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Original article

Thyroid function on admission and outcome in patients hospitalized for acute decompensated heart failure

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ABSTRACT

Background: Although thyroid dysfunction is a known prognostic factor for cardiovascular disease, the relationship between thyroid function and prognosis in patients with acute decompensated heart failure (ADHF) is poorly understood. Herein, we investigated the association between thyroid hormone levels and outcome in patients hospitalized for ADHF.

Methods: We evaluated 270 hospitalized ADHF patients with thyroid hormone levels measured at admission between April 2007 and May 2012.

Results: The median (interquartile range) thyroid stimulating hormone, free triiodothyronine (fT3), and free thyroxine were 2.79 (1.49–4.96) μU/ml, 2.32 (1.93–2.75) pg/ml, and 14.0 (12.1–15.7) pg/dl, respectively. Receiver operating characteristic (ROC) curve analysis was applied to assess their prognostic value for in-hospital outcome. The fT3 had the most favorable performance, with an area under the ROC curve of 0.791 (optimal cutoff point ≤2.05; sensitivity 85.0%; specificity 72.0%). Although patients in the low fT3 group (≤2.05) had higher age and lower body mass index, there were no significant differences with respect to systolic blood pressure and heart rate between the groups. In multivariate analysis adjusted for various markers of disease severity and amiodarone use, low fT3 level was independently associated with higher in-hospital mortality (odds ratio 14.4; $p < 0.001$). In addition, the probability of 1-year total death among patients with low fT3 was significantly higher than that among patients with normal fT3 (log-rank $p < 0.001$).

Conclusions: Low fT3 level was associated with adverse outcomes in patients hospitalized for ADHF. Thyroid hormone measurements might be useful in the risk stratification of ADHF patients.

Introduction

Acute decompensated heart failure (ADHF) is a common but poorly defined clinical syndrome in cardiovascular and emergency medicine, and is associated with a poor outcome [1,2]. In addition, ADHF is the most common cause of hospitalization in patients older than 65 years, and rates will continue to increase in the future [1,2]. However, assessment of prognosis in individual ADHF patients remains challenging because of the high variability in the clinical course of the disease [3–7].

Thyroid hormone affects the function of all cells, tissues, and organs, including the heart [8–11]. Previous studies have elucidated that altered thyroid hormone metabolism, such as low serum free triiodothyronine (fT3) concentration, was described in patients with cardiovascular disease including heart failure [8,12,13]. A low fT3 was associated with higher right atrial, pulmonary artery, and pulmonary capillary wedge pressures, and lower ejection fraction and cardiac index [12]. In addition, thyroid dysfunction may influence outcome in patients with cardiovascular disease, because the cardiovascular system is a key target of thyroid hormone [13–23]. However, the relationship between thyroid dysfunction and clinical outcomes in patients with established chronic heart failure remains controversial [14,16–18,20,23]. Furthermore, an association of thyroid function with outcome in patients with acute decompensated phase of heart failure is poorly understood. Thus, we investigated the association between thyroid hormone levels on admission and

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prognosis (in-hospital and 1-year outcome) in patients hospitalized for ADHF.

Methods

Patients and thyroid function measurements

We retrospectively evaluated 367 consecutive hospitalized patients who suffered from ADHF who were referred to the Cardiac Intensive Care Unit at Tokyo Women's Medical University Hospital, Tokyo, Japan, between April 2007 and May 2012. The diagnosis of heart failure was assessed based on modified Framingham criteria [24]. ADHF was defined as new onset of decompensated heart failure or decompensation of chronic, established heart failure meeting the criteria and sufficient to warrant hospitalization and urgent therapy. Patients were certified for enrollment if they were hospitalized for episodes of ADHF as the primary cause of admission. Patients aged less than 20 years old and those with acute coronary syndrome were excluded. The study was performed according to the principles of the Declaration of Helsinki, and this study protocol was approved by our institutional ethics committee.

