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Original Research Article

Morphometric study of abdominal aorta and its branches

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ABSTRACT

Introduction: A good knowledge on the morphology of abdominal aorta (AA) and its branches is important in diagnosis and surgical treatment. The aim of this study is to make morphometric measurements of AA and its branches.
Materials and Methods: The present study was conducted on 50 AA that has been removed in autopsies and were measured with calipers morphometrically to determine diameter and distances between branches. The variations of the vessels were investigated and photographed.
Result: The mean diameter of AA was studied at various levels and recorded. The study showed a decrease in caliber from above to below**.** In both sexes, diameter of Aorta above 40yrs age group is more than age group less than 40yrs. The average distance from CT-AB, CT-SMA, SMA-IMA and IMA-AB were measured as 10.92cm, 0.67cm, 4.9cm, 3.27cm, respectively.. Numerous variations were observed during the study which include absence of renal artery, origin of renal arteries one above the other, 3pairs of lumbar arteries etc.
Conclusion: An expertise knowledge in morphology of AA and its branches is crucial in the diagnosis, surgical treatment and endovascular interventions of these vessels.

1. Introduction

The incidence of arterial disease is in rise throughout the world due to altered dietary habits, sedentary life style, stress etc. Vascular abnormalities can result from either narrowing or obstruction of the vessel. Most of the times, an emergency surgical intervention has to be carried out to save the life of the individual.

Abdominal aorta (AA) is the major artery from which the abdominal organs receive their blood supply. Its terminal branches go on to supply the pelvis and lower limbs. It also supplies the undersurface of the diaphragm and parts of the abdominal wall. It is approximately 13cm long. It begins at T12 and ends at L4 with its bifurcation into the common iliac arteries.[1] The branches of the abdominal aorta may be divided into three sets: visceral, parietal, and terminal.

Table 1:

Visceral Branches	**Parietal Branches**
Coeliac.	Inferior Phrenics.
Superior Mesenteric.	Lumbars.
Inferior Mesenteric.	Middle Sacral.
Middle Suprarenals.	
Renals.	**Terminal Branches**
Internal Spermatics Ovarian (in female)	Common Iliacs.

Of the visceral branches, the coeliac artery, the superior and inferior mesenteric arteries are unpaired, while the suprarenals, renals, internal spermatics, and ovarian are paired. Of the parietal branches the inferior phrenics and lumbars are paired; the middle sacral is unpaired. The terminal branches are paired[2] (Figures 1 and 2).

The coeliac trunk (CT) arises from the AA immediately below the aortic hiatus at the level of T12-L1 vertebra. It is

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1.5-2 cm long.

Superior mesenteric artery (SMA) originates 1 cm below the CT, at the level of the L1 – L2.

The inferior mesenteric artery (IMA) arises from the anterior or left anterolateral aspect of the AA at the level of L3 and 3-4 cm above aortic bifurcation (AB).

Inferior phrenic arteries (IPA) arise just above the CT.

The left and right middle suprarenal arteries (MSRA) arise from the lateral aspect of AA, level with the SMA.

The left and right renal arteries (RA) originate just below SMA and the right arises slightly higher than the left.

Gonadal arteries (GA) arise inferior to the RA's

Lumbar arteries (LA) arise from the posterolateral aspect of AA and are usually 4 pairs.

Median sacral artery (MSA) is a small branch that arises from the posterior aspect of the aorta a little above its bifurcation.[3]

Variations in AA and its branches are frequently observed and they occur due to embryological developmental changes.[4–6] While performing surgical and/ or radiological procedures on kidneys, the variations of Gonadal artery should be looked for carefully.[4] Knowledge about morphology of AA and its branches is important in regards to renal transplantation, renal trauma surgery, radiological imaging and surgical treatment of aortic aneurysms.[7,8] Knowledge of the anatomical variations of Lumbar Arteries is important for surgical operations involving the retroperitoneal region.[9] Anatomical variations of the abdominal aorta should be considered by interventional radiologists before diagnostic imaging procedures like angiography and therapeutic procedures like transcatheter arterial chemoembolisation for treatment of hepatocellular carcinoma.[10]

2. Aim

The aim of this study was to a) make morphometric measurements of AA and its branches, b) to investigate sites of origin of the branches, their relationships and variations.

