Evaluation of pulmonary vein variations in the middle pulmonary lobe with 64-slice multidetector computed tomography


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Abstract. – Purpose: To evaluate the multidetector computed tomographic (CT) depiction of middle lobe vein variation of the right pulmonary vein and create a diagram for cardiologist and cardiovascular surgeons.

Materials and Methods: According to hospital records, between January 2009 and April 2010, 314 consecutive patients underwent pulmonary CT angiography (CTPA) and coronary CT angiography. The CT films from these patients were retrospectively analyzed.

Results: Under normal conditions, the middle pulmonary vein (MPV) drains into the left atrium either by the “direct” or “indirect” route. Direct (37 patients, 11.8%) drainage means that the MPV does not drain into the upper or lower pulmonary veins but instead drains directly into the right pulmonary vein system. In contrast, indirect (276 patients, 87.9%) drainage occurs when the MPV drains into the upper or lower pulmonary veins. In this study, 12 different variations in drainage patterns were found.

Conclusion: Increasing the number of patients may have led to the identification of additional variants. However, clinically important variations are rarely seen. Correct mapping of the MPV is very important for cardiologists and for surgeons in order to provide the best treatment and avoid complications.

Key Words:
Middle lobe vein, Pulmonary vein, Multi detector CT, Variation, Left atrium, Pulmonary edema, Arrhythmia, Ablation.

Introduction

The middle lobe pulmonary vein (MPV) is one of the major branches of the right pulmonary vein and it plays an important role in blood flow in the left side of the heart. It drains middle lobe of right lung. In surgery, knowledge of different drainage pattern or variation of MPV may have an important role at the success of operation. However, recently, the MPV has also become important for cardiologists. It has been well-established that there is a relationship between arrhythmias and pulmonary vein patterns and, therefore, pulmonary vein patterns have been previously established in patients with arrhythmias. Our study extends previous literature by determining the MPV variations in the normal population.

Materials and Methods

The CT scans from 314 consecutive patients who underwent Multi Detector Computed Tomography (MDCT) examinations between January 2009 and April 2010 in Dicle University School of Medicine were retrospectively reviewed by an experienced radiologist. The Institutional Review Board approved this retrospective study. Of these patients, 163 (51.9%) had been undergone coronary computed tomography angiography (CCTA) and 151 (48.1%) had been undergone computed tomography pulmonary angiography (CTPA).

Exclusion the Films

A film was excluded from evaluation if it contained factors that disrupted interpretation such as artifacts, pneumonia, multiple lymphadenopathy, lung cancer, radiotherapy, mediastinal masses and etc.
Scanning Protocol and Data Collection

All CT scans were taken with a Philips Brilliance computed tomography 64-channel scanner (Philips Medical Systems, Cleveland, OH, USA). Images were obtained during a single breath hold.

The routine scanning protocol of our Institution for CTPA includes a 64 × 0.625 mm collimation, 1 mm thick reconstruction, 0.5 mm reconstruction increment, and a 0.5 second rotation time. The scanning delay time was determined using the bolus-tracking technique in the lumen of the pulmonary trunk. The threshold value was 120 HU. The thorax scanning time was approximately 4-5 seconds.

The routine scanning protocol for CCTA includes a 64 × 0.625 mm collimation, 1 mm thick reconstruction, 0.5 mm reconstruction increment and 0.5 second rotation time and retrospective electrocardiography (ECG) gating. The scanning delay time was determined using the bolus-tracking technique in the lumen of the ascending aorta. The threshold value was 160 HU. The time taken to scan the heart was approximately 8-10 seconds. All patient films were evaluated in the R-R ECG interval, which generally made up 75% of the interval.

The contrast materials were administered with a power injector at a rate of 5 mL/sec through an 18- or 20-gauge catheter into an antecubital vein. The experienced radiologists retrospectively reviewed the CT films at a free-standing workstation (Philips Medical Systems, Cleveland, OH, USA). The films were primarily viewed in the axial, coronal and sagittal planes. However, in circumstances of controversy, they were also viewed as curved reformatted and volume rendering images. In 20% of patients, there was a difference of interpretation between the 2D and 3D images. Based on this finding, the study design was changed so that all films were reviewed in all planes. The MPV drainage pattern was documented for each patient.

Results

A total of 314 patients were evaluated. 166 of the patients were male (52.9%) and 148 were female (47.1%). The mean age was 48.7 ± 16.22 years (range 17 to 80 years). All patients had normal sinus rhythm. Over the course of the study, we classified and described the anatomy of the middle lobe vein on cross-sectional images. The classification was based on the relationship between the venous ostia of middle lobe vein, right upper lobe vein, right lower lobe vein and left atrium. Firstly, the drainage pattern of all patients was classified as indirect drainage (ID) and direct drainage (DD). Indirect drainage means that the MPV is drained by the right upper lobe vein or the right lower lobe vein. DD indicates that the MPV drains directly into the left atrium.

