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Cardiovascular risk factors in adults with congenital heart defects — Recognised but not treated? An analysis of the German National Register for Congenital Heart Defects

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ABSTRACT

Background: As adult congenital heart disease (ACHD) patients are aging, a high prevalence of cardiovascular risk factors is encountered similar to the general population. Currently, data regarding the primary and secondary prevention of acquired cardiovascular disease in ACHD is lacking.
Methods: The German National Register of Congenital Heart Defects was systematically screened for ACHD patients with established cardiovascular risk factors or documented acquired cardiovascular conditions. Data were analyzed with regard to the according medical treatment.
Results: Overall, 539 patients were included (mean age 38.4 ± 17.7 years, 49.2% female). Diabetes was present in 57 pts. (10.6%), arterial hypertension in 113 pts. (21.0%), hyperlipidaemia in 81 pts. (15.0%) and obesity in 271 pts. (50.2%). 31 pts. (5.8%) were smokers. Coronary artery disease was established in 16 pts. (3.0%), peripheral vascular disease in 9 pts. (1.7%), and cerebrovascular accidents in 141 pts. (26.2%). Out of the patients with coronary artery disease only 81.3% received antithrombotic treatment. Only 18.8% were prescribed a statin. Of the pts. with peripheral arterial disease, 44.4% received an antiplatelet drug, and only 22.2% were on a statin. Patients with arterial hypertension received antihypertensive drugs in 66.4%.
Conclusions: Primary and secondary prevention of acquired cardiovascular disease in ACHD is underutilized. This highlights the importance of educating primary physicians as well as ACHD physicians about the need of primary and secondary prevention for acquired cardiovascular disease.

1. Introduction

Patients with congenital heart disease (CHD) have an improved survival and 85% to 90% of affected children are expected to reach adulthood today in western countries [1]. This leads to an ever-increasing group of adults with congenital heart disease (ACHD). Currently, it is estimated that there are more adults than children with CHD [1]. There are even a growing number of elderly ACHD patients [2]. With increasing life expectancy acquired morbidities such as coronary artery disease are gaining importance for the outcome in ACHD patients in addition to the underlying congenital heart defect [2]. The prevalence of significant coronary artery disease in ACHD patients has been reported to be similar to that in the general population [3]. Furthermore, it has been shown that in a majority of ACHD patients at least one cardiovascular risk factor is present [4]. A recent study reported a similar atherosclerotic cardiovascular disease risk score for ACHD patients compared to matched controls [5]. These findings emphasize the importance of primary and secondary cardiovascular prevention in ACHD patients irrespective of age. Recommendations for the risk stratification and the risk management of acquired cardiovascular diseases have been published [6–8]. Currently, data regarding their application in ACHD patients are lacking. Therefore, the aim of this study was to investigate the current practice of primary and secondary cardiovascular prevention in a nationwide cohort of ACHD.

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2. Methods

The German National Register for Congenital Heart Defects provides a nationwide data base with a uniquely large population of patients with congenital heart disease not primarily gathered by tertiary referral centers but rather representing a community based population [9]. The main cardiac diagnosis, all concurrent cardiac anomalies as well as all performed cardiac interventions and operations are recorded in a database using the International Pediatric and Congenital Cardiac Code (IPCCC) published by the International Society for Nomenclature of Paediatric and Congenital Heart Disease (ISNPCHD; http://www.ipccc.net). In addition, extracardiac diagnoses and acquired diseases are recorded using the ICD-10 code (International Statistical Classification of Diseases and Related Health Problems) published by the World Health Organisation (WHO; http://www.who.int/classifications/icd/en/).

The register was systematically screened for patients ≥18 years of age (current age or age at time of death), who had at least one of the following cardiovascular risk factors or manifest cardiovascular disorders as per ICD-10 code: obesity, arterial hypertension, diabetes mellitus, hyperlipidaemia, atherosclerosis, coronary artery disease/myocardial infarction, cerebrovascular accidents (excluding intracranial hemorrhage). At the time of screening 47,954 patients were included in the register, and out of these 19,202 patients were ≥18 years of age.

