EVALUATION OF THE FREQUENCY OF EACH VARIATION IN PULMONARY VENOUS ARCHITECTURE ON CT AS WELL AS THE PATTERNS OF PULMONARY VENOUS DRAINAGE TO THE LEFT ATRIUM

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ABSTRACT

Background: Important sources of ectopic atrial electric activity, especially in patients with atrial fibrillation, include evaluating the patterns of pulmonary venous drainage to the left atrium and the frequency of each variable in pulmonary venous architecture on CT drainage sites in pulmonary veins. Variations in the pulmonary veins' anatomy are frequently seen. These differences can be crucial, especially when it comes to the preoperative planning of pulmonary and cardiac surgery.

Aim: The purpose of this study was to evaluate the frequency of each variation in pulmonary venous architecture on CT as well as the patterns of pulmonary venous drainage to the left atrium.

Methods: In order to evaluate the structural characteristics of the pulmonary vein and its drainage pattern into the left atrium, the current study retrospectively evaluated 600 thoracic multidetector CT (computed tomography) pictures.

Results: 266 girls and 326 men out of the 600 participants evaluated in the research had anatomical variance. Ostia was the most prevalent drainage pattern in the right pulmonary vein, occurring in 77.33% of participants, followed by 3 to 4 ostia in 19% of respondents, and a single ostium in 3.67% of subjects. Three patterns were seen on the left side, with 63.33% of participants displaying a single venous ostium, which was more prevalent than two ostia in 35.67% of subjects. Of the participants, 1% (n=6) had three ostia. Twelve patients exhibited bilateral single pulmonary venous ostium in both the left and right pulmonary veins.

Conclusion: The current study comes to the conclusion that the differences in pulmonary venous architecture are not unusual. Although they are often asymptomatic, understanding these differences is essential for both cardiothoracic surgery planning and pulmonary venous isolation planning.

Keywords: Computed tomography, pulmonary veins, pulmonary drainage, variations, anatomical variations.

INTRODUCTION

The vascular system in the human body exhibits a wide range of diverse patterns in different people, which is thought to be a typical anatomical variety of the human body. Although the pulmonary vein's importance as a conduit for oxygenated blood is obvious, radiologists also rely on it for a unique and essential function related to their physiological and anatomical roles.1

One important source of ectopic atrial electrical activity, which typically and frequently triggers atrial fibrillation paroxysms, is the drainage location of the pulmonary veins. Selective RF ablation of these arrhythmogenic foci has reportedly increased to manage and treat the subjects with refractory atrial fibrillation. The accuracy of charting the human body's atrial structure is crucial for these invasive operations.2

Particularly in the preoperative planning of cardiac and pulmonary surgery, variations in the pulmonary vein's morphology, as well as the existence of variations and cases of aberrant anatomy, can be extremely significant. Understanding the cardiac and pulmonary vasculature is particularly essential since it plays a significant role in thoracic interventions. This is true not only for diagnostic purposes but also for the prevention and prognosis of several potentially fatal consequences.3

The current study sought to determine the frequency of each variation in pulmonary venous architecture on CT (computed tomography) as well as the patterns of pulmonary venous drainage to the left atrium.

MATERIALS AND METHODS

The purpose of the current observational evaluation research was to evaluate the frequency of each variation in pulmonary venous architecture on CT (computed tomography) as well as the patterns of pulmonary venous drainage to the left atrium. The research participants were from the Institute's Department of Human and General Anatomy. Prior to their involvement in the study, all individuals gave their written and verbal informed consent.

During the designated study period, 600 individuals of both sexes were evaluated retrospectively utilizing thoracic multidetector computed tomography. Anatomical characteristics of the pulmonary vein and related drainage patterns to the left atrium were evaluated in each of the included patients. Additionally, the proportion of each pattern and combination was determined and evaluated.

All thoracic computed tomography scans of participants older than 15 years were required for participation in the research. The study excluded subjects whose pictures showed inadequate enhancement of the pulmonary vein or deformation of the architecture of the pulmonary veins or lung parenchyma as a result of lung or mediastinal diseases.

All of the CT (computed tomography) tests that were included were performed on a single machine utilizing 160 CT slices while the individuals were lying down and after taking a deep breath. One of these scans—CT coronary angiography, CT aortogram, CT pulmonary angiography, or contrast-enhanced conventional CT chest—was used to collect data for each instance. The scans had a thickness of 0.9 mm. DICOM images in soft copy were obtained from the institutional software data.

The data gathered were analyzed statistically using SPSS (Statistical Package for the Social Sciences) software version 24.0 (IBM Corp., Armonk. NY, USA) for assessment of descriptive measures, Student t-test, ANOVA (analysis of variance), and Chi-square test. The results were expressed as mean and standard deviation and frequency and percentages. The p-value of <0.05 was considered statistically significant.

