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ORIGINAL RESEARCH

Study of Thyroid Functions in Chronic Kidney Disease Patients

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ABSTRACT

Background: Abnormal thyroid function tests are frequently observed in patients of chronic kidney disease. Kidneys plays a significant role in thyroid hormone metabolism by conversion of T4 to T3 (the active metabolite). Low plasma free T3 in ESRD is a marker of the inflammation and endothelial activation; and is known to predict all cause mortality. The present study was done look for the biochemical abnormalities of thyroid function tests in chronic kidney disease and to correlate the severity of CKD and alterations of thyroid indices.

Materials and Methods: In a cross sectional study, thyroid function test [TT3, TT4, FT4, TSH] were estimated by CLIA in 50 patients of chronic kidney disease who were in various stages. Symptoms of hypothyroidism, thyroid hormone abnormalities and CKD stage were analyzed using Chi square test and ANOVA tests.

Results: Among the mean age was 48.8 ± 12.2 years of which 33 were male and 17 females. The mean value of TT3 in CKD stage 3, 4, 5 were 1.01±0.39; 1.05± 0.6; 0.95±1.09 µg/mL respectively. (p= 0.02 Significant). The mean value of TT4 in CKD stage 3, 4, 5 were 6.3± 2.4; 5.5± 1.5; 5.11 ± 1.01 µIU/ml respectively. (p=0.71 Not significant).

Conclusion: Total T3 and total T4 were found to be progressively decreased as stage of CKD increased. There was no significant correlation between TT4 and CKD stage. There was a significant correlation between the prevalence of thyroid dysfunction and the stage of chronic kidney disease.Higher the degree of renal insufficiency, the higher was the prevalence of thyroid hormone abnormalities, the levels of thyroid profile i.e T3, T4 decreases and TSH increases as severity of renal failure increases. Thyroid hormone abnormalities could represent a risk factor for cardiovascular disease and might also be implicated in kidney disease progression.

Keywords: Chronic kidney disease, Thyroid Function Test, Hypothyroidism, Subclinical Hypothyroidism.

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INTRODUCTION

"The world is facing a global pandemic of chronic kidney disease. As the morbidity and mortality from infectious diseases decline, life expectancy increases and chronic degenerative diseases have become more prevalent. CKD is unique amongst the chronic non-infectious illnesses…..".[1]

CKD is usually a progressive, irreversible condition that is the 8th leading cause of death in the United States. According to the population study, 1 in 10 American adults (more than 30million people) suffer from some level of CKD. It has been estimated from population

survey data that at least 6% of the adult population in the United States has CKD at stages 1 and 2. An unknown subset of this group will progress to more advanced stages of CKD. An additional 4.5% of the U.S. Population is estimated to have stages 3 and 4 CKD. The most frequent cause of CKD is diabetic Nephropathy, most often secondary to Type 2 DM.[2]

Indian prevalence of CKD as 13–15.04% with stage 1, 2 and 3 as 6.62%, 5.40% and 3.02% respectively. India being the diabetic capital of the world, diabetic Nephropathy is the commonest cause of CKD. There are about 7.85 million CKD patients in India.[3]

Patients with End Stage Renal Disease display a variety of endocrine disturbances. However the evidence of endocrine dysfunction commonly consists only of laboratory abnormalities, many of which are not associated with apparent clinical signs and symptoms of the disease.[4] Among which Thyroid function has been extensively evaluated in patients with CKD.

Chronic kidney disease affects thyroid function in multiple ways, including low circulating thyroid hormone concentration, altered peripheral hormone metabolism, disturbed binding to carrier proteins, possible reduction in tissue thyroid content and increased iodine stores in thyroid glands. TT3, TT4, FT3 are decreased more commonly in patients with CKD. But FT4, TSH levels are normal in these patients and indicate euthyroid status. We speculate that the low thyroid state in uremia serves to defend against protein wasting and misguided attempts to replete thyroid hormone stores may worsen protein malnutrition.[5]

Some studies showed an increased incidence of subclinical hypothyroidism in CKD patients and higher prevalence of hypothyroidism in patients with terminal renal failure. It has been estimated that primary hypothyroidism may occur in up to 9.5% of ESRD patients when compared to 0.6 to 1.1% of general population.[6,7]

When hypothyroidism becomes more severe it can cause reduced cardiac function and lead to progressively worsening kidney function. Thus the prevalence of subclinical hypothyroidism in patients with CKD might be a risk factor for both cardiovascular disease and progressive kidney disease.[6]

This study is designed to determine the prevalence of thyroid dysfunction in CKD patients in order to intervene at an early stage depending upon the hormone abnormalities and reduce both the cardiovascular risk and progressive worsening of kidney function.

