Original Article

DOI: 10.7860/JCDR/2022/59567.17062

Anatomy Section

Variations in the Ventral Branches of Abdominal Aorta by Computed Tomography: A Cross-sectional Study

TAJINDER PAL KAUR[1], MONIKA GUPTA[2], MANJOT KAUR[3]

ABSTRACT

Introduction: Computed Tomography is an advanced imaging technique of radiography which gives good information regarding vascular anatomy. Abdominal aorta and its branches show variations in their origin. The present study may facilitate the clinicians and surgeons for planning treatment and thus, post-treatment complications may be reduced.

Aim: To find out the variations in the origin of ventral branches of abdominal aorta in relation to vertebrae and diameters of these arteries at their level of origin.

Materials and Methods: A descriptive cross-sectional study was done on Contrast Enhanced Computed Tomography scan films of abdomen of 300 patients. The duration of study was of two years and four months, from September 2020 to January 2022. To determine the level of origin of ventral branches of abdominal aorta, every branch was divided into four types (Type I to IV) depending on the level of origin in relation to intervertebral disc, upper 1/3rd, middle 1/3rd and lower 1/3rd of body of corresponding vertebra. Diameter of each branch was measured at its level of origin.

Results: Statistical analysis of data had shown that the most common origin of Celiac Trunk (CT) was at the level of T12 vertebra (44.33%), for Superior Mesenteric Artery (SMA), the most common origin was at the level of L1 vertebra (64%) and for Inferior Mesenteric Artery (IMA), the most common origin was at the level of L3 vertebra (68.67%). Mean diameter of CT, SMA and IMA was 5.91±0.48 mm, 5.86±0.40 mm and 3.13±0.44 mm, respectively. Variations in the level of origin have significant correlation to vertebra (Pearson's correlation coefficient=0.01).

Conclusion: The CT, SMA and IMA have shown variations in their level of origin and significant correlation with each other in relation to corresponding vertebra. This knowledge can be helpful to the clinicians and surgeons while planning treatment of abdominal organs.

Keywords: Celiac trunk, Diameter, Inferior mesenteric artery, Superior mesenteric artery, Vertebrae

INTRODUCTION

Abdominal aorta is main artery which supplies the oxygenated blood to abdominal organs. It usually starts at the aortic hiatus of the diaphragm at the level of 12th thoracic vertebra and extends to the 4th lumbar vertebra. It is posteriorly related to 12th thoracic vertebra (T12), 1st to 4th lumbar vertebrae (L1, L2, L3, L4 vertebrae) and their intervertebral discs. Its ventral branches are celiac trunk, superior and inferior mesenteric arteries, lateral branches are paired right and left renal, suprarenal, gonadal arteries, dorsal branches are paired inferior phrenic and lumbar arteries and one median sacral artery. It bifurcates into right and left common iliac arteries at the level of 4th lumber vertebra [1]. Embryologically, it is formed from left dorsal aorta and fused median vessel [2]. Vasculature of abdominal organs shows many patterns of origin [3]. Knowledge of variations of abdominal aorta and its branches is important in organ transplants, laparoscopic surgeries and deep injuries to the abdomen [4]. Celiac trunk is most important branch which is affected by thrombosis and external compression [5]. Variations are mostly identified in the routine dissection of cadavers done in the educational Institutes and during routine surgical procedures [6]. These are also detected in advanced imaging techniques such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) techniques. MRI is good but, it is time consuming where as in Computed Tomography, large number of images at different levels are generated in short period of time and is preferred as compared to other techniques [3].

The previous studies have shown that there are number of variations in the branching pattern of abdominal aorta. Mokhasi V et al., in their study on 50 cadavers in Karnataka (South India), observed the variations in the origin of main branches of abdominal aorta in relation to vertebra [7]. Achantani YR et al., did a retrospective study in Puducherry (India) on the CT images of 200 patients and concluded that variations are common in celiac trunk, hepatic and renal arteries [8]. The present study was done to describe variations in origin of CT, SMA and IMA of abdominal aorta.

