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Morphogenesis Of Abdominal Aorta In Foetuses

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Abstract:
Background: *Knowledge of aortic morphometric parameters are important to define normal growth patterns to recognize the congenital aortic abnormalities.*
Aims: *To determine the location and development of the foetal abdominal aorta at different gestational age group.*
Settings and Design*: This was a cross-sectional study carried out in the Department of Anatomy, during January 2021to October 2022, after taking ethical clearance.*
Methods and Material*: 45 foetuses of different gestational age groups (22 males; 23 females) were dissected. Different measurements of the parameters of Abdominal aorta and the vertebral level of origin of coeliac trunk, superior mesenteric and inferior mesenteric artery were taken.*
Statistical analysis used*: Statistical analysis was performed using Statistical Package for Social Sciences. P-value < 0.05 were considered statistically significant.*
Results: *The length and diameters of the abdominal aorta increases with increasing gestational age and the measurements were more in males compared to females which was found to be statistically not significant. The diameter of the abdominal aorta at the middle was smaller as compared to the origin and above the bifurcation level. The most common level of origin of Abdominal aorta was at T12 (46.6%); bifurcation at L4(48.7%); coeliac trunk at T12-L1 (55.3%); superior mesenteric artery at L1(55.3%) and inferior mesenteric artery is at L3(53.2%) vertebra.*
Conclusions*: The present study provides normal dimensions of abdominal aorta and helps us to understand its development. The reference values could provide a database for intrauterine echographic examinations for early diagnosis, monitoring and management and also for predicting the outcome of various endovascular procedures.*
Key-words: *Morphometric parameters; Abdominal aorta; Coeliac trunk; Superior mesenteric artery; Inferior mesenteric artery; intrauterine echographic examinations*

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I. Introduction:

The abdominal aorta originates at the aortic hiatus of the diaphragm in front of the twelve thoracic vertebrae and as it descends it bifurcates into two common iliac arteries at the level of the fourth lumbar vertebra. As the age advances there is a gradual increase in aortic diameter in both the sexes. [1] After giving off many large branches, it diminishes rapidly in size and describes a forward convexity with its summit corresponding to the third lumbar vertebra.[2]

The need for nutrition increases with the growth of the embryo and the development of paired dorsal aorta helps in the maturation of the cardiovascular system. [3] Around the fourth week of development, the origin of the coeliac trunk lies at the C7 vertebra, and superior and inferior mesenteric arteries at T2 and T12 vertebra respectively.[4] In adults, the origin of the coeliac trunk lies at the level of the body of the T12 vertebra, superior and inferior mesenteric arteries at the L1 and L3 vertebra, and aortic bifurcation at the level of the L4 vertebra.[5]

In foetuses, neonates and infants, arterial malformations like aortic aneurysms, hypoplasia, atresia and agenesis are found at the level of the abdominal aorta.[6]. 43% of the aneurysms of the abdominal aorta in newborns and children were reported by some authors. The advances in ultrasound devices help in early diagnosis of congenital anomalies. Variables such as the length and diameter of the abdominal aorta can predict the outcome after the endovascular procedure. [7] The length of the abdominal aorta is considered as an independent biometric variable which is proportional to the size of the foetus and can be used alone for the calculation of gestational age.[8]

The study aimed to assess the development and morphology of the abdominal aorta in foetuses of different gestational age groups to improve knowledge of morphometric parameters.

II. Subjects And Methods:

After obtaining ethical clearance, a cross-sectional study was carried out in the Department of Anatomy, from January 2021 to October 2022. 45 aborted foetuses of different gestational age groups (22 males;23 females) and stillbirths ranging from 9-40 weeks of gestation without any gross congenital abnormalities were divided into 4 groups A, B, C and D. The sample size was calculated by using the formula: $N = (Z\alpha/2)\ S^2/d^2$, where S is the standard deviation [4.9~ 5, which is the maximum standard deviation of the length of the abdominal aorta according to Szpinda et al]; d is the error and $Z\alpha/2$ is a constant whose value is 1.96.

$N = (1.96)^2\ 5^2/\ (1.5)^2$,[d= 1.5]

N (sample size) = 43 (approximated to 45).

