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ORIGINAL ARTICLE

Is there any association between aortic root rotation angle and aortic dissection?

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Abstract

Introduction Thoracic aortic dissection is a probable fatal condition that requires early diagnosis and management. The underlying etiology of this disorder is an important issue that has not been completely responded yet. In the current study, the association between aortic root rotation and ascending aortic dissection has been assessed.

Methods This is a non-randomized retrospective case-control study conducted on twenty-five cases referring with ascending aortic dissection and seventy-five controls that underwent computed tomography (CT) angiography for reasons other than aortic dissection. Aortic root rotation angle and aortic diameter for both cases and controls were measured and then compared.

Results There was no significant difference regarding age and gender distribution (P value = 0.22 and 0.38 respectively) between patients in case and control groups. The mean values of aortic root rotation angle and aortic diameter in cases were 22.5 ± 10.5° and 43.1 ± 12.5 mm versus 15.7 ± 10.7° and 30.7 ± 5.3 mm in controls (P value = 0.007 and 0.001 respectively). Direct relation was found between aortic root rotation angle and aortic diameter (P value = 0.007, r = 0.276). Mean of aortic root rotation angle was significantly higher in females (P value = 0.02). No association between cases' age with either aortic root rotation angle or aortic diameter was found (P value = 0.33, r = 0.098, and P value = 0.085, r = 0.173 respectively).

Conclusion Based on the findings of the current study, aortic root rotation angle was independently in direct association with thoracic aortic dissection. In addition, females had higher aortic root rotation angles.

Keywords Computed tomography angiography · Aortic valve · Aortic root

Introduction

Thoracic aortic dissection is a clinical status with diverse presentations. Symptoms associated with this situation vary from acute back, chest, or abdominal pain with catastrophic outcomes to a silent situation without painful presentations [1, 2].

The specific mechanism is still not completely clarified [3], even though various risk factors including hypertension [2], aneurysm [4], aortic valve disease (such as aortic valve stenosis or regurgitation) [5], bicuspid aortic valve [6], and congenital cardiac disease such as tetralogy of Fallot [7] (TOF) have been mentioned as its predisposing factors.

Biomechanical properties leading to initiation and propagation of dissection are a challenging issue [8]. Shearing force and direction of existing blood from outflow tract are important factors in dissecting event [9]. Hemodynamic feature of helical pattern of blood flow in ascending aorta and its relation with aortic valve angle has been previously described [10]. According to these concepts and considering that aortic root and ascending aortic diseases are more common in patients with conotruncal anomalies, in particular TOF [11–14], we hypothesized that unusual rotation in axis of aortic outflow could be potentially important in the occurrence of dissection.

Since varying degrees of aortic root rotation angle are seen in normal population [15, 16], and recent study has shown relation between increased clockwise rotation of aortic root and dilation of ascending aorta [17], this presumption has been raised that unusual aortic root rotation angles have a potential role in occurrence of dissection. The aim of this

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study was to investigate the probable association of aortic root rotation with ascending aortic dissection.

Methods

This is a non-randomized retrospective case-control study conducted on cases referring with aortic dissection and controls that underwent thoracic CT angiography for reasons other than aortic dissection during 2016–2018.

Presence of findings of type A (the Stanford classification) of aortic dissection in CT angiography (as a gold-standard technique of diagnosis) was considered as inclusion criterion and controls were selected among age and gender matched coronary CT angiograms without any evidence of dissection.

Patients with history of aortic insufficiency, aortic stenosis, cardiomegaly, connective tissue disorders such as Marfan syndrome, bicuspid aortic valve, aortic valve replacement therapy, and any type of congenital heart dieses were considered as exclusion criteria in both case and control groups.

The proposal of this study was approved by the Ethics Committee of Isfahan University of Medical Sciences (project number 396830). Informed consent was not used because all CT angiograms had been performed with clinical indication, even though confidentiality reassurance of patient's information has been given to all patients who undergone CT in our institutes.

To compare the mean of our variables (aortic dimeter and rotation angle), if we want to obtain 80% power and a *P* value of 0.05 as significance, with mean difference of at least 0.8 s (*s*, standard deviation), the sample size for our cases was estimated as 25 cases and control cases, and we considered it as threefold of cases.

CT angiography was performed using a 64-multi-detector computed tomography (MDCT) scanner (LightSpeed VCT 64, GE Healthcare, USA) and also by a 256-slice MDCT scanner (BrillianceTM 256; Philips Medical System). Prospective gated protocol was used in all cases. Angiograms were performed in craniocaudal direction from the thoracic aorta and heart to the lower level of the diaphragm within a single breath hold. Multiplanar reformations were utilized to measure cross-sectional ascending aortic diameters at mid part of tubular portion, using double-oblique measuring method [18].

