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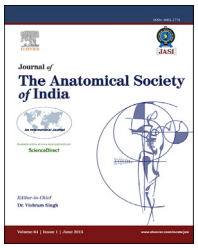

Original Article

Celiacomesenteric trunk and its variants a multidetector row computed tomographic study

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ARTICLE INFO

Article history:
Received 14 December 2014
Accepted 1 April 2015
Available online 25 April 2015

Keywords:
Celiacomesenteric trunk
Hepatosplenomesenteric trunk
Hepatomesenteric trunk
Celiac artery
Superior mesenteric artery

ABSTRACT

Introduction: Celiacomesenteric trunk is a very rare vascular anomaly with a reported incidence of 0.54 %–3.4 % and represents the common trunk of origin of celiac and superior mesenteric arteries. The aim of the present study is to evaluate variations of the celiacomesenteric trunk by multidetector row computed tomography.

Method: We have retrospectively reviewed contrast enhanced computed tomographic scans of 682 patients and found celiacomesenteric trunk and its variants in 19 cases, 9 males and 10 females.

Results: The classical celiacomesenteric trunk, dividing into celiac and superior mesenteric arteries, was observed in 3 cases only. Hepatosplenomesenteric trunk with independent origin of left gastric artery from aorta was noted in 3 cases. In one case hepatomesenteric trunk with independent origin of splenic and left gastric arteries was noted. Nine cases exhibited hepatomesenteric and gastrosplenic trunks. Only in one case, the hepatosplenic and gastromesenteric trunks were seen. Two cases exhibited incomplete type of hepatomesenteric trunk not classified before. The most common celiacomesenteric trunk variant observed in this study is the hepatomesenteric trunk.

Discussion: Any pathology involving this single celiacomesenteric trunk can lead to catastrophic consequences jeopardizing the vascular supply of major abdominal organs. Thorough knowledge of these anatomical variants is of paramount importance to laparoscopic surgeons, interventional radiologists and clinicians alike for proper preprocedural planning to prevent any inadvertent injury to the variant arterial trunks.

1. Introduction

Three ventral branches arising from the abdominal aorta, the celiac artery (CA), the superior mesenteric artery (SMA) and the inferior mesenteric artery (IMA) supply the derivatives of embryonic foregut, midgut and hindgut respectively. The CA arises just below the level of aortic hiatus and divides into three branches, left gastric artery (LGA), splenic artery (SA) and common hepatic artery (CHA). This classical branching

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http://dx.doi.org/10.1016/j.jasi.2015.04.007

pattern of the CA referred to as "tripus Halleri", has been reported to be present variably from as low as 51% to as high as 98.3% of cases.[1,2] Analyzing a combined total of 10750 cases from 19 studies, Matusz et al reported the incidence of complete CA in 90.70% cases and in 9.30% cases variations were noted.[3] Recently after analyzing the data from 36 studies, Panagouli et al reported that complete CA has an incidence of 89.42%.[4] One of the very rare variation involving the CA and SMA is the presence of celiacomesenteric trunk (CMT), representing a common trunk of origin, with an incidence varying from 0.54 % to 3.4 %.[1,5–8] A variant of CMT can be defined as the common trunk of origin of any one or two branches of CA with SMA and the other branch (es) either arising independently or as a common trunk from the aorta. The CMT and its variants may remain asymptomatic, their presence detected fortuitously during cadaveric dissection, autopsy, or accidentally detected during surgery, angiography and other diagnostic procedures.

The CMT may be associated with certain pathological conditions like aneurysm, occlusion and stenosis resulting in severe mesenteric ischemia.[9] Thrombosis of the CMT leading to a lethal effect on the patients because of complete cessation of splanchnic arterial supply and consequent ischemia of supramesocolic organs was also reported.[10,11] Presence of CMT is associated with intrinsic loss of CA-SMA collateral circulation, which is an important safeguard protecting against mesenteric ischemia, thus leaving a large segment of bowel with one dominant vascular feed. Compression of the CMT by the median arcuate ligament of the diaphragm resulting in clinical symptoms like epigastric pain, weight loss has also been reported in the literature.[12,13] The presence of CMT and its variants, especially hepatomesenteric trunk, can cause complications during hepatobiliary and pancreaticoduodenal surgeries.[14] Accurate knowledge of the anatomical variants of CA and SMA is very important to avoid surgical complications. Preoperative knowledge of the variant arterial anatomy may obviate extensive dissection to identify the aberrant vessel and avert vascular injury and help the surgeons to accomplish surgical, oncological and interventional procedures safely and successfully.

We have retrospectively reviewed multidetector row computed tomography (MDCT) angiographic scans of 682 patients to evaluate the presence of celiacomesenteric trunk and its variants. MDCT with its multiplanar ability and precise 3-D reconstruction clearly delineates aberrant vessels and is an effective tool for presurgical evaluation and planning.

2. Materials and methods

The present retrospective study was done at a single imaging centre in Meerut. The study group selected includes 682 patients (355 males and 327 females; age range 8–90 years) who underwent contrast enhanced MDCT angiography for evaluation of hepatobiliary, pancreatic and renal pathologies, malignancies, abdominal pain and other suspected abdominal pathologies. All the scans of the subjects who had undergone previous abdominal surgery or were suffering from any intra abdominal pathology which was likely to distort the anatomy of the region concerned and poorly enhanced scans were excluded from our study. The imaging centre routinely obtains written informed consent from the patients before contrast enhanced scanning and institutional ethical clearance was also obtained.

All 682 patients underwent MDCT angiographic evaluation (GE optima 660, 64 channels) and received 90–100 mL of nonionic contrast (omnipaque) at the rate of 5 mL/s intravenously. Scans were obtained from diaphragm to pubic symphysis and 0.625 mm thick sections were obtained. The scans were analyzed in a workstation (AW volume share 4.5). Volume rendered (VR) and maximum intensity projections (MIP) of axial, sagittal and coronal scans were studied for identifying the variations of celiac and superior mesenteric arteries.

3. Results

In our retrospective analysis of 682 MDCT scans, we found classical CA in 80.35% cases (548/682), variants of CA in 16.86% cases (115/682) and CMT and its variants in 2.78% cases (19/682). Incidence of classical CA and CMT reported by various authors is given in Table 1. The classical CMT dividing into CA and SMA was observed in 0.43% (3/682) cases and CMT

Table 1 – Incidence of classical type CA (Type- I) and CMT (Type- I′) reported by various authors.

