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A cohort research on the long-term survival of individuals diagnosed with radiation heart disease who had cardiac surgery

Sudhanshu Dev[1], Prashant S. Pawar[2], Shashikant Deepak[3], Sulabh Mahajan[4], Suhas Ballal[5]

[1] Chitkara Centre for Research and Development, Chitkara University, Himachal Pradesh, India
[2] Department of Cardiology, Krishna Institute of Medical, Maharashtra, India
[3] Department of UGDX, ATLAS SkillTech University, Mumbai, Maharashtra, India
[4] Centre of Research Impact and Outcome, Chitkara University, Rajpura, Punjab, India
[5] Department of Chemistry, School of Sciences, (Deemed to be University), Bangalore, India

ABSTRACT

Background: Radiation Heart Disease (RHD) results from thoracic radiotherapy and often necessitates Cardiothoracic Surgery (CTS). This study investigates the Long-Term Survival (LTS) of cardiac surgery patients with RHD.

Objective: To evaluate the LTS outcomes for patients with RHD who have undergone cardiac surgery.

Materials and Methods: This cohort study involved 268 RHD patients and 400 control patients, matched by age, gender, and type/time of CTS. Most RHD patients had a history of Hodgkin lymphoma or breast cancer, with an average of 20 years to 22 years since radiation therapy. Mortality was analyzed using Multivariate Cox Proportional Hazard Analysis (MCPHA).

Results: Clinical and surgical parameters, including all-cause mortality and preoperative STS score, were assessed. The mean STS score was comparable between RHD and control groups. RHD patients had a higher incidence of proximal coronary artery disease but lower rates of redo CTS compared to controls. Approximately two-thirds of patients in both groups underwent combined surgical procedures. Over an average follow-up period of 8 years, the RHD group had a significantly higher mortality rate compared to the control group. Higher mortality was linked to the absence of β-blockers, a higher STS score, and RHD status in the MCPHA.

Conclusions: RHD patients undergoing CTS have reduced LTS compared to non-RHD patients. Improved therapeutic strategies can be needed to enhance survival outcomes for RHD patients.

Keywords: Radiation Heart Disease (RHD), Cardiothoracic Surgery (CTS), long-term survival, Multivariate Cox Proportional Hazard Analysis (MCPHA)

Address for correspondence:

Sudhanshu Dev

Chitkara Centre for Research and Development, Chitkara University, Himachal Pradesh, India

E-mail: sudhanshu.dev.orp@chitkara.edu.in

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INTRODUCTION

Radiation Therapy (RT) is commonly utilized as surgery for treating lymphomas and thoracic cancers. While RT significantly improves cancer survival rates, it can also cause adverse effects on healthy tissues. Radiation Heart Disease (RHD) may develop either immediately or many years after X-ray exposure. Despite advancements in RT technology that have reduced the dose and cardiac exposure, RHD can still manifest decades later, posing a persistent challenge [1]. Often, recent cardiac symptoms are not linked to previous RT exposure, complicating accurate diagnosis due to the influence of other common cardiovascular risk factors. The cardiovascular effects from incidental radiation during meditational RT can be both immediate and long-term, with long-term effects often emerging years or even decades after treatment. As a result, the incidence of RHD increases over time following RT [2]. RHD can involve various cardiac issues, including vascular damage, myocarditis, ventricular problems, pericardial inflammation, disrupted vascular supply, and autonomic dysfunction, all contributing to high morbidity and mortality rates. Although cardiac toxicity has become less frequent in recent years, it remains a risk. Research into how individual patient characteristics impact the relationship between cardiac risk and RT is limited and despite significant regional variations in cardiac mortality rates [3]. Thoracic radiotherapy has been associated with various cardiac disorders, including acute inflammatory reactions shortly after treatment and complications may develop from eight months to years later [4].There is not enough information to support the prevention and treatment of the risks of certain cardiovascular problems in cancer survivors across the board. The extensive electronic health record data from many linked databases were examined [5]. The Stereotactic Body Radiation Therapy (SBRT) effects in chronic cardiovascular disease patients who were being treated with repeated Implanted Cardioverter-Defibrillator (ICD) therapies and were unresponsive to conventional therapy [6]. Many patients scheduled for cardiac surgery suffer from anemia and/or iron deficiency. The prompt preoperative care could reduce the requirement for perioperative RBC transfusions and improve patient care [7]. The cardiac toxicity of radiation for lung cancer, offer methods for preventing and treating cardiac toxicity, and recommend areas for future research [8]. The human tissue system's clinical settings path physiology, health conditions, appearance, as well as treatment of RT's complications by [9]. Ionizing radiation is effective against cancers because it damages

