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Original Research Article

A STUDY OF ANATOMICAL VARIATIONS IN THE ORIGIN, LENGTH AND BRANCHES OF CELIAC TRUNK AND ITS SURGICAL SIGNIFICANCE

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ABSTRACT

Introduction: The anatomical variations of the Celiac trunk and its branches are due to developmental changes in the ventral splanchnic arteries. The arterial variations like other anatomical variations cannot be ignored during the operative procedures in abdomen. It is of great importance for the surgeon and radiologists during surgical and radiological procedures in upper abdomen. Main objective of the present study is to known the level of origin, length and variation in the branches of the Celiac trunk.

Materials and Methods: Study included 35 embalmed cadavers and 15 post mortem specimens. After the student studied the Celiac trunk the finer dissection was done and all the branches were traced.

Results: Length of Celiac trunk was between 0.4-2.9 cms. In 52% of cases it was between 1.1 – 1.5 cms, followed by 0.5-1m in 25% , 11% is between 1.6-2cms, only in 3 cases it was more than 2 cms. Celiac trunk with only 3 branches –Leftgastric, Common hepatic and Splenic artery was seen only in 72% of cases. In 20% of cases there was more than 3 branches. In 18% of cases Celiac trunk was giving origin to Inferior phrenic arteries. In 4% of cases the Celiac trunk was incomplete (gastro splenic trunk) giving only Leftgastric and Splenic, Common hepatic was directly arising from Aorta. Celiac trunk was absent in 4% of cases and all the 3 branches were arising directly from Aorta.

Conclusion: Variation in the branches of Celiac trunk is very common. Knowledge about these variations is important for Surgeons during upper abdominal surgeries and for Radiologists during selective arteriography.

KEY WORDS: Anatomical variations, Celiac trunk, Hepatic artery, Upper abdominal surgery, Selective arteriography.

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INTRODUCTION

Curiosity is the history of investigative work on the arteries. The publication of Vesalie's De Human Corporis Fabrica at Basel in June 1543 marked the beginning of modern anatomy. Since then few books with colored plates and text on arterial variations were observed in the human body have been published [1].

Adachi, who gave an extensive description of the Celiac axis and made small schematic drawings of 6 types with 28 sub types. Late Sir Arthur Keith (1866-1955) stressed the fact that in the biliary region "variation is rampant". For the blood supply of the supramesocolic organs,

to which the author has devoted 18years of study, the phrase should be altered to read that here "variation is common". Haller, the great physiologist, emphasized the need of an atlas on the variational anatomy of the Celiac artery, which supplies the upper abdominal organs, 200 years ago. He stated that frequently authors have followed Vesalius in describing the celiac artery, where in Vesalius was not so well versed in arterial arrangement as he was in bones and muscles. Haller devoted 8 pages to the Celiac axis. Michel's in 1955 published a book on blood supply and Anatomy of the upper abdominal organs. He explained about 7 types of Celiac trunk.

The recent intense development in certain fields of abdominal surgery have made imperative to have descriptive atlas whereby surgeons may obtain a clear appreciation and knowledge of the varied blood supply of upper abdominal organs. Anatomic variations are worth knowing as accurately and extensively as possible. Responsibility for teaching arterial variations lies with the anatomist, aceliac trunkion in their mode of severance is the problem of the surgeons. Anatomy and surgery are intertwined. Anatomist need not be a surgeon, but surgeons must always know in detail the anatomy of the body region he has selected for his operative procedures. Halsted pioneer American surgeon is remembered for the message he left to surgeons that the best way to avoid injury to blood vessels is to know them and to know how, when and where to ligate them properly [1].

Keeping in view of the applied importance and to add up some more knowledge for already existing ones, the present study was under taken to know in detail the level of origin, length and variation in the branches of Celiac trunk.

MATERIALS AND METHODS

50 specimens included embalmed 35 cadavers given for dissection to undergraduate students in department of Anatomy and 15 fresh specimens from postmortem bodies from department of forensic medicine, JSSMC, Mysore were selected for the study. Dissection method was used to study the specimens. After dissection celiac trunk branching pattern was noted, painted and photographed.

