

Right Ventricular Function and Prognosis in Patients with Transthyretin Amyloid Cardiomyopathy

Función ventricular derecha y pronóstico en pacientes con cardiopatía amiloidótica por transtiretina

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ABSTRACT

Background: Transthyretin amyloid cardiomyopathy (ATTR-CM) is an infiltrative disease that impairs the diastolic and systolic function of the heart, affecting both left and right chambers.

Objective: To evaluate the frequency of right ventricle (RV) function involvement and its prognostic impact.

Methods: A retrospective analysis of a cohort of 154 patients with ATTR-CM in a specialized cardiology center. Clinical, laboratory and echocardiographic data, risk factors and cardiovascular events were collected. The relationship of RV function with prognosis was assessed using the Cox proportional hazards model.

Results: Median age was 81 years (interquartile range, IQR, 75-85), and 95% of patients were men. Forty-seven percent of cases had tricuspid annular plane systolic excursion (TAPSE) <17 mm and 52% had RV S-wave <9.5 cm/s. Mean pulmonary pressure was 40 mmHg (IQR 33-50), and 21.7% showed moderate-severe tricuspid regurgitation. During a median follow-up of 528 days (IQR 159-1004), total mortality was 19.3%, cardiovascular mortality 11.8%, hospitalization for heart failure (HHF) 30.5%, and incidence of atrial fibrillation (AF) 30.4%. TAPSE was an independent predictor of total mortality (HR 0.847, 95% CI 0.730-0.983, p=0.028), cardiovascular mortality (HR 0.725, 95% CI 0.600-0.875, p=0.001), HHF (HR 0.859, 95% CI 0.755-0.977, p=0.001), and AF (HR 0.841, 95% CI 0.727-0.972, p=0.019).

Conclusion: Right ventricular dysfunction is frequent in ATTR-CM. TAPSE, as a simple parameter, independently predicts mortality, cardiovascular events and AF in the mid-term.

Keywords: Cardiac amyloidosis - Right ventricle - Heart failure

RESUMEN

Introducción: La cardiopatía amiloidótica por transtiretina (CA-TTR) es una enfermedad infiltrativa que compromete la función diastólica y sistólica del corazón, y afecta tanto las cavidades izquierdas como las derechas.

Objetivo: Evaluar la frecuencia de afectación de la función del ventrículo derecho (VD) y su impacto pronóstico.

Material y métodos: Análisis retrospectivo de una cohorte de 154 pacientes con CA-TTR en un centro especializado en cardiología. Se recopilaron datos clínicos, de laboratorio y ecocardiográficos, factores de riesgo y eventos cardiovasculares. La relación de la función del VD con el pronóstico se evaluó mediante el modelo de riesgos proporcionales de Cox.

Resultados: La edad mediana fue 81 años (rango intercuartílico, RIC, 75-85), con 95% de hombres. El 47% presentó excursión sistólica del plano del anillo tricuspídeo (TAPSE) <17 mm y el 52% onda S del VD <9,5 cm/s. La presión pulmonar media fue 40 mmHg (RIC 33-50), y el 21,7% mostró insuficiencia tricuspídea moderada-grave. Durante una mediana de seguimiento de 528 días (RIC 159-1004), la mortalidad total fue 19,3%, la mortalidad cardiovascular 11,8%, la hospitalización por insuficiencia cardíaca (HIC) 30,5%, y la incidencia de fibrilación auricular (FA) 30,4%. El TAPSE fue predictor independiente de mortalidad total (HR 0,847, IC95% 0,730-0,983, p=0,028), mortalidad cardiovascular (HR 0,725, IC95% 0,600-0,875, p=0,001), HIC (HR 0,859, IC95% 0,755-0,977, p=0,001) y FA (HR 0,841, IC95% 0,727-0,972, p=0,019).

Conclusión: La disfunción del VD es frecuente en la CA-TTR. El TAPSE, como parámetro simple, predice independientemente mortalidad, eventos cardiovasculares y FA a mediano plazo.

