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The Comparison of Postoperative Complications in Hypothyroid and Euthyroid Patients Undergoing Cardiac Surgery: A Retrospective Cohort Study

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ABSTRACT

Background: Cardiac surgery plays a vital role in human health. Hypothyroidism is a common disorder that affects 4 - 10% of the world's population. One of the important challenges of cardiac surgery in hypothyroid patients is their perioperative management.
Objectives: In this study, we determined the effects of hypothyroidism on complications after cardiac surgery.
Methods: In this retrospective cohort study, patients who underwent cardiac surgery in Birjand, Iran, during 2016 - 2021 and had TSH > 5 μU/mL in adults ≤ 50 and TSH > 10 μU/mL in adults > 50 years old were included as the case group. Also, adults ≤ 50 with TSH 0.3 – 5 μU/mL and adults > 50 years old with TSH 0.3 – 10 μU/mL were included as the control group. The complications and outcomes of cardiac surgery were extracted from the patient files.
Results: This study involved 30 patients with hypothyroidism and 90 controls. The two study groups were comparable regarding gender, type of cardiac surgery, history of diabetes, hypertension, heart failure, myocardial infarction (MI), and dyslipidemia (P > 0.05). The frequency distribution of cardiac and pulmonary complications, delirium, acute kidney injury (AKI), sepsis, and mortality ratio was not significantly different between the two groups (P > 0.05); the mean systolic and diastolic blood pressure before and after the surgery, duration of mechanical ventilation, cardiopulmonary bypass time, aortic clamp time, duration of ICU hospitalization, and amount of use of dopamine, epinephrine, and norepinephrine were also similar (P > 0.05).
Conclusions: Hypothyroidism did not affect the frequency of complications and outcomes after cardiac surgery. Thus, achieving a euthyroid status in hypothyroid patients is unnecessary before cardiac surgery, and there is no need to postpone elective cardiac surgery until hypothyroidism is corrected.

1. Introduction

The prevalence of cardiovascular diseases is constantly increasing due to atherosclerosis, hypertension, and lifestyle-related risk factors, and cardiac surgery plays a vital role in cardiovascular health. There is a wide range of heart diseases that require surgical intervention; Coronary artery bypass grafting (CABG), heart valve replacement, left ventricular assist device implantation, heart tumor resection, and heart transplantation are among the areas of application of cardiac surgery (1-5).

Overall, mortality related to cardiac surgery occurs in only 2 – 3% of patients (5). However, as a procedure in which patients are subjected to severe surgical stress, cardiac surgery carries a high risk of postoperative cardiac, pulmonary, renal, central nervous system (CNS), and other complications (5, 6). Various underlying factors can affect the incidence and severity of these complications and the mortality rate after cardiac surgery, one of which is hypothyroidism.

Hypothyroidism is a relatively common underlying factor that has been the subject of various studies on

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cardiac and non-cardiac surgery complications since the 1980s. Hypothyroidism affects between 4% and 10% of the population, and the prevalence of subclinical hypothyroidism reaches up to 10%. Considering the wide range of effects of thyroid hormones, especially on the cardiovascular system, hypothyroidism might affect the complications and outcomes of cardiac surgery (7, 8). One hypothesis considers hypothyroidism to be associated with increased mortality rate, major cardiac complications, and infectious complications after surgery and recommends appropriate thyroid hormone replacement therapy before surgery and the postponement of elective surgery (8, 9).

One of the most serious challenges is related to the fact that in patients with coronary artery disease, thyroid hormone replacement therapy increases the myocardial demand for oxygen due to the inotropic and chronotropic effects of thyroid hormones, while the amount of myocardial oxygen delivery has not been changed. In fact, this problem should be treated by CABG, which theoretically leads to an increase in myocardial ischemia, although this has also been reported in some studies (10, 11).

In the study conducted by Ladenson et al. (1984), it was stated that pulmonary, neuropsychiatric, and gastrointestinal complications, along with surgical site infection, are more common among hypothyroid patients after cardiac surgery, while cardiac complications are less common in these individuals (11). Drucker and Burrow (1985) also conducted a prospective study on ten patients with mild to moderate hypothyroidism who underwent major cardiovascular surgeries and 490 patients as controls. They stated that there was no difference between the hypothyroid patients and the control group regarding the frequency of postoperative infections, arrhythmias, angina, myocardial infarctions, other perioperative complications, and the duration of hospitalization. They stated that there is sufficient evidence that thyroid hormone replacement therapy should be postponed until the accomplishment of cardiac surgery (12). However, there are contradictions between the results of studies conducted.