DNA, but it can have both short- and long-term bad impacts on normal tissue. Patients undergoing radiation therapy for lung cancer have an increased chance of dying if a dosage to the heart, although it is frequently not practical to spare the entire heart. The best cardiac components and dose limits to prevent early mortality are what we are trying to identify by [10]. Although myocardial radiation exposure has been reduced through modern techniques, it cannot be removed completely. The cardiac mortality and morbidity among German patients with breast cancer who had recently undergone radiation therapy was examined [11]. Patients with diffuse who had no history of cardiovascular illness were simulated using a multistate model technique was suggested [12, 13]. The purpose of this research was to identify risk factors for LTS in RHD patients who had had CTS by comparing them to a control group that had undergone the same procedures at the same time.

The remaining section of the research is assigned as demonstrated:

- phrase 2 explains methodologies,
- phrase 3 encompasses with the result
- phrase 4 explains discussion and
- phrase 5 accomplishes with the conclusion section.

MATERIALS AND METHODS

RHD prognosis post-thoracic radiotherapy

The long-term consequences of previous thoracic radiotherapy which is frequently used to treat diseases such as Hodgkin lymphoma and breast cancer have an impact on the prognosis of patients with RHD who have cardiac surgery. Significant cardiac issues from RHD can necessitate intricate surgical procedures. Due to factors including elevated STS scores and the degree of radiation-induced damage, RHD patients often face greater mortality risks compared to non-RHD patients despite these therapies. It is essential to comprehend these survival rates to create individualized treatment plans and enhance patient care.

Study framework

A prospective cohort study conducted from 2011 to 2014 involved 668 patients referred to a tertiary hospital for cardiac surgery. Research aimed to assess the Long-Term Survival (LTS) of patients with RHD who underwent Cardiothoracic Surgery (CTS).

Table 1 displays the clinical data of each group's baseline. Each of the relatively young patients had advanced symptoms warranting heart surgery. Because of subtle clinical distinctions between the 2 groups, including a higher rate of hypertension as well as previous CTS as well as a lower prevalence of cardioverter, patients in the control subjects had a marginally greater postoperative risk. Proximal obstructive coronary artery disease was more common in the radiation group. The left ventricular ejection percentage was higher in the control group, although the left ventricular as well as left atrial volume were larger.

Tab. 1. Description of clinical data

Factors	Control Group	RHDG	p-Value
Proximal obstructive CAD, n (%)	118(39)	79(46)	0.1
FEV_1, 1/s	1.76 ± 0.76	1.61 ± 0.63	0.3
FVC, cm^3	2.4 ± 0.10	2.3 ± 0.9	0.5
ACE inhibitors, n (%)	91 (31)	66 (37)	0.09
Aspirin, n (%)	187 (62)	95 (55)	0.07
Clopidogrel, n (%)	17 (6)	8 (4)	0.4
Statins, n (%)	96 (32)	57 (33)	0.6
Hemoglobin, mg/dL	12.6 ± 4	12.9 ± 1.8	0.7
Overall cholesterol, mg/dL	188 ± 46	186 ± 46	0.4
Low-density lipoprotein, mg/dL	106 ± 40	104 ± 40	0.4
Triglycerides, mg/dL	146 ± 86	151 ± 91	0.3
High-density lipoprotein, mg/dL	53 ± 17	54 ± 19	0.8
Creatinine, mg/dL	1.05 ± 0.8	0.99 ± 0.6	0.5
Age, year	64 ± 15	64 ± 15	0.1
Female gender, n (%)	227 (75)	131 (76)	0.6
Hypertension, n (%)	160(53)	70 (41)	0.007
Diabetes mellitus, n (%)	75 (25)	28 (17)	0.08
Prior stroke, n (%)	25(9)	19 (11)	0.3
Prior open-heart surgery, n (%)	87 (29)	34 (20)	0.03
Smoking history, n (%	114 (38)	64 (37)	0.6
ICD, n (%)	4(2)	9 (6)	0.02
STS score	7.5 ± 4	7.9 ± 4	0.13
β-Blockers, n (%)	180 (61)	112 (65)	0.3
Type of cardiothoracic surgery, n (%)	-	-	0.99

1 Valve only	68 (24)	39 (23)	-
≥ 2 Valves	48 (16)	28 (16)	-
Other	8 (5)	14 (5)	-
Bypass grafts, n	1.3 ± 1.7	1.3 ± 1.5	-
CABO+1 valve	66 (22)	39 (23)	-
CABO	47 (15)	24 (14)	-
CABO+ ≥ 2 valves	65(22)	38 (22)	-

Participants were organizes as given

RHD group:

This group comprise of 268 individuals who had previously received thoracic radiotherapy for a diagnosed malignancy, leading to significant coronary or valvular disease that required cardiac surgery. RHD was diagnosed based on thorough clinical evaluations by cardiologists, with records of cancer type, radiation site, and year of treatment when available. All patients in this group were approved for surgery by the oncology department.