Author	Year	Modality	No. of cases	% Of CA (Type- I)	% Of CMT (Type- I′)
Hiatt et al[2]	1994	Surgical	1000	98.3	–
Winston et al[1]	2007	CT Angio.	371	51.0	0.54
Iezzi et al[15]	2008	MDCT	524	72.1	–
Chen et al[16]	2009	Cadaveric	974	89.8	0.7
Malnar et al[17]	2010	Cadaveric	90	92.2	2.2
Ugurel et al[18]	2010	MDCT	100	89.0	–
Song et al[5]	2010	DSA,MDCT,CTA	5002	89.1	1.06
Kornafel et al[19]	2010	MDCT	201	95.5	1.5
Matusz et al[3]	2012	Combined data of 19 studies	10750	90.70	0.68
Sehgal et al[20]	2013	MDCT	70	–	2.85
Surekha et al[6]	2013	MDCT	600	91.0	0.66
Panagouli et al[4]	2013	Combined data of 36 studies	12196	89.42	0.76
Ognjanovic et al[8]	2014	MDCT	150	78.0	3.0
Wang et al[7]	2014	MDCT	1500	89.8	3.4
Present study	2014	MDCT	682	80.35	0.43

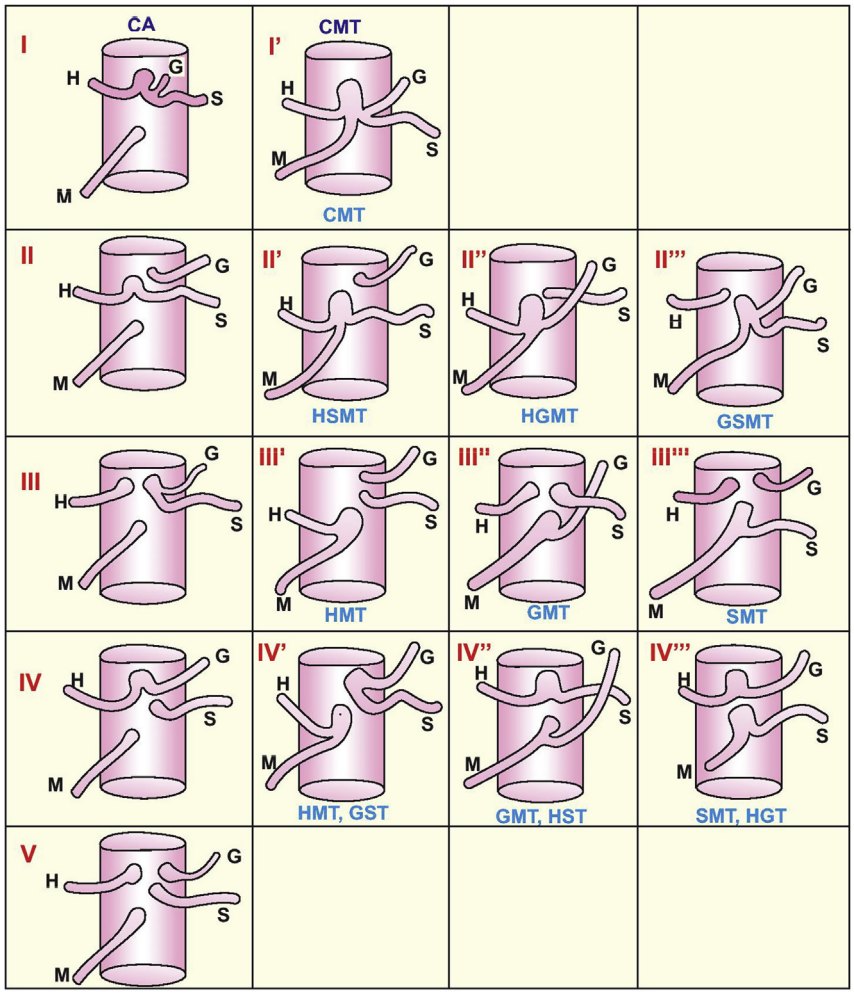

Fig. 1 – Types of celiac artery (CA) and celiacomesenteric trunk (CMT) variants according to Morita's classification (1935).[21]

variants in 2.34% cases (16/682). A number of classification systems were described in the literature and since each author proposes a classification of his own findings, it is natural that all the variations observed till date were not included. Moreover, existence of diverse nomenclatures is confusing and misleading. Therefore, we followed the classification system put forth by Morita who described the CA and CMT variants separately and suggested 5 types and 15forms.[21] (5 types with 5 forms of CA and 4 types with 10 forms of CMT) (Fig. 1; Table 2).

The classical CMT (Morita's Type I′) dividing into CA and SMA was observed only in 3 cases (0.43%; 2 females and 1 male) (Fig. 2A, B, C) and in one case a common inferior phrenic trunk took origin from CA as an additional branch (Fig. 2C). Hepatosplenomesenteric trunk (HSMT) with LGA arising directly from aorta (Morita's Type II′) was noted in 3 cases in our series (0.43%; 2 males, 1 female) (Fig. 3A, B, C) and in one case common inferior phrenic trunk originated with LGA (Gastrophrenic trunk) (Fig. 3C). The most common variant observed in our study is hepatomesenteric trunk (common origin of CHA and SMA) with gastrosplenic trunk (common origin of LGA and SA). This variant (Morita's Type IV′) was present in 9 cases (1.32%; 5 females; 4 males) (Fig. 4A, B). In one male patient the hepatomesenteric trunk was associated with polysplenia heterotaxy syndrome and in a female patient the gastrosplenic trunk gave origin to common inferior phrenic trunk (Fig. 4B). HMT with independent origin of SA and LGA from aorta (Morita's Type III′) was found in only one male patient (0.15%) (Fig. 5A, B). Another very rare variant, gastromesenteric trunk (GMT) and hepatosplenic trunk (HST) (Morita's Type IV″) was found in one male patient (0.15%) (Fig. 6). Two female patients exhibited incomplete HMT, not described in the literature. In one case SMA gave origin to proper hepatic artery with CA giving gastroduodenal, left gastric and splenic arteries (Fig. 7). In another case SMA gave origin only to right hepatic and gastroduodenal arteries and the LGA from gastrosplenic trunk gave rise to a replaced LHA.

