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Original Article

Biochemical Profile of Thyroid Abnormalities in Chronic Kidney Disease and Its Correlation with Glomerular Filtration Rate

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Abstract

Background: Thyroid functions are affected in chronic kidney disease by multiple ways. The decline in kidney Function is accompanied by changes in the synthesis, secretion, metabolism and elimination of Thyroid hormones. The study is planned to determine the correlation between severities of chronic Kidney disease and the status of thyroid function. ***Objectives:*** To study the biochemical abnormalities of thyroid function tests in CKD patients and to study the correlation between thyroid dysfunction and severity of renal diseases. ***Materials and Methods:*** The study was carried out among patients visiting the Department of General Medicine and Nephrology at tertiary care centre Bengaluru, for a period of 18 months. 50 CKD patients satisfying the inclusion and exclusion criteria were included in the study. Blood urea, serum creatinine and thyroid Profile was done in all the 50 patients. Estimated - GFR was calculated by MDRD formula staging was done according to KDIGO classification. The thyroid parameters were studied in various stages of CKD and correlation studies were done for eGFR with each of the thyroid parameters. ***Results:*** Majority of the patients belonged to 61-70 years age group & 62% were males & 38% were females. Overall 60% of the CKD patients had thyroid abnormalities among which 30% had low T3 syndrome, 16% had subclinical hypothyroidism, 14% had overt clinical hypothyroidism and 40% were euthyroid. When the distribution of these thyroid abnormalities were analyzed in relation to different CKD stages it is found that as the CKD stage progressed number of patients with different thyroid abnormalities also increased. 60% of the patients with thyroid abnormalities belonged to stage 5, 30% belonged to stage 4 while remaining 10% belonged to stage 3, Further correlation between TSH and GFR was analysed, it showed a inverse relationship with correlation coefficient [r] of -0.342 with P value of 0.0007 which is statistically significant stating that as the e-GFR decreased TSH increased. When correlational studies were done for e-GFR with FT4 and FT3 levels, they showed a positive correlation, with correlation coefficient [r] of 0.377 with P value of 0.003 in case of FT4 and coefficient [r] of 0.352 with a P value of 0.006 in case of FT3, both of which was statistically significant stating that as the e-GFR decreases FT3 and FT4 also decreases. ***Conclusion:*** Patients with CKD are at increased risk of developing Thyroid dysfunction either in the form of low T3 syndrome, subclinical or clinical hypothyroidism and is more significant as the stage of CKD progresses.

Keywords: ***Chronic kidney disease, Glomerular filtration rate, free*** **thyroxin, Thyrotropin.**

Introduction

Chronic kidney disease is a global health threat which is associated with increase in morbidity and mortality. It is defined as kidney damage or an estimated glomerular filtration rate eGFR <60ml/min/1.73m persisting for 3 months or more, irrespective of cause. Initially, it manifests only as a biochemical abnormality but, eventually, loss of excretory, metabolic and endocrine functions of the kidney leading to clinical symptoms and signs of renal failure, collectively referred to as uremia.

In physiologic conditions, both the kidneys and the thyroid are intimately related. While thyroid hormones are necessary for growth and development of kidney and for the maintenance of water and electrolyte balance, the kidneys are involved in the metabolism and clearance if thyroid hormones.

The decline in kidney function affects thyroid function in multiple ways, including effects on hypothalamo-pituitary-thyroid axis, low circulating thyroid hormone concentration, altered peripheral hormone metabolism and disturbed binding to carrier proteins [1-6].

There is a considerable overlap between the symptoms of CKD and hypothyroidism like fatigue, lethargy, edema, cognitive and sexual dysfunction. Hence it is difficult to exclude thyroid abnormality merely on clinical basis, Various studies have been conducted on thyroid profile in CKD patients, ending with conflicting results. It has been suggested that primary hypothyroidism may be more Common in patients with end stage

renal disease compared to general population. In addition a number of thyroid hormone abnormalities have been reported even among euthyroid CKD patients in the form of reduced total and free triiodothyronine and thyroxine levels [7,8].

Previous studies have suggested that uremic patients have an increased thyroid volume compared to subjects with normal renal function and a higher prevalence of goiter, mainly in women. Also, thyroid nodules and thyroid carcinoma are more common in uremic patients than in the general population.

In view of above, the relationship between kidney function and thyroid abnormalities have to be made clear. Therefore, the present study was planned to determine the correlation between severity of chronic kidney disease and the status of thyroid function.

Materials and Methods

Source of Data: Patients attending Department of General Medicine and Nephrology at tertiary care center in Bangalore diagnosed with chronic kidney disease.

Study Period: 18 months

Sample Size: 50 patients who are diagnosed to have chronic kidney disease.

Study Design: Descriptive Cross sectional study

Inclusion Criteria

1. Patients diagnosed as chronic kidney disease as per KDIGO Definition of CKD irrespective of aetiology
2. Age more than 18 years.

Kdigo Criteria for CKD

CKD is defined as abnormalities of kidney structure or function, present for more than 3 months, with implications for health.

Criteria for CKD (either of the following present for more than 3 months)

Markers of kidney damage (one or more)	• Albuminuria (AER more than 30mg/24 hours) • urinary sediment abnormalities • electrolyte and other abnormalities due to tubular disorders • abnormalities detected by histology • structural abnormalities detected by imaging • history of kidney transplantation
Decreased GFR	GFR less than60 ml/min/1.73m^2

Exclusion Criteria

1. Patients with known or clinically suspected thyroid dysfunction.
2. Patients who are already on thyroid hormone treatment or antithyroid medications.
3. Women with pregnancy.

Methodology

1. Patients with known case of chronic kidney disease after assessing for inclusion and exclusion criteria will be enrolled for study after informed consent.
2. Patients will be evaluated, followed by basic investigations like complete blood count, urine routine, blood urea and serum creatinine.
3. Thyroid Profile (FT3, FT4, TSH) will be done through ELISA method by COBALT 6000 Analyser by collecting 5 ml Venous blood in heparin free disposable syringe.
4. GFR will be calculated by MDRD formula.

   Equation from the Modification of Diet in Renal Disease study

   Estimated GFR (mL/min per 1.73 m²) = $1.86 \times (S_{cr})^{-1.154} \times (age)^{-0.203}$

   Multiply by 0.742 for women

   Multiply by 1.21 for African ancestry
5. TSH, FT3, FT4, values obtained in each patient will be correlated with e-GFR to find the nature of correlation and its significance by calculating P value in order to study the relationship between thyroid dysfunction and severity of CKD

Normal Laboratory Values

- Serum thyroid stimulating hormone (TSH) - 0.27 to 4.20 micro/ml
- Serum free T4 - 12.3 to 21.3 pmol/L
- Serum free T3 - 2.6 to 4.4 Pg/ml
- Blood urea - 17 to 43 mg/dl
- Serum creatinine - 0.6 to 1.2 mg/dl

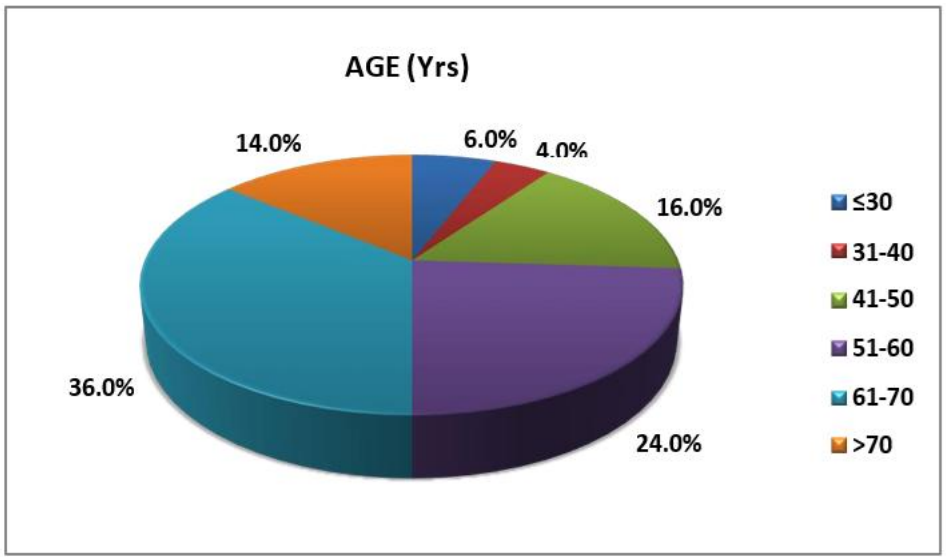
Results and Discussion

In this study, 50 patients, who were diagnosed to have chronic kidney disease were subjected to a number of investigations including thyroid profile. The following results were obtained after statistical analysis:

1. Age Distribution

Table 1: Distribution of Cases According to Age

AGE (in Years)	Number of subjects	Percentage (%)
≤30	3	6
31-40	2	4
41-50	8	16
51-60	12	24
61-70	18	36
>70	7	14
Total	50	100