Thyroid hormone levels [thyroid stimulating hormone (TSH), fT3, and free thyroxine (fT4)] were measured in hospitalized ADHF patients within 48 h after admission. A total of 97 patients were excluded from this analysis because of missing thyroid hormone measurements ($n = 92$), overt primary hypothyroidism (TSH $>$ 10 μU/ml and fT4 $<$ 6 pg/ml with or without thyroid replacement therapy) ($n = 3$), and overt primary hyperthyroidism (fT3 $>$ 4.5 pg/ml or fT4 $>$ 23 pg/ml with undetectable TSH levels) ($n = 2$) [14]. Therefore, the final study population consisted of 270 patients hospitalized for ADHF.

Follow-up and end-points

Follow-up started from the day of ADHF admission. Follow-up data were obtained from the following sources: reviewing our hospital records, periodically examining patients in the outpatient clinic, contacting patients' physicians, or interviewing the patients by phone. Complete information on the follow-up data was ascertained for 362 (98.6%) of the total 367 patients. The end-point of this study was in-hospital and 1-year all-cause death, cardiac death, and non-cardiac death. All end-points were ascertained by two experienced physicians who were not study investigators.

Statistical analysis

Analyses were performed with the SAS ver. 9.1 (SAS Institute, Cary, NC, USA) by an independent biostatistics and data center (STATZ Institute, Inc., Tokyo, Japan). Results are presented as the mean with standard deviation (SD), median with interquartile range, or frequencies (%). Student's *t*-test was used to compare normally distributed continuous variables between groups.The Mann–Whitney *U*-test was used for skewed continuous or ordinal variables. The chi-square test or Fisher's exact test (when an expected value was less than 5) was used to compare nominal variables. Sensitivity and specificity were calculated according to standard definitions. Receiver operating characteristic (ROC) curves were constructed and the area under the ROC curve was calculated to assess the usefulness of the thyroid hormone levels for predicting the in-hospital outcome. Best cutoff values were identified by ROC curves with Youden index. To evaluate the impact of low fT3 on the in-hospital prognosis, univariate and multivariate logistic regression models were used. Multivariate models included the age, sex, body mass index, systolic blood pressure, B-type natriuretic peptide, serum sodium, creatinine, blood urea nitrogen, hemoglobin, C-reactive protein, and amiodarone use before admission. The probability of 1-year all-cause, cardiac, and non-cardiac death was estimated by the Kaplan–Meier method, after which the log-rank test was used to compare survival curves. Two-tailed *p*-values of less than 0.05 were considered to indicate statistical significance.

Results

Thyroid function profile

The median (interquartile range) serum concentrations of TSH, fT3, and fT4 were 2.79 (1.49–4.96) μU/ml, 2.32 (1.93–2.75) pg/ml, and 14.0 (12.1–15.7) pg/ml, respectively, in 270 hospitalized patients with ADHF. ROC curve analysis was applied to assess their prognostic value for in-hospital all-cause death (Fig. 1). As a result, fT3 showed the most favorable performance, and the area under the ROC curve for TSH was 0.580 (optimal cutoff point $>$2.78; sensitivity 70.0%; specificity 51.6%, Fig. 1A), for fT3 was 0.791 (optimal cutoff point $\leq$2.05 pg/ml; sensitivity 85.0%; specificity 72.0%, Fig. 1B), and for fT4 was 0.552 (optimal cutoff point $\leq$16.1; sensitivity 95.2%; specificity 19.6%, Fig. 1C). Box-and-whisker plots of fT3 levels at admission in ADHF patients with or without end-point (in-hospital all-cause death) are shown in Fig. 2. In patients who died during hospitalization, fT3 at admission