Palabras clave: Amiloidosis cardíaca - Ventrículo derecho - Insuficiencia cardíaca

REV ARGENT CARDIOL 2025;93:182-187. <https://doi.org/10.7775/rac.v93.i3.20896>

Received: 01/17/2025 – Accepted: 03/14/2025

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INTRODUCTION

Amyloid cardiomyopathy (ACM) is characterized by the deposition of misfolded proteins in cardiac tissue, leading to progressive dysfunction of the heart. In its transthyretin-associated form (ATTR-CM), these proteins adopt abnormal folding and form fibrillar aggregates that accumulate mainly in the myocardium. This process initially affects diastolic function, and in advanced stages leads to heart failure (HF) with a significant impact on patients' quality of life. (1-3)

Historically, attention in ACM has been focused on left ventricular (LV) function, characterized by the development of cardiomyopathy with restrictive physiology. (4,5) The importance of the right ventricle (RV) has been underestimated, despite its growing recognition as a key determinant of prognosis in this disease. (6,7) Right ventricular dysfunction not only aggravates systemic venous congestion, but, together with tricuspid regurgitation and elevated pulmonary pressures, contributes to the functional and clinical deterioration of patients. (8,9)

In this context, the aim of our study was to evaluate the frequency of RV systolic dysfunction in patients with ATTR-CM and its prognostic impact. A deeper understanding of this alteration could improve risk stratification and favor the implementation of more effective therapeutic strategies aimed at optimizing the prognosis and quality of life of patients.

METHODS

Study design

A retrospective observational study was performed using data prospectively obtained from the electronic medical records of patients at Instituto Cardiovascular de Buenos Aires. Patients with ATTR-CM diagnosis under ambulatory follow-up performed by physicians from the cardiomyopathy clinic of the institution, were included between January 2011 and March 2024, according to the usual diagnostic criteria in force during that period. (10) Baseline demographic, clinical, laboratory, and echocardiographic data were collected, as well as risk factors and cardiovascular events before and after the diagnosis of amyloidosis.

Confirmation of cardiac amyloidosis by transthyretin.

Transthyretin amyloid cardiomyopathy was defined as the combination of typical echocardiographic imaging features (e.g., wall thickness ≥ 12 mm) with grade 2 or 3 cardiac uptake on ^{99m}Tc -HMDP (hydroxymethylene diphosphonate) scintigraphy, plus exclusion of clonal dyscrasia by serum free light chain assay (Freelite, Binding Site) and immunofixation in blood and urine to detect a monoclonal component. (11,12) Scintigraphy was performed in all patients with 20 mCi of ^{99m}Tc -HMDP administered intravenously, taking planar images 2 hours after dose administration. The degree of cardiac uptake in relation to bone tissue was assessed using two methods: 1) Semi-quantitative procedure, following the Perugini visual scale, where cardiac uptake was compared with the sternum: grade 0 = no cardiac uptake, 1 = cardiac uptake less than the sternum, 2 = cardiac uptake equal to the sternum, 3 = cardiac uptake greater than the sternum; and 2) Quantitative procedure: heart-lung ratio.

The final diagnosis of ATTR-CM was based on the results of clinical evaluation, electrocardiograms, echocardiograms

and scintigraphy, after exclusion of plasma cell disease (free light chains, serum and urine immunofixation). (6,7) Magnetic resonance imaging with gadolinium was performed in selected patients. In inconclusive cases, a tissue biopsy was performed.

Objective

To evaluate the frequency of RV systolic function involvement in our population with ATTR-CM and its prognostic impact.

Definition of right ventricular function impairment by echocardiography (Figure 1)

- Tricuspid annular plane systolic excursion (TAPSE) < 17 mm
- Right ventricular S-wave by tissue Doppler imaging (TDI) < 9.5 cm/s. (13)

Events analyzed in the follow-up

- Hospitalization or urgent emergency department visit for HF
- Development of atrial fibrillation (AF)
- Cardiovascular death
- All-cause mortality

Statistical analysis

Discrete variables were expressed as percentages and continuous variables were described using mean and standard deviation (SD) or median and interquartile range (IQR), according to normal or non-normal distribution, respectively. Normality of distribution was assessed using the Kolmogorov-Smirnov method. Categorical variables were analyzed using the Chi-square test or Fisher's exact test, and quantitative variables were analyzed with Student's t-test or the Mann-Whitney U test, depending on the distribution.