Aim & Objectives

1. Study of biochemical abnormalities of thyroid function tests in chronic kidney disease.
2. To correlate the severity of chronic renal failure and alterations of thyroid indices

MATERIALS & METHODS

Source of data:

Minimum 50 patients both male and female patients with CKD over period of Eighteen months admitted in Katuri Medical College, Guntur were included under study.

Study Period:

Study was conducted between March 2019 and August 2021 for a period of 18 months.

Sample Size:

50 patients both male and female patients with CKD over period of 18 months admitted to Katuri Medical College, Guntur.

Inclusion Criteria:

- Symptoms of uremia for 3 months or more.
- Ultrasound evidence of chronic kidney disease
  a) Bilateral contracted kidneys- size less than 8 cm in male and size less than 7 cms in female.
  b) Poor corticomedullary differentiation.

- Supportive laboratory evidence of CKD like anemia, urine specific gravity, changes in serum electrolytes, etc.,
- Patients with CKD more than 18 years.

Exclusion Criteria:

- Patients with CKD less than 18 years.
- Patients who have been diagnosed to be having thyroid disorder.
- Patients on drugs altering thyroid profile like amiodarone, steroids, dopamine, phenytoin, estrogen pills, iodine containing drugs.
- Patients on thyroid hormone replacement or on antithyroid drugs.

Study Design:

Single Centre, cross sectional study. In the study period of 18 months among patients admitted in Nephrology ward after applying inclusion and exclusion criteria 50 patients were included in this study. Patients who fulfilled the criteria for CKD and who are on conservative management and hemodialysis. Informed consent was obtained from all patients.

After selecting the patients, fulfilling the above criteria, about 5ml of blood sample is collected in non heparinised serum bottle and sent for thyroid profile.

Components of thyroid profile in this study are serum total triiodothyronine (TT3), serum total thyroxine (TT4), serum thyroid stimulating hormone (TSH), serum free triiodothyronine (FT3), serum free thyroxine (FT4).

Kidney function was assessed by estimated creatinine clearance which was calculated by using the Cockcroft – Gault Equation.

1.Cockcroft –

Gault Equation: Estimated creatinine clearance (ml/mt) (140-Age) X body weight in k.g.

=72 X Pcr (mg/dl) (multiply by 0.85 for women)

Thyroid function was assessed by measuring TT3, TT4 and TSH level in serum. Serum FT4 was estimated for all TSH levels >5 mIU/L. Serum TT3, TT4, and FT4 were estimated by competitive chemiluminescent immuno assay.

TSH estimation was done by ultra-sensitive sandwich Chemiluminescent immuno assay (CLIA).

Blood urea estimation was done by using diacetyl monoxime (DAM) method. And Serum creatinine estimation was done by modified kinetic Jaffe method.

Detailed clinical history and clinical examination was undertaken with preference to thyroid and renal diseases. The following investigations were performed.

1. Urine for specific gravity and broad cast.
2. Peripheral smear for anemia and burr cells.
3. Renal parameters like blood urea, Serum creatinine and Creatinine clearance (using Cockcroft- Gault formula).
4. Serum electrolytes with calcium and phosphorus.
5. ECG and chest X ray to look for features for hypothyroidism and renal failure like pleural effusion, pericardial effusion.
6. USG abdomen for evidence of chronic kidney disease

Limitations of the study:

- Small sample size. (only 50 patients)
- Prevalence of hypothyroidism increases as the age advances. So we have to consider the influence of age on hypothyroidism.

- Geographical variation of goiter and thyroid problems

Statistical Analysis

The information collected regarding all the selected cases were recorded in the master chart. Data analysis was done with the help of computer using The Statistical software namely SPSS 15.0, Stata 8.0, MedCalc 9.0.1 and Systat 11.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

RESULTS

In our study we evaluated 50 patients with various grades of chronic kidney disease

Table 1: Sex distribution

Sex	Cases	
	Number	Percentage
Male	33	66
Female	17	34
Total	50	100

Among 50 patients in the sample 33 patients were males, and 17 patients were females.