As in a previous study [15], aortic root rotation angle was measured in a true short axis view of aortic root. A line between mid-point of non-coronary sinus and anterior commissure was drawn and defined as "axis of non-coronary sinus." Also, "axis of interatrial septum" was drawn and the produced angle (whether clockwise or anti clockwise) was measured and defined as aortic root rotation angle (Fig. 1).

All images were reported by a target radiologist who was a specialist in cardiovascular imaging. All cases and controls data including age, gender, ascending aortic diameter, and aortic root rotation angle were recorded in a check list and

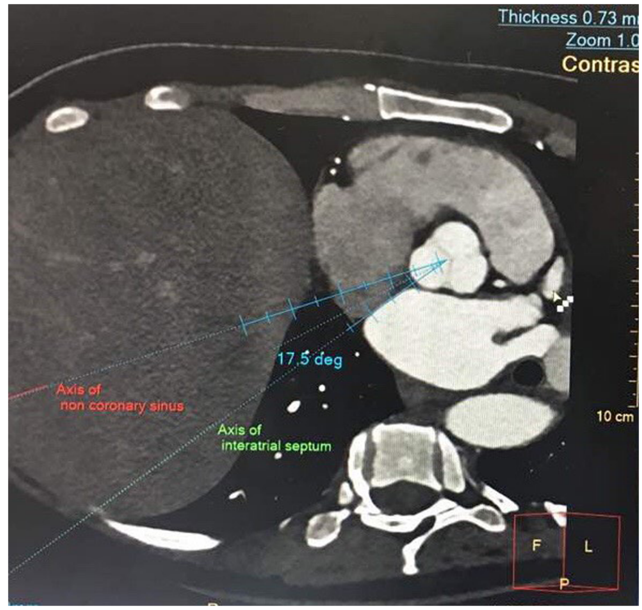

Fig. 1 The rotational angle is the angle between axis of non-coronary sinus and axis of interatrial septum

were analyzed using SPSS software (version 22, IBM® SPSS®, Statistics, USA). Descriptive data were presented in mean and percentages. For analytics, independent *T* test, the Pearson correlation test, and logistic regression test were utilized. *P* value < 0.05 was considered as significant level.

Results

This study was conducted on 25 patients with documented presentation of thoracic aortic dissection (Stanford type A) as cases and 75 patients who had undergone gated cardiac CT angiography for reasons other than dissection. Cases and controls of the current study had a mean age of 53.2 ± 15.02 years (range 23–84 years) and 57.2 ± 13.4 years (range 14–80 years) respectively. There was no statistical difference in age between two groups (*P* value = 0.22). Gender distribution of cases was 19 males (76%) and 6 females (24%) while this distribution was 50 males (66.7%) and 25 females (33.3%) for controls. Gender distribution of cases and controls was not significantly different (*P* value = 0.38). The mean of rotation angle in the case group was 22.5 ± 10.5 versus $15.7 \pm 10.7°$ in the control group (Table 1). All measured angles among the case and control groups were clockwise.

Independent *T* test showed that the mean angle of aortic root rotation (*P* value = 0.007) and aortic diameter (*P* value < 0.001) was significantly higher among those with thoracic aortic dissection in comparison with patients underwent CT angiography without presentations of aortic dissection.

Covariance analysis by controlling gender, age, and aortic diameter showed that aortic root rotation is in significant

Table 1 Comparison of aortic root rotation angle and aortic diameter based on cases and controls (A) and assessment regarding cases' gender (B)

	Mean ± standard deviation	Mean ± standard deviation	*P* value (independent *T* test)	*P* value (ANCOVA)
A	Cases	Controls		
Aortic root rotation angle	22.5 ± 10.5 (°)	15.7 ± 10.7 (°)	0.007	0.045
Aortic diameter	43.1 ± 12.5 (mm)	30.7 ± 5.3 (mm)	<0.001	–
B	Male	Female	*P* value (independent *T* test)	
Aortic root rotation angle	15.7 ± 9.9 (°)	21.1 ± 12.6 (°)	0.02	–
Aortic diameter (mm)	34.3 ± 10.1 (mm)	32.8 ± 7.6 (mm)	0.47	–

ANCOVA- Analysis of Co-variance

association with thoracic aortic dissection (P value = 0.045) (power of study was 80%).

Meanwhile, the Pearson coefficient correlation test found statistically direct association between aortic root rotation angle and aortic diameter (P value = 0.007, r = 0.276).

Gender-based assessment showed that the mean of aortic root rotation angle was significantly higher in females (P value = 0.02) but aortic diameter was not different considering gender (P value = 0.47).

Based on the Pearson correlation test, there was no association between either aortic root rotation angle or aortic diameter with cases' age (P value = 0.33, r = 0.098, and P value = 0.085, r = 0.173 respectively).

Discussion

The biophysical etiology of aortic dissection is still a question; however, according to literature review, we raised the hypothesis that aortic outflow angle may be a predisposing factor influencing incidence of dissection.

