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Clinical significance of celiac truncus variations in gastric cancer surgery: a retrospective cohort study in the Turkish population

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ABSTRACT

Aims: Gastric cancer is the fifth most common malignancy worldwide. Celiac truncus variations are one of the most important factors complicating the surgical process of total gastrectomy and D2 lymph node dissection in the surgical treatment of gastric cancer. This study aimed to evaluate the frequency of celiac truncus variations in patients undergoing gastrectomy for gastric cancer and their impact on clinical outcomes.

Methods: Preoperative computed tomography images of 114 patients who underwent total gastrectomy between January 2023 and June 2025 were retrospectively evaluated. Arterial variations were categorized according to the Michels classification. Postoperative liver enzyme levels, lymph node dissection efficacy, and clinical outcomes were analyzed in patients with arterial anatomic variations.

Results: Celiac truncus variations were detected in 19.3% of patients (n=22). The most common variation was ALHA (aberran left hepatic artery), at a rate of 9.6%. No statistically significant difference was found between postoperative 24-hour ALT and AST levels in patients with hepatic artery variations and those with normal anatomy. The increase in AST and ALT parameters at the 24th hour postoperatively in 22 patients with hepatic artery variations was not significant compared to the preoperative results (AST=22-26.5, p=0.476 and ALT=18-18.5, p=0.602). There was no significant difference between the groups in terms of lymph node dissection efficacy (22.8±7.7 vs 23.3±11.6, p=0.985) and oncological outcomes.

Conclusion: Celiac artery variations, especially those in the presence of ALHA, can be safely managed with appropriate perioperative assessment and experienced surgical technique. While these variations do not negatively affect oncological surgical outcomes, transient postoperative liver enzyme elevations may occur.

Keywords: Gastric cancer, celiac truncus variation, D2 lymph node dissection, Michels classification

INTRODUCTION

According to GLOBOCAN 2022 data gastric cancer is the fifth most common malignancy worldwide with approximately 968.000 new cases. It has a 6.8% mortality rate with approximately 660.000 deaths annually. This disease which shows particularly higher incidence in males also exhibits significant differences in geographical distribution. East Asian countries especially Japan, South Korea and Mongolia stand out as regions with the highest incidence and mortality rates for gastric cancer.[1] In Turkiye gastric cancer is the fifth most common cancer type in males with a rate of 12.7 per 100.000 and the seventh most common in females with a rate of 5.5 per 100.000. According to the Turkiye Cancer Statistics 2020 report, 9.143 new gastric cancer cases are diagnosed annually in our country.[2]

In the treatment of gastric adenocarcinoma resection is the cornerstone of curative approach and there is international consensus on the necessity of D2 lymphadenectomy especially in locally advanced stage (≥ pT2) and/or node-positive (cN+) cases. The current guidelines of the Japanese Gastric Cancer Association (JGCA,6th edition, 2021) clearly state that D2 lymph node dissection is standard for potentially curative purposes in cT2-T4 and cT1N+ tumors. JGCA also recommends D2+ No.10 (splenic hilar) dissection for total gastrectomy only in T4 proximal gastric tumors with greater curvature involvement.[3] Similarly the European Oncology Guidelines (ESMO) emphasize that D2 lymphadenectomy is the reference standard for curative surgery in both open and laparoscopic approaches in high-volume and experienced centers.[4]

The celiac truncus is the first major visceral branch arising from the abdominal aorta at the T12-L1 level and classically divides into three main branches through trifurcation-left gastric artery, splenic artery and common hepatic artery. Although this anatomy is the most commonly observed

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morphology in literature, it is reported in 85-90% of large series.[5] However variations of the celiac truncus are also quite common and have critical importance in surgical planning. Celiac truncus variations are not merely theoretical findings concerning vascular anatomy. On the contrary they are structures with direct clinical consequences, especially during D2 lymphadenectomy in gastric cancer surgery, hepatopancreatobiliary surgery and liver transplantation. Origin variations of the hepatic artery play a critical role in D2 lymph node dissection both in terms of preserving blood supply and ensuring oncologic dissection safety. Accurate recognition of vascular anatomy allows both safe extension of dissection boundaries to achieve oncologic radicality and reduces postoperative morbidity by preventing unnecessary vascular losses.[6]

Therefore systematic evaluation of celiac truncus variations and examination of their effects on surgical outcomes is important both nationally and internationally. In our study, we aimed to reveal the frequency of celiac truncus variations in the Turkish population and their possible effects on clinical outcomes in gastrectomy surgery. Thus we planned to present original data that could guide clinicians in terms of both surgical safety and oncologic outcomes.

