

## ORIGINAL ARTICLES

# Comparison of the Appendicular Emptying Velocity of Left Atrium in patient with moderate versus severe chronic rheumatic mitral stenosis measured by pulsed wave Doppler in Transesophageal echocardiography

GOUTOM CHANDRA BHOWMIK<sup>1</sup>, MD. FAKHRUL ISLAM KHALED<sup>1</sup>, TANJIMA PARVIN<sup>1</sup>, D.M.M. FARUQUE OSMANY<sup>1</sup>, MUSTASHIRUL HAQUE<sup>1</sup>, A.B.M.GOLAM MOSTOFA<sup>1</sup>, PALLOB KUMAR BISWAS<sup>1</sup>, ARIFUZZAMAN NOMAN<sup>2</sup>, AMIRUZZAMAN SUMON<sup>2</sup>, SAJAL KRISHNA BANERJEE<sup>1</sup>, MOHAMMAD AL MAMUN<sup>1</sup>, ATM IQBAL HASAN<sup>1</sup>, CHAUDHURY MESHKAT AHMED<sup>1</sup>

<sup>1</sup>Department of Cardiology, University Cardiac Center, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka,

<sup>2</sup>Department of Medicine, Sir Sulimullah Medical College & Mitford Hospital (SSMCH&MH)

**Address of Correspondence:** Dr. Goutom Chandra Bhowmik, MD student, Department of Cardiology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Email: dr.goutom@gmail.com

### Abstract:

**Background:** Left atrial appendage (LAA) is considered the “most lethal human appendage” as it causes significant mortality and morbidity in chronic rheumatic mitral stenosis patients due to cardiogenic cerebral infarct. Presence of LAA dysfunction has been shown to be a strong predictor of thrombus formation and the risk of embolic event, even if no clot is found at the time of initial examination. LAA emptying velocity are measured by trans esophageal echocardiography (TEE) represent as a surrogate marker for left atrial (LA) function. LAA emptying velocities (contraction velocity) < 20cm/s are associated with risk of spontaneous echo contrast (SEC), LAA thrombus, and subsequent cardio embolic events. So early detection of low emptying velocity without SEC or LA thrombus can reduce mortality & morbidity related to cardio embolic stroke and also helps in further management procedure like cardio version etc. So we will compare LAA emptying velocity moderate versus severe chronic rheumatic mitral stenosis patients in our population for further attention.

**Objective:** To assess emptying velocity of LAA in patient with moderate versus severe chronic rheumatic mitral stenosis, from a Bangladesh health service perspective.

**Method:** This was a cross sectional study which was conducted in UCC, BSMMU during the period of from February 2019 to September 2019 in Echo lab.

**Study Procedure:** We were enrolled 33 CRHD with MS (moderate to severe) patients who underwent TEE and met inclusion & exclusion criteria. The purpose of the study was explained to each subject & informed written consent was obtained. After getting consent relevant history, physical examination and preprocedural investigation was obtained in predesigned structured data collection sheet. TEE was done with Vivid E9® machine. Pulse wave Doppler was position at the tip of the LAA and then emptying velocity of LAA moderate and severe were compared.

**Outcome measure:** Among 33 patients, 3 patients were excluded due to outlier and inadequate data. In chronic rheumatic mitral stenosis in moderate versus severe cases average LAA emptying velocities were significantly higher moderate CRHD with MS compare to severe CRHD with MS, (26.57±4.91; 31.12±5.04), P=0.018.

**Conclusion:** Appendicular emptying velocity of LAA significantly lower in severe CRHD with MS compare to moderate CRHD with MS and it has temporal relation with MS severity. It can be used as a reliable, simple and semi-invasive tool to early predict severity and prevent complication in CRHD with MS as well as for prophylactic measure taken.

**Key words:** Mitral stenosis; left atrial appendage emptying velocity; right atrial emptying velocity; transesophageal echocardiography; atrial fibrillation

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### Introduction:

In Bangladesh, the proportion of rheumatic heart disease (RHD) among cardiovascular disease patients was about

26 percent in eighties.<sup>1</sup> It ranks 2<sup>nd</sup> among the cardiovascular disease in Bangladesh. Rheumatic mitral stenosis is common among patients with RHD.<sup>2</sup> Over 15

million people around the world suffer from RHD. RHD ranks among the leading causes of non communicable diseases in low –income and middle-income countries and accounts for up to 250,000 premature deaths every year worldwide.<sup>3</sup>

The Left atrial appendage (LAA) has a complex anatomical structures that is distinct from the rest of the left atrium as it has different embryologic, anatomic, and pathophysiologic characteristics LAA is a remnant of the embryonic left atrium, while the rest of the left atrial cavity derives from an outgrowth of the pulmonary vein.