Group A consists of 8 foetuses (3 males, 5 females) within the age group 9-16 weeks; Group B of 14 foetuses (7 males, 7 females) within the age group 17-24 weeks; Group C with 18 foetuses (9males,9 females) within the age group of 25-32 weeks and Group D with 5 foetuses (3 males, 2 females) within the age group of 33-40 weeks. All foetuses less than 9 weeks of gestation and with visceral anomalies have been excluded from the study (Fig-1). The foetuses were preserved in freshly prepared 10% formalin for 2 weeks. Digital calliper (Aerospace-300mm digimatic vernier calliper); standard measuring tape; thread and pins were used for the measurements. The abdominal cavity was opened after giving incision and visceras were removed. The vertebral level of origin of the abdominal aorta and its bifurcation, the origin of the coeliac trunk and superior and inferior mesenteric arteries were identified. The length (cm) of the abdominal aorta was measured from its origin to its bifurcation. The diameters(mm) of the abdominal aorta were measured at three different levels: a) at its origin, b) between the midpoint of origin and above the bifurcation and c) above the bifurcation level (Fig-2). Using SPSS (IBM) version 21.0 software, statistical analysis was done. The percentage was used to express the gestational age, sex of the foetuses, the level of origin and bifurcation of the abdominal aorta, the origin of the coeliac trunk, superior and inferior mesenteric arteries. Mean and Standard deviation were used to express the length and different diameters of the abdominal aorta. Comparison was done between sexes for the length and diameters at different gestational ages. Chi-square test, ANOVA and t-test were done to check the association between the variables. p-value <0.05 was considered statistically significant.

Fig -1: Foetuses Of Various Gestational Ages From 10 To 24 Weeks

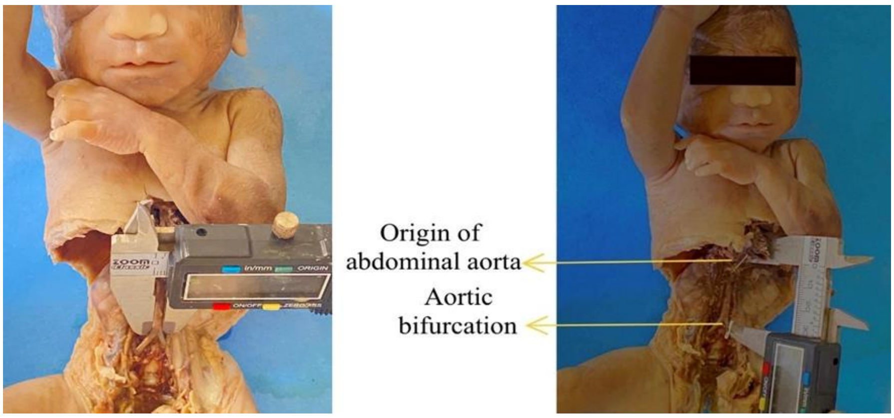

Fig-2: Photograph Of A 25-Week-Old Foetus Showing The Measurement For The Diameter And Length Of The Abdominal Aorta From Its Origin To The Bifurcation Level Using Vernier Calliper.

III. Results:

The level of origin of the abdominal aorta and bifurcation is shown in Table- 1. In the present study, the origin of the abdominal aorta ranged from the level of T10 to L1 vertebra in different gestational age groups. Out of 45 foetuses, 21 of them had their origin at the T12 vertebra in 46.6% of the cases, 15 foetuses at the T11 vertebra in 33.2%; 7 foetuses at the T10 vertebra in 15.5% and 2 foetuses at the level of L1 vertebra in 4.4% of the cases respectively. Bifurcation levels ranged from L3 to L5-S1 vertebra in different gestational age groups. Out of 45 foetuses, 22 of them had bifurcation at the L4 vertebra in 48.7% of the cases, 16 foetuses at the L5 vertebra in 35.3%, 4 foetuses at the L3 in 8.8% and 3 foetuses at L5-S1 vertebra at 6.6% of the cases respectively. The association between the origin of the abdominal aorta and the gestational age was found to be statistically significant and that of bifurcation was found to be statistically not significant. The most common level of origin of the abdominal aorta in the present study was found to be at the level of the T12 vertebra (46.6%) and that of bifurcation is at the L4 vertebra(48.7%).

Table – 1: Distribution of the vertebral level of origin of the abdominal aorta and bifurcation level according to gestational age (N=45)

Gestational Age		**Group A (9-16 Weeks)**	**Group B (17-24 Weeks)**	**Group C 25-32 Weeks)**	**Group C (33-40 Weeks)**	**Total n(%)**
Vertebral Level of Origin of Abdominal Aorta	**T10 n(%)**	6 (13.3)	1 (2.2)	0 (0.0)	0 (0.0)	7 (15.5)
	T 11 n(%)	2 (4.4)	6 (13.3)	7 (15.5)	0 (0.0)	15 (33.2)
	T12 n(%)	0 (0.0)	6 (13.3)	10 (22.2)	5 (11.1)	21 (46.6)
	L1 n(%)	0 (0.0)	1 (2.2)	1 (2.2)	0 (0.0)	2 (4.4)
	P-Value	0.00				
Bifurcation levels of Abdominal Aorta	**L3 n(%)**	2 (4.4)	1 (2.2)	1 (2.2)	0 (0.0)	4 (8.8)
	L4 n(%)	1 (2.2)	9 (20.0)	8 (17.7)	4 (8.8)	22 (48.7)
	L5 n(%)	3 (6.6)	4 (8.8)	8 (17.7)	1 (2.2)	16 (35.3)
	L5-S1 n(%)	2 (4.4)	0 (0.0)	1 (2.2)	0 (0.0)	3 (6.6)
	P -Value	0.11				

