SCIENTIFIC ARTICLE

Study on the variations of the ventral abdominal aortic branches : a computed tomography based study

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Abstract

Introduction

The abdominal aorta [AA] begins at the aortic hiatus [at the 12th thoracic vertebra [T12]] and ends at the fourth lumbar vertebra [L4]. The main ventral branches of the AA are Coeliac Axis [CA], Superior Mesenteric Artery [SMA] and Inferior Mesenteric Artery [IMA]. Variations occur in branching pattern and the level of origin.

Methods

This is a cross-sectional, descriptive Computed Tomographic imaging [CT] based study done at the Teaching Hospital Anuradhapura, Sri Lanka from November 2018 to March 2019. Consecutive patients undergoing CT abdomen at the radiology department were selected. All images were analysed by the author in conjunction with the radiologist. Images of patients less than 25 years, incomplete records, non-clear images and images with the non-identifiable origin of the arteries were also excluded.

Results

102 were included. 53.9% were males. The mean age was 58.0 years. CA originated at the level of T12 in 68.3%.SMA originated at the L1 level in 90.2%. IMA originated at the L3 level in 89.3%. AA divided at the level of L4 in 81.8%. Three [2.9%] had variations including coelio mesenteric trunk, splenic artery/left gastric artery directly arising from the aorta.

Discussion and Conclusions

Visceral branches of AA develop from omphalo-mesenteric arteries [vitelline arteries] and their ventral anastomosis. The regression pattern of these arteries results in variations. In this study, SMA had the most consistent level of origin at L1. Variations of CA and SMA occurred in 2.9%. Awareness of these is important to avoid complications, especially in emergency surgeries.

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Introduction

The abdominal aorta [AA] begins at the level of the twelfth thoracic vertebra [T12] at the aortic hiatus of the diaphragm and ends by dividing into common iliac arteries [CIA] at the level of the fourth lumbar vertebra [L4]. The main anterior visceral branches of the AA are coeliac axis [CA], superior mesenteric artery [SMA] and inferior mesenteric artery [IMA]. Generally, CA originates at the level of T12, SMA arises at the level of L1 approximately 1.5 cms below the CA and the IMA originates at the level of L3. CA divides into common hepatic artery [CHA], splenic artery [SA] and left gastric artery [LGA]. These branches supply the liver, stomach, duodenum, pancreas and spleen. The absence of LGA results in the hepatosplenic trunk [HST] and the absence of SA results in the hepato gastric trunk [HST]. SMA supplies the entire small intestine other than the first part of the duodenum and it also supplies part of the large intestine [up to the left 1/3 of the transverse colon]. IMA supplies left [distal] 1/3 of the transverse colon, descending colon and the upper part of the rectum.

Variations of the level of origin and branching patterns of these arteries are known to occur due to the changes which take place during embryonic development [1]. The reported incidence of variations of the CA and the SMA are between 3% to 7.2% [2] [3]. Awareness of these variations is important to avoid disasters during interventions and surgeries. Such an instance is the absence of a superior mesenteric artery which is associated with dilatation of the inferior mesenteric artery. In such a situation ligation of the IMA, when repairing abdominal aortic aneurysm, results in lower intestinal ischaemia. Awareness of variations in CA and SMA is also important in liver transplantation [also in organ retrieval], liver resection, surgeries of the stomach and chemoembolization of liver tumours. Also, awareness of these variations in anatomy will prevent unnecessary dissection and associated morbidity during surgery and will prevent prolongation of surgeries.

This study aimed to describe the prevalence of variations of the level of origin and branching pattern of the anterior visceral branches of the aorta among patients presenting to the

Teaching Hospital of Anuradhapura [THA] Sri Lanka.

Methods

This was a cross-sectional descriptive study. Consecutive patients undergoing CT abdomen at the radiology department were selected. The study was done at the THA, Sri Lanka, from November 2018 to March 2019. Contrast-enhanced computed tomographic angiography [CTA] images in an arterial phase were analysed. All CT scans were performed by 160 detectors Toshiba Aquilion scanner machine. All images were transferred to the console and 3D reconstructions were made before analysis. The CTA images were analysed by both the author and the radiologist in the CT scan working station [console room]. Data on the patient's age, gender, details on branching level [Vertebral level] variations, branching pattern variations and the vertebral level of aortic division were obtained. Patients younger than 25 years were excluded. Because the vertebral level of origin is known to vary with the growth of the individuals [4]. Besides incomplete records, non-clear images and images with the non-identifiable origin of the arteries were also excluded from the analysis.

Results

A series of images from 102 patients were included. There were 55 [53.9%] males and 47 females. The mean age was 58.0 years [30 -88]. CA originated at the level of T12 in 68.3% and L1 level in 31.7% of patients. In females, CA was arising at T12 in 66.0% of individuals whereas it was arising at T12 in 70.4% of males. But this difference was not statistically significant [P-0.30]. SMA originated at the L1 level in 92 [90.2%] and T12 level in 9 [8.8%]. Of the 9 patients on whom the SMA originated at T12, 6 [66.7%] were females.