RESULTS

The purpose of the current observational evaluation research was to evaluate the frequency of each variation in pulmonary venous architecture on CT (computed tomography) as well as the patterns of pulmonary venous drainage to the left atrium. In order to evaluate the anatomical characteristics of the pulmonary vein and its drainage pattern into the left atrium, the current study evaluated 600 thoracic multidetector CT (computed tomography) scans that were evaluated retrospectively.

Results were developed and a percentage was computed for each pattern. The average age of the research participants was 45.2±3.8 years, with 266 female and 326 male scans that ranged in age from 15 to 94.

The drainage patterns of the left pulmonary veins of the research participants were observed. The drainage pattern of L1a was observed in 33.67% (n=202) of the study subjects, which was the majority of the subjects. L1b was observed in 29.67% (n=178) of the study subjects, L2a in 19% (n=114), L2b in 16.67% (n=100), and L3 was least common in 1% (n=6) of the study subjects (Table 1).

According to the study's findings, R1 was seen in 3.67% (n=22) of the participants with drainage patterns in the right pulmonary veins, R2a was most prevalent in 37% (n=222) of the subjects, followed by R2b in 36.33% (n=218), R3a in 11.67% (n=70) of the respondents, and R2c in 4% (n=24) of the subjects. 3.67% (n=22) of the research individuals had R3b, 1.67% (n=10) had R3d and R4b, 0.33% (n=2) had R3c, and none of the study subjects had R4a or R5 (Table 2).

R1 was observed in 4, 8, 6, 4, and 0 patients from L1a, L1b, L2a, L2b, and L3 respectively, whereas R2a was observed in 64, 74, 30, 52, and 2 subjects from L1a, L1b, L2a, L2b, and L3 respectively, with regard to the combined patterns of pulmonary venous drainage in the study participants. In L1a, L1b, L2a, L2b, and L3 patients, R2b was seen in 80, 58, 50, 26, and 4 individuals, respectively. In L1a, L1b, L2a, L2b, and L3 patients, respectively, R2c was seen in 8, 6, 4, 6, and 0 subjects, R3a was seen in 30, 12, 18, 10, and 0 subjects from L1a, L1b, L2a, L2b, and L3 respectively, R3b was seen in 10, 6, 4, 2, and 0 subjects from subjects from L1a, L1b, L2a, L2b, and L3 respectively, R3c in L1a, L1b, L2a, L2b, and L3 individuals, respectively, 0, 0, 2, 0, and 0 In L1a, L1b, L2a, L2b, and L3 subjects, respectively, R3d was seen in 4, 6, 0, 0, and 0 subjects; in no subjects, R4a; in 2, 8, 0, 0, and 0 subjects from L1a, L1b, L2a, L2b, and L3 subjects, respectively; and in no subjects, R5. Overall, 202, 178, 114, 100, and 6 patients, respectively, had L1a, L1b, L2a, L2b, and L3 (Table 3).

In order to evaluate the anatomical characteristics of the pulmonary vein and its drainage pattern into the left atrium, the current study evaluated 600 thoracic multidetector CT (computed tomography) scans that were evaluated retrospectively. Results were developed and a percentage was computed for each pattern. The mean age of the research participants was 45.2±3.8 years, with 266 female and 326 male scans in the 15–94 age range. These results were similar to those of earlier investigations by Tekbas G et al. (2012) and Jongbloed MR et al. (2005), in which the authors evaluated participants for abnormalities in pulmonary venous drainage using demographics similar to those of the current research.

According to the study findings, the majority of the subjects had the drainage pattern of L1a in their left pulmonary veins, which was observed in 33.67% (n=202) of the subjects. This was followed by L1b in 29.67% (n=178) of the subjects and L2a in 19% (n=114) of the subjects.

L2b was seen in 16.67% (n=100) of the research participants, whereas L3 was least common at 1% (n=6). The findings of the current study were in line with those of Jongbloed MR et al. (2005) and MR et al. (2005), who observed drainage patterns in the left pulmonary veins that were comparable to the findings of their investigations.

Regarding drainage patterns in the right pulmonary veins, it was observed that R1 was observed in 3.67% (n=22) of the subjects, R2a was observed in 37% (n=222) of the subjects, followed by R2b in 36.33% (n=218), R3a in 11.67% (n=70) of the subjects, R2c in 4% (n=24) of the subjects, R3b in 3.67% (n=22), R3d and R4b in 1.67% (n=10) of the subjects, R3c in 0.33% (n=2) study subjects, and R4a and R5 was not seen in any study subject. These results were consistent with those of Akiba T et al. (2010) and Sizarov A et al. (2011), who also revealed drainage patterns in right pulmonary veins that were comparable to the current research in their separate investigations.