In addition to the research that has directly examined the effects of hypothyroidism on cardiac surgery complications, several studies have also examined the effects of low-T3 syndrome (non-thyroidal illness) on cardiac surgery complications and the possibility of enhancing the postoperative outcomes of patients with perioperative T3 replacement therapy (13-17). This issue becomes more important for hypothyroid patients because they are increasingly exposed to low-T3 status due to the general lack of thyroid hormones; moreover, low-T3 syndrome is a negative prognostic factor, well-known in patients with severe disease (8, 18).

Despite the concern of researchers from different countries regarding the importance of the relationship between hypothyroidism and the complications and outcomes of cardiac surgery, according to our knowledge, no research has been conducted in Iran regarding the mentioned issue. Thus, conducting a study on the proposed topic in Iran seemed necessary.

2. Objectives

This research was conducted based on the latest review article (6) that listed the complications of cardiac surgery.

3. Methods

3.1. Study Design and Participants

In this retrospective cohort study, patients who underwent several types of cardiac surgery in Birjand, Iran, during 2016 – 2021 and had TSH > 5 µU/mL in adults < 50 years old and TSH > 10 µU/mL in adults ≥ 50 years old, were included as the case group. Also, adults < 50 years old with TSH 0.3 – 5 µU/mL and adults ≥ 50 years old with TSH 0.3 – 10 µU/mL were included as the control group. These cutoffs were collated with the history and medical records of the patients. Individuals with BMI ≥ 40 kg/m^2, long-term users of corticosteroids, patients with an unknown history of thyroid profile or a thyroid profile indicating hyperthyroidism, and individuals with a history of pituitary disorders or prior cardiac surgery were excluded from the study. Thirty people in the hypothyroid group and 90 in the control group were included (control/case ratio = 3). To remove any confounding effect of the surgeon, all the studied patients were operated on by one expert cardiac surgeon.

3.2. Data Collection

The required information was extracted from the ICU report sheets and patients' files in Valiasr and Razi hospitals in Birjand, Iran, from 2016 to 2021. The variables of age, sex, and type of cardiac surgery were initially matched between the two study groups. Other confounding variables, including history of myocardial infarction (MI), heart failure, diabetes, hypertension, dyslipidemia, and chronic kidney disease (CKD), if present, were adjusted in the analysis. According to the patients' files, mortality ratio; cardiac complications such as heart failure, MI, vasodilator shock, and arrhythmias including atrial fibrillation (AF), ventricular fibrillation (VF), ventricular tachycardia (VT), and paroxysmal supraventricular tachycardia (PSVT); pulmonary complications such as respiratory failure, acute respiratory distress syndrome (ARDS), atelectasis, pleural effusion, pneumothorax, bronchospasm, and pneumonia; delirium; acute kidney injury (AKI); and sepsis during hospitalization in the cardiac surgical ICU, as well as the duration of mechanical ventilation and ICU hospitalization, cardiopulmonary bypass time, aortic clamp time, the amount of use of inotropic and vasopressor drugs after surgery, and the systolic and diastolic blood pressures were extracted.

Informed consent was obtained from all individuals. Also, this study was approved by Birjand University of Medical Science's Research Ethics Committee (Approval ID: IR.BUMS.REC.1398.379).

3.3. Statistical Analysis

Data were entered into SPSS v.26 for statistical analysis. In this study, percentage and frequency were used to describe qualitative variables, and mean and standard deviation (SD) were used to describe quantitative variables. The chi-squared or Fisher's exact test was used in bivariate analysis to compare two qualitative variables. The normality of the data was checked using the Kolmogorov-Smirnov test, and parametric tests including independent or paired t-tests were used. Also, logistic regression was used to adjust possible confounding variables. The significance level was considered as $P \leq 0.05$.

4. Results

The present study investigated 30 patients with hypothyroidism and 90 patients without hypothyroidism who underwent different types of cardiac surgery. According to Table 1, there were no significant differences between the two study groups in terms of frequency distribution of gender, type of cardiac surgery, history of diabetes, hypertension, heart failure, MI, and dyslipidemia ($P > 0.05$).

