ADDIS ABABA UNIVERSITY COLLEGE OF HEALTH
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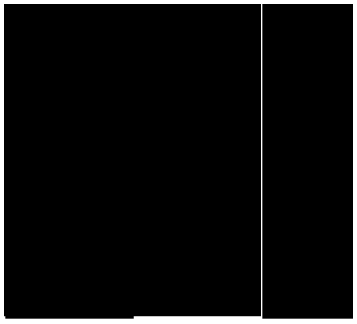
DEPARTMENT OF RADIOLOGY



# A CROSS SECTIONAL STUDY ONMAGNITUDE OF INCIDENTAL VASCULAR COMPRESSIONS IN ABDOMEN AND PELVIC CT, TIKURANBESSA HOSPITAL, ADDISABABA, ETHIOPIA

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A THESIS SUBMITTED TO THE RADIOLOGY DEPARTMENT, COLLEGE OF HEALTH SCIENCE, ADDIS ABABA UNIVERSITY IN PREPARATION FOR PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE POST GRADUATE STUDY IN RADIOLOGY.

ADDIS ABABA, ETHIOPIA
JULY, 2019

## ABSTRACT

**Background**:Certain abdominopelvic vascular structures may be compressed by adjacent anatomic structures or may cause compression of adjacent hollow viscera. The knowledge of these CT patterns of compression is also important because they may be asymptomatic; when symptomatic, however, they can lead to a variety of uncommonsyndromes in the abdomen and pelvis, including median arcuate ligament syndrome, May-Thurner syndrome, nutcracker syndrome, superior mesenteric artery syndrome, uretero-pelvic junction obstruction, ovarian vein syndrome, and other forms of ureteral compression. Computed tomography is particularly useful in that it allows a comprehensive single-studyevaluation of the anatomy and resultant morphologic changes.

**Objective**: To describe Abdominopelvic vascular compressions incidentally found on computed tomography.

**Method**: Hospital based prospective cross sectional study was conducted at TikurAnbessa Specialized Hospital who undergo computed tomography scan of the abdomen between January and April 2019. The study population was all patients who undergo computed tomography scan of the abdomen .Data was collected by evaluating abdominal Computed Tomographic scans from Picture archiving and communication system. The data was checked for clarity and completeness. Computerized data analysis was conducted by using SPSS version 25.0 software.

**Result**:Out of 623 multi detector abdominopelvic CT (MDCT)performed between January 2019 and April 2019;a total of 513 (N = 513) patients were included in the study out of which 35(6.8%) had fulfilled imaging features of SMA compression and 33(6.4%) of the patient fulfilled imaging features of nutcracker phenomenon and 22(4.28%) of the patients showed celiac compression by MAL. This study group comprised 277 (54 %) females and 236 male (46%) patients. Mean age of the patients was 38±20 (mean ± standard deviation).

**Conclusion**:Incidental SMA Compression of duodenum, MAL compression of celiac artery and left renal vein compression by SMA are not uncommon and syndromic diagnosis should not be made on radiologic diagnosis alone. The SMA compression and nutcracker sign are usually seen together. High origin of celiac artery and low insertion of MAL are the main risk factors for compression of celiac artery which were seen in previous studies as well.

## ACKNOWLEDGMENT

At first the slogan of my gratitude starts by expressing thanks to almighty God for Everything.

Secondly, my gratitude goes to my advisor their honorableconstructive commentsfrom the preparation of the proposal up to the end of thisstudy. I wouldalsolike to express myappreciation for mysisterswhohelped me to do myresidency.

Finally, I would like to thank Department of radiology, college of health sciences, Addis Ababa University for giving the chance to do this research.