3. Materials and Methods

The study was conducted on 50 AA specimens that were obtained from human cadavers during autopsies at Guntur General Hospital from 2012 to 2013. These specimens of AA and its branches were measured with a metal scale morphometrically to determine diameter of Aorta and distances between branches (CT-AB, CT-SMA, SMA-IMA and IMA-AB) and the results were noted. The demographic characteristics of the cases (sex, age, height and weight) and any encountered variations and anomalies were recorded during the macroscopical observations.

4. Results

Out of 50 specimens taken for the study, 40 were males and 10 were females. The mean diameter of Aorta was studied at various levels and was illustrated in Table 2. The mean diameter of Aorta according to age and sex was studied and it was found that in all specimens at all levels in females is less than that of males and in both sexes diameters above 40 years are greater than below 40 years age group (Table 3). The study of Sonesson B et al. in 1994 concluded that there was a decrease in abdominal aortic wall distensibility with age and this occurs at earlier age in men.[11]

Lederle, et al.[12] analyzed the variation in aortic diameters measured with both CT and ultrasonography in 258 patients. The Ultrasound based measurements were smaller than the CT-based measurements by an average of 0.27 cm. But Wanhainen, et al.[13] reported that Ultrasound based measurements were larger by 2.8 mm than CT-based measurements. The difference and variability of measurements between US and CT depends on the diameter of the aorta and how it is measured.

With regard to the distance measurement, the present study shows the average distance from CT-AB, CT-SMA, SMA-IMA and IMA-AB were measured as 10.92cm, 0.67cm, 4.9cm, 3.27cm, respectively. The various lengths of Aortic segments at different levels were shown in Table 5.

The average length of Rt. Common iliac artery is 3.95cm whereas Lt. is 4.15cms, which shows Lt. is longer than Rt.

Many variations were observed in the study such as absence of left renal artery, bilateral accessory renal arteries, in few origin of one renal artery above the other, 3pairs of lumbar arteries etc., (Figures 3, 4, 5 and 6).

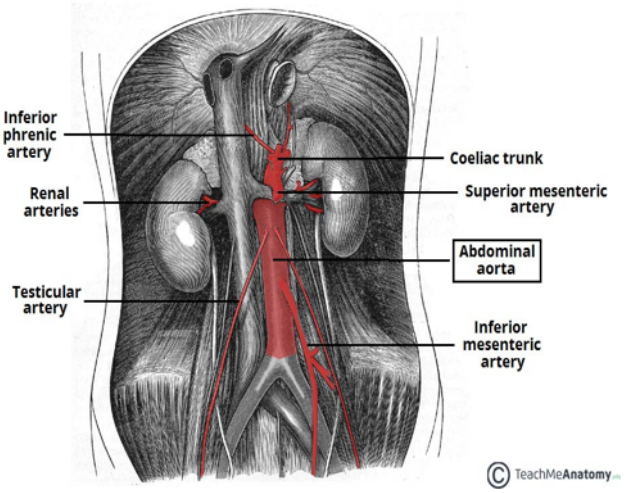

Fig. 1: Abdominal Aorta and its branches

5. Discussion

Now a day's endovascular surgeries are very important in the management of different vascular problems. Of the many vessels, gross anatomical aspects of coronary, cerebral arteries, abdominal aorta and its branches are very important

Table 2: Mean diameter of aorta at various levels (in cms)

No. of specimens	Level	value
50	D1	1.27
50	D2	1.06
50	D3	1.20
50	D4	0.98
50	D5	0.99
50	D6	0.63
50	D7	0.49

Table 3: Mean diameter of abdominal aorta according to age and sex (in cms)

Diameter levels	Less than 40 years age		More than 40 years age	
	Male specimens (21)	Female specimens (06)	Male specimens (19)	Female specimens (04)
D1	1.10	1.03	1.45	1.34
D2	0.979	0.838	1.21	1.08
D3	1.10	0.98	1.36	1.28
D4	0.9	0.8	1.136	1
D5	0.903	0.816	1.13	1.005
D6	0.570	0.513	0.734	0.607
D7	0.428	0.393	0.58	0.425

