A Study of Arch Anatomy for Transradial and for Carotid Angiography

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Received: January 2021
Accepted: February 2021

ABSTRACT

Background: The transradial approach for performing coronary angiography was initially proposed by Campeau in 1989, and a few years later its use was initiated for coronary angioplasty procedures and stent implantation. Although procedure failures can sometimes be due to radial artery anatomical variations; failures due to anatomical variations of the aortic arch are not infrequent. This study was designed to study the angiographic variables with regard to aortic arch and ascending aorta in patients with the favourable and unfavourable catheter course during transradial coronary procedures. Further, the study will also try to explain the anatomical variation in terms of the take-off angle of the brachiocephalic trunk BT and the branching pattern of the arch in these groups of the patients by echocardiographic suprasternal interrogation. **Methods:** The present study was conducted in the Cardiology department at Batra Medical Research Centre Delhi from 2014 to 2017. A total of 100 patients were included in present study; 50 in the retrospective component and 50 in the prospective component. Minimum sample size of 50 patients in each group was estimated Retrospective Analysis was done by reviewing of arch angiogram CDs of 50 arch angiograms in LAO view which were available from the previous records in CATH lab. Prospective Analysis was done by study of catheter course during radial route angiograms and study of Echocardiographic prediction of arch and brachiocephalic anatomy. The subjects were divided into favorable and unfavorable groups depending on the normal catheter course from the brachiocephalic artery to the ascending aorta. The patients studied prospectively for Echocardiographic prediction of arch and brachiocephalic anatomy underwent echocardiograms using the commercially available Vivid 9 System (GE, Horten, Norway) to record the arch anatomy from the suprasternal view. The arch and the brachiocephalic trunk take off were recorded for analysis. In the echo image, these parameters were assessed in 30 patients with normal course and 20 with abnormal guide wire course for meaningful comparisons to be made. **Results:** It was observed that the recorded data of Age, Distance and Take off angle is following normal distribution in all the observed groups and with all three variations of arch Type I Arch, Type II Arch and Type III Arch. Mean Take off Angle of Types of Aortic Arch and Mean Distance D. 50 patients observed in study: 76% patients with I Arch, 18 % patients with Type 11 and 6% patients with Type Ill Arch. In Type l, 38 patients observed had an average age around 43 years. No significant difference was seen in the subjects with Normal Catheter Course or Patients with Abnormal Catheter Course. On comparison of take of angle of the two groups by independent T test it was found that Take off Angle was significantly different in Patients with Normal Catheter Course and Patients with Abnormal Catheter Course (92.43±6.72 vs. 69.95± 4.23; p<0.001.). **Conclusion:** It was concluded from our study that echocardiographic interrogation from the suprasternal window in adult patients did not predict the normal and abnormal catheter course.

Keywords: Transradial, Carotid Angiography.

INTRODUCTION

The transradial approach for performing coronary angiography was initially proposed by Campeau in 1989, and a few years later its use was initiated for coronary angioplasty procedures and stent implantation.[1,2] The transradial technique is, however, associated with a significant learning curve even for experienced femoral operators.[3] Although procedure failures can sometimes be due to radial artery anatomical variations; failures due to anatomical variations of the aortic arch are not infrequent.[4] However, there is a limited data describing such variations. The aortic arch and supra-aortic branches are important anatomical structures for both surgeons and interventionists. Interventionists have to cross the aortic arch to access the supra-aortic arteries with catheters. Intravascular procedures, such as percutaneous angioplasty and stenting of the internal carotid arteries or other supra- aortic arteries and occlusion of intra-cerebral aneurysms with coils, are well accepted treatment options and have good acute and long term results.[5] Knowledge of morphometric data of the aortic arch can be of help for conceiving, designing and optimizing all types of diagnostic and/or therapeutic interventions involving the aortic arch.[6]

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More than 20 different aortic arch configurations have been described, but those specifically described here are by far the most commonly encountered variants.[7,8] In view of the increasing number of endovascular procedures being carried out via transradial route it has become imperative to study arch anatomy so as to predict the procedure success and complications. Unawareness of congenital anomalies of the aortic arch may significantly prolong time to reperfusion during primary percutaneous coronary intervention (PPCI) and, thus, total ischemic time in patients with ST elevation myocardial infarction (STEMI). This is of particular importance in the framework of increasing utilization of radial approach not only in diagnostic and elective procedures but in PPCI as well.[9-11] In addition, these anomalies may lead to increased fluoroscopy time and the usage of multiple consumables.[12]

Echocardiographic evaluation of the aorta is a routine part of the standard echocardiographic examination.[13] Although transthoracic echocardiography (TTE) is not the technique of choice for overall assessment of the aorta, it is useful for the diagnosis and follow-up of some segments of the aorta.[14] Anatomical features of the aortic arch such as its type, steepness, the take-off angles and the distances between its supra-aortic branches can influence the feasibility and difficulty of interventional and/or surgical maneuvers.