Data on age, gender, cardiac diagnosis, and New York Heart Association (NYHA) functional class were retrieved from medical reports. Complexity of cardiac lesions was classified according to the Bethesda classification [10]. Furthermore, the current cardiovascular medication (angiotensin-converting-enzyme [ACE] inhibitors, angiotensin-II-receptor antagonists, antiarrhythmic agents, oral anticoagulation [coumarin derivates, direct oral anticoagulants], anti-platelet drugs [acetylsalicylic acid/aspirin; other anti-platelet drugs, i.e. clopidogrel, prasugrel, ticagrelor], beta-blocking agents, calcium antagonists, digitalis, diuretics, lipid-lowering agents [statins, fibrates, cholesterol absorption inhibitors]) of these patients was identified from the latest medical report. Body Mass Index (BMI) was calculated from the last measurement of patient's body height and weight. Furthermore, information regarding smoking status (smoker/non-smoker, pack years, status unknown) and family history of cardiovascular events (myocardial infarction/stroke in a female relative <65 years of age or in a male relative <55 years) were retrieved from the medical records.

Statistical analyses were performed using MedCalc version 12.3.0.0 (MedCalc Software, Mariakerke, Belgium) and SPSS version 22 (IBM Corp., USA). Continuous variables are presented as mean ± standard deviation or median (interquartile range), whereas categorical variables are presented as number (percentage). Comparison between groups was performed using the Mann–Whitney *U* test or Student's *t*-test for continuous and Chi-square test for categorical variables. All tests were performed two-sided and for all analyses, a *p*-value <0.05 was considered statistically significant.

3. Results

3.1. Baseline characteristics of the study population

Overall, 539 patients with a mean age of 38.4 ± 17.7 years ($n = 265$ (49.2%) female) fulfilled the inclusion criteria. A simple defect was present in 180 patients (33.4%), a defect of moderate complexity in 191 (35.4%), and a complex defect in 155 (28.8%). In 13 patients (2.4%) the CHD could not be classified. Most of the patients were in NYHA class I ($n = 245$ (45.5%)) and II ($n = 176$ (32.7%)), while 92 patients (17.1%) were in NYHA class III, and 8 (1.5%) in NYHA class IV. In 18 patients information regarding the NYHA class was not available. More detailed information regarding baseline characteristics is provided in Table 1.

Table 1
Baseline characteristics.

	All n (%)	Female n (%)	Male n (%)
Total	539	265 (49.2)	274 (50.8)
Mean age (years)	38.4 ± 17.7	39.6 ± 18.1	37.2 ± 17.4
Deceased	32 (5.9)	12 (4.5)	20 (7.3)
Complexity of CHD			
Simple	180 (33.4)	96 (36.2)	84 (30.7)
Moderate	191 (35.4)	91 (34.3)	100 (36.5)
Severe	156 (28.8)	71 (26.8)	85 (31.0)
Others	13 (2.4)	8 (3.0)	5 (1.8)
NYHA class			
I	245 (45.5)	120 (45.3)	125 (45.6)
II	176 (32.7)	84 (31.7)	92 (33.6)
III	92 (17.1)	47 (17.7)	45 (16.4)
IV	8 (1.5)	5 (1.9)	3 (1.1)
Unknown	18 (3.3)	9 (3.4)	9 (3.3)

Table 2
Cardiovascular risk factors/acquired cardiovascular diseases.

	All n (%)	Female n (%)	Male n (%)	p
Total	539	265 (49.2)	274 (50.8)	
Obesity	271 (50.2)	121 (45.7)	150 (54.7)	0.04
Diabetes mellitus	57 (10.6)	30 (11.3)	27 (9.9)	n.s.
Hyperlipidaemia	81 (15.0)	35 (13.2)	46 (16.8)	n.s.
Coronary artery disease	16 (3.0)	4 (1.5)	12 (4.4)	n.s.
Cerebrovascular accidents	141 (26.2)	79 (29.8)	62 (22.6)	n.s.
Peripheral vascular disease	9 (1.7)	4 (1.5)	5 (1.8)	n.s.
Arterial hypertension	113 (21.0)	43 (16.2)	70 (25.5)	0.01
Smoking	31 (5.8)	13 (4.9)	18 (6.6)	n.s.

3.2. Cardiovascular risk factors and established disease

Arterial hypertension was encountered in 113 patients (21.0%). Hyperlipidaemia and diabetes mellitus were present in 81 (15.0 %), and 57 patients (10.6 %), respectively. Smoking was reported by 31 patients (5.8%). More than one of these risk factors was present in 54 patients (10.0%). Obesity was encountered in 271 patients (50.2%). A history of CVA was present in 141 patients (26.2%). Coronary artery disease was documented in 16 patients (3.0%), and 9 patients (1.7%) had peripheral arterial disease. Further details are provided in Table 2.