METHODS

Ethics

The study has been approved by the Scientific Researches Ethics Committee of Gülhane Training and Research Hospital, Health Sciences University (Date: 02.07.2025, Decision No: 13) and patient data were retrospectively evaluated in accordance with the Helsinki Declaration.

Study Population and Patient Selection

Patients who underwent gastrectomy (total or subtotal) operations with a diagnosis of gastric cancer between January 2023 and June 2025 at the Surgical Oncology Department of Health Science University Gülhane Training and Research Hospital were retrospectively screened. A total of 128 patients were found. Our study inclusion criteria encompassed patients over 18 years of age who had received a preoperative adenocarcinoma diagnosis and underwent D2 lymphadenectomy with celiac truncus hepatic artery anatomy confirmed in surgical reports. Exclusion criteria were considered as not being able to perform standard D2 lymph node dissection in patients undergoing palliative surgery due to the presence of metastatic disease and/or accompanying serious systemic comorbidities, the presence of a history of upper abdominal surgery, which could cause possible changes in vascular anatomy that could be considered variations, and the presence of incomplete imaging data, which could not allow for standard radiological evaluation and could lead to incomplete and/or erroneous evaluation. Eleven patients whose external center tomography images and reports were inaccessible and whose hepatic artery anatomy was not specified in surgical reports one 92 years old patient who underwent palliative surgery due to systemic comorbidities and 2 patients who were operated on with gastrointestinal system tumor and NET diagnoses and did not undergo standard D2 lymphadenectomy procedure were not included in the study. A total of 114 patients were included in the study.

Celiac Truncus Anatomy and Classification of Hepatic Artery Variations

The classification system developed by Nicholas Michels in 1955 systematically categorizes hepatic artery variations. This classification is used to evaluate the risks posed by arterial variations in surgical applications. Michels classification categorizes hepatic artery variations under 10 types. Type I (normal anatomy, 55-83%): Left and right hepatic arteries arise from the common hepatic artery. Type II (10-15%): Left hepatic artery arises from the left gastric artery (ALHA). Type III (11-18%): Right hepatic artery arises from the superior mesenteric artery. Type IV (1-4%): Both left and right hepatic arteries are in aberrant positions. Types V-X encompass other rare variations[7] (**Table 1**).

Study Design

Our study was designed as a single-center, retrospective and observational study. Patients who underwent gastrectomy+ D2 lymphadenectomy with a diagnosis of gastric adenocarcinoma at the Surgical Oncology Department of Health Science University Gülhane Training and Research Hospital between January 2023 - June 2025 were included in the study. The main objective of the study is to investigate the clinical importance of celiac truncus hepatic artery variations in the perioperative and postoperative periods in gastric cancer patients. In our clinic all patients are routinely evaluated for vascular anatomy in the arterial phase by preoperative abdominal tomography by both radiologist and clinician and recorded. In surgery especially in patients with vascular variation detected in the preoperative period dissection begins first with hepatic propria artery dissection to ensure identification and preservation of the artery during dissection around the hepatoduodenal ligament and lesser curvature. Patients with celiac truncus artery variation in the preoperative period and/or patients in whom hepatic artery variation is detected during operation are recorded in the surgical note. With these findings we divided patients into two classes: those with and without hepatic artery variation. We investigated the relationship of the groups with demographic, histopathological and biochemical parameters. We examined the distribution of liver function tests measured in the preoperative period and postoperative 24th hour values between hepatic artery variation groups. Additionally by comparing preoperative CT results with surgical findings, we observed which hepatic artery variations according to Michels classification could be radiologically overlooked. After the radiological variation classification was reported, the surgery and pathology teams followed the standard workflow to avoid being affected by this classification except for clinical necessity.