Table 2: Age Distribution

Age group (years)	Cases	
	Numbers	Percentage
21-30	6	12
31-40	6	12
41-50	10	20
51-60	20	40
>60	8	16
Total	50	100
Range	21-70	
Mean	48.8	
S.D	12.2	

The range was from 21 to 70 years. Most of the patients in the sample were in the age group of 51-60 years. And mean age was 48.8 years.

Table 3: Prevalence of diabetes mellitus and hypertension

Cases	Hypertension					
DM	YES	%	NO	%	Total	%
YES	13	26	9	18	22	44
NO	10	46	18	36	38	66
Total	23	46	27	54	50	100

Of the 50 patients with CKD, 22 patients (44%) were diabetic, and 23 patients (46%) were hypertensive. 13 patients (26%) were having both diabetes and hypertension. 18 patients (36%) were neither having diabetes nor hypertension.

Table 4: Prevalence of symptoms of hypothyroidism

Symptoms	Cases	
	Numbers	Percentage
YES	13	26

NO	37	74
Total	50	100

Symptoms of hypothyroidism like tiredness, somnolence, weight gain, cold intolerance, constipation, hoarseness of voice etc., were studied in CKD in the study population.
Of the 50 patients with CKD, 13 patients (26%) only were symptomatic and majorities (74%) were asymptomatic. Biochemically 5 patients were hypothyroid and rest 8 were in subclinical hypothyroid range.

Table 5: Prevalence of patients on hemodialysis

Hemodialysis	**Cases**	
	Numbers	**Percentage**
YES	31	62
NO	19	38
Total	50	100

Of 50 patients with CKD 31 patients (62%) were undergoing multiple haemodialysis and 19 patients were on conservative medical management.

Table 6: Prevalence of patients in various CKD stage

CKD Stage	**Cases**	
	Numbers	**Percentage**
3	6	12
4	6	12
5	38	76
Total	50	50

Of the 50 patients in this sample, 6 patients (8%) belonged to stage 3, and 6 patients (8%) to stage 4 and 38 patients (84%) to stage 5.

Table 7: Prevalence of abnormalities of thyroid function based on thyroid function tests.

Impression	**Cases**	
	Numbers	**Percentage**
HYOTHYROIDISM	5	10
SUBCLINICAL HYPOTHROIDISM	10	20
LOW TT3 OR TT4 WithNormalTSH	14	28
Normal	21	42
Total	50	50

Of the 50 patients in this sample, 5 patients (10 %) had hypothyroidism 10 patients (20%) had subclinical hypothyroidism 14 patients (28%) had Low TT3 or TT4 with normal TSH, Totally 29 patients (58%) had some abnormalities in thyroid function.

Table 8: Relationship between CKD Stage and Symptoms of Hypothyroidism

CKD Stage	**Symptoms**				**Total Number**
	YES		**NO**		
	Number	**%**	**Number**	**%**	**50**
STAGE3	-	-	6	100	6
STAGE4	1	16.67	5	83.33	6

STAGE5	12	31.58	26	68.42	38
CHISquareValue		2.9945			
PValue		0.23			

Out of 50 patients 13 had symptoms suggestive of hypothyroidism, of which 2 patient (15.4%) was in stage 4 CKD and rest 11 patients (84.6%) were in stage 5 CKD. Though symptoms were prominent in advanced renal failure, this correlation was statistically not significant.

Table 9: Relationship between CKD Stage & thyroid dysfunction

Thyroid Dysfunction	**CKD Stage**					
	3		**4**		**5**	
	No	**%**	**No**	**%**	**No**	**%**
Hypothyroidism	-	-	-	-	5	13.15
Subclinical Hypothyroidism	-	-	1	16.67	9	23.68
Low TT3 or TT4 withNormalTSH	-	-	1	16.66	13	26.31
Normal	6	100	4	66.67	11	36.84
Total	6	100	6	100	38	100
Chisquarevalue		12.765				
Pvalue		0.04				

Of the 50 patients in the study group, 38 patients had stage 5 CKD. 13.15% of stage 5 CKD pts had hypothyroidism when compared to stage 3 (0%) and stage 4(0%). A 23.68% of patients of stage 5 CKD had sub clinical hypothyroidism when compared to stage 3(0%) and stage 4 (16.67%).

