Original Article

Myocardial extracellular volume assessed by cardiovascular magnetic resonance may predict adverse left ventricular remodeling in rheumatic heart disease after valvular surgery

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Background: Only a few studies to date have focused on the application of cardiovascular magnetic resonance (CMR) in rheumatic heart disease (RHD); in particular, research on the application of T1-mapping CMR sequences is limited. This study aimed to investigate whether diffuse myocardial fibrosis evaluated using preoperative T1 mapping and extracellular volume (ECV) fraction measurement could predict the progression of adverse left ventricular remodeling (LVR) after surgery.

Methods: A total of 32 adult patients with RHD and 30 healthy controls were recruited. Baseline clinical characteristics, CMR findings, and T1 mapping measurements were compared between the two groups. Transthoracic echocardiography measurements were collected before and after surgery. Patients with an increase in left ventricular end-diastolic volume of >15% or a decrease in left ventricular ejection fraction of >10% were classified into the adverse remodeling group; otherwise, patients were categorized into the non-adverse remodeling group.

Results: Compared with the healthy controls, patients with RHD had impaired biventricular function, enlarged ventricular volume, and increased native T1 and ECV values. Patients in the adverse remodeling group had higher ECV values than those in the non-adverse remodeling group (33.25%±3.67% *vs.* 28.45%±4.46%, P=0.002). Binary logistic regression analysis showed that the ECV value was associated with adverse LVR (odds ratio: 1.273, P=0.045). ECV was found to be a sensitive biomarker for predicting adverse LVR (area under the curve: 0.78; sensitivity: 75.0%; specificity: 77.3%).

Conclusions: ECV has potential value for predicting the progression of adverse LVR and for identifying non-responders among patients with RHD undergoing surgery.

Keywords: Rheumatic heart disease (RHD); left ventricular remodeling (LVR); cardiac magnetic resonance (CMR); myocardial fibrosis; T1 mapping

Submitted Jun 28, 2021. Accepted for publication Dec 22, 2021; Published online: 10 Jan 2022.
doi: 10.21037/qims-21-678
View this article at: https://dx.doi.org/10.21037/qims-21-678

Introduction

Rheumatic heart disease (RHD) is caused by rheumatic fever, which occurs following oropharyngeal infection by hemolytic group A streptococcus (1). An estimated 33 million people are affected by rheumatic fever globally, and there are more than 400,000 new cases and over 230,000 deaths attributable to rheumatic fever or RHD each year, with South Asia, Africa, and the Pacific Islands particularly affected (2-4). According to previous studies, RHD is the dominant pathogenesis of multiple valvular diseases in both developed and developing countries (5,6).

Myocardial fibrosis (MF) is considered to be a significant predictor of adverse outcomes in various cardiovascular diseases, such as nonischemic and dilated cardiomyopathy and aortic stenosis (7-9). Late gadolinium enhancement (LGE) in cardiac magnetic resonance (CMR) imaging facilitates the identification of focal MF, while T1 mapping by CMR imaging makes it possible to quantify diffuse MF *in vivo* (9-11). Developing countries account for most patients with RHD, but in recent years, rapid economic development has seen CMR imaging become widely available in these countries.

Left ventricular remodeling (LVR) is defined as the accommodative process of the left ventricle (LV) and can be measured by changes in cardiac morphology and function (12). This process is characterized by ventricular dilation, shape distortion, and wall hypertrophy (13). According to clinical observations, not all patients achieve regression of cardiac dilatation and ventricular ejection fraction recovery after successful valvular surgery, some patients even have a poor prognosis and may experience progression of adverse LVR (14). This study aimed to investigate whether diffuse MF evaluated with preoperative T1 mapping and extracellular volume (ECV) fraction measurement can be used to identify adverse LVR in patients with RHD undergoing surgery.

We present the following article in accordance with the STARD reporting checklist (available at https://qims.amegroups.com/article/view/10.21037/qims-21-678/rc).