Statistical Analysis

The data analysis was performed using SPSS version 22.00. Kolmogorov Smirnov and Levene tests were performed for homogeneity and normality analysis of scaled data. Since it was a two-group study Pearson Chi-square and Fischer exact tests were used for evaluation of categorical data, Student's

Table 1. Michels & Hiatt celiac truncus hepatic artery variation classification

Type	Definition	Incidance	Clinical significance
I	Normal arterial anatomy	55-60%	Standard anatomy; however, this ratio is lower than expected, preoperative imaging is still mandatory.
II	Replaced LHA arising from LGA	10-15%	Total gastrectomy or left gastric artery ligation has a risk of left lobe ischaemia.
III	Replaced RHA arising from SMA	10-18%	There is a risk of serious vascular complications during pancreaticoduodenectomy because it is performed in the dissection area.
IV	Co-existence of type II and III	1-4%	The complexity of surgical dissection increases due to double replacement arteries; especially critical in transplant patients.
V	Accessory LHA arising from LGA	8-10%	If not detected during surgery, there is a risk of both bleeding and deterioration in left lobe perfusion.
VI	Accessory RHA arising from SMA	6-7%	If not detected during surgery, there is a risk of both bleeding and deterioration in right lobe perfusion.
VII	Accessory RHA arising from SMA and accessory LHA arising from LGA	1-2%	Complex vascular anatomy complicates surgery especially in D2 lymphadenectomy and transplantation.
VIII	Replaced RHA and accessory LHA or replaced LHA and accessory RHA	1-2%	It is very rare; combined variations may cause intraoperative bleeding and postoperative ichaemia
IX	The CHA arising from SMA	<1%	The SMA is the only supply of blood to the liver; its occlusion leads to life-threatening hepatic ischaemia.
X	The CHA arising from LGA	<1%	It is extremely rare; it presents a risk of serious hepatic ischaemic complications in total gastrectomy.

RHA: Right hepatic artery, LHA: Left hepatic artery, HPA: Common hepatic arteria, LGA: Left gastric artery, SMA: Superior mesenteric artery

t-test for scaled parametric data and Mann-Whitney U tests for scaled non-parametric data. Wilcoxon signed ranks test was performed to test the significance of the difference between the arithmetic medians of two dependent non-parametric groups. $p<0.05$ was considered significant.

RESULTS

Patient Characteristics

One hundred fourteen patients who underwent gastrectomy operation with a diagnosis of gastric cancer were retrospectively evaluated to investigate the perioperative and postoperative early period outcomes of Michels hepatic artery variation anomalies. Of the patients included in our study 72 were male and 42 were female. The mean age of patients was 63.97 (range 32-82). In 52 patients the tumor was located in the middle stomach and in 32 patients it showed proximal location. Subtotal gastrectomy was performed in 46 patients and total gastrectomy in 68 patients. In pathological stage evaluation 50.9% of patients had T3-T4 and 54.4% had lymph node metastasis. The mean number of lymph node dissections was 25.35 and the number of metastatic lymph nodes was 3.91. In tumor histopathology distribution 25 patients had signet ring cell adenocarcinoma and 27 had highly differentiated adenocarcinoma. The mean hospital stay was 6.85 days and the mean postoperative follow-up period was 25.98 months. Twenty-two patients had celiac truncus hepatic artery variation. Eleven patients had Michels type 2, 6 patients had type 3, 3 patients had type 4 and 2 patients had rare hepatic variations. In 4 of the 22 patients whose perioperative hepatic artery variation diagnosis was confirmed hepatic artery variation could not be detected in preoperative radiological examinations. The distribution of demographic, clinical and pathological characteristics of all patients is presented in detail in **Table 2**.

Analysis of Hepatic Artery Variation Groups According to Clinicopathological Factors