## ABBREVIATIONS AND ACRONYMS

AMA……..Aorto-mesenteric angle
AMD ……. Aorto-mesenteric distance
CIA …… common iliac artery
CIV …… common iliac vein
CT…….Computed Tomography
IVC…… inferior vena cava
IVU…… intravenous urography
LRV ……left renal vein
MALS……. medianarcuate ligament syndrome
MIP…… maximum intensity projection
MPR…… multiplanar reformation
OVS……. ovarian vein syndrome
SMA…… superior mesenteric artery
3D……... three-dimensional
UPJ…….. ureteropelvic junction
VR…… volume-rendered

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# INTRODUCTION

## Back ground

Vascular structures in the abdomen and pelvis may be compressed by adjacent anatomic structures, or they may cause compression of adjacent hollow viscera. Thus, compression of the proximal celiac artery, transverse duodenum, left common iliac vein (CIV), left renal vein (LRV), ureteropelvic junction (UPJ), and ureter can occur due to their close anatomic relationship to adjacent ligaments as well as bony and vascular structures. When symptomatic, such compressions can result in a variety of uncommon syndromes in the abdomen and pelvis, including median arcuate ligament syndrome (MALS), May-Thurner syndrome, nutcracker syndrome, superior mesenteric artery (SMA) syndrome, UPJ obstruction, ovarian vein syndrome (OVS), and other forms of ureteral compression.

Controversy surrounds the pathogenesis of some of these syndromes. Anatomic or morphologic findings that predispose to such compression may occasionally be encountered in asymptomatic patients who undergo imaging for unrelated causes. Thus, caution should be exercised to avoid over diagnosis of these syndromes. It is important that the diagnosis of these syndromes not be based on imaging findings alone.

Symptoms resulting from such compressions can be vague, nonspecific, and obscure, resulting in delayed, incorrect, or missed diagnoses. Although many of these syndromes were described decades ago, they remain poorly understood. If unrecognized and untreated, they can be associated with significant morbidity. These syndromes may be encountered by physicians in a variety of disciplines and can present a diagnostic dilemma. For all of these reasons, it is important that these syndromes be recognized.

Multidetector computed tomography (CT) is the imaging modality of choice for many of these syndromes owing to its high contrast and high spatial and temporal resolution, capacity for obtaining isotropic data sets that allow multiplanar two-dimensional and three-dimensional (3D) post processing, remarkable accuracy, widespread accessibility, speed, and relative noninvasiveness. CT is best performed on multidetector CT scanners with 16 or more detector rows. Multiplanar reformation (MPR) can be performed, not just in sagittal and coronal planes, but in any defined anatomic plane, thereby providing a novel perspective that is customized to the unique anatomy of the patient. By incorporating MPR and 3D volume rendering (VR), multidetector CT is truly 3D. Maximum intensity projection (MIP) techniques greatly enhance the depiction of vascular structures at CT angiography. However, radiation exposure to younger patients, especially premenopausal women, needs to be considered. Ultrasonography (US) is largely operator, patient, and region dependent; although duplex US can provide information on the hemodynamic significance of vascular compressions. Most non–cross-sectional imaging techniques have limitations in the evaluation of these syndromes, but direct venography remains valuable in the diagnosis of syndromes that involve venous compression.

When conservative management is not indicated or fails, surgery is the mainstay for treatment. Open surgical techniques are now being replaced by less invasive laparoscopic techniques. Outcomes following surgery may vary, and the decision to treat should be made only in those patients who are experiencing disabling or severe symptoms.

## Statement of the Problem

Vascular structures in the abdomen can compress or be compressed by adjacent structures. Although many of these conditions were discussed many years ago, they remain poorly understood. In some circumstances, they can be associated with significant morbidity and poor treatment outcome if left untreated and unrecognized.

However, such compressions in the abdomen may be incidentally found and be asymptomatic. Intermittent vascular compressions by anatomic abnormalities are more common than vascular compression syndromes. So, knowledge of these compressions is important to avoid over diagnosis or treat patients who are incidentally detected to have anatomical factors that predispose to vascular compression but are otherwise asymptomatic.