As displayed in Table 2, the mean serum TSH level was significantly higher in the hypothyroid group compared

Table 1. Comparison of the Frequency Distribution of Sex, Type of Cardiac Surgery, and Comorbidities across the Two Study Groups

Variable	Subgroup	Hypothyroid Group (%)	Control Group (%)	Chi-squared Test Result and P-value
Sex	Male	17 (56.7%)	50 (55.6%)	$X^2 = 0.011$
	Female	13 (43.3%)	40 (44.4%)	P = 0.915
Type of cardiac surgery	CABG	21 (70.0%)	65 (72.2%)	$X^2 = 0.076$
	HVS	6 (20.0%)	16 (17.8%)	P = 0.999
	Pericardiotomy	1 (3.3%)	3 (3.3%)	
	CABG + HVS	1 (3.3%)	3 (3.3%)	
	HVS + Atrial Septal Defect (ASD) repair	1 (3.3%)	3 (3.3%)	
Diabetes	No	24 (80.0%)	61 (67.8%)	$X^2 = 1.627$
	Yes	6 (20.0%)	29 (32.2%)	P = 0.202
Hypertension	No	20 (66.7%)	49 (54.4%)	$X^2 = 1.375$
	Yes	20 (33.3%)	41 (45.6%)	P = 0.241
Heart failure	No	22 (73.3%)	75 (83.3%)	$X^2 = 1.452$
	Yes	8 (26.7%)	15 (16.7%)	P = 0.228
Myocardial infarction	No	27 (90.0%)	81 (90.0%)	$X^2 = 0.000$
	Yes	3 (10.0%)	9 (10.0%)	$P^* = 1.00$
Dyslipidemia	No	11 (36.7%)	33 (36.7%)	$X^2 = 0.000$
	Yes	19 (63.3%)	57 (63.3%)	P = 1.00

*Fisher's exact test. Abbreviations: ASD; Atrial Septal Defect, HVS; Heart Valve Surgery, CABG; Coronary Artery Bypass Graft.

Table 2. Comparison of Mean Age, Paraclinical Tests, and Clinical Parameters between the Two Study Groups

Variable	Hypothyroid Group (Mean ± SD)	Control Group (Mean ± SD)	Independent t-test Result & P-value
Age (years)	57.36 ± 11.62	57.58 ± 11.20	t = 0.093 P = 0.926
TSH (mIU/L)	23.61 ± 18.39	2.56 ± 1.58	t = 6.260 P < 0.001
T4 (nmol/L)	79.67 ± 24.44	93.77 ± 17.92	t = 2.909 P = 0.006
T3 (nmol/L)	1.23 ± 0.47	1.31 ± 0.35	t = 0.931 P = 0.354
BMI (kg/m^2)	24.32 ± 4.18	24.51 ± 4.05	t = 0.225 P = 0.823
EF (%)	45.00 ± 11.06	48.59 ± 10.73	t = 1.574 P = 0.118
Urea (mg/dL)	36.20 ± 16.93	34.91 ± 13.99	t = 0.414 P = 0.680
Creatinine (mg/dL)	1.08 ± 0.31	1.02 ± 0.30	t = 1.014 P = 0.313
GFR (mL/min/1.73 m^2)	75.46 ± 22.91	79.96 ± 20.10	t = 1.025 P = 0.308
Systolic blood pressure (mmHg) before surgery	121.00 ± 16.29	125.72 ± 22.44	t = 1.075 P = 0.284
Diastolic blood pressure (mmHg) before surgery	75.40 ± 14.00	76.92 ± 13.73	t = 0.523 P = 0.602
Systolic blood pressure (mmHg) after surgery	116.90 ± 20.01	116.12 ± 17.01	t = 0.207 P = 0.836
Diastolic blood pressure (mmHg) after surgery	67.40 ± 13.28	65.07 ± 9.61	t = 0.883 P = 0.382

with the control group ($P < 0.001$), while the mean serum T4 level was significantly lower in the hypothyroid group than the control group ($P = 0.006$). However, the mean age, T3 level, BMI, cardiac ejection fraction (EF), urea and creatinine levels, glomerular filtration rate (GFR), and systolic and diastolic blood pressures before and after cardiac surgery were not significantly different between the two groups ($P > 0.05$).

As presented in Table 3, the frequency distribution of cardiac and pulmonary complications was not significantly different across the two study groups ($P > 0.05$). Moreover, the frequency distribution of delirium, AKI, sepsis, and death was similar between the two groups ($P > 0.05$).

