Variations of the celiac trunk and hepatic arteries: a study with 64-detector computed tomographic angiography

H. GÜMÜS, Y. BÜKTE, E. ÖZDEMIR*, S. SENTÜRK, G. TEKBAS, H. ÖNDER, F. EKICI, A. BILICI

Department of Radiology, Medical School, Dicle University, Diyarbakir, Turkey
*Department of Radiology, Mardin State Hospital, Mardin, Turkey

Abstract. – OBJECTIVES: The aim of the present study was to evaluate variations in celiac trunk and hepatic artery with multi-detector computed tomography (MDCT).

PATIENTS AND METHODS: Totally 820 patients who underwent angiography of the abdominal aorta were evaluated. Anatomical findings were grouped according to the Michels classification.

RESULTS: Several variations and/or anomalies were noted in 33.2% of the patients (n=272). The most common abnormality was Michels type III (10.1%), followed by type V (7.3%), type II (4.7%) and others. Type X was not observed in our series. We have noted additional, previously unclassified variations in 12 cases (1.5%).

CONCLUSIONS: Preoperative knowledge of variant anatomy may assist in the selection of treatment options and surgical planning, which in turn facilitates surgical dissection and helps avoiding iatrogenic injury. MDCT angiography allows detailed visualization of the vascular anatomy.

Key Words:
CT angiography, Celiac trunk, Hepatic artery, Arterial anomalies.

Introduction

Multiple configurations of the origin and branching pattern of abdominal aortic visceral arterial branches occur commonly[1]. Knowledge of the vascular system variants is important for surgical planning or interventional procedures. Celiac trunk and hepatic artery variants are especially important for liver transplantation and hepatic arterial infusion chemotherapy[2-4]. Main purpose of preoperative imaging is to obtain the road map of vascular arterial and venous structures. Despite the advances in hepatic surgery techniques, particularly in terms of microvascular reconstruction, vascular complications still play an important role in morbidity and mortality. Evaluation before transplantation is performed by multi-detector computed tomographic angiography (CTA) rather than by conventional angiography[5-8]. Non-invasive CTA is well correlated with conventional catheter angiography and successfully demonstrates even the slightest variations[2,6]. Multi-detector row scanners are particularly beneficial for angiographic applications due to their features of better complete anatomic coverage, contrast enhancement of the arteries, and longitudinal spatial resolution[9,10]. The capability of computed tomography (CT) in providing precise and high-definition vascular details noninvasively has further improved with the multi-detector CT (MDCT) technology[11]. MDCT angiography can provide the surgeon with necessary preoperative vascular data for surgical planning[2,9]. The aim of the present study was to evaluate variations in celiac trunk and hepatic artery by MDCT.

Patients and Methods

A total of 842 patients who underwent abdominal MDCT angiography of the abdominal aorta in our Department between 2007 and 2010 were consecutively enrolled in the study. Those patients with pathological conditions likely to affect normal vascular anatomy as well as CT scans which were technically inadequate were excluded (n=22). This study was approved by the institutional Ethics Committee, and informed consents were obtained from all patients.

CT angiography was performed with Philips Brilliance CT scanner (Philips Medical Systems,

Corresponding Author: Hatice Gümüş, MD; e-mail: drhaticegumus@hotmail.com

Cleveland, OH, USA). Scanning was performed using the following parameters: detector rows, 64; collimation, 0.625 mm; pitch, 0.92; gantry rotation time, 0.75 s; slice thickness 0.90 mm, slice increment, 0.45 mm; 250 mAs and 120 kV dose. A volume of 100 mL of non-ionic contrast medium was injected at 4.0 mL/s through an antecubital vein with an automatic power injector. Images were obtained from the level of the dome of the diaphragm to the pelvis. CTA studies reviewed on a workstation with interactive multiplanar manipulation of the images including multiplanar reformations (MPR), thin and/or oblique maximum intensity projections MIPs. Afterwards, axial, MIPs and volume-rendered images were produced from axial image data. Both the axial and reformatted images were assessed by a radiologist.

Different types of normal anatomy or anatomic variants of hepatic artery were described according to the Michels classification[12] (Table I).