LAA is not just an embryologic remnant, but it seems to play an important role in the regulation of heart rate and fluid balance. On the other hand, LAA dysfunction is known as a significant predictor of thrombus formation and cardio embolic cerebral infarcts in patients with AF. There LAA flow patterns have been described.<sup>4</sup>

Left atrial appendage (LAA) is considered the “most lethal human appendage” as it causes significant mortality and morbidity due to cardiogenic cerebral infarct. Presence of LAA dysfunction has been shown to be a strong predictor of thrombus formation and the risk of embolic event, even if no clot is found at the time of initial examination.<sup>5</sup> LAA emptying velocity are measured by trans esophageal echocardiography (TEE) represent as a surrogate marker for left atrial (LA) function .LAA emptying velocities (contraction velocity) < 20cm/s are associate with risk of spontaneous echo contrast (SEC), LAA thrombus, and subsequent cardio embolic events.<sup>6</sup>

Type 1, characterized by a regular biphasic emptying pattern, occurring in sinus rhythm. Type 2, characterized by a saw-tooth emptying pattern occurring in some patients with atrial fibrillation. Type 3, without any active emptying pattern, typically occurring during AF and this is associated with the highest incidence of spontaneous echo contrast and thrombosis.

Reduced LAA peak flow velocity is considered as one of the strongest independent predictors of an increased cardio embolic stroke risk Despite good progress in the management of patients. The LAA has a distinct pattern of contraction, extensively studied with TEE. The atrium has a biphasic pattern of emptying, a first passive phase in protodiastole and a second active phase during left atrial contraction and a prominent monophasic pattern of emptying. During atrial fibrillation, the pattern is characterized by a rapid alteration of emptying and filling with lower velocity. Abnormalities of the LAA function observed at TEE in

AF (perturbations of LAA emptying peak flow velocity, LAA fractional area change and LAA velocities <0.2m/sec), are associated with the occurrence of spontaneous echo-contrast and thrombus formation resulting from blood stagnation in the LA. These findings have been shown to be associated with the occurrence of ischemic strokes in several clinical reports. So comparison LAA emptying velocity may decided development of further evaluation method of LAA to support more evidence based treatment strategies for patients with rheumatic mitral stenosis.

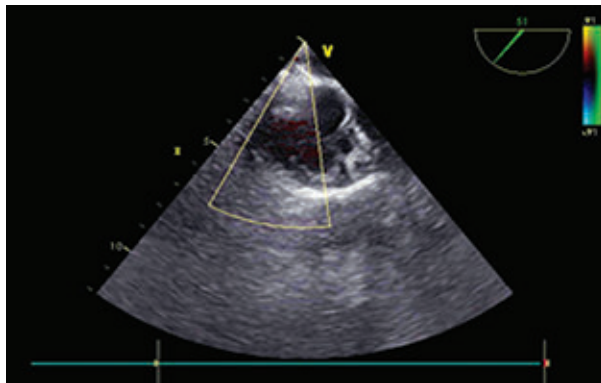
### Methodology

This Cross-sectional study was carried out in the University Cardiac Centre (UCC), Bangabandhu Sheikh Mujib Medical University, Shahbagh, Dhaka, Bangladesh from February, 2019 to September, 2019. Patient with moderate versus severe rheumatic mitral stenosis patients were undergoing TEE were included in this study. CRHD patients with moderate versus severe MS having pre-existing congenital heart diseases, implanted cardiac devices or mechanical valve replacement and previous cardiac surgery, Patients on anticoagulant cardiomyopathy, established thromboembolic event, previous with history of infective endocarditis, contraindication for TEE, poor echo window and Patients who do not give consent were excluded in this study. All patients with chronic rheumatic heart disease and moderate versus severe mitral stenosis underwent TEE department of cardiology as evidence by their clinician were screened for this study. A total of 30 patients were included in the study.