The mean length and standard deviation of the abdominal aorta increases with gestational age and the association between the two was found to be statistically significant (Table 2). Males have a higher length of abdominal aorta than females which was found to be statistically not significant (Table 3; Fig-3)

The diameters (mm) of the abdominal aorta were measured at three different levels: a) at the origin; b) midpoint between the origin and above the bifurcation and c) above the bifurcation. The present study shows a unique pattern of the diameter where its measurement at the midpoint between the origin and above the bifurcation was smaller than that of the other two (Fig-4). The association between the diameters at different levels and gestational age was found to be statistically significant (Table 4). Males have a larger diameter of abdominal aorta at all levels than females and was found to be statistically not significant (Table 5).

The coeliac trunk's origin ranged from the T11 to L1 vertebra; superior and inferior mesenteric arteries from T12 to L2 and L2-L3 to L4 vertebrae in different gestational age groups. The most common level of origin of the coeliac trunk was at T12-L1(55.3%); superior mesenteric at L1 vertebra (55.3%) and inferior mesenteric artery at the L3 vertebra (53.2%) in the entire population. The association between the origin of the coeliac trunk and inferior mesenteric artery was found to be statistically not significant while that of superior mesenteric artery was statistically significant (Table 6).

Table 2: Average length of abdominal aorta according to gestational age (N=45)

Age category	**No. of Foetuses**	**Mean±S.D**	**(Min-Max)**	**P-value**
Group A (9-16 weeks)	8	2.09±0.25	1.80-2.50	0.00
Group B (17-24 weeks)	14	3.01±0.55	2.20-3.60	
Group C (25-33 weeks)	18	3.92±0.47	3.30-4.90	
Group D (34-40weeks)	5	5.28±0.43	4.80-5.90	
Total	**45**	**3.46±1.04**	**1.80-5.90**	

Table – 3 Comparison of the average length of the abdominal aorta according to gender (N=45)

Gestational age	Average AA length (in cm)		Total Mean±S.D	95%CI		t-value	P-value
	Male (n) Mean±S.D	Female (n) Mean±S.D		Lower	Upper		
Group A	(3) 2.23±0.25	(5) 2.00±0.23	(8) 2.09±0.25	1.87	2.30	1.33	0.23
Group B	(7) 2.97±0.56	(7) 3.04±0.58	(14) 3.01±0.55	2.69	3.32	0.24	0.81
Group C	(9) 4.11±0.40	(9) 3.73±0.48	(18) 3.92±0.47	3.69	4.16	1.81	0.09
Group D	(3) 5.37±0.47	(2) 5.15±0.50	(5) 5.28±0.43	4.74	5.82	0.49	0.65

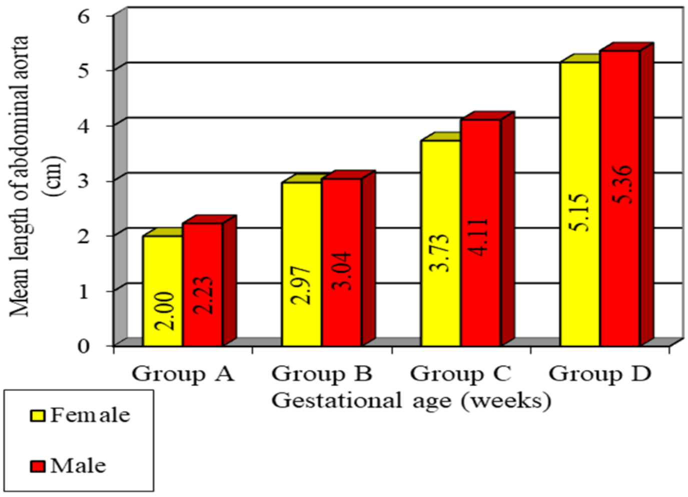

Fig-3 Bar diagram showing mean length of abdominal aorta in different gestational age group

Table – 4: Average diameters of abdominal aorta according to gestational age (N=45)