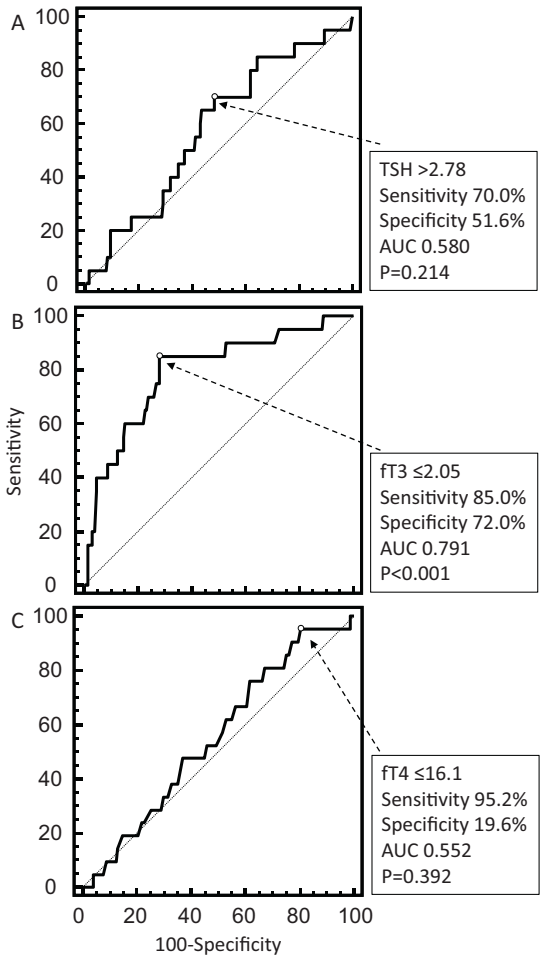

Fig. 1. Receiver operating characteristic (ROC) curves predicting the in-hospital all-cause death for hospitalized patients with acute decompensated heart failure. The area under the ROC curve (AUC) for thyroid stimulating hormone (TSH) (A) was 0.580, for free triiodothyronine (fT3) (B) was 0.791, and for free thyroxine (fT4) (C) was 0.552.

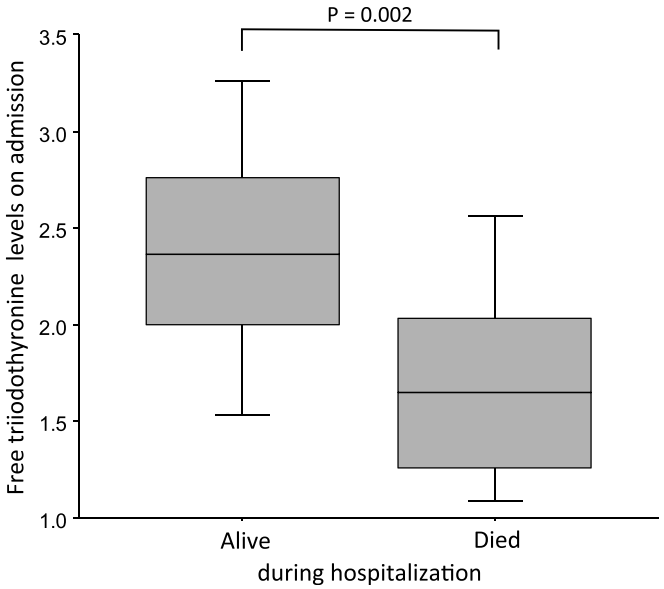

Fig. 2. Box-and-whisker plots of free triiodothyronine (fT3) levels at admission in acute decompensated heart failure patients with or without end-point (in-hospital all-cause death). The line across each box represents the median fT3, the box represents the interquartile range (25th–75th percentile), and the I-bars represent the 95% confidence intervals.

was significantly lower [1.65 (1.26–2.02) pg/ml] than in patients who remained alive during hospitalization [2.37 (2.00–2.76) pg/ml] ($p = 0.002$).