MATERIALS AND METHODS

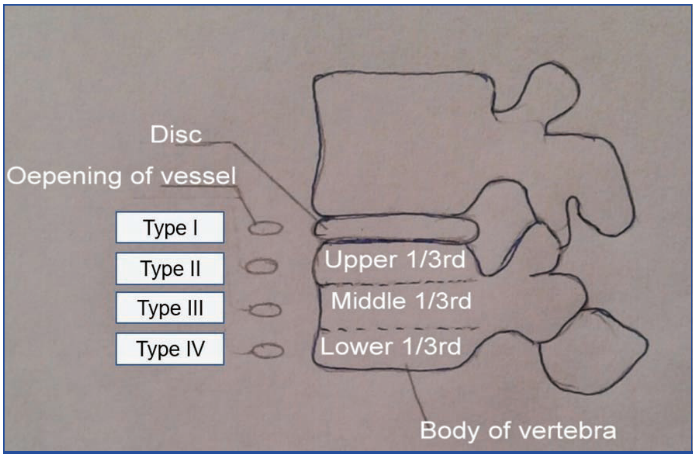
A descriptive cross-sectional study was conducted at the Department of Radiodiagnosis and Anatomy of Adesh Institute of Medical Sciences and Research, Bathinda, Punjab, India. The study was done for the period of two years and four months (September 2020 to January 2022). Permission to conduct the study was obtained from Institutional Research Committee and Institutional Ethics Committee of Adesh University, Bathinda, (AU/EC/FM/47/2020). Informed written consents from the patients were taken. Contrast Enhanced Computed Tomography (CECT) scan films of abdomen of the 300 patients were examined. These patients visited the Department of Radiodiagnosis for other reasons during research period. These scans were taken with 32-Slice Siemens Somatum Go Up Computed Tomography machine with inbuilt Syngo software. Counting of the vertebrae was done from sacral to lumbar region. Body of each vertebra was divided into three parts, upper 1/3rd, middle 1/3rd and lower 1/3rd. Intervertebral disc was taken into consideration. The origin of CT, SMA and IMA in relation to vertebrae was determined. Variations for each artery were noted as:

Type I: Origin at intervertebral disc

Type II: Origin at upper 1/3rd of vertebra

Type III: Origin at middle 1/3rd of vertebra

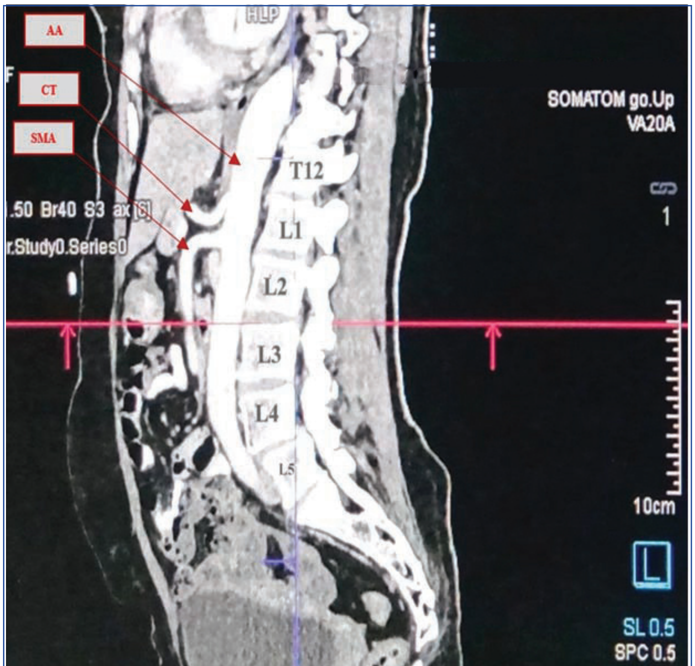
Type IV: Origin at lower 1/3rd of vertebra [Table/Fig-1].