Levels of Diameter	Age category	No. of Foetuses	Mean±S. D	(Min-Max)	P-value
Diameter at the origin	Group A (9-16 weeks)	8	3.25±0.70	2.00-4.00	0.00
	Group B (17-24weeks)	14	4.93±1.07	3.00-7.00	
	Group C (25-32weeks)	18	6.44±0.86	5.00-8.00	
	Group D (33-40weeks)	5	7.80±0.84	7.00-9.00	
	Total	**45**	**5.56±1.66**	**2.00-9.00**	
Diameter between origin and above the bifurcation	Group A (9-16weeks)	8	2.75±0.71	2.00-4.00	0.00
	Group B (17-24weeks)	14	4.29±1.07	3.00-6.00	
	Group C (25-32weeks)	18	6.06±0.73	5.00-7.00	
	Group D (33-40weeks)	5	7.20±0.84	6.00-8.00	
	Total	**45**	**5.04±1.66**	**2.00-8.00**	
Diameter above the bifurcation	Group A (9-16weeks)	8	3.75±0.71	3.00-5.00	0.00
	Group B (17-24weeks)	14	5.43±1.22	3.00-7.00	
	Group C (25-32weeks)	18	7.17±0.71	6.00-8.00	
	Group D (33-40weeks)	5	8.40±0.89	7.00-9.00	
	Total	**45**	**6.16±1.73**	**3.00-9.00**	

Fig-.4 bar diagram showing different mean diameters in different gestational age group

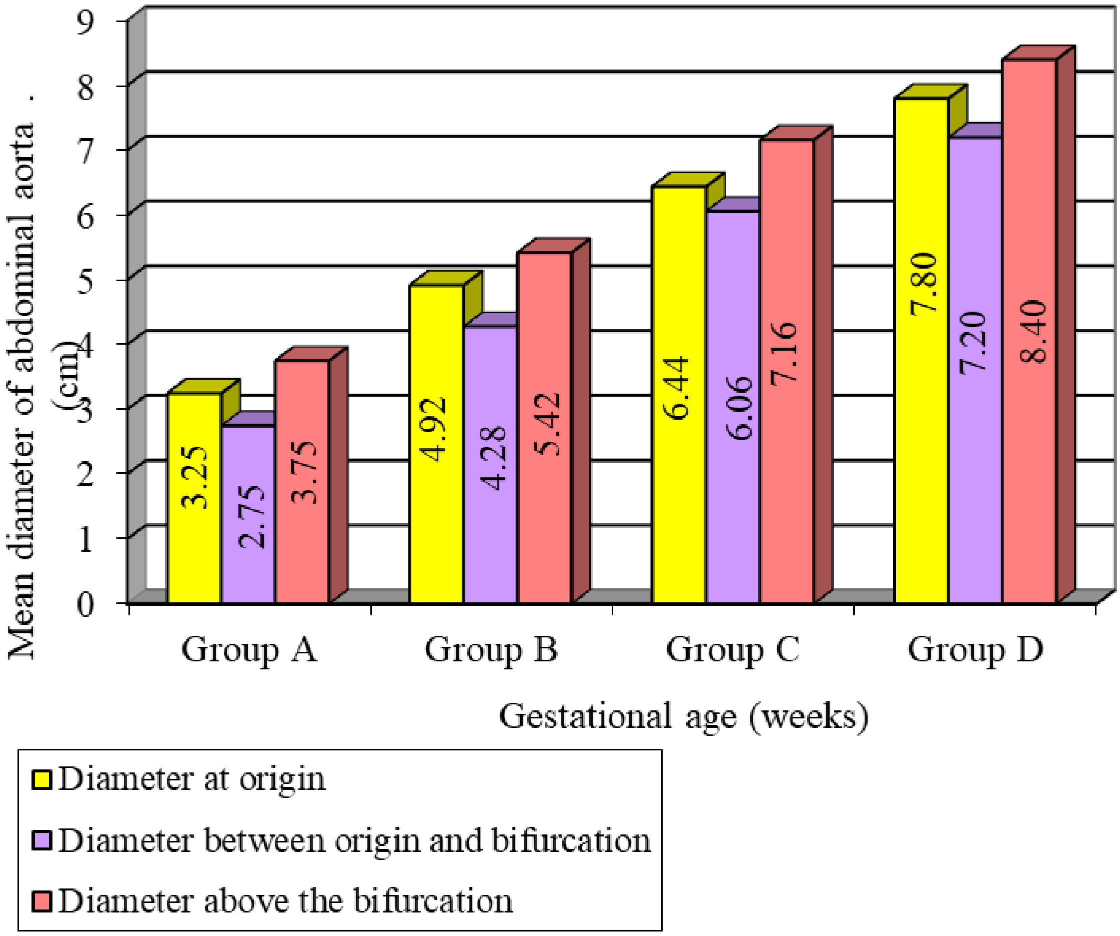

Table-5 Comparison of average diameters of abdominal aorta at different levels in both sexes by their gestational age (N=45)