4. Discussion

The celiac and superior mesenteric arteries develop from the 10th and 13th metameric ventral splanchnic (vitelline) arteries supplying embryonic gut. According to the scheme proposed by Tandler, initially the vitelline arteries are connected by a ventral longitudinal anastomosis. The celiac

Table 2 – Morita's classification of celiac artery (CA) and celiacomesenteric trunk (CMT) variants.

Type	Name of the trunk	Remark
Celiac artery variants		
Type I	Hepatogastrosplenic trunk. Classical type	Common trunk of origin of LGA, SA and CHA.
Type II	Hepatosplenic trunk	Common trunk of origin of CHA and SA with LGA directly from aorta
Type III	Gastrosplenic trunk	Common trunk of origin of LGA and SA with CHA directly from aorta
Type IV	Hepatogastric trunk	Common trunk of origin of CHA and LGA with SA directly from aorta
Type V	Absent celiac artery	Independent origin of LGA, SA and CHA directly from aorta.
Celiacomesenteric trunk variants		
Type I (Common trunk of all three branches of CA with SMA	Type I′ celiacomesenteric trunk (CMT) Classical type	Common trunk of origin of celiac and superior mesenteric arteries, dividing into CA and SMA. CA further divides into three branches- the left gastric, splenic and common hepatic.
Type II (Common trunk of any two branches of CA with SMA and the third arising directly from aorta)	Type II′ hepatosplenomesenteric trunk (HSMT)	Common origin of CHA, SA and SMA. LGA arise separately from aorta.
	Type II″ hepatogastromesenteric trunk (HGMT)	Common origin of CHA, LGA and SMA. Independent origin of SA from aorta.
	Type II‴ gastrosplenomesenteric trunk (GSMT)	Common origin of LGA, SA and SMA. Independent origin of CHA from aorta.
Type III (Common trunk of any one branch of CA with SMA and other two branches having independent aortic origin)	Type III′ Hepatomesenteric trunk (HMT)	Common origin of CHA and SMA. Independent origin of LGA and SA from aorta.
	Type III″ gastromesenteric trunk (GMT)	Common origin of LGA and SMA. Independent origin of CHA and SA from aorta.
	Type III‴ splenomesenteric trunk (SMT)	Common origin of SA and SMA. Independent origin of CHA and LGA from aorta.
Type IV (Common trunk of any one branch of CA with SMA and other two branches having common origin from aorta)	Type IV′ hepatomesenteric trunk (HMT) and gastrosplenic trunk (GST)	Common origin of CHA and SMA from aorta; Common origin of LGA and SA from aorta.
	Type IV″ gastromesenteric trunk (GMT) and hepatosplenic trunk (HST)	Common origin of LGA and SMA from aorta; Common origin of CHA and SA from aorta.
	Type IV‴ splenomesenteric trunk (SMT) and hepatogastric trunk (HGT)	Common origin of SA and SMA from aorta; Common origin of CHA and LGA from aorta.

artery and its three branches and the superior mesenteric artery develop from the 10th to 13th vitelline arteries. Normally the roots of origin of 11th and 12th vitelline arteries from the dorsal aorta disappear, while the 10th root along with longitudinal anastomosis give rise to celiac artery and its three branches. After the disappearance of longitudinal anastomosis between 12th and 13th vitelline arteries, the superior mesenteric artery develops from the 13th vitelline artery. Anomalies of the CA and SMA can occur due to persistence of the ventral longitudinal anastomosis and

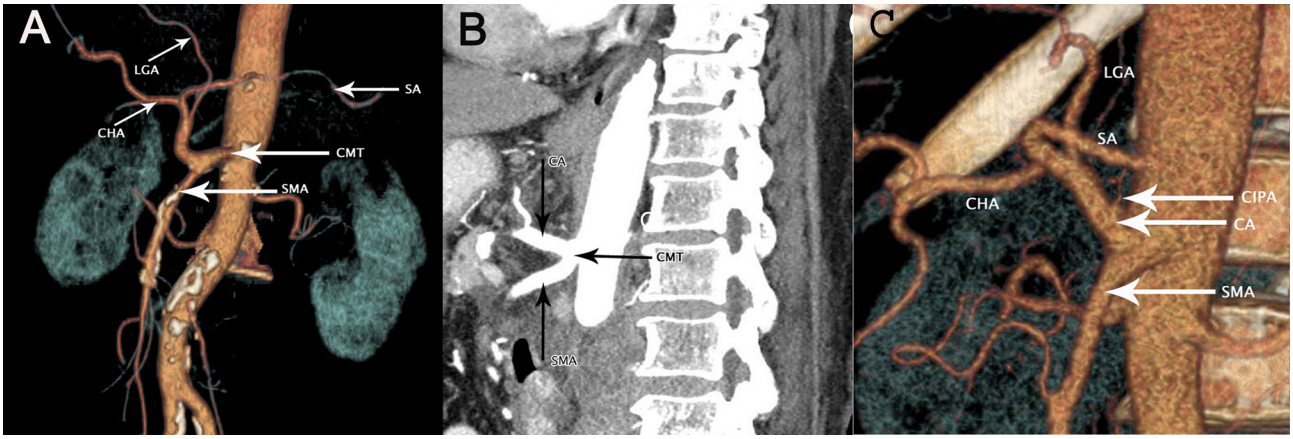

Fig. 2 – Showing Morita's Type I′ classical celiacomesenteric trunk (CMT). A: VR image of a 55 year old female showing CMT dividing into celiac artery (CA) and superior mesenteric artery (SMA) and CA further dividing into Left gastric (LGA), splenic (SA) and common hepatic (CHA) arteries. B: Sagittal MIP image of a 65 year old female showing classical CMT. C: VR image of a 55 year old male showing CMT dividing into CA and SMA. The CA is giving origin first to a common inferior phrenic trunk (CIPA) and then divides into LGA, SA and CHA.

