

## CASE REPORT

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# 4D flow MRI as a preoperative assessment tool for patients undergoing lobectomy for partial anomalous pulmonary venous return

Takashi Yamashita, Takahiro Mochizuki

## ABSTRACT

**Introduction:** Partial anomalous pulmonary venous return is a congenital malformation. The abnormal pulmonary to systemic blood flow ratio may affect general anesthesia. Therefore, it is important to figure out pulmonary to systemic blood flow ratio before surgery.

**Case Report:** A 62-year-old man was referred to our hospital. Close examination of a patient suspected with right upper lobe lung cancer revealed partial anomalous pulmonary venous return in the same lobe. Generally, if partial anomalous pulmonary venous return is present in the lung lobe to be resected, surgery can be performed as planned. However, we performed 4D flow magnetic resonance imaging (MRI) to evaluate pulmonary to systemic blood flow ratio for safer anesthesia and surgery. His pulmonary to systemic blood flow ratio was 1.04, which seemed safe for general anesthesia and surgery. Right upper lobectomy was performed, and the patient was discharged on postoperative day 7 without any circulatory complications.

**Conclusion:** We found that 4D flow MRI contributed to a safe perioperative management and it must be meaningful for partial anomalous pulmonary venous return in the other lobe.

**Keywords:** Four-dimensional flow magnetic resonance imaging, Lobectomy, Partial anomalous pulmonary venous return, Pulmonary to systemic blood flow ratio

Takashi Yamashita<sup>1</sup>, MD, Takahiro Mochizuki<sup>1</sup>, MD

**Affiliation:** <sup>1</sup>Thoracic and Breast Surgery, Iwata City Hospital, 512-3, Ohkubo, Iwata, Shizuoka 438-8550, Japan.

**Corresponding Author:** Takashi Yamashita, Head of Department, Thoracic and Breast Surgery, Iwata City Hospital, 512-3, Ohkubo, Iwata, Shizuoka 438-8550, Japan; Email: takashi-yamashita.md@gmail.com

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## INTRODUCTION

The causes of abnormal chest nodules are diverse and subsequent treatment is determined by a pathological diagnosis. As a diagnostic method, surgery is commonly performed for abnormal chest nodules if a diagnosis cannot be made by bronchoscopy or computed tomography (CT)-guided biopsy. Since the burden on the body is not small due to surgery, a thorough preoperative evaluation to examine the patient's operability is indispensable.

Herein, we report a case with a nodule in the right upper lobe with partial anomalous pulmonary venous return (PAPVR), which among the differential diagnoses includes lung cancer. Furthermore, we report the usefulness of four-dimensional flow magnetic resonance imaging (4D flow MRI) in preoperative circulatory evaluation for a safe perioperative management.

## CASE REPORT

A 62-year-old man was referred to our hospital for an abnormal nodule in the right upper lobe. The nodule had persisted on follow-up CT (Figure 1). His exercise tolerance was four or more metabolic equivalents. Tumor markers were within the normal ranges. Arterial

blood gas measurements were unremarkable in ambient air. Spirometry revealed normal respiratory functions. Bronchoscopy performed for the histologic diagnosis revealed no abnormalities. 3D CT angiography for pulmonary vascularization revealed PAPVR with the right upper lobe flow draining into the superior vena cava (SVC) (Figure 2). All venous return from the right upper lobe was drained into the SVC. Echocardiography performed for cardiac malformations revealed good cardiac function with an ejection fraction of 70.4% and a cardiac output of 3.89 L/min. No atrial septal defects (ASDs) or other cardiac abnormalities were detected.

No significant effect was suspected on the perioperative management during right upper lobe resection. However, the pulmonary to systemic blood flow ratio (Qp/Qs) might affect general anesthesia. Therefore, we considered performing additional tests. Since the catheter test, which is more-invasive, did not seem acceptable, we performed 4D flow MRI because it was minimally invasive (Figure 3). When blood flow was evaluated on 4D flow MRI, the aortic flow was 3.42 L/min, the pulmonary trunk flow was 3.57 L/min, and Qp/Qs was 1.04, which seemed safe for general anesthesia and surgery (Table 1).