We classified patients into two groups according to the presence of celiac truncus hepatic artery variation anomaly. While 92 patients in the first group had no hepatic artery variation, 22 patients in the second group had hepatic artery variation. The median age of patients without hepatic artery variation anomaly was 67, while those with it was 68.5. We found a statistically significant difference in the distribution of tumor localization according to groups. While distally located tumors were more common in the first group, the second group had the most middle-located tumors ($p=0.036$). This difference did not provide a significant effect on the distribution of the type of operation performed according to groups ($p=0.061$). While the absence of radiological anomaly was confirmed in the preoperative period in all patients without variation, 4 of the patients with variation could not be detected in preoperative radiological imaging methods ($p<0.001$). There was no significant statistical difference in the distribution of tumor histopathology, T invasion stage, n stage, PNI, LVI, lymph node dissection number and lymph node metastasis according to groups. There was no statistically significant difference in the distribution of ALT and AST values measured in the preoperative period of patients according to groups, showing homogeneous distribution between groups ($p=0.465$ and $p=0.640$). Similarly the distribution of ALT and AST values measured at postoperative 24th hour between groups was homogeneous with no statistically significant difference ($p=0.108$ and $p=0.570$). We found no significant difference between hepatic variation groups' hospital stay and postoperative follow-up periods ($p=0.131$ and $p=0.863$). In both groups the median hospital stay was 7 days and patients continue to be followed up (**Table 3**).

Table 2. Demographic and clinicopathological distribution of the patients

Age, year, mean±SD, range	63.97±12.97 (32-82)
Artery variation, n (%)	
Absent	92 (80.7%)
Present	22 (19.3%)
Michels & Hiatt hepatic artery variation classification, n (%)	
Type I (normal arterial anatomy)	92 (80.7%)
Type II (aberrant left hepatic artery)	11 (9.6%)
Type III (aberrant right hepatic artery)	6 (5.3%)
Type IV (co-existence of type II and III)	3 (2.6%)
Type V-X (rare variations)	2 (1.8%)
Radiology-surgery arterial variation confirmation, n (%)	
Absent	4 (3.5%)
Present	110 (96.5%)
Tumor localication, n (%)	
Distal	30 (26.3%)
Middle	52 (45.6%)
Proximal	32 (28.1%)
Operation type, n (%)	
Subtotal gastrectomy	46 (40.4%)
Total gastrectomy	68 (59.6%)
T stage, n (%)	
T insitu	13 (11.4%)
T1	21 (18.4%)
T2	22 (19.3%)
T3	30 (26.3%)
T4	28 (24.6%)
Lymph node dissection, number, mean±SD, range	25.35±8.98 (10-54)
Lymph node metastases, number, mean±SD, range	3.91±6.13 (0-27)
N stage, n(%)	
n0	52 (45.6%)
n1	27 (23.7%)
n2	17 (14.9%)
n3	18 (15.8%)
Tumor differentiation- morphology, n(%)	
Grade 1	27 (23.7%)
Grade 2	39 (34.2%)
Grade 3	23 (20.2%)
Signet ring cell	25 (21.9%)
PNI, n (%)	
Absent	72 (63.2%)
Present	42 (36.8%)
LVI, n (%)	
Absent	46 (40.4%)
Present	68 (59.6%)
Preoperative ALT, IU/L, mean±SD, range	20.22±11 (7-95)
Preoperative AST, IU/L, mean±SD, range	32.18±27.86 (5-208)
Postoperative 24th hour ALT, IU/L, mean±SD, range	23.69±26.68 (1-225)
Postoperative 24th hour AST, IU/L, mean±SD, range	37.20±39.68 (3-268)
Hospital stay, day, mean±SD, range	6.85±0.66 (6-11)
Follow-up time, month, mean±SD, range	25.98±14.22 (1-54)

LVI: Lymphovascular invasion, PNI: Perinoral invazyon, ALT: Alanine aminotransferase, AST: Aspartate aminotransferase, SD: Standard deviation

Evaluation of Liver Function Tests Before and After Gastrectomy

We examined the changes in preoperative and postoperative 24th hour AST and ALT values of 22 patients with celiac truncus hepatic artery variation (Table 4). First we subjected the data to homogeneity and distribution tests. We considered data that did not show homogeneous distribution as non-parametric and ran the Wilcoxon Signed Rank test. We didn't find statistically significant difference between the median AST value measured in the preoperative period and the median AST value at postoperative 24th hour (p=0.476). The median AST value was 22 IU/L in the preoperative period and 26.5 IU/L at postoperative 24th hour. We applied the same analysis for the ALT variable. We found no statistically significant difference between the median ALT value measured in the preoperative period and the median ALT value at postoperative 24th hour (p=0.602). The median ALT value was 18 IU/L in the preoperative period and 18.5 IU/L at postoperative 24th hour. That is careful lymphatic dissection performed without causing organ and vascular damage does not lead to significant changes in liver function tests. In the clinical context, these values are consistent with transient biochemical fluctuations in patients who are hemodynamically stable and have no perfusion problems.