RESULTS

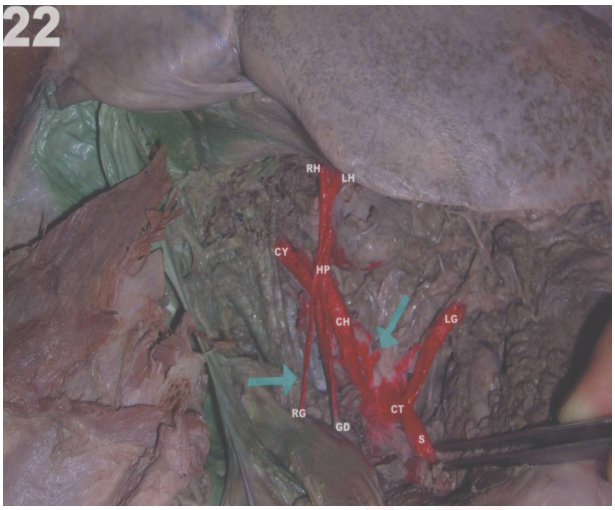
Celiac trunk was arising from Lower border of T12 in 66% of cases , followed by Upper border of L1 (24%) and in between T12 and L1 (4%). Length of celiac trunk varied from 0.4-2.9cms. The length of celiac trunk between 1.0 to 1.5 cm in 52.1%, <1.0 cm in25.0% and >1.5 cm in 22.9% specimens.

Complete celiac trunk with all the three branches arising from it was found in 92% of the cases; i.e.46 specimens. In two specimens celiac trunk was absent and all three branches were arising directly from Aorta and in two cases we observed Gastrosplenic trunk and Common hepatic was arising directly from Aorta. The 36 (75%) cases had trifurcation out of which 16 (45%) cases had classical variety remaining 20 (65%) cases had non classical variety, where in hepatic and splenic artery originated from a common point and left gastric from a different point. Collaterals were observed in 10 cases, among them in 8 cases (14.3%) celiac trunk had four branches out of which in 7specimens left inferior phrenic was the fourth branch and in one case dorsal pancreatic was fourth branch arising from Celiac trunk. In 2 cases (4.2%) of cases celiac trunk had five branches, both right and left inferior phrenic was from Celiac trunk.

A significant variations were observed in the frequencies of right & left hepatic arteries. Maximum number of cases right hepatic was arising from Hepatic artery proper (76%), followed by Common hepatic (20%) and least in Gastroduodenal (4%). Left hepatic from hepatic artery proper was observed in 76%, followed by Leftgastric (12%) and Common hepatic (12%). In 8% of the cases we observed Accessory hepatic artery and it was from Gastroduodenal (2%), Hepatic artery proper (2%), Leftgastric (2%) and from Superior mesenteric artery (2%).

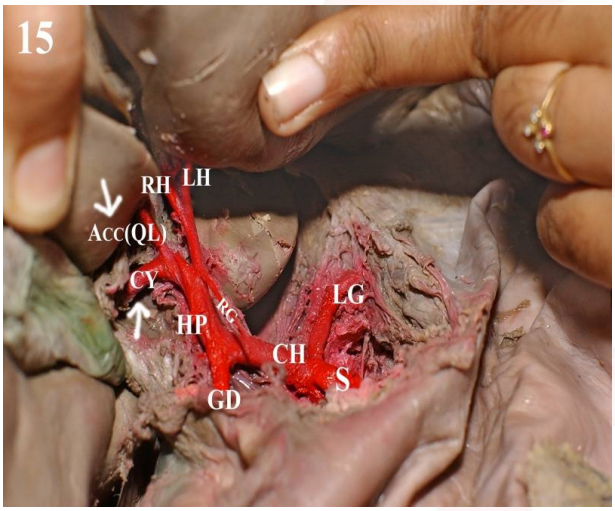
Origin of Rightgastric from Hepatic artery proper was observed in 46% followed by Common hepatic (28%) and in least number of the cases it was found from right hepatic (6%). Cystic artery was arising from right hepatic in 54%), Hepatic artery proper in 22%, Superior mesenteric artery in 2% and Accessory hepatic artery in 2% specimens 4.

Fig. 1: Gastro-Splenic trunk.



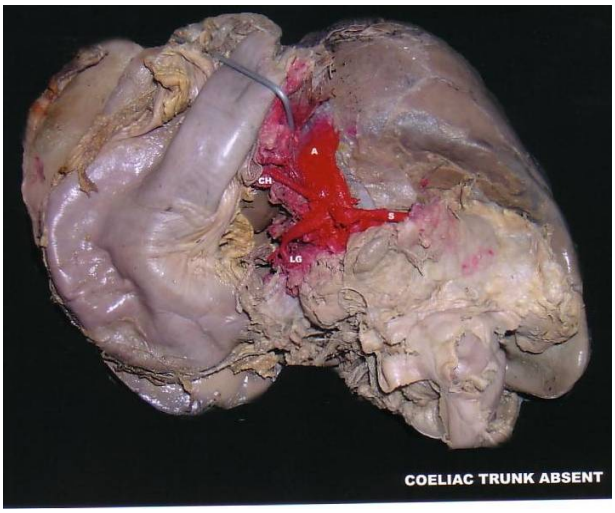
RH - Right hepatic, LH-Left hepatic, Cy-Cystic, CH-Common hepatic, RG-right gastric, CT-Celiac trunk, LG-Left gastric, S-Splenic

Fig. 3: Accessory Hepatic artery from Hepatic artery proper.



