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Original paper

HCM Risk-SCD score and its relation with functional status and comorbidities in HCM patients

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ABSTRACT

INTRODUCTION: Hypertrophic cardiomyopathy (HCM) is a genetic cardiac disorder associated with heart failure, arrhythmias, and an increased risk of sudden cardiac death (SCD). Functional status and the HCM Risk-SCD score are key parameters guiding management. This study assessed the relationship between functional status, comorbidity burden, and the HCM Risk-SCD score in patients with HCM.

MATERIAL AND METHODS: This retrospective single-cohort study included 56 patients with HCM. The HCM Risk-SCD score was calculated according to the 2023 ESC guidelines. Patients were stratified by heart failure symptoms into asymptomatic (NYHA I) and symptomatic (NYHA II–III) groups, and by comorbidity burden into low (0–1) and high (≥2) groups. Assessed comorbidities included systemic hypertension, hyperlipidemia, coronary artery disease, chronic kidney disease, COPD, and type 2 diabetes.

RESULTS: The median HCM Risk-SCD score was higher in asymptomatic than symptomatic patients (3.46% [IQR 2.38-4.44] vs. 2.07% [IQR 1.17-2.23]; p=0.005). No significant difference was observed between patients with low and high comorbidity burden (1.95% vs. 2.01%; p=0.765), and no correlation was found between the HCM Risk-SCD score and the number of comorbidities (rho=-0.07, p=0.607).

CONCLUSIONS: Asymptomatic patients with HCM had a higher estimated risk of SCD than symptomatic patients. The HCM Risk-SCD score appeared to be independent of comorbidity burden. This shows that HCM individuals with better clinical and functional status may be at higher risk of SCD.

KEYWORDS

comorbidities, NYHA, HCM, Risk-SCD score

INTRODUCTION

Hypertrophic cardiomyopathy (HCM) represents the most prevalent inherited cardiac disease with an estimated prevalence of 1:500 in the general population [1]. Approximately 40–60% of patients with clinically established HCM carry pathogenic autosomal dominant variants in genes encoding sarcomeric proteins [2]. Among these, mutations in MYH7 and MYBPC3, which encode the β-myosin heavy chain and cardiac myosin-binding protein C, respectively, constitute the most commonly identified pathogenic genetic abnormalities [3].

The HCM is associated with abnormal thickening of the ventricular wall, myofibrillar disarray, myocardial fibrosis and microvascular dysfunction leading to ischaemia [4,5]. These structural and functional abnormalities contribute to progressive heart failure and increase susceptibility to life-

threatening ventricular tachyarrhythmias, which represent two principal therapeutic challenges in patients with HCM [2,6].

Concerning arrhythmogenesis, the most devastating complication of HCM remains sudden cardiac death (SCD) especially considering its usual occurrence in younger patients, sometimes as the first manifestation of the disease with no other prodromal symptoms [7].

The efficacy of an implantable cardioverter-defibrillator (ICD) as the primary prevention of SCD was demonstrated for the first time in 2000 by Maron et al. [8] and allowed to reduce overall disease-specific mortality to 0.5% per year [9]. However, there are concerns about high rates of inappropriate shocks - the most frequent complication of ICD. The annual frequency of inappropriate interventions revealed in a meta-analysis by Wang et al. [10] was 4.9% in comparison with 4.8% of appropriate interventions. As patients with HCM are typically diagnosed at younger age than individuals with other cardiac disorders, their exposure to ICD-related complications is essentially greater. Consequently, decisions regarding prevention of SCD should be based on an individualised risk assessment concerning the anticipated therapeutic benefit and long-term risk of ICD-related adverse events [11].

The aim of the study was to analyse patients' HCM Risk-SCD score in regards to patients' functional status and comorbidities in order to verify whether they might be helpful in qualification for the ICD therapy.

