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ARTICLE

Urinary C-peptide Creatinine Ratio and Its Correlation with Parameters of Metabolic Syndrome

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ABSTRACT

To assess the correlation between urinary C peptide creatinine ratio with serum C peptide, serum insulin and its correlation with clinical and biochemical parameters of metabolic syndrome. A total of 100 subjects more than 18 years of age with metabolic syndrome according to ATP III criteria with 100 controls were included in a prospective observational study for a period of 1.5 years. Individual parameters of metabolic syndrome was higher in females with hypertriglyceridemia was most common and hyperglycaemia least common parameter of metabolic syndrome. Fasting urinary C peptide creatinine ratio and Stimulated urinary C peptide correlate significantly with fasting serum C peptide ($p<0.01$), stimulated serum C peptide ($p<0.01$), serum fasting insulin ($p<0.01$) and HOMA IR ($p<0.01$). A fasting urinary C peptide creatinine ratio of more than 1.8 nmol/mmol, stimulated urinary C peptide creatinine ratio more than 2.8 nmol/mmol and HOMA IR >2.7 can be used as a parameter to distinguish individual with and without metabolic syndrome. Urinary C peptide creatinine ratio correlate with serum C peptide and parameters of metabolic syndrome and can be used as a non-invasive simple tool to assess insulin resistance and also to distinguish patients with and without metabolic syndrome.

1. Introduction

Metabolic Syndrome (MetS) consists of physical conditions and metabolic abnormalities commonly found in association with increased risk for development of type-2 diabetes mellitus (T2DM), cardiovascular disease (CVD) and other medical conditions [1]. Worldwide prevalence of MetS ranges from <10% to as high as 84%. Higher socio-economic status, sedentary lifestyle and high Basal Metabolic Index (BMI) were significantly associated with MetS. The prevalence of metabolic syndrome is increasing in India, both in the urban and rural areas. It has escalated in different parts of India to figures now ranging from 11% to 41% [1]. Furthermore, the prevalence is 1.5 -2 times higher in women compared to men [2,3]. The proposed central abnormality associated with MetS is insulin resistance (IR) [4]. Insulin secretory capacity can be assessed by measuring C-peptide. Serum C-peptide is commonly used as a surrogate marker of endogenous insulin secretory capacity but due to perceived practical re-

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strictions associated with sample collection its widespread use is limited. A 24 hour urine C-peptide (UCP) excretion provides an accurate means of assessing beta cell-secretory capacity and correlate with both fasting and stimulated serum insulin and C-peptide [5,6]. However, obtaining an accurate and complete 24 hour urine collection has limited the utility of this test [7-9]. Creatinine adjusted urine C-peptide concentration enables the use of 'spot' urine samples in place of 24-h urine collection. Several workers have established that high serum C peptide levels coexist with hyperinsulinemia in metabolic syndrome but there are very few studies on correlation of urinary C peptide creatinine ratio with metabolic syndrome and so we decided to explore the correlation of urinary C-peptide creatinine ratio in patients with metabolic syndrome and also its correlation with parameters of metabolic syndrome at our place.

2. Materials and Methods

A prospective observational study was conducted from January 2018 to June 2019 on subjects attending Guwahati Medical College. For calculating the sample size, at 10% population prevalence and 5.8% margin of error the required minimum sample size was 100. Total 100 Individuals more than 18 years of age fulfilling criteria for metabolic syndrome according to ATP III with 100 control subjects were included. All agreed to participate and gave oral and written consent. Criteria for metabolic syndrome according to ATP III includes any three of five criteria. Waist circumference >90 cm (M), >80 cm (F), Fasting glucose ≥100 mg/dl, Triglycerides≥150 mg/dl, HDL cholesterol<40 mg/dl (M), <50 mg/dl (F), Blood pressure->130 mm Hg systolic or>85 mm Hg diastolic. Exclusion criteria includes patients with chronic kidney disease (egfr<60 ml/min), post pancreatectomy, patients on insulin and sulphonylureas. Detailed history and thorough clinical examination were done as per proforma. Anthropometric data collected from all the patients and includes height and weight measurement. BMI calculated for all patients and recorded, waist circumference and hip circumference was recorded in all patients and waist: Hip ratio calculated. Routine investigation like Haemoglobin (Hb), Total Leucocytes Count (TLC), Differential Leucocytes Count (DLC), Erythrocyte Sedimentation Rate (ESR), Liver Function Test (LFT), Kidney Function Test (KFT), Plasma glucose, HBA1C, eGFR Calculated, Thyroid function test, ECG, Chest x ray, USG abdomen. Markers of metabolic syndrome like hsCRP, serum uric acid, fasting lipid profile (Triglycerides, Total cholesterol, High Density lipoprotein, Low Density lipoprotein), fasting blood glucose (FBG) done in all cases.