Radiological and Surgical Correlation of Michels Hepatic Artery Variation Anomalies

We investigated the correlation between celiac truncus hepatic artery variations classified by preoperative radiological imaging methods and findings confirmed by observation during operation. Intravenous contrast-enhanced abdominal tomography correctly analyzed the hepatic artery origin according to Michels classification in 110 patients. In 4 patients hepatic artery anomaly was missed tomographically. In our sub-analysis we found that of the 4 patients whose tomography incorrectly analyzed, 2 had type IV, 1 had type III and one patient had other rare variations. This relationship was statistically significant with p<0.001 (Table 5). All 92 patients with type I were also correctly identified radiologically.

Limitations of Study

Our results should be evaluated in light of several methodological limitations, which we will summarize. The exclusion of some cases due to the heterogeneity of external center CT scans may reduce generalizability. The sample size for variation subtypes (especially type IV and rare types) is small, increasing the likelihood of type II error in detecting small-to-medium effect sizes. Liver enzyme levels were systematically compared only at 24 hours; late subclinical effects (e.g., 72 hours/7 days) were not evaluated. Long-term oncologic outcomes (DFS/OS) are beyond the scope of this study. Intraobserver/interobserver agreement between radiological assessment and surgical observation was not prospectively measured.

DISCUSSION

Our purpose in planning this study was to perform a systematic analysis of celiac truncus hepatic artery variations which have critical importance and to present them in conjunction with literature and current guidelines. As is known gastrectomy operation has a mortality rate of 10-20% in low-volume centers and 3-5% in high-volume centers. Postoperative mortality has a wide incidence range between institutions ranging from 11-46%.[8,9] The main factors causing morbidity include patient age, comorbidities, nutritional disorders, tumor tissue size, location and local invasion. Although not as common as these factors celiac truncus and hepatic artery variations are also an important factor of morbidity and even mortality. Partial or complete ligation of a hepatic artery that may occur if neglected can lead to ischemia or even necrosis

Table 3. Relationship between clinico-pathological factors and hepatic artery variation groups

Clinicopathological factors	No. of patients (%) Variation (-) (92 patients 80.7%)	Variation (+) (22 patients 19.3%)	p value
Age, year, median, range	67 (32-82)	68.5 (37-82)	p=0.706[U]
Radiology-surgery arterial variation confirmation, n (%)			
Absent	0 (0%)	4 (18.2%)	p<0.001[x2]
Present	92 (100%)	18 (81.8%)	
Tumor localication, n (%)			
Distal	29 (31.5%)	1 (4.5%)	p= 0.036[x2]
Middle	39 (42.4%)	13 (59.1%)	
Proximal	24 (26.1%)	8 (36.4%)	
Operation type, n (%)			
Subtotal gastrectomy	41 (44.6%)	5 (%22.6)	p=0.061[x2]
Total gastrectomy	51 (55.4%)	17 (%72.4)	
T stage, n (%)			
T insitu	11 (11.9%)	2 (9%)	p=0.4[x2]
T1	20 (21.8%)	1 (4.5%)	
T2	17 (18.5%)	5 (22.6%)	
T3	23 (25%)	7 (31.8%)	
T4	21 (22.8%)	7 (31.8%)	
Lymph node dissection, number, median, range	24 (10-54)	22.5 (13-38)	p=0.431[U]
Lymph node metastases, number, median, range	1 (0-27)	1 (0-20)	p=0.83[U]
N stage, n (%)			
n0	42 (45.7%)	10 (45.5%)	p=0.672[x2]
n1	23 (25%)	4 (18.2%)	
n2	12 (13%)	5 (22.6%)	
n3	15 (16.3%)	3 (13.7%)	
Tumor differentiation- morphology, n (%)			
Grade 1	22 (23.9%)	5 (22.6%)	p=0.280[x2]
Grade 2	28 (30.5%)	11 (50%)	
Grade 3	21 (22.8%)	2 (9%)	
Signet ring cell	21 (22.8%)	4 (18.4%)	
PNI, n (%)			
Absent	57 (61.9%)	15 (68.2%)	p=0.587[x2]
Present	35 (38.1%)	7 (31.8%)	
LVI, n (%)			
Absent	38 (41.3%)	8 (36.4%)	p=0.671[x2]
Present	54 (58.7%)	14 (63.6%)	
Preoperative ALT, IU/L, median, range	18 (7-95)	18 (10-40)	p=0.465[U]
Preoperative AST, IU/L, median, range	23.5 (5-208)	22 (12-73)	p=0.640[U]
Postoperative 24th hour ALT, IU/L, median, range	15 (1-119)	18.5 (8-225)	p=0.108[U]
Postoperative 24th hour AST, IU/L, median, range	23 (4-246)	26.5 (3-268)	p=0.570[U]
Hospital stay, day, median, range	7 (6-9)	7 (6-11)	p=0.131[U]
Follow-up time, month, mean±SD	25.87±14.32	26.45±14.09	p=0.863[T]