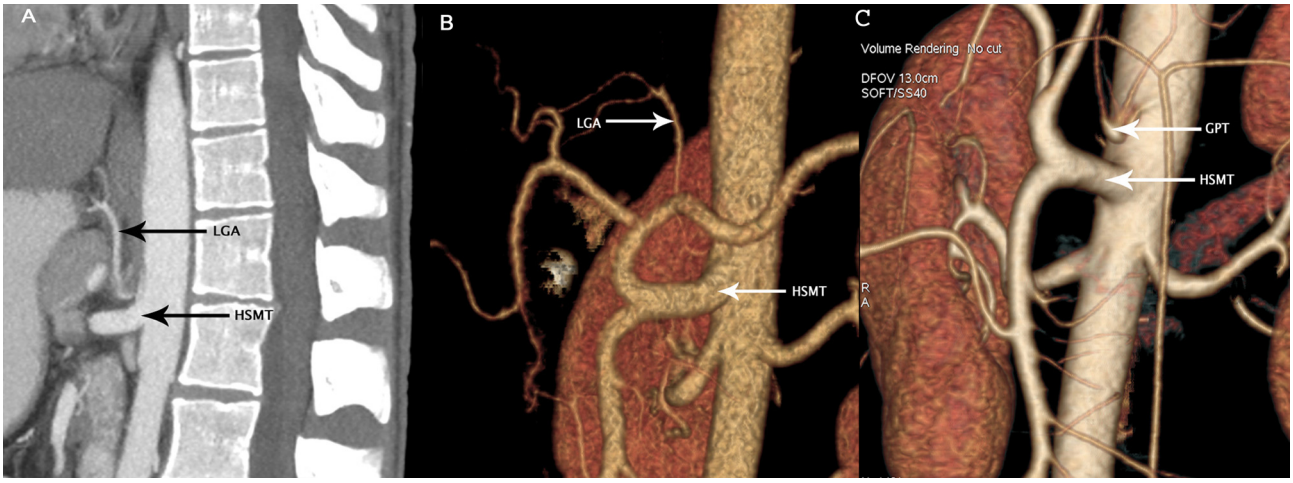

Fig. 3 – A, B: showing Morita's Type II′ variant, the hepatosplenomesenteric trunk (HSMT). Sagittal MIP and VR images of a 52 year old male showing HSMT with independent origin of left gastric (LGA) from aorta. HSMT divides into Superior mesenteric (SMA) and hepatosplenic trunk which further divides into splenic and common hepatic arteries. C: VR image of a 56 year old female showing HSMT and gastrophrenic trunk (GPT) arising from aorta. The GPT gives rise to LGA and common inferior phrenic trunk.

regression of some of the roots of vitelline arteries. Embryologically therefore, the occurrence of CMT can be explained by the regression of the 10th root and persistence of ventral anastomosis between 12th and 13th roots (Fig. 8).

Due to the complex development of CA and SMA, variations of their branching pattern are innumerable and Michels observed that "no two arterial vascularization patterns of any of the organs above the transverse colon are ever the same".[22] To simplify the understanding of these vascular variants of CA, SMA and hepatic arteries, many authors have proposed and adopted different classification systems. Since there is no universally accepted classification system, we have followed Morita's classification[21] which identifies celiac artery variants and celiacomesenteric trunk variants separately (Table 2).

We have observed CMT and its variants as described in the literature only in 17 cases. In 2 cases we have noted incomplete type of hepatomesenteric trunk not described before (Table 3). The classical CMT (Morita's Type I′) was observed only in 3 cases (0.43%). In one case CA arising from CMT gave rise to common inferior phrenic trunk as an additional branch (Fig. 2C). After analyzing a total of 10750 cases from 19 studies, Matusz et al reported that complete CMT was noted in 0.68% cases and incomplete CMT in 1.75% cases.[3] Panagouli et al reported that CMT has an incidence of 0.76% (93/12196 cases from 36 studies).[4] The incidence of CMT reported by other workers are given in Table 1. Yilmaz et al[23] and Anupama et al[24] reported the presence of classical CMT in cadavers and Rountas et al[25] demonstrated its presence in two cases by

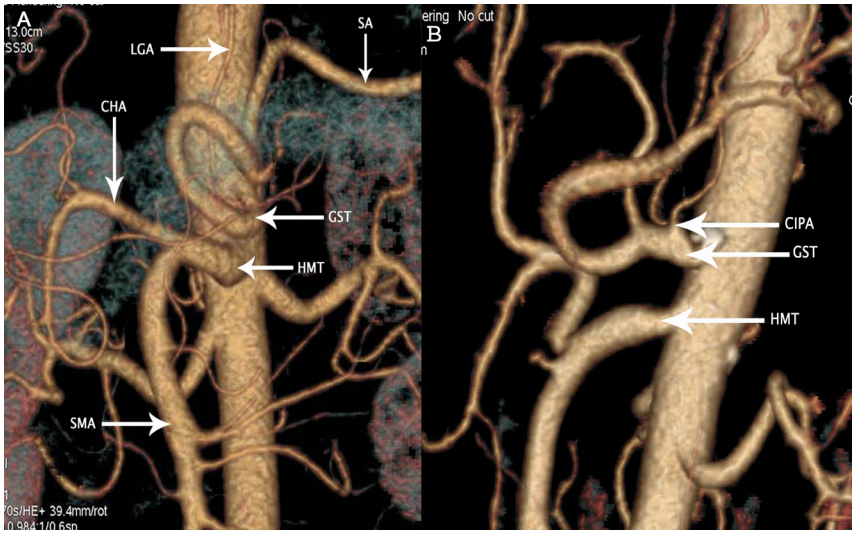

Fig. 4 – A- VR images of a 50 year old female showing Morita's Type IV ' variant, the hepatomesenteric trunk (HMT) and the gastrosplenic trunk (GST). HMT gives rise to SMA and CHA and GST divides into LGA and SA. B- VR image of a 46 year old female showing HMT and GST. A common inferior phrenic trunk (CIPA) arises from the GST.