3.3. Drug treatment

Beta-blockers were used in 178 patients (33.0%), 154 patients (28.6%) were on an ACE inhibitor or angiotensin-II-receptor antagonist and 128 patients (23.7%) were on diuretics, 30 patients (5.6%) on calcium antagonists. Overall, 223 patients (41.4%) were using antithrombotic drugs, eleven of them were on a combination of aspirin/other anti-platelet drugs and oral anticoagulants, 123 patients (22.8%) were on oral anticoagulants, and 111 patients (20.6%) used anti-platelet drugs. Thirty patients (5.6%) received lipid-lowering agents. Further details are provided in Table 3.

Of the patients with coronary artery disease, only 81.3% received antithrombotic treatment (62.5% were on antiplatelet drugs, 12.5% oral anticoagulants, 6.3% both), leaving 18.7% without any antithrombotic treatment (Fig. 1). Furthermore, only 50% of patients with coronary artery disease were treated with an ACE inhibitor or an angiotensin-II-receptor antagonist, 50% received beta-blocking agents, and 18.8% were on lipid-lowering agents.

Patients with peripheral arterial disease received anti-platelet drugs in 44.4%, while no patient received oral anticoagulants. In addition, only 22.2% of patients with peripheral arterial disease were on lipid-lowering agents (Fig. 1).

In patients with CVA, 36.2% received an anti-platelet drug, 27% oral anticoagulants, and 5.7% both. Furthermore, 2.1% of patients with a history of CVA received lipid-lowering agents.

Arterial hypertension was treated with antihypertensive drugs in 66.4% of patients: 46% of hypertensive patients received beta-blockers, 44.2% ACE inhibitors or angiotensin-II-receptor antagonists, 32.7% diuretics, and 10.6% calcium antagonists. Overall 24.8% of patients with arterial hypertension were under a single drug regime, 41.6% received a combination of antihypertensive drugs and 33.6% were without antihypertensive medication.

Patients with hyperlipidaemia received a lipid-lowering agent in 37% of patients, and diabetic patients in 7%.

4. Discussion

In this study of the current practice of primary and secondary cardiovascular prevention in a nationwide cohort of ACHD, a substantial number of patients did not receive the recommended medication for their

Table 3
Cardiovascular medication.

	All n (%)	Female n (%)	Male n (%)	p
Anti-platelet drugs	111 (20.6)	57 (21.5)	54 (19.7)	n.s.
Oral anticoagulation	123 (22.8)	59 (22.3)	64 (23.4)	n.s.
Anti-platelet drugs + oral anticoagulation	11 (2.0)	7 (2.6)	4 (1.5)	n.s.
Beta-blocking agents	178 (33.0)	80 (30.2)	98 (35.8)	n.s.
Angiotensin-converting-enzyme inhibitors/Angiotensin-II-receptor antagonists	154 (28.6)	59 (22.3)	95 (34.7)	<0.01
Calcium antagonists	30 (5.6)	11 (4.2)	19 (6.9)	n.s.
Digitalis	50 (9.3)	27 (10.2)	23 (8.4)	n.s.
Diuretics	128 (23.7)	65 (24.5)	63 (23.0)	n.s.
Lipid-lowering agents	30 (5.6)	11 (4.2)	19 (6.9)	n.s.

acquired risk factors or already established cardiovascular disorders. Especially worrisome is that approximately 20% of patients with coronary artery disease received no antithrombotic treatment and in 80% no lipid-lowering therapy. Furthermore, patients with peripheral arterial disease received in more than 50% no antithrombotic treatment and in 80% no lipid-lowering therapy. This is in contrast to current guideline recommendations [6–8,11]. These emphasize the importance of prevention since 50% of the reductions seen in coronary artery disease mortality relate to changes in risk factors, and only 40% to improved treatments [11].

Data regarding prevention efforts for acquired cardiovascular diseases in ACHD patients are sparse. In a recent study by Flannery and colleagues, only 42.3% of ACHD cases with a primary prevention indication for statins received such treatment as compared with 59% of controls [5]. In contrast, the EUROASPIRE III (European Action on Secondary and Primary Prevention by Intervention to Reduce Events) survey