In-hospital outcome

Among the 87 patients in the low fT3 group, 17 (19.5%) died during hospitalization including 9 (10.3%) with cardiac cause (8 with death from heart failure and 1 with death due to infective endocarditis) and 8 (9.2%) with non-cardiac cause (4 with pneumonia and respiratory failure, 3 with other infectious disease including sepsis, and 1 with gastrointestinal bleeding). By contrast, only 3 out of 183 patients (1.6%) in the normal fT3 group died in-hospital including 2 (1.1%) with cardiac death from heart failure and 1 (0.5%) with non-cardiac death due to cerebrovascular disorders. In univariate analysis, low fT3 level (≤2.05 pg/ml) on admission was associated with higher in-hospital all-cause death rate (crude odds ratio 14.6; $p < 0.001$), cardiac death rate (crude odds ratio 10.4; $p = 0.003$), and non-cardiac death rate (crude odds ratio 18.4; $p = 0.006$) (Table 1). In addition, low fT3 level was independently associated with higher in-hospital all-cause mortality (adjusted odds ratio 14.4; $p < 0.001$), cardiac death rate (adjusted odds ratio 9.62; $p = 0.037$), and non-cardiac death rate (adjusted odds ratio 17.1; $p = 0.016$) in multivariate analysis adjusted for various markers of disease severity and amiodarone use (Table 1). When in-hospital all-cause and cardiac deaths were considered, systolic blood pressure (per 1 mmHg increase, adjusted odds ratio for all-cause death 0.97; $p = 0.012$, adjusted odds ratio for cardiac death 0.96; $p = 0.049$) and hemoglobin level (per 1 g/dl increase, adjusted odds ratio for all-cause death 0.60; $p = 0.017$, adjusted odds ratio for cardiac death 0.48; $p = 0.016$) on admission were other independent predictors for outcome in multivariate analysis. However, low fT3 was the only independent predictor for in-hospital non-cardiac death in multivariate analysis.

Baseline characteristics

Baseline clinical characteristics according to thyroid status on admission based on fT3 levels are shown in Table 2. Although patients in the low fT3 group (≤2.05 pg/ml) had higher age and lower body mass index, there were no significant differences with respect to systolic blood pressure and heart rate between the groups. The prevalence of jugular venous distension was significantly higher in patients in the low fT3 group. In addition, patients in the low fT3 group had higher B-type natriuretic peptide, blood urea nitrogen, serum creatinine, and C-reactive protein levels, and lower serum sodium and hemoglobin levels, than those in the normal fT3 group (>2.05 pg/ml). Further, patients in the low fT3 group were more likely to be taking loop diuretics, amiodarone, and hemodialysis before ADHF admission.

One-year outcomes

Among the 87 patients in the low fT3 group, 26 (29.9%) died during the 1-year follow-up period including 16 (18.4%) with cardiac cause (12 with death from heart failure, 3 with sudden cardiac death, and 1 with death due to infective endocarditis) and 10 (11.5%) with non-cardiac cause (4 with pneumonia and respiratory failure, 3 with other infectious disease including sepsis, 2 with malignancy, and 1 with gastrointestinal bleeding). In contrast, 26 out of 183 patients (14.2%) in the normal fT3 group died during the 1-year follow-up period, including 15 (8.2%) with cardiac death (8 with death from heart failure and 7 with sudden cardiac death) and 11 (6.0%) with non-cardiac death (1 with cerebrovascular disorders, 2 with pneumonia and respiratory failure, 2 with other infectious disease including sepsis, 4 with malignancy, and 2 with gastrointestinal bleeding). One-year Kaplan–Meier survival curves for cumulative all-cause, cardiac, and non-cardiac death in patients with low fT3 level versus normal fT3 level (>2.05 pg/ml) are shown in Fig. 3. The probability of 1-year all-cause, cardiac, and non-cardiac death among patients with low fT3 level was significantly higher than that among patients with normal fT3 level (log-rank $p < 0.001$, $p < 0.001$, and $p = 0.015$, respectively).

Table 1
Crude and adjusted odds ratios for in-hospital outcomes.

Endpoints		No. of patients	No. of events (%)	Univariate		Multivariate	
				Crude odds ratio (95% CI)	*p*-value	Adjusted odds ratio (95% CI)	*p*-value
Total death	Normal fT3	183	3 (1.6%)	1.00		1.00	
	Low fT3	87	17 (19.5%)	14.57 (4.14–51.26)	<0.001	14.38 (2.95–70.00)	<0.001
Cardiac death	Normal fT3	183	2 (1.1%)	1.00		1.00	
	Low fT3	87	9 (10.3%)	10.44 (2.21–49.44)	0.003	9.62 (1.15–80.33)	0.037
Non-cardiac death	Normal fT3	183	1 (0.5%)	1.00		1.00	
	Low fT3	87	8 (9.2%)	18.43 (2.27–149.84)	0.006	17.08 (1.71–170.69)	0.016

Multivariate models included the age, sex, body mass index, systolic blood pressure, B-type natriuretic peptide, serum sodium, creatinine, blood urea nitrogen, hemoglobin, C-reactive protein, and amiodarone use before admission. fT3, free triiodothyronine.