LVI: Lymphovascular invasion, PNI: Perinoral invazyon, ALT: Alanine aminotransferase, AST: Aspartate aminotransferase, SD: Standard deviation, X^2: Chi-Square test, U: Mann-Whitney U test, T: t-test

Table 4. Preoperative and postoperative 24th hour analysis of AST and ALT parameters in patients with Michels hepatic artery variation

Variable	Pre-operative measurement (22 patients)	Post-operative 24th hour measurement (22 patients)	p value
ALT, IU/L, mean±SD, median (range)	20.36±7.20 18 (10-40)	36.05±47.14 18.5 (8-225)	p=0.602[Z]
AST, IU/L, mean±SD, median (range)	26.45±14.36 22 (12-73)	44.86±57.13 26.5 (3-268)	p=0.476[Z]

ALT: Alanine aminotransferase, AST: Aspartate aminotransferase, SD: Standard deviation, Z: Wilcoxon Signed ranks test

in the liver which can result in patient mortality. Even though arterial structures are visualized preoperatively with imaging methods the sensitivity and specificity of imaging methods in predicting hepatic artery variations are not at sufficient levels. Therefore it is recommended that the surgeon evaluate tomography and angio images together with the radiologist and start lymphatic dissection from this area by first exploring the hepatic artery during operation.

The trifurcation structure of the celiac truncus was first described in detail by Andrea Vesalius in his work "De Humani Corporis Fabrica" published in 1543, laying the scientific

Table 5. Distribution of surgical-radiological arterial variation confirmation according to Michels classification

Variable	Michels hepatic artery variation classification					p value
	Type I (normal arterial anatomy)	Type II (aberrant left hepatic artery)	Type III (aberrant right hepatic artery)	Type IV (co-existence of type II and III)	Type V-X (rare variations)	
Radiology-surgery arterial variation confirmation, n (%)						
Absent	0 (0%)	0 (0%)	1 (16.7%)	2 (66.6%)	1 (50%)	<0.001[x2]
Present	92 (100%)	11 (100%)	5 (83.3%)	1 (33.4%)	1 (50%)	

X^2: Chi-Square test

foundations of vascular anatomy. Haller in his work "Icones Anatomicae" published in 1756, described this trunk as "tripus Halleri" and introduced it to literature.[10] Although this anatomy is the most commonly seen morphology in literature, it is reported in 85-90% of large series.[5] The systematic description of hepatic artery variations was first performed by Nicholas Michels in 1955 over a series of 200 autopsies and a classification consisting of 10 types was established.[7] Michels classification was later modified by Hiatt and colleagues[11] in 1994 with a 1000-case cadaver series and a more practical 6-type system was proposed. In this series normal hepatic artery anatomy was found in 75% while clinically significant variations were found in the remaining 25% of cases. These data revealed that hepatic artery variations are more common than expected and should not be overlooked. In our study the rate of patients with normal arterial anatomy was 80.7%, showing similarity with current results of Michels and Hiatt. The rate of our patients with type II arterial variation was 9.6%, the rate of patients with type III arterial variation was 5.3% and the rate of patients with type IV arterial variation was 2.6%. In the study by Culcu and colleagues based in Turkiye, the incidence rate of celiac truncus arterial variation was 37.1% and the incidence rate of type 2 arterial variation was 13.4%. It is noted that the incidence rates of arterial variation anomalies in both Turkiye-based and foreign-based studies are higher than those reported in the literature. This is because many studies on arterial variation are based on autopsy data. However, the morbidity and mortality outcomes caused by these anomalies have prompted researchers, especially surgeons, to conduct more comprehensive studies and investigations on this subject. We believe that the higher rates of arterial variation anomalies detected in recent studies are due to these reasons.