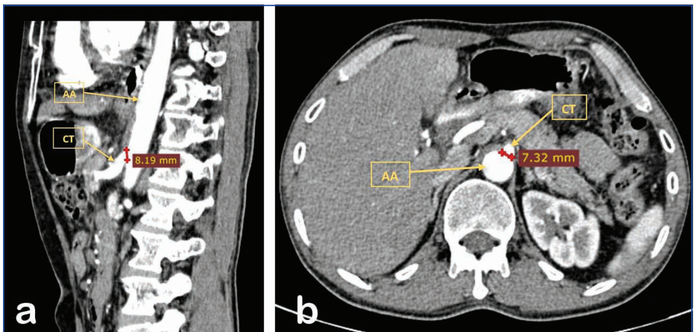
[Table/Fig-1]: Schematic diagram of two adjacent vertebrae with intervertebral disc showing the division of body of vertebra into three parts, upper 1/3rd, middle 1/3rd, lower 1/3rd and types of arteries depending on the level of opening: Type I, Type II, Type III and Type IV.

Contrast Enhanced Computed Tomography scan of abdomen of patient (sagittal section) showing T11 and T12 (11th and 12th thoracic vertebrae) and L1, L2, L3, L4 and L5 (five Lumbar vertebrae) [Table/Fig-2].

Vertical and horizontal diameter of each artery was noted at its origin from abdominal aorta. Mean of both diameters was considered final diameter [Table/Fig-3a,b].



[Table/Fig-2]: Contrast Enhanced Computed Tomography (CECT) scan film of abdomen (sagittal section) showing Abdominal Aorta (AA), origin of Celiac Trunk (CT level L1 Type II) and Superior Mesenteric Artery (SMA level L1 Type II) in relation to vertebrae.



[Table/Fig-3]: a) CECT scan sagittal section showing the measurement of vertical diameter of Celiac Trunk (CT) 8.19 mm. AA is abdominal Aorta; b) CECT scan (horizontal section) showing measurement of horizontal diameter of Celiac Trunk (CT) 7.2 mm. The mean of vertical (8.19 mm) and horizontal diameter (7.32 mm) was 7.7 mm, taken as final measurement.

STATISTICAL ANALYSIS

The collected data was analysed by using Statistical Package for the Social Sciences (SPSS) software version 23.0 and Independent t-test was applied for equality of means.

RESULTS

Mean age and SD of the patients was 49±16.48 years and range was (21-90) [Table/Fig-4]. Most common origin of CT was at the level of T12 vertebra which was 44.33% and Type IV was most prevalent (22%). There was no case of absence of CT [Table/Fig-5].

S. No.	Age group (years)	No. of patients	Percentage (%)
1.	21-30	49	16.3
2.	31-40	57	19.0
3.	41-50	50	16.7
4.	51-60	50	16.7
5.	61-70	64	21.3
6.	71-80	24	8.0
7.	81-90	6	2.0
	Total	300	100.0

[Table/Fig-4]: Distribution of cases according to age group in the patients.

Name of artery	Vertebra	Types				Total
		I (%)	II (%)	III (%)	IV (%)	
CT	T11	0	0	1 (0.33)	1 (0.33)	2 (0.67)
	T11-T12	5 (1.67)	0	0	0	5 (1.67)
	T12	0	33 (11)	34 (11.33)	66 (22)	133 (44.33)
	T12-L1	60 (20)	0	0	0	60 (20)
	L1	0	61 (20.33)	24 (8)	9 (3)	94 (31.33)
	L1-L2	4 (1.33)	0	0	0	4 (1.33)
	L2	0	2 (0.67)	0	0	2 (0.67)
Total		69 (23)	96 (32)	59 (19.67)	76 (26.33)	300 (100)

[Table/Fig-5]: Variations shown by CT in relation to vertebra.