This study was designed to study the angiographic variables with regard to aortic arch and ascending aorta in patients with the favorable and unfavorable catheter course during transradial coronary procedures. Further, we will also try to explain the anatomical variation in terms of the take-off angle of the brachiocephalic trunk BT and the branching pattern of the arch in these groups of the patients by echocardiographic suprasternal interrogation.

The present study was aimed to study the anatomy of the aortic arch from arch angiograms records of patients from Cath lab who had undergone aortic arch angiography for different valid indications, the study also aimed to study the relevant characteristics of aortic arch and its relation with the procedural difficulty at arch level during transradial coronary interventions, furthermore, to study the aortic arch and its branches echo-cardio graphically from suprasternal view and define its correlation with procedural difficulty.

MATERIALS AND METHODS

The present study was conducted in the Cardiology department at Batra Hospital and Medical research Centre Delhi from 2014 to 2017. A total of 100 patients were included in present study; 50 in the retrospective component and 50 in the prospective component .Minimum sample size of 50 patients in each group was estimated Retrospective Analysis was done By Reviewing of arch angiogram CDs of 50 arch angiograms in LAO view which were available from the previous records in CATH lab records of patients who had undergone arch for incidental reasons like saphenous grafts, rheumatic heart disease, planned for open heart surgery, VSD patients undergoing Cath studies were analyzed. The angiograms were played on the computer and paused at the best visualized frame and outlining of the aortic arches with branches were traced on the transparent paper. We measured the vertical distance from the origin of the brachiocephalic trunk (BT) to the top of the aortic arch to determine the arch type. This distance is < 1 diameter of the left common carotid artery (CCA) in a Type I arch, between 1 and 2 CCA diameters in a Type II arch, and > 2 CCA diameters in a Type Ill arch. This distance was determined and the mean distance calculated.

The angulated take-off of the brachiocephalic trunk BT from the aorta (angle between the aortic arch and BT) has been studied in carotid artery stenting CAS and predicts the procedural difficulty. This angle was measured and the mean angle was calculated in all three types of the aortic arches. Prospective Analysis was done by study of catheter course during radial route angiograms and study of Echocardiographic prediction of arch and brachiocephalic anatomy. 50 consecutive patients undergoing radial route angiography for valid indications were studied prospectively. The patients were divided into the two groups: patients with favorable brachiocephalic access and those with unfavorable brachiocephalic access. The group with favorable brachiocephalic access were those in which there was a normal catheter course from the brachiocephalic artery to the ascending aorta. And the group with unfavorable catheter course were those in which the guide wire was repeatedly going into the descending aorta instead of ascending aorta. After radial sheath insertion, the catheter and hydrophilic J 0.35 guide wire (Terumo) were advanced ante grade. The catheter was advanced till the middle of the arm in the brachial artery and the guide wire advanced into the aorta up to 2cms above the aortic valve such that it lied free in ascending aorta. A fluoroscopy recording of the guide wire including the brachial artery and the aorta were recorded in the AP view and in 450 LAO view.

In patients where the guide wire entered the descending aorta(unfavorable catheter course), a fluoroscopic record was taken, and the guide wire manipulated into the ascending aorta with the help of the catheter tip manipulations as necessary -Before proceeding with the angiography or after completion, the guide wire was kept in the ascending aorta and the catheter withdrawn into the brachial artery for taking AP and LAO fluoroscopy recordings, as was done for the patients with normal catheter course. The angle made by the guide wire at the bend along its length while negotiating into the ascending aorta from the brachiocephalic trunk was measured in both the groups of the patients with favorable and unfavorable catheter course. This angle was compared in two groups and its tactical significance sought to predict the procedure difficulty in transradial coronary interventions.