F1gure 1: Distribution of Cases According to Age

2. Gender Distribution

Table 2: Distribution of Cases According to Sex

SEX	Number of subjects	Percentage (%)
Male	31	62
Female	19	38
Total	50	100

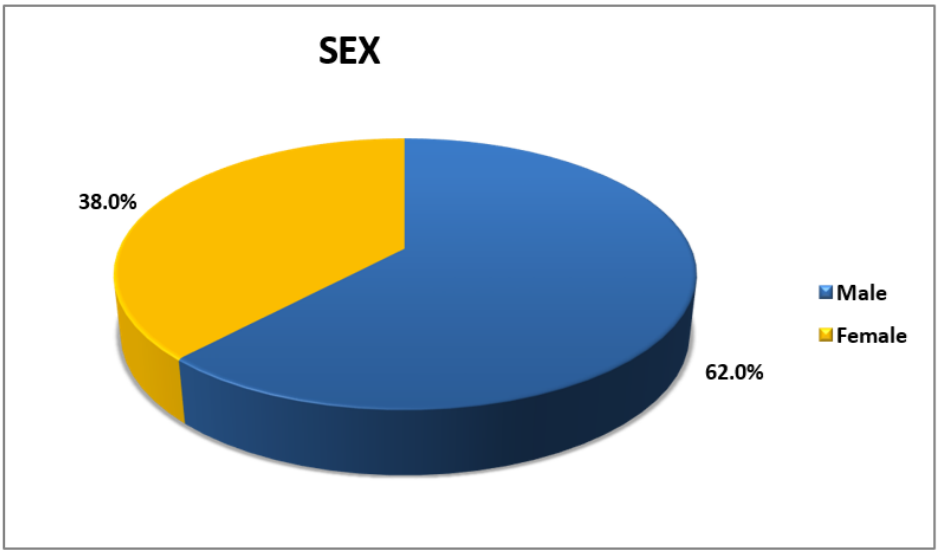


Figure 2: Distribution of Cases According to Sex

3. Distribution According to Stage of CKD

Table 3: Distribution of Cases According to CKD Stage

CKD STAGE	Number of subjects	Percentage (%)
3	5	10
4	12	24
5	33	66
Total	50	100

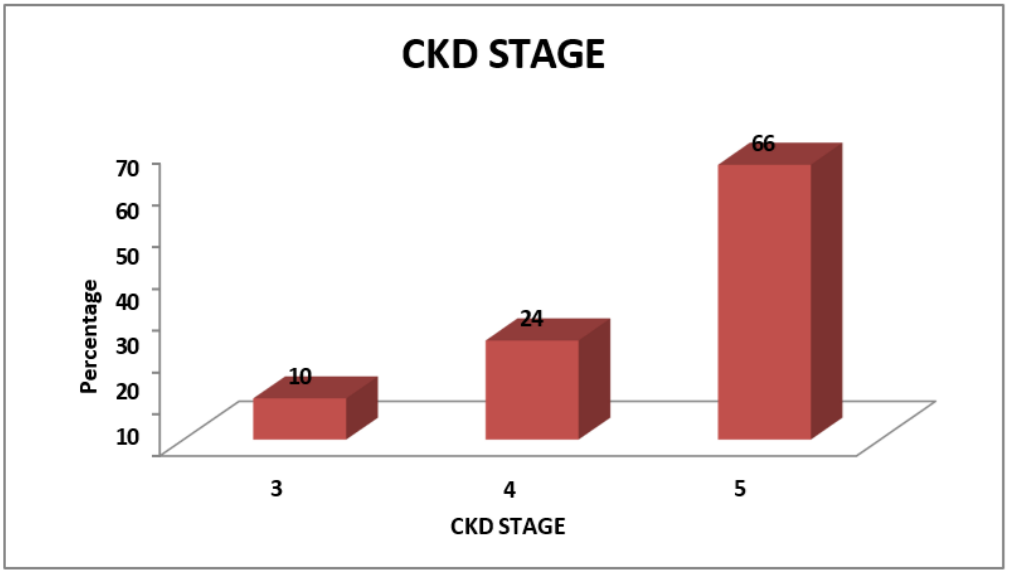


Figure 3: Distribution of Cases According to CKD Stage

4. Mean E-GFR, Blood Urea and Serum Creatinine in Relation to Stages Of CKD

Table 4: Mean E-GFR Values in Various CKD Stages

PARAMETER	CKD STAGE	Mean	SD	p value
e-GFR(ml/min/1.73 m2)	3	44.6	10.5	
	4	21.8	4.3	
	5	8.7	3.1	<0.001*

*Note: *means significant at 5% level of significance (p<0.05)*

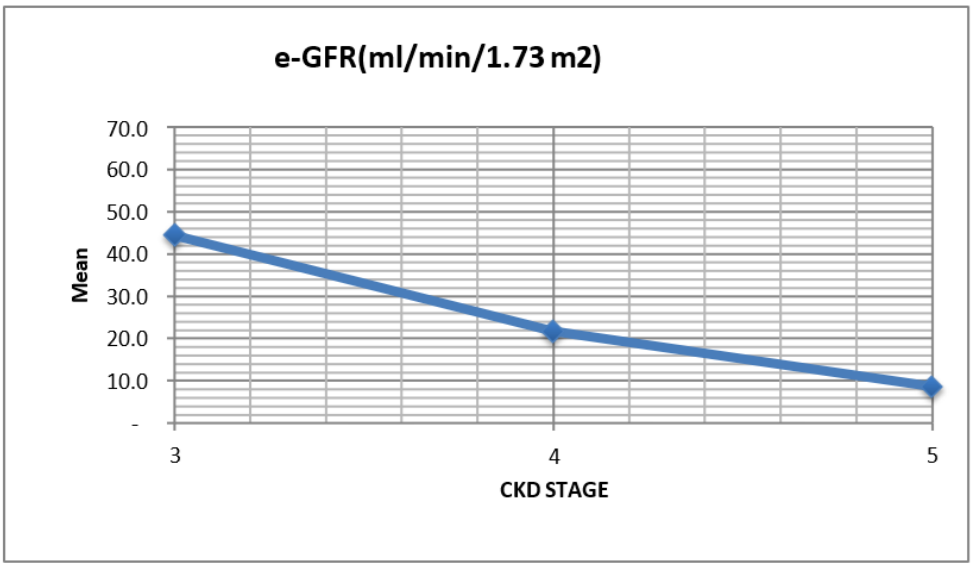


Figure 4: Mean E-GFR Values in Various CKD Stages

As the CKD stage progressed, mean e-GFR decreased.

Table 5: Mean Blood Urea Levels in Various CKD Stages

PARAMETER	CKD STAGE	Mean	SD	p value
BLOOD UREA (in mg/dL)	3	41.8	21.3	
	4	84.3	35.7	
	5	126.3	68.7	0.007*

*Note: *means significant at 5% level of significance (p<0.05)*

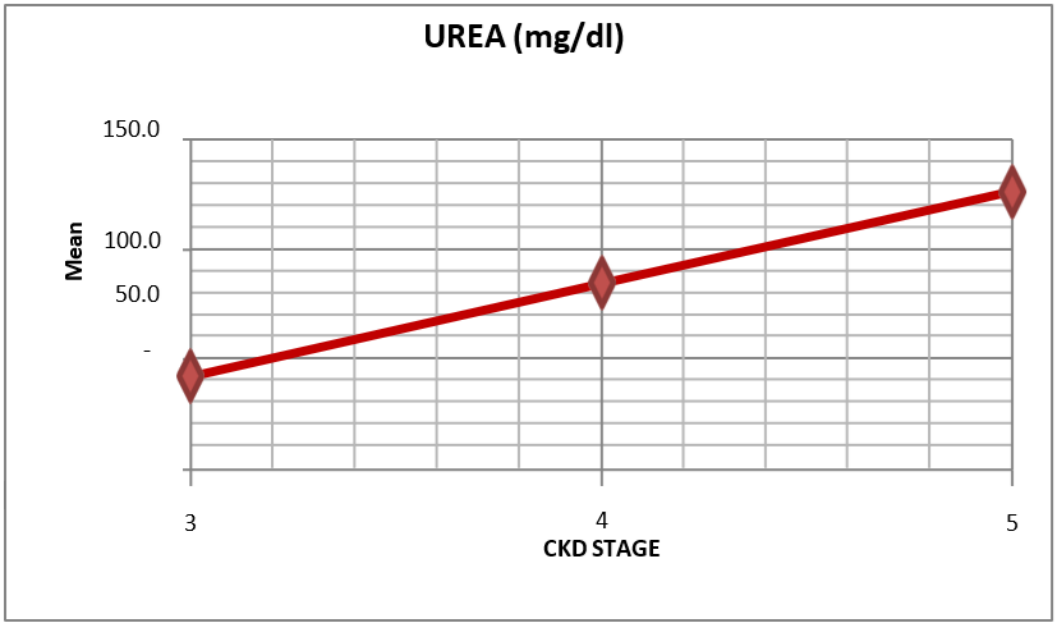


Figure 5: Mean Blood Urea Levels in Relation to CKD Stages

Table 6: Mean Serum Creatinine Levels in Various CKD Stages

PARAMETER	CKD STAGE	Mean	SD	p value
SERUM CREATININE (in mg/dL)	3	1.7	0.3	<0.001*
	4	2.8	0.8	
	5	7.0	3.6	