# CHAPTER TWO: LITRATURE REVIEW

## Celiac Compression by Median Arcuate Ligament

Because of the large increase in the number of abdominal CT examinations in the past decade, coupled with the ability to obtain sagittal reconstructed images at CT, proximal celiac compression is occasionally seen incidentally in patients who are undergoing CT for unrelated reasons (1). Some studies have investigated the incidence of celiac artery narrowing in asymptomatic adult patients. A report from a study of 83 cadavers, Lipchitz noted that the celiac axis "is not infrequently partly covered at its origin by the diaphragm." However, the location of the MAL is "exceedingly variable" and the celiac artery origin was either at or superior to the MAL in 33% of a 75-case autopsy study. The MAL may indent upon the celiac trunk and cause downward angulation, but this appearance may be a mere anatomic variant that is non-obstructive [2].

Another study done on 97 patients without any symptoms of mesenteric ischemia who were undergoing upper abdominal magnetic resonance (MR) angiography, narrowing of the proximal celiac artery by over 60% was present in 16 patients (16.5%) at end expiration and in 12 patients (12.4%) at full inspiration, findings that confirmed that compression of the celiac artery is more common during expiration (3).

There is also study done on CT angiographic findings obtained at full inspiration in 155 healthy asymptomatic kidney donors between 18 and 65 years of age showed narrowing of the celiac artery origin by more than 50% in eight individuals (5.2%). No significant collateral vessels were seen in any of the donors (4).

In a retrospective study of aortograms of 1500 patients discovered compression of the celiac artery severe enough to cause symptoms in approximately 1% of the patients [5].

A retrospective study of 14 patients with MAL syndrome found a mean age of 28.4 years and 71% femalepreponderance [6].

## Compression of Deudenum by SMA

Because SMA syndrome occurs relatively infrequently, its exact prevalence in the general population is extremely difficult to measure, although it has been estimated to be 0.1%–0.3% on the basis of gastrointestinal barium studies (7). However, in patients with scoliosis who undergo corrective spinal surgery, a prevalence of up to 2.4% has been reported (8).Whereas other sources quote a prevalence of 0.0965% in a chronic hospital setting versus 0.00108–0.0052% in an acute general hospital setting [9]. This syndrome is rare. There is a slight femalepreponderance (64–66%), with 75% of cases occurring in individuals who range in age from 10 to 39 years [10].
Another research done by Hines et al on 44 patients discharged with the diagnosis of superior mesenteric artery syndrome, only 6 fulfilled the strict clinical and radiographic criteria of this disorder. Three of the patients were women and three were men, with a mean age of 26 years,

an average height of 5 feet 8 inches, and an average weight of 101 lb. Three patients had a debilitating condition (head trauma, juvenile rheumatoid arthritis, and neck malignancy) and three had chronic illness plus a change in patient status (recent surgical procedure, body cast application, and development of pyodermagangrenosum.). All patients presented with the classical signs and symptoms of duodenal obstruction, namely nausea, vomiting, abdominal pain, distention, tympany, tenderness, and abnormal bowel sounds. These symptoms were aggravated by eating. The diagnosis was confirmed radiographically in all six patients.(11)

Even though there are many variations some literatures show for normal patients, the aortomesenteric angle is 28 to 65 degrees and the aortomesenteric distance is from 10 to 34mm.They also defined an angle of less than 22 degrees and a distance of less than 8 to 10mm as diagnostic. Earlier investigations had reported 10mm as the cut-off for the aortomesentericdistance (12 and 13). However, a recent investigation correlating CT and ultrasound to upper gastrointestinal and clinical symptoms in a small number of subjects reported that a cut-off of 8mm was 100% sensitive and specific.(14)

## Left renal vein compression by SMA

The exact prevalence of nutcracker syndrome is unknown, likely because of the variable presenting features [15]. However, it is estimated to be relatively more common in females and usually presents in the 3rd or 4$^{th}$ decade of life [16]. The severity of nutcracker syndrome is
Variable, and affected individuals may be completely asymptomatic or, in the most extreme cases, experience severe pelvic congestion [17].” However, the most common presenting symptom is micro- or macroscopic hematuria. Hematuria has been attributed to hemorrhage into the calyceal fornix from the thin-walled varices, which develop secondary to renal venous hypertension [18].