Average Diameter (mm)	Gestational Age	Male (n) Mean ± SD	Female (n) Mean ± SD	Total Mean ± SD	P-Value
At the origin	Group A (9-16 Weeks)	(3) 3.3 ± 0.58	(5) 3.20±0.84	(8) 3.25±0.71	0.81
	Group B (17-24 Weeks)	(7) 5.14± 1.07	(7) 4.71±1.11	(14) 4.93±1.07	0.47
	Group C (25-32 Weeks)	(9) 6.67 ± 0.71	(9) 6.22±.97	(18) 6.44±0.86	0.28
	Group D (33-40 Weeks)	(3) 8.00±1.00	(2) 7.50±0.71	(5) 7.80±0.84	0.59
Between Origin and Bifurcation	Group A (9-16 Weeks)	(3) 3.00±0.00	(5) 2.60±0.89	(8) 2.75±0.71	0.48
	Group B (17-24 Weeks)	(7) 4.57±1.27	(7) 4.00±0.82	(14) 4.29±1.07	0.33
	Group C (25-32 Weeks)	(9) 6.33±0.71	(9) 5.78±0.63	(18) 6.06±0.73	0.10
	Group D (33-40 Weeks)	(3) 7.67±0.58	(2) 6.50±0.71	(5) 7.20±0.84	0.13
Above Bifurcation	Group A (9-16 Weeks)	(3) 4.00±0.00	(5) 3.60±0.89	(8) 3.75±0.71	0.48
	Group B (17-24 Weeks)	(7) 5.86±1.07	(7) 5.00±1.29	(14) 5.43±1.22	0.20
	Group C (25-32 Weeks)	(9) 7.44±0.73	(9) 6.89±0.60	(18) 7.17±0.71	0.10
	Group D (33-40 Weeks)	(3) 8.67±0.58	(2) 8.00±1.41	(5) 8.40±0.89	0.50

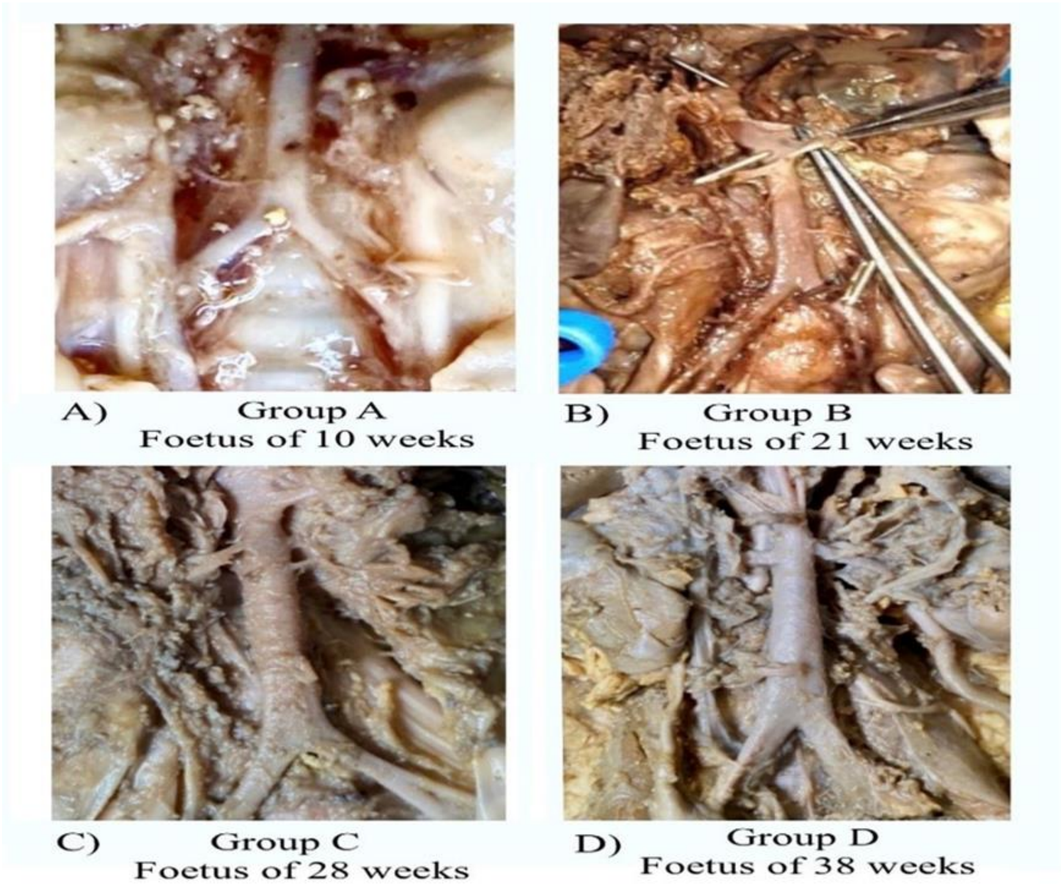

Fig-6 Foetuses of different gestational age groups showing the pattern of diameters at different levels of abdominal aorta