MATERIAL AND METHODS

Study design and data collection

It is a retrospective single-cohort study. Cohort analysed in the study included 56 patients diagnosed with HCM and hospitalized in 1st Department of Cardiology, Leszek Giec Upper-Silesian Medical Centre of the Medical University of Silesia (Katowice, Poland) between 2024 and 2026. Data collected during patients' hospitalization included demographics, family history of SCD, echocardiography, Holter monitoring, clinical and laboratory findings. The HCM Risk-SCD score was calculated according to the 2023 ESC recommendations which include age, maximal left ventricle (LV) wall thickness, left atrial diameter, maximal LV outflow track gradient, family history of SCD, non-sustained ventricular tachycardia (nsVT) and unexplained syncope.

Patients stratification

Patients were stratified by heart failure symptoms assessed in New York Heart Association (NYHA) Functional Classification into an asymptomatic (NYHA=I) and symptomatic group (NYHA=II or III) and by comorbidity burden into low burdened (0-1 comorbidity) and high burdened group (≥ 2 comorbidities). Comorbidities included in the study were systemic hypertension (HA), coronary artery disease (CAD), hyperlipidemia (HL), chronic kidney disease (CKD), chronic obstructive

pulmonary disease (COPD) and diabetes mellitus type 2 (DM2). Females represented 37.5% (n=21) of the global cohort. The mean age of the study population was 54.9 ± 13.6 years. The anthropometric characteristics of the total study population were as follows: height, 172.1 ± 9.8 cm; weight, 85.9 ± 14.3 kg; and body mass index (BMI), 28.5 (25.6–31.8) kg/m².

Statistics

Statistical analyses were performed using Statistica 14.1.0.4. The normality of the data distribution was assessed using the Shapiro-Wilk test. Since the HCM Risk-SCD score and number of comorbidities showed a non-normal distribution ($p<0.001$), non-parametric methods were used for further analyses. Difference in the HCM Risk-SCD score between NYHA groups and comorbidity burden groups was analyzed using Mann-Whitney U test. The relationship between HCM Risk-SCD score and absolute number of comorbidities was assessed using Spearman's rank correlation coefficient. For all statistical analyses, a p-value <0.05 was considered statistically significant. All tests were two-tailed.

RESULTS

Functional status

Based on the NYHA classification,14 (25%) patients were stratified into the asymptomatic group (NYHA I), whereas 42 (75%) patients constituted the symptomatic group (NYHA II-III). Within the symptomatic group, 32 patients (57.1% of the total cohort) presented with NYHA II and 10 patients (17.9% of the total cohort) presented with NYHA III. The analysis of group characteristics showed high homogeneity between these 2 subgroups. There was no significant difference between NYHA functional class subgroups neither in the mean age (57.2 ± 13.9 years in NYHA I vs. 54.2 ± 13.6 years in NYHA II-III, p=0.47) nor in the female representation (42.9% vs. 35.7%, p=0.75).

In regards to anthropometric parameters including height, weight and BMI, analysis did not show statistically significant differences between the groups ($p>0.05$ for all comparisons).

The most prevalent conditions across the entire cohort were hyperlipidemia (n=37/66.1%) and systemic hypertension (n=35/62.5%).

The CAD was documented in 17.9% (n=10) of the total population, showing a high increase from 1 case (7.1%) in the asymptomatic subgroup to 9 cases (21.4%) in the symptomatic subgroup, though analysis showed no statistically significant difference (p=0.42)

The DM2 and CKD were equally prevalent, each in 12.5% (n=7) for the overall cohort, with a strict prevalence in the symptomatic subgroup for all CKD cases (16.7% vs. 0.0%, p=0.17). The COPD was rare, affecting 5.4% (n=3) of the total cohort and only symptomatic subgroup (Table I).

The median HCM Risk-SCD score in groups created according to heart failure symptoms was 3.46%

(IQR: 2.38-4.44%) for the asymptomatic vs 2.07% (IQR: 1.17-2.23%) for the symptomatic group (p=0.005) (Figure 1).

