosis of NS. A study comparing the peak velocity compressed segment of the renal vein vs the hilar portion had a sensitivity of 69-90% and a specificity of 89-100%. (16).

CT Angiography and magnetic resonance angiography are useful for the assessment of aorto-mesenteric angle and varicose veins arising from the increased pressure of the left renal vein. The normal distance between the aorta and the SMA in an axial section is 10 to 20 mm in anteroposterior relationship.
Also, multiplanar reconstructions (MPR), 3D and MIP (minimum intensity projection) reached with CT made allow a comprehensive study of the vascular structures with great anatomical detail. Fig. 12 on page 25 This method is achieved by measuring tributary veins to the LRV. For example a gonadal vein greater than 7 mm in diameter as measured with CT is considered dilated. Fig. 13 on page 26

Other advantages of these methods are the ability to evaluate the entire abdomen in one-step, rule out other most frequent causes of hematuria. There are other anatomical structures and variations that can cause clinical symptoms NS.

For example, splenic vein, duodenum or diaphragmatic crura may be compressed or, in other cases, be compromised. (17) Another cause is the compression caused by the aorta and a vertebral body when the patient has retroaortic renal vein, also called posterior NS. (18) RM. Fig. 14 on page 27

DSA is considered as a reference for the NS diagnosis. (19 20 21). Identify the compression of the LRV, assessing adrenal and gonadal veins. Show the presence of perirenal and periureteral collateral vessels. (22)

Venography also measures the increase in blood pressure in the left renal vein and the pressure gradient between the vena cava and the distal portion of the LRV (cavo-renal gradient). Although there is no universally accepted value which makes the diagnosis of pathology, most jobs normal reference values below 1 mm Hg and pathological values exceeding 3 mm Hg. (22-23-24)
Table 1

References: Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR

WILKIE SYNDROME

At the SMFT can observe the dilation at the first and second portion of the duodenum and the third compression. You can also visualize a slow transit with stomach distension.

CT enterotomograph allow the display in one step of the digestive tract and the vascular axis. Demonstrates distention of the stomach and duodenum before the constriction, compression of the duodenum by the SMA and reduction AMC angle, that while there are no established values, usually located less than 20 degrees (25). (Figure 15)

DSA and CT angiography equipment, identify the arterial structures with great sensitivity. An aortomesenteric angle of 7° to 22° (normal: 25 to 50 degrees) and the distance between the aorta and the SMA is 2-8 mm (normal 10-28 mm) are indicative of this disease (21). Fig. 16 on page 29
The severity of symptoms correlates with distance-AMS aorta and upper gastrointestinal viedoendoscopia (VEDA), helps to rule out intrinsic lesions of the gastrointestinal tract that may cause obstruction and allows biopsy.

**Table 2: Diagnostic imaging findings of Wilkie Syndrome.**

<table>
<thead>
<tr>
<th>SMALL BOWEL FOLLOW THROUGH</th>
<th>dilation at the first and second portion of the duodenum and the third compression. You can also visualize a slow transit with stomach distension.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCMS/MR</td>
<td>Distention of the stomach and duodenum before the constriction, compression of the duodenum by the SMA and reduction AMC angle, usually located less than 20 degrees (25) The distance between the aorta and the SMA is 2-8 mm</td>
</tr>
<tr>
<td>DSA</td>
<td>The reduction of the AMC angle</td>
</tr>
</tbody>
</table>

**Table 2**

References: Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR

**INTESTINAL MALROTATION**

**Barium studies** demonstrate the abnormal position of the duodenojejunal junction, remembering that the normal position is to the left of the left pedicle of the vertebral body is found at the duodenal bulb in front of acquisitions (25)

**CT** findings include the appreciation of the small intestine and the right side of the left colon, the abnormal relationship between the superior mesenteric vessels and pancreatic uncinate process hypoplasia. The findings of small bowel volvulus include small bowel loops with U-shaped fluid level inside converging at a kink. The mesentery also be seen twisted (whirlpool sign). Fig. 17 on page 30 Fig. 18 on page 31
Table 3

**References:** Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR

**ANNULAR ANOMALIES**

**Small Bowel Follow Through.** reveals the focal area of stenosis in the periampullary region, with an extrinsic defect eccentric opacification in the second portion of the duodenum.

**CT and MRI** to visualize the pancreatic tissue completely or partially encircling the descending portion of the duodenum at / or below the ampulla of Vater. Also useful for abnormalities associated with chronic pancreatitis, pancreas divisum, etc. (26 27 28)

The methods of cross-section (CT-RNM) showed the pancreatic tissue completely or partially encircling the descending portion of the duodenum. Those are also useful for the diagnosis of abnormalities associated like chronic pancreatitis, pancreas divisum.