This difference was not statistically significant [p-0.20]. IMA originated at the L3 level in 89.3% and L2 level in 8.9%. IMA was not visualised in 29.1%. This happened in elderly patients due to atherosclerotic occlusion of the Ostia of the IMA. AA divided at the level of L4 in 81.8% and L3 in 18.2%. These differences of the level of origin were not significantly different between males and females. Three [2.9%] had variations, those were;

Coeliomesenteric trunk [CMT] in one patient [0.98%] [Figure 2]– In this variation, the CA and the SMA have a common origin.

Splenic artery [SA] arising directly from the aorta [this is also called the Hepato Gastric Trunk - HGT] – This was found in one [0.98%]. Left gastric artery [LG] arising directly from the aorta [in this situation the CHA and splenic arteries have a common origin i.e. hepatosplenic trunk - HST] – found in one [0.98%].

Discussion and conclusions

CA and SMA develop by a series of ventral branches [omphalomesenteric arteries -OMA or vitelline or ventral splanchnic arteries] from the dorsal aorta which appears during the embryological period [Figure 1]. These branches supply the yolk sac in the embryo [5]. A ventral longitudinal vessel connects the OMA [ventral longitudinal anastomosis] [1]. The first OMA develops into CA while the fourth develops into SMA. The common hepatic artery [CHA], LG and SA develop from this longitudinal anastomosis. The part of the longitudinal anastomosis distal to these branches and the second, third OMA disappear thus separating CA and SMA. If the First or the fourth OMA disappear common coelio mesenteric trunk develops. Other forms of regression of anastomosis and regression of OMA result in other variations.

The reported incidence of CMT is about 2.7% to 5.4% [1]. While the reported incidence of HGT is between 0.08% to

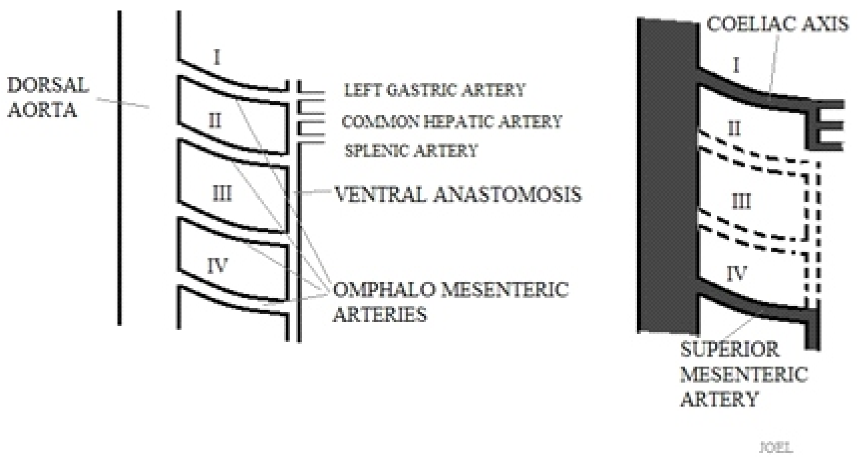

Figure 1. Coelio Mesenteric Trunk development

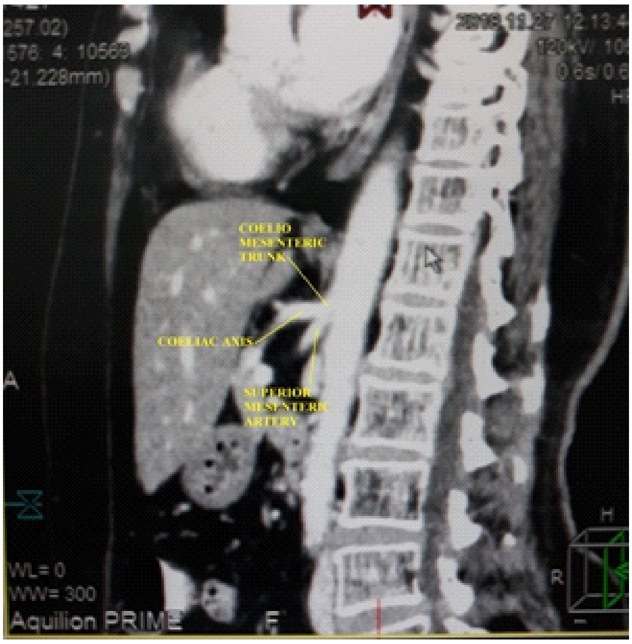

Figure 2. Coelio mesenteric trunk

7.2% [2] [6]. HST occurs at a rate of 0.02% [7]. In this series, CA originated at the level of T12 in 68.3% of individuals. Other similar series also report a similar level of origin in about 38% - 64% of cases [5] [8]. The SMA is fairly constant in respect to the level of origin i.e. 90.2% at the L1 level. The reported level of origin of IMA is at L3 in 47 - 66% of cases [9]. Knowing the level of origin of the CA and its branches variation is extremely important especially in upper abdominal and liver surgeries. Accidental ligation of variant arteries e.g in the case of Celio mesenteric trunk can result in disastrous complications [10]. Similarly in the case of bleeding pre-operative knowledge of the variations is important to prevent unnecessary complications. Besides in endovascular aneurysm repair, knowing the exact level of origin and the variations is important to prevent inadvertent occlusion of the origin and post-procedure organ ischemia. Another example is the absence of a superior mesenteric artery which is associated with dilatation of the inferior mesenteric artery. In such a situation ligation of the IMA, when repairing abdominal aortic aneurysm, results in lower intestinal ischaemia [11].