Correct identification of anatomical variations in the celiac truncus and its branches has critical importance in terms of preventing intraoperative complications and ensuring oncologic adequacy of lymphatic dissection especially in upper abdominal surgery and D2 lymphadenectomy applications. Currently the most reliable method used for this purpose is MDCTA (multidetector computed tomography angiography) which enables detailed revelation of vascular anatomy in the preoperative period. With this method the sensitivity and specificity of hepatic artery and celiac truncus variations are reported to be over 95%.[12,13] Furthermore MDCTA not only identifies variations but also provides information about vessel diameter, origin points and neighborhood relationships directly guiding the surgeon's intraoperative strategy. In our study artery variation could not be detected in radiological imaging examinations in 4 (3.5%) of our patients. Arterial phase abdominal tomography correctly identified all patients with type I, i.e., normal celiac truncus anatomy while it could not detect 66.6% of patients with type IV hepatic artery variation, 15.7% of patients with type III hepatic artery variation and 50% of patients with type V-X hepatic artery variation.

Being aware of celiac truncus and hepatic artery variations is not just an anatomical curiosity but a necessity directly related to surgical safety and oncologic radicality. Lack of knowledge about vascular variations in gastric cancer cases undergoing D2 lymphadenectomy can lead to both major vascular injuries that can increase mortality and inadequate lymphatic dissection that can negatively affect oncologic outcomes. We did not encounter any hepatic artery ligation or injury due to arterial anomaly in any of our patients who were operated on in our clinic and included in the study. This is because all our patients undergo evaluation of celiac truncus and hepatic arterial structures by us in addition to the radiology clinic. Vascular mapping and diagrams are prepared for all patients before operation and necessary briefing of the operation team and auxiliary healthcare personnel is performed. Indeed we see the results of this preparation in postoperative laboratory tests. There was no statistically significant difference between preoperative and postoperative values of our liver function tests. As is well known, ligation of even minor segmental branches of the hepatic artery can lead to temporary or permanent ischemia of the segment it supplies. This condition manifests itself as elevated AST and ALT values. Tao and colleagues[14] systematic review stated that the prevalence of ALHA variations ranges between 7% and 20.7% and there was a consistent difference between ligation and postoperative liver enzyme levels.[14,15] It supports that ligation of ALHAs with vessel diameter larger than 5 mm will cause postoperative hepatic dysfunction risk. Ang and colleagues[16] retrospective study shows that ligation is safe in patients with ALHA diameter >1.5 mm despite transient enzyme elevations.However possible hepatic artery injury or ligation in major arterial anatomic variations causes more morbid and mortal consequences. Kleive and colleagues[17] reported that even after planned hepatic artery resection and anastomosis in pancreaticoduodenectomy operations 73% of patients developed liver ischemia, necrosis, bleeding and liver abscess. We attribute the absence of uncontrolled ligation or injury in patients with hepatic variation in our study to multidisciplinary systematic evaluation, preparation of patients' vascular maps and diagrams and prior briefing of the operation team.

CONCLUSION

This study is a comprehensive research that systematically evaluates the frequency and clinical effects of celiac truncus arterial variations in the Turkish population. Our findings show that arterial variations especially the presence of ALHA, can be safely managed with appropriate preoperative evaluation and experienced surgical technique. Preoperative detailed imaging evaluation and individualized surgical planning are of critical importance for patient safety. We recommend that patients' preoperative imaging examinations be evaluated not only by radiology but also by the surgical team. Because while radiology evaluates a patient's operability decision considering main vascular anatomy, minor anatomic variations may be overlooked. Therefore we believe that, standardization of radiology reports and pre-meeting and case-specific vascular mapping review by the surgical team are two feasible steps we recommend to both reduce morbidity and maintain oncologic competence.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study has been approved by the Scientific Researches Ethics Committee of Gülhane Training and Research Hospital, Health Sciences University (Date: 02.07.2025, Decision No: 13).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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REFERENCES