Ethics approval

The Institutional Review Board of Guwahati Medical College and Hospital approved the study protocol (Number-MC/190/2007/PT-11/47).

3. Method

Patient preparation

Stimulated urine sample collected to assess maximum endogenous C-peptide response. Patients were asked to collect second void fasting urine sample after voiding early morning fasting urine. 75 gm of Glucose in water to be taken within 5-10 minute, patient should not eat anything else for the next 2 hours unless you have a hypoglycaemic episode, in which case test should be done on another day. Patient can drink water freely throughout the duration of the collection. 2 hours after collect urine and send for analysis. Sample processing done immediately for fasting C-peptide (Serum & Urine), Stimulated C peptide (120 minutes post glucose) (Serum & Urine), fasting urinary C peptide and stimulated urinary C peptide creatinine ratio calculated and finding recorded, fasting serum Insulin. HOMA IR calculated using fasting serum insulin and fasting plasma glucose and findings recorded. The C peptide and serum insulin measurement was done by electrochemiluminescence immunoassay "ECLIA" is intended for use on Elecsys and cobas e immunoassay analyzers. Urinary creatinine was assessed by Jaffé method using Roche/Hitachi cobas c systems..

Statistical analysis

Statistical analysis was done using SPSS software. The continuous data were expressed as mean± standard deviation (SD) and range. Correlation was established by Pearson correlation method. Multilinear regression analysis was used to determine association between dependent and independent variable.

Patient and Public Involvement (PPI) statement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

4. Results

Our study reveals significant gender differences with higher prevalence of metabolic syndrome in females as compared to males. Out of total 100 patients, 43 (43%) patients were male and 57 (57%) were females with higher rates of metabolic syndrome in elderly. Females have significantly

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higher baseline fasting urinary C peptide and fasting serum C peptide as compared to male (8.76±2.25 nmol/mmol; p-0.04; 1.74±0.65 nmol/mmol, p<0.0001). Similarly, fasting urinary C peptide creatinine ratio, stimulated urinary C peptide creatinine ratio (3.4±1.12 nmol/mmol, p<0.0001; 5.66±2 nmol/mmol p-0.02), serum insulin and HOMA IR (12.85±2.43 IU, p-0.04; 2.65±0.62, p-0.04) were statistically significant in female subjects as compared to males. Table 1 shows the baseline characteristics of patients and control subjects. Hypertriglyceridemia was the most common and hyperglycaemia least common component of metabolic syndrome in our study group (Table 2). There was significant positive correlation between fasting urinary C peptide creatinine ratio with Serum triglyceride (r-0.721, p<0.01), CRP(r-0.783, p<0.01), fasting serum C peptide (r-0.422, p<0.01) (Figure 1), stimulated serum C peptide (r-0.663, p<0.01) (Figure 2), Serum Insulin (r-0.528, p<0.01), HOMA IR (r-0.626,p<0.01), FBS (r-