Table–6: Distribution of the vertebral level of origin of coeliac trunk, superior mesenteric and inferior mesenteric artery according to gestational age (N=45)

Gestational Age		Group A (9-16weeks)	Group B (17-24weeks)	Group C (25-32weeks)	Group D (33-40weeks)	**Total n (%)**
Origin of the coeliac trunk	T11	2	1	0	0	3
	(%)	(4.4)	(2.2)	(0.0)	(0.0)	(6.6)
	T12	4	4	3	0	11
	(%)	(8.8)	(8.8)	(6.6)	(0.0)	(24.2)
	T12-L1	2	8	13	2	25
	(%)	(4.4)	(17.7)	(28.8)	(4.4)	(55.3)
	L1	0	1	2	3	6
	(%)	(0.0)	(2.2)	(4.4)	(6.6)	(13.2)
	P Value			**0.20**		
Origin of the superior mesenteric artery	T12	2	1	0	0	3
	(%)	(4.4)	(2.2)	0.0)	(0.0)	(6.6)
	T12-L1	5	2	1	0	8
	(%)	(11.1)	(4.4)	(2.2)	(0.0)	(17.7)
	L1	1	7	13	4	25
	(%)	(2.2)	(15.5)	(28.8)	(8.8)	(55.3)
	L2	0	4	4	1	9
	(%)	(0.0)	(8.8)	(8.8)	(2.2)	(19.8)
	P Value			**0.00**		
Origin of the inferior mesenteric artery	L2-L3	4	1	0	0	5
	(%)	(8.8)	(2.2)	(0.0)	(0.0)	(11.0)
	L3	3	11	10	0	24
	(%)	(6.6)	(24.4)	(22.2)	(0.0)	(53.2)
	L3-L4	1	2	6	3	12
	(%)	(2.2)	(4.4)	(13.3)	(6.6)	(26.5)
	L4	0	0	2	2	4
	(%)	(0.0)	(0.0)	(4.4)	(4.4)	(8.8)
	P Value			**0.74**		

IV. Discussion:

The origin of the abdominal aorta in adults is at the level of the T12 vertebra.[1] In foetuses, this level was found at T12(46.6%), T11(33.2%), T10(15.5%) and L1(4.4%) vertebra. The present study shows that its origin descends with increasing gestational age from T10 to L1 vertebra and attends the adult position from 33 weeks onwards. The present study shows the most common level of origin at the T12 vertebra which is similar to that of adults. Our study had similar findings to that of Ozguner and Sulak, Feller and Woodburne and Sahni et al.[7,9,10] The level of aortic bifurcation is essential for surgeons in any vertebral and lumbosacral spinal surgeries to prevent any harmful vascular injuries.[11] In the present study, the bifurcation tends to ascend gradually with increasing age and L4 vertebra being the most common level of bifurcation, which resembles the adult bifurcation level in most cases as reported by many authors and textbooks.[1,7,10] Khamanarong et al, Chithriki et al and George had similar findings of abdominal aortic bifurcation level at the L4 vertebra.[11,12,13] Various authors like Gregory et al, Prakash et al, Culdwell and Anson also reported the bifurcation level to be at the L4 vertebra[14,15,16] Sharma et al, and Voboril in their study reported the level of bifurcation between L3 and L5 and L3 vertebra which was different from the present study.[17,18] Methods and duration of the preservation of the foetuses could be a possible factor for differences in the levels of bifurcation due to tissue shrinkage while preserving in formalin.

The length and diameters of the abdominal aorta serve as an important parameter for the diagnosis of aneurysms and other abnormalities. The present study shows the mean length of the abdominal aorta increases with gestational age. Studies done by Kiyohide on Japanese foetuses, Szpinda et al, Pennington and Soames and Ozguner and Sulak show similar results.[19,5,20,7] Based on our results, the length of the abdominal aorta was more in the case of males compared to females which was statistically not significant. Szpinda et al observed a significant difference between males and females in the length of the abdominal aorta whereas Yahel and Arensburg reported the length of the abdominal aorta to be similar in both sexes.[5,21] There is an increase in the diameter of the abdominal aorta with age and also a unique pattern of the diameter was reported in the present study where the diameter was smaller in the middle as compared to its origin and above the bifurcation level in all gestational age group (Fig-6). A possible reason for such a pattern could be differences in the growth rate. Kahraman et al and Pearce et al observed a decrease in the diameter from its origin to bifurcation which was different from the present study.[22,23] It was also observed that males have larger diameters than females but it was statistically not significant which was similar to that of Dixon et al and Pearce et al.[24,23] Ozguner and Sulak observed during the first trimester there were no significant differences in the diameters at the origin and bifurcation but during the second trimester, the diameter at the origin was more than the bifurcation.[7] Szpinda et al observed an increase in abdominal aortic diameter with age and with no significant differences in both sexes.[5]