Results

Out of 820 patients included in the study, normal anatomy (Michels type I) (Figure 1) was observed in 66.8% (n=548) and several variations and/or anomalies were noted in 33.2% (n=272) as illustrated in Table II. The anomalies consisted of Michels type II in 39 cases (4.7%) (Figure 2), type III in 83 (10.1%) (Figure 3), type IV in 6 (0.7%) (Figure 4), type V (Figure 5) in 60 (7.3%), type VI (Figure 6) in 28 (3.4%), type VII (Figure 7) in 10 (1.21%), type VIII (Figure 8) in 19 (2.3%), and type IX (Figure 9) in 15 cases (1.8%). No type X was observed in our series. We have noted additional, previously unclassified variations in 12 cases (1.5%).

Table I. Michels classification of hepatic arterial anomalies (I-X).

Type	Description
I	Hepatic artery originates from the CHA and bifurcates into the RHA and LHA
II	Replaced LHA arising from LGA
III	Replaced RHA arising from SMA
IV	Replaced RHA and LHA arising from LGA
V	Accessory LHA arising from LGA
VI	Accessory RHA arising from SMA
VII	Accessory RHA arising from SMA and accessory LHA arising from LGA
VIII	Replaced RHA and accessory LHAor Replaced LHA and accessory RHA
IX	The CHA arising from SMA
X	The CHA arising from LGA
XI	For any variant not described for type I-X

CHA: common hepatic artery; RHA: right hepatic artery; LHA: left hepatic artery; LGA: left gastric artery; SMA: superior mesenteric artery.

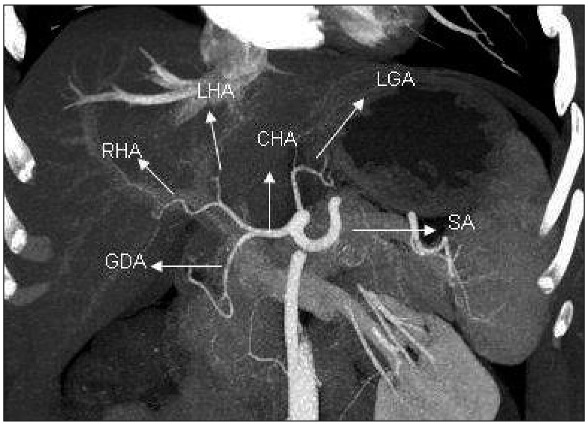

Figure 1. Maximum intensity projection image on coronal plane. Michel's classification type I hepatic artery anatomy. Celiac artery and its branches (SA; splenic artery, LGA; left gastric artery and CHA; common hepatic artery) are visible. CHA branches into the gastroduodenal artery (GDA), right hepatic artery (RHA), and left hepatic artery (LHA).

The trifurcation of the celiac trunk (hepato-spleno-gastric trunk) into its usual three branches, the left gastric artery, the common hepatic artery and the splenic artery, was observed in 752 patients of our series (91.7%).

The variation, in which the common trunk ends dividing (hepato-splenic trunk) into the common hepatic and splenic arteries, and the left gastric artery arises from the aorta, was observed in 18 patients (2.1%).

The variation, in which the common trunk ends dividing (spleno-gastric trunk) into a common artery from which the splenic and left gastric arteries originate, and the common hepatic artery arises from the aorta or the superior mesenteric artery, was observed in 21 patients (2.6%). The variation, in which the common hepatic and left gastric arteries originates from the common trunk (hepato-gastric trunk), and the splenic artery originates from the aorta or the superior mesenteric artery, was not observed in our series.

Absent celiac trunk was observed in 2 patients (0.24%).

Table II. Comparison of hepatic artery variants between our study and previous computed tomographic angiography (CTA) and digital subtraction angiography (DSA) studies.

	Our study	De Cecco et al.[15]	Coskun et al.[2]	Stemmler et al.[14]	Koops et al.[3]	Covey et al.[13]
Sample size (n)	820	250	48	63	604	600
Imaging	64 row	64 row	16 row	4/8 row	DSA	DSA
Type (%)						
I	66.8	66	54.1	80.9	79.1	61.3
II	4.7	5.2	0	0	2.5	3.8
III	10.1	9.2	6.3	6.3	8.6	8.7
IV	0.7	2.0	0	0	1.0	0.5
V	7.3	5.2	16.6	7.9	0.5	10.7
VI	3.4	4.0	2.1	0	3.3	1.5
VII	1.21	2.0	4.2	1.6	0.2	1.0
VIII	2.3	0.6	0	1.6	0.2	3.0
IX	1.8	2.0	0	1.6	2.8	2.0
X	0	0	0	0	0	0
XI*	1.5	3.3	16.6	0	1.8	7.5

DSA, digital subtraction angiography. *Type XI: Any variant not described as type I-X.

