Review Article

Risk of malignancy in adult patients with congenital heart disease: a clinical practice review

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Abstract: This paper presents case studies of adult patients with congenital heart disease (CHD) who developed cancer and also discusses relevant epidemiological studies, risk factors, and reports on early detection. Herein, we describe three cases: a 63-year-old man with an atrial septal defect and multiple myeloma; a 48-year-old man with tetralogy of Fallot and colorectal cancer; and a 25-year-old man with Fontan circulation and hepatocellular carcinoma (HCC). Previous studies have found that the incidence of cancer in adult patients with CHD is higher than that in the general population. The management of adult patients with CHD complicated by cancer requires careful attention because cancer treatment alone can affect the survival prognosis and quality of life, as well as the pathophysiology and treatment of underlying heart disease. Apart from known risk factors in the non-CHD population, specific risk factors have been reported, such as genetic abnormalities, low-dose ionizing radiation exposure, early thymectomy, Fontan-associated liver disease, and hypoxia. Encouraging patients to participate in cancer screening and avoid known risk factors is essential in daily practice for the early diagnosis and prevention of cancer. It is also important to be vigilant for initial signs that are indicative of cancer as well as avoidable risk factors.

Keywords: Adult congenital heart disease (adult CHD); malignancy; risk factor of malignancy

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Introduction

Background and rationale

Congenital heart disease (CHD) is among the most common congenital disabilities. Although prevalence rates vary by region and age group, studies indicate CHD affects approximately 1–2% of the population (1,2). Because of medical and surgical advancements, more patients with CHD reach adulthood (3). Moons *et al.* reported that over 90% of children born with CHD reach adulthood (4). Furthermore, Khairy *et al.* demonstrated that the mortality rate of patients with simple isolated CHD is similar to that of the general population (5). They also noted a shift in the age at death towards adulthood relative to the past, although patients with moderate or more complex CHD have a higher mortality rate compared with the general population. These surveys show that the CHD patient population is expanding and aging, which will inevitably lead to an increase in the number of adult patients with CHD and aging-related comorbidities (6). Goldstein *et al.* identified malignancy and ischemic heart disease as the most common causes of death in adults with non-severe CHD (7). Malignancy is a significant global public health issue that increases with aging (8). Indeed, several studies

Table 1 Physical examination and preoperative blood test results (Case 1)

Parameters	Value
Physical items	
Height (cm)	158
Body weight (kg)	49
Systolic blood pressure (mmHg)	112
Diastolic blood pressure (mmHg)	68
Hematology	
WBC (/μL)	8,100
Hb (g/dL)	13.4
Plt (/μL)	108,000
Biochemistry	
TP (g/dL)	9.1
Alb (g/dL)	3.8
UN (mg/dL)	38
Cre (mg/dL)	0.88
AST (U/L)	29
ALT (U/L)	28
T-Bil (mg/dL)	1.3
GTP (U/L)	689
TC (mg/dL)	113
HDL (mg/dL)	51
LDL (mg/dL)	44
TG (mg/dL)	44
Other biochemistry	
HbA1c (%)	6.4
Cardiac biomarker	
BNP (pg/mL)	322
Immunological items	
IgG (mg/dL)	589
IgA (mg/dL)	3,697
IgM (mg/dL)	14

WBC, white blood cell; Hb, hemoglobin; Plt, platelet; TP, total protein; Alb, albumin; UN, urea nitrogen; Cre, creatinine; AST, aspartate aminotransferase; ALT, alanine aminotransferase; T-Bil, total bilirubin; GTP, glutamyl transpeptidase; TC, total cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein; TG, triglyceride; HbA1c, hemoglobin A1c; BNP, brain natriuretic peptide; IgG, immunoglobulin G; IgA, immunoglobulin A; IgM, immunoglobulin M.

have reported that adult patients with CHD have a higher risk of morbidity from malignant neoplasms compared with the general population (9,10).

Objective

This paper presents cases of adult CHD complicated by cancer, including their diagnosis, treatment, and outcomes. Additionally, it summarizes and reviews previous reports on concomitant cancer in adult patients with CHD.