Table I. Characteristics of subgroups stratified by NYHA classification

Parameter	Asymptomatic (n=14)	Symptomatic (n=42)	p-value
Demography			
Age (years)	57.2±13.9	54.2±13.6	0.4718
Sex (Female)	6 (42.9%)	15 (35.7%)	0.7525
Height (cm)	173.6±9.8	171.5±9.9	0.6629
Weight (kg)	87.1±11.8	85.5±15.1	0.6701
BMI (kg/m²)	29.8 (25.4–32.0)	28.5 (25.7–31.0)	0.8499
Comorbidities			
Systemic hypertension	9 (64.3%)	26 (61.9%)	1
Hyperlipidemia	10 (71.4%)	27 (64.3%)	0.7508
Chronic artery disease	1 (7.1%)	9 (21.4%)	0.4226
Diabetes mellitus type 2	1 (7.1%)	6 (14.3%)	0.6662
Chronic kidney disease	0 (0.0%)	7 (16.7%)	0.1739
Chronic obstructive pulmonary disease	0 (0.0%)	3 (7.1%)	0.5652

BMI – body mass index

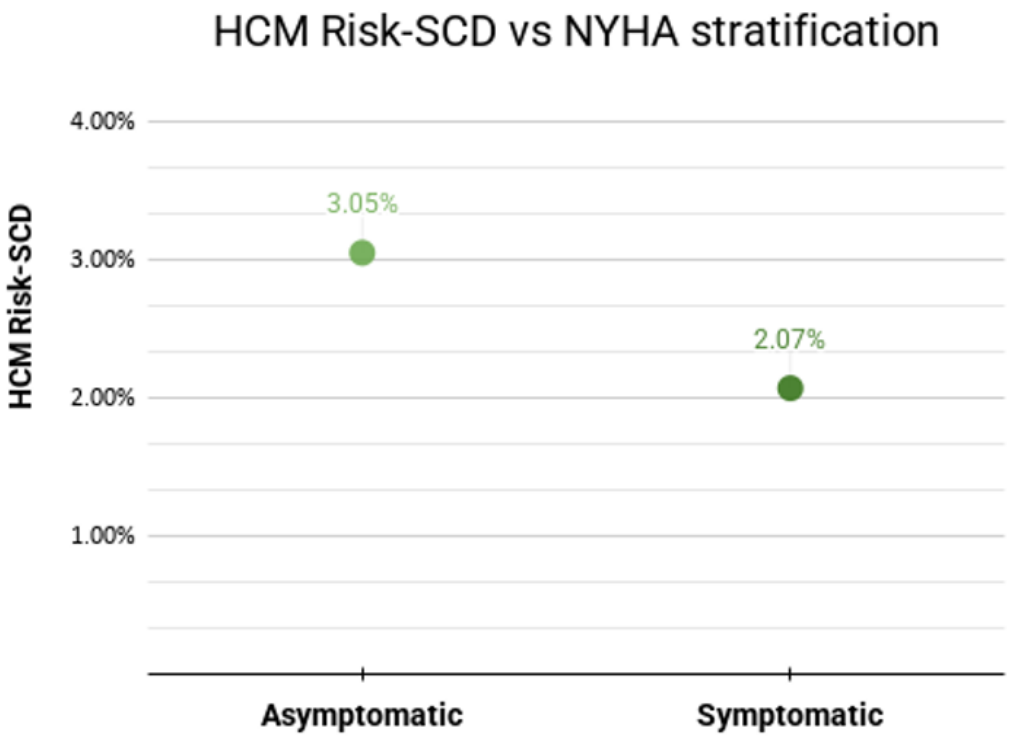


Fig. 1. HCM Risk-SCD score according to functional status

Comorbidity burden

In regards to comorbidities, 24 (42.9%) patients constituted the low burdened group while the high burdened group consisted of 32 (57.1%) patients. The low burdened population was younger than the high burdened (mean age 46.2±14.5 years in low burdened vs. 59.7±10.4 years in high burdened, p<0.001). There were no statistically significant differences in sex and height, however weight and BMI were lower for the low burdened group (weight: 80.4±13.1 vs. 89±14.2, p=0.031; BMI 26.4 vs. 29.4, p=0.012). The only comorbidities occurring in low burdened groups were systemic hypertension and hyperlipidemia - the dominant conditions across the entire population. (Table II).