Table 1. Baseline characteristics between cases and control

Variable	Control	Cases	P value
Age	36.69±12.9	35.95±12.1	0.672
Serum creatinine	0.82±0.1	0.83±0.1	0.578
Weight	63.69±8.83	84.82±12.33	<0.0001
EGFR	106.8±14.3	107.76±14.08	0.634
AST	19.27±4.25	40.79±9.14	<0.0001
ALT	17.32±3.87	40.94±13.84	<0.0001
Cholesterol	124.71±18.93	175.48±35.83	<0.0001
LDL	134.08±24.18	146.3±35.94	0.005
HDL	35.5±7.74	36.21±7.99	0.53
TG	207.27±44.16	208.27±47.72	0.878
Uric acid	6.01±0.85	6.02±0.87	0.902
hs-CRP	7.2±1.4	7.33±1.64	0.562
FBS	81.1±9.16	82.47±11.32	0.348
PPBS	128.96±9.02	134.78±13.16	<0.0001
Fasting urinary C peptide(nmol)	2.21±0.42	8.36±2.22	<0.0001
Stimulated urinary C peptide (nmol)	3.55±0.59	13.76±2.58	<0.0001
Urine creatinine(mmol)	2.73±0.69	2.83±0.84	0.371
Fasting serum C peptide (nmol)	0.87±0.29	1.51±0.73	<0.0001
Stimulated serum C peptide(nmol)	1.39±0.45	2.51±0.75	<0.0001
Fasting urinary C peptide creatinine ratio(nmol/mmol)	1.2±0.32	3.12±1.08	<0.0001
Stimulated urinary C peptide creatinine ratio(nmol/mmol)	2.05±0.37	5.28±1.86	<0.0001
Waist circumference(cm)	79.98±7.36	109.19±12.32	<0.0001
Hip circumference(cm)	85.62±7.71	105.88±7.57	<0.0001
W:H ratio	0.94±0.05	1.05±0.05	<0.0001
Height(cm)	161.98±9.33	162.58±9.58	0.654
Weight(kg)	65.28±9.6	84.82±12.33	<0.0001
BMI (kg/m^2)	24.63±2.34	31.97±3.31	<0.0001
HBA1C (%)	5.37±0.27	5.53±0.5	0.005
Fasting serum insulin (MIU/L)	10.98±1.46	12.43±2.32	<0.0001
HOMA IR	2.19±0.33	2.54±0.62	<0.0001

EGFR-Estimated glomerular filtration rate, AST-Aspartate transaminase, ALT-Alanine transaminase, FBS-Fasting blood sugar, PPBS-Post prandial blood sugar, TG-Triglycerides, LDL-Low density lipoprotein, HDL-High density lipoprotein, hs-CRP-High sensitivity C-reactive protein, BMI-Body mass index, HOMA IR-Homeostatic model assessment -Insulin Resistance

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0.384, p<0.01), PPBS (R-0.536 P<0.01), Waist: Hip ratio(r-0.421, p<0.01) (Table 3). Similarly there was significant negative correlation between fasting urinary C peptide creatinine ratio with HDL (r-0.195, p<0.01) (Table 4). Stimulated urinary C peptide creatinine ratio showed significantly positive correlation with Serum triglyceride (r-0.735, p<0.01), CRP (r-0.758, p<0.01), fasting serum C peptide (r-0.399, p<0.01) (Figure 3), stimulated serum C peptide (r-0.545, p<0.01) (Figure 4), Serum Insulin (r-0.580, p<0.01), HOMA IR (r-0.634, p<0.01), FBS (r-0.331, p<0.01), PPBS (r-0.386 p<0.01), Waist: Hip ratio (r-0.330, p-0.001) (Table 5&6). On multiple linear regression analysis with fasting urinary C peptide creatinine ratio as dependent variable there was significant association with stimulated serum C peptide (p-<0.0001), Serum FBS (p-0.04), Serum triglycerides (p<0.0001) and fasting serum insulin (p<0.0001) (Table 7). On multiple linear regression analysis with stimulated urinary C peptide creatinine ratio as dependent variable there was significant association with stimulated serum C peptide (p-0.03), Serum triglycerides (p<0.0001) and fasting serum insulin (p-<0.0001) (Table 8). The receiver operating characteristic (ROC) curve of fasting and stimulated urinary C peptide creatinine ratio for the diagnosis of Metabolic syndrome was depicted and the area under the curve (AUC) was calculated (Figure 5). The ROC curve identified a cut-off of fasting UCPCR ≥ 1.8 nmol/mmol and stimulated UCPCR >2.8 nmol/mmol for discriminating individual with metabolic syndrome from control population (AUC 0.980 & 0.999) with 100% sensitivity and specificity. The ROC curve identified a cut-off of HOMA IR ≥2.7 for discriminating patients with metabolic syndrome from control population (AUC 0.66) with 30% sensitivity and 95% specificity.