Table 2
Baseline characteristics according to thyroid status on admission based on fT3 levels.

Characteristics	Normal fT3 >2.05 pg/ml (*N* = 183)	Low fT3 ≤2.05 pg/ml (*N* = 87)	*p*-value
Age (years)	65.0 ± 16.0	72.3 ± 14.9	<0.001
Women, *n* (%)	55 (30.1)	30 (34.5)	0.464
Etiology of heart failure, *n* (%)			0.126
Ischemic	54 (29.5)	33 (37.9)	
Hypertensive	13 (7.1)	12 (13.8)	
Idiopathic	37 (20.2)	8 (9.2)	
Valvular	32 (17.5)	15 (17.2)	
Others	47 (25.7)	19 (21.8)	
Medical history, *n* (%)			
Prior hospitalization for heart failure	82 (44.8)	48 (55.2)	0.130
Hypertension	104 (56.8)	57 (65.5)	0.174
Dyslipidemia	91 (49.7)	34 (39.1)	0.101
Diabetes mellitus	75 (41.0)	35 (40.2)	0.906
Smoking	82 (44.8)	28 (32.2)	0.089
Ventricular tachycardia or fibrillation	51 (27.9)	25 (28.7)	0.882
Pacemaker or implantable cardioverter defibrillator	23 (12.6)	18 (20.7)	0.082
Cardiac resynchronization therapy	8 (4.4)	9 (10.3)	0.059
Stroke or transient ischemic attack	31 (16.9)	9 (10.3)	0.154
Chronic obstructive pulmonary disease or asthma	20 (10.9)	10 (11.5)	0.890
Hemodialysis	3 (1.6)	6 (6.9)	0.025
Medications prior to admission, *n* (%)			
Loop diuretics	83 (45.4)	54 (62.1)	0.010
Aldosterone antagonists	59 (32.2)	32 (36.8)	0.461
Thiazide diuretics	22 (12.0)	14 (16.1)	0.358
Angiotensin-converting enzyme inhibitors	29 (15.8)	11 (12.6)	0.489
Angiotensin receptor blockers	79 (43.2)	42 (48.3)	0.430
Calcium channel blockers	43 (23.5)	18 (20.7)	0.606
Beta blockers	90 (49.2)	39 (44.8)	0.503
Digitalis	40 (21.9)	19 (21.8)	0.997
Nitrates	47 (25.7)	29 (33.3)	0.191
Aspirin	62 (33.9)	31 (35.6)	0.777
Warfarin	68 (37.2)	26 (29.9)	0.241
Amiodarone	21 (11.5)	18 (20.7)	0.044
Statins	64 (35.0)	23 (26.4)	0.161
Initial clinical findings			
Paroxysmal nocturnal dyspnea, *n* (%)	76 (41.5)	38 (43.7)	0.758
Orthopnea, *n* (%)	113 (61.7)	56 (64.4)	0.717
Rales, *n* (%)	103 (56.3)	45 (51.7)	0.424
Third heart sound, *n* (%)	66 (36.1)	34 (39.1)	0.597
Jugular venous distension, *n* (%)	67 (36.6)	41 (47.1)	0.044
Peripheral edema, *n* (%)	116 (63.4)	54 (62.1)	0.881
Left ventricular ejection fraction ≤40%, *n* (%)	118 (64.5)	62 (71.3)	0.294
Atrial fibrillation, *n* (%)	76 (41.5)	31 (35.6)	0.354
Body mass index (kg/m^2)	24.0 ± 4.2	22.1 ± 3.9	<0.001
Heart rate (beats/min)	95.4 ± 28.0	89.1 ± 23.4	0.070
Systolic blood pressure (mmHg)	138.1 ± 33.3	130.8 ± 42.0	0.123
B-type natriuretic peptide (pg/ml[a])	750 [390–1237]	940 [530–1810]	0.002
Blood urea nitrogen (mg/dl)	26.1 ± 17.3	38.4 ± 23.9	<0.001
Serum creatinine (mg/dl)	1.29 ± 0.99	1.81 ± 1.31	<0.001
Serum sodium (mEq/l)	139.2 ± 4.0	137.4 ± 5.5	0.002
Hemoglobin (g/dl)	12.8 ± 2.4	11.5 ± 2.0	<0.001
C-reactive protein (mg/dl[a])	0.59 [0.18–1.46]	1.22 [0.32–3.89]	<0.001
Total bilirubin (mg/dl[a])	0.8 [0.6–1.3]	0.9 [0.5–1.4]	0.356
Length of hospital stay (days[a])	26 [15–47]	30 [18–51]	0.346

Plus minus value: mean ± SD. fT3, free triiodothyronine.
[a] Median [interquartile range].