The patients studied prospectively for Echocardiographic prediction of arch and brachiocephalic anatomy underwent echocardiograms using the commercially available Vivid 9 System (GE, Horten, Norway) to record the arch anatomy from the suprasternal view. Attempts were made to define the arch in an oblique section which opens the arch (transducer rotated to approximately 450 from the horizontal plane, equivalent to an LAO view.). The arch and the brachiocephalic trunk take off were recorded for analysis. In the echo image, these parameters were assessed in 30 patients with normal course and 20 with abnormal guide wire course for meaningful comparisons to be made. The brachiocephalic origin from arch was analyzed and its take-off angle was calculated in both the groups of the patients. Statically correlation of the take-off angle of the BT was sought in both the groups of patients so as to predict the procedural difficulty.

The data was analyzed with a statistical computer software package (SPSS version 20.0) and Graphical presentation was done in Microsoft EXCEL Continuous data was expressed as mean, standard deviation (SD), Median and Range. Categorical variable expressed as frequency and percentages. Normality of data was checked by using Shapiro-Wilk and Kolmogorov-Smirnov test. The difference of Continuous variables was analyzed by One Way ANOVA for more than two groups and two sample T test for two groups. The correlation of Continuous variables was analyzed by Pearson correlation. Probability values < 0.05 will be significant.

RESULTS

[Table 1] shows the results of the Normality Test on Data of Age Distance and Take off angle in prospective study subjects. It was observed that the recorded data of Age, Distance and Take off angle is following normal distribution in all the observed groups and with all three variations of arch Type I Arch, Type II Arch and Type III Arch. [Table 2] shows Age distribution of all the patients. It was seen that within 50 Retrospective patients. 35 were males and 15 females with a mean age (±SD) of 45.7 (±27.1) years. Minimum age observed was 7 years and maximum age was 79 years. Further the table shows that within the 50prospective patients 30 were male and 20 were female the mean age (±SD) was 62 (±8.2) Minimum age was 47 and maximum age observed was 81 Years.

Table 1: Normality Test on Data of Age Distance and Take off angle.

Tests of Normality							
Arch Types		**Kolmogorov-Smirnova**			**Shapiro-Wilk**		
		Statistic	**Df**	**Sig.**	**Statistic**	**Df**	**Sig.**
Age	1	.197	38	.001	.849	38	.000
	2	.379	9	.001	.696	9	.001
	3	.348	3	.	.834	3	.198
Distance	1	.203	38	.000	.914	38	.006
	2	.151	9	.200*	.977	9	.950
	3	.253	3	-	.964	3	.637
Take off angle	1	.184	38	.002	.778	38	.000
	2	.158	9	.200*	.936	9	.538
	3	.385	3	-	.750	3	.000
*. This is a lower bound of the true significance.							
Lilliefors Significance Correction							

Table 2: Age & gender distribution of patients

		Retrospective patients	Prospective patients
Age of patients(years) Mean ± SD		45.7±27.1	62±8.2
Gender	Male	35	30
	Female	15	20

Table 3: Overall analysis of the retrospective study of 50 arch angiograms for Arch distribution in respect to mean age. Mean Take off Angle of Types of Aortic Arch and Mean Distance D.

Characteristic	Type of aortic areli (n=50)			P value
	Type I	**Type II**	**Type III**	
Age years mean±sd	43.32 (26.08)	51.22 (31.79)	59.33 (29.02)	0.499
Distance d mean±sd	15.1 (0.43)	19.5. (0.55)	26.83 (0.44)	0.00
Angle degrees mean±sd	92.55 (.88)	74.33 (1.46)	59.33 (0.66)	0.00
P values calculated using one way Annova				

Table 4: Normality Test on Data of Take-off Angle of Patients with Abnormal Catheter Course and Patients with Normal Catheter Course in Prospective subjects.

Tests of Normality							
	Type	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	Df	Sig	Statistic	Df	Sig
Take off Angle	1	.141	30	.132	.935	30	.066
	2	.126	20	.200	.933	20	.176
* - This is a bound of the true significance.							
1=Patients with Normal Catheter Course , 2 =Patients with Abnormal Catheter Course							

Table 5: Comparison of take-off angle of two groups in Prospective subjects.

	Type	N	Mean	Std. Deviation	Std Error Mean
Take off angle	1	30	92.4333	6.72455	1.22773
	2	20	69.9500	4.23612	.94723

Table 6: Correlation between Age and the Take-off Angle in Patients with Abnormal Catheter Course in Prospective subjects.

