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EVALUATION OF INSULIN RESISTANCE AND LIPID PROFILE IN WOMEN WITH POLYCYSTIC OVARIAN SYNDROME

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ABSTRACT

Background: Polycystic ovary syndrome (PCOS) is the most common endocrine disorder of reproductive age women. It is associated with dyslipidemia and Insulin resistance which is a high risk factor for cardiovascular disease in the long-term. **Objectives:** Aim of study to determine Insulin Resistance, lipid profile, Apolipoprotein-A1 and Apolipoprotein- B levels in women with polycystic ovary syndrome. **Study Design:** Hospital based observational case control study. **Method:** We evaluated 80 polycystic ovary syndrome women as cases and age matched 80 women as controls visited to obstetrics and gynaecology OPD at NDMC Medical College and Hindu Rao Hospital, Delhi, India. The case selection was done according to Revised Rotterdam criteria (2003). Lipid parameters, Apo lipoprotein -A & Apo lipoprotein -B. Fasting blood sugar and fasting Insulin were measured. Insulin resistance (IR) was calculated by the HOMA-IR formula. **Results:** The present study showed significantly higher values of triglycerides (48%) , HDL-C(46.95 ± 10.21mg%) ,fasting glucose (25%) and IR (10 %)in case than control (8%, 41.78 ± 9.71 mg% , 7% and 5% respectively) and significantly low value of Apo lipoprotein-A (45%) in PCOS women than controls (1.25%).Whereas the values of Total cholesterol, LDL-C, VLDL-C, Apolipoprotein B, fasting insulin ,TC/HDL and LDL/HDL ratios was not significantly different between two groups. **Conclusion:** In the present study PCOS women had hypertriglyceridemia and raised IR whereas Apo lipoprotein -A was found low. These parameters are considered as high risk factors for cardiovascular disease. Early and regular screening of PCOS women can prevent progression of cardiovascular diseases.

KEYWORDS :

INTRODUCTION:

Polycystic ovary syndrome (PCOS) is a syndrome of ovarian dysfunction that is characterized by an ovulation, hyperandrogenism, and/or the presence of polycystic ovary (PCO) morphology (1), is regarded as the most common endocrine disorder of reproductive age (2). The aetiology of PCOS is not clear, but studies have suggested that PCOS appears to have a complex, multi-factorial aetiology (3) . It is associated with a wide range of metabolic and long term health risks including insulin resistance, type 2 diabetes, impaired glucose tolerance, dyslipidemia, metabolic syndrome and obesity(4-10). Dyslipidemia in PCOS women is a potential risk factor for cardiovascular disease in the long term (11,12).

Insulin Resistance is characterized by impaired glucose response to specific amounts of insulin and can be clinically defined as inability of known quantity of exogenous or endogenous insulin to increase glucose uptake and use in an affected individual as much as it does in a normal person (13) . Dyslipidemia is the most common metabolic abnormality in women with PCOS , specially , increased levels of low density lipoprotein cholesterol (LDL-C) and triglyceride (TG) , and decreased levels of high density lipoprotein-cholesterol (HDL-C) which are a more atherogenic (9,14-18). These changes in the lipid profile found in association with insulin resistance#.

Apo lipoproteins are located on the surface of lipoproteins, and regulate lipoprotein metabolism and lipid transport. Apolipoprotein (apo)A-I, the major structural protein component of HDL particles and has cardioprotective properties, whereas ApoB represents the total amount of potentially atherogenic circulating lipoproteins, including LDL, intermediate density lipoprotein (IDL), very low-density lipoprotein (VLDL) and lipoprotein (a). Insulin resistance contributes to decrease plasma levels of HDL-C and Apolipoprotein (Apo) A-I, and higher levels of Apo B. For the last few years several studies have suggested that, plasma lipids as well as, alterations of Apo lipoprotein- A and apolipoprotein B significantly increase the cardiovascular risk., apoB/apoA-I ratio predicts cardiovascular risk better than any cholesterol index (19-23).