Control group:

This group included 400 patients, matched with the RHD group by age, gender, and the type and timing of CTS, but with no history of cancer or chest radiation prior to surgery.

The study, spanning from 2011 to 2014, provides critical insights into the LTS of patients with RHD undergoing CTS and highlights the need for improved therapeutic strategies to enhance survival outcomes in this high-risk population.

Diagnostic overview

Data were obtained through individualized analyses of computerized medical records, with Institutional Review Board approval. The electronic health records included clinical and demographic data entered prospectively. Documentation covered the type and timing of recent cardiac surgeries. Throughout the follow-up period, researchers assessed for persistent atrial fibrillation at both the start and end of the study. Pacemakers and Cardiac Resynchronization Therapy (CRT) were identified as essential interventions. Surgical details were categorized as follows: initial procedures included Heart Bypass Surgery (HBS), followed by HBS combined with one or two valve repairs or replacements, then standalone valve repairs or replacements, and other surgical interventions. Preoperative data were used to compute the additive Society of Thoracic Surgeons (STS) score, which predicts the likelihood of postoperative mortality.

Statistical assessment to estimate the cardiac survival curves

The study used Kaplan-Meier method to calculate event rates and log-rank test to analyze survival curves. Independent predictors of mortality were identified using Cox Proportional-Hazards analysis. The study population was matched with 268 controls, and data analysis was performed using SPSS 11.5 for Windows.

RESULTS

Study investigates the long-term survival outcomes of patients with RHD who have undergone cardiac surgery. Compared to a matched control group, RHD patients experienced higher mortality rates, more frequent occurrences of atrial fibrillation, and greater need for permanent pacemakers. Over an average follow-up period of 8 years, RHD patients had significantly worse survival rates. Specifically, among RHD patients, 53 died from cardiovascular disease, 10 from recurrent malignancy, and 50 from undetermined causes. The findings underscore the need for improved therapeutic approaches to enhance survival for RHD patients undergoing cardiac surgery.

Unique RHDG qualities

Half of the 268 patients, which equates to 134 individuals, exhibited symptoms of obstructive proximal Coronary Artery Disease (CAD). Among these, 32 had extremely severe proximal left anterior descending artery disease, and 28 had significant left main coronary disease. Additionally, 25% of the group, or 67 patients, had a history of previous open-heart surgery, and 28 patients had undergone prior Coronary Artery Bypass Operation (CABO). On average, 18 years had elapsed since the last heart surgery.

Data for the control and radiotherapy groups treated

Table 2 outlines the postoperative clinical outcomes for RHD patients compared to controls. RHD patients exhibited a significantly higher mortality rate with 40 days, an increased occurrence of atrial fibrillation, and a greater need for permanent pacemakers than those without RHD. No cases of delayed wound healing were observed. During an average follow-up period of 8 years, 200 individuals in the cohort died. The mortality rate for RHD patients was markedly higher than that of the control group. Specifically, 53 RHD patients died from cardiovascular conditions, 10 from recurrent malignancies, and 50 had causes of death that could not be determined.

Tab. 2. Clinical outcomes for both groups during the postoperative

	Postoperative				
Factors	**Postoperative Permanent Pacemaker, n (%)**	**Mortality with 30 d, n (%)**	**Postoperative Stroke, n (%)**	**Postoperative Permanent Atrial Fibrillation, n (%)**	**Postoperative Permanent Atrial Fibrillation, n (%)**
Control	15 (6)	2 (0.4)	5 (1.7)	13 (5)	13 ± 21
RHD	19 (11)	8(5)	2 (0.07)	29 (17)	18 ± 21
p value	0.03	0.02	0.3	<0.002	<0.002

Outcomes of statistical analysis

To find potential determinants of survival, we then conducted univariable and MCPHA across the entire study population group. The outcomes are displayed in tables 3 and 4.

