Coeliac trunk and common hepatic artery variations in children: an analysis with computed tomography angiography


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Background: Understanding the coeliac trunk (CeT) and hepatic artery anatomy is important not only in preventing iatrogenic injuries but also in planning surgical procedures in children. Therefore, the aim of this study is to analyse the prevalence of CeT and common hepatic artery (CHA) variations in the paediatric population.

Materials and methods: One hundred and seventy-four children who underwent abdominal multidetector computed tomography (MDCT) angiography, either because of trauma or liver transplantation, were analysed retrospectively. The patterns of CeT, CHA and their variant branches were revealed and compared with previous studies involving adults.

Results: A total of 157 (90.2%) of the 174 patients had normal CeT anatomy, whereas 17 (9.8%) had variations. Five types of CeT variations were identified according to Song’s classification in which ‘hepatosplenic trunk + left gastric artery + superior mesenteric artery’ was the most prevalent. One hundred-twelve (64.4%) of the 174 patients had normal CHA anatomy; however, 62 (35.6%) had variations. Six types of CHA variations were identified according to Michel’s and Hiatt’s classification. The most common was ‘replaced left hepatic artery originating from left gastric artery’.

Conclusions: The prevalences of CeT and hepatic artery variations are high in children, as they are in older patients. Awareness of these variations is important in terms of avoiding iatrogenic injury and in promoting surgical procedure planning for liver transplantation or abdominal tumour surgery. (Folia Morphol 2018; 77; 4: 670–676)

Key words: coeliac trunk, computed tomography angiography, hepatic artery, variation

INTRODUCTION

The coeliac trunk (CeT) is the first and most important branch of the abdominal aorta. Characteristically, the common hepatic artery (CHA), the left gastric artery and the splenic artery are known as the main branches of the CeT. Currently, the segment from the hepatic artery to the branch point of the gastroduodenal artery is defined as CHA [5]. The branches of the CHA arising from the CeT are described as having normal course when the right hepatic artery and left hepatic artery originate from the proper hepatic artery which supplies the liver, gastroduodenal artery and right gastric artery. In variant anatomy, vessels do not arise from their usual source and present as accesso-
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prior to examination. We presented the information and images of the patients fully anonymous.

Ethical approval
The institutional review board approved the study and waived the need for patient consent.

MDCT angiography examination
All MDCT angiography examinations were performed by a 64-slice CT scanner (Aquilion 64; Toshiba Medical Systems). The imaging data were acquired during an intravenous injection of 1.5 to 2 mL/kg of the contrast agent at a rate of 1 to 3 mL/s for children, but the contrast media was manually injected for infants. Saline solution of 4 to 15 mL followed the contrast material. The voltage and tube current were adjusted to the patient’s weight as follows: 80 kV was used for patients weighing < 30 kg, and 100 kV for those weighing 30–60 kg; tube current was 10 mA/kg for patients weighing < 9 kg, and 5 mA for each additional kg. Section thickness was 0.5 mm, reconstruction interval was 0.3 mm and the scan revolution time was 0.4 s. All MDCT angiography data were transferred to a workstation (Osirix MD 7 for MAC) in order to evaluate vascular anatomy. Basically, axial and sagittal-coronal reformat images were analysed for each case. In appropriate minority of the cases, three-dimensional post-processing such as multiplanar image reformatting (MPR) and maximum intensity projections (MIP) were also performed where possible.

Statistical analysis
Descriptive statistics regarding the age and gender of the patients were presented with minimum, maximum, mean and standard deviation via SPSS 22.0 (SAS version 9.2; SAS Institute Inc., Cary, NC, USA). The distributions of the variations were provided as frequencies. All data were managed, processed, and compiled in Microsoft Office Excel. Mann-Whitney U test was used to compare the distribution of CeT and CHA variations in males and females.

RESULTS
One hundred seventy-four cases (99 males, 75 females; aged between 5 months and 16 years; mean 7 years ± 2 months) were enrolled in the study. There was no significant difference between males and females in terms of CeT and CHA variations (35.3%, 35.9%, respectively).
Coeliac trunk variations

A total of 157 (90.2%) of the 174 patients had normal CeT anatomy with hepatogastroplenic trunk separating from the aorta, which was called trifurcation, and 17 (9.8%) had variant anatomy. In our study, 5 of the 15 possible CeT variations were identified according to the classification by Song et al. [25] (Table 3). ‘Hepatosplenic trunk + left gastric artery + superior mesenteric artery’ was seen in 7 (4%) patients, ‘hepatomesenteric trunk + gastrosplenic trunk’ was seen in 5 (2.8%) patients, ‘coeliacomesenteric trunk’ was seen in 3 (1.8%) patients, ‘hepatosplenomesenteric trunk + left gastric artery’ was seen in 1 (0.6%) patient, and ‘hepatogastric trunk + splenic artery + superior mesenteric artery’ was seen in 1 (0.6%) patient.