The median HCM Risk-SCD score was 1.95% (IQR:1.42-2.55%) for low burdened vs 2.01% (IQR:1.18-3.03%) for high burdened group (p=0.765) (Figure 2).

The analysis of correlation between HCM Risk-SCD score and the number of patients' comorbidities revealed a Spearman's rank correlation coefficient of rho=-0.07, p=0.607 (Figure 3).

Table II. Characteristics of subgroups stratified by comorbidity burden

Parameter	Low comorbidity burden (n=20)	High comorbidity burden (n=36)	p-value
Demography			
Age (years)	46.2±14.5	59.7±10.4	<0.001
Sex (Female)	9	12	0.385
Height (cm)	173.2±9.1	171.5+10.3	0.541
Weight (kg)	80.4±13.1	89±14.2	0.031
BMI (kg/m²)	26.4 (24.1-28.9)	29.4 (27-32.3)	0.012
Comorbidities			
Systemic hypertension	4 (20.0%)	31 (86.1%)	<0.001
Hyperlipidemia	7 (35.0%)	30 (83.3%)	<0.001
Chronic artery disease	0 (0.0%)	10 (27.8%)	0.01
Diabetes mellitus type 2	0 (0.0%)	7 (19.4%)	0.041
Chronic kidney disease	0 (0.0%)	7 (19.4%)	0.041
Chronic obstructive pulmonary disease	0 (0.0%)	3 (8.3%)	0.291