The most common origin of SMA was at the level of L1 vertebra which was 64% and Type II was most prevalent (30.33%). There was no case of absence of SMA [Table/Fig-6].

Name of artery	Vertebra	Types				Total (%)	
		I (%)	II (%)	III (%)	IV (%)		
SMA	T12	0	6 (2)	6 (2)	22 (7.33)	34	(11.33)
	T12-L1	39 (13)	0	0	0	39	(13)
	L1	0	91 (30.33)	73 (24.33)	28 (9.33)	192	(64)
	L1-L2	22 (7.33)	0	0	0	22	(7.33)
	L2	0	6 (2)	5 (1.67)	2 (0.67)	13	(4.34)
Total		61 (20.33)	103 (34.33)	84 (28)	52 (17.33)	300	(100)

[Table/Fig-6]: Variations shown by SMA in relation to vertebrae.

Most common origin of IMA was at the level of L3 which was 68.67% and Type II was most prevalent (29.33%) [Table/Fig-7]. Statistical analysis of the data had shown that there was significant correlation between vertebral levels of origin of CT, SMA and IMA with each other in relation to vertebra as the Pearson's correlation coefficient was significant at the level of 0.01 (2-tailed) and p-value was <0.05 (significant) [Table/Fig-8].

It was observed that diameter of three arteries (CT, SMA and IMA) increased with advancing age upto the age groups 1-5 (21-70 years). In the age group 6 (71-80 years) and 7 (81-90 years) there was decline in diameter [Table/Fig-9].

Diameters: For CT mean±SD was 6.31±0.43, for SMA mean±SD was 6.37±0.43 and for IMA mean±SD was 3.67±0.53 [Table/Fig-10].

Name of artery	Vertebra	Types				Total
		I (%)	II (%)	III (%)	IV (%)	
IMA	L1	0	0	0	2 (0.67)	2 (0.67)
	L1-L2	1 (0.33)	0	0	0	1 (0.33)
	L2	0	4 (1.33)	9 (3)	24 (8)	37 (12.33)
	L2-L3	22 (7.33)	0	0	0	22 (7.33)
	L3	0	88 (29.33)	76 (25.33)	42 (14)	206 (68.67)
	L3-L4	7 (2.33)	0	0	0	7 (2.33)
	L4	0	18 (6)	5 (1.67)	0	23 (7.67)
	L4-L5	2 (0.67)	0	0	0	2 (0.67)
Total		32 (10.67)	110 (36.67)	90 (30)	68 (22.67)	300 (100)

[Table/Fig-7]: Variations shown by IMA in relation to vertebrae.

Artery	Correlation (r-value)			p-value
	CT	SMA	IMA	
CT	1	0.861	0.858	<0.05
SMA	0.861	1	0.906	<0.05
IMA	0.858	0.906	1	<0.05

[Table/Fig-8]: Pearson's correlation coefficient between CT, SMA AND IMA.

S. No.	Age groups (years)	CT (Diameter) Mean±SD	SMA (Diameter) Mean±SD	IMA (Diameter) Mean±SD
1.	21-30	5.91±0.48	5.86±0.40	3.13±0.44
2.	31-40	6.15±0.35	6.18±0.40	3.37±0.46
3.	41-50	6.39±0.20	6.41±0.30	3.63±0.34
4.	51-60	6.44±0.31	6.44±0.19	3.89±0.26
5.	61-70	6.52±0.45	6.62±0.23	4.09±0.46
6.	71-80	6.47±0.40	6.59±0.45	3.93±0.35
7.	81-90	6.41±0.46	6.45±0.51	4.06±0.44

[Table/Fig-9]: Comparison of diameter of CT, SMA and IMA Values presented in mm.

Name of artery	Minimum diameter in mm	Maximum diameter in mm	Mean±SD
Celiac trunk	4.65	8.85	6.31±0.43
Superior mesenteric artery	4.85	7.05	6.37±0.43
Inferior mesenteric artery	2.50	4.75	3.67±0.53

[Table/Fig-10]: Statistical analysis of diameters of CT, SMA and IMA (Total cases=300).