Therefore, the aim of the present study was to evaluate Insulin resistance and lipid profile in Indian women with PCOS.

MATERIAL AND METHODS

Study Design:

A hospital based observational case control study.

Study Population:

The study was comprised on women of 18-40 years of age attending gynaecological OPD at Hindu Rao Hospital with polycystic ovarian syndrome took as cases and age matched women without PCOS as controls. The cases were selected on the basis of Revised Rotterdam diagnostic criteria for PCOS (2003)Oligomenorrhea- infrequent, irregularly timed episode of bleeding occurring at intervals of >35 days or 4-6 menstrual cycle per year OR / AND Amenorrhoea / absence of menstruation for 6 months. Clinical and /or biochemical signs of hyperandrogenism include hirsutism, male pattern alopecia, and acne. Biochemical hyperandrogenism is defined when total testosterone is >80 ng/ml ruling out genital hyperplasia, androgen-secreting neoplasm, and Cushing's syndrome. If on ultrasonography ≥12 follicles in either ovary measuring 2-9mm located peripherally along the surface of the ovary "necklace appearance" or increased ovarian volume >10cm^3. A single ovary meeting these criteria is sufficient for the diagnosis of PCOS (1)

Sample Size:

This study consisted of 160 women of reproductive age. The sample size had been calculated by using SPSS software version 21.

Inclusion Criteria:
Women of the 18-40 years age group with polycystic ovarian syndrome as case and without PCOS as controls were willing to participate in the study and gave written consent.

Exclusion Criteria:
Patients with a history of diabetes mellitus, impaired glucose tolerance test, untreated hypothyroidism, and other causes of hirsutism. On drug treatment eg. Antihypertensive, contraceptives, lipid-lowering agents, drugs affecting glucose and lipid metabolism, Pregnancy and lactating mother

Study Methods:
Detailed history of menstruation, hyperandrogenism, medical illness, surgical procedure, drug treatment, and family were taken after written informed consent. All participants underwent general, physical and systemic examinations. Weight and height were measured and Body Mass Index (BMI) was calculated for each woman to classify the state of obesity by the formula BMI = Weight in Kg / Height in m^2. An ultrasound of the abdomen was done to rule out polycystic changes in the ovaries. For estimations of lipid profile, fasting glucose and fasting insulin, a 5 ml venous blood sample was collected from all participants after overnight fasting of 12 hours by venipuncture and tests were performed by the standard laboratory method by the Auto analyzer. Insulin resistance is calculated mathematically by using HOMA-IR (homeostatic model assessment – insulin resistance) which is Fasting glucose(mg/dl) X Fasting Insulin(mU/ml) / 405(24). Patients are evaluated to find out the prevalence of insulin resistance and for a relationship of HDL, LDL, VLDL, Apolipoprotein A& B, total cholesterol, and triglycerides in polycystic ovarian disease. VLDL-Cholesterol is calculated using the formula VLDL= Triglycerides/5.

LDL cholesterol is calculated from the values of total cholesterol, triglycerides and HDL cholesterol by applying Friedewald's equation. TC/ HDL and LDL/HDL ratios were determined.

Statistical Analysis
Continuous variables are presented as their mean ± SD and categorical variables as numbers (percentage). Student's unpaired t-test was used for the analysis of continuous variables. Categorical variables were analyzed by Chi-square test or Fisher exact test if the numbers were small. P <0.05 was considered as the level of significance and two-tailed probability was used. All analysis was carried out by using SPSS software version 21.