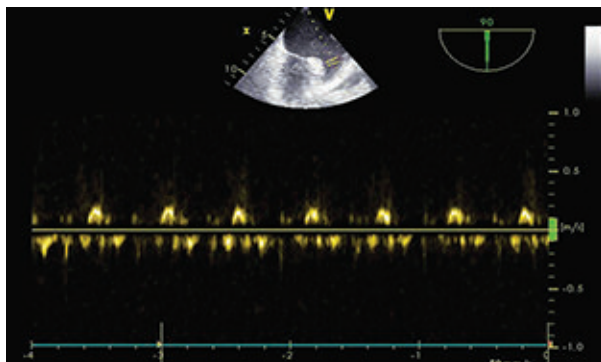
TEE was performed using a 5 MHz phase array biplane transducer. Patients was in fasting state for 6 hours , after application of topical anesthesia of hypo pharynx with 1% lidocaine spray or gargles with out additional premedication. The probe was inserted with patient left lateral decubitus position. the LAA is best visualized in the mid-esophageal two-chamber view (80-100°) and the mid-esophageal aortic valve short-axis view (30-60°). In most patients, these two views allow satisfactory imaging of the LAA, therefore the recommended views for this purpose were those views. However, as the LAA has complex, multilobed configuration, imaging in one or two planes were not sufficient to exclude thrombus with certainty. Therefore, to exclude thrombus, it was essential to image the LAA from multiple imaging planes. This was done be easily accomplished by first developing the mid-esophageal aortic valve short-axis view (30-60°) and then ante flexing the transducer and rotating the multiplane angle

from 0° to 180°. This approach allowed complete delineation of LAA anatomy, its different lobes and the pectinate muscles. The recent availability of live-three dimensional TEE should render imaging of the complex LAA anatomy was much easier then.

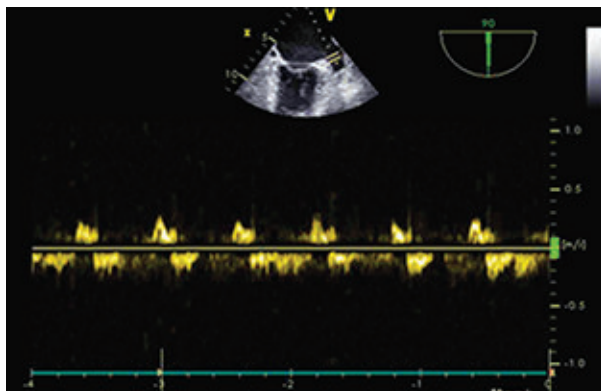
The LAA flow velocity pattern was recorded by pulsed Doppler echocardiography with sample volume 1 cm from the LAA orifice leading into the left atrial main chamber and LAA. From the flow velocity pattern, the peak atrial systolic emptying velocity, peak early diastolic emptying velocity and atrial systolic velocities was obtained.



**Figure :** Morphology of LAA in TEE in midesophageal two-chamber view (80°-100°)



**Figure B:** Emptying velocity of LAA in PWD (moderate case)



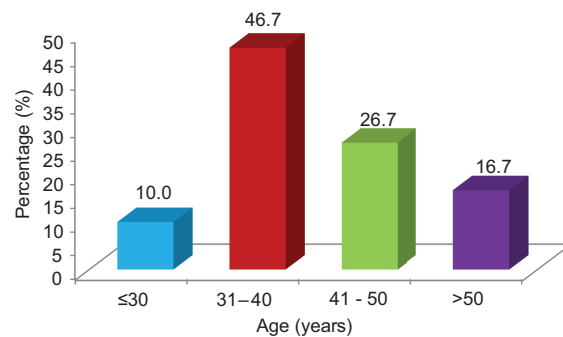
**Figure B:** Emptying velocity of LAA in PWD (severe case)

**Result:**

The expected sample size was 30. All patients with chronic rheumatic heart disease and moderate versus severe mitral stenosis undergoing TEE department of cardiology as advised by their clinician will be screened for this study. Left Atrial Appendage (LAA) emptying velocities are measured and compared in Moderate versus severe CRHD with MS. Considers of all inclusion and exclusion criteria total 33 patients were taken. Among them two patients were excluded from analysis due to outlier value and one patient was excluded due to incomplete information. Finally 30 patients were taken for analysis. The result is describe here after.