Methods

Study design and population

Patients from West China Hospital were consecutively identified through the hospital database search for the period from 2013 to 2020. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013), and was approved by West China Hospital's ethics board (No. 2019-756). The requirement to obtain individual consent for this analysis was waived due to its retrospective nature.

The inclusion criteria for patients in this study were as follows: (I) clinically diagnosed with RHD; (II) had undergone comprehensive preoperative CMR; and (III) had undergone pre- and postoperative echocardiography. The exclusion criteria were as follows: (I) patients with other organic heart diseases (based on history, or echocardiography or CMR findings), or with a history of cardiac surgery; and (II) patients with poor-quality CMR images that were inadequate for analysis.

Baseline demographic and clinical data of all the included patients were collected. Also, a group of healthy volunteers who underwent CMR were enrolled as healthy controls (HCs).

CMR scanning protocol and imaging analysis

All study participants underwent CMR on a 3.0-T MRI scanner (Magnetom Skyra or Tim Trio; Siemens Medical Solutions, Erlangen, Germany). Following the acquisition of localizers, balanced, steady-state free precession (SSFP) cine images were obtained in 8–12 matching short-axis and 3 radial long-axis planes (3-, 4-chamber, and LV 2-chamber views). The cardiac frame number of each short-axis plane was 25. The parameters for cine imaging were as follows: field of view (FoV), 250 mm × 300 mm; matrix size, 208×139 pixels; integrated parallel acquisition technique (iPAT), 2; repetition time (TR), 3.3 ms; echo time (TE), 1.22 ms; slice thickness, 8 mm; and, flip angle, 40°.

T1 mapping was performed using modified Look-Locker inversion recovery (MOLLI) imaging. The parameters for MOLLI were as follows: TR 346.56 ms, TE 1.22 ms, thickness 8 mm, and flip angle 35 degrees. Contrast media, 0.5 mmol/mL gadobenate dimeglumine (MultiHance, Bracco, Milan, Italy) was injected at a dose of 0.1 mL/kg body weight with 20 mL saline solution at a flow rate of 3.0 mL/s at first, and then at a dose of 0.05 mL/kg body weight with 20 mL saline solution after the perfusion images were acquired. The LGE images were acquired 10 to 15 minutes after administration of the contrast media.

All image data were uploaded to the dedicated cardiac MRI post-processing software cvi42 (version 5.11.3, Circle Cardiovascular Imaging, Inc., Calgary, Canada). The endocardial and epicardial borders of the left and right ventricles were traced in short-axis slices, and the left

and right ventricular end-systolic volumes (LVESV and RVESV, respectively), end-diastolic volumes (LVEDV and RVEDV, respectively), and ejection fractions (LVEF and RVEF, respectively) were calculated automatically. Native T1 and post-contrast T1 values were measured in the whole myocardium and a region of interest (ROI) was manually traced in the septal myocardium of the left ventricular basal and middle segments. Finally, the average T1 values and ECV fractions were acquired. The ECV was calculated from native and post-contrast T1 mapping values using the following formula (15):

$$ECV = (1 - hematocrit)\frac{\left(\frac{1}{T1_{myo\ post}} - \frac{1}{T1_{myo\ pre}}\right)}{\left(\frac{1}{T1_{blood\ post}} - \frac{1}{T1_{blood\ pre}}\right)} \quad [1]$$

The hematocrit was derived from the routine blood test closest in time to the CMR examination. The borders and ROIs were traced manually by two radiologists, respectively.

Transthoracic echocardiography (TTE) and follow-up

All participants underwent TTE before and after surgery. The average follow-up duration was 16.7 months (range, 1–60 months). If a patient had undergone several postoperative examinations, the latest one was used in our study. Patients in this study were retrospectively recruited from the hospital's imaging database. Their LVEF, LVESV, and LVEDV before and after surgery were collected from the electronic records. TTE was performed on a Philips 7500, Philips IE 33, or Philips EPIQ 7C system (Philips Ultrasound System, the Netherlands). The ultrasonic probe was X7-2t, and the frequency ranged from 2 to 7 MHz. Color Doppler was used to assess valvular stenosis or regurgitation. If a patient had ventricular chamber distortion and dilation, the LVEF was measured using the biplane Simpson's method.