RESULTS:
Mean age was significantly more in cases as compared to controls, 26.49 ±4.65 versus 28.61 +- 5.59 yr (P 0.009) (Table-1). There was no significant difference between the mean BMI or proportion of women with BMI>25 in the two groups. Mean menstrual cycle length was significantly high in cases as compared to controls,39.92 ± 8.46 versus 31.09 d± 2.39 d (<0.0001), the proportion of women with menstrual cycle length >35 days was also high(66.25%) in cases as compared to controls(10%)(P < 0.001). The proportion of women with ultrasonographic appearance of polycystic ovaries was significantly high in cases at 31.25% as compared to controls at 6.25 % (P <0.001). The mean FSH/LH ratio had no significant differences between cases and controls (P 0.963) and no significant difference in the proportion of women with FSH/LH >2 (P 0.057).

Mean fasting insulin was significantly more in cases as compared to controls 7.30 ± 1.64 mIU/L, 6.79 ± 1.49 mIU/L (P 0.037) (Table 2). Mean Fasting blood sugar was significantly high 93.01±15.75 mg/dl in cases as compared to controls 85.91±10.41 mg/dl(P .001).Proportions of women between two groups with fasting blood sugar>100 mg/dl was significantly high in cases 25% compared to controls 7.5% (P 0.004). Mean HOMA-IR was significantly higher in cases1.72± 0.55 compared to controls 1.45±0.42 (P<0.001), however, the proportion of cases 10% with HOMA-IR >2.5 was not significantly different from control(2) (P 0.23).

Mean Triglycerides were significantly high in cases (147.14 ± 22.48 mg/dl) as compared to controls (102.99 ± 27.79 mg/dl) (P<0.0001) and the proportion of triglycerides >150mg/dl was also significantly high in cases (48.75%) as compared to controls (8.75%) (P <0.001) (Table 3). Mean Cholesterol was also high in cases (164.58 ± 22.24 mg/dl) compared to controls (134.28± 22.23 mg/dl)(P 0.001) However no significant difference in the proportion of women with cholesterol > 200mg/dl was found in the two groups (P 0.12). Mean HDL was significantly higher (46.95 ± 10.21mg /dl) in cases compared to control (41.78 ± 9.71 mg/dl) (P 0.0013). Whereas the proportion of women with HDL <40mg/dl was significantly more among controls (38.75 %) compared to cases 22.55% ((P 0.0257). There is no significant difference between mean LDL among the two groups. (78.21 ± 10.35mg/dl and 77.49 ± 14.12 mg/dl) (0.713). No women in either group had LDL >I30 mg/dl. Mean VLDL was significantly high in cases as compared to controls 29.45 ± 4.45 mg/dl & 20.58 ± 5.54 mg/dl (P <0.001) However no women in either group had VLDL>40mg.

Mean Apo lipoprotein A was significantly low in cases (139.99 ± 47.05 mg/dl) as compared to controls (193.74 ± 23.40mg/dl) and the proportion of women with Apolipoprotein A <140 mg/dl was significantly high in cases as compared to controls (45% and 1.25%) (P<0.001). However, mean Apolipoprotein B was significantly low (81.2 ± 30.18mg/dl) among cases compared to controls (98.63 ±16.44mg/dl) (P <0.001). The proportion of women with Apolipoprotein B >130 mg/dl was not significant (P 0.2453) between the two groups. Mean TC/HDL and LDL/HDL ratios were significantly low in women with PCOS (P <0.05). The difference in the proportion of women with TC/HDL >4.99 and LDL/HDL >3.25 in the two groups was not significant.

Table1. Comparison of demographic characteristics, ultrasound findings, and LH/FSH ratio between two groups.

Variables	Data Mean + SD or Numbers(%)		p Value
	Case (N=80)	Control (N=80)	
Age (yrs)	26.49+ 4.65	28.61+ 5.59	0.009
BMI (kg/m2)	25.51 +3.96	24.97 + 4.33	0.418
>25	8(10%)	4(5%)	0.367
Menstrual cycle length (days) >35 days	39.92 + 8.46	31.09 + 2.39	<0.0001
	53(66.25%)	8 (10%)	<0.0001
Polycystic ovary finding in USG	33 (41.25%)	5 (6.25%)	<0.0001
LH/FSH	1.25 + 0.68	1.24 + 0.53	0.963
>2	11(13.75%)	4 (5%)	0.057

p <0.05 - statically significant
p<0.001- statistically highly significant

Table2. Fasting Insulin, Fasting Blood Sugar, and Insulin Resistance between two groups.