Table 4: Comparative measurements of proximal and distal Aorta and iliac vessels

Name of the Author & year	Proximal Aorta (Supra Renal)		Distal Aorta (Infra Renal)		Common Iliac Artery	
Pederson et al 1993	Below 50 1.69	Above 50 1.99	Below 50 1.51	Above 50 1.68	Below 50 0.97	Above 50 1.0
B Sonneson et al 1994	Below 40	Above 40	Below 40 1.62	Above 40 1.75	Below 40	Above 40
Present study 2012	1.12	1.44	1.07	1.34	0.56	0.71

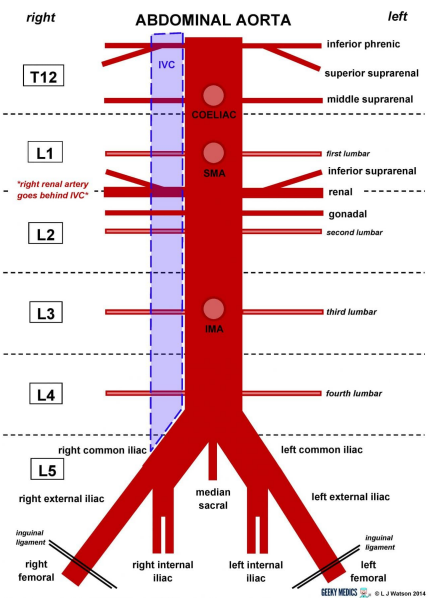

Fig. 2: Abdominal aorta and its branches

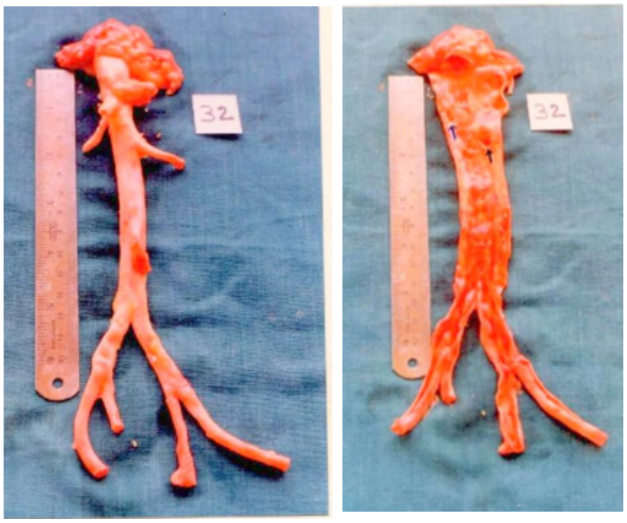

Fig. 3: Origin of Lt. renal artery at lower level than Rt.

and were extensively studied by many authors.

PM Shah et al. studied the morphometry of abdominal aorta, its bifurcation and common iliac arteries. Their study revealed lengths of common iliac arteries which can be