ID was seen in 276 (88.2%) patients. ID1 was found to be the most frequent type (82.5%). Also, we classified the ID1 in five subtypes (Figure 1). In ID1a (63.4%), one trunk of MPV joins the SPV less than 1 cm from the ostium. In ID1b (10.5%), the distance is more than one cm. In ID1c (8%), the medial and lateral branch of the MPV as a root, joins the SPV less than one cm before the ostium. In ID1d (0.6%) the distance the medial and lateral branch of the MPV as a root, joins the SPV more than one cm before the ostium. In ID1e (1.6%), three branches of the MPV are drained by the SPV.

ID2 frequency was found 5.4%. In this type as reported above, MPV is drained by IPV. A rare type of ID group is ID3 which was found only one patient (0.3%). In this type, the medial branch of the MPV is drained by the SPV whereas the lateral branch is drained by the DD group constitutes small part of MPV variation (11.8%). We classified this group in to 6 subtypes. In D1 (4.5%), the medial and lateral branch of MPV join together less than 1 cm before the left atrium and are directly drained by left atrium. In D2 (2.9%), one branch of the MPV directly joins to the left atrium. In D3 (1.6%), a triple branch of the MPV directly drains into the left atrium. In D4 (1.2%), the medial and lateral branches of the MPV are separately draining by left atrium. In D5 (1%), the MPV merges with both the IPV and

Figure 1. Volume rendering MDCT image shows most frequent type of MPV drainage pattern.
SPV and is then directly drained by the left atrium. In D6 (0.6%), the superior segment of the IPV joins with the lateral segment of MPV and drained by left atrium. Medial segment of MLV drains into the left atrium too. Male predominance was found more than female according to drainage pattern and gender \((p=0.024)\). All drainage pattern have depicted in Figure 2.

**Discussion**

Pulmonary blood vessels occur during the 5th week of gestation1. The common pulmonary vein (PV) canalizes in the dorsal mesocardium2. The left atrium (LA) has the same histological characteristics with the PV because of PVs contributes to the size and texture of the smooth-walled LA. At the end of development, typically two right and two left PVs enter the LA3.

The pulmonary venous system is conventionally divided into SPV and IPV on both the right and left sides. As demonstrated by this study, the MPV is usually drained by the SPV (82.6%). However, sometimes the MPV directly joins the left atrium (11.8%) as a separate vessel1,4,5. In a study with 120 subjects, Yamashita et al6 found that the MPV drained into the IPV 4.8% of the time. In this study we found 5.1%. The results of our investigation agree with the previous reports, demonstrating that increasing the study size had little effect on the measured frequency.

The drainage variant where the MPV drains into the IPV is surgically important. In patients with this variation who undergo a right lower lobectomy, since the inferior PV trunk is ligated without exposing its branches, the venous return from the middle lobe will be occluded. Accidental ligation of a PV that should be preserved can lead to severe lung edema, which may cause infection or respiratory distress and postoperative complications that can be life-threatening5,7. Moreover, in this study we found type ID-3 and DD-5 that had never been reported before to the best of our knowledge variations and may have surgical importance. In the type ID-3 variation, the medial part of the MPV is drained by the IPV and lateral part is drained by the SPV. In the type DD-5 variation, the medial segment of MLV drained by left atrium with separate branch and superior segmental vein of the IPV is joins to the lateral segment of MPV which directly drains into the left atrium.

Pulmonary veins have importance for cardiologists as well as surgeons. Pulmonary veins are an important site of ectopic atrial electrical activity, which leads to frequent paroxysms of atrial fibrillation8-10. Selective radiofrequency ablation helps eliminate arrhythmogenic foci and is being used to treat patients with refractory atrial fibrillation. A detailed knowledge of the pulmonary venous anatomy and the relationships between the pulmonary veins and the left atrium is important for identification and ablation of these ectopic sites. In this work we classified the MPV as DD and ID. Subsegmenter classification has no importance for the exact ablation procedures, but number of the atrial ostium is an important factor. However, type ID1a, ID1b and direct group variations theoretically should be control before the intervention and/or surgery for the preserve complications. The success of selective radiofrequency ablation increases with correct mapping and complete disconnection of the electrical initiators from the atrial tissue.

Angiography is often diagnostic of pulmonary vein abnormalities, but is invasive and usually requires multiple wedge injections into the pulmonary arteries. Echocardiography may not optimally show the entry site of all four pulmonary veins. MDCT and magnetic resonance (MR) imaging are valuable techniques to image pulmonary vein anomalies and are more effective at delineating variant PV anatomy than angiography or echocardiography1,11-13. Studies have been performed using MDCT and MRI to image PVs; however, to the best of our knowledge, specific MPV variations imaged by MDCT have not been previously reported8,14-16.

In conclusion, we investigated different MPV variations with MDCT. To the best of our knowledge specifically MPV variations were not reviewed with MDCT. MDCT which is noninvasive method depicts whole anatomic variations accurately In this study DD and ID drainage have importance for the cardiologist also rare variations as ID2 and ID3 is important for the surgeons. Correct mapping of MPV and PVs are for endovascular interventions and operations and can help prevent complications.

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Middle lobe vein variations

References


Figure 2. Schematic drawing of MPV variations. (D: Direct drainage, ID: Indirect drainage, SPV: Superior pulmonary vein, MPV: Middle pulmonary vein, IPV: Inferior pulmonary vein, M: medial branch, L: Lateral branch).