Low TT3 or TT4 with normal TSH abnormalities in stage 3 is 0% and in 4 &5 CKD were 16.67% and 26.31% respectively.So higher the stage of CKD, higher was the prevalence of thyroid dysfunction. This correlation was found to be statistically significant.

Table 10: Relationship between CKD Stage & hematological parameters and their significance.

	CKD stage						**Significance**		
Paremeters	**3**		**4**		**5**				
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**F***	**P value**	
BlUrea	75.76	29.65	91.5	23.5	163.02	38.03	14.75	<0.01	HS
SrCreat	2.88	0.29	3.4	0.5	7.05	2.1	13.47	<0.01	HS
T3	1.01	0.34	1.05	0.6	1.07	1.94	4.72	0.02	S
T4	6.33	2.42	5.54	1.55	5.11	2.02	0.335	0.71	NS
TSH	2.16	1.25	3.67	1.35	5.76	3.94	9.683	<0.01	HS

F *- Oneway ANOVA test; P value: < 0.001 Highly Significant (HS); P value: < 0.05 Significant (S): P value: > 0.05 -Not Significant (NS)

Table 11: Relationship between Abnormal thyroid function and Hematological parameters and their significance

	Abnormal Thyroid Functions				
Paremeters	**Hypo**	**Sub Clinical**	**Low TT3 or TT4**	**Normal**	**Statistical Significance**

	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F	P	
BlUrea	190.4	21.5	148.8	41.8	150.9	39.8	126.7	53.3	3.25	<0.01	HS
SrCreat	7.6	1	7.6	3.6	6.5	1.3	4.8	2.02	5.01	<0.01	HS
T3	0.6	0.2	2.3	0.39	0.22	0.12	0.94	0.3	116.8	<0.01	HS
T4	3.28	1.5	4.7	0.83	5.04	1.6	6.14	2.3	4.32	<0.01	HS
TSH	12.9	3.4	8.06	1.88	3.19	1.5	3.12	1.2	60.83	<0.01	HS

F *- Oneway ANOVA test ; P value: < 0.001 Highly Significant (HS); P value: < 0.05 Significant (S): P value: > 0.05 -Not Significant (NS).

Blood urea and Serum Creatinine in our study:

The mean blood urea was 75.76± 29.5; 91.5 ± 23.5; 163.02 ± 38.03 mg/dL, and serum creatinine was 2.88 ± 0.29; 3.4± 0.5; 7.05 ± 2.1 mg/dL in stages of CKD 3,4,5 respectively.

The mean blood urea was 126.4± 13.5; 148.6± 33.8; 194.1± 28.8 mg/Dl and serum creatinine was 6.4± 2.2; 7.4± 2.4; 7.66± 1.66 mg/dL in patients with thyroid function tests showing normal, subclinical and overt hypothyroidism respectively.

Blood urea and serum creatinine level increased as stage of CKD increases and also in patients with TFT showing hypothyroid compared to normal patients. This correlation was statistically significant.

T3 in our study:

The average Total T3 (TT3) value was 1.06 µg/mL. The mean value ofTT3 in CKD stage 3, 4, 5 were 1.01±0.39; 1.05± 0.6; 0.95±1.09 µg/mL respectively.

TT3 was decreased in 18 patients of which 5 were hypothyroid. 13 patients who were in CKD stage 5 without symptoms of hypothyroidism had decreased TT3. Of which 6 patients had associated decreased TT4.

According to our study as CKD stage increases there was progressive decrease in TT3 levels and is statistically significant. There was progressive decrease in TT3 as renal dysfunction increases and was statistically significant.

T4 in our study:

The average Total T4 (TT4) value was 5.31µIU/ml. The mean value of TT4 in CKD stage 3, 4, 5 were 6.3± 2.4; 5.5± 1.5; 5.11 ± 1.01 µIU/ml respectively. TT4 was decreased in 10 patients of which 4 were hypothyroid and rest 5 had decreased TT4 without any symptoms of hypothyroidism.

There was decrease in TT4 as CKD stage increases but this was statistically not significant.