Univariate analysis was performed with Cox regression, including all variables biologically relevant to the event. After confirming statistical significance, multiple Cox regression was performed using a backward selection strategy, based on the Z value associated with each variable (Wald test), estimated from the ratio of each coefficient over its standard error. In this multivariate analysis, variables with a level of statistical significance in the univariate analysis with $p < 0.10$ were included.

Event-free survival during follow-up was analyzed using the Log-Rank test and plotted on Kaplan-Meier curves. Statistical significance was considered with $p < 0.05$ (two-tailed test). All data analyses were performed using IBM SPSS version 29.0 software.

Ethical considerations

This study was evaluated and approved by the institutional Ethics Committee. The study was registered in the PRIISA. BA platform of the Ministry of Health of the Autonomous City of Buenos Aires and was conducted in accordance with national and international regulations for the protection of research subjects, such as the latest version of the Declaration of Helsinki, (14) Resolution 1480/2011 of the National Ministry of Health, Law 3301 of the City of Buenos Aires, and ANMAT Resolution 6677/10 and its amendments 4008 and 4009.

RESULTS

A total of 154 patients were included in the study, 95% male ($n=147$), and with median age of 81 years (IQR 75-85). Most patients had comorbidities: 77% hyper-

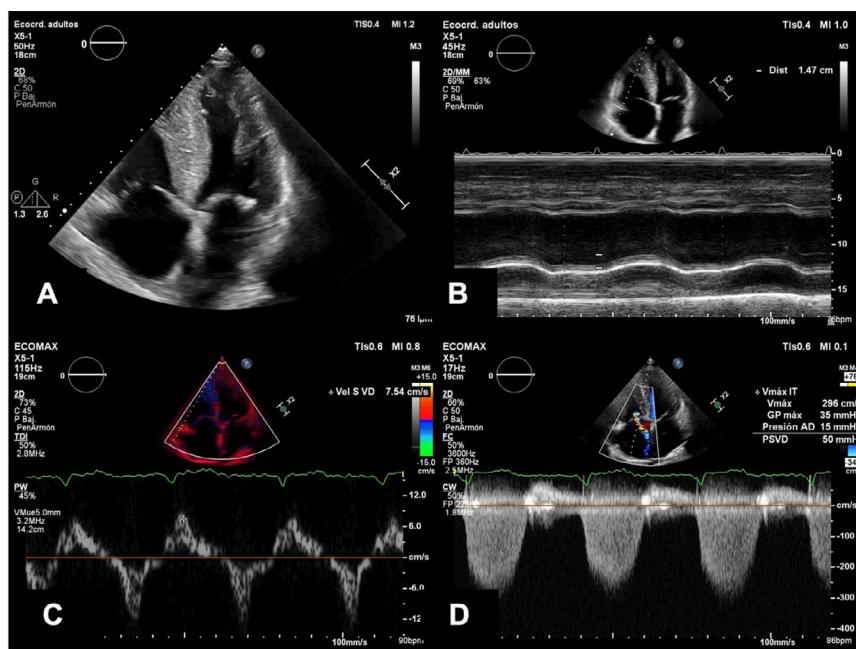


Fig. 1. Evaluation of the right ventricle. **A:** 4-chamber view of a patient with amyloid cardiomyopathy. **B:** Tricuspid annular plane systolic excursion (TAPSE). **C:** Right ventricular S-wave. **D:** Estimation of pulmonary artery systolic pressure.

tension, 17% diabetes, 58% dyslipidemia and 41% had a history of smoking or were ex-smokers. Regarding other relevant conditions, 25% had coronary artery disease and 8% previous coronary artery bypass grafting (CABG). Twenty-seven percent of patients had a permanent pacemaker (PPM) and only one patient had an implantable cardioverter-defibrillator (ICD). Atrial fibrillation was present in 53% of cases before diagnosis. Among the red flags associated with ATTR-CM, 6% had neuropathy, 29% carpal tunnel syndrome and 6.5% narrow spinal canal.

Laboratory parameters showed a median N-terminal pro-B-type natriuretic peptide (NT-proBNP) of 3800 ng/L (IQR 1200-7600) and high-sensitivity troponin T of 62 ng/L (IQR 42-91), along with an estimated glomerular filtration rate of 54 ml/min/1.73 m² (IQR 40-68).