RH - Right hepatic, LH-Left hepatic, CH-Common hepatic, HP-Hepatic proper, RG-right gastric, LG-Left gastric, S-Splenic, ACC(QL)- Accessory hepatic artery to Quadrate lobe, Cy-Cystic, GD-Gastroduodenal.

Fig. 2: Absence of Celiac trunk.



A- Aorta, CH-Common hepatic, LG-Left gastric, S-Splenic

Table 2. Origin of Left hepatic compared with other study.

Source	Michel et al. (1955) [1]	R M Jones & K J Hardy (2010) [10]	Nikha bhardwaj (2010) [11]	Present study
CH	85%	81%	16.70%	12%
HP	0%	0%	71.60%	76%
LG	11%	15%	----	12%
Others	4%	4%	11.70%	0%

CH - Common Hepatic, HP - Hepatic Proper, LG - Left Gastric

Table 3: Origin of Right hepatic compared with other study.

Source	Michel (1955) [1]	R M Jones & K J Hardy (2010) [11]	Nikha bhardwaj [11]	Present study
CH	82.50%	75%	20%	20%
HP	0%	0%	65%	76%
SMA	12.50%	15%	---	0%
Others	5%	10%	14.90%	4%

CH - Common Hepatic, HP - Hepatic Proper, SMA - Superior Mesenteric Artery

Table 1: Type of Celiac trunk compared with other study [8].

Name	No of specimens	Celiac Trunk Complete (%)	Incomplete Celiac Trunk (%)	Celiaco Mesenteric trunk (%)	No Celiac Trunk (%)	Others(%)
Rossi	102	84	11	2.5	2.5	0
Leriche	55	84	9	1	0	6
Descomps	50	88	12	0	0	0
Branco	50	89	8	2	0	1
Picquard	50	82	14	2	2	0
Lipchutz	838	72	25	3	0	0
Eaton	206	90	9	1	0	0
Poynter	160	89	9	2	0	0
Mburu KS	123	61.7	17.9	-	-	20.3
Ugural	100	89	7			
Present Study	50	70	4	0	4	22

Table 4: Origin of RG compared with others study [1].

Source	Michel (1955) [1]	Present study
CH	40%	28%
LH	41.50%	10%
RH	5.50%	6%
MH	5%	0%
GD	8%	10%
HP	0%	46%

CH - Common Hepatic, LH - Left Hepatic Proper, RH - Right Hepatic, MH - Middle Hepatic, GD - Gastroduodenal, HP- Hepatic Proper.

Table 5: Origin of cystic artery compared with other study [13].

Origin	Anson	Michels	Moosman	Present Study
RH	74.70%	89%	87%	54%
LH	5.90%	4%	3%	0%
CH	14.90%	3%	5%	12%
GD	2.50%	4%	2%	8%
Others	1%	RARE	3%	0%
HP	0%	0%	0%	22%
SMA	0%	0%	0%	2%
AHA	0%	0%	0%	2%

CH - Common Hepatic, LH - Left Hepatic Proper, RH - Right Hepatic, MH - Middle Hepatic, GD - Gastroduodenal, HP- Hepatic Proper, AHA - Accessory Hepatic Artery.

DISCUSSION

Embryological Basis for the variations of celiac trunk: There is established a bilateral segmental distribution of arteries from the dorsal aortae to the viscera, before the primitive paired dorsal aortae become fused [2]. 2 types of visceral branches are formed

1. Paired lateral segmental branches

2. Paired ventral segmental branches (omphalomesenteric)

By obliteration of one artery, 2 primitive dorsal aortae become a single vessel. With the establishment of midgut, a group of paired vitelline arteries (right and left) coursing in its mesentery fuses to become common superior mesenteric trunk. Another group of paired ventral segmental arteries distributed to the infradiaphragmatic portion of the foregut form the Celiac artery cephalad to the group that gave rise to the Superior mesenteric trunk [1].