Recently, studies have investigated aortic root rotation and its association with various aortic complications. Proper studies have demonstrated that malrotation in conotruncal angle leads to aortic dextroposition and also TOF [15], while mild clockwise rotation in this angle may also be seen in normal population. Further evaluations showed that this mild angle change can predispose patients to ascending aortic diseases including dilation, aneurysm, or dissection [15, 17].

In the current study, up to our knowledge and due to our researches, we have assessed relation of aortic root rotation angle with aortic dissection incidence, through a case-control study for the first time.

In the current study, cases and controls were not statistically different regarding their age and gender; thus, probable confounding roles of these demographic variables have been almost eliminated. Cases with aortic dissection had significantly higher rotation angle and aortic diameter. Even by controlling other factors including age, gender, and aortic diameter, patients with dissection had significantly higher rotation angle. Furthermore, the Pearson coefficient correlation test showed statistically direct association between this angle and diameter of aortic root.

Saremi et al. [17] in a study conducted in 2017 declared similar results as they found significant direct association between rotation angle and diameter of the aorta. However, they had performed their study among cases without presentation of dissection. Regarding our finding, question will be raised of whether aortic rotation is due to abnormal development of outflow tract or is secondary to aortic dilation, or aneurysm. Since this rotation angle is altered by conotruncal anatomy, it seems that it is a primary factor, and also Saremi et al. presented that developmental status is more probable [17]. To validate this finding, other investigations are needed. In a study conducted by Isaaz et al. [15], in order to compare normal population with patients who had TOF, they presented that normal population had significantly less aortic clockwise rotation in comparison with patients with TOF. Also, it should be mentioned that their control group had mean rotation angle of 23° which is significantly higher than our control group and even similar to our cases. This difference in angle might be due to significant difference in the age of population who were evaluated in these two studies; additionally, they used echocardiography for angle measurement and we used CT. Although age was not correlated with angle in our study, our study population was in a different age group (middle age in the opposite to childhood).

In another study conducted by Bissell et al. [19] in 2013, they performed their study on patients with bicuspid aortic valve, using cardiac magnetic resonance imaging, and presented that those with bicuspid aortic valve in comparison with normal volunteers had significant higher rotation angle and also higher aortic diameter. A limitation of our study is that we did not have any case with bicuspid valve and did not describe aortic valve cupidity.

The other finding of our study was a comparison of aortic root rotation angle and its diameter in different genders. We found that females had higher angle while aortic diameter was not statistically different between males and females. This finding is inconsistent with a previous study that the rotation angle was not affected by patients' genders [17]. Hager et al. used helical computed tomography in order of aortic index assessment. They mentioned that men had slightly higher diameter of aortic valve while it was not significant. On the other hand, they found that aortic diameter had direct association with aging [20]. Lin et al. in a study utilizing multi-detector computed tomography showed that the diameter of aortic valve was directly associated with age but not gender [21]. Although females had higher angle in this study, more than half (76%) of our dissection patients were males. This controversy could be explained by a small number of our cases, which was our limitation, but more importantly, presence of dissection risk factors such as hypertension or connective tissue disorder had not been compared among males and females in the case group. Actually, we did not have any fundamental concept of possible gender difference in rotation angle according to previous limited studies and consequently, we did not match risk factors of dissection among male and female in the case group. Since this hypothesis has been raised in this study, for further studies, attention to it is recommended. Another equivocal point is that all patients with dissection in this study had large aorta. Actually, normal aortic diameter in the setting of dissection is uncommon. Usually, when we see dissection, false lumen has been expanded, and regardless of primary size, in the acute stage, dilation is seen. Even though normal diameter in the dissected area will not probably be easily detected, in future complementary studies, these kinds of cases might be found, provided that larger sample size is included.

It should be mentioned that all of studies presented above have not been conducted on patients with chief complaint of thoracic aortic dissection. Although study population of our study for generalizing these results are few, which was our limitation, this hypothesis that aortic root rotation angle may play role in occurrence of dissection is more considered and also this relation might be potentially more prominent among females. Further evaluations in this regard are recommended.

Conclusion

Based on findings of the current study, aortic root rotation angle was independently in direct association with thoracic aortic dissection. In addition, females regardless of dissection had higher aortic root rotation angles. In addition, aortic diameter was considerably higher among those with dissection while it was affected by neither gender nor age.

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Compliance with ethical standards

The proposal of this study was approved by the Ethics Committee of Isfahan University of Medical Sciences (project number 396830). Informed consent was not used because all CT angiograms had been performed with clinical indication, even though confidentiality reassurance of patient's information has been given to all patients who undergone CT in our institutes.

Conflict of interest The authors declare that they have no conflict of interest.

Human and animal rights There is no objection to animal or human rights in this study.

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We confirm that this work is original and has not been submitted simultaneously nor been currently under consideration for publication elsewhere.