Echocardiogram showed a median left ventricular ejection fraction (LVEF) of 50% (IQR 42-60), interventricular septum (IVS) of 16 mm (IQR 14-19) and posterior wall of 13 mm (IQR 12-15).

Median TAPSE was 17 mm (IQR 14-19), and RV S-wave 9 cm/s (IQR 8-10). Median left atrial (LA) area was 29 cm² (IQR 26-32). Tricuspid regurgitation (TR) was mild in 47% of patients (n=67), moderate in 17% (n=25) and severe in 4.2% (n=6). In 6.2% of cases (n=9), patients had mild aortic stenosis, 10.3% (n=15) moderate and 5.5% (n=8) severe. Sixty per cent of patients (n=85) had mild mitral regurgitation,

17.5% (n=25) moderate, and there were no cases of severe mitral regurgitation (Tables 1 and 2).

With respect to the study objective, 47% presented TAPSE value <17 mm and 52% RV S-wave <9.5 cm/s.

Median follow-up was 528 days (IQR 159-1004), during which total mortality was 19.3% and cardiovascular mortality 11.8%. In addition, 30.5% of patients were hospitalized for HF and 30.4% of those free of AF at baseline developed this arrhythmia during follow-up.

Univariate analysis identified TAPSE as an independent predictor of adverse clinical events. Even after adjusting for multiple echocardiographic (LVEF, IVS, LV lateral and medial S-wave, filling pattern, pulmonary systolic pressure, RV S-wave and E/e' ratio), demographic (age and sex) and clinical (previous HF, diabetes, PPM, previous coronary artery disease, and previous AF) variables, TAPSE remained as an independent predictor of total mortality (HR 0.847; 95% CI 0.730-0.983, p=0.028), cardiovascular mortality (HR 0.725; 95% CI 0.600-0.875, p=0.001), hospitalization for HF (HR 0.859; 95% CI 0.755-0.977, p=0.001) and development of AF (HR 0.84; 95% CI 0.727-0.972, p=0.019). (Figure 2)

DISCUSSION

This study evaluated a cohort of patients diagnosed with ATTR-CM followed up by physicians from the cardiomyopathy service of a single center in Argenti-

Tabla 1. Population characteristics

Variable	Value
Male sex	147 (95.2%)
Age, years	81 (75-85)
Hypertension	126 (77.3%)
DM	29 (17.8%)
Dyslipidemia	95 (58.3%)
Smoking	66 (41.3%)
Stroke / TIA	20 (12.4%)
PCI	34 (21.1%)
CABG	14 (8.7%)
Coronary artery disease	41 (25.5%)
PPM	44 (27%,3)
VRS	10 (6.3%)
ICD	1 (0.6%)
CRT	2 (1.3%)
Previous AF	82 (50.9%)
Neuropathy	9 (6.2%)
Carpal tunnel	46 (29.3%)
Narrow medullary canal	10 (6.5%)

AF: atrial fibrillation; CTA: coronary transluminal angioplasty; CABG: coronary artery bypass grafting; CRT: cardiac resynchronization therapy; DM: diabetes mellitus; ICD: implantable cardioverter-defibrillator; PCI: percutaneous coronary intervention; PPM: permanent pacemaker; TIA: transient ischemic attack; VRS: valve replacement surgery. Qualitative variables are presented as frequency and percentage, and quantitative as median and interquartile range.

na. The frequency of RV systolic dysfunction was analyzed in this population and its prognostic impact was investigated. We consider it is important to highlight three aspects of our work.

Firstly, it is relevant to know the prevalence of RV impairment in our population. In the echocardiogram, we found TAPSE <17 mm in 47% of patients and RV S-wave < 9.5 cm/s in 52%, as an expression of right ventricular dysfunction. In the study by Diane Bodez et al. non-survivors showed worse RV systolic function on echocardiography assessed by TAPSE and RV free wall deformation. Significantly, RV free wall deformation was independently associated with all-cause mortality in several multivariate Cox regression models, with incremental prognostic value over conventional parameters of RV function. (15) Right ventricular involvement is common in patients with cardiac amyloidosis. (16) It is proposed that this dysfunction may be mediated by amyloid infiltration of the RV wall itself, by increased afterload in cases of pulmonary hypertension, and by ventricular interdependence.