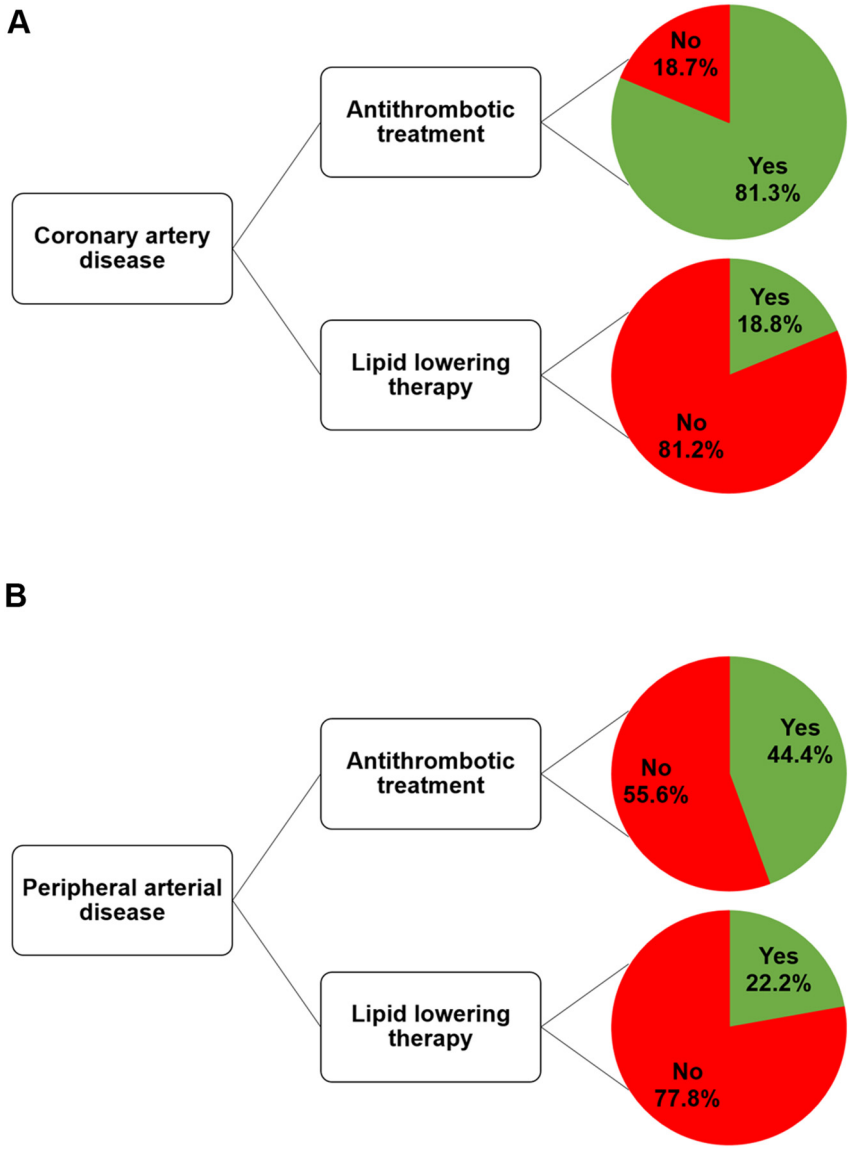

Fig. 1. A. Medical treatment in patients with coronary artery disease; B. Medical treatment in patients with peripheral artery disease.

reported that in patients with coronary artery disease, 90% received antiplatelets, and around 80% received a statin [12]. Therefore, these preventive measures are clearly underutilized in the ACHD population. Regarding primary prevention, in the EUROASPIRE III survey, only 13.8% of patients with hypertension did not receive any medication [13]. In the current study, more than 30% of ACHD patients with hypertension did not receive any medication; definitely, a signal that clinical practice has to improve.

One possible explanation for these differences could be, that in ACHD patients treatment of acquired cardiovascular diseases is not perceived to be a main priority. Indeed, in the study by Flannery et al. more than 60% of ACHD patients over the age of 40 did not even have a lipid panel [5]. Furthermore, a perceived shorter life expectancy in ACHD patients could lead to the assumption that prevention of acquired cardiovascular diseases may be less important [5]. However, there is a growing number of elderly ACHD patients. Furthermore, acquired morbidities, such as coronary artery disease, seem to be key determinants of outcome in this growing population in conjunction with the underlying congenital heart disease [2].

We have to keep in mind, that some patients with hyperlipidaemia or systemic hypertension can be successfully managed with lifestyle modification only. This could be a reason why a proportion of the patients did not receive any medication to control their risk factors. However, this holds also true for patients from the general population, and therefore, does not explain why ACHD patients are undertreated compared to the general population.

Undertreatment of acquired heart disease in our study could also be partly explained by the German healthcare system, where many ACHD patients are often followed by paediatric cardiologists specializing in ACHD care. It could be assumed that there might be a difference in adherence to general cardiology treatment guidelines depending on the setting in which the ACHD patients are followed (primary physician vs. local centre vs. tertiary centre/ACHD service led by adult cardiologist vs. ACHD service mainly run by paediatric cardiologists). It was beyond the scope of our study to elucidate this further.