Tab. 3. MCPHA outcomes of the statistical analysis of post operative

Factors	Univariable	Multivariable	95%CI	p Value
	95%CI	p Value		
Hyperlipidemia	1.12	0.5	-	-
Prior stroke	1.09	0.6	-	-
RHD	2.56	0.003	2.47(1.82-3.36)	0.001
Hypertension	1.34	0.02	-	-
Diabetes mellitus	1.02	0.2	-	-
Age	1.04	0.06	-	-
Gender	1.03	0.7	-	-
Atrial fibrillation	1.16	0.3	-	-
Implantable cardioverter-defibrillator	1.17	0.6	-	-
Proximal obstructive CAD	1.59	0.002	-	-
Permanent pacemaker	1.45	0.1	-	-
Prior open-heart surgery	1.67	0.003	-	-
FVC	0.81	0.1	-	-
ACE inhibitors	1.15	0.6	-	-
Aspirin	0.68	0.03	-	-
Serum creatinine	1.37	0.06	-	-
LV ejection fraction	0.99	0.003	-	-
Type of cardiac surgery	0.92	0.06	-	-
LV end-systolic dimension	0.97	0	-	-
Left atrial dimension	0.95	0.6	-	-
Mitral regurgitation	0.95	0.7	-	-
Aortic regurgitation	1.01	0.4	-	-
Clopidogrel	1.03	0.6	-	-
Statins	1.06	0.11	-	-

Tab. 4. MCPHA outcomes of the statistical analysis of post operative

Factors	Univariable	Multivariable	95% CI	p-Value
	95% CI	p-Value		
Diastolic dysfunction	0.95	0.4	-	-
Mitral regurgitation	0.97	0.5	-	-
RV dysfunction	1.11	0.7	-	-
Permanent atrial fibrillation	1.07	0.5	-	-
RVSP	1.03	0.4	-	-
Aortic regurgitation	1.05	0.6	-	-
RVSP	1.03	0.2	-	-
Aortic valve dimension less index	1.15	0.5	-	-
STS score	1.23	0.003	1.22 (1.16-1.29)	0.001
β-Blockers	0.63	0.003	0.66 (0.47-0.93)	0.01

The use of blockers, as well as the STS score and RHD, were significantly correlated negatively with LTS. Lastly, taking into account the matched pairings in the stratum statement, we conducted conditional Cox regression analysis. It was shown that radiation heart disease, the absence of -blockers, and STS score remained significant predictors of mortality.

Figure 1 depicts the relative risk ratio in different patients. The control group for heart attacks significantly outperforms the radiation group, even in segments of the population where radiation has substantially engaged the control. The findings for attack are similar; however, the age-specific rates for radiation and control are typically closer than for CHD.

Figure 2 depicts the cost (STS score) for different patients. The overall value of subsequent hospital admissions and in-hospital spending tended to increase as STS score did, both for the index admission and also for total follow-up based on the duration of stay in various wards. Patients in the STS score group with the highest risk had total follow-up costs that were nearly twice as high as those in the low-risk category.

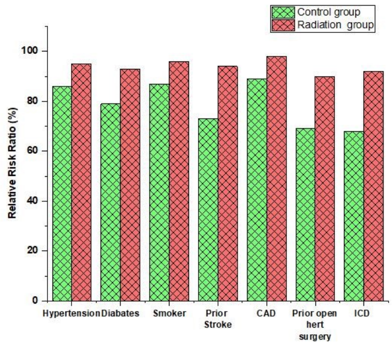

Fig. 1. Relative risk ratio

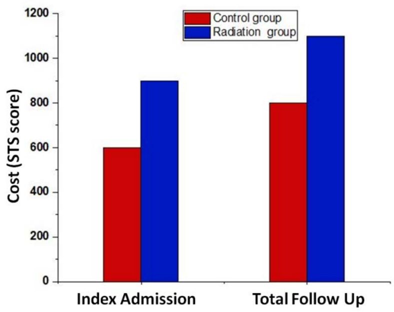

Fig. 2. Cost (STS score)

Enhancing risk management and survival rates

Figure 3 displays Kaplan-Meier survival curves comparing deaths in the radiation group to those in the control group. Overall, mortality rates in the radiation group were high (43% and 45%, respectively) even among subgroups predicted to have a low risk of dying. Also, the radiation group saw significantly greater fatality rates across all types of surgical intervention compared to the control group.