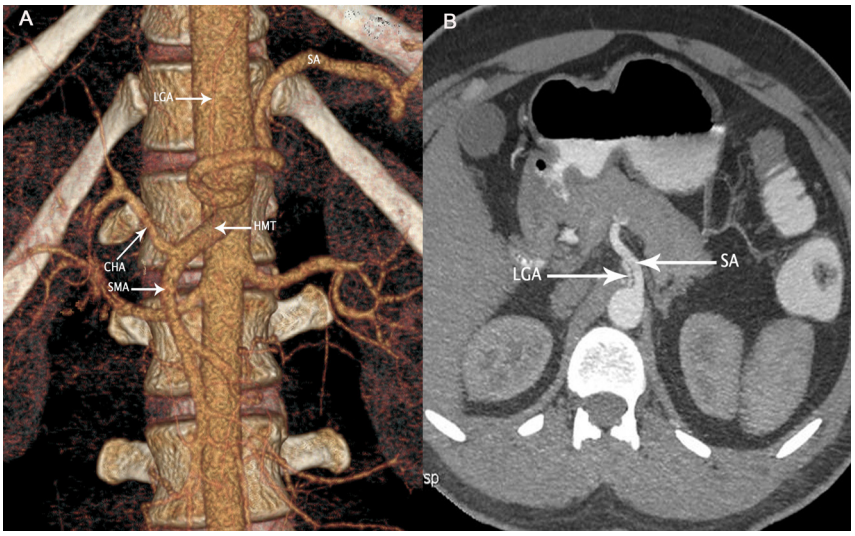

Fig. 5 – A, B: VR and axial MIP images showing Morita's Type III′ variant with HMT and independent aortic origin of LGA and SA. The HMT divides into SMA and CHA. Axial MIP image clearly show independent origin of LGA and SA from aorta.

MDCT angiography. Origin of right or left inferior phrenic or common inferior phrenic trunk as an additional branch from celiac artery arising from CMT was reported by Bhatnagar et al.[26] Sridhar Verma et al[27] reported the initial division of CMT into gastrosplenic and hepatomesenteric trunks and Kara et al[28] reported that the CMT after giving origin to CHA and SA continued as the gastromesenteric trunk which then split into LGA and SMA. It is observed that there is a male preponderance in the occurrence of CMT in the published case reports.

Morita's Type II′ variant (Hepatosplenomesenteric trunk and LGA) was noted in 3 cases only (0.43%). The incidence of HSMT as reported in the literature varies from 0.16% to 1.0%.[5,6,18] Presence of HSMT, incidentally found during cadaveric dissection, has been reported.[29–31] Johnson et al[32] and Hiremath et al[33] found HSMT during CT angiographic evaluation, though Johnson et al described this variant as celiacomesenteric trunk in their report. Loukas et al[34] described a splenomesenteric trunk in a female cadaver which divided into SMA and splenic artery. The splenic artery following a looped course

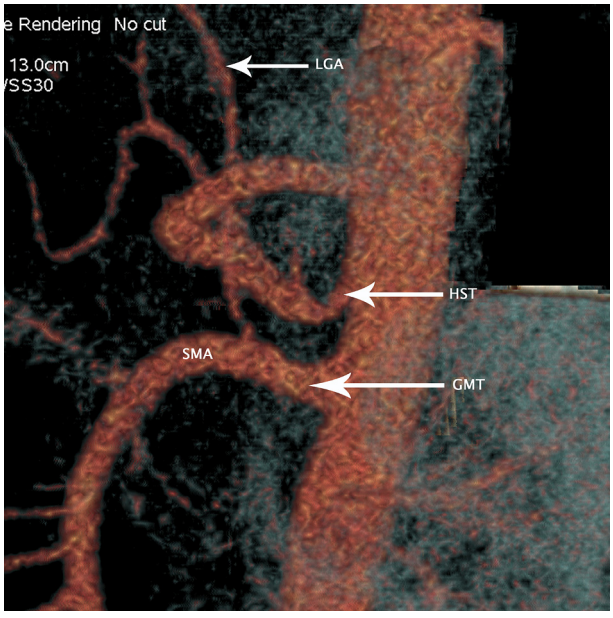

Fig. 6 – VR image of a 31 year old male showing Morita's Type IV″ variant, the Gastromesenteric trunk (GMT) and hepatosplenic trunk (HST). GMT divides into LGA and SMA. HST gives rise to SA and CHA.

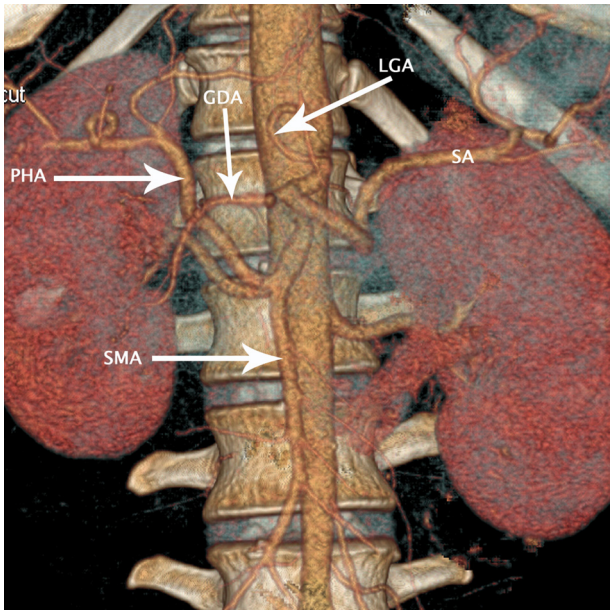

Fig. 7 – VR image of a 40 year old female showing an incomplete HMT giving rise to SMA and proper hepatic artery (PHA). The celiac artery is dividing into LGA, SA and gastroduodenal arteries (GDA). In this case a retroaortic left renal vein was also observed.