Many researchers have studied LVR across a wide range of diseases, among which the definition of LVR differs. Olsen *et al.* (16) defined patients with an increase in LVEDV of >15% or a decrease in LVEF of >10% as being in progression. Legallois *et al.* (17), who reviewed 37 studies involving 4,209 patients (from January 2010 to August 2019), proposed that an increase in LVESV of 12% to 15% and an increase in LVEDV of 12% to 20% might be the optimal criterion or defining adverse LVR in patients with myocardial infarction. In our study, patients with an increase in LVEDV of >15 or a decrease in LVEF of >10% were categorized into the adverse remodeling group; otherwise, patients were assigned to the non-adverse remodeling group.

Statistical analysis

Continuous variables were expressed as mean ± standard deviation. Differences in continuous variables were analyzed using the Mann-Whitney U-test or Student's *t*-test. An intraclass correlation coefficient (ICC) was used to measure the reliability of ratings in CMR measurement. Linear correlation analyses were performed to evaluate the relationships between ECV and postoperative LVESV, LVEDV, and LVEF. Binary logistic regression was performed to identify the predictors of LVR. Receiver operating characteristic (ROC) analysis was performed to determine whether ECV can be used to differentiate adverse LVR from reverse LVR. Statistical analyses were performed using the SPSS software v. 19.0 (SPSS Inc., Chicago, IL, USA).

Results

Clinical manifestations of the patients with RHD

The process of patient selection is shown in the flow diagram in *Figure 1*. A total of 89 patients were diagnosed with RHD and underwent CMR for the period from 2013 and to 2020. Patients were excluded from the study due to having the following conditions: congenital heart disease (n=2, including 1 case of tetralogy of Fallot and 1 case of foramen ovale), infective endocarditis (n=1), dilated cardiomyopathy (n=1), and coronary heart disease (n=1). Thirteen outpatients were also excluded. Of 71 hospitalized patients, 58 underwent valvular surgery, 13 patients did not undergo surgery (including 8 high-risk patients, 4 patients who refused surgery, and 1 patient without indication for surgery). All 58 patients who underwent surgery had preoperative TTE; in 46 cases, the TTE was performed in our institution. Among these 46 patients, 32 patients underwent preoperative T1 mapping, and their cardiac function was also measured. These 32 patients (scanned between October 2013 and May 2019) were included in the study.

A total of 30 healthy volunteers (mean age, 48.40±14.08 years; range, 35–65 years; male, n=12; female, n=18) were enrolled as HCs. The demographic data of all participants were collected (including age, sex, height,

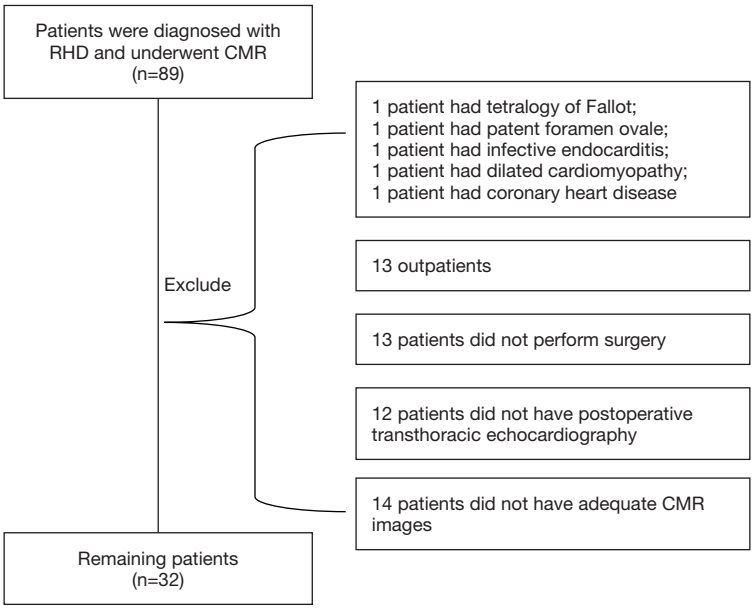


Figure 1 Flow diagram of the study population. RHD, rheumatic heart disease; CMR, cardiovascular magnetic resonance.

weight, blood pressure, and heart rate) together with their CMR imaging findings.