Case reports

Case 1: multiple myeloma with atrial septal defect and tricuspid valve regurgitation

A 63-year-old man with severe tricuspid valve regurgitation was referred for intracardiac surgery. His tricuspid valve regurgitation, which was initially unproblematic, deteriorated after patch closure of an atrial septal defect at 52 years of age. He visited our facility and expressed a desire to receive a surgical operation after his work situation as a professional driver stabilized. Preoperative tests showed elevated serum total protein and immunoglobulin A (IgA) (*Table 1*), with protein electrophoresis suggesting an M protein (*Figure 1*), raising the possibility of IgA-producing multiple myeloma. A hematologist advised prioritizing cardiac treatment if his immunoglobulin G (IgG) levels exceeded 300 mg/dL, which would indicate that his immunity was clinically sufficient, and no bone lesions were present. Contrast-enhanced computed tomography (CT) confirmed the absence of bone lesions, leading to tricuspid valve replacement before a definitive diagnosis of multiple myeloma was made. In the postoperative period, he experienced persistent pleural effusion. Echocardiography showed unchanged right ventricular dysfunction and a normal left ventricular ejection fraction. CT showed no signs of constrictive pericarditis. The detection of CD38-positive plasma cells in pleural fluid prompted a bone marrow biopsy, and multiple myeloma with CD38 and CD138 positivity and lambda chain restriction was confirmed by immunostaining. The findings were consistent with the bone marrow infiltration of multiple myeloma. He was transferred to a facility for chemotherapy and received inpatient chemotherapy without significant adverse events. After being discharged, he was readmitted with respiratory distress and bacterial pneumonia. He received antibiotic therapy but developed fungal pneumonia and cytomegalovirus infection, leading to acute renal

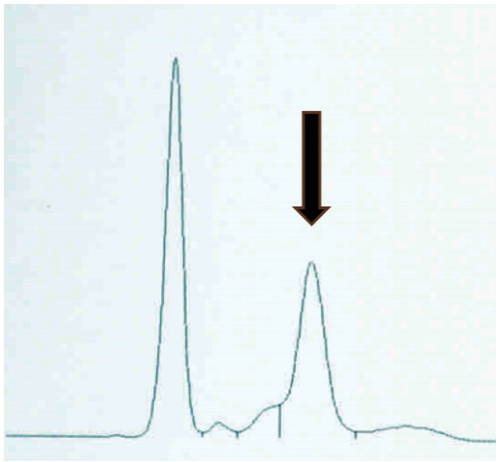

Figure 1 Protein electrophoresis in Case 1. The black arrow represents a band in the beta region, suggesting the presence of an M protein.

failure. Despite intensive care, including continuous hemodiafiltration, he died after starting palliative care.

Case 2: colorectal cancer with tetralogy of Fallot

A 48-year-old man with a history of tetralogy of Fallot repair was referred for severe pulmonary valve regurgitation and tricuspid valve regurgitation. He presented with severe pulmonary valve regurgitation, tricuspid valve regurgitation, and bradycardic atrial fibrillation, which were identified during a thorough examination that was performed because of his poor physical condition. He was transferred to our department after transvenous pacemaker implantation at a nearby hospital. Upon admission at our department, he was conscious and stable. Blood tests revealed mild anemia and elevated brain natriuretic peptide (*Table 2*). His 12-lead electrocardiogram showed atrial fibrillation and complete right bundle branch block with a heart rate of 66 bpm. Transthoracic echocardiography revealed severe regurgitation of the pulmonary and tricuspid valves, moderate regurgitation of the mitral valve, and enlargement of the left and right ventricles and right atrium. Anticoagulant therapy and anti-heart failure treatment improved his condition, but anemia progressed at the same time. He experienced melena and underwent an emergency upper gastrointestinal examination, which revealed acute gastric mucosal lesions. A subsequent colonoscopy revealed a 2-cm well-differentiated adenocarcinoma in the ascending colon (*Figure 2*). Contrast CT revealed no signs of lymph node metastasis or distant metastasis. Based on the findings, stage T2N0M0 disease was diagnosed according to the tumor-node-metastasis (TNM) classification. Considering the risk of gastrointestinal bleeding under cardiopulmonary bypass, we first performed colorectal cancer surgery. He underwent ileocecectomy with hemodynamic management using catecholamines, diuretics, and blood products in the intensive care unit, followed by pulmonary valve

Table 2 Physical examination and blood test results at transfer (Case 2)