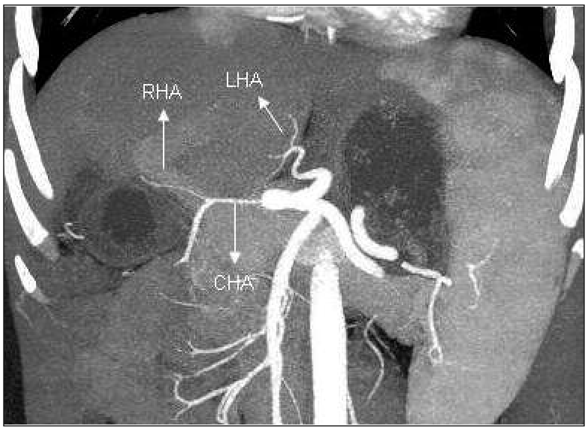

Figure 2. Maximum intensity projection image on coronal plane. Michels classification type II hepatic artery anatomy. Replaced left hepatic artery (LHA) originates from left gastric artery (LGA), right hepatic artery (RHA) originates from the common hepatic artery (CHA).

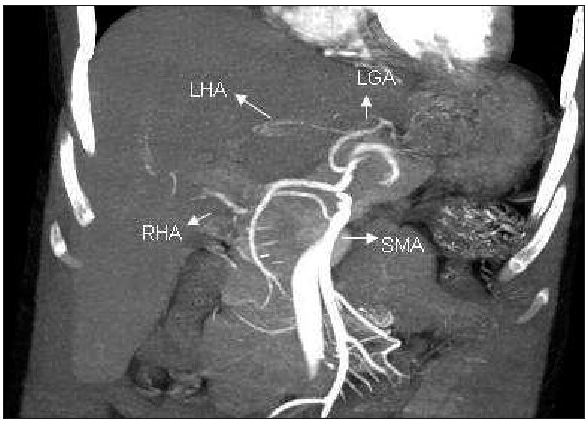

Figure 4. Maximum intensity projection image on the coronal oblique plane. Michels classification type IV hepatic artery anatomy. Left hepatic artery (LHA) originates from the left gastric artery (LGA) and the right hepatic artery (RHA) originates from the superior mesenteric artery (SMA).

Discussion

Various variants and abnormal conditions of the celiac trunk and hepatic arteries were described in the present investigation. Comparison of hepatic artery variations according to Michels classification determined in digital subtraction angiography (DSA)[3,13] and CTA[2,14,15] studies are presented in Table II. Ours is the first study reporting the results of a large series evaluated by 64-detector CTA. As presented in Table II, normal hepatic artery (Michels classification type I) was noted in 66.8% of the patients, similar to the results of the previous studies. The most common abnormality in our series was Michels type III (10.1%), followed by type V (7.3%), type II (4.7%) and others. No type X was observed in our series. We have noted additional, previously unclassified variations in 12 cases (1.5%).

In the present work, the rates of type II and type III hepatic artery (replaced hepatic artery) were similar to those reported in the previous 64-detector CTA study, but greater than those reported in DSA and 4-, 8-, 16-detector CTA studies. These variations can be better demonstrated by 64-detector CTA compared to other methods. However, type IV hepatic artery rate in our study group was lower compared to those in 64-detec-

