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Mitral Regurgitation in Heart Failure: Echocardiographic Aspects and Prognostic Impact from A Series of 170 Cases

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Abstract | **Original Research Article**

Background: Mitral regurgitation (MR) is a common and prognostically important complication of heart failure. Echocardiography is the gold standard for its assessment, yet data on its independent prognostic impact in real-world cohorts remain limited. ***Methods:*** We conducted a retrospective, observational, single-center study including 170 patients with heart failure (HFrEF or HFpEF) and at least moderate MR. All patients underwent complete transthoracic echocardiography with quantification of MR using vena contracta width (VCW), effective regurgitant orifice area (EROA), and regurgitant volume (RVol). Patients were followed for a median of 30 months. The primary endpoint was all-cause mortality. ***Results:*** Mean age was 68 +/- 11 years; 68% were male. Severe MR was present in 65 patients (38%). Compared to moderate MR, severe MR was associated with larger indexed left atrial volumes (LAVi 58 +/- 12 vs 42 +/- 10 mL/m2, p<0.001), lower ejection fraction (32 +/- 8% vs 41 +/- 9%, p<0.001), and higher estimated pulmonary artery pressures (52 +/- 11 vs 43 +/- 9 mmHg, p<0.001). In multivariate Cox regression analysis, severe MR (HR 2.1; 95% CI 1.4-3.2; p<0.001) and LAVi >48 mL/m2 (HR 1.8; 95% CI 1.2-2.7; p=0.004) were independent predictors of mortality. ***Conclusions:*** Severe MR and left atrial dilation are independent and powerful prognostic markers in heart failure, identifying a very high-risk subgroup. Echocardiographic quantification of MR should integrate proportionality assessment, left atrial remodeling, and global longitudinal strain to guide optimal therapeutic strategies, including percutaneous repair.

Keywords: Heart failure, Functional mitral regurgitation, Echocardiography, Prognosis, Left atrium, MitraClip.

1. BACKGROUND

Heart failure (HF) is a global public health problem, associated with high morbidity and mortality. Mitral regurgitation (MR), whether primary (degenerative) or secondary (functional) due to ventricular and/or annular remodeling, frequently coexists with heart failure and significantly worsens its prognosis [1]. Functional MR is particularly common in HF with reduced ejection fraction (HFrEF), resulting from dilation of the mitral annulus and displacement of the papillary muscles secondary to left ventricular remodeling [2]. This creates a vicious cycle: MR increases left ventricular volume overload, which exacerbates dilation and systolic dysfunction, in turn worsening MR [3].

Transthoracic echocardiography (TTE) is the cornerstone of MR diagnosis and assessment. Current recommendations from the ASE and EACVI emphasize systematic quantification using VCW, EROA, and RVol [4]. These measurements demonstrate stronger prognostic correlation than qualitative grading alone [5]. Furthermore, modern echocardiography allows evaluation of left atrial dilation, a marker of chronicity and pressure overload, and elevated pulmonary artery pressures [6]. Global longitudinal strain (GLS) enables detection of subclinical systolic dysfunction with additive prognostic value [7].

The objective of this study was to characterize the echocardiographic profile of patients with HF and MR, and to determine echocardiographic parameters independently associated with long-term mortality.

2. METHODS

2.1. Study population

We conducted a retrospective, observational, single-center study in accordance with STROBE reporting guidelines. Between January 2022 and December 2024, 170 patients diagnosed with HF according to ESC criteria, presenting with at least moderate MR on TTE, were consecutively included.

Patients with severe organic MR (prolapse, chordal rupture) or significant associated valvulopathy were excluded.

2.2. Echocardiographic assessment

All examinations were performed on state-of-the-art equipment and interpreted by two experienced operators blinded to clinical data. Parameters collected included: MR quantification (VCW, EROA and RVol by the PISA method; MR was considered significant if EROA >=0.2 cm2 or VCW >=0.7 cm); left ventricular function (indexed end-diastolic and end-systolic volumes, LVEF by biplane Simpson method); indexed left atrial volume (LAVi, biplane method); and estimated systolic pulmonary artery pressure (PAPs, from tricuspid regurgitation velocity).

2.3. Statistical analysis

Statistical analysis was performed using R software. Continuous variables are expressed as mean +/- standard deviation and categorical variables as percentages. Comparisons used Student's t-test and Chi-squared test. Survival was analyzed by the Kaplan-Meier method with log-rank testing. A multivariate Cox regression model was used to identify independent predictors of mortality, adjusting for age, sex, LVEF, type 2 diabetes, and renal failure.

Use of artificial intelligence: The manuscript was prepared with the assistance of an AI language model (Claude, Anthropic) for text structuring and formatting. All scientific content, data, and conclusions are the sole responsibility of the authors.

3. RESULTS

3.1. Population characteristics

Mean age was 68 +/- 11 years; 68% were male. The etiology of HF was ischemic in 45% of cases. Mean LVEF was 37 +/- 10%. Significant MR (EROA >=0.2 cm2) was present in 65 patients (38%); the remaining 105 patients (62%) had moderate MR. Baseline characteristics by MR severity are presented in Table 1.