Parameters	Value
Physical items	
Height (cm)	158
Body weight (kg)	53
Systolic blood pressure (mmHg)	116
Diastolic blood pressure (mmHg)	70
Hematology	
WBC (/μL)	3,040
Hb (g/dL)	12.3
Plt (/μL)	126,000
Biochemistry	
TP (g/dL)	6.7
Alb (g/dL)	3.6
UN (mg/dL)	11
Cre (mg/dL)	0.68
AST (U/L)	29
ALT (U/L)	32
T-Bil (mg/dL)	1.6
GTP (U/L)	205
TC (mg/dL)	116
HDL (mg/dL)	31
LDL (mg/dL)	72
TG (mg/dL)	47
Cardiac biomarker	
BNP (pg/mL)	248.4

WBC, white blood cell; Hb, hemoglobin; Plt, platelet; TP, total protein; Alb, albumin; UN, urea nitrogen; Cre, creatinine; AST, aspartate aminotransferase; ALT, alanine aminotransferase; T-Bil, total bilirubin; GTP, glutamyl transpeptidase; TC, total cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein; TG, triglyceride; BNP, brain natriuretic peptide.

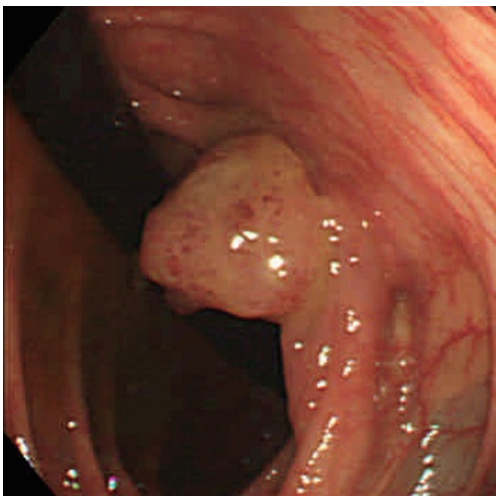

Figure 2 Colonoscopy in Case 2. Colonoscopy revealed a 2-cm tumor in size in the ascending colon.

replacement and tricuspid valvuloplasty, which led to improvement in his cardiac enlargement and brain natriuretic peptide level.

Case 3: hepatocellular carcinoma (HCC) with Fontan circulation

The patient was a 25-year-old man who had undergone a Norwood operation at 1 month of age, a Hemifontan operation at 7 months of age, and a total cavo-pulmonary connection at 16 months of age. At 21 years of age, his central venous pressure was 18 mmHg. After transitioning to adulthood, hypertension was diagnosed. However, he tended to neglect regular visits because he was asymptomatic. He was transported to the emergency department with right-sided abdominal pain and fever. Assessments showed a Glasgow Coma Scale of 15 and oxygen saturation of 93% on room air. Blood tests revealed mild anemia and elevated liver enzymes and bilirubin levels, and he was negative for hepatitis B virus surface antigen (HBs-Ag) and hepatitis C virus antibody (HCV-Ab) (*Table 3*). Abdominal contrast-enhanced CT revealed an enlarged liver with an irregular surface and blunted edges, along with a 13 cm × 9 cm mass protruding from the posterior segment of the liver. The mass was suspected to be either a necrotic part of an HCC or an intratumoral hemorrhage (*Figure 3*). He was transferred for cancer treatment, which proved ineffective. Metastasis to the lungs and bones occurred and the patient died 6 months later.

Table 3 Physical examination and blood test results at the time of emergency transport (Case 3)

Parameters	Value
Physical items	
Height (cm)	164
Body weight (kg)	65
Systolic blood pressure (mmHg)	113
Diastolic blood pressure (mmHg)	60
Hematology	
WBC (/μL)	9,200
Hb (g/dL)	11.9
Plt (/μL)	194,000
Biochemistry	
TP (g/dL)	7.1
Alb (g/dL)	3.6
UN (mg/dL)	22
Cre (mg/dL)	0.78
AST (U/L)	63
ALT (U/L)	25
T-Bil (mg/dL)	2.1
GTP (U/L)	395
TC (mg/dL)	126
HDL (mg/dL)	27
LDL (mg/dL)	88
TG (mg/dL)	78
Cardiac biomarker	
BNP (pg/mL)	79.6
Other liver-related items	
AFP (ng/mL)	339
Hyaluronic acid (ng/mL)	168
Type IV collagen (ng/mL)	530
HBs-Ag	Negative
HCV-Ab	Negative

WBC, white blood cell; Hb, hemoglobin; Plt, platelet; TP, total protein; Alb, albumin; UN, urea nitrogen; Cre, creatinine; AST, aspartate aminotransferase; ALT, alanine aminotransferase; T-Bil, total bilirubin; GTP, glutamyl transpeptidase; TC, total cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein; TG, triglyceride; BNP, brain natriuretic peptide; AFP, alpha-fetoprotein; HBs-Ag, hepatitis B virus surface antigen; HCV-Ab, hepatitis C virus antibody.