*Note: *means significant at 5% level of significance (p<0.05)*

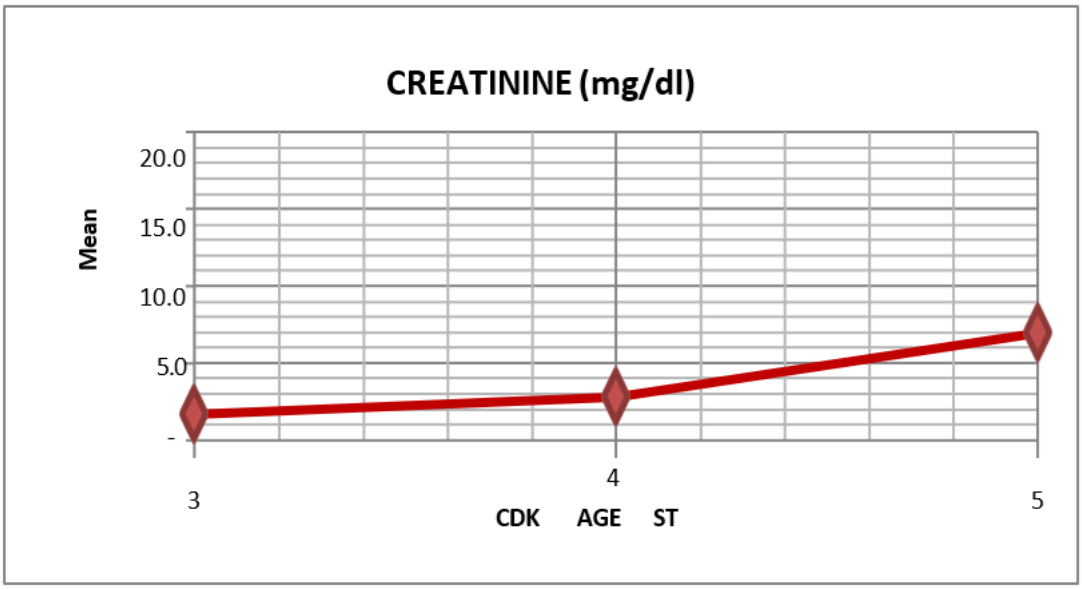


Figure 6: Mean Serum Creatinine Levels in Various CKD Stages

5. Case Distribution According to TSH Levels

Table 7: Distribution of Cases According to TSH Levels

TSH Levels	Number of subjects	Percentage (%)
Increased	15	30
Normal	35	70
Total	50	100

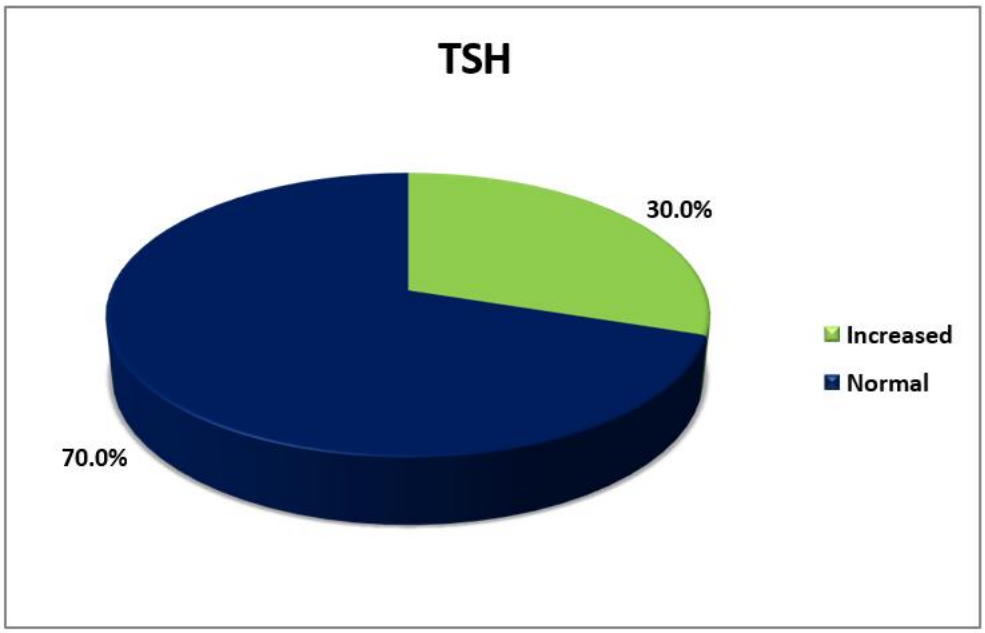


Figure 7: Distribution of Cases According to TSH Levels

6. Case Distribution According to Free T4 Levels

Table 8: Distribution Of Cases According to Ft4 Levels

FT4 Levels	Number of subjects	Percentage (%)
Decreased	25	50
Normal	25	50
Total	50	100

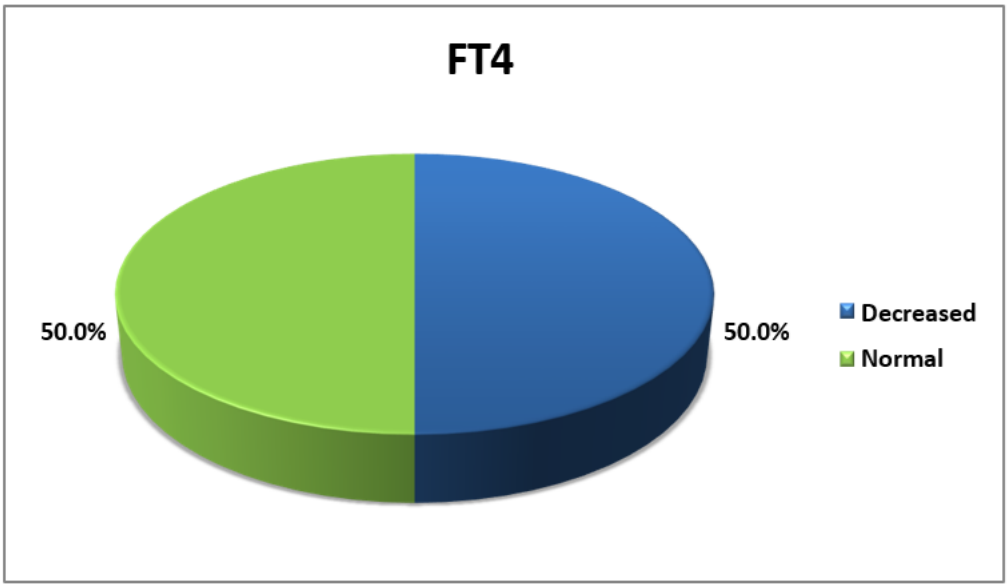


Figure 8: Distribution of Cases According to Ft4 Levels

7. Case Distribution According to Free T3 Levels

Table 9: Distribution of Cases According to Ft3 Levels

FT3 Levels	Number of subjects	Percentage (%)
Decreased	21	42
Increased	23	46
Normal	6	12
Total	50	100

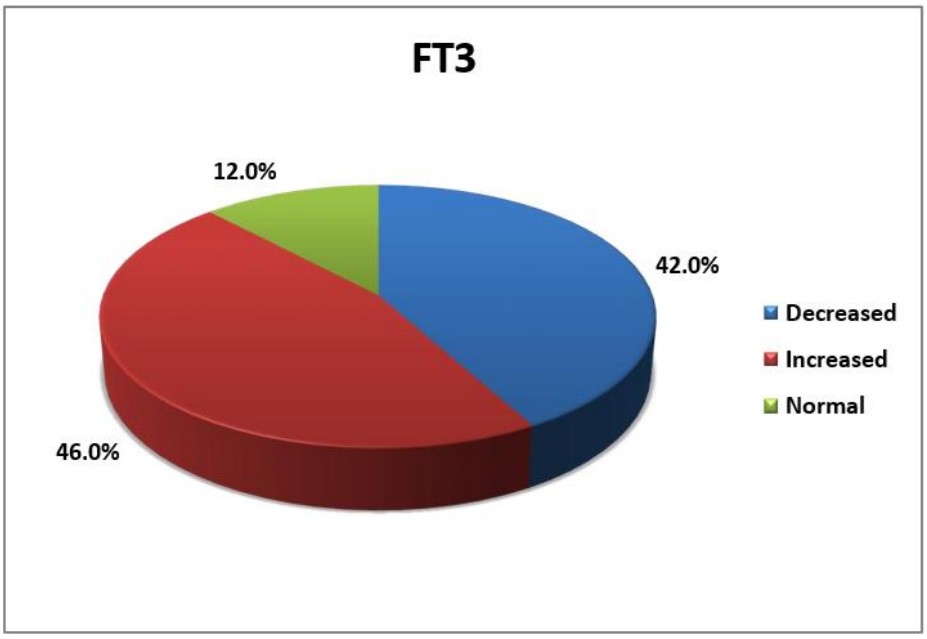


Figure 9: Distribution of Cases According to Ft3 Levels

8. Mean TSH Levels in Various CKD Stages

Table 10: Mean TSH Levels in Relation to CKD Stages

PARAMETER	CKD STAGE	Mean	SD	p value
TSH Levels in (micro/ml)	3	2.6	1.8	<0.001*
	4	3.9	2.9	
	5	5.5	1.9	