The present study shows the most common level of origin of the coeliac trunk at the T12-L1 vertebra, and superior and inferior mesenteric arteries at the L1 and L3 vertebra respectively. Different authors reported on the coeliac trunk, according to Pennington and Soames, Kao et al, and Bhutia et al, the coeliac trunk originated at the T12 vertebra.[20,25,26] Sahni et al and Prakash et al also had the same findings as the previous authors.[12,17] Yang et al, Anson and McVay and George reported it to be at the level of L1vertebra.[27,16,13] George, Nigah et al, Prakash et al and Bhutia et al reported on the origin of the superior mesenteric artery at the level of the L1 vertebra, similar to the present study.[13,26,15,26] Authors like Niscoveanu et al reported it to be at the T12 vertebra and Anson and McVay at the L2 vertebra.[29,16] Gregory et al and Sahni et reported the inferior mesenteric artery originates at the L3 vertebra which was similar to the present study.[14,10] Balcerzak et al reported the inferior mesenteric artery originates at the L2-L3 vertebra which was different from the present study.[30] These differences in the level of origin should be noted as they are important morphometric parameters for approaching any endovascular procedures.

V. Limitations Of The Study

The sample size was limited and the foetal dissection in the early gestational age group was challenging.

VI. Conclusion

The present study provides normal dimensions of the abdominal aorta and helps us to understand its development. Since less literature was available on the foetal abdominal aorta, these morphometric data can be useful as a reference value for Doppler studies in prenatal diagnosis and monitoring of congenital abnormalities. The feasibility of endovascular abdominal aortic aneurysm repair depends on aorto-iliac anatomy.

Knowledge of the vascular variations of the aorta is important in different laparoscopic surgeries, liver and kidney transplantation, and oncologic resections in the abdominal region and is essential for interventional radiologists before diagnostic imaging procedures like angiography and therapeutic procedures like transcatheter arterial chemoembolisation. Prior knowledge of aortic variations is required to accomplish aortic replacement by implementing coeliac trunk and superior mesenteric arteries.

Conflict Of Interest

There is no conflict of interest.

Refernces:

[1] Stringer Md, Smith Al, Wein Aj. Abdomen And Pelvis. In: Standring S,Pitman Ag, Moss D, Stringer Md, Smith Al, Wein Aj, Et Al, Editors. Gray's Anatomy: The Anatomical Basis Of Clinical Practice. 41st Ed. London: Elsevier; 2016. P.1033-315.

[2] Sinnatamby Cs. Last's Anatomy Regional And Applied. 10th Ed. Edinburgh: Churchill Livingstone; 2000. P.268.

[3] Bree K, Baker Bs, Oostra Rj. The Development Of The Human Notochord. Plos One. 2018 Oct 22;13(10): E0205752.

[4] Schoenwolf Gc, Bleyl S, Braver Pr, Francis-West P, Larsen W. Larsen's Human Embryology. 5 Th Ed. Philadelphia: Churchill Livingstone; 2015. P.304-40.

[5] Szpinda M, Szpinda A, Wozniak A, Kierzenkowska Cm, Kosinski A, Grzybiak M. Quantitative Anatomy Of The Growing Abdominal Aorta In Human Foetuses: An Anatomical, Digital And Statistical Study. Med Sci Monit. 2012;18(10):Br419-26.

[6] Mendeloff J, Stallion A, Hutton M, Goldstone J (2001) Aortic Aneurysm Resulting From Umbilical Artery Catheterization: Case Report, Literature Review, And Management Algorithm, Vasc Surg 33:419-424.

[7] Ozguner G, Sulak O. Development Of The Abdominal Aorta And Iliac Arteries During The Fetal Period: A Morphometric Study. Surg Radiol Anat. 2011;33:35-43.

[8] Hanoon N, Akram W. The Use Of Abdominal Aorta Length In The Fetuses' After 34 Weeks Of Gestation For Calculating Gestation Age Among Primigravida Healthy Women. Eur J Mol Clin Med. 2020;7(05):2020.

[9] Feller I, Woodburne Rt. Surgical Anatomy Of Abdominal Aorta. Ann. Surg.1961 Dec;154(Suppl 6):239.

[10] Sahni D, Aggarwal A, Gupta T, Kaur H, Gupta R, Chawla K, Et Al. Bergman's Comprehensive Encyclopedia Of Human Anatomic Variation. Bergman's Comprehensive Encyclopedia Of Human Anatomic Variation. 2016 Jul;5:619-70.