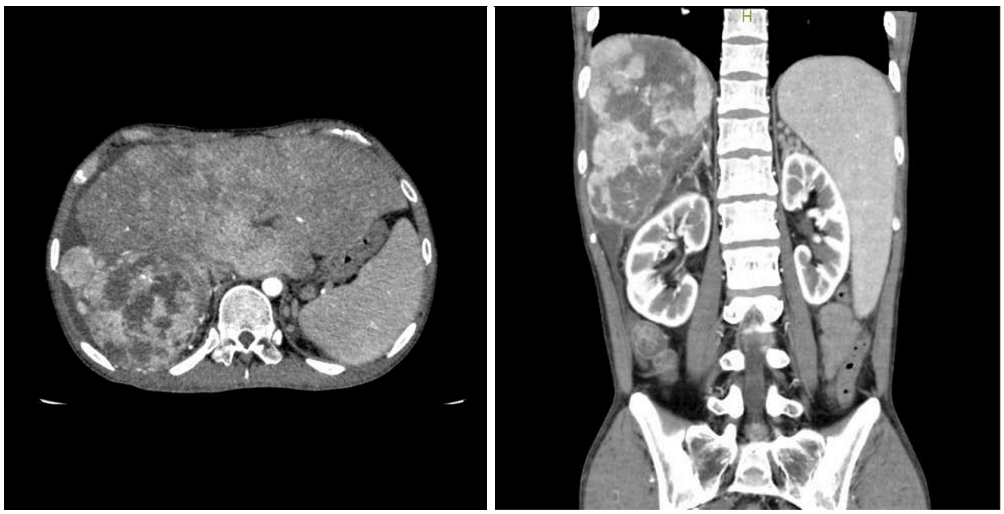

Figure 3 Abdominal contrast-enhanced CT in Case 3. Abdominal contrast-enhanced CT revealed liver enlargement and a 13 cm × 9 cm mass, suggesting HCC with partial necrosis or an intratumoral hemorrhage. CT, computed tomography; HCC, hepatocellular carcinoma.

Table 4 Summary of case reports

Attributes	Case 1	Case 2	Case 3
Diagnosis of CHD	ASD	TOF	HLHS
Diagnosis of cancer	MM	CR	HCC
Age at cancer diagnosis (years)	63	48	25
NYHA at cancer diagnosis	III	II	II
BMI at cancer diagnosis (kg/m^2)	20	21	24
Number of cardiac catheterizations before cancer diagnosis	1	Unknown	6
Smoking status	Smoking	Never	Never
Non-cardiac comorbidities	DM	(–)	HT
Other potential risk factors of cancer	Occupation	(–)	FALD

(–) indicates negative. CHD, congenital heart disease; ASD, atrial septal defect; TOF, tetralogy of Fallot; HLHS, hypoplastic left heart syndrome; MM, multiple myeloma; CR, colorectal cancer; HCC, hepatocellular carcinoma; NYHA, New York Heart Association functional classification; BMI, body mass index; DM, diabetes mellitus; HT, hypertension; FALD, Fontan-associated liver disease.

Discussion

We described the cases of three adult patients with concomitant CHD and cancer (*Table 4*).

Case 1 was a professional driver with an atrial septal defect, severe tricuspid valve regurgitation, and multiple myeloma. Multiple myeloma is frequently observed in older adults and is a disease in which plasma cells become cancerous. It is often diagnosed based on the detection of elevated total protein, positive urine protein, anemia, and hypercalcemia (11,12). Multiple myeloma also exhibits characteristics of occupational cancers (OCs) (13,14). OCs are cancers that develop as a result of occupational exposure to carcinogenic agents. Several substances that are generated in processes at the workplace are recognized as carcinogenic agents (15,16). Sonoda *et al.* described a significant positive association between engine exhaust exposure and multiple myeloma (17). In Case 1, the patient had a typical diagnostic opportunity but there were difficulties in determining the timing of surgery due to work commitments. Unfortunately, the infection led to death after difficulties in managing the

patient's comorbid heart failure. The extent to which his occupational exposure contributed to the development of multiple myeloma remains unclear.