Variable	Data Mean+SD or bers(%)		P
	Case (n=80)	Control (n=80)	Value
Fasting Insulin (mIU/L)	7.31+ 1.64	6.97 + 1.49	0.037
Fasting Blood Sugar	93.01 + 15.75	85.91 + 10.41	0.001
(mg/dl) >100 mg/dl	20(25%)	6(7.5%)	0.00435
Insulin Resistance	1.72 + 0.55	1.45 + 0.42	0.0012
(HOMA-IR). >2.5	8(10%)	4 (5%)	0.23

p <0.05 - statically significant
p<0.001- statistically highly significant

Table3. Comparison of lipid profile and Apo lipoprotein A and Apolipoprotein B between two groups

Variable	Data Mean+SD or Numbers (%)		p Value
	Case (N=80)	Control(N=80)	
Triglycerides mg/dl >150/dl	147.14 + 22.48	102.99 + 27.79	<0.0001
	39(48.75%)	7(8.75%)	<0.0001
Total Cholesterol mg/dl>200 mg/dl	164.58 + 22.24	134.28 + 22.23	<0.0001
	4(5.00%)	0(0%)	0.12
HDL mg/dl <40 mg/dl	46.95 + 10.21	41.78 + 9.71	0.0013
	18(22.5%)	31(38.75 %)	0.0257
LDL mg/dl >130 mg/dl	78.21 + 10.35	77.49 + 14.12	0.713
	0(0%)	0(0%)	
VLDL mg/dl >40 mg/dl	29.45 + 4.45	20.58 + 5.54	<0.0001
	0(0%)	0(0%)	
APO-A mg/dl <140 mg/dl	139.99 + 47.05	193.74 + 23.40	<0.0001
	36(45.00%)	1(1.25%)	<0.0001
APO-B mg/dl >130 mg/dl	81.2 + 30.18	98.63 + 16.44	0.0014
	3(3.75%)	0(0%)	0.245
TC/HDL >4.99	3.67 + 0.93	3.35 + 0.82	0.022
	8(10.00%)	5(6.25%)	0.562
LDL/HDL >3.25	1.76 + 0.5	1.96 + 0.63	0.027
	1 (1.25%)	3(3.75%)	0.62

p <0.05 - statically significant
p<0.001- statistically highly significant.

DISCUSSION

This study has been conducted to evaluate insulin resistance and alteration in lipid profiles in Indian women with PCOS. The polycystic ovarian syndrome is a complex heterogeneous disorder that has a multifactor etiology.(25) . This syndrome is associated with impaired lipid metabolism, insulin resistance, hyperinsulinemia, hyperandrogenism, and obesity. In dyslipidemia extent and type of alteration in lipid levels are variable for different lipids (7,26) . These alterations play a crucial role in atherosclerosis and high risk for CVD in long term.

It is well known that Insulin Resistance (IR) is associated with PCOS. IR is characterized by reduced sensitivity to insulin in peripheral tissues which are muscle and adipose tissue, but not in the liver. Hyperinsulinemia in women with PCOS is due to compensatory hyper secretion of insulin by itself under the influence of IR(27) .