Table 2. Distribution of component metabolic syndrome among subjects(N-100) according to ATP III criteria

Component	Male (N-43)	Female (N-57)	Total
FBS >100mg/dl	2(25%)	6(75%)	8(100%)
TG >150mg/dl	41(43.2%)	54(56.8%)	95(100%)
	HDL		
<40mg/dl (Males)	32 (74.4%)	-	43(100.0%)
<50mg/dl (Females)	-	47 (82.5%)	57 (100.0%)
	Waist Circumference		
Males >90cm	38 (88.4%)	-	43 (100.0%)
Females >80cm	-	51 (89.5%)	57(100.0%)
Systolic blood pressure (>130mmHg)	18(43.9%)	23(56.1%)	41(100%)
Diastolic blood pressure (>85mmHg)	33(49.3%)	34(50.7%)	67(100%)

Table 3. Pearson correlation: Fasting Urinary C peptide creatinine ratio in metabolic syndrome(N-100)

Parameter	Correlation coefficient r	P Value
Fasting serum C peptide(nmol)	0.422	<0.01
Stimulated serum C peptide(nmol)	0.663	<0.01
Serum Insulin (MIU/L)	0.528	<0.01
HOMA IR	0.626	<0.01

Table 4. Pearson correlation: Fasting urinary C peptide creatinine ratio in metabolic syndrome(N-100)

Parameter	Correlation coefficient r	P Value
Low Density Lipoprotein(mg/dl)	0.078	0.44
High Density Lipoprotein(mg/dl)	-.195	<0.01
Triglyceride(mg/dl)	0.721	<0.01
Uric acid(mg)	-0.011	0.913
hs-CRP (mg)	0.783	<0.01
Fasting Blood Sugar(mg/dl)	0.384	<0.01
Post Prandial Blood Sugar(mg/dl)	0.536	<0.01
HBA1C (%)	0.099	0.105
Waist Circumference(cm)	0.114	0.261
Waist: Hip Ratio	0.421	< 0.01
BMI (kg/m^2)	0.188	0.06

Table 5. Pearson correlation: Stimulated Urinary C peptide creatinine ratio in metabolic syndrome

Parameter	Correlation coefficient r	P Value
Fasting serum C peptide(nmol)	0.399	<0.01
Stimulated serum C peptide(nmol)	0.545	<0.01
Serum Insulin (MIU/L)	0.580	<0.01
HOMA IR	0.634	<0.01

Table 6. Pearson correlation: Stimulated Urinary C peptide creatinine ratio in metabolic syndrome

Parameter	Correlation coefficient r	P Value
Low Density Lipoprotein(mg/dl)	0.049	0.628
High Density Lipoprotein(mg/dl)	-.163	0.105
Triglyceride(mg/dl)	0.735	<0.01
Uric acid(mg)	0.108	0.283
hs-CRP (mg)	0.758	<0.01
Fasting Blood Sugar(mg/dl)	0.331	<0.01
Post Prandial Blood Sugar(mg/dl)	0.386	<0.01
HBA1C (%)	0.105	0.298
Waist circumference (cm)	0.055	0.589
Waist:Hip Ratio	0.330	0.001
BMI (kg/m^2)	0.142	0.16

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Table 7. Multiple linear regression analysis with fasting urinary C peptide creatinine ratio as dependent variable

Dependent Variable: Fasting urinary C peptide creatinine ratio				95.0% Confidence Interval for B	
	B	T	Sig.	Lower Bound	Upper Bound
Fasting serum C peptide(nmol)	.091	.886	.378	-.114	.296
Stimulated serum C peptide(nmol)	.405	3.677	<0.0001	.186	.624
Triglycerides(mg/dl)	.009	4.931	<0.0001	.005	.012
Waist:Hip Ratio	2.584	1.851	.067	-.189	5.357
Fasting Blood Sugar (mg/dl)	.012	1.994	.049	.000	.024
Fasting serum Insulin (MIU/L)	.119	3.833	<0.0001	.057	.180
Low Density Lipoprotein (mg/dl)	.000	-.170	.865	-.004	.003
High Density Lipoprotein (mg/dl)	.004	.469	.640	-.013	.022

Table 8. Multiple linear regression analysis with stimulated urinary C peptide creatinine ratio as dependent variable