According to the study's findings, R1 was observed in 4, 8, 6, 4, and 0 of the study participants' L1a, L1b, L2a, L2b, and L3 subjects, R2a in 64, 74, 30, 52, and 2 of the study participants' L1a, L1b, L2a, L2b, and L3 subjects, and R2b in 80, 58, 50, 26, and 4 of the study participants' L1a, L1b, L2a, L2b, and L3 subjects, respectively.

R2c was seen in 8, 6, 4, 6, and 0 subjects from L1a, L1b, L2a, L2b, and L3 respectively, In L1a, L1b, L2a, L2b, and L3 participants, respectively, R3a was seen in 30, 12, 18, 10, and 0 patients. Subjects from L1a, L1b, L2a, L2b, and L3 showed R3b in 10, 6, 4, 2, and 0 instances, respectively. R3c in L1a, L1b, L2a, L2b, and L3 individuals, respectively, 0, 0, 2, 0, and 0 In L1a, L1b, L2a, L2b, and L3 individuals, respectively, R3d was seen in 4, 6, 0, 0, and 0. R5 in no individuals, R4a in no subjects, and R4b in 2, 8, 0, 0, and 0 patients from L1a, L1b, L2a, L2b, and L3 respectively.

Overall, 202, 178, 114, 100, and 6 patients, respectively, had L1a, L1b, L2a, L2b, and L3. These findings were compatible with those of the research conducted by van den Berg G. et al. (2012) and Niinuma H. et al. (2013), whereby the authors' findings about combined patterns of pulmonary venous drainage were in agreement with the findings of the current investigation.

CONCLUSION

Taking into account its limitations, the current study comes to the conclusion that the differences in pulmonary venous architecture are not unusual. Although they are often asymptomatic, understanding these differences is essential for organizing cardiothoracic operations and pulmonary venous isolation. Future research is need to evaluate participants from various geographic locations, though, and a multi-institutional setting is required to reach a conclusion.

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Drainage pattern	Description	N	%
L1a	**Upper and lower lobe vein from common trunk <1cm long draining into left atrium (one ostium)**	202	33.67
L1b	**Upper and lower lobe vein from common trunk >1cm long draining into left atrium (one ostium)**	178	29.67
L2a	**The upper and lower lob vein drains to two separate atrial ostia separated by the left atrial wall**	114	19

L2b	**Upper and lower lob vein drains atrial ostia not separated by left atrial wall**	100	16.67
L3	**Three atrial ostia from the lingular segment, lower lobe, and upper lobe**	6	1
Total		600	100

Table 1: Drainage patterns in left pulmonary veins

Drainage pattern	**Description**	**N**	**%**
R1	**Lower, middle, and upper lobe veins draining to the single common ostium**	22	3.67
R2a	**Upper and lower lobe draining to 2 different ostia and middle joining proximal upper lobe vein <1cm from the ostium**	222	37
R2b	**Upper and lower lobe draining to 2 different ostia and middle joining proximal upper lobe vein <1cm from the ostium**	218	36.33
R2c	**Upper and lower lobe draining to 2 different ostia and middle joining lower lobe vein**	24	4
R3a	**Lower, middle, and upper lobe veins draining to 3 separate ostia**	70	11.67
R3b	**Lower, middle, and upper lobe veins draining to 3 separate ostia with middle lobe vein joining proximal upper lobe vein <1cm from the ostium**	22	3.67
R3c	**Lower, middle, and upper lobe veins drain to 3 separate ostia with the middle lobe vein joining the proximal upper lobe vein >1cm from the ostium**	2	0.33

R3d	**3 atrial ostia for Lower, middle, and upper lobe veins with upper lobe vein accompanied with medial segment of middle lobe vein making common channel**	10	1.67
R4a	**One upper, 1 lower, and 2 middle veins draining to 4 separate ostia**	0	0
R4b	**Superior, middle, and upper segments with lower lobe vein drain to 4 separate ostia**	10	1.67
R5	**One upper, 2 lower, and 2 middle segments with lower lobe vein drain to 5 separate ostia**	0	0
Total		600	100

Table 2: Drainage patterns in right pulmonary veins

	L1a	**L1b**	**L2a**	**L2b**	**L3**	**Total**
R1	4	8	6	4	0	22
R2a	64	74	30	52	2	222
R2b	80	58	50	26	4	218
R2c	8	6	4	6	0	24
R3a	30	12	18	10	0	70
R3b	10	6	4	2	0	22
R3c	0	0	2	0	0	2
R3d	4	6	0	0	0	10
R4a	0	0	0	0	0	0
R4b	2	8	0	0	0	10
R5	0	0	0	0	0	0
Total	202	178	114	100	6	600

Table 3: Combined patterns of pulmonary venous drainage in study subjects