All patients had multiple or mixed valvular diseases. All 32 patients were symptomatic, and most of them complained of chest tightness or tightness in breathing (26/32, 81.3%). Lower extremity edema (4/32, 12.5%), abdominal distension (3/32, 9.4%), cough or dry cough (4/32, 12.5%), palpitations (4/32, 12.5%), dizziness (1/32, 3.1%), and chest pain (1/32, 3.1%) were also reported. Some patients experienced multiple clinical symptoms simultaneously. The duration of clinical symptoms ranged from 1 to 360 months (average time, 67.5 months). A total of 28 (87.5%) patients presented with atrial fibrillation. The majority of patients (22/32, 68.8%) were categorized as New York Heart Association (NYHA) class III, 9 (28.1%) patients were categorized as class II, and 1 patient was categorized as class IV (18).

Valvular surgery procedures received by the patients included the following: mitral valve replacement (MVR) and tricuspid valve valvuloplasty (TVP) (18/32, 56.3%); aortic valve replacement (AVR), MVR, and TVP (6/32, 18.8%); MVR and AVR (2/32, 6.3%); MVR and tricuspid valve replacement (TVR) (1/32, 3.1%), MVR alone (1/32, 3.1%); TVR alone (1/32, 3.1%); MVR, TVR, and AVR (1/32, 3.1%); MVR, TVP, and pulmonary valve valvuloplasty (1/32, 3.1%); and MVR, pulmonary valve replacement, and TVP (1/32, 3.1%).

Comparison of different methods for evaluating T1 values

As shown in *Figure 2*, native T1 and post-contrast T1 values were measured in two different ways. There was no statistically significant difference in the native T1 or post-contrast T1 values of the whole myocardium and septal myocardium in patients with RHD (native T1: 1,308.54±79.58 *vs.* 1,303.19±79.67 ms, P=0.39; post-contrast T1: 481.58±61.40 *vs.* 486.07±82.39 ms, P=0.47). Also, the interobserver reproducibility was good, with ICC values ranging from 0.893 to 0.938 (all P<0.05). The values measured in the septal myocardium were used in this study.

Comparisons of patients with RHD and HCs

The demographic data and CMR findings of the patients with RHD and HCs were compared (*Table 1*). No differences in demographic data were observed. Patients with RHD had significantly reduced ejection fraction, enlarged ventricular volume, and higher left ventricular mass (all P<0.05). Regarding T1 mapping parameters, the RHD group had statistically significantly higher native T1 (RHD group *vs.* HCs: 1,306.34±83.23 *vs.* 1,210.15±46.33 ms, P<0.001) and ECV (RHD group *vs.* HCs: 30.25%±4.56% *vs.* 27.95%±3.14%, P=0.024) values than did the HCs.