The segmentally arranged gut arteries apparently appear for a short duration and vary in number at different stages. The arteries, which are cranial to the Celiac trunk, disappear very early. According to Peen Kopf (1922) the 4mm embryo shows only unpaired visceral branches, which are not striceliac trunkly segmentally arranged. At the 8mm stage, all ventral branches of the Aorta have disappeared except the roots of the 3 main gut arteries.

Embryologically, Celiac artery represents the roots or the proximal ends of the vitelline arteries near the 7th cervical segment but subsequently in 17mm stage it is moved caudally to the 12th thoracic vertebra. According to Peen Kopf, the definitive stem of the Celiac artery is visible as early as 5mm stage of embryo. Celiac artery arising with 2 or 3 roots these roots fuses to form single root. Then with only one root, the origin of the artery wanders 10 segments caudally, so that in the 14mm stage it is already at the level of 9th thoracic segment. The branches of Celiac trunk are visible as early as 10mm embryo.

Formation of celiaco mesenteric trunk as been explained by Tandler (1904) on the following basis: In 4-17mm stage of embryo, omphalo mesenteric artery arises by 4 roots (10-13 ventral segments), which are united by a ventral longitudinal anastomosis running parallel to the Aorta. Normally greater part of this ventral longitudinal anastomosis disappears, along with the 2 middle roots (11 and 12), leaving the first root to become the stem of the Celiac and the last root becomes the stem of Superior mesenteric trunk. If the roots, which should have given origin to the celiac, undergo retrogression, while the ventral longitudinal anastamosis persists, a celiaco mesenteric trunk is formed.

Normally 3 main branches of the celiac trunk arises in series successively from the cranial end of the longitudinal anastomosis, these accounting for the fact that the Left gastric arises proximal to the origin of the Common hepatic and splenic. If the ventral anastomosis is interrupted between the Left gastric and splenic then the Left gastric will arise separately from the aorta, splenic and Common hepatic from Superior mesenteric trunk.

In short, ventral longitudinal anastomosis between the roots of the primitive arteries is the common source of origin of all the branches of the celiac artery and of the accessory Hepatic

artery, persistence of interrupted sections accounting for aberrancy in origin of the regional arteries [1].

Six types of Celiac trunk have been described by Hollinshed:

Type I - Hepato lieno gastric trunk - most common

Type II - Hepato lieneal trunk - Left gastric artery from Aorta

Type III - Hepato lieno mesenteric trunk - Hepatic, Splenic and Superior mesenteric arteries from a common Trunk and left gastric from Aorta

Type IV - Hepato gastric trunk - splenic artery takes separate origin

Type V - Lieno gastric trunk - Hepatic artery takes separate origin

Type VI - Celiaco mesenteric trunk

Type VI - Celiaco colic trunk - very rare

Celiac trunk normally arises at the level of lower border of T_{12} vertebra from abdominal aorta. In the present study celiac trunk was arising at the level of lower border of T12 in 66% few cases was at either upper border of T12 or L1. Previous authors have not mentioned about the level of origin of celiac trunk. The origin at the L1 level is of great importance for clinicians because SMA and renal arteries also arise from Aorta at L1.

In the present study the length varied from 0.4-2.9cms among 50 cases but as observed by others it varied from 0.8-4cms [1] 200 in cases.

Type of Celiac trunk: In the present study complete Celiac trunk was seen in 70% cases, which was close to Lipchutz study (72%) (Table 1). But in most of the earlier studies it was between 82-90%. Gastrosplenic trunk (fig.1) was observed in 2 cases (4%) but Sureka found gastrosplenic trunk only in 0.83% [3] & song et al found only in 0.40% [4]. Similar observation was made by ugurel that a normal coeliac trunk formed from the left gastric, splenic and common hepatic arteries was present in 89% of patients. Gastrosplenic trunk (Type V) was the most prevalent variation (4%), followed by hepatosplenic trunk (Type II) (3%) [5].

We observed trifurcation in 75% of cases out of which 45% of cases had classical trifurcation & 65% had non classical trifurcation. 20 % of cases had collaterals. Almost similar prevelencs of classical trifurcation is reported by Prakash in 76% [6] & Mburu etal observed the trifurcated in 61.7%, bifurcated in 17.9% and gave collateral branches in 20.3%, gastrosplenic trunk in 4.9% of cases [7].

