International Journal of Research and Development in Pharmacy and Life Sciences
Available online at http//www.ijrdpl.com
October - November, 2015, Vol. 4, No.6, pp 1820-1826
ISSN (P): 2393-932X, ISSN (E): 2278-0238

Research Article

ESTIMATION OF AROMATASE ENZYME IN OBESE INFERTILE MEN

Ula M. AL-Kawaz*, Nawal Khairy AL-Ani, and Hikmat Fakhri Wassef

High Institute of Infertility Diagnosis and Assisted Reproductive Technologies, Al-Nahrain University, Baghdad-Iraq.

***Corresponding Author: Email**

(Received: August 11, 2015; **Accepted:** September 22, 2015**)**

ABSTRACT

Male obesity is associated with physiological changes that can negatively affect male fertility. Obese men have demonstrated a 3-fold increase in the prevalence of oligozoospermia when compared with men with normal Body Mass IndexBMI .The experiment was conducted to find the correlation between Aromatase enzyme and FSH, LH, E2 , testosterone and BMI.

Seventy obese infertile male (patients) and twenty obese fertile male (control) are enrolled in this study. Aromatase enzyme, FSH, LH, E2 and testosterone hormones were measured in their serum.Median human cytochrome enzyme level was significantly higher in patients than in control group, 87.55 versus 56.95, (P= 0.014). In patients group, a significant positive correlation was found between human cytochrome enzyme, FSH and LH. The present study showed clearly that male obesity negatively impacts fertility through changes in hormone levels. The results suggest that increased estrogen as a result of aromatization in the fatty tissue, reflected through the increase in human cytochrome enzyme (aromatase), may be an important mechanism for the hypoandrogenemia and altered sperm parameters.

Keywords: Aromatase enzyme, Male infertility, Obesity.

INTRODUCTION

Male factor infertility is associated with a higher incidence of obesity and it is well recognized as a risk factor for female infertility. Male fertility both directly and indirectly has been proposed to be affected by obesity, which inducing variation in erectile dysfunction, hormonal profiles behaviour, scrotal temperatures and sleep (1).

The relationship between infertility and male obesity can be attributed to more than just sexual dysfunction and other altered physical manifestations of obesity. Erectile dysfunction is significantly associated with overweight or obesity, and about 76% of men who reported with an erectile dysfunction or decrease in libido are overweight or obese (2). Regarding the hormonal profile, there is a complicated network of hormones negative and positive feedback mechanisms which include testosterone, FSH, LH and E2 (3).

Aromatase enzyme (called estrogen synthetize or estrogen synthase) converts androgen hormones, which are involved in the sexual development of the male, to another forms of the female sex hormone estrogen. Aromatase alter testosterone to estradiol and androstenedione to estrone (4). Different tissues expressed this enzyme such as brain, ovary, placenta, bone, skin, and adipose tissue. A single gene CYP 19A1 encoded the aromatase enzyme and its expression is controlled by tissue-specific promoters. Aromatase enzyme is a member of the cytochrome P450 enzyme family and a product of the CYP 19A1 gene (5).

The location of aromatase enzyme is in theendoplasmic reticulam of the cell, where it is well-regulated by tissue-specific promotors that are in turn controlled by cytokines,hormones , and other factors. The last steps of estrogens biosynthesis from androgens catalyzed by this enzyme, specifically it convert androstenedione (the common

precursor of male and female sex hormones to E1 andtestosterone to E2 (6).

Some unanimity on the effects of obesity on sperm motility has been established, however there is no complete agreement. Researchers found that sperm motility correlated negatively with BMI, and concluded that the incidence of low progressively motile sperm count increased with increasing BMI (7).

Some studies concluded that the total motile sperm count as well as the rapid progressively sperm motility correlated negatively with the waist and hip circumference of men. Despite this evidence, not all studies have included sperm motility within their measurement parameters, and other studies have found no effect of (BMI) or obesity on sperm motility (3).

A decrease in the testosterone - estrogen ratio is consistently displayed in obese infertile men. These obese had 6% higher levels of estradiol and 25–32% lower levels of testosterone than normal weight men (8). The severity of obesity determines the degree to which levels of estradiol are increased and testosterone decreased (9). On the other hand, the increased conversion of androgens into estrogens, which is characteristic of obesity, depresses the function of the pituitary gland by disturbing normal feedback in the testis. (BMI) negatively correlated with testosterone, FSH, and Inhibin B levels and positively correlated with E2 levels (3).