Also, based on the data presented in Table 4, there was no significant difference between the duration of mechanical ventilation, cardiopulmonary bypass time, aortic clamp time, duration of ICU hospitalization, and use of dopamine, epinephrine, and norepinephrine between the two investigated groups ($P > 0.05$).

5. Discussion

Cardiac surgery, as a procedure in which patients are subjected to severe surgical stress, has a high risk of being associated with postoperative cardiac, pulmonary, renal, and CNS complications (6). Considering the wide range of effects of thyroid hormones on the body, especially on the cardiovascular system, hypothyroidism can affect the outcomes and complications of cardiac surgery (7, 8). Thus, this study aimed to compare the complications and outcomes of cardiac surgery between hypothyroid and euthyroid patients undergoing different types of cardiac surgery.

Table 3. Comparison of the Frequency Distribution of Cardiac Complications, Pulmonary Complications, Delirium, AKI, Sepsis, and Mortality Rate between the Two Study Groups

Variable	Subgroup	Hypothyroid Group (%)	Control Group (%)	Chi-squared Test Result & P-value
Cardiovascular complications				
PSVT	No	30 (100%)	85 (94.4%)	$X^2 = 1.739$
	Yes	0 (0.0%)	5 (5.6%)	P = 0.330
Ventricular tachycardia	No	30 (100%)	89 (98.9%)	$X^2 = 0.336$
	Yes	0 (0.0%)	1 (1.1%)	P = 1.000
Heart failure	No	30 (100%)	85 (94.4%)	$X^2 = 1.739$
	Yes	0 (0.0%)	5 (5.6%)	P = 0.330
Myocardial infarction	No	30 (100%)	90 (100%)	---
	Yes	0 (0.0%)	0 (0.0%)	
Arial fibrillation	No	24 (80.0%)	76 (75.4%)	$X^2 = 0.486$
	Yes	6 (20.0%)	13 (14.6%)	P = 0.566
Vasodilator shock	No	29 (96.7%)	82 (96.5%)	$X^2 = 0.003$
	Yes	1 (3.3%)	3 (3.5%)	P = 1.000
Ventricular fibrillation	No	30 (100)	90 (100%)	---
	Yes	0 (0.0%)	0 (0.0%)	
Pulmonary complications				
Respiratory failure	No	30 (100%)	87 (96.7%)	$X^2 = 1.026$
	Yes	0 (0.0%)	3 (3.3%)	P = 0.572
Acute respiratory distress syndrome	No	30 (100%)	88 (97.8%)	$X^2 = 0.678$
	Yes	0 (0.0%)	2 (2.2%)	P = 1.000
Atelectasis	No	26 (86.7%)	83 (92.3%)	$X^2 = 0.834$
	Yes	4 (13.3%)	7 (7.8%)	P = 0.464
Pleural effusion	No	9 (31.0%)	16 (18.4%)	$X^2 = 2.057$
	Yes	20 (69.0%)	71 (81.6%)	P = 0.152
Pneumothorax	No	30 (100%)	90 (100%)	---
	Yes	0 (0.0%)	0 (0.0%)	
Bronchospasm	No	30 (100%)	82 (91.1%)	$X^2 = 2.857$
	Yes	0 (0.0%)	8 (8.9%)	P = 0.199
Pneumonia	No	29 (96.7%)	85 (94.4%)	$X^2 = 0.234$
	Yes	1 (3.3%)	5 (5.6%)	P = 1.000
Other complications				
Delirium	No	29 (96.7%)	86 (95.6%)	$X^2 = 0.070$
	Yes	1 (3.3%)	4 (4.4%)	P = 1.000
Acute kidney injury	No	30 (100%)	89 (98.9%)	$X^2 = 0.336$
	Yes	0 (0.0%)	1 (1.1%)	P = 1.000
Sepsis	No	29 (96.7%)	78 (86.7%)	$X^2 = 2.329$
	Yes	1 (3.3%)	12 (13.3%)	P = 0.181
Mortality rate	No	30 (100%)	89 (98.9%)	$X^2 = 0.336$
	Yes	0 (0.0%)	1 (1.1%)	P = 1.000

Abbreviations: PSVT; paroxysmal supraventricular tachycardia

Table 4. Comparison of the Duration of Mechanical Ventilation, Duration of Hospitalization in ICU, and the Amount of Use of Inotropic and Vasopressor Drugs between the Two Study Groups