Bergman et al published a metaanalysis of ''no coeliac trunk reports'' in the literature and calculated the average absence rate of coeliac trunk as 0.4% [8]. In our study, coeliac trunk was absent in 2 of the 50 cases (4%) which is highly significant (Fig. 2). Absence of celiac trunk was reported by petru et.al and all the three branches were originating from abdominal aorta. Arterial variations can have important implications during procedures such as chemoembolization of pancreas and liver tumors as well as in surgical intervention in this region [e.g., en-bloc resection of the CT with total gastrectomy and distal pancreatectomy for the treatment of advanced gastric cancer (Appleby procedure) [9].

Hepatic artery Variations: An intact hepatic artery is the gateway to successful hepatobiliary surgery. Introduction of laparoscopic cholecystectomy has stimulated a renewed interest in the anatomy of the hepatic artery [1]. Division or damage with subsequent thrombosis produces ischemia of the liver or bile duct which can have devastating consequences for the patient. Surgeons undertaking hepatobiliary surgery must know their hepatic artery anatomy and be able to recognise the multiple variants for safe surgery and low morbidity [10]. Anatomical variations of the hepatic arteries are of considerable importance in liver transplants, laparoscopic surgery, radiological abdominal interventions and penetrating injuries to the abdomen. Ugurel in his study reported normal hepatic arteries (Type I) in 52% of patients & the most common hepatic artery variations were replaced right hepatic artery (Type III) (17%), replaced left hepatic artery (Type II) (11%) and accessory left hepatic artery (Type V) (10%) according to Michels's classification. On the basis of Hiatt's classification, on the other hand, the most common hepatic artery variation was accessory or replaced left hepatic artery (Type 2) (22%) [5].

In the present study 92% of specimens common hepatic artery was arising from celiac trunk and in 8% was from Aorta. Accessory hepatic artery was present in 8% of cases, from Gastro duodenal (2%), Hepatic proper (2%, fig 3) , Superior mesenteric artery (2%) and from Left gastric (2%). Accessory hepatic artery which was from Gastro duodenal and Hepatic proper supplied the quadrate lobe and it is described as middle hepatic by previous worker and he found middle hepatic from Right hepatic and Left hepatic in 45% of cases each and in 10% from other sources [1]. A nother author observed middle hepatic in 103 cases out of 180 specimens. They found middle hepatic from Left hepatic/Right hepatic in 82 cases, in 9 cases from Gastro duodenal, from Superior mesenteric artery and Splenic in 2 cases each and from Left gastric and Common hepatic in one cases each [10]. In present study in one case accessory hepatic artery was from Gastro duodenal but previous authors observed in 9 cases. Previous authors noted accessory hepatic artery from Left gastric in 11.5% of cases [1]. Accessory hepatic artery is advantageous for safe arterializations in partial Liver grafts than with normal hepatic artery because thicker and longer arterial branches can be obtained with accessory hepatic artery. Accessory hepatic artery from SMA passes through head of Pancreas. Particulars about this variant are of great importance prior to pancreatectomy and hemihepatectomy. Sound knowledge of hepatic artery variations is helpful while planning treatment for esophageal varices and portal hypertension. During transartrial chemoembolization variation in the origin of Common hepatic artery should be kept in mind.

In majority of cases we observed Left hepatic was arising from Hepatic proper (76%) but other authors observed in majority of cases it was arising from Common hepatic [1,10] (Table 2). Present study value of Left hepatic from Left gastric was almost near to their study. We noticed Right hepatic from Hepatic proper in 76% (Table 3) of cases but previous authors observed in majority of cases it was from Common hepatic and they have not mentioned about Right hepatic & Left hepatic from Hepatic proper except Nikha Bhadwaj [11] but we noticed it in 76% of cases. Probably this difference is due to because we have considered the Hepatic artery into Common hepatic and Hepatic artery proper.

Left hepatic from Left gastric artery lies in the hepatogastric ligament and one must consider the possibility of such an artery before dividing the ligament to reach the gastro esophageal junction. Extra-hepatic arterial distribution of Liver is important because of higher demand on liver transplantation and advanced Liver surgery technique like split Liver surgery.

Origin of Left Gastric artery: Left gastric is the first branch of celiac trunk, its point of origin varies along the length of Celiac trunk. Left gastric from distal end of Celiac trunk was called as tripod type by many authors. We found tripod type or trifurcation of Celiac trunk into left gastric, Common hepatic and Splenic artery in 45% of cases. Previous authors observed tripod type in 25% [1] of cases and another found in 24% [12] of cases. In 20 cases (40%) Left gastric was given off first and then Celiac trunk bifurcates into Common hepatic and Splenic artery, previous authors mentioned this in 60% [12] and 49% [13] of cases.