Discussion

In this study, we identified fT3 as a useful prognostic marker in patients hospitalized for ADHF, while fT3 was superior to other thyroid hormones including TSH and fT4. In multivariate analysis adjusted for various markers of disease severity and amiodarone use, low fT3 level on admission was independently associated with higher in-hospital all-cause, cardiac, and non-cardiac death rates. In addition, lower fT3 was associated with increased medium-term (1-year) mortality in ADHF patients.

Thyroid hormone affects every cell, tissue, and organ in the body, and its homeostasis has a fundamental role in normal cardiac function [8–11]. The majority of serum thyroid hormones (95–99%) are bound to the carrier proteins including thyroxin-binding globulins, transthyretin, and albumin, which carry 75%, 20%, and 5%, respectively, of thyroid hormones within blood circulation, while a small fraction circulates unbound or free [25,26]. The free or unbound fraction of thyroid hormone is responsible for its biological functions in all tissues, with the major cardiovascular effects regulated by fT3, which increases tissue thermogenesis, cardiac contractility, heart rate, and cardiac output, and decreases systemic vascular resistance including that of the coronary artery [8,9,11]. As such, reduced fT3 levels may have adverse effects on the cardiovascular system, and thus cause poor prognosis in patients with cardiovascular disease [13,14,16].

