Original Research Paper

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Radiology

COMPUTED TOMOGRAPHY BASED STUDY OF FACTORS AFFECTING ANGLE OF AORTIC BIFURCATION

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ABSTRACT **Introduction:** An individual's unique arterial geometry might influence that person's risk of arterial diseases. Abdominal aorta bifurcation angle is one of the important geometric parameters to have an effect on atherosclerosis. Computed tomography (CT) with its advanced applications plays an indispensable role in aorto-iliac disease. Increased use of endovascular intervention, aortic bifurcation evaluation is must for stenosis, plaque, angle of bifurcation, tortuosity and level of bifurcation. Level of bifurcation provide useful information to the surgeon for the anterior lumbosacral approach and retroperitoneal surgeries. **Objective:** To determine the factors affecting the angle of aortic bifurcation and assess the relationship between angle of aortic bifurcation and level of aortic bifurcation. **Materials And Methods:** Retrospective evaluation of 122 patients, who had undergone contrast enhanced CT examination of abdomen and abdominal aorta was done from picture archiving and communication system (PACS) database. Bifurcation angle was measured. Vertebral level at which aortic bifurcation occurred was also recorded. Abdominal aortic and iliac atherosclerosis was assessed. Subjective assessment of abdominal and iliac tortuosity was also done. Effect of variables such as age, sex, atherosclerosis, tortuosity and level of bifurcation on the aortic angle was statistically evaluated **Results:** Of total 122 patients, 60.7% were male (n=74) and 39.3% are female (n=48). Mean aortic bifurcation angle was 43.1 degree. Mean angle of bifurcation for male and female were 41.4 and 46.6 degree respectively. Most frequent site of bifurcation was L4 vertebra (69.7%) followed by L4-L5 disc (17.2%) and least at L3-L4 disc (13.1%).There was inverse relationship between angle of bifurcation and the level of bifurcation. **Conclusion:** There is no statistically significant association between the angle of bifurcation and the age, sex, presence or absence of atherosclerosis and tortuosity. There is significant association between angle of bifurcation and level of bifurcation, with inverse relation between aortic angle and level of bifurcation i.e. the higher the angle; lower is the level of bifurcation.

KEYWORDS :

INTRODUCTION:

Abdominal aorta is the largest artery which extends from diaphragmatic hiatus to its bifurcation in to common iliac arteries.(1) The geometry of the arteries at or near bifurcation affects the blood flow pattern, an important factor affecting atherogenesis. An individual's unique arterial geometry might influence that person's risk of arterial diseases. Abdominal aorta bifurcation angle is one of the important geometric parameter to have an effect on atherosclerosis. (2) Variation in angle of aortic bifurcation and its normal distribution in population have been reported in many cadaveric and conventional angiographic studies.(3)(6)(7)(8)(9) With the advent of extensive use computed tomography (CT) and advanced applications of multislice CT scanners, preoperative imaging in abdominal aortic disease is indispensable. With ever increasing use of endovascular intervention and trans femoral artery approach being the most common, aortic bifurcation evaluation is must for stenosis, plaque, angle of bifurcation , tortuosity and level of bifurcation (4)The anatomy of the aorta and its relationship to the vertebra would provide useful information to the surgeon for the anterior lumbosacral approach and retroperitoneal surgeries.(5) The objectives of present study was to determine the factors affecting the angle of aortic bifurcation and assess the relationship between angle of aortic bifurcation and level of aortic bifurcation