*Note: *means significant at 5% level of significance (p<0.05)*

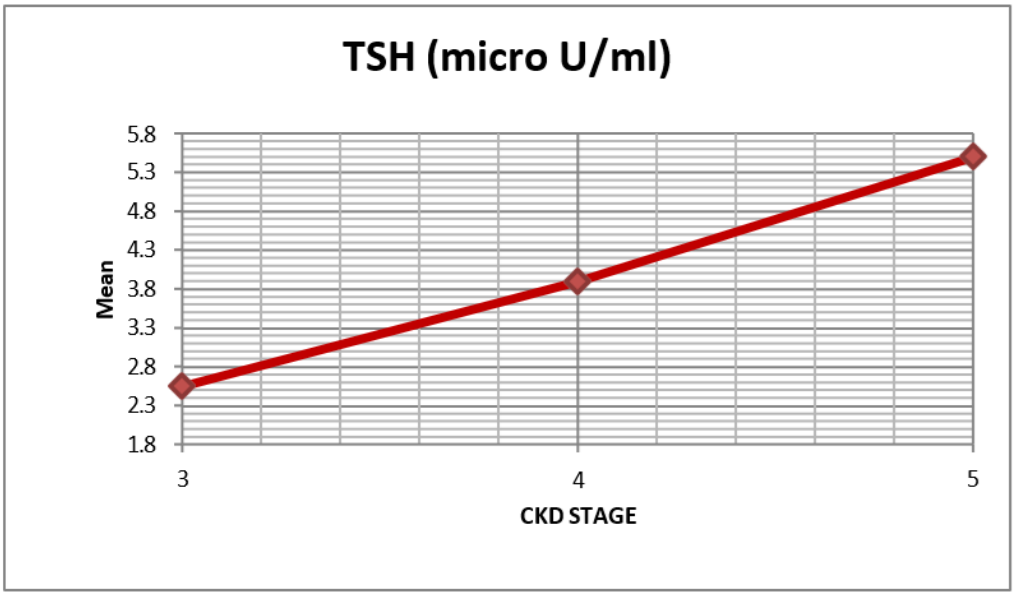


Figure 10: Mean TSH Levels in Relation to CKD Stages

9. Mean Ft4 Levels in Various CKD Stages

Table 11: Mean Ft4 Levels in Relation to CKD Stages

PARAMETER	CKD STAGE	Mean	SD	p value
FT4 Levels in (pmol/L)	3	12.2	5.2	0.596
	4	9.5	6.0	
	5	8.9	5.1	

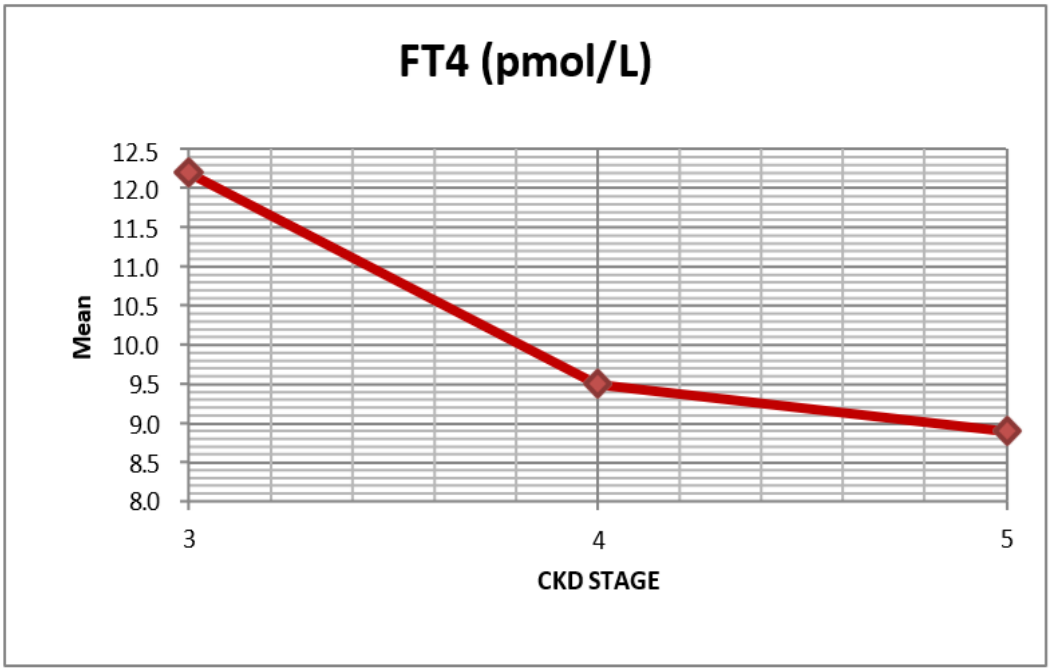


Figure 11: Mean Ft4 Levels in Relation to CKD Stages

Results revealed that, as the stage of CKD worsened, mean FT4 levels decreased.

10. Mean Ft3 Levels in Various CKD Stages

Table 12: Mean Ft3 Levels in Relation to CKD Stages

PARAMETER	CKD STAGE	Mean	SD	p value
FT3 Levels (in pg/ml)	3	34.6	45.6	0.825
	4	32.6	37.9	
	5	27.9	34.4	