Because of the variability of symptoms and the absence of consensus regarding diagnostic criteria, the exact prevalence of nutcracker syndrome is unknown. The majority of affected patients are young or middle aged, and nutcracker syndrome is slightly more common in females. No consensus exists as to what symptoms are severe enough to warrant the designation of a clinical syndrome, and the diagnosis is often overlooked and delayed.

One retrospective research done on Ninety-nine consecutive CT angiograms for potential renal transplant donors (mean age, 39.0 years; 42 males) without variant renal vein anatomy showed twenty-three patients had 50% to 70% stenosis, and 4 patients had greater than 70% stenosis of the left renal vein. Dilated gonadal and lumbar veins were found in 16 and 28 patients, respectively. Four patients had hematuria. These findings were not significantly associated with left renal vein compression.(19)

# 3. OBJECTIVES

## 3.1. General objective

- To assess the compression of hollow visceral structures and blood vesselsby surrounding abdomino-pelvic structures.

## 3.2. Specific objectives

- To assess the magnitude of common incidental vascular abdominal compressions.
- To discuss CT imaging featuresof vascularcompressions.

# 4. METHODS AND MATERIALS

## 4.1 Study area and period

The study was conducted at TASH, College of health science, Addis Ababa University, Addis Ababa Ethiopia. TASH, located in the nation's capital Addis Ababa. It is the largest referral as well as a main teaching hospital in Ethiopia. The hospital provides a tertiary level referral treatment with over 900 beds. The study was conducted from January 2019-April 2019 G.C.

## 4.2 Study design

A prospective cross sectional studywas employed.

## 4.3 Population

### 4.3.1 Source population

The source population was all patients who had CT during the study period.

### 4.3.2 Study population

This is a cross-sectional study which will include a total number of 623 patients that were referred to the Radiology Department TikurAnbessa Hospital to do Post contrast abdominal or abdominopelvic CT during the period from January 2019-april, 2019 G.C.

### 4.3.3 Inclusion and exclusion criteria

#### *4.3.3.1 Inclusion criteria*

- All patients evaluated with abdominal and Abdominopelvic CT during the study period.

#### *4.3.3.2 Exclusion criteria*

- Patients who has large intra-abdominal mass that distorted arterial or venous anatomy
- Patients who had poor enhancement of the venous and arterial structures due to different reasons
- Patients for whom good sagittal reconstruction cannot be done.

## 4.4 Sampling technique and sample size

Nonprobability sampling technique was used and all patients with abdominal and abdominopelvic CT during the study period was included in the study.