Dependent Variable: Stimulated urinary C peptide creatinine ratio				95.0% Confidence Interval for B	
	B	T	Sig.	Lower Bound	Upper Bound
Fasting serum C peptide(nmol)	.202	1.145	.255	-.148	.551
Stimulated serum C peptide(nmol)	.409	2.173	.032	.035	.782
Triglycerides(mg/dl)	.019	6.338	<0.0001	.013	.025
Waist:Hip Ratio	2.454	1.030	.306	-2.276	7.183
Fasting Blood Sugar (mg/dl)	.019	1.842	.069	-.001	.039
Fasting serum insulin (MIU/L)	.231	4.382	<0.0001	.126	.336
Low Density Lipoprotein (mg/dl)	.000	.074	.941	-.006	.006
High Density Lipoprotein (mg/dl)	.021	1.410	.162	-.009	.051

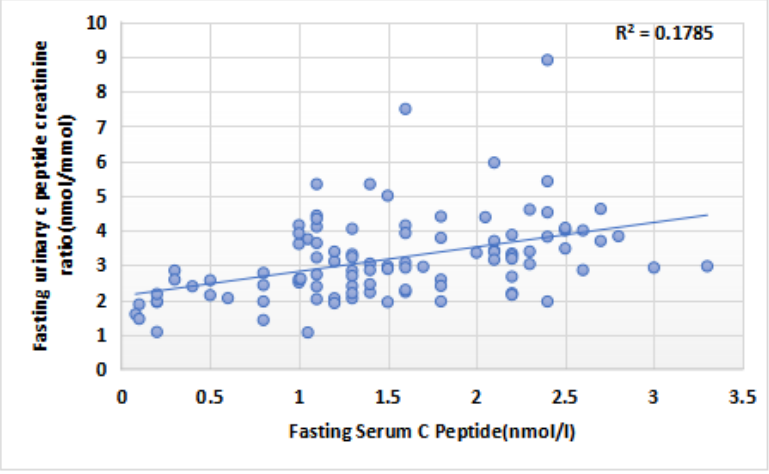

Figure 1. Scatter plot: Fasting urinary c peptide creatinine ratio and Fasting Serum C Peptide

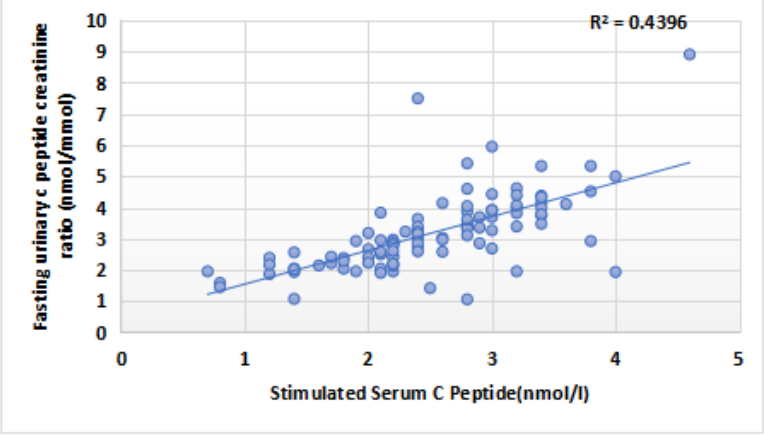

Figure 2. Scatter plot: Fasting urinary c peptide creatinine ratio and stimulated Serum C Peptide

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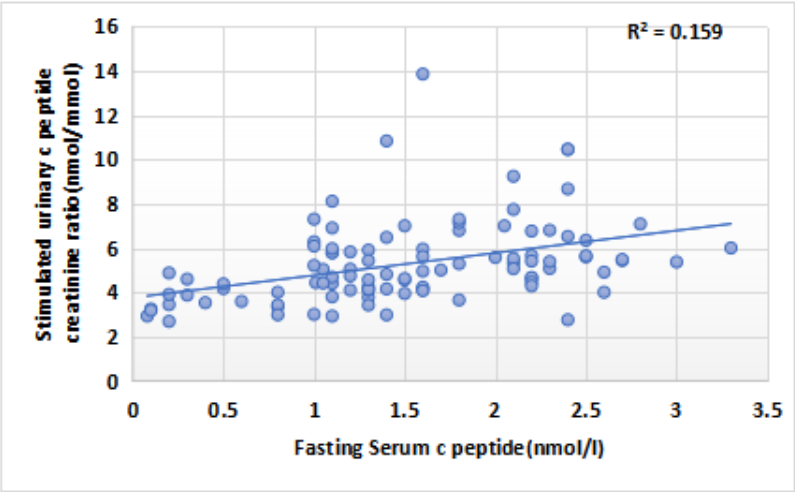