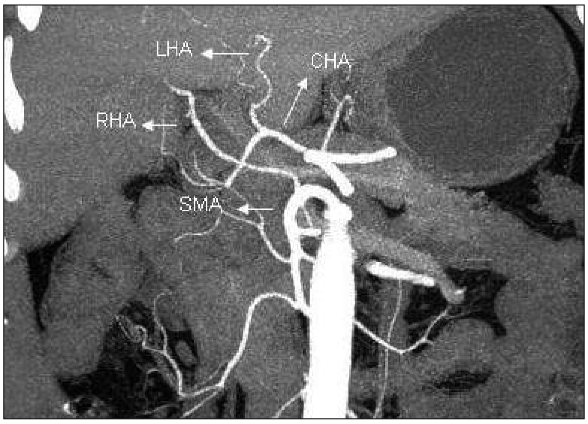

Figure 3. Maximum intensity projection image on the coronal plane. Michels classification type III hepatic artery anatomy. Replaced right hepatic artery (RHA) originates from superior mesenteric artery (SMA) and left hepatic artery (LHA) originates from the common hepatic artery (CHA).

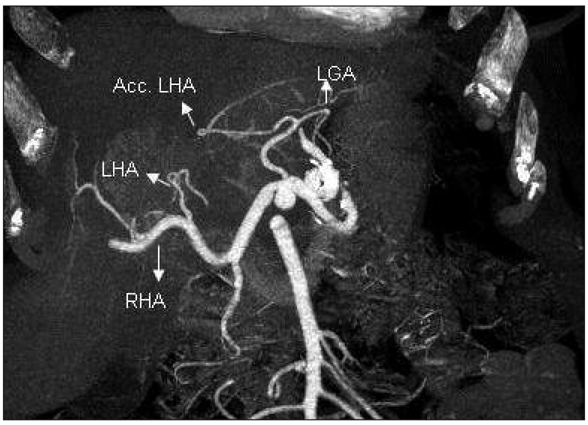

Figure 5. Maximum intensity projection image on the coronal oblique plane. Michels classification type V hepatic artery anatomy. Accessory left hepatic artery (Acc. LHA) arising from left gastric artery (LGA).

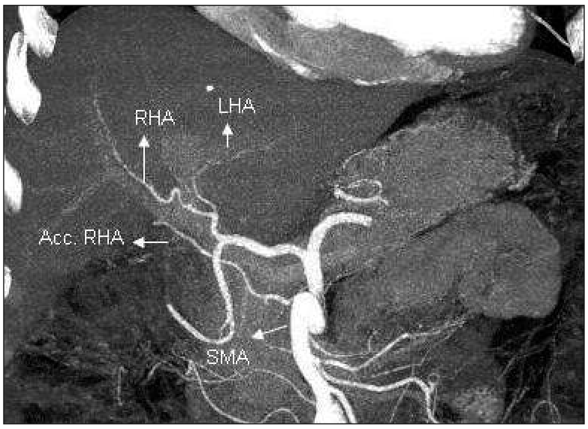

Figure 6. Maximum intensity projection image on the coronal oblique plane. Michels classification type VI hepatic artery anatomy. Accessory RHA (Acc. RHA) arising from superior mesenteric artery (SMA).

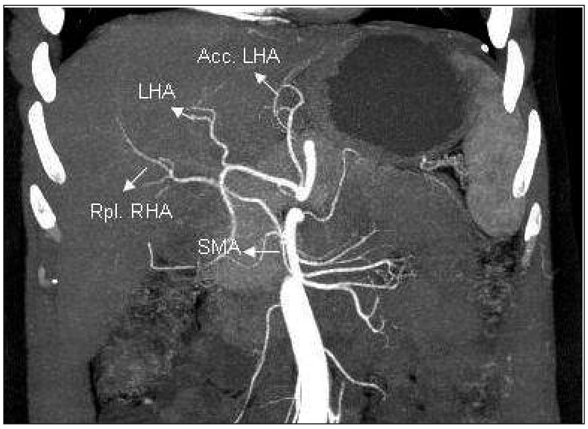

Figure 8. Maximum intensity projection image on the coronal plane. Michels classification type VIII hepatic artery anatomy. Replaced right hepatic artery (Rpl. RHA) arising from superior mesenteric artery (SMA) and accessory left hepatic artery (Acc. LHA) arising from left gastric artery (LGA).

tor CTA study, and higher compared to those in DSA and other CTA studies. This may be due to greater sample size of the present study. Moreover, type VI and type VII hepatic artery (accessory hepatic artery) rates of our study group were similar to those in 64-detector CTA study, but greater than those in other CTA and DSA researches. As accessory arteries are thinner and have shorter calibration compared to other arteries, they may be demonstrated better by 64-detector CTA. In our investigation, type VIII hepatic artery rate was higher than those in CTA and DSA studies. This may be due to our greater sample size. Type IX hepatic artery rate in our study group was similar to those in DSA and 64-detector CTA investigations, but higher compared to those in other CTA studies. DSA and 64-detector CTA might have demonstrated the superior mesenteric artery better compared to CTA with a lower number of detectors.