In our study we observed a significant difference in insulin sensitivity between women with PCOS and healthy control, although absolute elevation of fasting insulin level in the study population is not significant. Prevalence of insulin resistance in our study group is 10% , by using Homa-IR cut of value >2.5 , which is lower than other studies (28,29) The low prevalence of IR may be due to 41.5 5 % of study population are overweight and 10% are obese .There are Various studies suggested that Insulin resistance in women with polycystic ovary syndrome increases triglyceride level and decreases HDL-C level (30-32.). Women with PCOS were found to have higher mean serum triglyceride and very-low-density-lipoprotein (VLDL) levels, but lower HDL values than control women [9]. Hyperinsulinemia due to insulin resistance has been associated with lipid and lipoprotein abnormalities in women with PCOS (7). High androgen(testosterone) levels in the circulations have been associated with lowering HDL levels by increasing hepatic lipase (HL) activity, this enzyme has a role in the catabolism of HDL(26,33). Obesity increases free fatty acid level.IR reduces lipoprotein lipase activity(LPL) and high androgen level increases hepatic lipase activity. IR has a vital role in stimulating lipolysis in adipose tissue and the release of free fatty acid into circulation. Increased FFA flows to the liver and stimulates increased VLDL synthesis and secretion in the plasma leading to elevated plasma TG concentration. TGs are exchanged for cholesterol esters by the activity of CE transfer protein. This process results in TG-enriched HDL particles catabolized rapidly and leads to decreased HDL levels whereas CE-enriched VLDL is converted into small dense LDL particles. Due to reduced levels of HDL-C, reverse transport of cholesterol to the liver is impaired, leading to reduced excretion and increased concentration of total cholesterol.

In the current study levels of TG, TC, and HDL-C are statically higher and levels of apo-A1 and apo-B lipoproteins are lower in women with PCOS compared to control. We did not find any differences in LDL-C levels between the two groups. Our study did not observe classical atherogenic dyslipidemia of IR, measured as lower levels of HDL-C in women with PCOS as compared to control. We found significantly higher levels of HDL-C in PCOS as compared to control. Similar results were observed in another study conducted by Richard Largo et al(2001) and Eqbal A et al. (25, 34), whereas, both studies reported higher levels of LDL-C which is not consistent with our study.

The present study is not consistent with many studies which reported classical IR atherogenic dyslipidemia - lower levels of HDL-C and higher levels of triglycerides among women with PCOS as compared to controls (9, 28,35,36).

On the other hand, our results are not concurrent with other studies (4,37, 38) that failed to demonstrate any significant differences in lipid and lipoprotein concentrations between women with PCOS and controls.

Increased TG levels may be due to the accumulation of TGs as a consequence of increased lipogenesis, decreased clearance, or reduced fatty acid oxidation. IR plays an important role in TG metabolism. Evelyn Talbott reported substantially higher LDL-C in young PCOS than control.

Apolipoprotein-A1 (apo-A1) and Apolipoprotein –B (apo-B) are antiatherogenic and atherogenic lipoproteins respectively. Apo-B level and apoB/apoA1 ratio might be a potential biomarker in predicting the risk of CVD than traditional lipid levels, in women with PCOS (19-23) . Obesity has an apparent effect on apo-B level and apo B/apo-A1 ratio (21). Apo-B, the ligand of LDL receptor (B100), is able to exactly represent the total amount of potentially atherogenic circulating lipoprotein, since there is only one apo B moiety per particle of apoB containing lipoprotein including VLDV, IDL, LDL, chylomicrons, and lipoprotein(a) (21, 22).

The present study shows significantly lower levels of Apo –A1 and Apo- B among PCOS women as compared to controls. Valkenburg et al(9) found significantly lower levels of apoA-1 and no difference in apoB levels and Zang et al (21) reported increased Apo-B and Apo- B /Apo-A1 ratio in the women with PCOS as compared to the control group. They observed obesity and hyperandrogenism were contributing factors to these changes. Atherogenic Apo-B is supposed to be high but in our study levels of apo-B are lower in women with PCOS than controls, it may be due to the small sample size or because of no difference in the levels of LDL-C among the two groups.