Common hepatic artery variations

A total of 112 (64.4%) of the 174 patients had normal CHA anatomy originating from the CeT and 62 (35.6%) had variant anatomy. In our study, 6 of the 10 possible CHA variations were identified according to the classification by Michel [16] and Hiatt et al. [10] (Table 4). ‘Replaced left hepatic artery originating from left gastric artery’ was seen in 21 (12.0%) patients.
Table 3. Results in the current study (according to abbreviations of Song et al. [25])

<table>
<thead>
<tr>
<th>Coeliac trunk anatomy type</th>
<th>Number of patients (n = 174)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal anatomy</td>
<td>157 (90.2%)</td>
</tr>
<tr>
<td>Variant anatomy</td>
<td>17 (9.8%)</td>
</tr>
<tr>
<td>Hepatosplenic trunk + left gastric artery + superior mesenteric artery</td>
<td>7 (4%)</td>
</tr>
<tr>
<td>Hepatomesenteric trunk + gastrosplenic trunk</td>
<td>5 (2.8%)</td>
</tr>
<tr>
<td>Gastromesenteric trunk</td>
<td>3 (1.8%)</td>
</tr>
<tr>
<td>Hepatosplenomesenteric trunk + left gastric artery</td>
<td>1 (0.6%)</td>
</tr>
<tr>
<td>Hepatogastric trunk + splenomesenteric trunk</td>
<td>1 (0.6%)</td>
</tr>
</tbody>
</table>

Table 4. Results in the current study (according to the classification of Michel et al. [16] and Hiatt et al. [10])

<table>
<thead>
<tr>
<th>Common hepatic artery anatomy type</th>
<th>Number of patients (n = 174)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal anatomy</td>
<td>112 (64.4%)</td>
</tr>
<tr>
<td>Variant anatomy</td>
<td>62 (35.6%)</td>
</tr>
<tr>
<td>The replaced LHA originating from LGA (type II)</td>
<td>21 (12.0%)</td>
</tr>
<tr>
<td>The replaced RHA originating from the SMA (type III)</td>
<td>23 (13.2%)</td>
</tr>
<tr>
<td>The accessory LHA originating from LGA (type V or type II)</td>
<td>18 (10.3%)</td>
</tr>
<tr>
<td>The accessory RHA originating from SMA (type VI or type III)</td>
<td>7 (4%)</td>
</tr>
<tr>
<td>The CHA originating from SMA (type IX or type V)</td>
<td>1 (0.6%)</td>
</tr>
<tr>
<td>The CHA directly originating from the aorta (NOD or type VI)</td>
<td>1 (0.6%)</td>
</tr>
</tbody>
</table>

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

Figure 1. Axial computed tomography scan illustrates replaced left hepatic artery (white arrow) originating from left gastric artery (black arrow).

Figure 2. Coronal maximum intensity projection image shows replaced right hepatic artery (white arrow) originating from the superior mesenteric artery (black arrow).

Figure 3. Coronal maximum intensity projection image shows common hepatic artery (white arrow) originating from superior mesenteric artery (black arrow).

patients (Fig. 1), ‘Replaced right hepatic artery originating from the superior mesenteric artery’ was seen in 18 (10.3%) patients (Fig. 2), ‘Accessory left hepatic artery originating from left gastric artery’ was seen in 14 (8.0%) patients, ‘Accessory right hepatic artery originating from superior mesenteric artery’ was seen in 7 (4%) patients, ‘CHA originating from superior mesenteric artery’ was seen in 1 (0.6%) patient (Fig. 3), and ‘CHA directly originating from the aorta’ was seen in 1 (0.6%) patient (Fig. 4).

**DISCUSSION**

The present study demonstrates that vascularity of CeT and CHA have a high variation rate. Classical arterial anatomy is that the CeT originates from the abdominal aorta at the level of the T12 thoracic vertebra and divides into three main branches as CHA, splenic artery and left gastric artery [26]. The vascularisation of the liver is provided by the CHA originating...
from the CeT. The CHA bifurcates into gastroduodenal artery and proper hepatic artery which divides into right hepatic artery and left hepatic artery. It is very important to understand the variant anatomy of these arteries for safe liver transplantation, traumatic vascular injury repair and abdominal tumour surgery in children as much as in adults [3].

Although digital subtraction angiography is regarded as the gold standard imaging method in the evaluation of abdominal vascular structures, MDCT angiography is cheaper, easily accessible, safer and particularly noninvasive when compared to digital subtraction angiography. MDCT angiography has become a widely used imaging method which provides highly accurate results and has gained acceptance in the identification of vascular anatomy [2, 24]. Magnetic resonance angiography is another useful method used to define the anatomy of the abdominal vascular structure in children. The greatest advantage is that it does not use ionizing radiation.