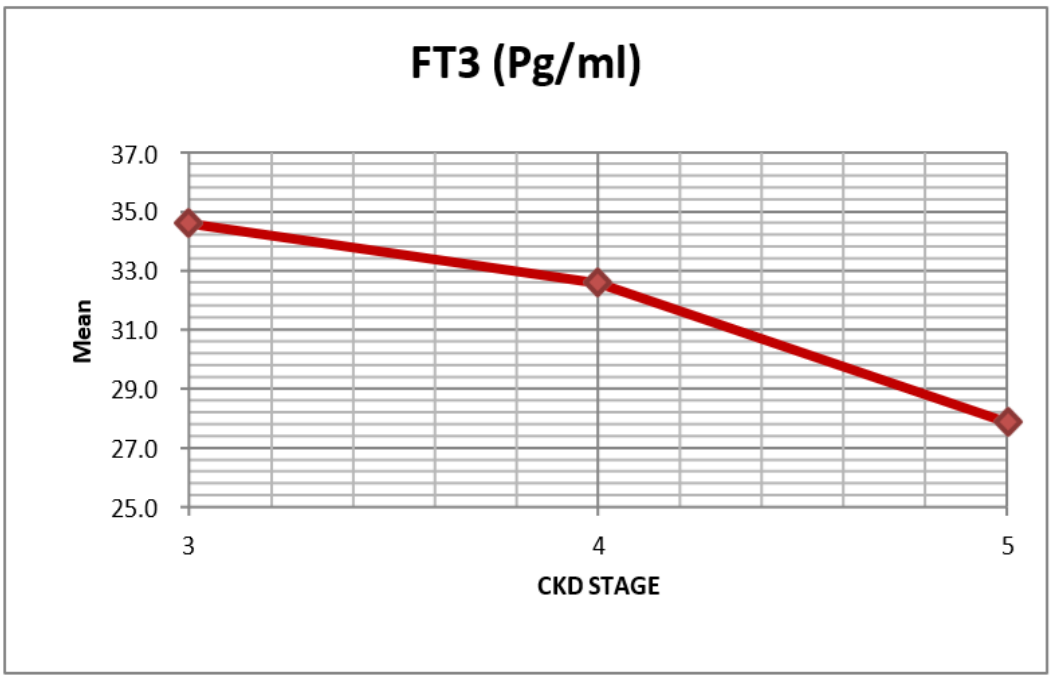


Figure 12: Mean Ft3 Levels in Relation to CKD Stages

11. Correlation Of E-GFR In Relation to TSH, Ft4 and Ft3

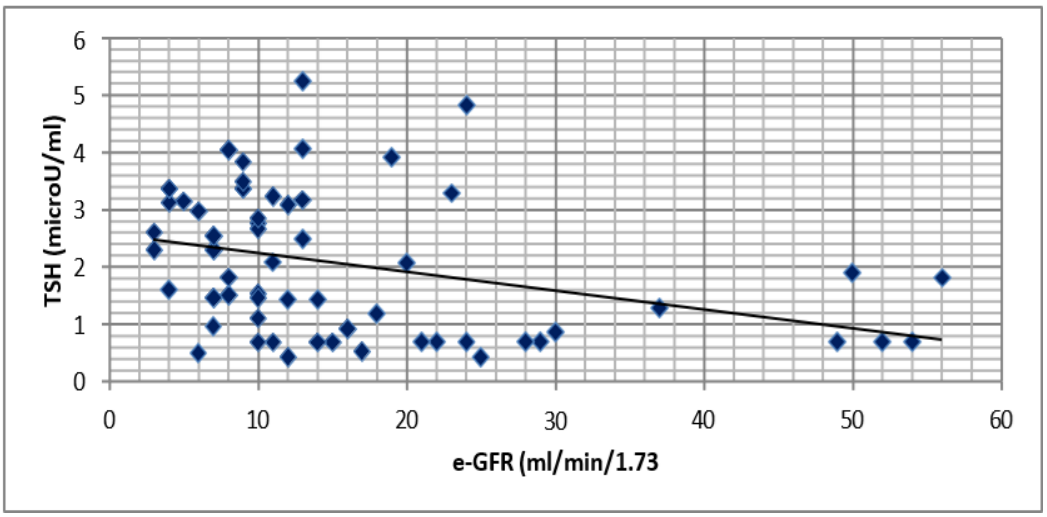


Figure 13: Correlation Of E-GFR with TSH

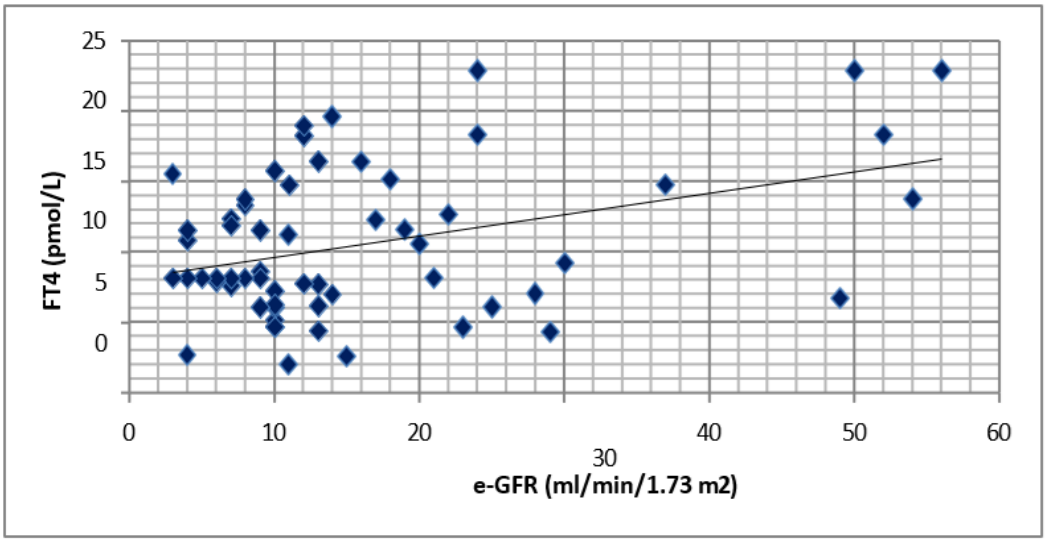


Figure 14: Correlation Of E-GFR with Ft4

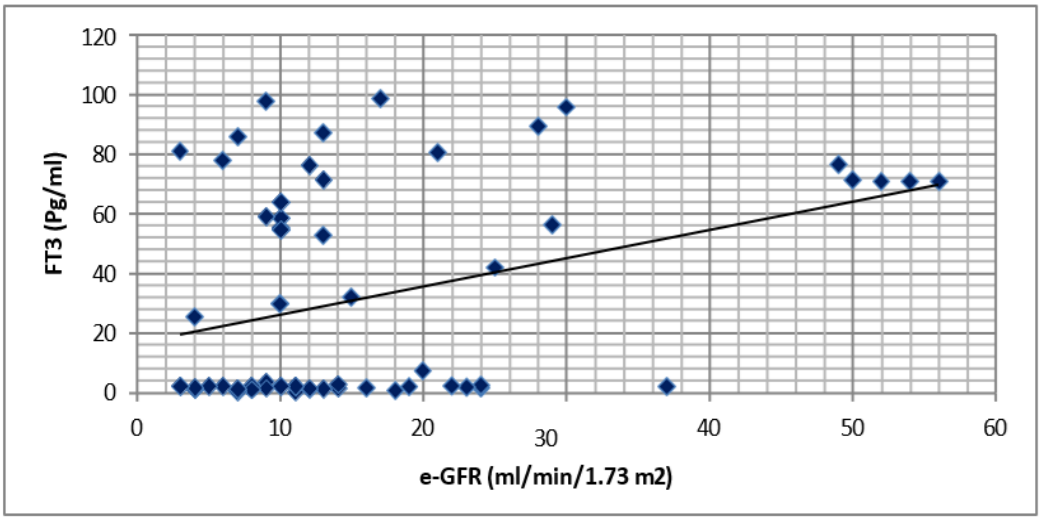


Figure 15: Correlation Of E-GFR with Ft3

Table 13: Correlation of E-GFR With TSH, Ft4, Ft3

e-GFR(ml/min/1.73 m2)		
Parameters	**Correlation coefficient**	**p value**
TSH	-0.342	0.007*
FT4	0.377	0.003*
FT3	0.352	0.006*

Note: *means significant at 5% level of significance (p<0.05)

12. Analysis of Thyroid Function Test in CKD Patients

Table 14: Thyroid Abnormalities in 50 CKD Patients

Thyroid Abnormalities	Number of subjects	Percentage (%)
Euthyroid	20	40
Sub Clinical Hypothyroid	8	16
Hypo Thyroid	7	14
Low T3 Syndrome	15	30
Total	50	100

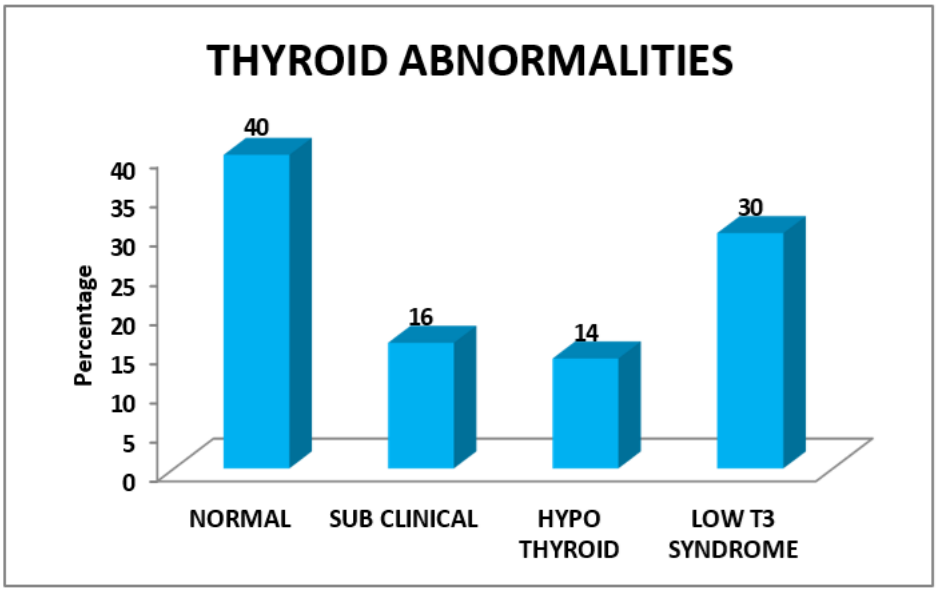


Figure 16: Thyroid Abnormalities in 50 CKD Patients

13. Distribution of Thyroid Abnormalities in Relation to the Stage of CKD

Table 15: Distribution of Thyroid Abnormalities in Relation to the Stage of CKD

Thyroid Abnormalities	CKD STAGE						Total	p value
	3		4		5			
	N	%	N	%	N	%		
Euthyroid	2	10.0	3	15.0	15	75.0	20	0.893
Subclinical- Hypothyroid	1	12.5	3	37.5	4	50.0	8	
Hypo-Thyroid	0	0.0	2	28.6	5	71.4	7	
Low T3 Syndrome	2	13.3	4	26.7	9	60.0	15	
Total Number of Patients with Thyroid Abnormality	**3**	**10.0**	**9**	**30.0**	**18**	**60.0**	**30**	