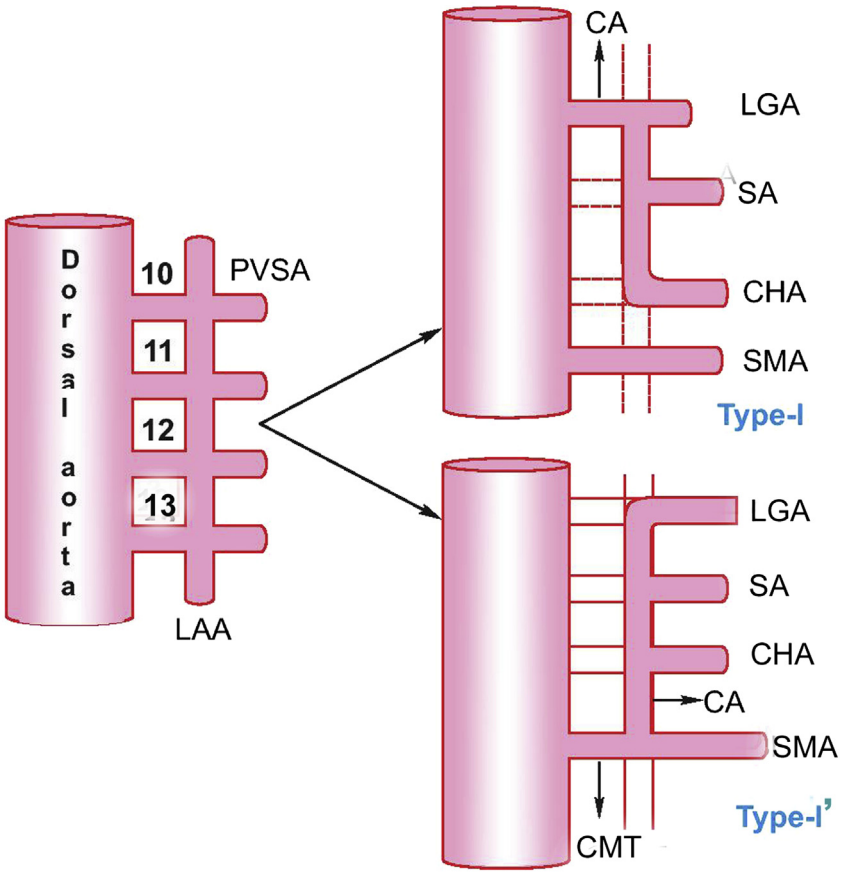

Fig. 8 – Development of CA and CMT as proposed by Tandler. Normally CA develops from the 10th root and the longitudinal anastomosis and regression of longitudinal anastomosis between 12th and 13th roots. SMA develops from 13th root. CMT develops when the 10th root regresses and longitudinal anastomosis between 12th and 13th roots persists. PVSA- Primitive Ventral Splanchnic Arteries; LAA- Longitudinal Arterial Anastomosis.

near the hepatobiliary triangle gave origin to CHA. Though the authors did not specify the origin of LGA, in reality the trunk described by them should have been named as HSMT.

The most common variant observed in our study is hepatomesenteric trunk (common origin of CHA and SMA) with gastrosplenic trunk (common origin of LGA and SA). This variant (Morita's Type IV′) was present in 9 cases (1.32%; 5 females; 4 males). The incidence of HMT as reported in the literature vary from 0.4 % to 4.47 %.[5–7] Origin of inferior phrenic arteries, either separately or as a common trunk, from

Table 3 – Summary of celiacomesenteric trunk variants observed in the study.

Sl.no	Description of variant	Type (Morita's classification)	Number of cases	Remarks
1	Celiacomesenteric trunk (classically divides into CA and SMA)	Type I′	3 (F = 2; M = 1)	In one case CMT gave an additional branch- common trunk of inferior phrenic arteries.
2	Hepatosplenomesenteric trunk (LGA from aorta)	Type II′	3 (F=1; M = 2)	In one case LGA gave common Inferior phrenic trunk.
3	Hepatomesenteric trunk (Independent origin of LGA and SA from aorta)	Type III′	1 (M = 1)	
4	Hepatomesenteric trunk (Gastrosplenic trunk- common origin of LGA and SA from aorta)	Type IV′	9 (F = 5; M = 4)	In one case GST gave common inferior phrenic trunk. In another case HMT was seen in a patient of polysplenia heterotaxy syndrome.
5	Gastromesenteric trunk (Hepatosplenic trunk from aorta)	Type IV″	1 (M = 1)	
6	Incomplete HMT- Proper hepatic artery from SMA (celiac artery gives rise to LGA, SA and GDA); RHA & GDA from SMA (LGA gave rise to replaced LHA)	Not described	2 (F = 2)	

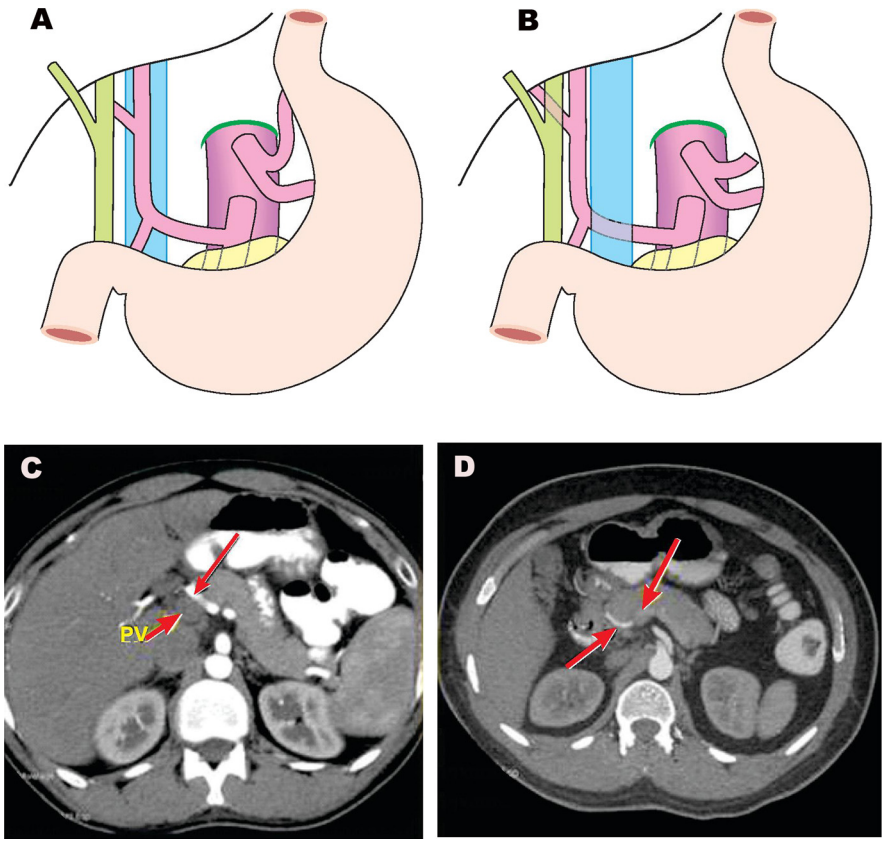

Fig. 9 – Variable relationship of CHA arising from SMA with portal vein. A: CHA having preportal course (Adachi Type V). B: CHA having retroportal course (Adachi Type VI). C: Axial MIP image Long arrow shows retropancreatic and preportal CHA (Adachi Type V) Short arrow shows portal vein (PV). D: Axial MIP image. Short arrow shows retropancreatic and retroportal CHA (Adachi Type VI). Long arrow shows portal vein.