**Endoscopic retrograde cholangiopancreatography** (ERCP) allows accurate delineation of aberrant pancreatic duct encircling the duodenum. Currently this is achieved with high accuracy with MR cholangiopancreatography. MR cholangiopancreatography can display aberrant pancreatic duct encircling the duodenum. ERCP is useful in substantiating the diagnosis and defining the ductal anatomy. ERCP shows a normally located main duct in the pancreatic body and tail and encirclement of the duodenum by a small duct in the pancreatic head. ERCP is recommended. With injection of material of contrast into the major papilla, the common bile duct and ventral pancreatic duct opacify. The latter is abbreviated and tapered and demonstrates early arborization. Injection of contrast material into the minor papilla fills the dorsal pancreatic duct. No communication between the ventral and dorsal ducts is
demonstrated, and drainage of the pancreatic body and tail is through the minor papilla.
ERCP is recommended. With injection of contrast material into the major papilla, the
common bile duct and ventral pancreatic duct opacify. The latter is abbreviated and
tapered and demonstrates early arborization. Injection of contrast material into the minor
papilla fills the dorsal pancreatic duct. No communication between the ventral and dorsal
ducts is demonstrated, and drainage of the pancreatic body and tail is through the minor
papilla Fig. 19 on page 32

| SMALL BOWEL FOLLOW THROUGH | Reveals the focal area of stenosis in the periampullary region, with an extrinsic
defect eccentric opacification in the second portion of the duodenum. |
|----------------------------|-------------------------------------------------------------------|
| TCMS/MR                    | To visualize the pancreatic tissue completely or partially encircling the descending portion of the duodenum at /
or below the ampulla of Vater. Also useful for abnormalities associated with chronic
pancreatitis, pancreas divisum, etc. (26 27 28)
The methods of cross-section (CT-RNM) showed the pancreatic tissue completely or partially encircling the descending portion of the duodenum. Those are also useful for the diagnosis of abnormalities associated like chronic pancreatitis, pancreas divisum. |

Table 4
References: Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital
Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
Figure 11. A. B-mode ultrasound "axial view" aortomesenteric aneurysm level where the distance is diminished and the left renal vein of small caliber passes through it. B. Doppler ultrasound: axial view at the same level where LRV sees through the flow meter with aliasing level gauge reduction that results in an abrupt increase in speed. C. Shows the measurement of the speed at which the stenosis is 145 cm/sec. The flow rate should exceed 100 cm/sec at the junction of the SMA and the LRV for the Nutcracker diagnosis.

Fig. 11

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
**Figure 12**: Nutcracker syndrome. A. Coronal and B. axial reconstruction of TCMD with which shows the relationship of the aorto mesenteric compass and the LRV (red arrow). Collateral vascular dilation of vessels of drainage congestion (blue arrow).

Fig. 12

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
Figure 13: Female patient, 33 years of age, with long history of hematuria and pelvic pain. A. Sagittal computed tomography which measures the aorto mesenteric angle. B. Axial section which shows the decrease of the distance between the SMA and the aorta. D-E. Coronal where shows dilated left gonadal vein and dilated periumbilical left venous plexus. C-F. MIP and 3D reconstruction that show dilatation of the left gonadal vein.

Fig. 13

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
Figure 14: Patient, 59 years old, with hematuria. The initial suspicion was a complication of known renal cyst and performed an MRI of abdomen with intravenous contrast (IVC). A. Axial T1 with IVC, there is narrowing of the renal vein between the aorta and SMA. D. Similar axial CT of the same patient. B-C. Axial T1 fat suppression with IVC, measured reveals narrowing of the LRV at the passage level by the AMC and in the middle third. E. Oblique sagittal CT image where the aortomesenteric angle is measured. Perirenal varices are observed (red arrows). F. Coronal oblique MIP reconstruction which show multiple varices (red arrows) (Referencias in spanish)

Fig. 14

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
Figure 15: **SMA syndrome or Wilkie syndrome. A.B.C.** SBFT shows the difficulty progression of oral contrast and duodenal dilation under (B) and mark the shaft (C). **D.E.F.** Images seen postsurgical correct passage and decreased diameter proximal duodenum compared to images before surgery. **G.H.I.** Images laparotomy where the duodenum is released (arrows)

**Fig. 15**

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
Figure 16: **SMA or Wilkie syndrome.** A. CT enterography coronal reconstruction with distended stomach with negative contrast. **B.** Sagittal reconstruction: AMC angle reduction with third portion of the duodenum through the same. **C.** Axial section which is delimited by the dotted line between the aorta and distacia MSA.

**Fig. 16**

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
Fig. 17: A. SBFT which is shown the proximal jejunum and ileum to the right of the midline of the patient. B-C. Treitz anomalous position. These findings are consistent with intestinal malrotation. D. inversion is observed the arrangement of the superior mesenteric vessels with a medial disposition but the vein. E. Axial MIP reconstruction showing the "swirl sign" that make the mesenteric vessels around the SMA axis. F. 3D reconstruction of CT showing the same phenomenon.

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
Figure 18: **Surgical correlation.** A. Picture of the bowel detorsion "swirling" (asterisk) and fibrous tissue bands (Ladd bands) trapping small bowel loops (arrowheads). B. Dilated veins are observed along the mesentery (filled arrow) interpreted as responsible for filling defect images observed in SBFT. C. Ladd bands section needed to complete the devolvulation. D. Root of mesentery with varicose veins identification.