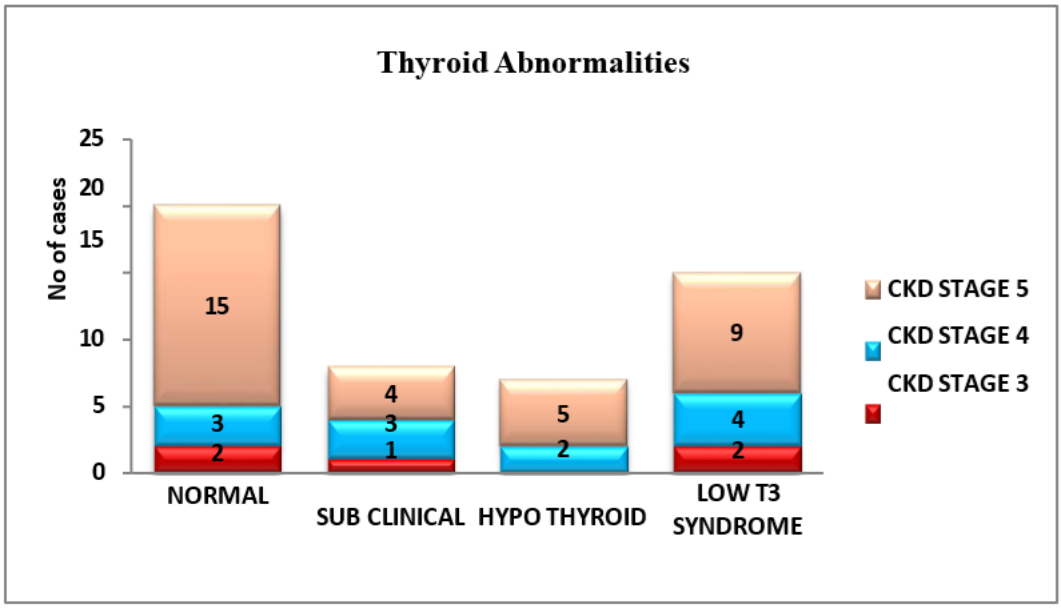


Figure 17: Distribution of Thyroid Abnormalities in Relation to the Stage of CKD

Discussion

Our study was a descriptive cross sectional study conducted on 50 patients diagnosed to have a chronic kidney disease as per KDIGO criteria, fulfilling inclusion and exclusion criteria, presenting to Department of General Medicine and Nephrology in tertiary care Centre in south India. The study was conducted over a period of 18 months. All the 50 patients were subjected to number investigations like thyroid function tests and renal function test. e-GFR was calculated according to MDRD formula and staged according to KDIGO classification of chronic kidney disease.

Majority of the subjects were, i.e 36%, belonged to the age group of 61-70 years whereas in the study conducted by Joan C Lo, Glenn M, *et al.*[9], the mean age was 48.7 years. Our study had the least distribution, i.e 4%, in the age group of 31- 40 years.

In our study 62% of the subjects were males and 38% were females as compared to the study by Joan C Lo, Glenn M, *et al.*[9] where 48% were males and 52% were females.

The 50 subjects were then categorized into various stages using e-GFR according to KDIGO classification of chronic kidney disease. In the present study, 10% of the subjects belonged to stage 3, 24 % belonged to stage 4 and 66 % belonged to stage 5. The study conducted by Asif M, Akram M, *et al.*[10], in 2012, had 29.2% in stage 3, 36.9% in stage 4, 29.2% in stage 5 and the rest in stages 1and 2.

Mean urea levels (in mg/dL) in our patients belonging to stage 3 was 41.8 +/- 21.3, stage 4 was 84.3+/-35.7and those belonging to stage 5 was 126.3+/-68.3.

Similarly mean creatinine levels (in mg/dL) in our patients belonging to stage 3 was 1.7 +/- 0.3, stage 4 was 2.8+/-0.8 and those belonging to stage 5 was 7.0+/-3.6

Mean e-GFR of our patients was 44.6+/-10.5, 21.8+/- 4.3 and 8.7 +/- 3.1 which are comparable to 41.01+/- 8.32, 21.35 +/-3.59 and 10.41+/-4.61 in stages 3, 4 and 5 respectively according to study done by Asif M, Akram M, *et al.*[10].

Study of Thyroid Profile in CKD Patients

All the above 50 CKD patients were evaluated for TSH, FT4 & FT3 levels. It was found that 15 patients (30%) had increased TSH levels and in 35 patients (70%) TSH levels were in normal range. This is comparable to a study by Gandham Rajeev *et al.* conducted on 45 CKD patients in NRI medical college and General Hospital Guntur in the year 2015, where 70% of them had increased TSH

Likewise, 25 patients (50%) had decreased FT4 levels while 25 patients (50%) had normal values. In case of FT3 levels, it was found that 21 patients (42%) had decreased levels, 23 patients (46%) had increased levels and remaining 6 patients (12%) had normal levels. A similar study done by K. Liewendahl *et al.* on 56 CKD patients concluded that mean concentration of FT4, more significantly, and to an extent FT3 decreases in patients with chronic renal failure.

The mean TSH values (microU/mL) of subjects categorised under stages 3 is 2.6 +/-1.8, stage 4 is 3.9+/-2.9 and stage 5 is 5.5+/-1.9. Hence, it can be concluded that as CKD progressed, mean TSH levels increased.

Our study revealed mean FT4 values (pmol/L) of 12.2+/-52, 9.8+/-6.0 and 8.9+/-5.1 in CKD stages 3, 4 and 5. From the above results it can be concluded that as the CKD stage worsened FT4 levels decreased.

The above results are comparable to that derived in the previous study conducted by Asif M, Akram M, *et al.* (10) wherein FT4 levels decreased and TSH levels increased similarly with progression of the CKD stage.

On analyzing the Thyroid function tests in 50 subjects, overall 30 patients (i.e 60%) had thyroid abnormalities. Among which 14% had hypothyroidism, 16% had subclinical hypothyroidism and 30% had low T3 syndrome. The remaining 20 patients (i.e 40%) were in euthyroid state.

These results are comparable to the previous studies like the one conducted by Asif M, Akram M, *et al.*[10] where the prevalence of hypothyroidism was more than 20% in patients with CKD stage 3 or above. A study by Michel Chonchol, Giuseppe Lippi *et al.* from university hospital of Verona, Italy in the year 2008 which demonstrated subclinical hypothyroidism in 18% of patients with CKD. Sang Heon Song, Ihm Soo kwak, *et al.* from Pusan National University Hospital, Korea in the year 2008 showed that 11.3% of the patients enrolled had low T3 levels as compared to 30% as found in our study.

Lin Y, Tarng D, *et al.* from china in the year 2012 [11] described CKD is a well-known cause of non-thyroidal illness syndrome and affects all levels of the hypothalamo-pituitary-thyroid axis. The study also quoted that low T3 syndrome (which reflect a diminished conversion of T4 to T3 in the periphery) is the most frequently observed thyroid alteration in CKD patients.

Furthermore when these thyroid abnormalities were analyzed in relation to various stages of CKD, it was found that among 30 patients with thyroid

Abnormalities 10% of the patients belonged to stage 3, 30% of the patients belonged to stage 4 and remaining 60% belonged to stage 5

This is consistent with the study by Lo *et al.*[12] wherein they showed that the prevalence of clinical and subclinical hypothyroidism increased with progressively lower levels of kidney function. The prevalence of hypothyroidism was 5.4%, 10.9%, 20.4%, 23.0%, and 23.1 % in stages 1, 2, 3, 4, and 5

From above results it is evident that patients with CKD are more prone to develop thyroid dysfunctions like hypothyroidism, subclinical-hypothyroidism and low-T3 syndrome. It is also evident that as the severity of kidney disease increases, the number of patients having thyroid abnormalities increases

Correlation of Thyroid Profile with E-GFR in CKD Patients

GFR values of the 50 CKD patients included in our study was correlated with TSH, FT4 & FT3 values individually and a linear regression analysis graphs were plotted as shown in Figure 15, 16 &17. Co-efficient of correlation (r) and p value were calculated separately for each of the above parameters.

The linear regression graph plotted between e-GFR Vs TSH (as seen in Figure 15) showed an inverse correlation suggesting that as e-GFR decreases, TSH levels increases. The p value calculated was 0.007 which is statistically significant.

Whereas regression graph plotted between e-GFR Vs FT4 and e-GFR Vs FT3 showed a positive correlation (as shown in Figures 16 & 17), suggesting that as e- GFR decreased, FT4 & FT3 levels decreased. The p values calculated for the above were 0.003 and 0.006 respectively, both of which are statistically significant.

Our above correlation study is consistent with study by, Asif M, Akram M, *et al.*[10] where they described that there was a graded increase in likelihood of subclinical hypothyroidism and clinical hypothyroidism with progressively lower e- GFR. The study showed a significant inverse association between e-GFR and TSH levels.

Similarly, Sang Heon Song, IhmSooKwak, *et al.* did a study using linear regression analysis to find out the relationship between eGFR and serum T3 and concluded that there is a positive relationship between the two in both males and females.

Hence it can be derived that, as eGFR decreases, TSH increases, while FT3 and FT4 decreases.

Finally to summarize, according to our study, biochemical parameters of thyroid function gets altered in patients with chronic kidney disease. The TSH values increases, while FT3 and FT4 values decrease. These changes become more apparent as the stage of CKD worsens. These changes can manifest either as clinical hypothyroidism, subclinical hypothyroidism or low T3 syndrome.

Similar correlation was obtained between e-GFR values with TSH, FT3 and FT4 levels. As e-GFR decreases, TSH increases whereas FT3 and FT4 decreases.

Conclusion

In our study, we found that patients with chronic kidney disease are frequently associated with biochemically altered thyroid function. The overall prevalence of thyroid dysfunction among 50 CKD patients included in the study is 60%.