Correlations			
		Age	Take-off
Age	Pearson Correlation	1	.350
	Sig. (2-tailed)		.130
	N	20	20
Take off	Pearson Correlation	.350	1
	Sic. (2-tailed)	.130	-
	N	20	20

Table 7: Correlation between age and take off angle in patients with abnormal and normal catheter

Correlations			
		Abnormal	Normal
Abnormal	Pearson Correlation	1	-.021
	Sig. (2-tailed)	11	.964
	N		7
Normal	Pearson Correlation	-.021	1
	Sic. (2-tailed)	.964	-
	N	7	21

Table 8: Correlation of Angle between Arch and BT as measured on 2D echo of Patients with Normal and Abnormal Catheter Course

Correlations			
		Abnormal	Normal
Abnormal	Pearson Correlation	1	-.021
	Sig. (2-tailed)	11	.964
	N		7
Normal	Pearson Correlation	-.021	1
	Sic. (2-tailed)	.964	-
	N	7	21

[Table 3] presents the overall analysis of the retrospective study of 50 arch angiograms for Arch distribution in respect to mean age. Mean Take off Angle of Types of Aortic Arch and Mean Distance D. 50 patients observed in study: 76% patients with I Arch, 18 % patients with Type 11 and 6% patients with Type Ill Arch. In Type l, 38 patients observed had an average age around 43 years with standard deviation 26.1, 9 patients Type II Arch 51 years with standard deviation 31.7 and 3 patients in Type III Arch around 59 years with standard deviation 29.0. 38 arch angiograms observed in Type I Arch had an average Take off Angle of 92.55±0.88, 9 observed in Type II Arch had 74±1.46 and remaining 3 observed in Type Ill Arch had Taken off Angle of 59±0.66. 38 arch angiograms observed in Type I Arch had an average Distance D 15.1±43 mm, 9 observed in Type II Arch had 19.5± (0.55) and remaining 3 observed in Type Ill Arch had Distance D of 26.83± (0.44)

[Table 4] presents the normality test on data of Take-off Angle of Patients with Abnormal Catheter Course and Patients with Normal Catheter Course in Prospective subjects. No significant difference was seen in the subjects with Normal Catheter Course (1) or Patients with Abnormal Catheter Course (2). The analysis represented that the normal distribution was followed in data from the study subjects using Lilliefors Significance Correction test.

[Table 5] depicts the comparison of take-off angle of two groups in Prospective subjects. The mean in take-off angle in type 1 was 92.4333±6.72455 in comparison to the mean of type II which was 69.9500±4.23612. On comparison of take of angle of the two groups by independent T test it was found that Take off Angle was significantly different in Patients with Normal Catheter Course and Patients with Abnormal Catheter Course (92.43±6.72 vs. 69.95± 4.23; $p<0.001$.)

[Table 6] shows the Correlation between Age and the Take-off Angle in Patients with Abnormal Catheter Course in 20 Prospective subjects. [Table 7] presents the correlation between age and take off angle in patients with abnormal and normal catheter No significant correlation was found between Age and the Take-off Angle among Patients with Abnormal Catheter Course ($r = .350$, $p > 0.05$). [Table 8] shows correlation of Angle between Arch and BT as measured on 2D echo of Patients with Normal and Abnormal Catheter Course No significant correlation was found in Echo Angle between two groups (r=-.021 -p> 0.05).

DISCUSSION

Anatomical features of the aortic such as its steepness, the take-off angles and the distance between the supra-aortic branches can influence the feasibility and difficulty of interventional and/or surgical maneuvers.

There are three types of the aortic arches using a criterion the vertical distance D from the origin of the brachiocephalic trunk (BT) to the top of the aortic arch. In our study, we calculated this mean distance D for different types of aortic arches and observed that this distance increased as we moved from Type I (15.1±0.43mm) to Type II (19.5±0.55mm) and type 3 (26.83±0.44mm). Similar results were observed by S. Madhwal et al. in their study.[15] This could be due to the elongation of the aortic arch and leftward shift of the brachiocephalic origin secondary to age related dilatation of the aortic root and hypertension as studied by Sugwara et al. in their study.[16]

In preset study, Type I was the commonest variant in 38 patients (76 %) followed by Type II in 9 patients (18%). Type Ill aortic arch was least common and was present in 3 patients (6%). Stefanos Demertzis et al. found similar results.[17] It was observed that patients with type I aortic arch were usually younger in age (mean age ESD years 43.32±26.084) than those with type II (51±22) and 3 (59.33± 29.02).