Variable	Hypothyroid Group (Mean ± SD)	Control Group (Mean ± SD)	Independent T-test Result & P-value
Duration of mechanical ventilation (hours)	3.42 ± 0.99	3.79 ± 3.16	t = 0.626 P = 0.533
Cardiopulmonary bypass time (minutes)	142.48 ± 44.04	131.07 ± 44.34	t = 1.167 P = 0.246
Aortic clamp time (minutes)	100.15 ± 41.35	93.62 ± 42.39	t = 0.701 P = 0.485
Duration of hospitalization in ICU (days)	4.13 ± 4.38	3.56 ± 3.25	t = 0.920 P = 0.359
Amount of use of dopamine (μg/kg)	8812 ± 5350	10768 ± 8540	t = 0.838 P = 0.405
Amount of use of epinephrine (μg/kg)	73.55 ± 77.96	46.31 ± 31.71	t = 0.679 P = 0.541
Amount of use of norepinephrine (μg/kg)	47.36 ± 41.82	42.96 ± 46.98	t = 0.639 P = 0.754

In this study, the frequency distribution of cardiac complications, including heart failure, MI, vasodilator shock, and arrhythmias (AF, VF, VT, PSVT), was not significantly different across the hypothyroid and control groups. Studies conducted by Ladenson et al. (1984) (11), Drucker and Burrow (1985) (12), Park et al. (2009) (19), Worku et al. (2015) (20), Martinez-Comendador et al. (2016) (21), Komatsu et al. (2018) (18), and Kong et al. (2018) (22) demonstrated similar results. In all these studies, no significant difference was observed between the patients with hypothyroidism and the control group in terms of cardiac complications except for AF, regarding which there was heterogeneity between the studies. Park et al. (2009) (19), Worku et al. (2015) (20), Martinez-Comendador et al. (2016) (21) (despite the administration of prophylactic antiarrhythmic medications including oral beta blockers or amiodarone), and Jaimes et al. (2017) (23) reported a significantly higher incidence of AF in the hypothyroid group, while Komatsu et al. (2018) (18) reported a significantly lower incidence of AF in the hypothyroid group compared to the euthyroid group. Druker et al. (1985) (12), Kong et al. (2018) (22), and Zhao et al. (2021) (24, 25), similar to our study, did not report any significant difference in the incidence of AF in the investigated groups. Although there was no significant difference in the frequency of AF between the two groups of the present study, the frequency of this cardiac complication was higher in the hypothyroid group compared to the control group (20.0% vs. 14.6%). However, preparing for managing AF after cardiac surgery in hypothyroid patients seems necessary. In this way, subsequent complications such as thromboembolic events, remodeling of the heart structure (26), and the need for revascularization (22) can be prevented.

The frequency distribution of pulmonary complications including respiratory failure, ARDS, atelectasis, pleural effusion, pneumothorax, bronchospasm, and pneumonia was not significantly different between the two study groups. Consistent with our results, Park et al. (2009) (19) and Martinez-Comendador et al. (2016) (21) stated that pulmonary complications in two groups of patients with and without hypothyroidism were not significantly different. However, Ladenson et al. (1984) (11) showed that the frequency of pulmonary complications after cardiac surgery in patients with hypothyroidism was significantly higher than in the control group. The reasons for this inconsistency could be justified by the differences in study timings, surgeon's experience and skills, and facilities.

In the present study, the frequency distribution of delirium, AKI, and sepsis was similar between the two investigated groups. Contrary to this study, Ladenson et al. (1984) (11) showed that neuropsychiatric complications were significantly more common in hypothyroid patients than in the control group. Also, in the studies conducted by Park et al. (2009) (19), Worku et al. (2015) (20), and Martinez-Comendador et al. (2016) (21), renal complications in hypothyroid and euthyroid groups were comparable, consistent with our results. Similarly, Weinberg et al. (1983) (27) showed no significant difference between the hypothyroid and control groups regarding sepsis and septic shock frequency after surgery.