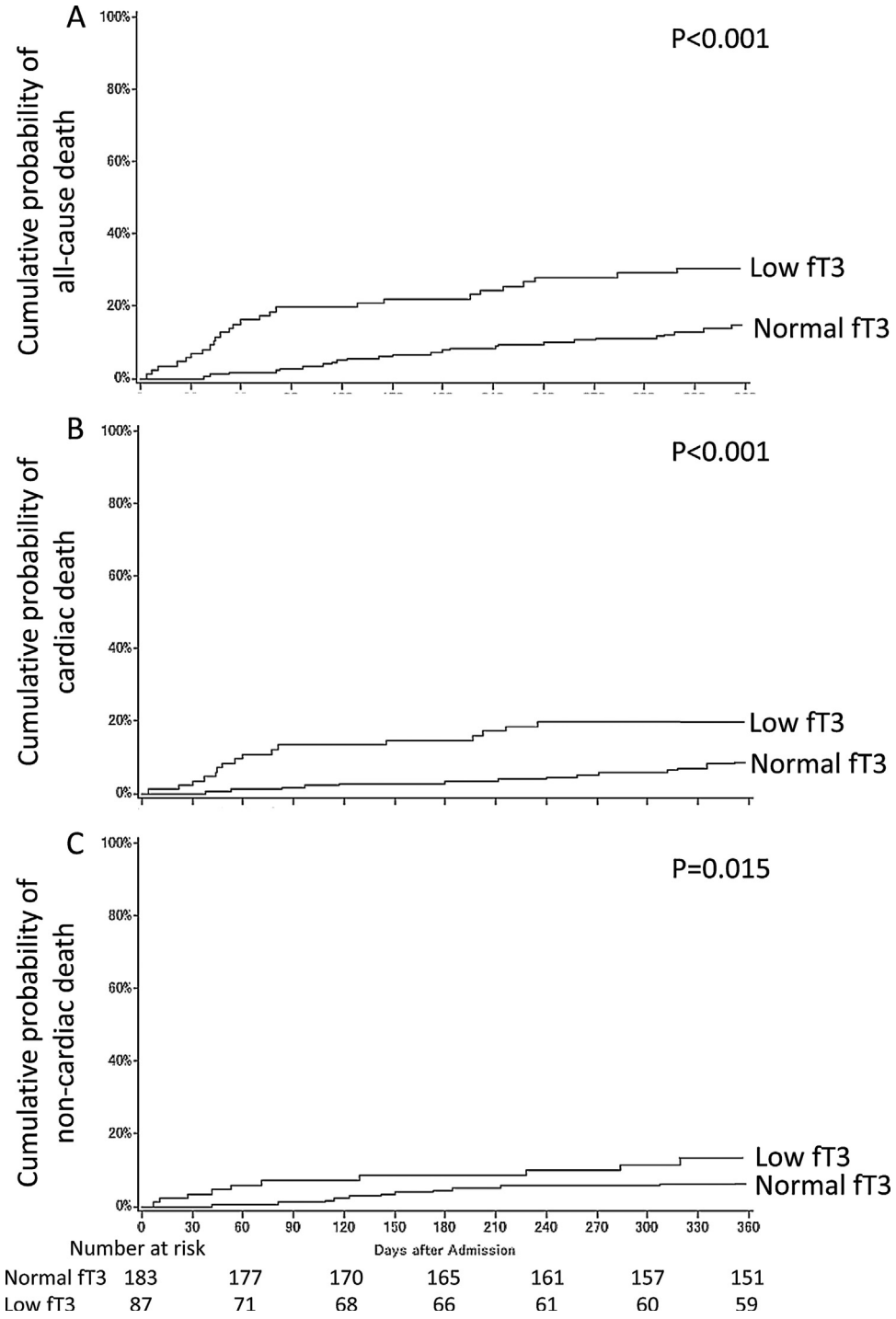

Fig. 3. Outcomes in acute decompensated heart failure patients with low or normal free triiodothyronine (fT3) levels. Kaplan–Meier estimate of all-cause death (A), cardiac death (B), and non-cardiac death (C) in 87 patients with low fT3 compared with 183 patients with normal fT3.

Numerous studies have also examined the relationship between TSH levels and outcomes in patients with chronic congestive heart failure [18,20,23]. However, the prognostic value of TSH remains controversial. For example, both elevated and suppressed TSH values were associated with an increased risk of death in patients with chronic heart failure, even after adjustment for other prognostic markers [18]. By contrast, abnormal TSH levels were not found to be an independent predictor of death in chronic heart failure patients from a randomized controlled trial cohort [20]. With respect to the association between fT3 and outcomes in patients with chronic congestive heart failure, the prognostic value of low fT3 has been reported in several studies. For example, Pingitore et al. and Kozdag et al. reported that low fT3 was an independent predictor of adverse outcomes [14,16]. Thus, we suggest that the prognostic value of low fT3 for predicting outcomes in patients with chronic phase congestive heart failure is superior to use of TSH levels. In the present study, lower fT3 level without overt thyroid dysfunction (low-T3 syndrome) on admission was a strong predictor of in-hospital and 1-year mortality, in terms of both cardiac causes and non-cardiac causes, in patients in the acute phase of decompensated heart failure needing urgent hospitalization and treatment. These findings expand upon

previous knowledge of the prognostic implication of fT3 value in patients with heart failure.