The configuration of the whole aortic arch and the take-off angle of the brachiocephalic trunk from the arch of aorta are of particular interest, in the present study we calculated the mean take-off angle of the brachiocephalic trunk BT with the arch of aorta in the 50 arch angiograms and was 87.3±11.20, which was similar to the findings of Demerttzis (84.79±SD 13.750).[17]

However, this take-off angle varied in the three types of the aortic arches and was more acute in Type II (74.33±1.460) and Type Ill arches (59.33±0.660) as compared to Type I aortic arch (92.55±38). Similar results were observed by Sadhwal et al. in their study.[15]

In present study 50 out of the 51 arch angiograms studied (50 in retrospective and one in prospective studies), only one patient (1.96%) had an abnormal origin of the right subclavian artery from the descending aorta and separate origins of carotid arteries from the arch. In all other studied arch anomalies in terms of abnormal branching pattern varies in different cadaveric anatomical and non-cadaveric radiological studies; 9.60%, 11.7%, 20.8% and 36.5%.[18-21] The results of the present study could be explained by very small number of the patients in the study.

In the group of 20 patients with unfavorable catheter course in whom the guide wire was repeatedly going into the descending aorta, the angle at the bend along the long axis of the guide wire was calculated and means angle was smaller in this group of the patients as compared to group with favorable catheter course (69.95^0 vs. 92.43^0, p value <0.000).

Normality test of the data on take-off angles followed the normal distribution in both the groups of the patients. We did not find any significant correlation between age and the guide wire angles in the two groups of the patients.

In present study, in three of the twenty patients with the abnormal catheter course, the route needed to be changed to the femoral site for the coronary intervention. In one of these patients, repeated attempts to manipulate guide wire into the ascending aorta failed PCI was done via femoral route. Although it was not a part of our Protocol, aortic arch angiogram was taken and recorded at the end of the procedure which showed abnormal origin of right subclavian artery from descending aorta. We would not take aortic arch angiograms in the other two patients showed origin the artery the descending because of the grossly abnormal renal function tests.

We did not find any significant between age and the guide wire angles in the two group. the present study examined the aortic 2D interrogation from suprasternal view in both the groups of the patents and an attempt was made to define arch characteristic in the oblique section. Amongst the 30 patients with the normal catheter course, the arch could be visualized in the 21 patients and the remaining nine had poor echo window -In the 20 patients with the unfavorable catheter course, the arch could be interrogated only in eleven patients for similar reasons.

Non-invasive imaging of the extracardiac cardiovascular anatomy such as the aorta is more difficult than the evolution of intra-cardiac anatomy. The suprasternal approach for examination has been more successful in children because of the shorter involved and because of improved echocardiographic penetration. Huhta et al., in their study were able to make complete diagnostic examination of aorta of congenital disease in 98% of new-borns, infants and younger children but the sensitivity decreased with increasing age.[22] Also, our significant number of patients had an associated history of COPD and obesity which further added to the poor echo window and, thus, limited our suprasternal echo interrogation and arch visualization.

The angle between the brachiocephalic tank and the arch was studied in both the groups of the patients having good echo window by two different observers. This angle was 90.76±7.880 in a group with favorable catheter course and 80.18±5.890 in the group with unfavorable catheter course and comparison of the two groups didn't achieve statistical significance (P value>0.05).

We therefore concluded from our study that echocardiographic interrogation from the suprasternal window in adult patients did not predict the normal and abnormal catheter course.

The small number of subjects as well as the inability to randomize the subjects was a basic limitation in the present study sample was small in both the components of our study. In the prospective part of the study, we measured the angle of the guide wire at its bend while negotiating into the ascending aorta which may not represent the true anatomical dimensions of the brachiocephalic trunk and aorta. We did not have the arch angiograms of the all patients in the prospective part of our study to delineate the appropriate functional anatomy and branching pattern.

CONCLUSION

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How to cite this article: Shah KSH, Shafi HM, Hakeem AA, Khan SA. A Study of Arch Anatomy for Transradial and for Carotid Angiography. Ann. Int. Med. Den. Res. 2021; 7(2):ME17-ME22.

Source of Support: Nil, **Conflict of Interest:** None declared