Figure 3. Scatter plot: stimulated urinary c peptide creatinine ratio and Fasting Serum C Peptide

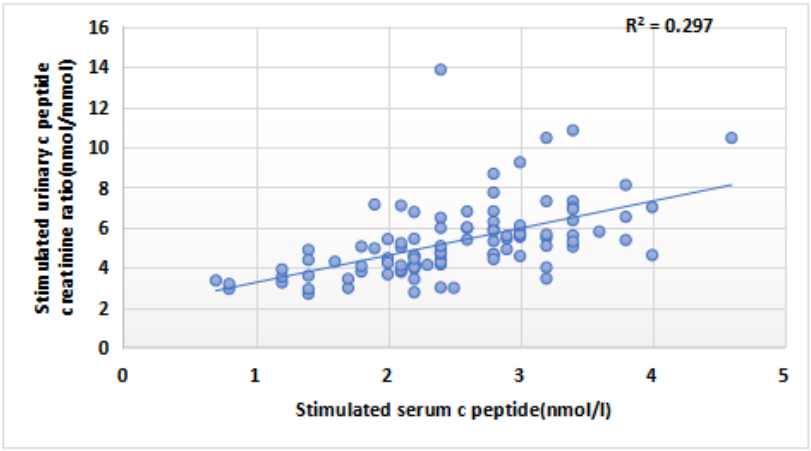

Figure 4. Scatter plot: stimulated urinary c peptide creatinine ratio and stimulated Serum C Peptide

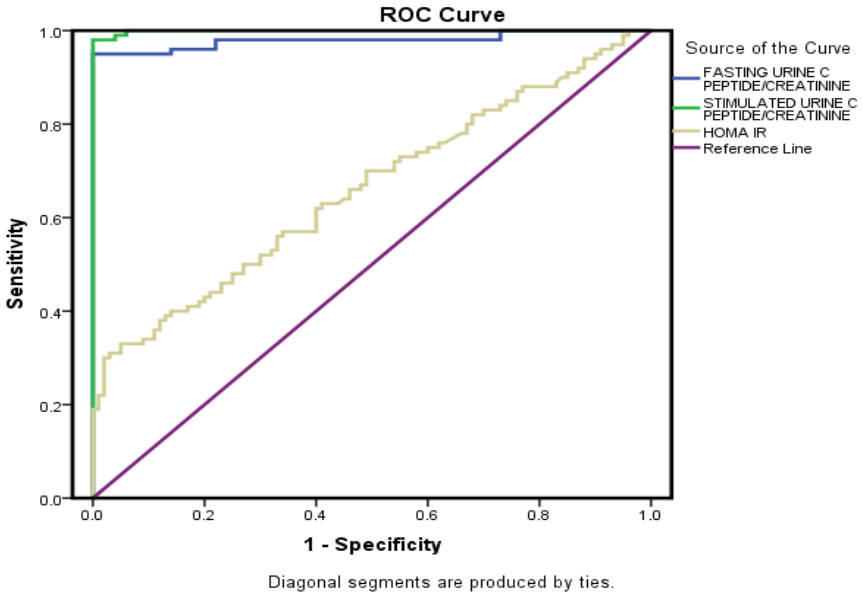

Figure 5. ROC curve to identify patients with metabolic syndrome from control population

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ROC curve to identify patients with metabolic syndrome from control population. The ROC curve identified a cut-off of fasting UCPCR ≥ 1.8 nmol/mmol and stimulated UCPCR >2.8nmol/mmol for discriminating individual with metabolic syndrome from control population (AUC 0.980 & 0.999) with 100% sensitivity and specificity. The ROC curve identified a cut-off of HOMA IR ≥2.7 for discriminating patients with metabolic syndrome from control population (AUC 0.66) with 30% sensitivity and 95% specificity.