BMI – body mass index

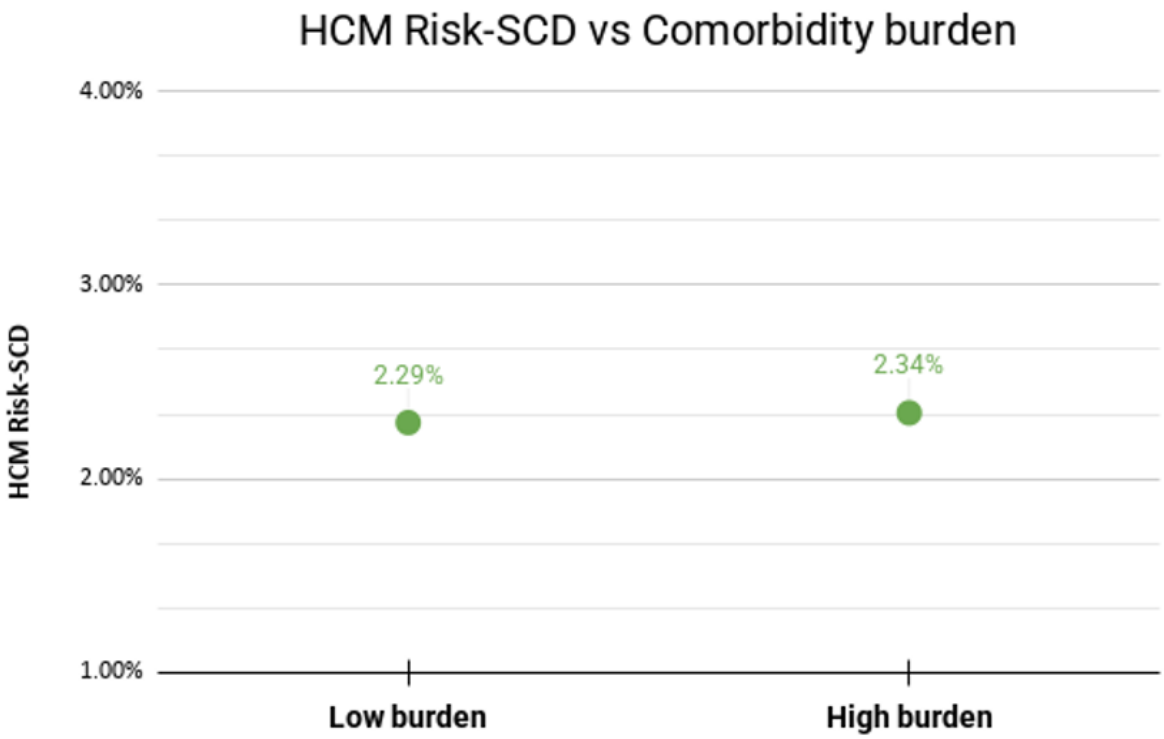


Fig. 2. HCM Risk-SCD score according to comorbidity burden

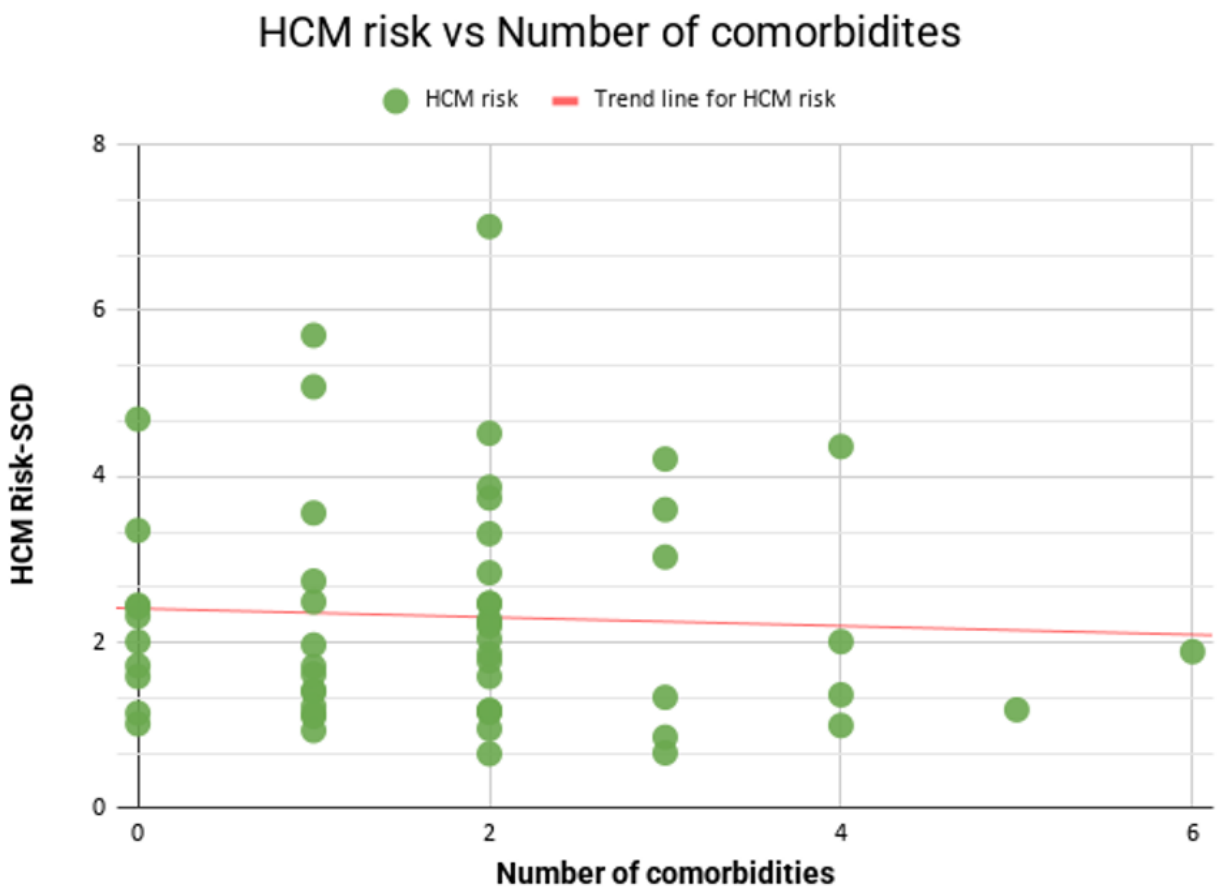


Fig. 3. Correlation between HCM Risk-SCD score and number of comorbidities

DISCUSSION

Presented findings indicate that patients with HCM can constitute a highly heterogeneous population, despite sharing the same diagnosis. Furthermore, their clinical status may be influenced by a wide range of factors beyond the presence of HCM itself**.** Although the risk of SCD is known to be associated with younger age [12], age alone does not provide a sufficient basis for unequivocal stratification of patients with HCM. Significant interindividual differences exist with respect to functional status, symptom burden, echocardiographic characteristics, comorbid conditions, and the overall clinical course of the disease, all of which should be taken into account during patient assessment. Additionally, beyond these non-genetic determinants, genetic variants associated with HCM play a role in shaping disease phenotype and influencing long-term prognosis [13]. Collectively, the interplay between clinical characteristics and genetic background contributes to the marked heterogeneity of the HCM population, underscoring the necessity for individualized evaluation and risk assessment.

Presented data suggest that the risk of SCD may be higher among asymptomatic patients. Worsening functional status in HCM patients is primarily associated with LV outflow tract obstruction, defined as basal gradient ≥30 mmHg, which significantly increases the risk of progression to limiting congestive heart failure symptoms and heart failure-related mortality [14]. By contrast, the association between obstruction and arrhythmias remains less clearly established [15,16]. Ventricular tachycardia (VT) and ventricular fibrillation (VF), the principal mechanisms of SCD, are more strongly associated with non-obstructive HCM.