MATERIALS AND METHOD

Retrospective evaluation of 122 patients from 2019 to 2020, who had undergone contrast enhanced CT examination of abdomen and abdominal aorta at department of radiology, Greater Noida, Uttar Pradesh, India. Images were retrieved from PACS database and bifurcation angle was measured along the medial walls of common iliac artery (Fig 1) using radiant DICOM viewer (version 2020.2). Measurements were done three times and mean of the measurement was recorded. Level of bifurcation were recorded at the level of L3-L4 disc, upper half of L4 vertebra, lower half L4 vertebra, L4-L5 disc or any other level. Abdominal aortic and iliac atherosclerosis was assessed for calcified and non-calcified plaques and presence or absence of atherosclerosis was recorded if any of the one (calcified and non-calcified plaques) was present in any aorto-iliac segment. Subjective assessment of abdominal and iliac tortuosity was also recorded. Statistical analysis was done for any association between angle of bifurcation with respect to age, sex, level of bifurcation, atherosclerosis and tortuosity. Patients with abdominal mass distorting the angle of bifurcation, artefacts at the site of aortic bifurcation, deformity of spine, poor contrast opacification of vessels, large calcified plaques at aortic bifurcation which precludes accurate measurements of angle of aortic bifurcation were excluded from the study.

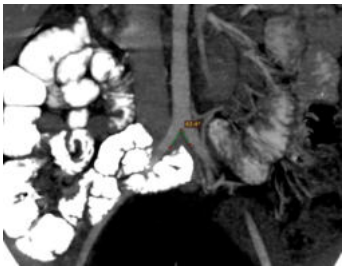

Fig. 1: Aortic bifurcation angle was measured along the medial walls of common iliac artery

RESULTS:

Of total 122 patients, 60.7% were male (n=74) and 39.3% are female (n=48). Mean aortic bifurcation angle was 43.1°. Mean angle of bifurcation for male and female were 41.4° and 46.6° respectively. Atherosclerosis was seen in 28.9% patient with 44.1° as mean angle of bifurcation. Non atherosclerotic patients had mean bifurcation angle of 42.6°. Mean angle of bifurcation in tortuous and non-tortuous vessels were 43.9° and 42.6° respectively. Most frequent site of bifurcation was L4 vertebra (69.7%) followed by L4-L5 disc (17.2%) and least at L3-L4 disc (13.1%). No other level of bifurcation was seen. At L4 vertebra

level of bifurcation at upper half of L4 vertebra was 36.9% and lower half was32.8% (Table 1). Distribution of angle of bifurcation in relation the age is plotted in scatter diagram (Fig. 2), which revealed wide variation in angle beyond 40 years of age as and when there is increased atherosclerosis and tortuosity beyond 40 years. Age, sex, presence or absence of atherosclerosis and tortuosity did not have statistically significant impact on aortic angle bifurcation (Table 2). One-way ANOVA showed statistically significant relationship between aortic angle and the level of bifurcation. There was inverse relationship between angle of bifurcation and the level of bifurcation i.e., higher angles have lower levels of bifurcation and vice versa. (Table 2)

Table 1: Characteristics of patients. *Mean ±*SD*

Sno	Characteristic (N=122)	Description
1	Mean Age	39.4 17.2*
2	Sex F M	 48 (39.3%) 74 (60.7%)
3	Atherosclerosis Yes No	 35 (28.9%) 86 (71.1%)
4	Tortuosity Yes No	 33 (27.3%) 88 (72.7%)
5	Mean Aortic Angle	43.115.2*
6	Level of Bifurcation Upper half of L4 Lower half of L4 L4-L5 disc L3-L4 Disc Level	 45 (36.9%) 40 (32.8%) 21 (17.2%) 16 (13.1%)

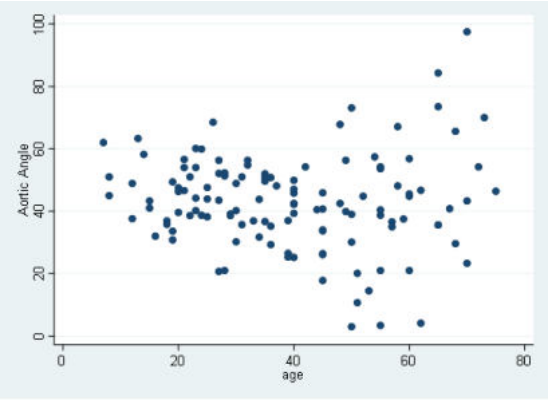

Fig 2 : Scatter diagram of Age and Aortic angle

Table 2: Aortic angle and association of various variables. *One way ANOVA ** Bonferroni test significant for L3-L4 Disc Level and Lower half of L4 and L3-L4 Disc Level and L4-L5 disc, * ttest**