## 4.5 Data collection

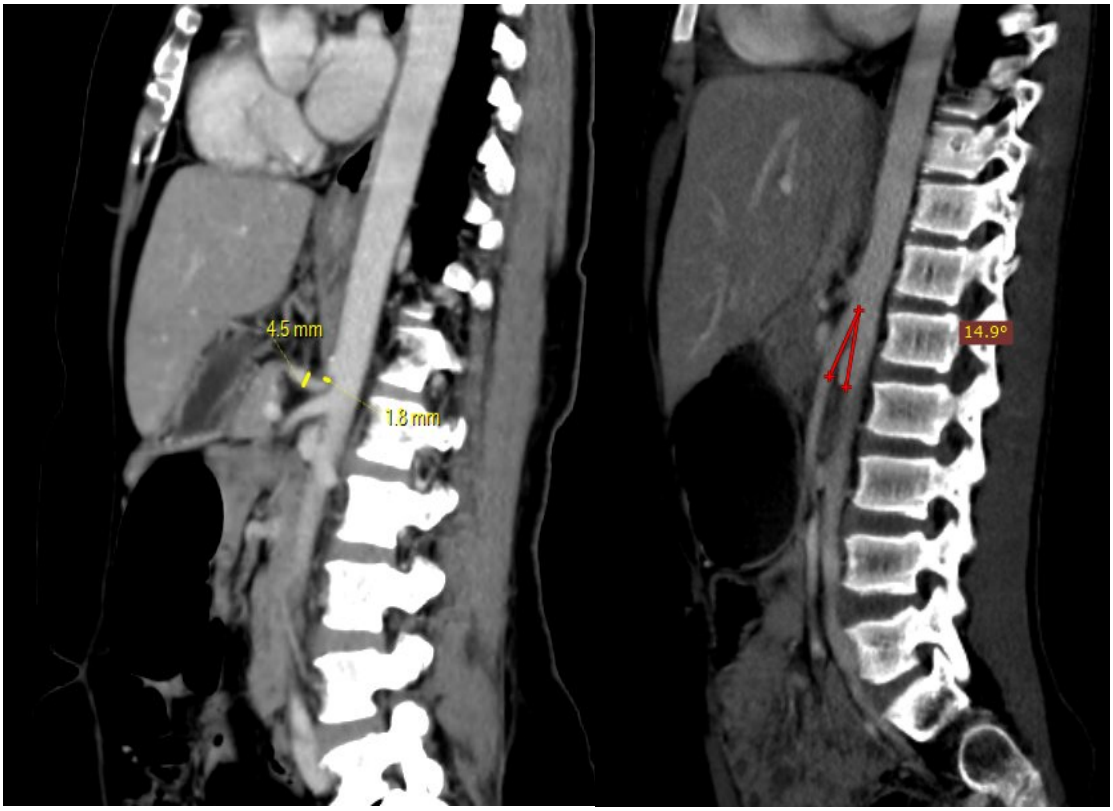
Data was collected using structured questionnaire from Picture Archive Communication System. Patient's image was reviewed for presence ofceliac artery compression, SMA compression of duodenum and left renal vein.

MAL was taken as compressing the celiac artery, if celiac artery had a hooked appearance on sagittal reconstruction images.In image with this finding, the vertebral level at which the MAL crossed the celiac axis origin, post-stenotic dilatation and presence of collaterals were also looked for and recorded.(Fig1.1a)

Sagittal images were obtained for assessment of the branching configuration of the SMA from the aorta. AMD was measured as the maximum distance between the anterior margin of the aorta and the posterior aspect of the superior mesenteric artery at a level where the duodenum was crossing .For angle measurements(AMA), a line was drawn between the root of SMA and an imaginary point on the SMA where SMA begins to descend parallel to the abdominal aorta .Measurements were obtained by electronic calipers. The angles were obtained by manual tracing and the degrees were automatically calculated. AMA <22 degree and AMD of< 8 mm was used for definition of compression in this research.(fig1.1b)

The left renal vein diameter was measured on an axial image closest to the centerline of the vein as it crosses between the aorta and the SMA. On this same axial image, the antero-posterior distance between the aorta and the SMA was measured.Between this axis and the left kidney, the maximal axial diameter of the left renal vein was then measured. The compression ratio was calculated .In this study CR of greater than 3 and those with 2.7-3 with beak angle of greater than 32 degree were included. (fig1.1c)

And each parameter was assessed, measured and a finding was recorded in the questionnaires. The data was entered, after data cleaning for accuracy and Data was analyzed using statistical methods with the help of SPSS version 25 software package.



A B


Fig1.1 representative images from our study

a) A mid sagittal image shows the celiac artery is compressed by median arcuate ligament.

b) A post contrast mid sagittal image showing very acute AMA

c) Post contrast axial abdominal CT at the level of renal vein shows significant compression of left renal vein as it passes between abdominal aorta and SMA.

C

## 4.6 Data quality control

The simplified questionnaire was used and difficult images were re-evaluated by another resident independently and results were obtained by consensus.