Case 2 involved a man with tetralogy of Fallot with severe pulmonary valve regurgitation and colorectal cancer. The incidence of colorectal cancer increases with age from the 50s, and both morbidity and mortality rates are twice as high in men as in women (18,19). Colorectal cancer is often found after the observation of bloody stool, changes in defecation habits, or the detection of anemia (20). In this case, the diagnosis of colorectal cancer was made after observing hematochezia, and we worked closely with the relevant staff to successfully treat both the cancer and comorbid heart failure.

In Case 3, the patient had Fontan circulation and HCC, and follow-up had been inconsistent. HCC develops due to chronic inflammation and cirrhosis of the liver caused by viruses and other factors in the general population (21,22). Recent reports have indicated that congestive hepatic cirrhosis can serve as a precursor to HCC, highlighting the need to monitor this condition in the long-term management of adult patients with CHD (23-27). Based on the elevated central venous pressure and the presence of cirrhosis observed on the CT scan, the patient was presumed to be experiencing liver congestion, which may be indicative of liver cancer associated with congestive cirrhosis.

As mentioned above, reports of cancer complications among adult patients with CHD have increased with the aging of this population (10,28). To cover this topic comprehensively, we will divide our review into three sections: epidemiology, specific risk factors, and management.

Epidemiology

Previous studies have shown that cancer develops more frequently in individuals with CHD than in the general population (9,10). Gurvitz *et al.* reported a population-based analysis of cancer prevalence in adult patients with CHD compared with the general population in Canada and showed that the cancer prevalence in adult patients with CHD was 1.6–2 times higher during the follow-up period (29). Lee *et al.* performed a nationwide cohort study on cancer risk among adult patients with CHD in Taiwan and found an elevated standardized incidence ratio (1.45) for all cancer types (30). El-Chouli *et al.* reported that there was no significant increase in the lifetime risk of cancer in patients with simple CHD (31). In contrast, Mandalenakis *et al.*, who focused on relatively young age groups, showed that the lifetime risk of cancer was elevated even in simple CHD and that more complex CHD was associated with a higher cancer risk (32). Furthermore, Sakowitz *et al.* reported that, in adult patients, CHD complicated by cancer tends to be associated with a considerable length of hospitalization and increased cost after resection of cancer (33). In contrast, Karazisi *et al.* showed that the mortality rate of adult patients with CHD and cancer, excluding those with genetic syndromes and transplant recipients, was similar to that of control patients without CHD (34), indicating the need for vigilance.

Specific risk factors

Various risk factors have been identified as contributing to the higher incidence of cancer in adult patients with CHD compared with the general population, including genetic effects (35), low-dose ionizing radiation exposure (36), early thymectomy (9), and organ-specific risk factors such as Fontan-associated liver disease for liver cancer (37) and cyanosis for pheochromocytomas and paragangliomas (PPGLs) (38). Although medications used in the treatment of heart failure have been reported to influence the risk of cancer incidence and the prognosis after cancer diagnosis, some studies have reported opposite effects for the same medications and the same types of cancer, indicating a lack of consistency (39). Regarding beta-blockers, meta-analyses have reported an increased melanoma risk (40,41). However, these studies did not focus on heart failure patients, nor did they conduct a dose-response analysis. Moreover, no evidence explicitly addresses adult patients with CHD; therefore, this paper does not discuss it, but caution may be warranted.

The first risk factor—genetic influence—has been recognized for a long time. In 1967, Miller reported an increased risk of acute lymphocytic leukemia occurrence in Down syndrome (42). Day *et al.* conducted a survey about mortality and causes of death among individuals with Down syndrome in California and found that the patient population had a higher rate of mortality from leukemia, with a standardized mortality ratio of 17 (43). Toth *et al.* revealed a 2.8 Mb germline deletion in the 22q11.2 region containing the SMARCB1 tumor suppressor gene in a patient with CHD and an axillary rhabdoid tumor (44). Moreover, there are well-known syndromes, such as Noonan syndrome (45), in which high rates of co-occurring

CHD and malignancies are recognized. In addition to these syndromes, Morton *et al.* reported that loss-of-function variants in regulatory cancer risk genes were detected significantly more frequently in patients with CHD compared with control participants, although long-term observation is required to determine whether these variant carriers develop cancer (35).