Panagouli et al. [21] published a systematic review about CeT variations including a total of 36 studies with 12,196 Japanese, Korean, Caucasian and Indian individuals from different countries [4, 10, 18, 22]. The CeT was trifurcated into the three basic branches of the classical anatomy in 89.42% of cases. They mentioned different forms of bifurcation were recorded in 19 out of the 36 articles. Bifurcation of CeT as hepatosplenic trunk with the left gastric artery arising from the aorta was the most common (7.4%) variation. Absence of the CeT was the rarest variation (0.38%). In the present study, a total of 157 (90.2%) of the 174 Turkish children had normal CeT anatomy similar to cases from other countries including adults (Table 5). ‘Hepatosplenic trunk + left gastric artery + superior mesenteric artery’ was the most common variation (4%) which confirmed data reported by most authors. ‘Absence of the CeT’ was not seen in this study.

Table 5. Normal and variant pattern of the coeliac trunk

<table>
<thead>
<tr>
<th>Study</th>
<th>Race</th>
<th>Number of the study</th>
<th>Normal pattern</th>
<th>Variant pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current study (children)</td>
<td>Turkey</td>
<td>174</td>
<td>90.2%</td>
<td>9.8%</td>
</tr>
<tr>
<td>Chen et al. [4] (adults)</td>
<td>Japanese</td>
<td>974</td>
<td>89.8%</td>
<td>10.2%</td>
</tr>
<tr>
<td>Song et al. [25] (adults)</td>
<td>Korean</td>
<td>5002</td>
<td>89.1%</td>
<td>10.9%</td>
</tr>
<tr>
<td>Prakash et al. [22] (adults)</td>
<td>Indian</td>
<td>50</td>
<td>86%</td>
<td>14%</td>
</tr>
<tr>
<td>Iezzi et al. [12] (adults)</td>
<td>Caucasian</td>
<td>524</td>
<td>87.6%</td>
<td>12.4%</td>
</tr>
</tbody>
</table>

Table 6. Normal and variant pattern of the hepatic artery

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Number of the study</th>
<th>Normal pattern</th>
<th>Variant pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current study (children)</td>
<td>Turkey</td>
<td>174</td>
<td>64.4%</td>
<td>35.6%</td>
</tr>
<tr>
<td>Gumus et al. [9] (adults)</td>
<td>Turkey</td>
<td>820</td>
<td>76.8%</td>
<td>33.2%</td>
</tr>
<tr>
<td>Bertevello et al. [1] (adults)</td>
<td>Brazil</td>
<td>60</td>
<td>68.3%</td>
<td>31.7%</td>
</tr>
<tr>
<td>Song et al. [25] (adults)</td>
<td>Korean</td>
<td>5002</td>
<td>58%</td>
<td>42%</td>
</tr>
<tr>
<td>Sureka et al. [27] (adults)</td>
<td>India</td>
<td>600</td>
<td>79.6%</td>
<td>20.4%</td>
</tr>
<tr>
<td>Tharangarajah et al. [28] (adults)</td>
<td>India</td>
<td>200</td>
<td>57%</td>
<td>43%</td>
</tr>
<tr>
<td>Koops et al. [13] (adults)</td>
<td>Germany</td>
<td>604</td>
<td>79.1%</td>
<td>20.9%</td>
</tr>
</tbody>
</table>

Figure 4. Axial maximum intensity projection image shows common hepatic artery (white arrow) directly originating from the aorta (black arrow).
left hepatic artery is usually from the branch of the CeT (most frequently from the left gastric artery) [11].

Iatrogenic arterial injuries include pseudoaneurysm, extravasation, arteriovenous fistula, arteriobiliary fistula, and dissection. Onizuka et al. [20] reported that arterial injuries occurred in 38 of 906 cases during transcatheter arterial chemoembolisation for hepatocellular carcinoma. They mentioned that iatrogenic arterial injuries frequently occurred in the extrahepatic artery or replaced hepatic artery. In addition, Catalano et al. [3] published that ‘CHA trifurcation into the right hepatic artery, left hepatic artery and gastroduodenal artery’ can cause gastric or duodenal hypoperfusion due to clamping or ligation of the CHA. They also postulated that ‘replaced or accessory left hepatic artery’ increases complexity of the surgery. If paediatric surgeons or other clinicians are aware and take care of CHA variations, children can avoid iatrogenic surgical injuries. It is important to be aware of CeT and CHA variations in children to increase their life span.

A potential limitation of our study is the relatively small number of cases involved and the retrospective design. The reason of the small number of cases is that MDCT angiography rarely is used in children because of the high ionising-radiation exposure. Another limitation is that the present study included some children with MDCT angiography images before liver transplantation. It was different from bias of patients’ selection compared to the previous adult studies. It may be more accurate to make comparisons of completely healthy children with adults. Since optimal timing for arterial and/or venous phase MDCT images was not always possible to obtain in every paediatric cases, three-dimensional reconstruction images could not be collected for all of the cohort enrolled and diagnosis were basically made with source images which is another limitation in the current study. Due to the small vessel lumen diameter, as expected in paediatric population, optimal imaging was not obtained.

CONCLUSIONS

The prevalences of CeT and hepatic artery variations are high in children, as they are in older patients. Awareness of these variations by paediatric surgeons is important in terms of avoiding iatrogenic injury and in promoting surgical procedure planning for liver transplantation and abdominal tumour surgery.

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REFERENCES