5. Discussion

Higher levels of central obesity are found among South Asians compared to European Whites with insulin resistance is the central feature of the Metabolic syndrome. In our study, we found higher prevalence of metabolic syndrome in females (57%) as compared to males (43%), metabolic syndrome rate increases with increasing age and was higher in elderly. In a similar study Seerat Beigh [10] and D S Prasad [11] found that female have higher prevalence of metabolic syndrome as compared to males and rates are higher in older age groups. On the other hand, Anthonia o ogbera [12] found that frequency of occurrence of the metabolic syndrome was similar for men and women and it increases with age in both sexes. Hypertriglyceridemia (95%) was the most common and hyperglycaemia (8%) least common component of metabolic syndrome in our study group. Also, individual component of metabolic syndrome was higher in female subjects as compared to males. Yasmeen khan [13] in her study found hyperglycaemia as the most common parameter of metabolic syndrome followed by high Triglyceride, obesity, high blood pressure and low HDL. Seerat Beigh [10] found hypertension (38%) the most important metabolic syndrome parameters in the study subjects. Fasting urinary C peptide creatinine ratio and stimulated urinary C peptide creatinine ratio was higher in females as compared to male subjects (2.76±0.93 nmol/mmol vs 3.4±1.12 nmol/mmol, p<0.0001) & (5.66±2 nmol/mmol vs 4.79±1.56 nmol/mmol, p-0.02) which was very similar to study by Nicholas J Thomas [14] where he found that gender affects urinary C peptide excretion, with values 1.48-fold higher in women than men. This difference is because of gender differences in muscle mass in females as compared to males which leads to higher creatinine excretion (3.02±0.91 vs 2.69±0.77, p-0.05). Similarly, Kulkarni et al [15] found that urinary C peptide creatinine ratio to be 1.5 times higher in women than men. Serum fasting insulin (12.85±2.43 IU vs 11.88±2.06 IU, p-0.04) and HOMA IR (2.65±0.62 vs 2.39±0.6, p-0.04) was significantly higher in female subjects than males which is similar to study by Chen-Huan Chen [16] in Chinese population. In our study fasting urinary C peptide creatinine ratio was positively correlated with fasting serum C peptide (r-0.422, p<0.01), stimulated serum C peptide(r-0.663, p<0.01), fasting Serum Insulin (r-0.528, p<0.01), HOMA IR (r-0.626,p<0.01) and Waist: Hip ratio(r-0.421, p<0.01).Richard A Oram [17] found that in participants with normal renal function, fasting second void UCPCR correlate with serum insulin, serum C peptide, and HOMA2- IR. kulkarni et al [15] and Jose E [18] similar to our study found urinary C peptide correlated with serum C peptide and serum insulin. Mary T [19] found that the fasting urinary C peptide may serve as a practical method for estimating the secretion rate of insulin. Studies on correlation between serum C peptide with blood sugar level shows positive correlation but there are sparse studies on urinary C peptide and blood sugar level. We found fasting urinary C peptide creatinine ratio to be positively correlated with FBS (r-0.384, p<0.01) and post prandial blood sugar (r-0.536, p-0.01). HsCRP and dyslipidaemia known to be associated with metabolic syndrome and its component but studies on urinary C peptide are lacking, our study showed significant positive correlation with hsCRP (r-0.783, p<0.01) and Serum triglyceride (r-0.721, p<0.01). Yanai Wang [20] on the other hand didn't find correlation between fasting urinary C peptide creatinine ratio and triglyceride, HDL and LDL cholesterol. In our study stimulated urinary C peptide creatinine ratio has significant positive correlation with fasting serum C peptide (r-0.399 p<0.01), stimulated serum C peptide (r-545 p<0.01), fasting serum insulin (r-580 p<0.01), HOMA IR (r-634 p<0.01) which is in accordance with study conducted by Richard A Oram [17] where he showed 120 min stimulated urinary C peptide creatinine ratio correlate with serum insulin and serum C-peptide. Mary T [19] found that post prandial and 24 hour urinary C peptide excretion correlate with secretion rate of insulin. Renato pasquali [21] while evaluating clinical application of the 24-h urinary C-peptide excretion rate found positive correlation with fasting and post prandial serum C peptide. Pokhriyal BN [22] found that home urine C-peptide determination could be practical alternative to serum C-peptide in detecting severe insulin deficiency. Although no study has correlated stimulated urinary C peptide with metabolic syndrome parameters, we found significant positive correlation between stimulated urinary C peptide creatinine ratio with waist: Hip ratio (r-0.330 p<0.01), serum triglyceride (r-735 P<0.01), hsCRP (R-0.758 p<0.01), fasting blood sugar (r-331 p<0.01) and significant negative correlation with High density lipoprotein (r-241 p-0.016). We found that on multivariate analysis both fasting and stimulated urinary C peptide creatinine ratio correlate with stimulated