In the present study, the frequency distribution of death and the duration of hospitalization in the ICU in the two investigated groups did not differ significantly. In contrast, Ladenson et al. (1984) (11) found that hypothyroid patients' mortality after cardiac surgery was 18%, significantly higher than 3% in the control group. Nonetheless, the duration of hospitalization of patients in the ICU was not significantly different between the two study groups, which is consistent with the current study's findings. Also, in the studies conducted by Drucker and Burrow (1985) (12), Martinez-Comendador et al. (2016) (21), Jaimes et al. (2017) (23), Kong et al. (2018) (22), and Zhao et al. (2021) (24, 25), the frequency distribution of death in the two investigated groups was not significantly different, which is consistent with the findings of the present study. Similarly, in the studies of Ladenson et al. (1984) (11), Drucker and Burrow (1985) (12), Park et al. (2009) (19), Martinez-Comendador et al. (2016) (21), and Komatsu et al. (2018) (18), the mean duration of hospitalization was similar between the two study groups.

According to our results, the mean systolic and diastolic blood pressures before and after cardiac surgery in the two investigated groups did not differ significantly. In other studies, the blood pressure variable was not quantitatively analyzed. However, complications related to blood pressure disorders such as hypotension and shock were investigated in the studies of Ladenson et al. (1984) (11) and Komatsu et al. (2018) (18), showing no significant difference between hypothyroid and euthyroid patients.

In this study, the duration of mechanical ventilation and the amount of use of inotropic drugs (dopamine, epinephrine, and norepinephrine) were comparable across the two groups. Komatsu et al. (2015) (9) and Martinez-Comendador et al. (2016) (21) achieved similar findings regarding the use of inotropic and vasopressor drugs. However, Zhao et al. (2021) (24, 25) showed that the mean amount of use of inotropic and vasopressor drugs (dopamine, epinephrine, milrinone, and dobutamine) was significantly higher in the hypothyroid group who underwent CABG compared to the control group. Also, the duration of mechanical ventilation was longer in the hypothyroid group compared to the control group. One of the causes of this difference can be related to the type of cardiac surgery performed. In our study, the patients underwent various cardiac surgeries (CABG, heart valve surgery, etc.), while in Zhao et al.'s study (2021) (24, 25), only patients who underwent CABG were involved. Another reason for this heterogeneity in findings may be related to the difference in the management of patients. Regardless of the role of all confounding factors, it is not unlikely that genetics and race play an important role in this apparent difference in findings.

In the present study, the cardiopulmonary bypass and aortic clamp times were comparable between hypothyroid and control groups. Similar to our results, Wang et al. (2022) (28) showed no significant difference in cardiopulmonary bypass time and aortic clamp time between patients with TSH < 10 mU/L and TSH ≥ 10 mU/L undergoing aortic surgery. It should be mentioned that cardiopulmonary bypass is accompanied by explicit changes in levels of thyroid hormone, which is usually known as transient secondary hypothyroidism (29). Transient secondary hypothyroidism, like sick euthyroid syndrome, reduces circulating thyroid hormone levels (30). However, unlike sick euthyroid syndrome, transient secondary hypothyroidism adversely affects the hypothalamic-pituitary axis, causing a reduction in TSH secretion and decreasing plasma T3 and T4 levels (31, 32). In this regard, the cardiopulmonary bypass time should not be prolonged, especially in patients with underlying hypothyroidism, to prevent the deterioration of thyroid status.

5.1. Strengths and Limitations

In this study, we considered various complications of cardiac surgery, and the research was conducted based on the latest review article (6) that listed the complications and outcomes of cardiac surgery. Also, one of the essential points of our study was controlling the confounding variables, rendering the conclusion more reliable. The study groups were perfectly matched. However, this study had some limitations, especially the retrospective nature and collection of recorded data from patients' files, medical records, and ICU report sheets, where a high input quality could not be assured.

5.2. Conclusions

In conclusion, hypothyroidism did not affect the frequency of complications and early outcomes after cardiac surgery. Thus, achieving euthyroid status in hypothyroid patients is not necessary before cardiac surgery, and there is no need to postpone elective cardiac surgery until hypothyroidism is biochemically corrected. Proceeding with reasonable thyroid hormone replacement therapy is the preferred option for managing hypothyroid patients requiring cardiac surgery.

5.3. Ethical Approval

Informed consent was obtained from all individuals. Also, this study was approved by Birjand University of Medical Science's Research Ethics Committee (Approval ID: IR.BUMS.REC.1398.379). https://ethics.research.ac.ir/ProposalCertificate.php?id=123149

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Authors' Contribution

Conceptualization: [A.A and F.S]; Formal analysis and investigation: [S.M.R]; Writing - original draft preparation: [M.R]; Writing - review and editing: [S.E.H];

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