The preoperative diagnosis was a nodule in the right upper lobe with PAPVR. The extent of resection of the lung may vary depending on the tissue type of the nodule. In this case, since the aberrant vessel exist in the same lung lobe, we planned right upper lobectomy with PAPVR treatment and if the quick-frozen section diagnosis of the tumor showed malignancy, subsequently lymph node dissection would be added.

Right upper lobectomy was performed, and the quick-frozen section diagnosis revealed no tumor malignancy. The patient was discharged on postoperative day 7 without any circulatory complications. The final pathological result was organizing pneumonia.

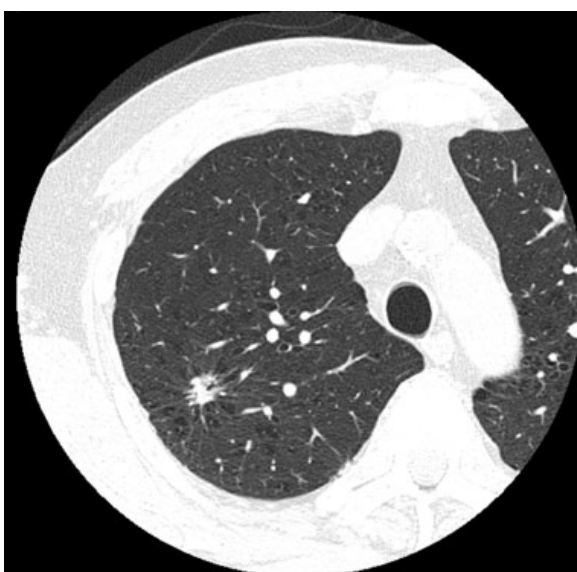


Figure 1: Chest CT with lung window, axial scan, showing a 10 mm spiculated nodule in the upper lobe of the right lung.

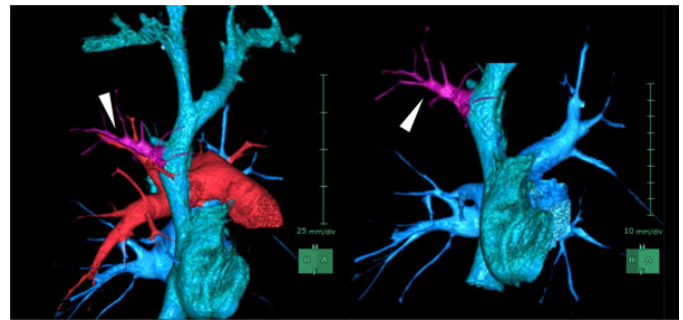


Figure 2: CTA with VR reconstruction showing an aberrant vessel (purple, white arrow head) flowing around the junction of the SVC and the azygos vein.

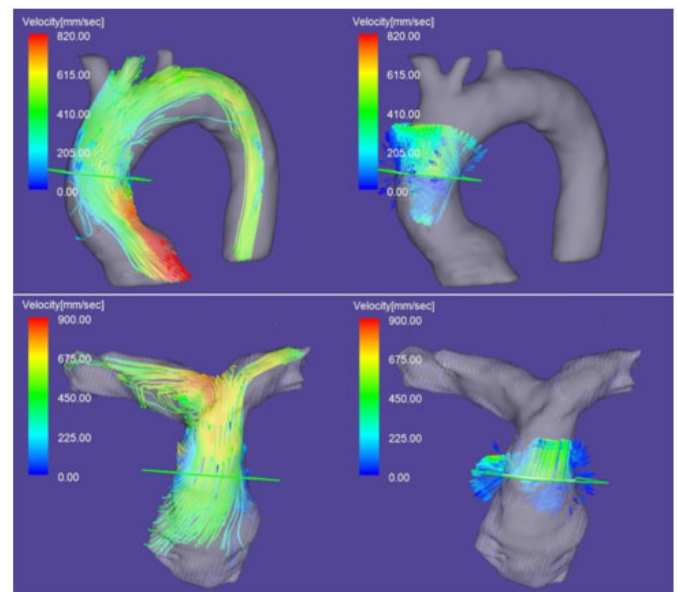


Figure 3: Flow measurement by 4D flow MRI. 4D flow MRI measures every 40 milliseconds and visualizes the streamline and vector of blood flow passing through an arbitrary cross section per measurement. The value obtained in this case is the sum of the products.