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serum C peptide as compared to fasting serum C peptide. Literature also suggests that stimulated serum C peptide to be more accurate as compared to fasting serum C peptide. The receiver operating characteristic (ROC) curve of fasting and stimulated urinary C peptide creatinine ratio for the diagnosis of Metabolic syndrome was depicted and the area under the curve (AUC) was calculated (Figure 5). The ROC curve identified a cut-off of fasting UCPCR ≥ 1.8 nmol/mmol and stimulated UCPCR >2.8 nmol/mmol for discriminating individual with metabolic syndrome from control population (AUC 0.980 & 0.999) with 100% sensitivity and specificity. HOMA IR cut-off of 2.5 is established for the diagnosis of metabolic syndrome with sensitivity of >70% and specificity of >60% as shown by previous studies in Indian adolescents [23]. The ROC curve identified a cut-off of HOMA IR ≥2.7 for discriminating patients with metabolic syndrome from control population (AUC 0.66) with 30% sensitivity and 95% specificity.

This study opens the door for future clinical research to establish additional criteria for diagnosis of Metabolic syndrome and to assist in refining the definition of Metabolic syndrome. In view of lack of comparative studies on urinary C peptide creatinine ratio in patients with metabolic syndrome, small sample size and observational design it is difficult to establish clinical significance of subtle abnormalities noticed in this study. Further studies are needed to verify the finding of our studies

In conclusions, urinary C-peptide is a useful indicator of beta cell function owing to sensitivity, reproducibility and convenience of the test. Urinary C peptide creatinine ratio is feasible and reliable marker of insulin secretion and insulin resistance in patient with metabolic syndrome. Fasting and stimulated urinary C peptide creatinine ratio correlate positively with markers of metabolic syndrome and can be used for differentiating individuals with and without metabolic syndrome with high sensitivity and specificity. Urinary C peptide creatinine ratio may be incorporated in diagnostic criteria in the future. Similarly, HOMA IR of >2.7 can also be used as cut off in individual at high risk of metabolic syndrome. Further work is needed to examine the potential clinical uses of this novel test and to verify the finding of our study.

6. Strength and Limitation

Very few studies have been done on fasting and stimulated urinary C peptide creatinine ratio and its correlation in metabolic syndrome.

This study opens the door for future clinical research to establish additional criteria for diagnosis of Metabolic syndrome and to assist in refining the definition of Metabolic syndrome.

In view of lack of comparative studies on urinary C peptide creatinine ratio in patients with metabolic syndrome, small sample size and observational design it is difficult to establish clinical significance of subtle abnormalities noticed in this study.

Further studies are needed to verify the finding of our studies.

Contributor Ship Statement

Dr Dipti Sarma developed the research concept presented here along with Dr Manoj Gedam and Dr Bipul Choudhury. Dr Manoj contributed to the study design and managed the database. Dr Dipti Sarma, Dr Manoj Gedam and Dr Bipul Choudhury participated in the data analysis. Dr Dipti Sarma and Dr Manoj Gedam wrote the first draft along with Dr Bipul Choudhury and were primary responsibility for final content. All authors have read and approved the final draft of the manuscript.

Conflict of Interest

No conflict of interest.

Source of Funding

This research did not receive any specific grant from any funding agency in the public, commercial or not-for-profit sector.

Patient Consent

Informed verbal consent was obtained from the patient or primary caregiver.

Data Sharing Statement

Data are available upon reasonable request. Extra data is available by emailing- dr.manojvgedam@gmail.com.

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