Fig. 18

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR

Figure 19: **Annular pancreas enterotomography.** A. Annular pancreas forming a semicircle around the duodenum (red arrows). B. Coronal reconstruction obtained at the level of the pancreatic head in a patient with (recurrent acute pancreatitis) shows that pancreatic tissue (arrows) completely surrounds the descending duodenum (green). C. MIP coronal reconstruction shows the relation between the duodenum and the annular pancreas.

Fig. 19
### Table 2: Diagnostic imaging findings of Wilkie Syndrome.

<table>
<thead>
<tr>
<th>SMALL BOWEL FOLLOW THROUGH</th>
<th>dilation at the first and second portion of the duodenum and the third compression. You can also visualize a slow transit with stomach distension.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCMS/MR</td>
<td>Distention of the stomach and duodenum before the constriction, compression of the duodenum by the SMA and reduction AMC angle, usually located less than 20 degrees (25) The distance between the aorta and the SMA is 2-8 mm</td>
</tr>
<tr>
<td>DSA</td>
<td>The reduction of the AMC angle</td>
</tr>
</tbody>
</table>

**Table 2**

### Table 3: Diagnostic imaging findings of Intestinal malrotation.

<table>
<thead>
<tr>
<th>SMALL BOWEL FOLLOW THROUGH</th>
<th>Abnormal position of the duodenojejunal junction</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCMS/MR</td>
<td>Appreciation of the small intestine and the right side of the left colon, the abnormal relationship between the superior mesenteric vessels and pancreatic uncinate process hypoplasia. The findings of small bowel volvulus include small bowel loops with U-shaped fluid level inside converging at a kink. The mesentery also be seen twisted (whirlpool sign).</td>
</tr>
</tbody>
</table>

**Table 3**
**Table 4:** Diagnostic imaging findings of Annular Pancreas.

<table>
<thead>
<tr>
<th>SMALL BOWEL FOLLOW THROUGH</th>
<th>Reveals the focal area of stenosis in the periampullary region, with an extrinsic defect eccentric opacification in the second portion of the duodenum.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCMS/MR</td>
<td>To visualize the pancreatic tissue completely or partially encircling the descending portion of the duodenum at / or below the ampulla of Vater. Also useful for abnormalities associated with chronic pancreatitis, pancreas divisum, etc. (26 27 28) The methods of cross-section (CT-RNM) showed the pancreatic tissue completely or partially encircling the descending portion of the duodenum. Those are also useful for the diagnosis of abnormalities associated like chronic pancreatitis, pancreas divisum.</td>
</tr>
</tbody>
</table>

**Table 4**

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
**TABLE 1: Diagnostic imaging findings of Nutcracker Syndrome.**

<table>
<thead>
<tr>
<th>Test</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doppler ultrasound</td>
<td>Anteroposterior diameter is measured, in this position, two points in the narrower area at the junction of the aorta with a diameter mesenteric and distal portion of the IVC. A less than 1.5 mm diameter is a stenosis. The flow rate of the LVR at the AMC level should exceed 100 cm / sec</td>
</tr>
<tr>
<td>TCMS/MR</td>
<td>The narrowing of the aorto-mesenteric angle (&lt;40°) and varicose veins arising from the increased pressure of the left renal vein. The distance between the aorta and the SMA less than 10 mm in anteroposterior relationship.</td>
</tr>
<tr>
<td>DSA</td>
<td>A cavo-renal gradient &gt; 3 mm Hg. (22-23-24) Identify the compression of the LRV, assessing adrenal and gonadal veins</td>
</tr>
</tbody>
</table>

Table 1

© Diagnostico por Imagenes del Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires, Hospital Italiano de Buenos Aires - Buenos Aires/AR
Conclusion

CONCLUSION

• The clinical suspicion is the first step for the approach of these syndromes, after ruling out other most frequent pathology causes.

• To keep in mind this forgotten carrefour allows the rapid recognition of the abnormality leading towards a proper diagnosis crucial for the correct treatment.

• The first method is a doppler ultrasound diagnosis because their availability and noninvasive feature. It is a dynamic study and it is important for the recreation of situation that the symptoms increased.

• The TCMS angiography shows not only vascular anatomy information if intestinal characteristics in the same study. An other advantages is that we can see them together in the same picture for the analyses between them, and also, make a sustraction and measured de angle and distance between the vascular componenets. In some cases could bring information that provide diagnostic accuracy, without the need of other more invasive methods like DSA, which should be reserved for doubtful cases where the diagnostic confirmation results indispensable. Generally de CT is usefull for rule out other common symptoms causes for example neoplasms, nephrolithiasis, prostate disease, metastases, etc in a patient with haematuria.

• The diagnosis of these syndromes unlike most diseases, it has not a correlative pathological for given us a diagnostic confirmation. Therefore, it is a challenge for the physician to make a diagnosis recalling the embryology, anatomy and symptomatology to power through the pictures explain the pathophysiology of this.
References


25. Ruth Eliahou, MD • Jacob Sosna, MD • Allan I. Bloom, MD. Between a Rock and a Hard Place: Clinical and Imaging Features of Vascular Compression Syndromes, RadioGraphics 2012; 32:E33-E49 • Published online 10.1148/ rg.321115011