Environmental factors acting in a genetic background [39], and ethnicity can play an important role [40]. Lifestyle (41) diet rich in fat and reuse of cooked oil (20) may increase metabolic syndrome. The use of different diagnostic criteria for PCOS might at least partially account for the inconsistent and often controversial findings regarding dyslipidemia in PCOS. Low HDL-C and high LDL-C and apo-B are associated with

atherosclerosis and a high risk for CVD, not observed in our study group. Rather we found higher HDL-C levels which may reduce the risk of CVD among PCOS women.

CONCLUSION

The present study did not observe a classical atherogenic alteration in the levels of HDL-C, LDL-C, and apolipoprotein-B whereas lowering in the levels of apo-A1 and higher TG is consistent in women with PCOS. Apolipoprotein A1 may be a better parameter than lipoprotein levels to predict the risk of atherosclerosis and CVD. Dyslipidemia and Insulin resistance is associated with PCOS and are a high-risk factor for atherosclerosis and CVD, therefore PCOS women should screen and keep in follow up.

Limitations:

Small sample size - a larger number of cases required to assess alterations in the Apolipoprotein-A, B, and insulin resistance. A detailed history of lifestyle, diet, reuse of cooked oil, alcohol - environmental factors which influence to regulate Apolipoprotein A and B levels. A follow-up study is required to validate insulin resistance in PCOS women.

