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Anatomic Variations of Aortic Arch Branches and Relationship with Diameter of Aortic Arch by 64-row CT Angiography

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Abstract: There are different variations in the branching pattern of the Aortic Arch (AA). The aim of the present study was to study and evaluation of anatomic variations of aortic arch branches and relationship with diameter of aortic arch by 64-row computed tomography angiography (CT angiography). This descriptive analytical study was performed on 503 human by using of CT Angiography (CTA) to evaluation of anatomic variations of aortic arch. Patients underwent three dimensional restoration of aorta arch images and its branches using MIP and VRT software following intravascular injection of vein material (100 mL) and conducting CT. Then, kind of their divisions were registered. Additionally, diameter of aorta arch was measured at its cross section immediately before and after separation of its first and last branches, respectively. This study was performed on 503 specimen that 269 (53.5%) was male and 234 (46.5%) was female. The most common AA branching pattern was found in 346 (68.8%) of 503 specimens. There was no significant correlation between sex and type of variations ($p = 0.073$). There was no significant correlation between type of AA variations and AA diameter in the early branching area ($p = 0.446$) and there is no significant correlation between type of AA variations and AA diameter in the last branching area ($p = 0.887$). The different branching patterns of the AA observed in this study and the morphometric measurements taken can assist doctors in performing safe and effective surgeries in the superior mediastinum and also a safe interventional procedures.

Key words: Variation, aorta arch, diameter, CT angiography, diagnosis

INTRODUCTION

Vascular variations are branched from several aorta arches. Cardiovascular, thorax and neck surgeons as well as radiologists and anatomists should be familiar with these variations (Goldust *et al*., 2013a; Mirjalili *et al*., 2012). Aorta arch is a part of body complex vascular system which can be evolved with congenital variations (Goldust *et al*., 2013a; Vasava *et al*., 2012). Aorta arch may have different locations in different persons and even it is possible that aorta arch is seen with random branches (Goldust *et al*., 2011; Mohebbipour *et al*. 2012; Trachet *et al*., 2011). Also, aorta diameter may vary considering shear stress variations resulting from blood turbulence at the location of aorta branches division at different kinds of variations (Goldust *et al*., 2013a; Sasaki *et al*., 2011). There are several ways to study different variations of aorta arch including MRI, echocardiography and angiography using catheter (Sakamoto *et al*., 2011). Each of the methods carries their own problems: limited use in sever vascular diseases and non-cooperation of the patients with this technique (MRI), limitations in detecting some diseases including abnormality of big arteries (echocardiography) and invasive and expensive (angiography using catheter) (Milan *et al*., 2011). T-angiography especially CT with 64-rows detector is another method used in detecting aorta arch variations. Its non-invasive and inexpensive nature as well as its requiring less time in comparison with other detective techniques can be referred to as its advantages (Choi *et al*., 2011; Goldust *et al*., 2013a-d). CT angiography is a noninvasive method which is essentially inexpensive than other common digital angiography methods. Taking a three dimensional image from all angles of a unit vascular complex is possible in this method (Goldust *et al*., 2013a; Muhs *et al*., 2006). Comparing with digital angiography, capability to demonstrate form, size and density of vessels wall and

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adjacent limbs is another advantage of CTA. Additionally, high expenses, incapability in detecting Intramural Hematoma (IMH) and need to clinical examination have been introduced as main disadvantages of angiography in comparison with CTA (Sadighi *et al*., 2011; Yamada *et al*., 1998). During the last decade, CT angiography has become a standard noninvasive imaging technique to describe vascular anatomy and pathology (Goldust *et al*., 2012; Karabulut *et al*., 2010). Imaging quality and speed of CT angiography has significantly promoted and developed from single canal spiral systems to multi-canal spiral systems (Goetti *et al*., 2010; Milan *et al*., 2011). CT 64-row detector systems were available since 2004. The imaging method is often used as a supplementary detect tool of aorta diseases specified by esophageal Trans echocardiography, MRI and aortography. The imaging technique is widely used in more applications at several imaging methods (Golfurushan *et al*., 2011; Kovacs *et al*., 2009; Sadeghpour *et al*., 2011). Therefore, the present study aims at evaluating variations of aorta arch branches using 64-row detector CT angiography as well as its relationship with variations of aorta arch diameter.