Similar to the previous researches included in Table II, the type X abnormality, which is very rare, was also not observed in our series.

For surgical resection of liver tumors, hepatic vascular architecture should be delineated comprehensively and accurately. This becomes especially important in terms of surgical approach and patient management, especially during placement of an intraarterial chemotherapy pump, which may be decided upon during the surgical procedure as an alternative to resection[11]. MDCT angiography allows rapid acquisition of high-resolution images

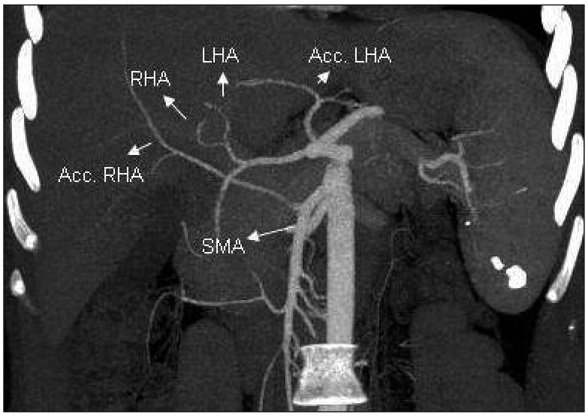

Figure 7. Maximum intensity projection image on the coronal plane. Michels classification type VII hepatic artery anatomy. Accessory right hepatic artery (Acc. RHA) arising from superior mesenteric artery (SMA) and accessory left hepatic artery (Acc. LHA) arising from left gastric artery (LGA).

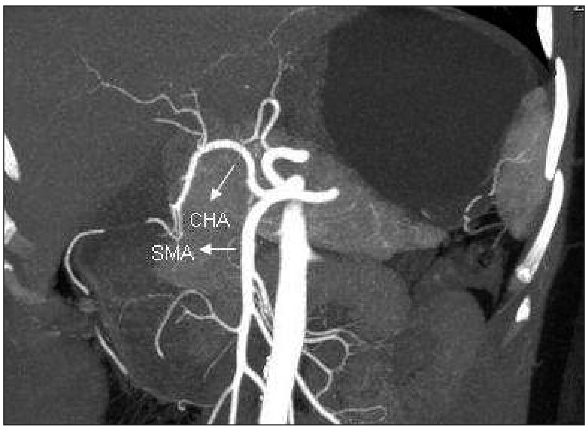

Figure 9. Maximum intensity projection image on the coronal plane. Michels classification type IX hepatic artery anatomy. Common hepatic artery (CHA) arising from the superior mesenteric artery (SMA).

of hepatic arteries during the phase of maximal contrast enhancement. The role of CTA in the determination of tumor resectability in patients with pancreatic and hepatobiliary malignancy has been well-described[16]. Preoperative knowledge of variant anatomy may assist in the selection of treatment options and surgical planning, which in turn facilitates surgical dissection and helps avoiding iatrogenic injury[2,11,13,16,17].

CT angiography is noninvasive, allows three-dimensional visualization of vessels from any angle from a single set of data acquisition and is substantially less expensive compared to conventional DSA[18]. MDCT angiography is a fast technique that depicts hepatic vascular anatomy with high sensitivity and specificity. MDCT angiography has progressively been replacing conventional angiography for evaluating vascular anatomy, liver parenchyma, adjacent organs, and soft tissues. Axial and coronal MIP and volume-rendered images allow virtual anatomic mapping for the transplant surgeon[2].

Conclusions

Preoperative knowledge of the arterial pattern provides great help for surgical planning and 64-detector CT angiography allows detailed visualization of the vascular anatomy in this respect.

Conflict of Interest

None to declare.

References

1) Budovec JJ, Pollema M, Grogan M. Update on multidetector computed tomography angiography of the abdominal aorta. Radiol Clin North Am 2010; 48: 283-309.