A cohort study by Pozios et al. [17] demonstrated that the VT/VF episodes occurred four times more frequently for non-obstructive patients compared with those with labile-obstructive, and approximately three times more frequently compared with obstructive patients. The non-obstructive group also exhibited a higher prevalence of extensive late gadolinium enhancement (LGE) on cardiac magnetic resonance imaging and microvascular ischemia by positron emission tomography (PET), relative to both labile-obstructive and obstructive groups. Furthermore, ICD discharges were more frequently observed in non-obstructive patients during follow-up. Notably, VT/VF episodes were not significantly associated with left ventricular systolic or diastolic dysfunction, nor with the LV outflow tract gradient. Both LGE, as the fibrosis index and microvascular ischaemia contribute to arrhythmogenesis, whereas their impact on afterload and cardiac function is less significant than left ventricular outflow track obstruction (LVOTO). Therefore, asymptomatic patients with HCM may require additional tests for more accurate SCD risk stratification and the ICD as the primary prevention should be considered in high risk individuals.

The analysis of comorbidity burden demonstrated the independent contributions of both the HCM Risk-SCD score and overall comorbidity load in patients with HCM. In contrast to other cardiovascular diseases, in which comorbid conditions have been shown to increase the risk of arrhythmic events [18], arrhythmogenesis in HCM appears to be primarily driven by sarcomeric gene mutations, myocyte disarray, and replacement fibrosis [19], whereas comorbidities are more strongly associated with heart failure progression [20].The annual incidence of SCD in pediatric patients with HCM has been estimated at 1–7%, whereas in the adult population it approximates 1% [21]. The observation that younger patients, despite a lower comorbidity burden, exhibit a higher prevalence of malignant ventricular tachyarrhythmias further supports the hypothesis of predominantly genetically mediated arrhythmogenesis in HCM. Consequently, the burden of comorbid conditions should not constitute a primary determinant in regarding the ICD therapy. Instead, careful consideration should be given to balancing the potential benefits of primary SCD prevention against the risk of device-related and post-implantation complications, which may be increased in patients with a higher comorbidity burden.