Secondly, it is crucial to understand the role of the right ventricle in the prognosis of patients with cardiac amyloidosis. Right ventricular dysfunction, often underestimated in clinical practice, plays a crucial role in the progression of HF and in the development of AF, probably due to pressure overload and fibro-

Tabla 2. Baseline laboratory and echocardiogram characteristics

Variable	Value
Laboratory	
NT-proBNP, ng/L	3800 (1200-7600)
Glomerular filtration rate, mL/min/1.73 m ²	54 (40-68)
Ultra-sensitive troponin T, ng/L	62 (42-91)
Echocardiographic characteristics	
LVEF, %	50 (42-60)
IVS, mm	16 (14-19)
PW, mm	13 (12-15)
LVDD, mm	44 (40-49)
LVSD, mm	30 (25-25)
Lateral S-wave, cm/s	5.8 (5-6.8)
Medial S-wave, cm/s	4.65 (3.9-5.4)
LA, cm ²	29 (26-32)
Filling pattern	
Prolonged relaxation	8 (5.6%)
Pseudonormal	41 (29%)
Restrictive	34 (24%)
Monophasic	57 (40%)
TAPSE, mm	17 (14-19)
PASP, mmHg	40 (33-50)
RV S-wave, cm/s	9 (8-10)
E/e' ratio	16 (12-19)
Septal E, cm/s	5 (4-5.3)
Lateral E, cm/s	6.7 (5.3-8)
Tricuspid regurgitation	
M	67 (47%)
Mod	25 (17%)
S	6 (4.2%)
Aortic stenosis	
M	9 (6.2%)
Mod	15 (10.3%)
S	8 (5.5%)
Mitral regurgitation	
M	85 (60%)
Mod	25 (17.5%)
S	0 (0%)

LA: left atrium; IVS: interventricular septum; LVDD: left ventricular diastolic diameter; LVSD: left ventricular systolic diameter; LVEF: left ventricular ejection fraction; M: mild; Mod: moderate; NT-proBNP: N-terminal pro-B-type natriuretic peptide; PW: posterior wall; PASP: pulmonary artery systolic pressure; RV: right ventricular. S: severe; TAPSE: tricuspid annular plane systolic excursion.

Qualitative variables are presented as frequency and percentage and quantitative variables as median and interquartile range.

sis induced by amyloid infiltration. TAPSE, a simple and widely available echocardiographic parameter, emerged in our study as an independent predictor of adverse clinical events even after adjusting for other demographic and echocardiographic variables. Our

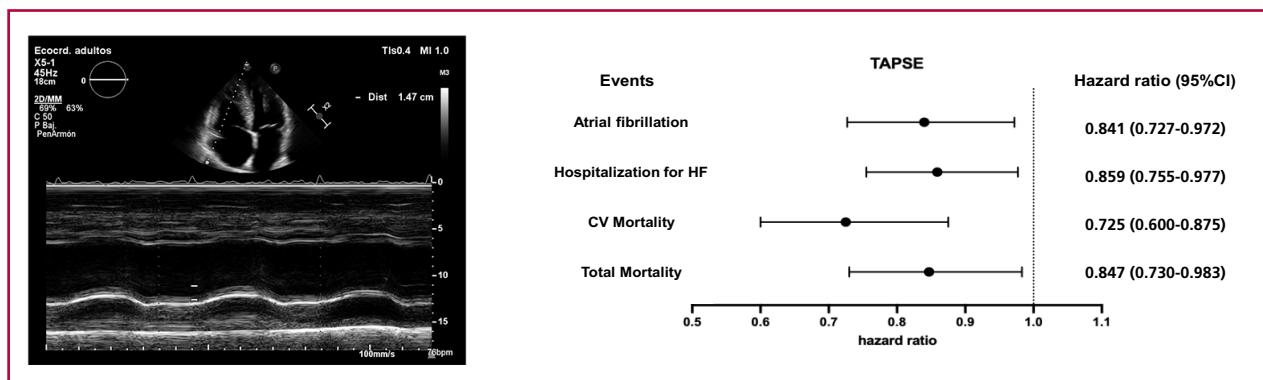


Fig. 2. Prognostic value of TAPSE (tricuspid annular plane systolic excursion) for major events.