Division of aorta occurs above the level of L4 vertebral level in 18.2% [as in this series] to as high as 53.84% in some series [10]. Knowing this level is also important in clinical practice. When radiotherapy is utilised to treat carcinoma of the cervix, usually the upper limit is determined as L4-L5 intervertebral disc. This level is chosen to cover the iliac lymph nodes. If there is a higher division of the aorta [i.e. at L3 level in 18.2% as in this series], a significant length of CIA and therefore a significant number of iliac lymph nodes would be missed if the radiotherapy field is not shifted upwards. Therefore knowing the level of aortic division is important.

Therefore as discussed above branching variations occur in the anterior visceral branches of the abdominal aorta especially about the level of origin and the branching pattern especially in CA and its branches [2.9%] as in this series. The awareness of these variations in the branches of the aorta is important especially during emergency surgeries. The practice of pre interventional imaging and determination of the variations is important to prevent unwanted complications.

All authors disclose no conflict of interest. The study was conducted in accordance with the ethical standards of the relevant institutional or national ethics committee and the Helsinki Declaration of 1975, as revised in 2000.

References

1. Coeliomesenteric trunk - a rare variation to be aware of. Arudchelvam, J. 3, 2019, Sri Lanka Journal of Surgery, Vol. 37, pp. 8-9. DOI: http://doi.org/10.4038/sljs.v37i3.8621
2. Variations in the anatomy of the celiac trunk: A systematic review and clinical implications. Panagouli, E, Venieratos, D and Lolis E, Skandalakis, P. 6, 2013, Ann Anat, Vol. 195, pp. 501-511. doi: 10.1016/j.aanat.2013.06.003.
3. Analysis of anatomical variations of the main arteries branching from the abdominal aorta, with 64-detector computed tomography. Kornafel, O., Baran, B., Pawlikowska, I., Laszczyński, P., Guziński, M., & Sąsiadek, M. 2, 2010, PMID: 22802775; PMCID: PMC3389861.
4. Variation in the vertebral levels of the origins of the abdominal aorta branches: a retrospective imaging study. Fataftah, J., Amarin, J. Z., Suradi, H. H., Hadidi, M. T., Shatarat, A. T., Manasra, A., Shahin, S., Badran, D. H. 3, 2020, Anatomy & cell biology, Vol. 53, pp. 279–283. doi: 10.5115/acb.20.048.
5. The abdominal aorta and its branches: anatomical variations and clinical implications. Prakash, Mokhasi V, Rajini T, Shashirekha M. 4, Nov 2011, Folia Morphologica, Vol. 70, pp. 282-286. PMID: 22117246
6. A composite study of the celiac axis artery. Lipshutz, B. 1917, Ann. Surg, Vol. 65, pp. 159–169. doi: 10.1097/00000658-191702000-00006.
7. Celiac axis and common hepatic artery variations in 5002 patients: systematic analysis with spiral CT and DSA. Song, S.Y., Chung, J.W. and Yin, Y.H. 2010, Radiology, Vol. 255, pp. 278–288. doi: 10.1148/radiol.09090389.
8. A study of morphology of the proximal part of ventral branches of abdominal aorta in cadavers. Kruti Bharatkumar Tapiyawala, M. Natarajan. 24, 2015, International Journal of Current Research and Review, Vol. 7, pp. 01-05. DOI 10.31782/2231-2196
9. Inferior mesenteric arterial patterns. An angiographic study. Kahn P, Abrams HL. 1964, Radiology, Vol. 82, pp. 429–42. doi.org/10.1148/82.3.429
10. Multiple variations in the branching pattern of abdominal aorta. DV. Prabhakar, SM. Santram, KP. Raghunath, GS. Hanumant. 2014, Int J Anat Var [IJAV], Vol. 7, pp. 86–88.
11. Absence of the superior mesenteric artery in an adult and a new classification method for superior-inferior mesenteric arterial

variations. Wu Y, Peng W, Wu H, Chen G, Zhu J, Xing C. 5, 2014, Surg Radiol Anat, Vol. 36, pp. 511-5.
DOI: https://doi.org/10.1007/s00276-013-1183-4

12. Implication of Bifurcation of Abdominal Aorta for Radiotherapy Planning for Cervical Cancers. Thiru Raju Arul Ponni, Handanakere Udayashankara Avinash, Manur Gururajachar Janaki, Agrahara Srinivas Kirthi Koushik , Mohan Kumar Somashekar. 12, 2015, J Clin Diagn Res, Vol. 9, pp. XC01–XC03. doi: 10.7860/JCDR/2015/15051.6902