REFERENCES

1. Rotterdam ESHRE/ASRM Sponsored PCOS Consensus Workshop Group 2004 Revised 2003 consensus on diagnostic criteria and long-term health risks related to polycystic ovary syndrome. Fertil Steril 81:19–25
2. Wild RA 2002 Long-term health consequences of PCOS. Hum Reprod Update 8:231–241
3. Goodarzi MO. Looking for polycystic ovary syndrome genes: rational and best strategy. Semin Reprod Med 2008;26:5–13.
4. Bickerton AS, Clark N, Meeking D, Shaw KM, Crook M, Lumb P, Turner C,Cummings MH 2005 Cardiovascular risk in women with polycystic ovarian syndrome (PCOS). J Clin Pathol 58:151–154.
5. Dokras A, Bochner M, Hollinrake E, Markham S, Vanvoorhis B, Jagasia DH. Screening women with polycystic ovary syndrome for metabolic syndrome. Obstet Gynecol 2005;106:131-7.
6. Lorenz LB, Wild RA 2007 Polycystic ovarian syndrome: an evidence-based approach to evaluation and management of diabetes and cardiovascular risks for today's clinician. Clin Obstet Gynecol 50:226–243
7. Talbott E, Guzick D, Clerici A, Berga S, Detre K, Weimer K, Kuller L 1995 Coronary heart disease risk factors in women with polycystic ovary syndrome. Arterioscler Thromb Vasc Biol 15:821–826
8. Ehrmann DA, Liljenquist DR, Kasza K, Azziz R, Legro RS, Ghazzi MN 2006 Prevalence and predictors of the metabolic syndrome in women with polycystic ovary syndrome. J Clin Endocrinol Metab 91:48–53
9. Valkenburg O, Steegers-Theunissen RP, Smedts HP, DallingaThie GM, Fauser BC, Westerveld EH, et al. A more atherogenic serum lipoprotein profile is present in women with polycystic ovary syndrome: a case-control study. J Clin Endocrinol Metab 2008;93(2):470–6
10. Moran L, Teede H. Metabolic features of the reproductive phenotypes of polycystic ovary syndrome. Hum Reprod Update 2009; 15:477–488
11. Dokras A. Cardiovascular disease risk factors in polycystic ovary syndrome. Semin Reprod Med 2008;26:39–44.
12. Shaw LJ, Bairey Merz CN, Azziz R, Stanczyk FZ, Sopko G, Braunstein GD, Kelsey SF, Kip KE, Cooper-Dehoff RM, Johnson BD et al. Postmenopausal women with a history of irregular menses and elevated androgen measurements at high risk for worsening cardiovascular event-free survival: results from the National Institutes of Health—National Heart, Lung, and Blood Institute sponsored Women's Ischemia Syndrome Evaluation. J Clin Endocrinol Metab 2008; 93:1276–1284.
13. Xiang S, Hua F, Tang Y, Jiang X, Zhuang Q and Qian F .Relationship between serum Lipoprotein ratio and insulin resistance in polycystic ovarian syndrome. International journal of Endocrinology .2012;1155/17328
14 Diamanti-Kandarakis E, Papavassiliou AG, Kandarakis SA, Chrousos GP. Pathophysiology and types of dyslipidemia in PCOS. Trends Endocrinol Metab. 2007 Sep;18(7):280-5. doi: 10.1016/j.tem.2007.07.004. Epub 2007 Aug 10. PMID: 17692530.
15. Dejager S, Pichard C, Giral P,Bruckert E, Federspiel NC, Beucler I, Turpin G. Smaller LDL particle size in women with polycystic ovary syndrome compared to controls. Clin Endocrinol (Oxf) 2001; 54:455–462.
16. Macut D, Panidis D, Glisic B, Spanos N, Petakov M, Bjekic J, Stanojlovic O, Rousso D, Kourtis A, Bozic I et al. Lipid and lipoprotein profile women with polycystic ovary syndrome. Can J Physiol Pharmacol 2008; 86:199–204.
17. Wild RA, Carmina E, Diamanti-Kandarakis E, Dokras A, Escobar-Morreale HF, Futterweit W, Lobo R, Norman RJ, Talbott E, Dumesic DA. Assessment of cardiovascular risk and prevention of cardiovascular disease in women with the polycystic ovary syndrome: a consensus statement by the Androgen Excess and Polycystic Ovary Syndrome (AE-PCOS) Society. J Clin Endocrinol Metab 2010; 95:2038–2049.
18 Wild RA, Rizzo M, Clifton S, Carmina E. Lipid levels in polycystic ovary syndrome: systematic review and meta-analysis. Fertil Steril 2011; 95:1073–1079
19. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) Final Report. (2002, December 17). Circulation, 106(25), 3143–3143. https://doi.org/10.1161/circ.106.25.31433
20. Kim, J. J., & Choi, Y. M. (2013). Dyslipidemia in women with polycystic ovary syndrome. Obstetrics & gynecology science, 56(3), 137–142. https://doi.org/10.5468/ogs.2013.56.3.137