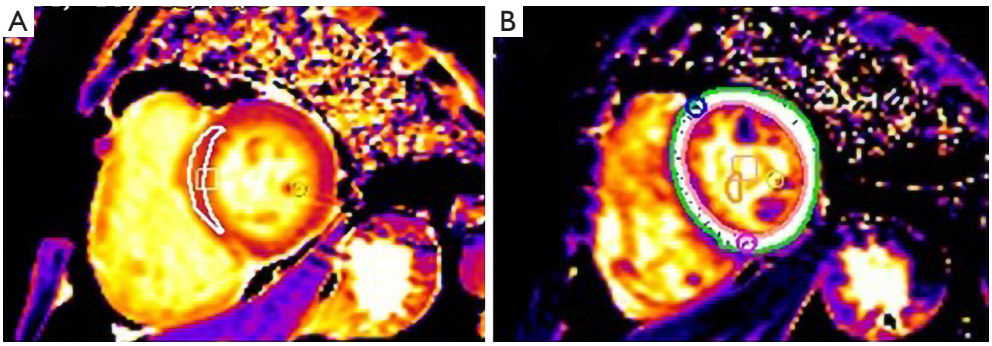


Figure 2 Different measurement methods of T1 mapping. Native T1 and post-contrast T1-values were measured by manually tracing a region of interest in the septal myocardium of the left ventricular basal and middle segments (A) and the whole myocardium (B).

Table 1 Comparisons of patients with RHD and healthy controls

Parameters	Control group (n=30)	RHD group (n=32)	P value
Baseline characteristics			
Male, n [%]	12 [40]	8 [25]	0.207
Age (years)	48.40±14.08	51.72±12.89	0.337
BMI (kg/m^2)	22.97±2.58	25.33±6.12	0.102
Heart rate (bpm)	75.65±7.76	80.69±12.28	0.089
SBP (mmHg)	119.21±9.27	118.22±14.34	0.771
DBP (mmHg)	71.70±5.00	75.59±13.28	0.137
Cardiac function			
CMR-LVEF (%)	63.45±4.78	40.41±12.53	<0.001
CMR-LVESV (mL)	43.91±12.12	98.77±59.35	<0.001
CMR-LVEDV (mL)	119.44±22.98	162.72±77.07	0.004
CMR-RVEF (%)	56.93±7.64	37.19±9.50	<0.001
CMR-RVESV (mL)	43.91±12.12	96.75±42.26	<0.001
CMR-RVEDV (mL)	119.43±22.97	155.80±72.02	0.002
LV mass (g)	73.99±18.19	96.96±44.99	<0.001
T1 mapping			
Native T1 (ms)	1,210.15±46.33	1,306.34±83.23	<0.001
Post-contrast T1 (ms)	472.34±41.23	511.39±65.13	0.07
ECV (%)	27.95±3.14	30.25±4.56	0.024

Data are expressed as mean ± standard deviation if not otherwise specified. RHD, rheumatic heart disease; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; CMR, cardiac magnetic resonance; LVEF/RVEF, left/right ventricular ejection fraction; LVESV/RVESV, left/right ventricular end-systolic volume; LVEDV/RVEDV, left/right ventricular end-diastolic volume; LV, left ventricular; ECV, extracellular volume fraction.

Table 2 Pre- and postoperative TTE findings of patients with RHD

Parameters	Non-adverse remodeling (n=20)	Adverse remodeling (n=12)	P value
LVEF (%)			
TTE_{-pre}	55.95±10.72	55.25±10.72	0.84
$TTE-_{post}$	63.00±7.34	50.25±12.85	0.01
LVESV (mL)			
$TTE-_{pre}$	54.37±44.73	61.92±40.80	0.64
$TTE-_{post}$	40.00±28.17	62.64±23.55	0.03
LVEDV (mL)			
$TTE-_{pre}$	117.37±61.11	121.60±40.47	0.85
$TTE-_{post}$	101.11±40.88	126.27±29.57	0.09

Data are expressed as mean ± standard deviation. TTE, transthoracic echocardiography; RHD, rheumatic heart disease; TTE-pre, preoperative TTE; TTE-post, postoperative TTE; LVEF, left ventricular ejection fraction; LVESV, left ventricular end-systolic volume; LVEDV, left ventricular end-diastolic volume.

Pre- and postoperative TTE findings of patients with RHD

Postoperative TTE-LVESV (non-adverse remodeling *vs.* adverse remodeling: 40.00±28.17 *vs.* 62.64±23.55 mL; P=0.03) and TTE-LVEF (non-adverse remodeling *vs.* adverse remodeling: 63.00%±7.34% *vs.* 50.25%±12.85%, P=0.01) were statistically significantly different between patients with non-adverse remodeling and adverse remodeling (*Table 2*).