Out of the above 60%, 14 % of the patients had clinical hypothyroidism, 16 % had subclinical hypothyroidism & 30 % of the patients were categorised under low T3 syndrome.

The prevalence of each of the above thyroid abnormalities were then studied in various stages of CKD. The results revealed that as the stage of CKD progressed, the prevalence increased.

Among all the CKD patients with thyroid abnormalities, 10 % of them belonged to stage 3, 30 % belonged to stage 4 while majority of them, i.e 60%, belonged to stage 5.

Furthermore, our correlation studies of eGFR with TSH, FT3 and FT4 individually, revealed that eGFR has an inverse relationship with TSH and direct relationship with FT3 and FT4. This implies that as eGFR decreases TSH increases whereas FT3 and FT4 levels decrease.

List of abbreviations

CKD: Chronic Kidney Disease

ESRD: End stage renal disease

FT3: Free Tri-iodothyronine

FT4: Free Tetra-iodothyronine

eGFR: Estimated Glomerular Filtration Rate

PTH: Parathyroid hormone

T3: Tri-iodothyronine

T4: Tetra-iodothyronine

TBG: Thyroid binding globulin

TSH: Thyroid stimulating hormone

TT3: Total Tri-iodothyronine

TT4: Total Tetra-iodothyronine

Declarations

Ethics approval and consent to participate

Ethical committee approval was obtained from institute

Informed written Consent

Obtained from participants

Conflicts of Interest

There is no conflict of interest regarding the publication of this paper

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Nil

Authors' contributions

All the authors are equally contributed for concept, study design, data collection, Analysis.

References

[1] Coresh J, Selvin E and Stevens LA. Prevalence of chronic kidney disease in the United States. JAM 2007; 298(17):2038-47.

[2] Hosseinpanah F, Kasraei, F, Nassiri AA, and Azizi F. High prevalence of chronic kidney disease in Iran: A large population based study. B MC Public health 2009; 9:44-52.

[3] Levey AS, Eckardt KU, Tsukamoto Y, Levin A, Coresh J, and Rosset, J. Definition and Classification of Chronic Kidney Disease: a positive statement from kidney disease: Improving Global Outcomes (KDIGO). Kidney Int 2005; 67(6):2089-100.

[4] Iglesias P and Diez JJ. Thyroid dysfunction and kidney disease. European journal of endocrinology 2009; (160):503-15.

[5] Abozenah H, Shoeb S, Sabry A and Ismail H. Relation between thyroid hormonal concentration and serum levels of interleukin-6 and interleukin-10 in patients with Non-thyroid illness including chronic kidney disease. IJKD 2008; (2):16-23.

[6] Lim VS. Thyroid function in patients with chronic renal failure. Am J Kidney Dis 2001; 38:80-84.

[7] Chonchol M, Lippi G, Salvagno G, Zoppini G, Muggo M and Targher G. Prevalence of subclinical Hypothyridism in patients with Chronic kidney Disease. Clin J Am Nephrol 2008: (3); 1296-1300.

[8] Lo JC, Chertow MG, Go AS and Hsu CY. Increased prevalence of subclinical and clinical hypothyroidism in persons with chronic kidney disease. Kidney international 2005; 67:1047-52.

[9] Joan CL, Glenn M, Chertow, Alan A, and Chi-yuan H;. Increased prevalence of subclinical and clinical hypothyroidism in persons with chronic kidney disease; Kidney International, 2005; Vol. 67: pp. 1047–1052

[10] Asif M, Akram M, Ullah A. Chronic kidney disease; correlation between free thyroxin, thyrotrophin and glomerular filtration rate. Professional Med J 2013;20(4): 506-512.

[11] Lin Y, Tarng D. Abnormal thyroid function in peritoneal dialysis patients: Lots of smoke but no fire. Journal of the Chinese Medical Association. 2012;75(2):47-48.

[12] Lo JC, Chertow MG, Go AS and Hsu CY. Increased prevalence of subclinical and clinical hypothyroidism in persons with chronic kidney disease. Kidney international 2005; 67:1047-52

[13] Enia G, Panuccio V, Cntupi S, Pizzim P, Tripepi G and Mallamaci F *et al.* Subclinical hypothyroidism is linked to microinflammation and predicts death in continuous ambulatory peritoneal dialysis. Dial Transplant 2007; (22):538-54.

[14] Lo JC, Chertow MG, Go AS and Hsu CY. Increased prevalence of subclinical and clinical hypothyroidism in

persons with chronic kidney disease. Kidney international 2005; 67:1047-52.
[15] Alsaran K, Sabry A, Alshahat H, Babgy E and Alzaharani F. Free thyroxine, free triiodothyronine and thyroid stimulating hormone before and after hemodialysisin Saudi patients with end stage renal disease: Isthere any difference? Saudi J Kidney Dis Transpl 2011;22(5):917-21
[16] Joanne M.B, Karl S, Chronic kidney disease, Harrison's principles of internal medicine, 19th edition, part 13, chapter 335.
[17] Suresh C and Sanjay K.A, Incidence of chronic kidney disease in India, Nephrol. Dial. Transplant; 2006 21(1):232-233.
[18] Knochell.JP, Endocronic changes in patients on chronic dialysis, In: replacement of function by dialysis", W. Drukker, FM Parsons, JF Maher, editors, 2nd edition, Boston: Martinus Nijhoff publishers; 1983; 712-723.
[19] De Groot LJ: Dangerous Dogmas in Medicine: The non thyroidal illness syndrome, J. Chin endocrine metabol 1999; 84: 151-164.
[20] Lim VS: Thyroid function in patients in CRF; Am J Kidney disease 2001;38(Supplement 1): 880-884.
[21] Lo JC, Cherton GM, Go AS, HSU CY: Increased prevalence of subclinical and clinical hypothyroidism in persons with chronic kidney disease, Kidney Int 2005;67(3):1047-1052.
[22] Mehta HJ, Joseph LJ, Desai KB, Mehta MN, Samuel AM, Almeida AF, Acharya VN. Total and free thyroid hormone levels in chronic renal failure. J Postgrad Med 1991;37:79-83
[23] Domenico S, Terry F, Davies, Martin S, Ian D. Hay, R Larsen; Thyroid Physiology and Diagnostic Evaluation of Patients with Thyroid Disorders. Williams textbook of endocrinology 12edn. 2011; chapter 11:327-361
[24] Larsen PR, Ingbar SH, Kronenberg, The Thyroid Gland; Text book of Endocrinology, 12th edtn 389- 498.
[25] Utinger GJ, Manowitz NR, Mayor G, Ridway CE, The Colorado thyroid disease prevalence study. Arch Intern Med, 2000: 160; 526-34.
[26] J, Larry Jameson, Anthony P, Weetman, Disorders of the thyroid gland, Harisson's Endocrinology 2010; 2nd edn; chapter 4; 62-98.
[27] Gregory A B, Terry F. Davies; Hypothyroidism and Thyroiditis; Williams Textbook of Endocrinology 12edn, 2011; chapter 13 406- 429:
[28] Canaris DS. Subclinical hypothyroidism. N Engl J Med 2001: 345; 260-65.
[29] Cooper DS. Subclinical hypothyroidism. N Engl J Med 2001: 345; 260-65.
[30] Dickman T, Lansberg PJ, Kastelein JJP, Weirsinger WM. Prevalence and correlating hypothyroidism in a large cohort of patients referred for dyslipidemia. Arch Int. Med, 1995: 155; 1490-95.
[31] Coopan R, Kozak GP, Hyperthyroidism and diabetes mellitus, Arch Intern Med 1980: 140; 370-3.
[32] Dal G, Levyo, Carrasco N. Cloning characterization of the thyroid iodide transporter, Nature 1996: 379; 458-60.
[33] Immunoradiometric assay protocol (IRMAK-9) Board of Radiations Isotope technology, Vashi complex, Navi Mumbai.
[34] Anastassios G, Pittas, Stephanie L, Lee; Evaluation of Thyroid Function; Handbook of Diagnostic Endocrinology 2003, chapter 6; 107-155
[35] Shah NF, Tests of thyroid function, JAPI 2000: 48; 51, 15-18.
[36] Spitzzweg C, Morris JC; The immune response to the iodide transporter. Endocrinal MetabClin North Am 2000; 29: 389-98.
[37] Staub JI, Althaus BU, Englor H, Ruff AS *et al.* Spectrum of subclinical and overt hypothyroidism Am J Med 1992: 92; 631-42.
[38] Ayala AR, Danese MP, Ladenson PW. When to treat mild hypothyroidism. Endocrinal metabClin North Am J 2000: 29, 2; 399-415.
[39] Custro N *et al.*, Prospective study on thyroid function anomalies in seriously ill patient. Ann Ital med Int, 1992; 7:8-13.
[40] Hasegawa K *et al.* Abnormal response of thyrotrophin and growth hormone to thyrotrophin releasing hormone in chronic renal failure. Acta Endocrinol1975; 79:635– 43.
[41] Ramirez G *et al.* Thyroid dysfunction in uraemia. Evidence for thyroid and hypophyseal abnormalities. Ann Inter med 1976 84:672-6.
[42] Silverberg DS *et al.* Effect of chronic hemodialysis on thyroid function in chronic renal failure. Can Med An 1973; 109:282 – 6.
[43] Weissel M *et al.* Basal and TRH stimulated Thyroid and Pituitary hormones in various degree of renal insufficiency. Acta Endocrinol,1979; 90:23 – 32.
[44] Dandona P *et al.* Thyroid function in chronic renal failure. Proc Eur Dial transplant Assoc, 1976; 12:268 – 71.
[45] Hegedus L *et al.* Thyroid gland volume and serum concentrations of thyroid hormone in chronic renal failure. Nephron, 1985; 40:171 – 4.
[46] Kaptein E *et al.* Thyroid function in renal failure. Contrib Nephrol, 1986; 50:64 – 72.
[47] K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification, Am. J. Kidney Dis. 2002; 39 (2 Suppl 1):S1-S266.
[48] Brenner: Pathogenesis of Renal Disease; Brenner and Rector's The Kidney, 8th ed 2007 chapter 32; 705-729.
[49] All India CKD registry of the Indian Society of Nephrology.
[50] Robert GL, Chronic renal failure, CECIL Text Book of medicine, 21st edn.,571 78.
[51] Kalz IA, Emmanovel DS, Lindheimer MD, Thyroid hormone and the kidney. Nephron 1975;15:223-249
[52] Kautras DA, Maekat SG, Riagopulos GA, Malamos B. Iodine metabolism in CRF; Nephron 1972; 9:55-65.
[53] Robertson BF, Prestwich S, Ramirez G *et al.*, The role of iodine in the pathogenesis of thyroid enlargement in patients with CRF: J Clin Endocrinolmetab 1983; 57:181.
[54] Thyroid dysfunction in uremia: Evidence for thyroid and hypophyseal abnormalities Ann Intern med 1976; 84:672-676.
[55] Kaptein EM, Quion-verde H, Chooljian CJ: The thyroid in end-stage renal disease. Medicine (Baltimore) 1988; 67:187–197, 44. J. J. Carrero1 *et al.*, J of Int Med 1988; 262; 690–701
[56] C Zoccali1, F Mallamaci1, G Tripepi1, S Cutrupi1 and P Pizzini; Kidney International, 2006; 70, 523–528.
[57] Carmine Z, Giovanni T, Sebastiano C, Patrizia P, Francesca M; J Am SocNephrol 2005;16: 2789–2795.