MATERIALS AND METHODS

Subjects: This descriptive-analytical study conducted on 503 patients at Parsian CT angiography ward of Shahid Madani Hospital, Tabriz from March 2011-2012. The patients were selected using random sampling method.

Methods: Considering that all understudy patients were referred by different physicians to thorax CT using injection of veil material and it was regarded as the essential element of diagnostically evaluate their disease indicated by the related specialist, we worked only on the above-mentioned images using restoration and software techniques and registered the required findings. In this study, those patients referred by different physicians to thorax CT using injection of veil material (for any reason) underwent three dimensional restoration of aorta arch images and its branches using MIP and VRT software following intravascular injection of vein material (100 mL) and conducting CT. Then, kind of their divisions were registered. Additionally, diameter of aorta arch was measured at its cross section immediately before and after separation of its first and last branches, respectively.

Statistical analysis: All data was collected at a special checklist and statistically analyzed using SPSS-15 statistical software. The results were stated as Mean ±SD. To compare data using one way ANOVA method and Pierson correlation coefficient, Chi-square and multiple regression methods were used. Also, Fischer's exact test was used to compare qualitative variables. In this study, reliance coefficient and p-value were regarded as 95% and <0.05, respectively.

RESULTS

The study was consisted of 503 participants out of them 269 (53.5%) were males and 234 (46.5%) were females. Mean age of all subjects was 56.70±16.79 years. In this study, mean age of males was 57.51±17.20 and that of females was 55.76±16.29 years. Mean cross sectional diameter of aorta arch immediately before and after separation of the first and last branches was 32.05±4.99 and 23.82±3.48 mm, respectively (Table 1). Considering frequency of variations of aorta arch branches in the understudy subjects, the patients were divided into following categories: (a) 346 patients (68.8%) were among No. 1 variation that 192 (38%) subjects were male and 154 (30.6%) were female. (i.e., aorta arch with three branches), (b) 60 subjects (11.9%) were among No. 2 variation that 27 (5.3%) subjects were male and 33 (6.5%) were female (i.e., aorta arch with two branches), (c) 21 cases (4.2%) were among No. 3 variation that 16 (3.2%) subjects were male and 5 (1%) were female (i.e., left vertebral artery separated from aorta rather than left sub-clavin artery), (d) One female (0.2%) was among No. 4 variation (i.e., common origin of common carotid arteries of aorta arch), (e) 72 subjects (14.3%) were among No. 5 variation that 34 (6.7%) subjects were male and 38 (7.5%) were female (i.e., common origin of left carotid artery with brachiocephalic artery), (f). There was not found any case who can be placed among No.6 variation (i.e., common origin of common carotid arteries and sub-clavin arteries), (g) One female (0.2%) was among No. 7 variation (i.e., lack

Table 1: Demographic data of study population

Parameters	Male	Female
N	269 (53.5)	269 (53.5)
Age	57.51±17.20	55.76±16.29
Mean cross sectional diameter of aorta arch immediately before separation of the first and last branches (mm)	32.05±4.99	3.82±3.48
Variations		
1	192 (38)	154 (30.6)
2	27 (5.3)	33 (6.5)
3	16 (3.2)	5 (1)
4	-	1 (0.2)
5	34 (6.7)	38 (7.5)
6	-	-
7	-	1 (0.2)
8	-	-
Right-oriented aorta arch	-	1 (0.2)
Aberrant sub-clavin	-	2 (0.4)

Values in parenthesis are percentages

of brachiocephalic body) and (h). There was not found any case who can be placed among No. 8 variation (i.e., additional branch of thyroid artery of aorta arch). Also, there were three other cases of variation which are not regarded among the above-mentioned divisions: 2 cases (0.4%) of aberrant sub-clavin artery, 1 case (0.2%) of right-oriented aorta arch. Gender frequency of kinds of variations has been demonstrated in Table 1.

