Knowledge-Based Automatic Slice-Alignment Method of Cardiac Magnetic Resonance Imaging for Right Ventricular Evaluation in Patients with Pulmonary Arterial Hypertension

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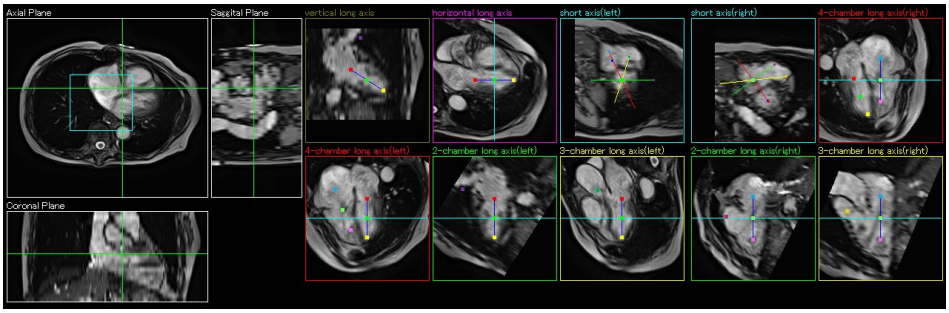
Target Audience Radiologist, Radiologic technologist, Cardiologist

Purpose

Pulmonary arterial hypertension (PAH) is a progressive condition characterized by elevated pulmonary arterial pressure, leading to right ventricular (RV) failure and death. Early recognition and early treatment is associated with improved survival. Traditionally, the diagnostic imaging work-up includes echocardiography and right-sided heart catheterization (RHC). However, these imaging modalities suffer from a number of inherent limitations. The conventional 2D echocardiography remains difficult owing to the inherently complicated geometry. RHC is invasive and carries a small but definite risk of severe complications. Cardiac magnetic resonance imaging(CMR) is a noninvasive 3D tomographic technique that allows the detailed morphologic assessment of the cardiac chambers and the accurate quantification of RV volumes, myocardial mass, and transvalvular flow. SCMR guidelines specify the following requirements for the evaluation of RV function: 1) RV short-axis views can be obtained in a similar fashion to the left ventricular (LV) structure and function module, 2) a transaxial stack of cine images covering the RV enable the best identification of the tricuspid valve plane, and 3) long-axis images should include an RV vertical long-axis view aligned with tricuspid inflow and an RV outflow tract view (sagittal plane through the pulmonary valve). However, determining these planes requires that complex procedures be performed to obtain the necessary scout scans in a minimal amount of time. In a previous report, we described a new automatic slice-alignment method based on gated breath-hold axial multislice scout images to simplify cardiac LV scan planning. This method employs knowledge-based recognition techniques in order to achieve higher accuracy and greater robustness for a variety of cardiac shapes. In the present report, we propose a new automatic slice-alignment method to simplify cardiac RV scan planning and discuss its clinical usefulness in the evaluation of patients with PAH.

Methods

Steady-state free precession sequences covering the range from the cardiac base to the apex were used to acquire multislice images in approximately 20 s (matrix = 256×256, slice spacing = 1.17×1.17, slice thickness = 7 mm, interslice gap = 7 mm, 16-21 slices). These images were scanned using a 1.5-T MRI system (Excelart Vantage^{TM} powered by Atlas, Toshiba Medical Systems, Otawara-shi, Japan). The morphological features of the heart were extracted from these series of images using the knowledge-based recognition method, and all of the planes required for cardiac imaging were calculated based on the extracted features.The subjects were 33 patients (11 men and 22 women with an average age of 54.3 years) who underwent CMR examination during the period from July to October 2012. These 33 subjects included 25 patients with chronic thromboembolic pulmonary hypertension and 8 patients with idiopathic pulmonary arterial hypertension. Informed consent was obtained from all subjects. The RV reference planes including RV short-axis(RV-SAX), 4-chamber(4-ch), 2-chamber(2-ch), and 3-chamber(3-ch) views were evaluated. The images acquired with different scan conditions were visually scored by two cardiac radiologists using a 4-point scale (4 points = excellent, 3 points = good, 2 points = marginal but diagnostically useful, 1 point = not diagnostically useful). In addition, the planes set using the conventional method were compared against the planes calculated by our method to measure the angular errors.



Results

Automatic slice alignment was performed successfully in all subjects, and slice alignment was performed quickly and accurately for each of the RV-SAX, 4-ch, 2-ch, and 3-ch views. For all subjects, the average scores were 3.9±0.4 for RV-SAX, 3.8±0.4 for 4-ch, 3.8±0.4 for 2-ch, and 3.5±0.6 for 3-ch. The angular errors were 8.7±5.3 for RV-SAX, 8.3±4.9 for 4-ch, 8.1±4.8 for 2-ch, and 7.9±5.3 for 3-ch.

Discussion and Conclusion

The knowledge-based automatic slice-alignment method described here enables the RV reference planes, which are difficult to determine using the conventional method, to be detected without difficulty. The scores were lower than those for LV images, but this is attributable to the variation in the shape of the cardiac chambers due to the RV enlargement typically seen in patients with PAH. Even in the cases for which correction was required, however, correction could be performed using the set planes. With the conventional method, the planes cannot be confirmed unless images are actually acquired, and actual scanning must therefore be performed every time correction is necessary. In our method, actual scanning is not needed to correct the planes. This is clinically useful, especially for patients with PAH who have severe breathing difficulties.

In conclusion, the results of this study suggest that our method is clinically useful for evaluation of the right ventricle in patients with PAH.

References

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