A typical pattern of altered thyroid hormone metabolism, characterized by low serum fT3 concentration, was described in patients with non-thyroidal illnesses, including acute myocardial infarction, adults and children after cardiopulmonary bypass, and heart failure [12,27–29]. The pathophysiological role of low-T3 syndrome is commonly interpreted as an 'adaptive' compensatory and beneficial response, which decreases metabolic demand in diseased states [30]. Reduced fT3 is more frequent in patients with NYHA III–IV severe heart failure, and is frequently related to a catabolic pattern characterized by lower plasma lipid levels, body weight, albumin levels, and lower cardiac index with increased left ventricular end diastolic pressure [10]. In the present study, patients with low fT3 had significantly higher age, B-type natriuretic peptide, and creatinine levels, and lower body mass index and hemoglobin levels, compared with patients with normal fT3. These data suggest that low fT3 may be an adaptive response to severely reduced conditions. This interpretation, however, has been questioned in recent years. Numerous reports, including the present study, have found that low-T3 syndrome is a strong independent predictor of poor outcome in hospitalized patients with cardiac disease and ADHF, even after multivariate analysis adjusted for various markers of disease severity [13,14,16]. Based on knowledge of the fundamental role of fT3 on cardiovascular homeostasis, a direct relationship between low-T3 syndrome and adverse outcome in patients with heart disease represents an attractive 'mal-adaptation' hypothesis. Because thyroid hormone action in the myocardium is via specific T3 receptors, low fT3 levels may worsen contractility, increase susceptibility to arrhythmias, and contribute to mortality in patients with heart failure despite normal T4 and TSH levels suggesting a euthyroid state [31]. A previous study demonstrated that a short-term intravenous infusion of T3 is well tolerated in patients with advanced heart failure, and there was an increase in cardiac output and a reduction in systemic vascular resistance, without change in blood pressure or heart rate [32]. In addition, short-term T3 replacement therapy significantly improved not only ventricular performance, but also the neuroendocrine profiles including noradrenaline, N-terminal pro-B-type natriuretic peptide, and aldosterone levels in patients with ventricular dysfunction and low-T3 syndrome [33]. Furthermore, one week of oral T3 administration in patients with milder heart failure has been shown to cause a moderate increase in left ventricular ejection fraction and exercise tolerance [34]. Although several inotropic agents have been shown to have deleterious effects on long-term survival, T3 has unique cellular mechanisms of action [35] that may not be associated with similar outcomes. Additional studies are required to clarify whether the decreased fT3 concentration is an 'adaptive' beneficial response or 'maladaptive' adverse process. Further, larger-scale multicenter and/or multinational randomized controlled trials are needed to define the effects of T3 replacement therapy in patients with heart failure.

Cardiac cachexia and poor nutritional status is a serious complication of heart failure, and is associated with poor prognosis [36]. In this study, patients in the low fT3 group had higher blood urea nitrogen, B-type natriuretic peptide, and C-reactive protein levels, and had lower body mass index, sodium, and hemoglobin levels than those in the normal fT3 group. Similarly, patients with cachexia had higher B-type natriuretic peptide and C-reactive protein levels, and had lower body mass index and hemoglobin levels than those without [36]. Above results suggest that reported characteristics of patients with cachexia were similar to those with low fT3 in this study. In addition, poor nutritional status may also contribute to altered thyroid metabolism in heart failure patients, because T3 production is known to be reduced in the fasting state [12,37]. Accordingly, it is our impression that there are many unanswered questions about the relationship between low fT3, cardiac cachexia, and prognosis in patients hospitalized for ADHF. Although our multivariate models included nutritional markers such as body mass index, B-type natriuretic peptide, serum sodium, blood urea nitrogen, hemoglobin, and C-reactive protein, further investigation is required to clarify the association of thyroid functional and nutritional status with the outcome of hospitalized ADHF patients.

There are several limitations to the present study. First, this is a single-center observational study with a limited number of study patients, making it difficult to establish causal relationships. Second, even with adjustments by multivariate analysis, we cannot exclude the possibility that residual measured and/or unmeasured confounders may have influenced our results. Third, the measurement of thyroid hormone was not performed in all ADHF patients, and was dependent on the physician's judgment, which introduces the potential for selection bias. Fourth, as we did not have follow-up thyroid function data, the prevalence and prognostic impact of persisting thyroid function abnormality in this study population are unclear. Fifth, as we have no data on thyroid sonography or autoantibodies, the prevalence of autoimmune thyroid disorders in this study ADHF cohort is unclear. Finally, right heart catheterization, exercise tolerance capacity, and detailed echocardiographic study were not performed in all the study patients, and we cannot demonstrate more detailed echocardiographic, hemodynamic, and exercise tolerance data in this ADHF cohort.

Conclusions

Low fT3 levels on admission were associated with in-hospital short-term outcome and 1-year medium-term prognosis in patients hospitalized for ADHF. Thyroid hormone measurements might be useful in the risk stratification of hospitalized ADHF patients.

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Conflict of interest

The authors declare that there is no conflict of interest.

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Appendix. Collaborator (Statistical analysis and data center)

Katsunori Shimada PhD (STATZ Institute Inc., Tokyo, Japan).

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