DISCUSSION

There were more than 500 subjects in this study and frequency of kinds of variations of aorta arch and their branches. Additionally, the relationship found between aorta diameter and variation and gender was also studied. There are few studies all over the world in this regard and similar researches may be helpful at different areas (Satyapal *et al*., 2003; Sora *et al*., 2002). In this study, the highest rate of frequency belonged to No. 1 variation (aorta arch with three branches) and then, No. 5 variation (common origin of left carotid artery with brachiocephalic artery) and No. 2 variation (aorta arch with two branches). Also, there was not found any meaningful relationship between cross sectional aorta diameter immediately before the firs branch and immediately after the last branch and variation. In a previous study, authors evaluated celiac network and mesenteric arteries using CT angiography 64-row detector. They found that only 56.7% of subjects had classic anatomy with branch of 3 arteries and common hepatic artery was seen in only 60% of cases at normal anatomic view. Also, they stated that CT angiography 64-row detector is able to detect small vessels which can hardly be seen in other techniques. This is the most ideal method in evaluating vascular variations (Carvey *et al*., 1935). In this study on aorta arch variations, 64-row detector CT angiography was used similar to the above-mentioned study. It was concluded that only 68.8% of cases have three-branch aorta arch variations and frequency of other variations is significantly high. This study evaluated the relationship found between kinds of aorta variations and aorta arch diameter at two points, i.e., immediately before the first and immediately after the last branch, resulting from shear stress variations. There was not found any meaningful relationship between kind of variation and values of aorta arch diameter. In a previous study, authors evaluated variations and carotid artery branches and its effects on mechanical stresses and shear stress and indicated to the relationship found between values and intensity of turbulence currents and shear stress with states, variations and branches of carotid artery (Lakoumentas *et al*., 2006). This study did not refer to any meaningful relationship between kinds of aorta arch variations and its lumen diameter. It shows that shear stress is not at an extent which can change vessel diameter. In this study, only 68.8% of cases were regarded as No. 1 variations (three-branched aorta arch), 11.9% were of No. 2 variation (two-branched aorta arch), 4.2% of No. 3 variation (left vertebra artery separated from aorta rather than left sub-clavin artery), 0.2% of No. 4 variation (common origin of common carotid arteries of aorta arch 0, 14.3% of No.5 variations (common origin of left carotid artery with braciocephalic artery). There was not found any cases of No. 6 (common origin of common carotid arteries and sub-clavin arteries) and No. 8 (additional branch of thyroid artery of aorta arch) variations in this study. In a previous research, authors studied aorta arch variations and anomalies at Australia. They studied the relationship between gender and frequency of anomaly and stated that the relationship was not meaningful. Additionally, there was not any meaningful relationship between race and frequency of aorta arch anomalies (Bhatia *et al*., 2005). This study did not refer to any meaningful relationship between gender and kinds of aorta arch variations. In a previous study, authors evaluated frequency of different aorta arch variations and in their study 75% of cases had normal three-branched variations. Also, branch diameter of aorta arch was measured to determine weather kinds of variations play a role in thickness and diameter of aorta arch branches. The study demonstrated that the rest 9 cases (25%) had other variations (Goray *et al*., 2005). This study was conducted on 503 patients and out of them, 346 cases (68.8%) had normal three-branched variations. In comparison with the above-mentioned research, it was less frequent. Additionally, this study only used CT-scan to evaluate and measure the desired parameters. This study did not refer to any meaningful relationship between value of aorta arch diameter immediately before the first branch and kind of variation. It was true about aorta arch diameter immediately after the last branch and kind of variation. There was not any meaningful relationship in this regard, too.

CONCLUSION

In this study, no meaningful relationship was found between gender and kind of variation. Also, there was not any meaningful relationship between kind of variation and cross sectional aorta arch diameter immediately before the first and after the last branch.

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