Thyroid Hormone Alterations Following Cardiopulmonary Bypass and Its Effect on Ventilator Weaning Time and Hemodynamic Parameters

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Abstract

Introduction- Cardiac diseases managed with surgery are growing increasingly because of technologic progress and sedentary lifestyles on one hand and progression of diagnostic procedures on the other. Thyroid dysfunction and alterations in thyroid hormones have a direct effect on the cardiovascular system, and special attention to this issue is required to counter the effects of these two systems (thyroid hormones and cardiovascular system) on each other, especially during and after cardiac surgery and resultant thyroid hormone alterations due to surgery. Frequent use of cardiopulmonary bypass (CPB) during cardiac surgical procedures makes this issue very important. The goal of this research is to study thyroid hormone alterations after cardiopulmonary bypass and its effect on hemodynamic parameters and weaning time of patients from ventilatory support after cardiac surgery.

Methods- Sixty patients undergoing CPB who had no previous history of thyroid disease and who did not have any diseases affecting weaning time from ventilator were studied. Thyroid hormone levels were measured before and after CPB, and hemodynamic parameters (including mean arterial pressure, heart, HR, rate and central venous pressure, CVP) were measured every 5 minutes in the operating room and every 15 minutes in the ICU. The time of patient arrival to the ICU until extubation of the patient (after meeting the criteria of extubation) was measured in minutes, and the relations between the variables were studied.

Results- Among all the variable parameters, the correlation between free T3 (FT3) and CVP after discontinuing CPB; TSH alterations and heart rate at arrival to ICU; and TSH alterations and time-to-extubation of the patient were statistically meaningful (P<O.O5). Except for the relation between TSH alterations and HR upon arrival to the ICU, the others had “low predictive value” and the latter had “medium predictive value”.

Conclusion- Thyroid hormones differ after CPB, and this difference has correlations with hemodynamic parameters and time-to-extubation of the patient (weaning time) ***(Iranian Heart Journal 2006; 7 (1): 21-24)***.

Key words: thyroid hormones■ hemodynamic parameter changes■ cardiopulmonary bypass ■ weaning time

It seems that the coincidence of thyroid dysfunction and cardiac operations leads to many problems that involve the anesthesiologists in hemodynamic and respiratory management of patients after the operation, like low cardiac output after

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the operation or lengthening of the rewarming process at the end of the operation.[1]

Also, the inotropic and chronotropic effects of thyroid hormones are well known.[2]

According to the existing studies on the alterations of thyroid hormones during cardiac operations using cardiopulmonary bypass pump (CPB), the patient experiences major alterations of thyroid hormone indexes after CPB.[2-6]

There are many mechanisms suggested for this: one of them is the dilution of the patient's blood to approximately two times of its volume, causing a relative decrease in all components in blood, including thyroid hormones. Another probable cause is hypothermia and its effect on the hypothalamus-hypophysis axis (probably due to a relative ischemia of this axis) and consequently, inability of suitable response to this stimulus.[5]

Holland et al. showed a marked decrease in the active form of thyroid hormone, total T3 (TT3) during and after CPB, leading to sick euthyroid syndrome (SES).[2] This syndrome consists of a severe decrease in TT3, free T3 (FT3) and increased levels of reverse T3 (RT3).

There are many other studies considering these hormonal alterations and their effects on cardiovascular performance. We could not find any data on this issue of whether administering thyroid hormone during surgery has any benefit for the cardiovascular system; therefore, this is the first study that has evaluated the effects of this hormonal alteration on the length of ventilatory support needed after surgery and on weaning time from the ventilator after operation.

Thus the aim of this research was to study thyroid hormone alterations after cardiopulmonary bypass and the effects of these alterations on the patients' hemodynamic parameters (defined as mean arterial pressure, MAP; central venous pressure, CVP; and heart rate, HR) and on weaning time (defined as the time of entry to the open heart ICU until the time of reaching the criteria for extubating the patient and discontinuing ventilatory support, in minutes).

Methods

We performed this study in two sections: a "before-after" type and a "cross-sectional" type study on 60 patients (Table I) in our department in 2003.

The study population was all adult patients undergoing CPB for any reason provided that the operation was performed on an elective basis and the patients' thyroid hormone levels before the operation were within normal range and that the patient had a negative history of both thyroid diseases (treated or untreated) and any respiratory complaints affecting the course of weaning from the ventilator. All the patients had a normal pulmonary function test (PFT).

A blood sample was taken before surgery (at first visit in clinic) to measure thyroid hormone levels. The induction protocol was based on premedication with diazepam and fentanyl (at a dose proportional with he patient's cardiac performance and cardiac output) and induction of anesthesia with thiopental-Na (Nesdonal) and succinylcholine followed by halothane and fentanyl for the maintenance of anesthesia. Hemodynamic parameters (as described above) were measured each 5 minutes in the operating room. A blood sample was obtained at the end of CPB as to measure thyroid hormone levels again.