TSH in our study:

Values of TSH vary from 0.24-18.92 µIU/mL with mean value in 5.08 µIU/mL. Among the 50 patients, TSH was normal in 36 patients (72%) and In 10 patients (20%) with subclinical hypothyroidism TSH values were between 5.84 and 9.26 µIU/ml and 6 patients with hypothyroidism TSH values varied between 10.78 to 18.92 µIU/ml.

TSH level increased as stage of CKD increased and this correlation was statistically significant.

Ultra sound abdomen showed evidence of CKD in all patients. Bilateral contracted kidney was present in 72% of the patients and remaining 28% patients had poor corticomedullary differentiation.

This study was designed to determine the prevalence of thyroid dysfunction in CKD patients in order to intervene at an early stage depending upon the hormone abnormalities and reduce both the risk of cardiovascular disease and progression of kidney dysfunction.

DISCUSSION

The kidney normally plays an important role in the metabolism, degradation, and excretion of several thyroid hormones. It is not surprising therefore that impairment in kidney function leads to disturbed thyroid physiology. All levels of the hypothalamic-pituitary-thyroid axis may be involved, including alterations in hormone production, distribution, and excretion.[7-9]

A large number of hormonal systems are affected by CKD, yet it remains unclear to what extent these changes are responsible for manifestations of uremic syndrome. Patients with CKD often have signs & symptoms suggestive of thyroid dysfunction & hence the diagnosis of thyroid disease in these patients has obvious prognostic implications. The data reported deals primarily with the clinical symptoms sign index & biochemical parameters.[10]

Several investigators have studied thyroid hormone levels in CKD and obtained variable results.

Overall 9% of patients with CKD had subclinical hypothyroidism. 7% of patients with mild CKD had low thyroid function, compared to 18% of those with moderate CKD.

Recently, Quion-verde et al have also reported higher prevalence of upto 5% of frank hypothyroidism in patients with chronic renal failure, in comparison with hospitalised patients with normal renal function (0.6%).[11]

In an Indian study, of 127 patients with CKD studied, 93 patients (73%) showed significant [‘p’ value (<0.05)] reduction in their TT3,TT4,FT3 levels in serum.[12]

Many studies conducted in CKD showed Low TT3 normal TT327 low FT3 normal FT3 in patients on HD.70 Even some studies have reported low TT4 (low T4 syndrome), normal TT414 and low normal or lower FT4 levels. Basal concentrations of circulating TSH have been found at different levels in different studies. Normal levels or TSH were reported from previous Indian studies.71,72 Thus a multitude of defects at all levels of hypothalamicpituitary- thyroidal-peripheral axis does seem to exist in uremia.[8]

In the majority of studies, TT4 concentrations were found to be low or low normal. However, FT4 levels were within normal limits. This is attributed to lowering of thyroxine binding globulin concentration as well as presence of inhibitors of thyroid hormone bindings to the thyroid binding proteins. Levels of TT3 and FT3 suffer further reductions in CKD, which is thought to be due to impairment in deiodination of T4, a principal process by which T3 is produced at peripheral levels.

Avasthi et al showed that mean T3 level was reduced below normal in GFR less than 10 ml/min. In higher GFR, it was present in low normal and there was no linear correlation between T3 level and GFR.

In our study, study of thyroid dysfunctions in chronic renal failure is done with 50 cases. Cases were selected according to inclusion and exclusion criteria which are mentioned earlier. The cases and controls included different age groups. The range was from 21 to 70 years. Most of the patients in the sample were in the age group of 51-60 years.

Of the 50 patients studied, 5 patients (10%) had hypothyroidism, 10 patients (20%) had subclinical hypothyroidism and 14 patients (28%) had some thyroid hormone abnormalities in the form of reduction in TT3, TT4 levels. So totally 58% of patients with CKD had some thyroid hormone abnormalities.

Among 14 patients with some thyroid hormone abnormalities 3 patients (6%) had only decreased TT4, 6 patients(12%) had decreased TT3, 5 patients(10%) had decreased TT4 and TT3 . All these patients were euthyroid and TSH levels were within normal limits.