Table 1: Baseline clinical and echocardiographic characteristics by MR severity (n=170)

Variable	Severe MR (n=65)	Moderate MR (n=105)	p-value
Age (years)	69 ± 10	67 ± 12	0.34
Male sex (%)	71%	66%	0.48
Ischemic HF etiology (%)	52%	40%	0.12
HFrEF (%)	80%	58%	0.002
HFpEF (%)	20%	42%	0.002
LVEF (%)	32 ± 8	41 ± 9	<0.001
Indexed LVESV (mL/m²)	72 ± 18	54 ± 14	<0.001
EROA (cm²)	0.38 ± 0.12	0.12 ± 0.04	<0.001
Regurgitant volume (mL)	52 ± 18	28 ± 10	<0.001
LAVi (mL/m²)	58 ± 12	42 ± 10	<0.001
LAVi >48 mL/m² (%)	72%	28%	<0.001
Estimated PAPs (mmHg)	52 ± 11	43 ± 9	<0.001
E/e' ratio	14.8 ± 4.2	11.2 ± 3.6	<0.001
GLS (%)	-12.4 ± 3.8	-16.2 ± 3.2	<0.001
NYHA class III-IV (%)	68%	44%	0.002

MR: mitral regurgitation; LVEF: left ventricular ejection fraction; LVESV: LV end-systolic volume; EROA: effective regurgitant orifice area; LAVi: indexed left atrial volume; PAPs: pulmonary artery systolic pressure; GLS: global longitudinal strain; HFrEF/HFpEF: HF with reduced/preserved ejection fraction.

3.2. Echocardiographic profile and prognosis

Patients with significant MR exhibited more pronounced echocardiographic alterations compared to those with moderate MR: higher LAVi (58 +/- 12 vs 42 +/- 10 mL/m2, p<0.001), lower LVEF (32 +/- 8% vs 41 +/- 9%, p<0.001), and higher estimated PAPs (52 +/- 11 vs 43 +/- 9 mmHg, p<0.001). After a median follow-up of 30 months, 78 patients (46%) had died. In multivariate Cox regression, after adjustment for age, sex, LVEF, and comorbidities, only severe MR (HR 2.1; 95% CI 1.4-3.2; p<0.001) and LAVi >48 mL/m2 (HR 1.8; 95% CI 1.2-2.7; p=0.004) remained independent predictors of mortality. Outcome data and Cox regression results are presented in Table 2.

Table 2: Outcomes at 30-month follow-up and multivariate Cox regression predictors of mortality

Parameter	Severe MR (n=65)	Moderate MR (n=105)	p-value
All-cause mortality (%)	58% (n=38)	38% (n=40)	0.012
HF hospitalisation (%)	72%	52%	0.008
Median survival (months)	22	34	0.004
Multivariate Cox predictor	HR (95% CI)	p-value	
Severe MR (EROA >=0.2 cm2)	2.1 (1.4-3.2)	<0.001	

Parameter	Severe MR (n=65)	Moderate MR (n=105)	p-value
LAVi >48 mL/m2	1.8 (1.2-2.7)	0.004	
Age (per 1 year)	1.04 (1.01-1.07)	0.012	
LVEF (per 1%)	0.96 (0.93-0.99)	0.018	

HR: hazard ratio; CI: confidence interval; EROA: effective regurgitant orifice area; LAVi: indexed left atrial volume; LVEF: left ventricular ejection fraction. Multivariate Cox regression adjusted for age, sex, LVEF, type 2 diabetes, and renal failure.

4. DISCUSSION

Our study confirms that significant MR is a powerful and independent prognostic marker in HF. The concept of MR proportionality is fundamental: MR is disproportionate when its severity exceeds what is expected for the degree of LV dilation and dysfunction, identifying patients with the highest mortality risk [12, 17]. Although we did not formally calculate the EROA/LV end-diastolic volume ratio, the coexistence of significant MR with moderately increased LV volumes and severely impaired LVEF suggests a substantial proportion of disproportionate MR in our cohort.

The vicious cycle between MR and HF manifests in our data as elevated LAVi, a marker of chronic pressure overload, and elevated PAPs, both independently predictive of outcome. Modern echocardiographic tools, including GLS and left atrial strain (LAS), add prognostic information beyond classical parameters [19].

Our findings have direct therapeutic implications aligned with the COAPT and MITRA-FR paradigm. The COAPT trial demonstrated dramatic benefit of MitraClip in disproportionate MR [10], while MITRA-FR found no benefit in proportionate MR with severely dilated, dysfunctional LVs [11]. Accurate echocardiographic characterization using the criteria we identified -- severe MR, LAVi >48 mL/m2, moderately increased LV volumes -- provides practical real-world criteria for patient selection for percutaneous repair.

5. CONCLUSIONS

Echocardiographic quantification of MR in HF must extend beyond severity grading to incorporate proportionality assessment, left atrial remodeling, and modern techniques such as strain imaging. Severe MR and left atrial dilation are independent and powerful risk markers that identify a very high-risk subgroup. Precise characterization of these patients is essential to guide optimal therapeutic strategy -- whether medical optimization or percutaneous intervention -- in order to interrupt the vicious cycle and improve prognosis.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board of Moulay Ismail Military Hospital, Meknes, Morocco. Patient informed consent was waived due to the retrospective nature of the study.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The author declares no competing interests.

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