the gastrosplenic trunk was also reported.[35,36] Adachi has classified the CHA originating from SMA passing ventral to portal vein as Type V and dorsal to portal vein as Type VI.[37] Based only on the hepatic arterial pattern Michels[22] and Hiatt[2] classified the CHA origin from SMA as Type IX and Type V respectively and these authors did not take the mode of origin of LGA and SA into consideration. Discussing the significance of presurgical evaluation of such arterial aberrations in extended pancreatic resections, Egorov et al found an incidence of 2.6% by CT angiography and 5.1% by operative data for CHA origin from SMA.[38]

The presence of CMT variants, especially the CHA arising from SMA and its variable relationship with pancreas and portal vein, is very important for hepatobiliary and pancreaticoduodenal surgeries. Song et al[5] described the variable course of CHA in relation to pancreas as suprapancreatic (along upper border of head of pancreas), infrapancreatic (inferior to head and uncinate process), retropancreatic (posterior to head of pancreas) and transpancreatic (through pancreatic parenchyma). Presence of transpancreatic CHA complicating pacreaticoduodenal surgery has been reported.[17] CHA arising from SMA can have a preportal (Adachi Type V) or retroportal course (Adachi Type VI) (Fig. 9A, B). Out of 9 cases of HMT observed in the present study, retropancreatic preportal CHA was observed in 3 cases and retropancreatic retroportal CHA in 6 cases (Fig. 9C, D).

HMT with independent origin of SA and LGA from aorta (Morita's Type III′) was found only in one male patient (0.15%) (Fig. 5A, B). Similar such variant was reported by Saga et al in a female cadaver.[39] Recently Iacob et al reported what they claimed to be the first case report with this variant (Morita's Type III′) using MDCT angiography.[40] The incidence of this variant reported in the literature using radiological procedures varies from 0.24% (12/5002 cases)[5] to 0.33% (2/600 cases).[6] Another very rare variant, gastromesenteric trunk (GMT) and hepatosplenic trunk (HST) was found in one male patient (0.15%) (Fig. 6). Two female patients exhibited incomplete HMT, not described in the literature. In one case SMA gave origin to proper hepatic artery with CA giving gastroduodenal, left gastric and splenic arteries (Fig. 7). In another case SMA gave origin only to right hepatic and gastroduodenal arteries and the LGA from gastrosplenic trunk gave rise to a replaced LHA.

5. Conclusion

Accurate knowledge of the anatomical variations of the CA and SMA will help to avoid complications in abdominal surgeries and successful accomplishment of surgical, oncological or interventional procedures. The all important factor in the management of vascular anomalies is its recognition to

prevent any inadvertent injury. Forewarning in the form of clues provided by preoperative imaging can help better preparation and planning, decreasing the chances of intraoperative vascular injury and potentially help in avoiding postoperative complications. It is desirable that when a CMT variant is observed the associated variation of the CA should also be noted to avoid any ambiguity and the surgically important relations of the CMT variant with pancreas and portal vein should also be emphasized. Better delineation of aberrant vessel and its relationship with the surrounding structures and organs can be easily achieved by MDCT angiography.

Conflicts of interest

All authors have none to declare.

Acknowledgement

Authors thankfully acknowledge the help rendered by Mr. Arjun Singh, Radiology Assistant of Dr. O.P. Gupta Imaging Center, Meerut and Mr. Chandra Prakash, Mr. Sushil Kumar and Mr. Titendher of Muzaffarnagar Medical College, Muzaffarnagar, in the preparation of images and figures.