Predictors of post-operative adverse LVR

The clinical characteristics, CMR findings, and T1 mapping parameters of patients with non-adverse remodeling and adverse remodeling were compared (*Table 3*). Preoperative parameters, including CMR-LVEDV, CMR-RVESV, CMR-RVEDV, and ECV (P≤0.10), were assessed by binary logistic regression analysis (*Table 4*). ECV was the only variable found to be associated with adverse LVR (P=0.045, odds ratio: 1.273, 95% CI: 1.001–1.604). Two representative cases are presented in *Figure 3*.

ROC curve analysis

ROC curve analysis showed that 30.5 % was the optimal ECV cutoff value to identify patients with adverse LVR (sensitivity: 75.0%; specificity: 77.2%; AUC: 0.78) (*Figure 4*).

Discussion

This study investigated the MF in chronic RHD assessed by T1 mapping, and explored the significance of MF in predicting postoperative outcomes. The main findings are that diffuse MF can exist in patients with RHD and that an ECV of ≥30.5% may predict the progression of adverse LVR after valvular surgery, with a high sensitivity of 75.0% and a specificity of 77.3%.

MF is a common finding in patients with RHD. It is secondary to abnormal hemodynamics caused by valvular diseases and is the sequelae of the chronic inflammatory process of rheumatic fever (19-21). As a pathophysiological mechanism of cardiac structural and functional changes, MF has been reported to be associated with LV dysfunction, heart failure, and a poor prognosis (22). Diffuse MF results from collagen deposition and myofibroblastic activity in the early stages of valvular disease, which may lead to ventricular wall stiffness and, ultimately, left ventricular decompensation. Therefore, monitoring the changes of diffuse MF is especially important.

Endomyocardial biopsy is an established gold standard for MF detection and quantification (23). However, this procedure is uncommonly used in clinical practice due to its invasiveness and sampling bias (9). LGE imaging can identify focal MF, and T1 mapping imaging can quantify diffuse MF, noninvasively (10). Studies have also confirmed an excellent correlation between measurement of MF by histopathology and CMR (7). The ECV was calculated by combining native and post-contrast T1, and hematocrit reflecting an expanded extracellular matrix (15). Previously, Monti *et al.* demonstrated that contrast-enhanced computed tomography also has potential value for assessing ECV (24).

Table 3 Baseline and CMR findings of patients with different outcomes

Parameters	Non-adverse remodeling (n=20)	Adverse remodeling (n=12)	P value
Clinical characteristics			
Age (years)	49.91±14.24	56.25±8.57	0.17
Clinical duration (months)	72.00±90.29	53.42±78.15	0.55
AF (n)	17	11	1.00
NYHA (n)			
II	7	2	0.30
III	12	9	
IV	1	1	
Cardiac function			
CMR-LVEF (%)	40.29±12.91	40.60±12.43	0.95
CMR-LVEDV (mL)	146.11±79.68	190.41±66.61	0.10
CMR-LVESV (mL)	91.77±67.46	110.43±42.76	0.39
CMR-RVEF (%)	36.23±9.03	38.79±10.44	0.47
CMR-RVEDV (mL)	135.72±50.75	189.26±90.63	0.04
CMR-RVESV (mL)	85.42±31.84	115.62±51.58	0.05
LV mass (g)	87.01±47.56	115.07±40.61	0.20
T1 mapping			
Native T1 (ms)	1,285.14±73.34	1,345.17±86.27	0.04
Postcontrast T1 (ms)	500.14±70.89	513.83±81.35	0.87
ESV (%)	28.45±4.46	33.25±3.67	0.002