## 4.7 Data analysis and interpretation

The data was checked for clarity and completeness. Data was analyzed using statistical methods with the help of SPSS version 25 software package. Then comparison of the data with previous study was done.

## 4.8 Ethical considerations

In order to respect patient's bill of right, regulation of the hospital where the study was conducted, ethical considerations was taken in to account. Any piece of information was kept confidential by keeping anonymity of the study subjects.

## 4.9 Plan of disseminating study finding

After the formal preparation of the final report the copy of the report will be Submitted for evaluation, and possible future publication.

## 5.RESULT

Out of 623 multi detector abdominopelvic CT (MDCT) performed in our institution between January 2019 and April 2019; a total of 513 (N = 513) patients were included in the study out of which 35(6.8%) hadfulfilled imaging features of SMA compression and 33(6.4%) of the patient fulfilled imaging features of nutcracker phenomenon and 22(4.2%) of the patients showed celiac compression by MAL. This study group comprised 277 (54 %) females and 236 male (46%) patients. Mean age of the patients was 38±20 (mean ± standard deviation).

### 5.1 Median arcuate ligament compression of celiac artery

The age range was 11-71 with mean of 47.41 ± 17.67.This study showed slight male predominance with 59.1% (13 males) and 40.9% (9 females). In 19 out of 22patients with celiac axis compression, the origin of the celiac artery was high (above the first lumbar vertebra). In 18 persons, MAL was located below the level of L1, indicating that a low insertion of MAL and normal in 4 patients(but low in relation to celiacorigin in all 22 patients). Only three CT showed poststenotic dilatation of the celiac artery, and none showed significant collaterals.

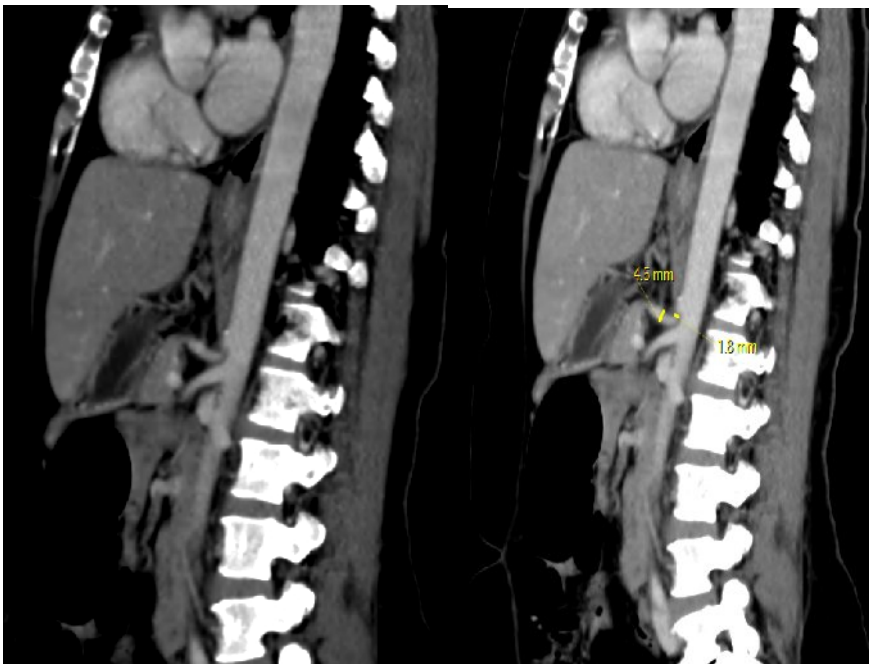



Figure2 -60 year old known cervical ca patient who underwent abdominopelvic CT. This mid sagittal image shows the celiac artery is compressed by median arcuate ligament and it has hooked appearance.

### 5.2 Superior mesenteric artery compression of duodenum

The imaging sign of SMA causing duodenal compression was seen in 27 females and 10 males. The minimum and maximum age was 12 years and 79 years respectively.