[58] Hardy MJ. Ragbeer SS, Nascrimnto L. Pituitary Thyroid Function in CRFassessed by a highly sensitive thyrotropin assay. J clin Endo Met lab 1988: 66:233-236.
[59] Mujais SK, Sanitini S, Kurtzman NA, Pathophysiology of uremic syndrome. In: "The Kidney", Brenner, FC Rector, Editors. Philadelphia: WB Saunders Company: 1986, pp 1587- 1630.
[60] Silverberg DS, Ulan RA, Faweett DM. Dossetor JB, Grace M, Beitcher K. Effects of Chronic haemodialysis on thyroid function in CRF. Can med assoc J 1974:109: 282-286.
[61] Bartalena L *et al.*, (1990). Lack of nocturnal serum Thyrotropin surge in patients with chronic renal failure undergoing regular maintenance hemofiltration; a case of central hypothyroidism. Clinical Nephrology, 34: 30 – 4.
[62] Carter JN *et al.*, (1977). Effects of triiodothyronine administration in patients with chronic renal failure. AustNz J Med, 7:612 – 6.
[63] Hardy MJ *et al.* (1988) Pituitary –Thyroid function in chronic renal failure assessed by a highly sensitive thyrotropin assay; J clin Endocrinol metab, 66:233-6.
[64] Amato *et al.*, Thyroid hormone action in chronic kidney disease: Current Opinion in Endocrinology, diabetes& obesity; Oct 2008-vol 15; issue 5-p 459-465
[65] Spector DA *et al.*, (1976). Thyroid function and metabolic rate in chronic renal failure. Ann Intern Med. 85:724 – 30.
[66] Harrison's principles of internal medicine, 19th edition, Disorders of lipoprotein metabolism, part 16.421
[67] Rober W. Schrier, Manual of Nephrology, 6th edition; page:25.
[68] Michel Chonchol, Giuseppe Lippi, GianlucaSalvagno, Giacomo Zoppini, Michele Muggeo, and Giovanni Targher;Clin J Am SocNephrol 2008 3:1296–1300,.
[69] La Franchi S *et al.*, (1991). Thyroid function in children with renal failure. J Pediatr. 118:896 – 8.
[70] Gaskin JH, (1976). Thyroid gland in uraemia. Am Intern Med.85:680 – 1.
[71] Chopra IJ, Chopra U, Smith, SR, Reza M,Solomen DH. Reciprocal changes in serum concentrations of 3, 3', 5 triiodothyronine (reverse T3) and 3, 3', 5 triiodothyronine (T3) in systemic illnesses. J Clin Endocrinol Met 1975; 41:1043- 1049.
[72] Lim VS, Fang VS, Katz AI, Refetoff S. Thyroid dysfunction in chronic renal failure. A study of the pituitary thyroid axis and peripheral turnover kinetics of thyroxine and triiodothyronine. J Clin Invest 1977; 60:522-534.
[73] Silverberg DS *et al.* Effect of chronic hemodialysis on thyroid function in chronic renal failure. Can Med An, 1973;109:282 – 6.
[74] G Avasthi, S Malhotra, APS Narang, S Sengupta; Study of thyroid function in patients of chronic renal failure; Indian J Nephrol 2001;11: 165-169
[75] Lindner A, Charna B, Sherrard DS, Scribner BH: Accelerated atherosclerosis in prolonged maintenance hemodialysis. N Eng J med 1974: 290:697-701
[76] Stenvinker L *et al.*: Strong association between malnutrition, inflammation and atherosclerosis in CRF. Kidney int 1999; 55: 1899-1911.
[77] Cheung AK, Sarnalk MJ, Yan G, Dwyer JT, Heyka RJ, Roceo Mu *et al.*: Atherosclerotic cardiovascular disease risks in chronic hemodialysis patients; Kidney Int 2000; 58:353-362.
[78] Rodrigues *et al.*; Thyroid Hormone Transport is Disturbed in Erythrocytes from Patients with Chronic Renal Failure on Hemodialysis; Renal Failure, 2004, Vol. 26, No. 4: Pages 461-466
[79] Ron Hogg; Textbook of Kidney disorders in children and adolescents: a global perspective of clinical practice- "Effect of kidney disorders on endocrine system" 2006 chapter 17;203-211
[80] Savdie E, Stewart JH, *et al.* Circulating thyroid hormone levels and adequacy of dialysis. ClinNephrol 1978; 9:68-72
[81] Pagliacci MC, *et al.* Thyroid function tests in patients undergoing maintenance dialysis: Characterisation of 'Low T4 Syndrome' in subjects on regular haemodialysis and continuous ambulatory peritoneal dialysis. Nephron 1987; 46: 225-230.
[82] Dudani RA, Desai KB, Mehta MN, Mani LS, Acharya VN. Thyroid dysfunction in uremia. J Assoc Phys India 1981; 29: 1038-1040
[83] Karunanidhi A, Kanagasabapathy AS, Shastry JCM, Koshi TS. Thyroid function in patients with chronic renal failure. Ind J Med Res 1979; 69
[84] Hollander JG, Wulkan RW, Mantel MJ, Berghout A.; Correlation between severity of thyroid dysfunction and renal function; Clin Endocrinol.; 2005 Apr;62(4):423-7.
[85] Subhashish A, Michael GS, H Kramer, Aditya J, David MH. The Association of Chronic Kidney Disease and Metabolic Syndrome with Incident Cardiovascular Events: Multiethnic Study of Atherosclerosis; Cardiology Research and Practice 2011;Vol 2012; p 1-8.
[86] Robert G luke, Chronic renal failure, CECIL TB of medicine, 21s t edn., 571-78.
[87] Malhotra KK: Chronic renal failure. API TB of medicine, 7t h edn., 695-99.
[88] Kaptein EM *et al.*; The thyroid in end stage renal disease. Medicine, 1988: 67; 187.
[89] Procci WR *et al.*: sexual dysfunction in the male patients with uremia; A reappraisal. Kid. Int., 1981: 19; 317.
[90] Tyler HR: Neurological disorders seen in uremic patients. Arch. Intern Med, 1970: 126; 781-86.
[91] Erslev AJ; Anemia of Chronic renal disease Arch. Intern Med, 1970: 126; 774-80 89. Chonchol M, Lippi G, Salvagno G, Zoppini G, Muggeo M, Targher G. Prevalence of Subclinical Hypothyroidism in Patients with Chronic Kidney Disease. Clinical Journal of the American Society of Nephrology. 2008;3(5):1296-1300.
[92] Zoccali C, Mallamaci F. Thyroid Function and Clinical Outcomes in Kidney Failure. Clinical Journal of the American Society of Nephrology. 2011;7(1):14.