Excluding hypothyroidism and subclinical hypothyroidism, the mean TSH level in our study is within normal limits. The mean TSH levels are also within normal limits for the various ranges of GFR. But TSH level does show any linear correlation with the severity of renal failure. This is consistent with the study conducted by Joseph et.al and Hardy et.al.[13] These

studies demonstrated abnormality in hypophyseal mechanism of TSH release in uremic patients as the as the TSH response to the TRH was blunted.

Other studies conducted by Spector and Ramirez etal,[14,15] revealed low T3 T4 level with high TSH level suggesting maintenance of pituitary thyroid axis.

In our study total 13 patients were having symptoms suggestive of hypothyroidism of which 5 were hypothyroid biochemically and rest 8 patients had TFT was in subclinical range. Thus some of the symptoms of CKD tend to be overlap with hypothyroidism and may pose difficulty in diagnosis.

Our study is consistent with the results of Zoccali C et al,[16] and Ramirez et al,[14] study showing low T3, low T4 and normal or mild elevation of TSH. Yet it is unclear that to what extent these changes are responsible for the manifestations of uremic syndrome. From the various studies it has been suggested that this thyroid profile derangements is a part of body adaptation mechanism.

Ramirez et al,[14] and associates, reported high prevalence upto 58% of goitre in patients with CKD as compared to 8% in control are as from the same geographic area especially those on chronic dialysis. The possible explanation is due to accumulation of iodides in Thyroid gland due to decreased renal clearance in CKD patients. Apart from goiter, study conducted by Hegedus etal showed thyroid gland volume was significantly increased in patients with CKD.

Relationship between CKD stage and thyroid dysfunction: Higher the stage of CKD, there is an increased prevalence of thyroid dysfunction in CKD patients.

In our study, 13.15% of stage 5 CKD patients had hypothyroidism when compared to stage 3 (0%) and stage 4 (0%). 9 patients of stage 5 patients had subclinical hypothyroidism when compared to no patients in stage 3 and 1 patient in stage 4. Low TT3 or TT4 according to stage 4 and satge 5 are found in 1 and 13 patients respectively.

TT3, TT4, FT4 levels progressively decreased as the CKD stage increased but FT4, TSH levels were normal except in patients with overt hypothyroidism. Even though symptoms of hypothyroidism were prominent in advanced stage of renal disease, statistical analysis did not show significant correlation.

Despite the recent considerable improvements in renal replacement therapy, cardiovascular disease still remains the main cause of morbidity and mortality in CKD patients. It is evident from various studies conducted by Lindner, et.al (1974).[17]

So many traditional and nontraditional risk factors are therefore cardiovascular disease and its related morbidity and mortality. Apart from them hypothyroidism and subclinical hypothyroidism are linked to an increased risk of cardiovascular disease and reduced cardiac function.

Patients with CKD are at greatly increased risk of thyroid dysfunction. “Thyroid hormone abnormalities could represent a risk factor for cardiovascular disease and might also be implicated in kidney disease progression”.[6]

CONCLUSION

Thyroid disorders and CKD are independently some of the most prominent medical conditions found in patients. Due to the high prevalence of both, it is important to consider the physiological association of thyroid dysfunction in relation to kidney disease.The most common changes in CKD relating to the thyroid gland are of low T3 levels and subclinical hypothyroidism.

The prevalence of subclinical hypothyroidism increases consistently in patients who have a decline in GFR. Low T3, normal to reduced T4 levels, and normal TSH often result in increased thyroid gland volume. In turn, a decrease in renal function also accounts for an ineffective clearance of abnormal serum constituents, inflammatory cytokines, iodide

excretion, and an increase of nitrogen conservation. All of these factors have been clinically proven to affect the normal physiology and metabolism of thyroid hormones.

Hyperthyroidism is usually not associated with CKD but is known to accelerate it. It is very important to consider all clinical features and thyroid manifestations in those patients with CKD.As seen in many evidence-based studies and current clinical cases, there are distinct relationships in thyroid dysfunction and kidney disease and vice versa.

Clinicians, including nephrologists, must consider the dangers of thyroid disease and its appropriate treatment in conjunction to treating CKD. Patients who receive appropriate treatment for their thyroid disease have a decreased chance of developing or exacerbating renal dysfunction. However, treating patients with a mild elevation of TSH (less than 10 IU/mL) results in a negative nitrogen balance by increased muscle catabolism. Clinicians should look for low T3 levels in patients prior to renal transplant as low levels are associated with renal graft loss.

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