[11] Khamanarong K, Sae-Jung S, Supa-Adirek C, Teerakul S, Prachaney P. Aortic Bifurcation: A Cadaveric Study Of Its Relationship To The Spine. J Med Assoc Thai. 2009;92:47-56.

[12] Chithriki M, Jaibaji M, Steele R. The Anatomical Relationship Of The Aortic Bifurcation To The Lumbar Vertebrae: A Mri Study. Surg Radiol Anat. 2002 Dec;24(5):308-12.

[13] George R. Topography Of The Unpaired Visceral Branches Of The Abdominal Aorta. J Anat. 1934;69:96-205.

[14] Gregory Ls, Mcgifford Oj, Jones Lv. Differential Growth Patterns Of The Abdominal Aorta And Vertebrae During Childhood. Clin Anat. 2019;32(6):783-93.

[15] Prakash, Rajini T, Mokhasi V, Geethanjali Bs, Sivacharan Pv, Shashirekha M. Coeliac Trunk And Its Branches: Anatomical Variations And Clinical Implications. Singapore Med J. 2012;53(5):329-31.

[16] Anson Bj, Mcvay Cb. The Topographical Position And The Mutual Relations Of The Visceral Branches Of The Abdominal Aorta. A Study Of 100 Consecutive Cadavers. Anat Rec. 1936;67:7-15.

[17] Sharma, Maneesha1; Sharma, Tripta2; Singh, Richhpal3. Variations In The Aortic - Common Iliac Bifurcation In Man - A Cadaveric Study. National Journal Of Clinical Anatomy 2(2):P 56-60, Apr–Jun 2013. | Doi: 10.4103/2277-4025.297872

[18] Voboril R. The Position Of The Aortic Bifurcation In Humans. Sbornik Vedeckych Praci Lekarske Fakulty Karlovy Univerzity V Hradci Kralove. Supplementum. 1993 Jan 1;36(1-2):87-104.

[19] Hirata K. A Metrical Study Of The Aorta And Main Aortic Branches In The Human Foetus. Nihon Ika Daigaku Zasshi. 1989 Dec 1;56(6):584-91.

[20] Pennington N, Soames Rw. The Anterior Visceral Branches Of The Abdominal Aorta And Their Relationship To The Renal Arteries. Surg Radiol Anat.2005;27:395-403.

[21] Yahel J, Arensburg B. The Topographic Relationships Of The Unpaired Visceral Branches Of The Aorta. Clin Anat. 1998;11(5):304-9.

[22] Kahraman H, Ozaydin M, Varol E, Aslan Sm, Dogan A, Altinbas A, Demir M, Gedikli O, Acar G, Ergene O. The Diameters Of The Aorta And Its Major Branches In Patients With Isolated Coronary Artery Ectasia. Tex. Heart Inst. J. 2006;33(4):463.

[23] Pearce Wh, Slaughter Ms, Lemaire S, Salyapongse An, Feinglass J, Mccarthy Wj, Yao Js. Aortic Diameter As A Function Of Age, Gender, And Body Surface Area. Surgery. 1993 Oct 1;114(4):691-7.

[24] Dixon Ak, Lawrence Jp, Mitchell Jr. Age-Related Changes In The Abdominal Aorta Shown By Computed Tomography. Clin. Radiol. 1984 Jan 1;35(1):33-7.

[25] Kao Gd, Whittington R, Coia L. Anatomy Of The Celiac Axis And Superior Mesenteric Artery And Its Significance In Radiation Therapy. Int J Radiat Oncol Biol Phys. 1993 Jan 1;25(1):131-4.

[26] Bhutia K, Sinha P, Tamang B, Sarda Rk. Branching Pattern Of Abdominal Aorta. A Cadaveric Study. Int J Health Sci Res. 2016;6(9):150-5.

[27] Yang Iy, Oraee S, Viejo C, Stern H. Computed Tomography Celiac Trunk Topography Relating To Celiac Plexus Block. Reg Anesth Pain Med. 2011 Jan 1;36(1):21-5.

[28] Nigah S, Patra A, Chumbar S, Chaudhary P. Topographic Location And Branching Pattern Of The Superior Mesenteric Artery With Its Clinical Relevance: A Cadaveric Study. Folia Morphol. 2022;81(2):372-8.

[29] Niscoveanu C, Bordei P, Baz R. Morphological Characteristics Of Origin Of Superior Arterial Mesenteric Trunk. Ars Medica Tomitana. 2016 Aug 1;22(3):145- 52.

[30] Balcerzak A, Kwaśniewska O, Podgórski M, Polguj M. Types Of Inferior Mesenteric Artery: A Proposal For A New Classification. Folia Morphol. 2021;80(4):827-38.