The diameters of CT, SMA and IMA at their origin were more in males as compared to females of same age group, as p-value for CT, SMA and IMA was <0.05, <0.04 and <0.001, respectively [Table/Fig-11].

Name of artery	Gender	Mean±SD	Minimum diameter in mm	Maximum diameter in mm	p-value
CT	Male	6.58±0.29	5.65	8.85	<0.05
	Female	5.94±0.31	4.65	6.40	
SMA	Male	6.60±0.27	5.80	7.05	<0.04
	Female	6.04±0.39	4.85	6.55	
IMA	Male	3.98±0.37	3.15	4.75	<0.001
	Female	3.26±0.42	2.50	3.75	

[Table/Fig-11]: Comparison of diameter of CT, SMA, IMA in males and females (Total cases=300).

DISCUSSION

Anatomic variations in the origin and course of branches of abdominal aorta should be taken into consideration during abdominal investigations and operative procedures because many complications can be avoided [9]. In the present study, the most common origin of CT, SMA and IMA has been compared with previous studies is shown in [Table/Fig-12].

Study	Sample size	CT most common vertebral level (%)	SMA most common vertebral level (%)	IMA most common vertebral level (%)
Mokhasi V et al.,[7] 2011, Karnataka, India	50	T12 (64%)	L1 (76%)	L3 (68%)
Wamanrao MU and Ramakrishna KY [9], 2016, Maharashra, India	40	L1 (Upper border)	L1 (Lower border)	L3 (Lower border)
Fatafthah J et al., [10], 2020, Jorden	227	T12-L1 (42.3%)	L1 (46.3%)	L3 (53.7%)
The present study, 2022, Punjab, India	300	T12 (44.33%) Level T12 Type IV (22%)	L1 (64%) Level L1 Type II (30.33%)	L3 (68.67%) Level L3 Type II (29.33%)

[Table/Fig-12]: Comparison of present study with previous studies [7,9,10].

In present study, the most common level is T12 (44.33%) which is considered normal and the remaining levels of vertebrae (55.67%) are considered variations while in Mokhasi V et al., study in South Indian the origin of CT at T12 (64%) and there is remarkable differences in the origin of CT in relation to T12 vertebra [7]. In Wamanrao MU and Ramakrishna KY study on West Indian population, the most common origin of CT was at the level of L1 vertebra [9]. In a study by Fatafthah J et al., in Jordan, the most common origin of CT was at the level of intervertebral disc between T12-L1 vertebra [10]. Ugurel MS et al., in his study reported 1% absence of CT [11]. In the present study there was no case of absence of CT. In present study, the most common level of origin of SMA was at the level of L1 vertebra 64% and the most common level is L1 (64%) which is considered normal and the remaining level of vertebrae (36%) are considered variations. In the case of IMA, most common origin was found at the level of L3 vertebra 68.67% which is slightly close to Mokhasi V et al., study in which IMA was at level of L3 vertebra (76%). Another finding in the present study was that the vertebral level of origin of CT, SMA and IMA had correlation with each other as Pearson's correlation coefficient was significant at the level of 0.01 (2-tailed).

Diameter: It was observed in the present study that the diameter of CT, SMA and IMA had shown regular increase in the age groups 1-5 (21-70 years) and there was decrease in age groups 6-7 (71-90 years). An increase in the diameter with increasing age can be explained on the basis of blood pressure changes taking place in the arteries and decrease after 71 years of age, may be due to regressive changes taking place in anatomy of arteries. These are the assumptions, but further studies on diameter should be done to find the exact reason, of this type of changes with age.

Limitation(s)

In CT scans of abdomen, pressure of visceral organs on the vessels may affect measurements.