S. no	Characteristic	Mean Aortic angle (SD)	P value
1	Sex F M	 45.6 (16.4) 41.4 (14.2)	 0.13***
2	Atherosclerosis No Yes	 42.6 (11.6) 44.1 (21.9)	 0.6***
3	Tortuosity No Yes	 42.6 (11.1) 43.9 (23.1)	 0.6***
4	Level of Bifurcation* Upper half of L4 Lower half of L4 L4-L5 disc L3-L4 Disc Level	 42.9 (14.3) 43.3 (15.1) 51.5 (14.7) 31.9 (11.7)	 0.002**

DISCUSSION:

Mean angle of bifurcation is in our study was found 43.1° which is comparable to previous angiographic and cadaveric studies.(6)(7)(8)(9). We did not find the impact of atherosclerosis and tortuosity on bifurcation angle, though there was increased variation in the angle of bifurcation beyond 40 yrs of age (Fig. 2), which can be attributed to higher incidence of atherosclerosis and tortuosity in these age groups. (10) Angle of bifurcation is independent of age and sex. Similar findings have been reported by reported by Bargeron et al and sun et al. (3)(7). Significant association between angle of aortic bifurcation and aorto-illiac occlusive disease was reported by Shakeri et al, who reported, higher aortic angle of bifurcation, an independent risk factor for aortoiliac occlusive disease, the potential secondary effect of atherosclerosis on bifurcation anatomy remains a matter of debate. In our study there was no significant difference between the two groups having atherosclerosis or no atherosclerosis. This may be due to difference in the study population of our study, whose primary indication for study for CT scan was not aorto-occlusive disease, whereas it was primary indication in case of shakeri et al. (8) Narrower angles of bifurcation associated with high level of bifurcation had been reported by Bargeron et al.(3) The level of aortic bifurcation was approximately 69.7 % at L4 vertebra, which is comparable to; similar studies done previously done by lakchayapakron et al, in which they reported the incidence of 63% and Lee et al; it was 83% cases.(11)(9) After L4 vertebra, L4-L5 disc was the next most common site reported in 17.2% of patients followed by L3-L4 disc in 13.1% patients. Chithriki et al reported aortic bifurcation at L4 in two-thirds of cases and in remaining 1/3rd, level of bifurcation was variable. They attributed lumbosacral transitional vertebra as a significant cause for the deviation from L4 level bifurcation.(12) With the advent of endovascular procedures and transfemoral approach and use large endovascular devices, angle of aortic bifurcation and its relation with iliac arteries is of extreme importance.(5)

CONCLUSION

There is no significant association between the angle of bifurcation and the age, sex, presence or absence of atherosclerosis and tortuosity. There is significant association between angle of bifurcation and level of bifurcation, with inverse relation between aortic angle and level of bifurcation i.e. the higher the angle; lower is the level of bifurcation. Association between aortic-occlusive disease and angle of bifurcation needs further evaluation as this study did not have any patient with significant aorto-occlusive disease.

Limitations

Height and weight of the patient was not taken in to consideration. Atherosclerosis was defined on the basis of visualized portion of the abdominal aorta, which necessarily may not have the any plaque, but plaque may be present elsewhere in the body vessels. Tortuosity was also defined in the imaged body segment, as like atherosclerosis may also present elsewhere in other vessels. No patients were with aorto-occlusive disease were in the study, so differentiation between angle correlation between atherosclerosis and aorto-occlusive disease may need further investigation

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