The second risk factor is exposure to low-dose ionizing radiation, which is a well-documented carcinogen (46,47). Cohen *et al.* showed that cumulative exposure to low-dose ionizing radiation was independently associated with concomitant cancer in adult patients with CHD, and that, relative to cases in which low-dose ionizing radiation was administered either 0–1 time, the odds ratio was 1.39 in cases where it was administered 2–3 times and was 2.37 in cases where it was administered ≥6 times (36). They also reported that the odds ratio increased by 2.67 when the dose was either <15 or >55 mSv. Danieli *et al.* showed that CHD patients exposed to high low-dose ionizing radiation doses 2–6 years previously had an increased risk of developing cancer, suggesting the need for diligent surveillance of these patients (48).

The third risk factor, early thymectomy, has become apparent in recent years. Karazisi *et al.* showed that patients who underwent congenital cardiac surgery before 1 year of age (suggesting that the thymus gland was removed intraoperatively) had a higher risk of cancer, with a hazard ratio of 1.83 (9). Deya-Martinez *et al.* reported that thymectomy during infancy can lead to early diminution of thymic output, potentially adversely affecting the immune mechanisms (49). Considering the role of the immune system functions in the elimination of abnormal cells such as cancer cells, this could be an essential factor.

The fourth risk factor is organ-specific conditions. As patients who have undergone the Fontan procedure age, attending physicians increasingly encounter issues related to the chronic elevation of systemic venous pressure and decreased cardiac output (37,50). One resulting condition is Fontan-associated liver disease (25,51). This can progress to liver fibrosis and cirrhosis, commonly known as cardiac cirrhosis, which can serve as a basis for the development of HCC over time (24). Despite having higher levels of liver fibrosis indicators [e.g., aspartate aminotransferase (AST)-to-platelet ratio and fibrosis-4] and cardiac comorbidities (e.g., arrhythmia and heart failure), the central venous pressure in Fontan patients with HCC is not significantly different from that in Fontan patients who do not develop HCC (52). This suggests that the pathogenesis of HCC in cases of cardiac cirrhosis is not uniform (53). Rodriguez De Santiago *et al.* described Fontan patients who developed HCC but who did not have liver cirrhosis (54). Furthermore, HCC has been reported in patients with single ventricular circulation as well as in those with conditions that result in right heart failure and cardiac cirrhosis, such as repaired tetralogy of Fallot and pulmonary valve regurgitation (55,56). Taken together, it is crucial to be aware that chronic right heart failure conditions may lead to the development of liver disease (57). Cyanosis, or chronic hypoxia, is another organ-specific risk factor for PPGLs, which commonly produce catecholamines. One oncogenic cause of PPGLs is a series of polymorphisms belonging to pseudohypoxic signaling, which may exist in the germline or the somatic lineage (38). Opotowsky *et al.* showed that hospitalized cyanotic CHD patients had an odds ratio of 6 for developing the PPGLs relative to non-CHD patients, whereas the odds ratio in noncyanotic CHD patients showed no significant increase compared with non-CHD patients (58). The occurrence of both cyanotic CHD and PPGLs is consistent with prior findings (59,60), suggesting that chronic hypoxia might increase the risk of developing PPGLs in patients with cyanotic CHD (61). In addition to unrepaired cyanotic CHD and Eisenmenger syndrome with severe cyanosis, there are also reports of complications in postoperative Fontan patients with mild cyanosis (87–92%) (62). Consequently, for patients with cyanosis, the attending physicians should attempt to ascertain whether there are any symptoms or findings that may be caused by excess catecholamine, including palpitations, headache, tachyarrhythmia, or hypertension.