In the present study 12% of cases Left gastric gave origin to Left hepatic and one author found in 15% [10] of cases and another found in 11.5% of cases [1]. Incidence of this variation is almost similar to the previous workers. This variation is important because in some cases it forms sole blood supply to the left lobe of Liver. In such cases if Left gastric ligated during gastrectomy then left lobe of the liver will suffer from ischemic necrosis. Prior knowledge of variation in origin of these arteries is important for oncosurgeons.

Origin of Splenic artery: Splenic artery was arising from Celiac trunk in 46 cases (92%), from Aorta in 4% of cases and as a Gastro splenic trunk in 4% of cases. Previous author observed Splenic artery from Celiac trunk in 86% of cases, from Aorta in 2% of cases, as a Gastro splenic trunk in 6% of cases, as a Hepato splenic trunk in 6% of cases [14]. Present study value is almost same as previous study, only difference is that we have not found Hepato splenic trunk.

Knowledge of variations of splenic artery is of extreme clinical importance while performing

Appleby procedure that is total pancreatectomy in case of carcinoma of pancreas body and tail [15]. Vascular anomalies are usually asymptomatic; they may become important in patients undergoing diagnostic angiography for gastrointestinal bleeding/transcatheter therapy [16]. Variations in the origin of Splenic artery is important for surgeons during splenectomy, gastrectomy and hepatic segmental resection and also while planning treatment for portal hypertension.

Haller first described dorsal pancreatic artery and he referred to it as arteria pancreatica suprema [13]. Dorsal pancreatic artery may arise from Splenic, Celiac trunk, Common hepatic or Superior mesenteric artery. Less frequently from Gastro duodenal, Aorta, Left inferior phrenic artery, Right gastric, Left gastric or Hepatic proper. The dorsal pancreatic artery arises from the splenic in 37% of cases, the celiac in 33%, the superior mesenteric in 21%, and the common hepatic artery in 8%, typically close to the aortic source [8]. In the present study, in one case Dorsal pancreatic artery was from Celiac trunk.

Normally Inferior phrenic artery arises from abdominal aorta. Occasionally it takes origin from Celiac trunk. We found in 9(18%) cases Inferior phrenic was from Celiac trunk out of which 2 (4%) (In Specimen No-4 and 7,) cases both right and left from Celiac trunk, and in 14% of cases only left was from Celiac trunk . Previous author mentioned Inferior phrenic from Celiac trunk in 50%[6] and another mentioned right inferior phrenic from Celiac trunk in 41.4% and left in 52.2% of cases [12].

In the present study good number of variations regarding the hepatic arterial pattern and Left gastric artery pattern were noticed. These observations are the guiding factors for interventional radiologist while performing Celiac angiographic studies and for surgeons performing gastrectomies, hepatic segmental resections and split liver transplantations.

Origin of Right Gastric artery: Previous workers observed in majority of cases Right gastric was from Common hepatic / Left hepatic but we noticed in majority of cases it was from Hepatic proper and from Common hepatic in 28% and from Left hepatic in 10% of cases [1]. Percent in origin of Right gastric from Gastro duodenal was almost same as previous study [1] (Table 4). Variation in the origin of Right gastric is important during ligating Common hepatic artery. Ligation of Common hepatic proximal to origin of Right gastric is compatible with normal functioning of the liver and if it is ligated distal to right gastric, total or severe necrosis is produced.

Origin of Cystic artery: Typically cystic artery arises from Right hepatic in calots triangle. In the present study cystic artery from Right hepatic was seen only in 54% of cases, which is less compared to previous study. Cystic artery was arising from Hepatic proper and Superior mesenteric artery in 22% and 2% of cases respectively. Previous workers have not observed this variation (Table 5). Cystic artery from Superior mesenteric artery passes through head of pancreas. This variation is important during resection of Pancreas. These days where laparoscopic cholecystectomy are very popular, the sound knowledge regarding variation of cystic artery origin is very essential. Because very limited field is magnified on the videomonitor, haemorrhcage could be a problem if these variations are not noted.

CONCLUSION

In the present study 20% of the cases had collateral branches. Celiac trunk variations are very common. To facilitate the safe operative procedures on the Liver and gall bladder, there is a need of exact and comprehensive knowledge of the varied patterns of hepatic and cystic arteries. Celiac trunk patterns are of importance in the planning and performance of all surgical and radiological procedures in the upper abdomen.

Conflicts of Interests: None

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