2) Co kun M, Kayahan E-M, Ozbek O, Cakir B, Dalgiç A, Haberal M. Imaging of hepatic arterial anatomy for depicting vascular variations in living related liver transplant donor candidates with multidetector computed tomography: comparison with conventional angiography. Transplant Proc 2005; 37: 1070-1073.

3) Koops A, Wojciechowski B, Broering DC, Adam G, Krupski-Berdien G. Anatomic variations of the hepatic arteries in 604 selective celiac and superior mesenteric angiographies. Surg Radiol Anat 2004; 26: 239-244.

4) Iezzi R, Cotroneo AR, Giancristofaro D, Santoro M, Storto ML. Multidetector-row CT angiographic imaging of the celiac trunk: anatomy and normal variants. Surg Radiol Anat 2008; 30: 303-310.

5) Stehling MK, Lawrence JA, Weintraub JL, Raptopoulos V. CT angiography: expanded clinical applications. AJR Am J Roentgenol 1994; 163: 947-955.

6) Duran C, Uraz S, Kantarci M, Ozturk E, Doganay S, Dayangac M, Bozkurt M, Yuzer Y, Tokat Y. Hepatic arterial mapping by multidetector computed tomographic angiography in living donor liver transplantation. J Comput Assist Tomogr 2009; 33: 618-625.

7) Winter TC 3rd, Nghiem HV, Freeny PC, Hommeyer SC, Mack LA. Hepatic arterial anatomy: demonstration of normal supply and vascular variants with three-dimensional CT angiography. Radiographics 1995; 15: 771-780.

8) Smith PA, Klein AS, Heath DG, Chavin K, Fishman EK. Dual-phase spiral CT angiography with volumetric 3D rendering for preoperative liver transplant evaluation: preliminary observations. J Comput Assist Tomogr 1998; 22: 868-874.

9) Kawamoto S, Montgomery RA, Lawler LP, Horton KM, Fishman EK. Multi-detector row CD evaluation of living renal donors prior to laparoscopic nephrectomy. Radiographics 2004; 24: 453-466.

10) Hazirolan T, Metin Y, Karaosmanoglu AD, Canyigit M, Turkbey B, Oguz B-S, Ariyurek M. Mesenteric arterial variations detected at MDCT angiography of abdominal aorta. AJR Am J Roentgenol 2009; 192: 1097-1102.

11) Sahani D, Saini S, Pena C, Nichols S, Prasad SR, Hahn PF, Halpern EF, Tanabe KK, Mueller PR. Using multidetector CT for preoperative vascular evaluation of liver neoplasms: technique and results. AJR Am J Roentgenol 2002; 179: 53-59.

12) Michels NA. Newer anatomy of the liver and its variant blood supply and collateral circulation. Am J Surg 1966; 112: 337-347.

13) Covey AM, Brody LA, Maluccio MA, Getrajdman GI, Brown KT. Variant hepatic arterial anatomy revisited: digital subtraction angiography performed in 600 patients. Radiology 2002; 224: 542-547.

14) Stemmler BJ, Paulson EK, Thornton FJ, Winters SR, Nelson RC, Clary BM. Dual-phase 3D MDCT angiography for evaluation of the liver before hepatic resection. AJR Am J Roentgenol 2004; 183: 1551-1557.

15) De Cecco CN, Ferrari R, Rengo M, Paolantonio P, Vecchietti F, Laghi A. Anatomic variations of the hepatic arteries in 250 patients studied with 64-row CT angiography. Eur Radiol 2009; 19: 2765-2770.

16) Winston CB, Lee NA, Jarnagin WR, Teitcher J, DeMatteo RP, Fong Y, Blumgart LH. CT angiography for delineation of celiac and superior mesenteric artery variants in patients undergoing hepatobiliary and pancreatic surgery. AJR Am J Roentgenol 2007; 189: 13-19.

17) Chitra R. Clinically relevant variations of the coeliac trunk. Singapore Med J 2010; 51: 216-219.

18) Yu T, Zhu X, Tang L, Wang D, Saad N. Review of CT angiography of aorta. Radiol Clin North Am 2007; 45: 461-483.