Management

As is widely known, early detection of various types of cancer increases the likelihood of successful treatment while also reducing the costs and physical burden of treatment (63-65). In addition, cancer treatment itself can cause cardiovascular toxicity (66,67). The baseline risk factors for cardiotoxicity include current myocardial disease, including heart failure and significant cardiac arrhythmias (68,69), suggesting that patients with CHD may experience a worsening of their condition as a result of the treatment. Initial detection, prompt treatment, and a focus on prevention are crucial. Screening for cancer facilitates early diagnosis and therapeutic intervention, while lifestyle modifications, including patient education, enable prevention. According to Venkatesh *et al.*, who conducted

a study at a single institution in Los Angeles, only 16% of their patients had received cancer screening (70), and Christman *et al.* reported a breast cancer screening rate of 48% among women with CHD, which was significantly lower than the screening rate of 72% in the general United States population (P<0.001) (71). In their investigation of factors influencing participation in screening, Prowse *et al.* demonstrated that fear of poor screening results deters individuals from undergoing screening, while the recommendation of screening by healthcare professionals improves its uptake (72). Given this background, it is essential to ensure that patients receive cancer screenings and they should be encouraged to undergo screening during routine medical examinations. Further testing (beyond standard screening) is required in conditions associated with cardiac cirrhosis (73). Sessa *et al.* recommend that patients with Fontan circulation who are ≥18 years of age undergo serum fibrosis biomarker and liver elastography (via ultrasound or magnetic resonance imaging) checks every 1–2 years (23). For patients with fibrosis, they advise laboratory liver tests, blood cell counts, and prothrombin time/international normalized ratio checks every 6 months, although the laboratory items for the evaluation of liver fibrosis in patients with Fontan-associated liver disease have not been established (73). Hilscher *et al.* stated that AFP >200 ng/mL with a hepatic mass is highly indicative of HCC, necessitating careful follow-up with imaging studies (74). While age-matched cohort studies have demonstrated a higher incidence of cancer among adult patients with CHD (9,32), there remains a lack of consensus and established guidelines regarding the optimal age to initiate cancer screening within this population. Building on the findings of Liu *et al.*, which indicate that the discrepancy between biological age—reflecting an individual's overall health status—and chronological age—defined by the number of years lived—is associated with cause-specific mortality, including cancer and multi-system diseases (75), investigating this discrepancy within adult patients with CHD may offer insights into predicting the optimal timing for individualized cancer screening. However, the ideal framework for accurately modeling biological age remains to be established. Regarding patient education, it is important to persuade adult patients with CHD to avoid common risk factors among the general population (e.g., smoking, overweight, lack of exercise, and excessive salt intake), which may lead to metabolic syndrome (76-80). Adult patients with CHD (81,82) have a higher prevalence of metabolic syndrome, highlighting the importance of repeatedly discussing lifestyle habits with patients during daily practice.

Limitations and prospects

The clinical condition of adult patients with CHD, even those with the same diagnosis, is influenced by their genetic background, treatment history, and lifestyle factors, including environmental factors, making it difficult to discuss and generalize these factors. However, the importance of care for noncardiac complications is becoming recognized with the aging of patients with CHD (83). Cancer incidence is influenced by both genetic background and environmental factors, with several studies documenting ethnic disparities in cancer rates (8,84,85). Although an individual's place of residence can have a significant impact on their genetic background and the environmental factors to which they are exposed, there seems to be a lack of large-scale research conducted in Asia. Therefore, we are planning to conduct a nationwide survey of Japan, with the aim of gaining new insights by characterizing adult CHD and cancer in Japan and comparing it with those reported in other countries.

Conclusions

Advances in surgical technology and internal medicine management have extended the lifespans of patients with CHD. As a result, physicians treating adult patients with CHD must now address age-related comorbidities. A crucial consideration is that cancer treatments can cause hemodynamic instability and impact patients' work and family lives, particularly as they reach adulthood. Therefore, multidisciplinary collaboration is essential. Because the reported inherent risk factors such as genetic polymorphisms and necessary treatments for CHD are unavoidable, it is essential to take steps not only to reduce exposure levels of radiation and make modifications to treatment but also to offer lifestyle guidance on the avoidance of risk factors (e.g., smoking cessation and the prevention of lifestyle diseases), along with ensuring early detection and treatment. It is also desirable to develop personalized screening plans for adult CHD patients and management methods for cancer treatment.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All clinical procedures described in this study were performed in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). At Chiba Cerebral and Cardiovascular Center, patients are informed via the website and in written form upon admission that their personal information, including medical records, may be used for research purposes after anonymization. At Chiba Kaihin Municipal Hospital, the same information is conveyed to patients through the website. To date, none of the patients involved in this case report have declined participation. The data are used in compliance with each facility.

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