21. Zhang, J., Fan, P., Liu, H., Bai, H., Wang, Y., & Zhang, F. (2012). Apolipoprotein A-I and B levels, dyslipidemia and metabolic syndrome in south-west Chinese women with PCOS. Human reproduction (Oxford, England), 27(8), 2484–2493. https://doi.org/10.1093/humrep/des19122.
22. Sierra-Johnson J, Fisher RM, Romero-Corral A, Somers VK,Lopez-Jimenez F, Ohrvik J, Walldius G, Hellenius ML, Hamsten A.Concentration of apolipoprotein B is comparable with the apolipoprotein B/apolipoprotein A-I ratio and better than routine clinical lipid measurements in predicting coronary heart disease mortality: findings from a multi-ethnic US population. Eur Heart J 2009;30:710–717.
23. Lee YH, Choi SH, Lee KW, Kim DJ. Apolipoprotein B/A1 ratio is associated with free androgen index and visceral adiposity and may be an indicator of metabolic syndrome in male children and adolescents.Clin Endocrinol (Oxf) 2011; 74:579–586.
24. Matthews, D. R., Hosker, J. P., Rudenski, A. S., Naylor, B. A., Treacher, D. F., & Turner, R. C. (1985). Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia, 28(7), 412–419. https://doi.org/10.1007/BF00280883
25. Legro, R.S. et al. (2001) Prevalence and predictors of dyslipidemia in women with polycystic ovary syndrome. Am. J. Med. 111, 607–613
26. Wild, R.A. et al. (1985) Lipoprotein lipid concentrations and cardiovascular risk in women with polycystic ovary syndrome. Clin. Endocrinol. Metab.61, 946–951
27. Franks S. Polycystic ovarian syndrome .N Engl J Med. 1995;333:853-61.
28. Sudha A: Study of Insulin Resistance and Lipid Profile in Polycystic Ovarian Syndrome. International Journal of Scientific and Research Publications, Volume 6, Issue 2, February 2016:ISSN 2250-3153 .
29. Ishrat S,Hossian M,Biswas SK. Insulin resistance in relation to clinical, endocrine and metabolic profile of infertile women with polycystic ovary syndrome. Bangabandhu Sheikh Mujib Med univ J.2021;14(1):1-6 DOI: 10.3329/bsmmuj.v14i1.50989.
30. Robinson, S. et al. (1996) Dyslipidemia is associated with insulin resistance in women with polycystic ovaries. Clin. Endocrinol. (Oxf.) 44, 277–284
31. Meirow, D. et al. (1996) Dyslipidemia in polycystic ovarian syndrome: different groups, different aetiologies? Hum. Reprod. 11,1848–1853
32. Cheung LP, Ma RC, Lam PM, Lok IH, Haines CJ, So WY, Tong PC,Cockram CS, Chow CC, Goggins WB. Cardiovascular risks and metabolic syndrome in Hong Kong Chinese women with polycystic ovary syndrome. Hum Reprod 2008;23:1431–143843
33. von Eckardstein, A. (1998) Androgens, cardiovascular risk factors, and atherosclerosis. In Testosterone: Action, Deficiency, Substitution (2ndedn) (Nieschlag, E. and Behre, H.M., eds), pp. 229–258, Springer
34. Eqbal A. Gatea, Isra Abd Alhassan Hamdan, Ferhan Ala Allah Eabaid.Effect of Polycystic Ovarian Syndrome on the Lipid Profile and sexual Hormones. J. Pharm. Sci.& Res.Vol.11(5).2019.2048-2050
35. Rocha, M. P., Marcondes, J. A., Barcellos, C. R., Hayashida, S. A., Curi, D. D., da Fonseca, Â. M., Bagnoli, V. R., & Baracat, E. C. (2011). Dyslipidemia in women with polycystic ovary syndrome: incidence, pattern and predictors. Gynecological endocrinology : the official journal of the International Society of Gynecological Endocrinology, 27(10), 814–819. https://doi.org/10. 3109/09513590.2010.508852
36. Omer M S, Saadalnour M S, Ihab H N: Serum lipid profile of polycystic ovary syndrome in Sudanese women. International Journal of Medical Science and Public Health | 2015 | Vol 4 | Issue 111606.
37. R. Shwetha, B.V. Ravi, K.S. Nalini: Serum lipoprotein(a) and lipid profile in polycystic ovarian syndrome. J Clin Sci Res 2015;4:2-6. DOI: http://dx.doi.org/10.15380/2277-5706.JCSR.14.007
38. Amini, Leila & Sadeghi, Mohammad & Oskouie, Fatemeh & Kamali, Koorosh & Maleki, Haleh. (2014). Lipid Profile in Women with Polycystic Ovary Syndrome. Crescent Journal of Medical and Biological Sciences. 1. 147-150
39. Diamanti-Kandarakis, E. et al. (2006) Polycystic ovary syndrome: the influence of environmental and genetic factors. Hormones (Athens) 5,17–34
40. Carmina, E. et al. (2003) Difference in body weight between American and Italian women with polycystic ovary syndrome: influence of the diet. Hum. Reprod. 11, 2289–2293
41. Turley, M.L. et al. (1998) The effect of a low-fat, high-carbohydrate diet on serum high density lipoprotein cholesterol and triglyceride. Eur. J.Clin. Nutr. 52, 728–732.