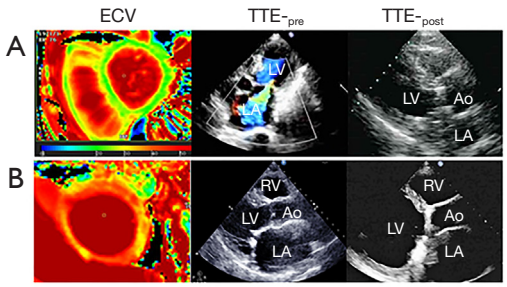
Data are expressed as mean ± standard deviation if not otherwise specified. AF, atrial fibrillation; NYHA, New York Heart Association; CMR, cardiac magnetic resonance; LVEF/RVEF, left/right ventricular ejection fraction; LVESV/RVESV, left/right ventricular end-systolic volume; LVEDV/RVEDV, left/right ventricular end-diastolic volume; LV, left ventricular; ECV, extracellular volume fraction.

Table 4 Binary logistic regression analysis of independent predictors of outcomes

Variables	OR (95% CI)	P value
CMR-LVEDV (mL)	1.003 (0.991–1.015)	0.64
CMR-RVESV (mL)	1.012 (0.946–1.083)	0.73
CMR-RVEDV (mL)	1.002 (0.963–1.043)	0.91
ECV (%)	1.273 (1.001–1.604)	0.045

OR, odds ratio; CI, confidence interval; CMR, cardiac magnetic resonance; LVEDV/RVEDV, left/right ventricular end-diastolic volume; RVESV, right ventricular end-systolic volume; ECV, extracellular volume fraction.

In recent years, researchers have reported on the application of T1 mapping technology in non-rheumatic valvular diseases, such as aortic stenosis, and aortic and mitral regurgitation. Dusenbery *et al.* (25), for instance, demonstrated that young patients with congenital aortic stenosis had higher ECV than HCs. Furthermore, T1 mapping measurements also hold promise for predicting clinical outcomes. A multicenter study of 440 patients undergoing valve replacement for moderate aortic stenosis found that the ECV value was not only associated with cardiovascular mortality but was also independently associated with all-cause mortality (26). However, the value



Patients	TTE	LVESD (mm)	LVEDD (mm)	LVEF (%)
Patient 1	TTE-$_{pre}$	41	62	63
ECV (27.64%)	TTE-$_{post}$	34	44	61
Patient 2	TTE-$_{pre}$	41	60	58
ECV (36.88%)	TTE-$_{post}$	58	77	34

Figure 3 Representative images of two patients with different ECV values. Patient 1 (A) is a 65-year-old male with a low ECV value (27.64%), and patient 2 (B) is a 55-year-old man with a high ECV value (36.88%). Both patients underwent aortic valve replacement, mitral valve replacement, and tricuspid valvuloplasty. Patient 2 was rehospitalized for heart failure 2 years after surgery. TTE, transthoracic echocardiography; LV, left ventricle; LA, left atrium; RV, right ventricle; RA, right atrium; Ao, aortic; ECV, extracellular volume fraction; LVESD, left ventricular end systolic dimension; LVEDD, left ventricular end diastolic dimension; LVEF, left ventricular ejection fraction.

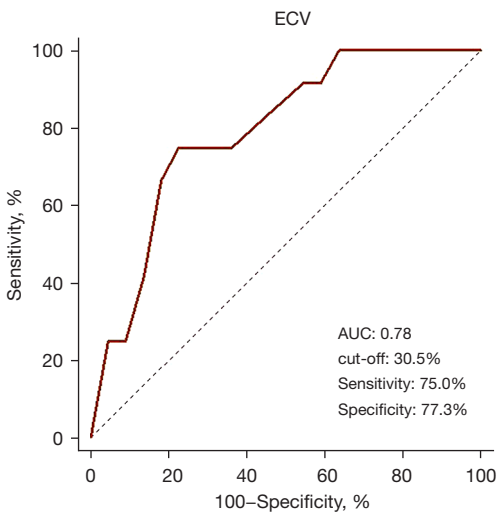


Figure 4 ROC analysis to differentiate adverse LVR from non-adverse LVR. In ROC analysis, the sensitivity and specificity of ECV for differentiating the adverse LVR in patients with RHD are 75.0% and 77.3%, respectively, and the optimal cutoff value of ECV for identification of adverse LVR is 30.5%. ROC, receiver operating characteristic; AUC, area under the curve; LVR, left ventricular remodeling; ECV, extracellular volume fraction; RHD, rheumatic heart disease.

of ECV in patients with rheumatic valvular disease has not been well studied so far.