**Age distribution of Chronic Rheumatic Mitral Stenosis patients:**

The mean (SD) age of 30 CRHD with moderate versus severe mitral stenosis, was 45.4(±9.9) years ,the range was 30-50 years and maximum patients (46.7%) fell in 31-40 age groups.

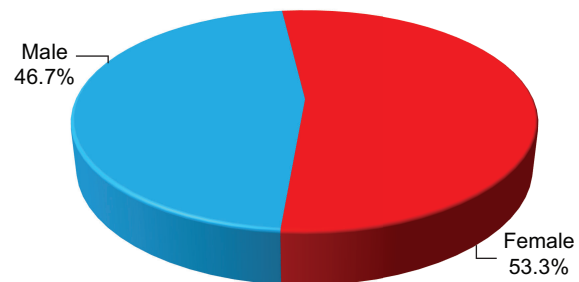


**Fig.-1:** Presentation of study population according to age (n = 30)

Figure in the parentheses indicate percentage n = number of study population

**Sex distribution of chronic rheumatic mitral stenosis patients:**

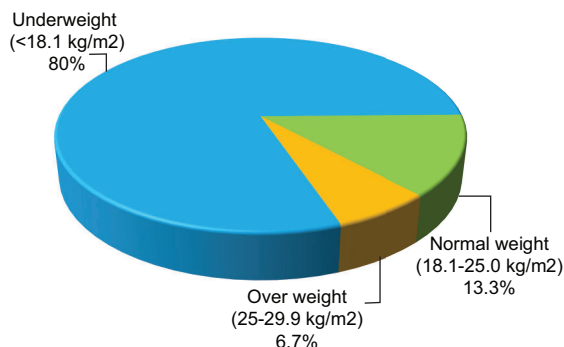
Out of chronic rheumatic mitral stenosis patients who underwent transesophageal echocardiography (TEE), among them 16 (53.3%) patients were female. So in our study female were predominant.



**Fig.-2:** Pie diagram showing the sex distribution Figure in the parentheses indicate percentage n=number of study population

**BMI of study subjects :**

Out of 30 patients, majority of the patient 24cases (80%) were underweight (< 18.1 Kg/m<sup>2</sup>), normal body weight (18.1-25.0kg/m<sup>2</sup>) were 13.3% and rest of the patients were overweight (25-29 kg/m<sup>2</sup>).



**Fig.-3: BMI of the study subjects (n=30)**

Figure in the parentheses indicate percentage

n = number of study population

BMI= Body mass index

**Clinical finding's of study population:**

Majority of study subjects were symptom free and NYHA class- I,II,III breathlessness were present in 20%,10%, 6.7% respectably. Other clinical finding were chest pain, leg oedema, anaemia. On examination of pulse irregular pulse (AF) was found in 40% cases.

**Table-I**

*Clinical finding's of the study subjects (N=30)*

History of	Frequency (n)	Percentage
Breathlessness		
NYHA class I	6	20.0
NYHA class II	3	10.0
NYHA class III	2	6.7
Chest pain	6	20.0
leg oedema	7	23.1
Anaemia	3	10.0
Pulse		
AF	12	40.0
SR	18	60.0

N= number of study population

n = Frequency according to clinical finding's

NYHA = New York Heart Association

AF = Atrial Fibrillation

SR = Sinus Rhythm

**TTE finding of study population:**

Majority of the patients were moderate versus severe according to MVA (cm<sup>2</sup>), LA diameter (mm), Mean Trans-mitral gradient, PASP expect LVEF were normal

**Table-II**

*TTE findings of the study subjects (N=30)*

TTE findings	Moderate MS (n=16)	Severe MS (n=14)	p-value
MVA (cm <sup>2</sup> )	1.25±0.12	0.73±0.11	<0.001
LA diameter (mm)	35.0±4.0	42.0±6.0	<0.001
Mean trans mitral gradient	9.63±1.31	15.12±1.52	<0.001
LVEF	61.52±1.93	60.55±2.19	0.207
PASP	49.6±6.3	59.0±6.2	<0.001

Unpaired t test was done

N= number of study subject

n = Number in each group

MVA = Mitral valve area

LVEF = Left ventricular ejection fraction

PASP = Pulmonary artery systolic pressure

LA = Left atrium

TTE = Trans thoracic echocardiography

Severity of mitral stenosis in chronic rheumatic heart disease in study group patients: Among 30 patient with CRHD with MS, moderate MS were present in 53.3%patients.