CONCLUSIONS

In conclusion, asymptomatic patients with HCM had a higher estimated risk of SCD than symptomatic patients. The HCM Risk-SCD score appeared to be independent of comorbidity burden. This shows that HCM individuals with better clinical and functional status may be at higher risk of SCD.

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Informed consent

Informed consent was not required due to the retrospective, anonymous design.

Conflict of interest

The authors declare no conflict of interest.

Authors' contribution

Study design – K. Mizia-Stec, M. Podolski

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Data interpretation – Z. Niedoba, M. Kaspera, B. Krywult, J. Kromołowski, J. Nowak, K. Nogala

Statistical analysis – J. Kromołowski

Manuscript preparation – B. Krywult

Literature research – Z. Niedoba, B. Krywult, M. Kaspera

Final approval of the version to be published – K. Mizia-Stec, M. Podolski, B. Krywult, J. Kromołowski, M. Kaspera, Z. Niedoba, K. Nogala, J. Nowak

REFERENCES

1. Liew AC, Vassiliou VS, Cooper R, Raphael CE. Hypertrophic Cardiomyopathy–Past, Present and Future. J Clin Med. 2017;6(12):118. doi: 10.3390/jcm6120118.

2. Arbelo E, Protonotarios A, Gimeno JR, Arbustini E, Barriales-Villa R, Basso C, et al. 2023 ESC Guidelines for the management of cardiomyopathies: Developed by the task force on the management of cardiomyopathies of the European Society of Cardiology (ESC). Eur Heart J. 2023;44(37):3503–3626. doi: 10.1093/eurheartj/ehad194.

3. Marian AJ, Braunwald E. Hypertrophic Cardiomyopathy: Genetics, Pathogenesis, Clinical Manifestations, Diagnosis, and Therapy. Circ Res. 2017;121(7):749–770. doi: 10.1161/CIRCRESAHA.117.311059.

4. Schlittler M, Pramstaller PP, Rossini A, De Bortoli M. Myocardial Fibrosis in Hypertrophic Cardiomyopathy: A Perspective from Fibroblasts. Int J Mol Sci. 2023;24(19):14845. doi: 10.3390/ijms241914845.

5. Aguiar Rosa S, Thomas B, Fiarresga A, Papoila AL, Alves M, Pereira R, et al. The Impact of Ischemia Assessed by Magnetic Resonance on Functional, Arrhythmic, and Imaging Features of Hypertrophic Cardiomyopathy. Front Cardiovasc Med. 2021;8:761860. doi: 10.3389/fcvm.2021.761860.

6. Cheng Z, Fang T, Huang J, Guo Y, Alam M, Qian H. Hypertrophic Cardiomyopathy: From Phenotype and Pathogenesis to Treatment. Front Cardiovasc Med. 2021;8:722340. doi: 10.3389/fcvm.2021.722340.

7. Sanchez DJ, Lozano IF. Implantable cardioverter-defibrillator in hypertrophic cardiomyopathy. Glob Cardiol Sci Pract. 2018;2018(3):31. doi: 10.21542/gcsp.2018.31.

8. Maron BJ, Shen WK, Link MS, Epstein AE, Almquist AK, Daubert JP, et al. Efficacy of implantable cardioverter-defibrillators for the prevention of sudden death in patients with hypertrophic cardiomyopathy. N Engl J Med. 2000;342(6):365–373. doi: 10.1056/NEJM200002103420601.

9. Maron BJ, Estes NAM, Rowin EJ, Maron MS, Reynolds MR. Development of the Implantable Cardioverter-Defibrillator: JACC Historical Breakthroughs in Perspective. J Am Coll Cardiol. 2023;82(4):353–373. doi: 10.1016/j.jacc.2023.04.056.