1. Bray F, Laversanne M, Sung H, et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2024;74(3):229-263. doi:10.3322/caac.21834
2. Bakır G. Kadınların meme kanseri korkusu, kadercilik algısı ve seçilmiş faktörlerin erken tanı davranışlarına etkisi: İzmir Ekonomi Üniversitesi; 2022.
3. Marano L, Carbone L, Poto GE, et al. Extended lymphadenectomy for gastric cancer in the neoadjuvant era: current status, clinical implications and contentious issues. *Curr Oncol*. 2023;30(1):875-896. doi:10.3390/curroncol30010067
4. Lordick F, Carneiro F, Cascinu S, et al. Gastric cancer: ESMO Clinical Practice Guideline for diagnosis, treatment and follow-up. *Ann Oncol*. 2022;33(10):1005-1020. doi:10.1016/j.annonc.2022.07.004
5. Song S-Y, 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(1):278-288. doi:10.1148/radiol.09090389
6. Cirocchi R, D'Andrea V, Amato B, et al. Aberrant left hepatic arteries arising from left gastric arteries and their clinical importance. *Surgeon*. 2020;18(2):100-112. doi:10.1016/j.surge.2019.06.002
7. Michels NA. Blood supply and anatomy of the upper abdominal organs, with a descriptive atlas. (No Title). 1955.
8. Messager M, De Steur W, Van Sandick J, et al. Variations among 5 European countries for curative treatment of resectable oesophageal and gastric cancer: a survey from the EURECCA Upper GI Group (EUropean REgistration of Cancer CAre). *Eur J Surg Oncol (EJSO)*. 2016;42(1):116-122. doi:10.1016/j.ejso.2015.09.017
9. Pasquer A, Renaud F, Hec F, et al. Is centralization needed for esophageal and gastric cancer patients with low operative risk?: a nationwide study. *Ann Surg*. 2016;264(5):823-830. doi:10.1097/SLA.0000000000001768
10. Haller A. Lcones anatomicae in quibus aliquae partes corporis humani delineatae preponuntur et arteriarum potissimum historia continetur. 1756; Gottingen: Vandenhoeck. Vandenhoeck, Gottingen: (in German).
11. Hiatt JR, Gabbay J, Busuttil RW. Surgical anatomy of the hepatic arteries in 1000 cases. *Ann Surg*. 1994;220(1):50. doi:10.1097/00000658-199407000-00008
12. Valji K. Hepatic, splenic, and portal vascular systems. The Practice of Interventional Radiology, with online cases and video: Expert Consult Premium Edition-Enhanced Online Features and Print. 2011:356.
13. Sakamoto S, Kiura Y, Okazaki T, et al. Carotid artery stenting for vulnerable plaques on MR angiography and ultrasonography: utility of dual protection and blood aspiration method. *J Neurointerv Surg*. 2016;8(10):1011-1015. doi:10.1136/neurintsurg-2015-012052
14. Tao W, Peng D, Cheng Y-X, Zhang W. Clinical significance of aberrant left hepatic artery during gastrectomy: a systematic review. *World J Clin Cases*. 2022;10(10):3121-3130. doi:10.12998/wjcc.v10.i10.3121
15. Cui Z, Ding C, Li C, et al. Preoperative evaluation of the segmental artery by three-dimensional image reconstruction vs. thin-section multi-detector computed tomography. *J Thorac Dis*. 2020;12(8):4196-4204. doi:10.21037/jtd-20-1014
16. Ang RRG, Lee H-J, Bae JS, et al. Safety of ligation of aberrant left hepatic artery originating from left gastric artery in laparoscopic gastrectomy for gastric cancer. *Sci Rep*. 2020;10(1):5856. doi:10.1038/s41598-020-62587-7
17. Kleive D, Sahakyan MA, Khan A, Fosby B, Line P-D, Labori KJ. Incidence and management of arterial injuries during pancreatectomy. *Langenbecks Arch Surg*. 2018;403(3):341-348. doi:10.1007/s00423-018-1666-1