REFERENCES

1. Winston CB, Lee NA, Jarnagin WR, et al. CT angiography for delineation of celiac and superior mesenteric artery variants in patients undergoing hepatobiliary and pancreatic surgery. *AJR*. 2007;188:w13–w19.
2. Hiatt JR, Gabbay J, Busuttil RW. Surgical anatomy of the hepatic arteries in 1000 cases. *Ann Surg*. 1994;220:50–52.
3. Matusz P, Miclaus GD, Ples H, et al. Absence of the celiac trunk: case report using MDCT angiography. *Surg Radiol Anat*. 2012;34:959–963.
4. Panagouli E, Venieratos D, Lolis E, Skandalakis P. Variations in the anatomy of the celiac trunk: a systematic review and clinical implications. *Ann Anat*. 2013;195:501–511.
5. Song SY, Chung JW, Yin YH, et al. Celiac axis and common hepatic artery variations in 5002 patients. Systematic analysis with spiral CT and DSA. *Radiology*. 2010;255:278–288.
6. Sureka B, Mittal MK, Mittal A, et al. Variations of the celiac axis, common hepatic artery and its branches in 600 patients. *Indian J Radiol Imag*. 2013;23:223–233.
7. Wang Y, Cheng C, Wang L, et al. Anatomical variations in the origins of the celiac axis and the superior mesenteric artery: MDCT angiographic findings and their probable embryological mechanisms. *Eur Radiol*. 2014;24:1777–1784.
8. Ognjanovic N, Jeremic D, Zivanovic-Macuzic I, et al. MDCT angiography of anatomical variations of the celiac trunk and superior mesenteric artery. *Arch Biol Sci Belgr*. 2014;66:233–240.
9. Addicott B, Nguyen M, Pedro P. Common celiacomesenteric trunk presenting with mesenteric ischemia: 2 case reports with a review of literature. *J Hosp Med*. 2013;8(suppl 1):915.
10. Lagoutte N, Facy O, Guin B, et al. Celiacomesenteric trunk: a variation that must be known before aortic surgery. *Clin Pract*. 2011;1:e 69.
11. Lovisetto F, De Lorenzi GF, Stancampiano P, et al. Thrombosis of celiacomesenteric trunk: report of a case. *World J Gastroenterol*. 2012;18:3917–3920.
12. Lee V, Alvarez MD, Bhatt S, Dogra VS. Median arcuate ligament compression of the celiacomesenteric trunk. *J Clin Imaging Sci*. 2011;1:8.
13. Chaiwatcharayut W, Lekah A, Kurklinsky A. Celiacomesenteric trunk as a cause of median arcuate ligament syndrome. *J Med Ultrasound*. 2013;21:39–42.
14. Rammohan A, Sathyanesan J, Palaniappan R, Govindan M. Transpancreatic hepatomeseneteric trunk complicating pancreaticoduodenectomy. *J Pancreas (online)*. 2013;14:649–652.
15. Iezzi R, Cotronco RA, Giancristofaro D, et al. Multidetector-row CT angiographic imaging of the celiac trunk: anatomy and normal variants. *Surg Radiol Anat*. 2008;30:303–310.
16. Chen H, Yano R, Emura S, Shoumura S. Anatomical variation of the celiac trunk with special reference to hepatic artery patterns. *Ann Anat*. 2009;191:399–407.
17. Malnar D, Klasan GS, Miletic D, et al. Properties of the celiac trunk- anatomical study. *Coll Antropol*. 2010;34:917–921.
18. Ugurel MS, Battal B, Bozlar U, et al. Anatomical variations of hepatic arterial system, celiac trunk and renal arteries: an analysis with multidetector CT angiography. *Br J Radiol*. 2010;83:661–667.
19. Kornafel O, Baran B, Pawlikowska I, et al. Analysis of anatomical variations of the main arteries branching from the abdominal aorta with 64-detector computed tomography. *Pol J Radiol*. 2010;75:38–45.
20. Sehgal G, Srivastava AK, Sharma PK, et al. Celiacomesenteric trunk: an unusual variation. *J Anat Sci*. 2013;21:1–6.
21. Morita M. Reports and conception of three anomalous cases in the area of the celiac and superior mesenteric arteries. *Igaku Kenkyu*. 1935;9:1993–2006 [in Japanese].
22. Michels NA-. *Blood Supply and Anatomy of the Upper Abdominal Organs with a Descriptive Atlas*. Philadelphia, PA: Lippincott; 1955.
23. Yilmaz MT, Tezer M, Cicekcibaci AE, et al. A case report of celiaco-mesenteric trunk. *Biomed Res*. 2013;24:150–152.
24. Anupama D, Lakshmi Prabha, Subhash R. Celiacomesenteric trunk- A case report. *IOSR J Pharm Biol Sci (IOSR-JPBS)*. 2013;6:28–29.
25. Rountas Ch, Fanariotis M, Vlychou M, et al. Celiacomesenteric trunk demonstrated by multidetector computed tomography angiography: two cases of rare vascular variation. *Folia Morphol*. 2013;72:171–175.
26. Bhatnagar S, Rajesh S, Jain VK, et al. Celiacomesenteric trunk: a short report. *Surg Radiol Anat*. 2013;35:979–981.
27. Sridhar Varma K, Pamidi N, Vollala VR. Common celiacomesenteric trunk: a rare anatomic variation. *J Vasc Bras*. 2009;8:271–273.
28. Kara E, Celebi B, Yildiz A, et al. An unusual case of a tortuous abdominal aorta with a common celiacomesenteric trunk: demonstrated by angiography. *Clinics*. 2011;66:169–171.
29. Hirai Y, Yamaki KI, Saga T, et al. An anomalous case of the hepatospleno-mesenteric and the gastro-phrenic trunks independently arising from the abdominal aorta. *Kurume Med J*. 2000;47:189–192.
30. Samarawickrama MB. Hepatospleno-mesenteric trunk: a rare variation of the celiac trunk. *Galle Med J*. 2010;15:39–41.
31. Hemant K, Garg S, Yadav TD, Sahni D. Hepato-gastro-phrenic and hepato-spleno-mesenteric trunk: a rare anatomical variation. *Trop Gastroenterol*. 2011;32:56–59.
32. Johnson PB, Cawich SO, Shah S, et al. Vascular supply to liver. A report of a rare arterial variant. *Case Reports Radiology*; 2013. Article ID: 969327 http://dx.doi.org/10.1155/2013/969327.
33. Hiremath R, Aishwarya KC, Pailoor A, Bhatt R. CT angiographic diagnosis of hepatosplenomesenteric trunk – a rare variation. *IJAV*. 2014;7:37–39.

34. Loukas M, Shah R, Tubbs S, Merbs W. Multiple variations of the hepato-biliary vasculature including a splenomesenteric trunk. *Singap Med J*. 2010;51:e6–e8.
35. Hirai Y, Yamaki KI, Saga T, et al. Two anomalous cases of the hepato-mesenteric and the gastro-splenic trunks independently arising from the abdominal aorta. *Kurume Med J*. 2000;47:249–252.
36. Nayak SB. Hepatomesenteric trunk and gastro-splenico-phrenic trunk. *IJAV*. 2008;1:2–3.
37. Adachi B. *Das Arteriensystem der Japaner*. **2. Verlag der Kaiserlich-Japanischen Universitat zu Kyoto; 1999:18–71.**
38. Egorov VI, Yashina NI, Fedorov AV, et al. Celiaco-mesenterial arterial aberrations in patients undergoing extended pancreatic resections: correlation of CT angiography with findings at surgery. *JOP. J Pancreas (on line)*. 2010;11:348–357.
39. Saga T, Hirao T, Kitashima S, et al. An anomalous case of left gastric artery, splenic artery and hepato-mesenteric trunk independently arising from the abdominal aorta. *Kurume Med J*. 2005;52:49–52.

FURTHER READING

40. Iacob N, Pureca A, Belic O, Matusz P-A. Hepatomesenteric trunk, in association with left gastric and splenic arteries arising independently from the abdominal aorta: a case report using MDCT angiography. *J Anat Soc India*. 2014;63:179–182.