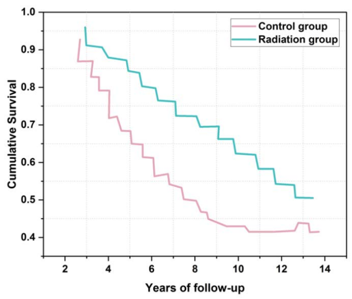

Fig. 3. Kaplan Meier survival curves contrasting mortality

The Kaplan-Meier survival curves illustrate that patients with RHD face significantly worse long-term survival compared to those without RHD. Mortality rates in the RHD group are high, even among individuals initially predicted to be at lower risk. This elevated mortality persists across various types of surgical interventions, suggesting that RHD substantially worsens patient outcomes regardless of the procedure performed. The findings indicate that RHD patients have a more challenging prognosis, underscoring the need for specialized strategies to address their increased risk. Effective treatment plans and risk management approaches are crucial to improve survival rates and overall outcomes for these high-risk individuals.

DISCUSSION

Long-term suicide rates for RHD patients treated with CTS were found to be higher than those observed in a comparison group that had received the same therapies. Compared to a healthy time-of-life group who did not undergo cardiac surgery, patients with RHD had a much worse 10-year survival rate. For the total term of follow-up, the survival rate for the radiation group was 95%, while it was 79% for the control group. This finding held across a wide range of subgroups, including those with lower-than-expected mortality. We also demonstrate that the comparative group of seniors fared substantially better than the radiation group of younger adults. Patients in the control group with STS score scores above the median fared as well as those in the radiation group with scores below the standard. When the underlying cause of death for individuals with radiation heart disease was investigated, we learned that cardio respiratory issues, rather than recurrent malignancies, accounted for the majority of these deaths [14]. According to the documented pattern of radiation heart disease, proximal Coronary Artery Disease (CAD) and alular heart disease were especially common in this population. 25% of the sample group underwent cardiac surgery, and 88% of the group had several procedures, including valve operations with or without CABO. Just 14% of the population had a single CABO [15]. The research looked for more markers of greater mortality in the population under study [16]. Long term survival was significantly poorer in those with a higher STS score, RHD. LTS was not significantly predicted by the type of heart surgery performed on the study population. By comparing the radiation group to the control group, the mortality rate for all surgical procedures was significantly higher in the radiation group. No type of heart surgery was found to improve survival rates over the others in the study population. The radiation group had a considerably greater death rate from any kind of operation compared to the control group. This study demonstrates that preoperative standard scores should not be used only by patients with RHD before cardiac surgery [17]. According to a separate study, patients who had been exposed to substantial amounts of radiation in the past had a worse chance of surviving cardiac surgery [18]. This is the largest study to date that directly compares the LTS of individuals who have undergone major heart surgery to that of a similar reference group. Since actual survival cannot always correspond to what would be expected in a group not exposed to radiation, surgery should be used with caution in patients who have received extensive thoracic radiation in the past, as indicated by the findings. Individuals who have had open-heart surgery before having far lower survival rates. Pulmonary problems are possible for radiation patients who have had open heart surgery, including severe restrictive lung disease and recurring pleural effusions. In individuals who have had a lot of radiation in the past, pulmonary problems can seriously affect function and survival. This condition can result from the underlying cardiac condition on by the effects of radiation.

CONCLUSION

Patients suffering from severe RHD often need complex cardiac surgery due to the common presence of proximal coronary artery disease and valvular heart disease in this group. They face elevated mortality rates and a higher risk of complications such as atrial fibrillation and the necessity for permanent pacemaker implantation. Over an average follow-up period, RHD patients show significantly reduced survival compared to controls. Improved therapeutic strategies are necessary to enhance outcomes for RHD patients undergoing cardiac surgery. RHD is independently connected to much lower LTS following cardiothoracic surgery when compared to a control group, even though the procedure itself had positive results. The findings that full conventional cardiothoracic surgery has poor long-term outcomes in patients with RHD suggest that other treatment methods or even treatment at an earlier stage can be necessary for the future to improve LTS. Further study is required to gain a complete understanding of this high-risk population.

Limitation and future scope of the research

The study may have inherent selection bias if the cohort was not randomly selected or if the inclusion criteria favored certain patient characteristics. This could affect the generalizability of the findings. A relatively small sample size, especially in subgroups, may limit the statistical power of the study and the reliability of the conclusions drawn. Refine risk stratification tools to better predict outcomes and guide clinical decision-making for RAHD patients undergoing cardiac surgery. Influence healthcare policies and update clinical guidelines based on new research findings to enhance patient care and survival outcomes.

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