**Table-III**

*Type of chronic rheumatic mitral stenosis of the study subjects (n=30)*

Type of chronic rheumatic mitral stenosis	Frequency (n)	Percentage
Severe	14	46.7
Moderate	16	53.3

n= number of study subject

Comparison between appendicular emptying velocity of left atrium in patients with chronic rheumatic mitral stenosis:

In chronic rheumatic mitral stenosis in moderate cases average LAA emptying velocities were significantly higher than and severe severe cases

**Table-IV**

*Comparison between appendicular emptying velocity of LAA in patients with chronic rheumatic MS (n=30)*

	Moderate	Sever	p-value
Chronic rheumatic MS	31.12 ± 5.04 (20-37)	26.57 ± 4.91 (17-34)	0.018

Paired t test was done to measure the level of significance

Data expressed in Mean±SD

s = significant

SD= Standard deviation

LAA=left atrial appendage

MS= mitral stenosis

E°= emptying velocity

### Discussion:

The present research addressed the emptying velocity of Left atrial appendage (LAA) in patient with moderate versus severe chronic rheumatic mitral stenosis by pulse wave echocardiography in TEE and compare the LAA emptying velocity in moderate and severe CRHD with MS.

While looking for age distribution of the Chronic Rheumatic Heart Disease (CRHD) patients with moderate versus severe mitral stenosis, it was observed that more than 80% patients fell in 31-40 groups with SD 45.4 ( $\pm 9.9$ ) year, ranging from 30 to 50 yrs. Considering the baseline characteristics, the mean age of present research subjects is higher as compared with global researches, such as 'World Heart Federation' criteria for echocardiographic diagnosis of rheumatic heart disease-an evidence based guideline' concluded that about 38% belonged to juvenile age (<20yrs) group of RHD.<sup>7</sup> It may be fair enough to accept that increased CRHD with MS in this age group may be due to ignorance of symptoms and delayed to attend the physicians in younger population in our country or may be due to conduction of research among adult population attending in BSMMU echo lab. A research conducted among Nigerian population showed that mean age of RHD was 24 $\pm$ 12 yrs which was may be due to sample taken from 5 to 60 years old patients.<sup>8</sup> It is observed through an American research, the mean age at the appearance of symptom is 31 yrs and progression of mitral stenosis common in the fourth and fifth decades of life.<sup>9</sup> This research quite similar to present one because all were CRHD who attended in BSMMU echo lab for Transesophageal echocardiography (TEE) to detect any complication or further management strategy.

A recent research conducted for observing the frequencies and pattern of chronic rheumatic heart disease in patients undergoing echocardiography in a tertiary level hospital of Bangladesh showing maximum patients fell in 30-39 age group.<sup>10</sup> While dictating Mitral Stenosis with complication, most of the patients are fell in fourth and onward decade.<sup>11,12</sup> So study populations are more vulnerable to development of complication and needed specialized care and regular follow up to prevent dangerous complications like cardio-embolic stroke, pulmonary embolism and others.

A higher female predominance was observed in the present research in patients of CRHD with MS occurred as compared to male and their ratio was 1.18: 1. It was personal view of us that, this female predominance may reflects the higher number of female patients attending

hospitals, their socio-economic and cultural issues. On the other hand, many researches shows the female predominance in patients with MS in Bangladesh.<sup>13,14</sup>

In the present research, majority (more than 80%) patients of CRHD with MS had under BMI as most of the patients in previous researches were under weight. The findings of the present research reflects the present health awareness of study population attending to the doctor as well as came to tertiary level hospital like as BSMMU. A recent research conducted in Brazil supports the findings of present research.<sup>15</sup> In their research they found that around 84% of patients with RHD had normal BMI. This finding necessitates the further evaluation of the nutritional status in a patient with CRHD in Bangladesh.