Figure 3-12 year old known ALL patient who underwent follow up abdominal pelvic CT.This is a post contrast mid sagittal image showing very acute AMA ($14.9^0$)

| | Mean ± st.dev | Median |
|---|---|---|
| Aorto-mesentric angle | 16.19 ± 2.96 | 17.00 |
| Aorto-mesentric distance | 5.32 ±1.18 | 5.60 |

Table 1.1 Mean, median and range of AMA and AMD in patients with imaging features of SMA compression

| Degree of AMA compression(degree) | Frequency and % | Degree of AMD compression(mm) | Frequency and % |
|---|---|---|---|
| less than 12 | 4(10.8) | less than 4mm | 9(24.3) |

| | | | |
|---|---|---|---|
| 13-15 | 13(35.1) | 4-6 | 21(56.8) |
| 16-18 | 8(21.6) | 6-8 | 7(18.9) |
| 19-22 | 12(32.4) | | |

Table1.2Frequency and percentage of degree of compression AMA and AMD.

## 5.3 Compression of Left renal vein by SMA (Nutcracker phenomenon)

Out of 34 patients who has fulfilled CT signs of nutcracker phenomenon 9 (26.5%) were male and 25(73.5%) were female.

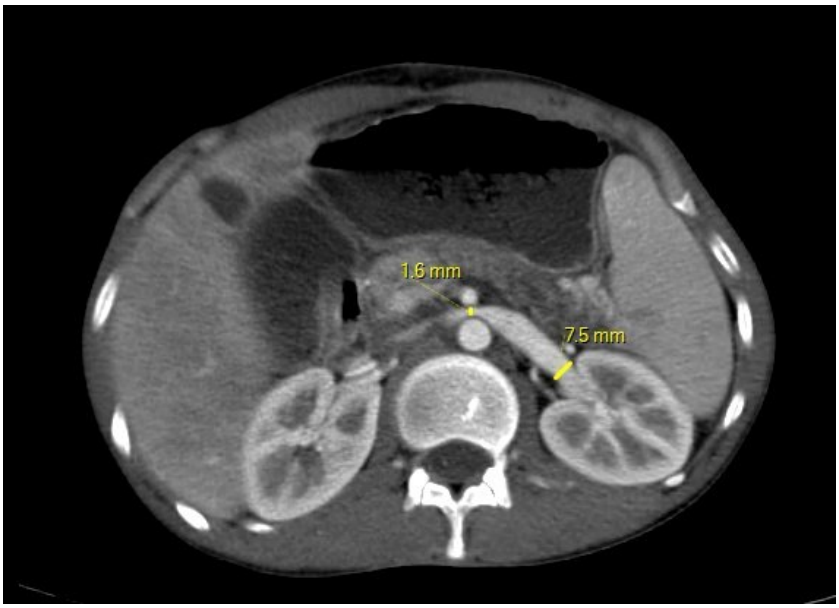



Figure 4-30 year old malepatient presented with left chest painwho underwent abdominal CT as work up for unknown primary. Post contrast axial abdominal CT at the level of renal vein shows significant compression of left renal vein as it passes between abdominal aorta and SMA.

## 6. DISCUSSION

Several methods have been used to look for MAL, such as autopsy studies, conventional angiography, MDCT, ultrasonography with Doppler and magnetic resonance imaging. MDCT can not only show both the artery and the MAL and their relationship with each other, but also identify post-stenotic dilatation of the artery and collateral vessels to help determine hemodynamic significance of the arterial narrowing. Sagittal reconstructions of images to show the characteristic hooked appearance of the artery on a 'lateral' view provides additional confirmation of the finding.