Table 1: Flow measurement by echocardiography and 4D flow MRI

Flow measurement	Findings in the flow measurement
Cardiac output (echocardiography)	3.89 L/min
Aortic flow (4D flow MRI)	3.43 L/min
Pulmonary trunk flow (4D flow MRI)	3.57 L/min
Qp/Qs	1.04 blood flow ratio

4D flow MRI; four-dimensional flow MRI magnetic resonance imaging, Qp/Qs; pulmonary to systemic blood flow ratio.

## DISCUSSION

Partial anomalous pulmonary venous return is a congenital malformation, with a frequency of

approximately 0.5%. Most cases occur on the right side and are often complicated by ASDs. Furthermore, the risk of pulmonary hypertension is increased in the late stage if ASD is present. If PAPVR persists after lobectomy, it can lead to postoperative death. Many reports of the surgical treatment of PAPVR emphasize the importance of assessing their presence preoperatively [1–3]. At the time of evaluation, software that automatically reconstructs images should be dealt with caution. Because of the lack of continuity with pulmonary circulation, PAPVR might not appear in the automatically reconstructed images. In our case, we found PAPVR on axial images and the right upper pulmonary vein defect on 3D images.

Right upper lobe resection is reportedly performed in patients with PAPVR in the same lobe without any perioperative event, and there have been no reports on circulatory complications of lung lobe resection with PAPVR. Therefore, no additional inspection seemed necessary for this patient. However, subject to the availability of diagnostic modalities, more information seemed necessary to further enhance the perioperative safety. And if less-invasive tests are feasible, they should be performed for a safe perioperative management. Therefore, we performed minimally invasive 4D flow MRI to evaluate Qp/Qs, which enabled safe anesthesia and perioperative management. This method must contribute to the case of PAPVR in the other lobe.

Performing a catheter test is the standard method for determining Qp/Qs. However, 4D flow MRI is also sufficiently reliable [4, 5]. In this case, Qp/Qs was almost equivalent to the value obtained by subtracting approximately 5% of the coronary blood flow from the cardiac output obtained with echocardiography.

Stable evaluation of the blood flow of PAPVR was not possible because of the poor blood circulation. The accuracy of detecting regions with poor unstable flow, jet flow with high flow velocity, and turbulent flow is reduced because of the wide blood flow velocity range [6–8]. Although relatively large pressure gradients, as in ASD, are useful for assessing cardiac shunts, PAPVR measurement seems challenging. The accuracy may improve with appropriate settings of velocity encoding.

## CONCLUSION

We reported a case of PAPVR preoperatively evaluated using 4D flow MRI for safe lobectomy. The evaluation of Qp/Qs was minimally invasive, which contributed to a safe perioperative management. It may be meaningful wherever PAPVR is.

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## Author Contributions

Takashi Yamashita – Conception of the work, Design of the work, Acquisition of data, Analysis of data, Interpretation of data, Drafting the work, Revising the work critically for important intellectual content, Final approval of the version to be published, Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

Takahiro Mochizuki – Acquisition of data, Analysis of data, Interpretation of data, Revising the work critically for important intellectual content, Final approval of the version to be published, Agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

## Guarantor of Submission

The corresponding author is the guarantor of submission.

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**Consent Statement**

Written informed consent was obtained from the patient for publication of this article.

**Conflict of Interest**

Authors declare no conflict of interest.

**Data Availability**

All relevant data are within the paper and its Supporting Information files.

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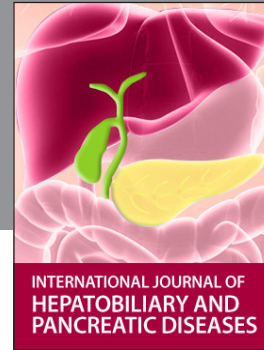
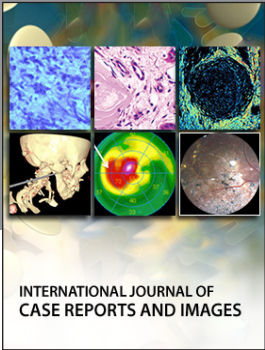
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