10. Wang N, Xie A, Tjahjono R, Tian DH, Phan S, Yan TD, et al. Implantable cardioverter defibrillator therapy in hypertrophic cardiomyopathy: an updated systematic review and meta-analysis of outcomes and complications. Ann Cardiothorac Surg. 2017;6(4):298–306. doi: 10.21037/acs.2017.07.05.

11. Pay L, Çetin T, Dereli Ş, Kadı H, Yumurtaş AÇ, Çınar T, et al. Validation of the HCM Risk-SCD model in patients with hypertrophic cardiomyopathy and future perspectives. Pacing Clin Electrophysiol. 2023;46(12):1519–1525. doi: 10.1111/pace.14876.

12. Norrish G, Niemiec M, Kaski JP, Mizia-Stec K. How to assess sudden cardiac death risk in hypertrophic cardiomyopathy? Current challenges and future directions. Kardiol Pol. 2025;83(1):8–17. doi: 10.33963/v.phj.104052.

13. García-Giustiniani D, Arad M, Ortíz-Genga M, Barriales-Villa R, Fernández X, Rodríguez-García I, et al. Phenotype and prognostic correlations of the converter region mutations affecting the β myosin heavy chain. Heart 2015;101(13):1047–1053. doi: 10.1136/heartjnl-2014-307205.

14. Liu J, Wang D, Ruan J, Wu G, Xu L, Jiang W, et al. Identification of heart failure with preserved ejection fraction helps risk stratification for hypertrophic cardiomyopathy. BMC Med. 2022;20(1):21. doi: 10.1186/s12916-021-02219-7.

15. Maron MS, Olivotto I, Betocchi S, Casey SA, Lesser JR, Losi MA, et al. Effect of left ventricular outflow tract obstruction on clinical outcome in hypertrophic cardiomyopathy. N Engl J Med. 2003;348(4):295–303. doi: 10.1056/NEJMoa021332.

16. Maron BJ, Olivotto I, Maron MS. The dilemma of left ventricular outflow tract obstruction and sudden death in hypertrophic cardiomyopathy: do patients with gradients really deserve prophylactic defibrillators? Eur Heart J. 2006;27(16):1895–1897. doi: 10.1093/eurheartj/ehl130.

17. Pozios I, Corona-Villalobos C, Sorensen LL, Bravo PE, Canepa M, Pisanello C, et al. Comparison of Outcomes in Patients With Nonobstructive, Labile-Obstructive, and Chronically Obstructive Hypertrophic Cardiomyopathy. Am J Cardiol. 2015;116(6):938–944. doi: 10.1016/j.amjcard.2015.06.018.

18. Kingma J, Simard C, Drolet B. Overview of Cardiac Arrhythmias and Treatment Strategies. Pharmaceuticals (Basel). 2023;16(6):844. doi: 10.3390/ph16060844.

19. Varnava AM, Elliott PM, Mahon N, Davies MJ, McKenna WJ. Relation between myocyte disarray and outcome in hypertrophic cardiomyopathy. Am J Cardiol. 2001;88(3):275–279. doi: 10.1016/s0002-9149(01)01640-x.

20. Sridharan A, Maron MS, Carrick RT, Madias CA, Huang D, Cooper C, et al. Impact of comorbidities on atrial fibrillation and sudden cardiac death in hypertrophic cardiomyopathy. J Cardiovasc Electrophysiol. 2022;33(1):20–29. doi: 10.1111/jce.15304.

21. Thakkar K, Karajgi AR, Kallamvalappil AM, Avanthika C, Jhaveri S, Shandilya A, et al. Sudden cardiac death in childhood hypertrophic cardiomyopathy. Dis Mon. 2023;69(4):101548. doi: 10.1016/j.disamonth.2023.101548.