In our study the incidence of celiac artery compression by median arcuate ligament as defined by 50% luminal narrowing and hooked appearance on sagittal image with or without presence of ancillary findings was 4.3%.In 19 out of 22 patients with celiac axis compression, the origin of the celiac artery was high (above the first lumbar vertebra). In 18 persons, MAL was located below the level of L1, indicating that a low insertion of MAL and normal in 4 patients (but low in relation to celiac origin in all 22 patients). Only three CT showed post stenotic dilatation of the celiac artery, and none showed significant collaterals.This shows high origins of celiac artery and low insertion of MAL are risk factors for celiac compression. This finding is in keeping with previous study done by Indian Society of Gastroenterology 2010 which showed celiac artery compression by the MAL in eight (5.1%) of 155 angiograms. In this study all the 8 subjects with celiac axis compression, the origin of the celiac artery was above the first lumbar vertebra. In 6 persons, MAL was located below the level of L1, indicating that a low insertion of MAL was responsible for the compression. Only three angiograms showed poststenotic dilatation of the celiac artery, and none showed significant collaterals Many other previous studies also show that 4–24% of healthy persons have evidence of celiac axis compression by MAL.

Because SMA syndrome occurs relatively infrequently, its exact prevalence in the general population is extremely difficult to measure, although it has been estimated to be 0.1%–0.3% on the basis of gastrointestinal barium studies (7). However, in patients with scoliosis who undergo corrective spinal surgery, a prevalence of up to 2.4% has been reported (8).

Our study showed 35 patients out of 513(6.8%) had CT signs of duodenal compression by SMA which is estimated to be 6.8 %.This could be probably due to most of our patients are very ill who might have lost significant weight which is common risk factor .

Another study showed a slight femalepreponderance (64–66%), with 75% of cases occurring in individuals who range in age from 10 to 39 years [10].Our study also showed comparable sex distribution with female predominance (73%) but with regard to age distribution our study showed two peak ages (third and fifth decades).

The term Nutcracker refers to compression of left renal vein between SMA and abdominal aorta and it is called nutcracker syndrome when symptomatic and nutcracker sign when only imaging feature is present.

The exact prevalence of nutcracker syndrome is unknown, likely because of the variable presenting features [11]. However, it is estimated to be relatively more common in females and usually presents in the 3rd or 4$^{th}$ decade of life [12].our study showed the prevalence of

6.4 % and female preponderance (73.5%) which goes in line with many previous studies. The common age group in our study was 3rd and 5th decades of life.

## 7. CONCLUSION

Incidental SMA Compression of duodenum, MAL compression of celiac artery and left renal vein compression by SMA are not uncommon and syndromic diagnosis should not be made on radiologic diagnosis alone. The SMA compression and nutcracker sign are usually seen together. High origin of celiac artery and low insertion of MAL are the main risk factors for compression of celiac artery which were seen in previous studies as well.

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## 9. ANNEX

### QUESTIONNAIRE

I. ID :( CT Number or MRN) =_____

II. PART ONE: SOCIO DEMOGRAPHIC CHARACTERSTICS

1. SEX=_____
   MALE=1 FEMALE=2

2. AGE(IN YEARS)=_____

III. IMAGING FINDINGS (Definitions and measurements are attached on the next page)

3. Does the patient have imaging features of celiac artery compression by Median arcuate ligament.1.Yes 2.No
4. If yes to question 3 fill parts a-d ;if no jump to question 5
   a) Post stenotic dilatation.
   b) celiac artery–SMA collateral vessels
   c) origin of celiac artery 1.normal 2.High
   d) insertion of MAL 1.Normal 2.low
5. Does the patient have imaging features of duodenal compression by SMA 1.yes 2.No
6. If yes to question 5 fill parts;if no jump to question 7
   a) Aorto-mesentric angle (AMA)=_____degrees
   b) Aorto-mesentric distance(AMD) =_____mm
   c) Dilatation of stomach and duodenum up to mid third part 1.yes 2.No
7. Does the patient have imaging features of left renal vein compression by SMA 1.yes 2.No
8. If yes to question 7 fill the following parts
   a) Compression ratio=_____
   b) AMA=_____
   c) AMD=_____
   d) Beak angle=_____
   e) Enlargement of left gonadal vein or lumbar veins or adrenal vein 1.yes 2.No