Table 5: Lengths of aortic segments at different levelsin centimeters

S.No	Age	Sex	Height of the cadaver	L1 (full length)	L2 Supra renal segment		L3 Infra renal Segment		L4 Coeliac to superior Mesenteric artery	L5 Superior Mesenteric artery to Bifurcation	L6 Inferior Mesenteric artery to Bifurcation
					Right	left	Right	left			
1	46	M	160	10.2	2.3	1.9	7.2	7.6	1.5	4.8	3.3
2	46	M	164	12	4.8	4.2	7	7.2	0.9	4.4	3.6
3	20	F	162	7.9	2.6	3	4.3	4	1.1	3	2.5
4	26	M	164	9.3	2	1.7	7	7.3	0	3.8	3.7
5	27	M	152	9.2	2.5	2	6.5	6.8	0.5	4.9	2.5
6	28	M	160	11.2	2.9	2.3	7.5	8.5	0.7	4.9	3.3
7	35	M	162	9.1	2.7	3	5.8	5.5	0.5	4.2	2.1
8	60	M	172	12.7	2.6	2.5	9.4	9.8	1	4.6	4.9
9	30	F	150	9.5	2	1.9	6.8	6.9	0.5	3.9	2.8
10	20	M	165	9.9	1.9	2	7.7	7.3	0.8	5.1	2.3
11	60	M	167	12.9	1.9	3.5	10.5	9	0.4	5.7	3.8
12	35	M	150	9.4	2.4	2.9	6.2	6	0.5	3.5	3.2
13	55	F	150	12	2.5	2.4	9.1	8.9	0.8	4.5	4.7
14	20	M	169	11	1.8	2.2	8.7	8.2	0.2	4.1	3.3
15	50	M	150	13.8	4.5	4.3	8.5	8.9	0	6.3	4.3
16	39	F	150	11.6	3.2	2.6	8.1	9.4	0.5	5	6.3
17	42	M	155	11.5	3.4	3.1	7.6	7.6	0.3	4.4	3.8
18	22	M	154	9.5	3.1	3.2	5.8	5.8	0.4	3.7	2.3
19	40	M	164	9.8	2.5	2.3	6.6	7	0.5	5	3
20	50	M	174	13.5	2.5	3.5	10.5	9.3	1.2	6.5	4.1
21	45	M	180	14.5	4.2	4	9.8	9.5	1.2	7.1	4.5
22	25	M	150	11.1	3.8	4.3	5.8	6.2	0.5	4.5	3.1
23	30	F	150	9.5	3.4	3.2	5.4	5.8	0.6	4.1	2.8
24	40	M	180	12	3.9	3.5	7.5	7.7	0.5	7	2.5
25	60	M	150	11.1	2.1	2.3	8.4	8.3	0.3	0	3.9
26	36	M	150	10	2.9	2.3	6.9	7.1	0	5.8	2.9
27	50	M	164	9.5	1.7	1.5	7.5	7.7	0.1	3.9	4
28	20	M	164	9.8	2.3	2.5	7.46	7.1	0.5	4.3	3.1
29	60	F	150	11.5	3.5	3.6	7.4	7.2	0.2	5.4	3
30	40	M	179	12.9	2.9	2.8	9.3	9.2	0.9	5.4	3.8
31	68	M	180	14.3	3.9	4.1	10.1	9.9	1.4	7.1	4
32	60	F	147	12.1	2.6	4.2	9.4	7.9	0.5	6.7	3
33	25	M	165	10.3	2.6	3.1	7.1	6.5	0.7	4.3	3
34	21	M	167	10.3	3.8	3.2	5.9	6.6	0.7	4.2	2.6
35	45	M	174	10.7	2.3	2.7	8.1	7.4	0.9	4.7	3.4
36	20	M	169	11.3	3.4	3.7	7.4	7.1	0.8	5.7	2.7
37	60	M	169	12.1	3.9	4.1	8.25	8.15	0.9	5.7	4
38	22	M	165	9.8	3.5	2.9	5.8	6.4	0.7	4.8	2.5
39	65	M	175	13.2	5.2	3.8	7.5	8.7	1	5.5	4.3
40	35	M	165	7.8	3.8	4	7.7	7.5	0.5	5.9	3
41	21	F	150	8.1	2.5	2.7	5.4	5	0.3	3.6	2.6
42	28	M	169	12.5	4	4.3	8	8.3	1	5.4	3.7
43	40	F	150	11.7	3.6	4.1	7.85	7.23	0.6	5.1	3.7
44	50	M	167	11.3	1.6	1.6	9.1	9	1	5	4
45	35	F	150	11.1	2.9	2.9	7.8	7.8	1.3	6.1	2.4
46	35	M	155	9.7	3.5	4	5.9	5.25	1	4.5	2.1
47	24	M	157	9.1	2.9	3.2	4.8	5.4	0.8	3.4	2.6
48	40	M	150	9.8	3.1	aa	8.3	aa	0.3	6.9	3.1
49	33	M	170	10.9	3.2	3	7.1	7.75	1	5.1	3.2
50	37	M	165	9.6	3.5	2.9	5.3	7.2	1	4.9	2.8