results are in the same direction of published data in patients with light chain (AL) amyloidosis. (17-19) In 2007, Ghio et al. reported the association of TAPSE <17 mm with BNP elevation and mortality in patients with AL amyloidosis. (17)

Finally, the findings of our study, which show an inverse association between TAPSE and heart failure, mortality, and atrial fibrillation events in patients with ATTR-CM, reinforce its potential value as a prognostic tool in this disease. It is essential to have a widely available and simple to obtain parameter, to stratify risk in this population. Although our observational design does not allow us to establish causality, the detection of RV dysfunction could motivate closer clinical surveillance, favoring the early detection of events such as AF, in which case timely intervention -such as the initiation of anticoagulation- could have a relevant clinical impact. (20,21)

Limitations

The retrospective and single-center nature of the study limits the generalization of results, highlighting the need to reproduce them in other cohorts. Furthermore, it was not possible to evaluate myocardial deformation parameters in all patients, which prevented the inclusion of this variable, despite its recognized diagnostic and prognostic value, as well as right ventricular ejection fraction by a 3-dimensional method. Nevertheless, the fact that simple and accessible parameters, such as TAPSE, demonstrate prognostic value reinforces its clinical relevance.

CONCLUSION

Echocardiographic RV impairment is common in patients with ATTR, and TAPSE stands out as a simple and accessible echocardiographic parameter, due to its predictive capacity in the clinical course of these patients. A reduced TAPSE is associated with a higher risk of total and cardiovascular mortality, hospitalizations for HF and development of AF in the mid-term, highlighting the importance of its evaluation in clinical

practice for better risk stratification and disease management.

Conflicts of interest

None declared.

(See authors' conflict of interests forms on the web).

REFERENCES

- Grogan M, Scott CG, Kyle RA, Grogan M, Scott CG, Kyle RA, Zeldenrust SR, Gertz MA, Lin G, et al. Natural history of wild-type transthyretin cardiac amyloidosis and risk stratification using a novel staging system. *J Am Coll Cardiol* 2016;68:1014–20. <https://doi.org/10.1016/j.jacc.2016.06.033>
- Binder C, Duca F, Stelzer PD, Nitsche C, Rettl R, Aschauer S, et al. Mechanisms of heart failure in transthyretin vs. light chain amyloidosis. *Eur Heart J Cardiovasc Imaging* 2019;20:512–24. <https://doi.org/10.1093/ehjci/jez225>
- González-López E, Gallego-Delgado M, Guzzo-Merello G, de Haro-Del Moral FJ, Cobo-Marcos M, Robles C, et al. Wild-type transthyretin amyloidosis as a cause of heart failure with preserved ejection fraction. *Eur Heart J* 2015;36:2585–94. <https://doi.org/10.1093/eurheartj/ehv338>
- Kein AL, Hatle LK, Taliercio CP, Taylor CL, Kyle RA, Bailey KR, et al. Serial Doppler echocardiographic follow-up of left ventricular diastolic function in cardiac amyloidosis. *J Am Coll Cardiol* 1990;16:1135–41. [https://doi.org/10.1016/0735-1097\(90\)90545-Z](https://doi.org/10.1016/0735-1097(90)90545-Z)
- Bellavia D, Pellikka PA, Abraham TP, Al-Zahrani GB, Dispenzieri A, Oh JK, et al. Evidence of impaired left ventricular systolic function by Doppler myocardial imaging in patients with systemic amyloidosis and no evidence of cardiac involvement by standard two-dimensional and Doppler echocardiography. *Am J Cardiol* 2008;101:1039–45. <https://doi.org/10.1016/j.amjcard.2007.11.047>
- Konstam MA, Kiernan MS, Bernstein D, Bozkurt B, Jacob M, Kapur NK, Kociol RD, et al. Evaluation and management of right-sided heart failure: A scientific statement from the American Heart Association. *Circulation* 2018;137:e578–e622. <https://doi.org/10.1161/CIR.0000000000000560>
- Cappelli F, Porciani MC, Bergesio F, Perlini S, Attanà P, Moggi Pignone A, et al. Right ventricular function in AL amyloidosis: characteristics and prognostic implication. *Eur Heart J Cardiovasc Imaging* 2012;13:416–22. <https://doi.org/10.1093/ehjcard/jez289>
- Haddad F, Doyle R, Murphy DJ, Hunt SA. Right ventricular function in cardiovascular disease, part II: Pathophysiology, clinical importance, and management of right ventricular failure. *Circulation* 2008;117:1717–31. <https://doi.org/10.1161/CIRCULATIONAHA.107.653584>
- Friedberg MK, Redington AN. Right versus left ventricular failure: Differences, similarities, and interactions. *Circulation* 2014;129:1033–