Next most common co-morbid factor was Atrial Fibrillation (AF) which similar to a British research conducted by Wood.<sup>16</sup> They state that patients with AF tend to be older than those with sinus rhythm. In the present research, most of the patients were older and CRHD may be related to AF common presentation. AF and advanced age are associated with the development of embolism.<sup>17</sup> A sudden cerebral embolism often kills or cripples patients with mitral stenosis who are otherwise free of symptom and in a fair state of cardiac compensation.<sup>18</sup> The incidence of systemic embolism is low before 35 yrs but it gradually increases from 31.6% to 36% over 36 yrs of age concluded that approximately 50% of emboli were cerebral, with almost 50% mortality within a year of onset.<sup>19</sup> As the AF is the prominent risk factor found in the present research so it is a matter of concern that needs further attention.

While examine the study populations clinically, all patients were found haemo-dynamically stable with medical management. Transthoracic echocardiogram (TTE) was done to exclude intra cardiac thrombus and SEC and confirmed moderate to severe mitral stenosis. More than 90% patients had mid diastolic murmur in the apical region where few cases had no murmur due to severe mitral stenosis. More than one third of the patients present with arrhythmia. On the other hand rest of patients had sinus rhythm (SR). Most of the chronic MS patients with SR were also chronic low flow state and increase chance to blood stasis leading to thrombus formation as well as embolism. An American research showed that 47% of emboli occurred in patients with sinus rhythm.<sup>20</sup>

Another finding of the present research, about 10% of patients was anemic although all patients were clinically stable with medical management and had no haemoptysis or other blood loss history. Wood states that anaemia in RHD may be due to haemoptysis of different five types;

sudden profuse haemorrhage (pulmonary apoplexy), acute pulmonary congestion, winter bronchitis, presumably due to a combination of bronchial inflammation and pulmonary venous congestion, acute pulmonary edema and pulmonary infraction.<sup>16</sup> Dyspnea was less common in study population which may be due to most of the patient were clinically stable and in medical treatment. Among them, NYHA class I,II,III breathlessness were present in 20%, 10%, 6.2% of patients respectably. Chest pain and Leg oedema were present in 20% and 23.1% of patients respectably.

In the present research, more than 50% had moderate CRHD with MS. Moderate and severe MS were categories by some TTE parameter like MVA, LA diameter, Mean trans mitral gradient, LVEF, PASP. While comparing the emptying velocity of LAA, it was found that patients with chronic rheumatic mitral stenosis, both moderate and severe cases LAA emptying velocities significantly higher in moderate than severe. The findings of the present research similar to an Egyptian research, where LAA emptying velocity were lower in severe MS ( $16.1\pm 3.7; 16.7\pm 2.9$ ) compare to mild MS ( $26.5\pm 0.7; 17.7\pm 1.6$ ).<sup>21</sup> Patient with severe MS had low emptying velocity of LAA due to low atrial myocardial contraction velocity that causes blood stasis in its cavity and favors the presence of SEC and thromb.<sup>22</sup>

The LAA emptying velocity was significantly lower in AF compared to sinus rhythm which supports the findings of one Bangladeshi research conducted<sup>12</sup>, states flow velocities are the main way to determine LAA function in patients with AF. So decrease emptying velocity of LAA is a surrogate marker of blood stasis and development of cardio-embolic stroke.

So needs comparison LAA emptying velocity in chronic rheumatic mitral stenosis in moderate versus severe patients for further attention, management and prevent catastrophic complication.

### Conclusion:

In addition to compare the emptying velocity of left atrial appendages in patients with moderate versus severe chronic rheumatic mitral stenosis measured by pulse wave Doppler in TEE, it can be used as a reliable, simple and semi-invasive tool to predict the severity and complication in CRHD with MS. The findings of present research will play an important role in further management like monitoring of the medical therapy, intervention or surgical procedures for patients with CRHD with MS.

### Limitations

Some limitations were encountered in the present research that could not be avoided during research conduction.

- As it was a semi-invasive procedure, so not applied in clinically unstable patients.
- It is a single center study.
- Purposive sampling technique was done so there is a risk of selection bias.

### Recommendations

- Further research involving multiple centers with adequate study population to find out the utility of emptying velocity of LAA to predict the severity and complication in CRHD with MS will represent the actual footage of Bangladeshi patients.
- Future research can be carried out to find whether the emptying velocity of LAA can be used as a prognostic marker or a predictor of clinical outcome in patients with CRHD with MS.
- Research to evaluate the changes of dynamics like emptying velocity before and after treatment.

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