Previous CMR findings in RHD have mainly focused on the pathophysiologic changes of valves and cardiac function (27). Only a few published studies have evaluated MF in patients with RHD using CMR, with most studies on this topic presented as case reports or short case series. Shriki *et al.* (28) reported on 3 patients with LGE in the atrial wall, and Meel *et al.* reported on 21 patients with chronic rheumatic mitral regurgitation, 4 of whom had evidence of LGE in the LV (29). A study of 47 patients with mitral stenosis found that LGE was associated with postoperative morbidity following mitral valve surgery (30). To our knowledge, ours is the first study to comprehensively evaluate T1 mapping measurements in the septal and whole myocardium using a 3T MR system.

In our study, all patients had multiple or mixed valvular diseases. Patients with heterogeneous valve conditions were included, despite the potential differences in LV volume overload and pressure overload. Isolated cardiac valve affection is unusual in rheumatic valvular disease, especially in patients at the advanced stages of disease. Although more than a third of patients who present for surgery have more than one valve affected (31), single valve disease (regurgitation or stenosis) has received the most attention in published studies (32,33). Due to this lack of data, there are no evidence-based recommendations for the timing of surgery in mixed or multiple valve disease (32).

In our preliminary study, we used CMR to evaluate patients with RHD to promote precision treatment. The results hint that patients with RHD who have more diffuse MF preoperatively have an increased risk of experiencing adverse LVR than those who do not. We speculate that the stiffness of the ventricular wall may increase with the accumulation of myocardial interstitial fibrosis, manifesting as a rise in the ECV value. As the ECV increases, the ventricular elasticity may decompensate, making LVEF recovery impossible after correction of hemodynamic abnormality with valvular surgery in patients with RHD.

Hence, a more intensive follow-up plan could be deployed to prevent fatal cardiac complications in these patients. Future investigations should focus on whether diffuse MF evaluated based on the ECV can help to monitor myocardial change early and identify the optimal time for surgery.

Our study has several limitations. Firstly, the limited number of patients may result in a type II error. Secondly, it would have been better if the patients had undergone postoperative CMR to assess the changes of MF in patients before and after surgery. Thirdly, the patients with RHD who were included had mixed or multiple valvular diseases. Despite the heterogeneity of valvular etiology of the study, the ECV value gave a moderate performance for predicting adverse LVR in patients with RHD following surgery. Finally, because many patients were lost to follow-up, our study could not focus on long-term clinical outcomes, such as death or rehospitalization.

Conclusions

ECV may be able to predict the progression of adverse LVR and identify non-responders among patients with RHD undergoing surgery. Studies with a larger sample size are needed in the future.

Acknowledgments

Funding: This work was supported by the National Natural Science Foundation of China (No. 81601462), the Key Research & Development Project of Science and Technology of Sichuan Province (No. 2021YFS0142), and 1·3·5 Project for Disciplines of Excellence, West China Hospital, Sichuan University (No. ZYGD1801).

Footnote

Reporting Checklist: The authors have completed the STARD reporting checklist. Available at https://qims.amegroups.com/article/view/10.21037/qims-21-678/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-21-678/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are 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. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013), and was approved by West China Hospital's ethics board (No. 2019-756). The requirement to obtain individual consent for this analysis was waived due to its retrospective nature.

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Cite this article as: Li S, Wang S, Yu J, Sun J, Cheng W, Liu J, Pu H, Chen Y, Peng L. Myocardial extracellular volume assessed by cardiovascular magnetic resonance may predict adverse left ventricular remodeling in rheumatic heart disease after valvular surgery. Quant Imaging Med Surg 2022;12(4):2487-2497. doi: 10.21037/qims-21-678