44. <https://doi.org/10.1161/CIRCULATIONAHA.113.001375>
10. Gillmore JD, Maurer MS, Falk RH, Merlini G, Damy T, Dispenzieri A, et al. Nonbiopsy diagnosis of cardiac transthyretin amyloidosis. *Circulation* 2016;133:2404–12. <https://doi.org/10.1161/CIRCULATIONAHA.116.021612>
11. Garcia-Pavia P, Rapezzi C, Adler Y, Arad M, Basso C, Brucato A. Diagnosis and treatment of cardiac amyloidosis: a position statement of the ESC Working Group on Myocardial and Pericardial Diseases. *Eur Heart J* 2021;42:1554–68. <https://doi.org/10.1093/eurheartj/ehab072>
12. Brito D, Albrecht FC, de Arenaza DP, Bart N, Better N, Carvajal-Juarez I, et al. World heart federation consensus on transthyretin amyloidosis cardiomyopathy (ATTR-CM). *Glob Heart* 2023;18:59. <https://doi.org/10.5334/gh.1262>
13. Zaidi A, Knight DS, Augustine DX, Harkness A, Oxborough D, Pearce K, et al. Echocardiographic assessment of the right heart in adults: A practical guideline from the British Society of echocardiography. *Echo Res Pract* 2020;7:G19–G41. <https://doi.org/10.1530/ERP-19-0051>
14. World Medical Association. World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects. *JAMA*. 2013;310:2191 <https://doi.org/10.1001/jama.2013.281053>
15. Bodez D, Ternacle J, Guellich A, Galat A, Lim P, Radu C, et al. Prognostic value of right ventricular systolic function in cardiac amyloidosis. *Amyloid* 2016;23:158–67. <https://doi.org/10.1080/13506129.2016.1194264>
16. Arvidsson S, Henein MY, Wikström G, Suhr OB, Lindqvist P. Right ventricular involvement in transthyretin amyloidosis. *Amyloid* 2018;25:160–6. <https://doi.org/10.1080/13506129.2018.1493989>
17. Ghio S, Perlini S, Palladini G, Marsan NA, Faggiano G, Vezzoli M, et al. Importance of the echocardiographic evaluation of right ventricular function in patients with AL amyloidosis. *Eur J Heart Fail* 2007;9:808–13. <https://doi.org/10.1016/j.ejheart.2007.05.006>
18. Bellavia D, Pellikka PA, Dispenzieri A, Scott CG, Al-Zahrani GB, Grogan M, et al. Comparison of right ventricular longitudinal strain imaging, tricuspid annular plane systolic excursion, and cardiac biomarkers for early diagnosis of cardiac involvement and risk stratification in primary systemic (AL) amyloidosis: a 5-year cohort study. *Eur Heart J Cardiovasc Imaging*. 2012;13:680–9. <https://doi.org/10.1093/ehjci/jes009>
19. Cappelli F, Porciani MC, Bergesio F, Perlini S, Attanà P, Moggi Pignone A, et al. Right ventricular function in AL amyloidosis: characteristics and prognostic implication. *Eur Heart J Cardiovasc Imaging*. 2012;13:416–22. <https://doi.org/10.1093/ejehocardi/jer289>
20. Donnellan E, Elshazly MB, Vakamudi S, Wazni OM, Cohen JA, Kanj M, et al. No association between CHADS-VASc score and left atrial appendage thrombus in patients with transthyretin amyloidosis. *JACC Clin Electrophysiol* 2019;5:1473–4. <https://doi.org/10.1016/j.jacep.2019.10.013>
21. El-Am EA, Dispenzieri A, Melduni RM, Ammash NM, White RD, Hodge DO, et al. Direct current cardioversion of atrial arrhythmias in adults with cardiac amyloidosis. *J Am Coll Cardiol* 2019;73:589–97. <https://doi.org/10.1016/j.jacc.2018.10.079>