Awareness for acquired cardiovascular disease must be increased in ACHD patients and should include preventive measures in daily clinical practice. Systematic assessment of the risk for acquired cardiovascular risks should be performed regularly as recommended by recent guidelines [8]. Scoring systems for total risk estimation like the Systemic Coronary Risk Estimation chart could be useful [8]. Their value for ACHD patients however needs to be evaluated.

5. Limitations

A limitation of our study is that we did not have direct access to laboratory data. In addition, it is unclear if all patients reported their smoking status accurately and this was documented accordingly by the treating physician. Therefore, the number of smokers may be underestimated by the current study.

In conclusion, in this large registry based study of ACHD patients with cardiovascular risk factors or already established acquired cardiovascular diseases measures of primary and secondary prevention were markedly underutilized. This highlights the importance of educating primary physicians as well as ACHD physicians about the need of risk assessment as well as primary and secondary prevention for acquired cardiovascular disease in patients with congenital heart disease.

Conflict of interest

The authors report no relationships that could be construed as a conflict of interest.

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References

[1] M. Gurvitz, K.M. Burns, R. Brindis, et al., Emerging research directions in adult congenital heart disease: a report from an NHLBI/ACHA working group, J. Am. Coll. Cardiol. 67 (2016) 1956–1964.
[2] O. Tutarel, A. Kempny, R. Alonso-Gonzalez, et al., Congenital heart disease beyond the age of 60: emergence of a new population with high resource utilization, high morbidity, and high mortality, Eur. Heart J. 35 (2014) 725–732.
[3] G. Giannakoulas, K. Dimopoulos, R. Engel, et al., Burden of coronary artery disease in adults with congenital heart disease and its relation to congenital and traditional heart risk factors, Am. J. Cardiol. 103 (2009) 1445–1450.
[4] P. Moons, K. Van Deyk, D. Dedroog, E. Troost, W. Budts, Prevalence of cardiovascular risk factors in adults with congenital heart disease, Eur. J. Cardiovasc. Prev. Rehabil. 13 (2006) 612–616.
[5] L.D. Flannery, A.C. Fahed, D. DeFaria Yeh, et al., Frequency of guideline-based statin therapy in adults with congenital heart disease, Am. J. Cardiol. 121 (4) (2018) 485–490.
[6] V. Aboyans, J.B. Ricco, M.E.L. Bartelink, et al., 2017 ESC guidelines on the diagnosis and treatment of peripheral arterial diseases, in collaboration with the European Society for Vascular Surgery (ESVS): document covering atherosclerotic disease of extracranial carotid and vertebral, mesenteric, renal, upper and lower extremity arteries, Eur. Heart J. 39 (2018) 763–816.
[7] G. Montalescot, U. Sechtem, S. Achenbach, et al., 2013 ESC guidelines on the management of stable coronary artery disease: the Task Force on the management of stable coronary artery disease of the European Society of Cardiology, Eur. Heart J. 34 (2013) 2949–3003.
[8] M.F. Piepoli, A.W. Hoes, S. Agewall, et al., 2016 European guidelines on cardiovascular disease prevention in clinical practice: the Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice, Eur. Heart J. 37 (2016) 2315–2381.
[9] C.C. Engelings, P.C. Helm, H. Abdul-Khaliq, et al., Cause of death in adults with congenital heart disease - an analysis of the German National Register for Congenital Heart Defects, Int. J. Cardiol. 211 (2016) 31–36.
[10] C.A. Warnes, R. Liberthson, G.K. Danielson, et al., Task force 1: the changing profile of congenital heart disease in adult life, J. Am. Coll. Cardiol. 37 (2001) 1170–1175.
[11] J. Perk, G. De Backer, H. Gohlke, et al., European guidelines on cardiovascular disease prevention in clinical practice (version 2012). The Fifth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of nine societies and by invited experts), Eur. Heart J. 33 (2012) 1635–1701.
[12] K. Kotseva, D. Wood, G. De Backer, D. De Bacquer, K. Pyorala, U. Keil, EUROASPIRE Study Group, EUROASPIRE III: a survey on the lifestyle, risk factors and use of cardioprotective drug therapies in coronary patients from 22 European countries, Eur. J. Cardiovasc. Prev. Rehabil. 16 (2009) 121–137.
[13] K. Kotseva, D. Wood, G. De Backer, et al., EUROASPIRE III. Management of cardiovascular risk factors in asymptomatic high-risk patients in general practice: cross-sectional survey in 12 European countries, Eur. J. Cardiovasc. Prev. Rehabil. 17 (2010) 530–540.