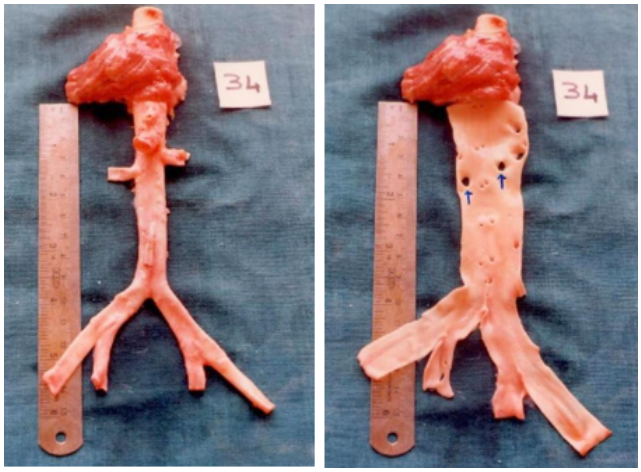

Fig. 4: Origin of Lt. renal artery is at higher level than Rt

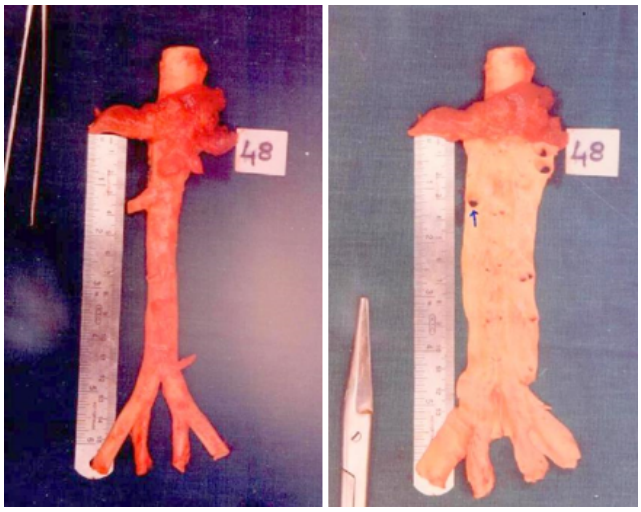

Fig. 5: Aorta with absence of Lt. Renal artery

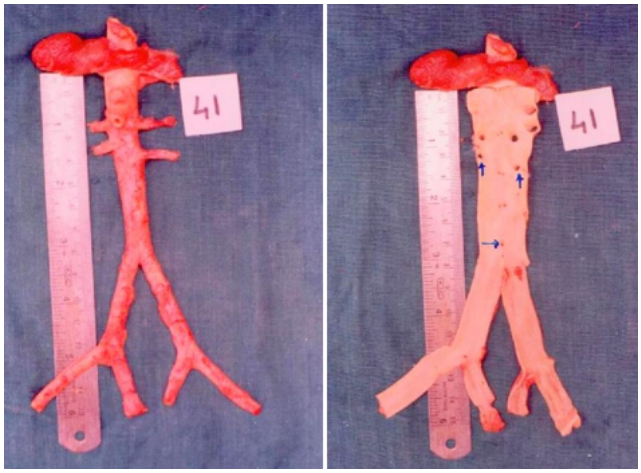

Fig. 6: Aorta with bilateral accessory renal arteries

compared with present study. According to them, the length of right common iliac in males ranged between 8.2 cm – 3.3 cm with an average of 6cm and the left ranged between 7.6 – 3.8cm with an average of 5.8cm. Whereas in females the average length of right and left is 5.63cm and 5.4 cm respectively. This shows that right common iliac artery is lengthier than left common iliac arteries.

The present study showed the average lengths of right common iliac in males and females are 3.93cm and 4.10 cm respectively. In females, the right is 3.99cm and left is 4.34cm. This indicates the left common iliac is longer than the right. The present readings are in contradiction to the study of Shah et al.[14]

Ole martin Pedersen et al. and Sonesson B studied diameters of proximal and distal aortic segments and stated that as age advances the diameter of the distal aortic segment and iliac artery increases. Present study also revealed the same (Table 4).[15,16]

According to the study of Ozan H et al., ostium of Rt. Renal artery was more cranial than that of left (53.3%) and in 10% both the ostia are at same level. In the present study, the ostium of Rt. Renal artery is cranial than that of left in 50% and the left renal artery is cranial to Rt in 46%. Both ostia are at same level in the remaining.[17]

6. Conclusion

To perform various surgical maneuvers a thorough knowledge of different parameters of AA is important. With the advent of noninvasive procedures such as ultrasonography, CT angiography, MR angiography it has become easy to study the variations and locate the lesion and proceed for surgical intervention. Though they give the morphometry, actual cadaveric measurements are also important for comparison**.**

7. Source of Funding

None.

8. Conflict of Interest

Nil.

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