CONCLUSION(S)

From the present study, it is concluded that variations exist in the level of origin of ventral branches of abdominal aorta in relation to vertebra. CT had shown more variations as compared SMA and IMA. Diameter of these branches was affected by gender and by advancing age. Knowledge of variations can be helpful to the clinicians in diagnosis of developmental clinical conditions and their treatment. These may help the surgeons, while planning abdominal surgeries and organ transplantations.

Acknowledgement

Authors are thankful to Dr. Anshul, Dr. Navdeep (Postgraduate students) in the Radiology Department for their contribution to complete the present study. Authors are also grateful to Mr. Jaspreet and Mr. Nirbhau radio technicians for their help in the present study.

REFERENCES

[1] Mirjalili. Abdomen and Pelvis. Susan S. Gray's Anatomy. 41st ed. New Delhi: Elsevier. 2016.p.1083-90.
[2] Singh I. Cardiovascular System. Human Embryology. 10th ed. New Delhi: JP Medical Ltd. 2014. p. 260-62.
[3] Brasil IR, Araujo IF, Lima AA, Melo EL, Esmeraldo RD. Computed tomography angiography study of variations of the celiac trunk and hepatic artery in 100 Patients. Radiol Bras. 2018;51(1):32-36.
[4] Dao SB, Boubakar O, Moussa Z, Bénild KT, Nina NO, Annick R, et al. Anatomical variants of celiac trunk in relation to its branching: A preliminary sub-saharan study. Open J Radio. 2019;9(02):151-61.
[5] Farghadani M, Momeni M, Hekmatnia A, Momeni F, Mahdavi MM. Anatomical variation of celiac axis, superior mesenteric artery, and hepatic artery: Evaluation with multidetector computed tomography angiography. J Res Med Sci. 2016;21:01-05.
[6] Tiwari S, Kataria S, Verma R. Symmetrical variations in the branching pattern of abdominal aorta: A case report. Int J Anat Var (IJAV). 2014;7:83-85.
[7] Mokhasi V, Rajini T, Shashirekha M. The abdominal aorta and its branches: Anatomical variations and clinical implications. Folia Morphol. 2011;70(4):282-86.
[8] Achantani YR, Ramushothama Raju N, Ramesh Kumar R. Variants of coeliac trunk, hepatic artery and renal arteries in Pondicherry population. Int J Anat Radiol Surg. 2018;7(1):RO38-43.
[9] Wamanrao MU, Ramakrishna KY. Anatomical study of abdominal aorta and its branches for multiple variations. Int J Anat Res. 2016;4(2):2320-27.
[10] Fatafthah J, Amarin JZ, Suradi HH, Hadidi MT, Shatarat AT, Al Manasra AR, et al. Variation in the vertebral levels of the origins of the abdominal aorta branches: A retrospective imaging study. Anat Cell Biol. 2020;53(3):279-83.
[11] Ugurel MS, Battal B, Bozlar U, Nural MS, Tasar M, Ors F, et al. Anatomical variations of hepatic arterial system, celiac trunk and renal arteries: An analysis with multidetector CT angiography. Br J Radiol. 2010;83(992):661-67.

PARTICULARS OF CONTRIBUTORS:

1. PhD Scholar, Department of Anatomy, Adesh Institute of Medical Scienecs and Research, Bathinda, Punjab, India.
2. Professor and Head, Department of Anatomy, Adesh Institute of Medical Scienecs and Research, Bathinda, Punjab, India.
3. Professor and Head, Department of Radiodiagnosis, Adesh Institute of Medical Scienecs and Research, Bathinda, Punjab, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Monika Gupta,
House No. 19184, Street No. 8, Opposite D.A.V. College, Bathinda, Punjab, India.
E-mail: drmonikagupta76@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Aug 14, 2022
- Manual Googling: Oct 10, 2022
- iThenticate Software: Oct 12, 2022 (6%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Aug 08, 2022**
Date of Peer Review: **Sep 13, 2022**
Date of Acceptance: **Oct 19, 2022**
Date of Publishing: **Nov 01, 2022**