At the end of the operation, the intubated patients were transferred to the open heart ICU, and after arrival, hemodynamic parameters were measured and recoded every 15 minutes. The patients were extubated after reaching the essential criteria for extubation. This time interval (from arrival to ICU until extubation) was measured in minutes.

After collecting the data, we used independent sample T-test for the analysis of quantitative data and Chi-square test for the analysis of qualitative data.

Results

Five patients from the 65 who entered our study were omitted (one case because of postoperative bleeding; a second due to an addiction history, which was kept hidden by the patient and which required administering repeated doses of opioids in the ICU interfering with extubation time; and 3 cases because of a CPB time longer than usual 2 hours). Finally, 60 patients entered our study with a mean age of 53.5±11.7 years old (the youngest was 22 and the oldest was 77 years old).

Forty-five patients were male (75%) and 15 were female (25%). All thyroid hormone indices had a meaningful change (an increase in TSH and a decrease in other indices, p=0.05, Table I).

Table I: Age groups in detail

Age groups	Absolute frequency	Relative frequency
21-30	2	3.33%
31-40	4	6.67%
41-50	24	40.00%
60-51	14	23.33%
70-61	11	18.33%
80-71	5	8.33%
sum	60	100.00%

Among correlations between variables, FT3 and CVP after weaning from CPB had a direct correlation with "low" predictive value (r2=0.12, p=0.05), and TSH alterations and heart rate at the time of entering the ICU had a direct correlation with "low" predictive value (r2=0.1, p=0.025). TT3 alterations and MAP; TSH alterations and heart rate; TSH alterations and CVP; and FTI alterations and CVP (all of them immediately after extubation) all had a direct correlation with "low" predictive value (p=0.05), except for TSH alterations and heart rate, which had a "moderate" predictive value. Also, the correlation between TSH alterations and weaning time from ventilator had a "low" predictive value (p<0.05). We found no correlation between patient age and thyroid hormone indices (Tables II, III).

Table II: Mean thyroid hormone levels before and after CPB.

	Mean	S.D.	T	P Value
Mean FT3 preop	3.94	0.81	2.12	0.04
Mean FT3 postop	3.12	0.24		
Mean FT4 preop.	3.96	0.08	2.71	0.01
Mean FT4 postop	1.13	0.36		
Mean TT3 preop	102.66	33.45	6.76	0.001
Mean TT3 postop.	62.50	24.69		
Mean TT4 preop.	8.98	2.59	2.08	0.04
Mean TT4 postop.	8.02	2.70		
Mean TSH preop	1.89	0.21	0.30	0.03
Mean TSH postop.	2.21	0.16		
Mean FTI preop	3.17	0.03	2.43	0.02
Mean FTI postop.	2.11	0.07		

Table III: Correlation between thyroid hormone alterations and CPB time.

		CPB time	Weaning time
Mean FT3 changes	r	0.92	0.126
	p	0.538	0.399
Mean FT4 changes	r	0.131	0.009
	p	0.380	0.953
Mean TT3 changes	r	0.216	0.040
	p	0.140	0.786
Mean TT4 changes	r	0.178	0.102
	p	0.225	0.486
Mean TSH changes	r	-0.25	-0.380
	p	0.08	0.008
Mean FTI changes	r	0.082	-0.060
	p	0.583	0.687

Table IV: Thyroid hormone alterations and hemodynamic parameters before extubation.

	Immediately before extubation			
		MAP	HR	CVP
FT3 changes	r	-0.080	0.071	0.112
	p	0.595	0.638	0.455
FT4 changes	r	-0.091	0.046	0.048
	p	0.543	0.761	0.746
TT3 changes	r	0.299	0.048	0.128
	p	0.039	0.745	0.384
TT4 changes	r	0.098	-0.182	0.022
	p	0.509	0.215	0.883
TSH changes	r	0.115	0.516	0.285
	p	0.438	0.001	0.049
FTI changes	r	-0.074	-0.121	-0.365
	p	0.620	0.416	0.012

MAP: mean arterial pressure, HR: heart rate, CVP: central venous pressure

Discussion

We tailored this study because there were no documented studies on the relation between these hormonal changes with weaning time from the ventilator and hemodynamic parameters.

These parameters are one of the most important and challenging issues involving anesthesia groups and other specialties with problems after operations using CPB.

As with the study of Holland et al., we showed that the most altered parameter among thyroid hormones after CPB is the decrease in TT3. Another issue not having been studied by any group was the study of correlations between these hormonal changes and weaning time of patients from the ventilator.

We found that there is a meaningful correlation between TSH alterations and heart rate just before extubation (with "moderate" predictive value) and also between TSH alterations and weaning time from ventilator (with "low" predictive value).

On account of the fact that there are numerous parameters influencing these two items (heart rate and weaning time from ventilator), it seems that more accurate studies with more specialized groups are needed to increase the predictive value of these correlations. In addition, we recommend that further studies be undertaken to investigate whether administering thyroid hormones before or during surgery has any effect on improving the patient's hemodynamics and shortening the weaning time from the ventilator, subsequently decreasing the costs and improving outcomes.

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