SUBJECTS, MATERIALS AND METHODS:

This study is carried out between 1st of July 2014 and the 15th of January 2015. A group of 70 infertile obese patients and 20 fertile obese male was recruited in the High Institute of Infertility Diagnosis and Assisted Reproductive Technologies, AL-Nahrain University, Baghdad-Iraq. The patients were included in this study according to the following criteria:

- Ensuring male factor (exclusion of female cause and proven male cause by seminal fluid analysis),stopping hormonal treatment to patients for at least two months prior to sample collection and no other possible secondary cause for male infertility (by clinical examination and US examination) done by specialists Urologist.
- (BMI) was calculated by dividing the subject's mass by the square of his or her height, typically expressed in metric(kg/m2), this shown as in table 1

Five millilitres of venous blood was collected from each male of this study (patient and control) in a plain tube, serum was separated immediately after coagulation then stored frozen at -20°C in a deep freeze. The deep frozen serum samples were thawed, kept to reach room temperature, and brought for the estimation of the following hormones and enzyme: Aromatase enzyme, Follicular Stimulating Hormone (FSH), Luteinizing Hormone (LH), Estradiol (E2), and testosterone.

Statistical Analysis:

Data were summarized, presented and analyzed using Statistical Package for Social Sciences (SPSS) software program version 16. Chi-square test was conducted to study the association between nominal variables such as the association between groups and BMI classes. Unpaired t-test was used to compare the difference in mean numeric variables between two groups. Mann Whitney U test was used to compare median human cytochrome enzyme (aromatase) difference between patient and control groups. P-value of ≤ 0.05 was considered significant.

RESULTS:

Mean of (BMI) kg/m2 in patients and in control groups is shown in table 2. There was no significant difference in mean of (BMI) between control subjects and patients, P= 0.705.

Table 1: The BMI classification

≥40.0 (Kg/m²)	35.039.9 (Kg/m²)	30.0-34.9 (Kg/m²)	25.0-29.9 (Kg/m²)	18.5-24.9 (Kg/m²)	<18.5 (Kg/m²)	**BMI**
Class III obesity	Class II obesity	Class I obesity	overweight	Normal weight	Underweight	**Classification**

Table 2: Comparison of mean (BMI) between control group and patient group

P-value	Maximum	Minimum	SE	Mean(BMI)	N	Group
	41.52	31.04	0.70	35.81	20	Control
0.705	46.32	30.01	0.47	35.45	70	Patients
	46.32	30.01	0.40	35.51	90	Total

Table 3: Comparison of mean and median human cytochrome enzyme level between patients and control groups.

P-value	Maximum	Minimum	SE	Mean	Median	Groups
	176.76	32.12	9.88	76.46	56.95	Control
0.014	470.37	23.37	12.48	137.40	87.55	Patients
	470.37	23.37	10.29	123.86	76.61	Total

Table 4: Coordinates of ROC curve

1 - Specificity	Sensitivity	Positive if more than or equal to
….	….	….
….	….	….
0.300	0.543	79.003
0.250	0.543	79.634
0.250	0.529	82.148
0.250	0.514	85.636
0.250	0.500	87.554
0.250	0.486	88.649
0.250	0.471	91.439
0.200	0.471	96.436
0.200	0.457	99.276
0.200	0.443	104.661
….	….	….
….	….	….

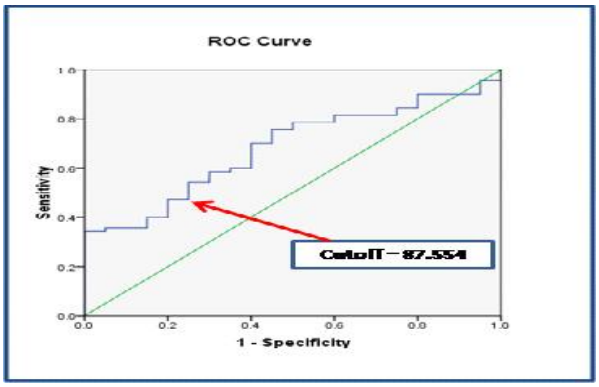

Figure (1): ROC curve showing the best human cytochrome enzyme cutoff value.

Comparison of mean and median human cytochrome enzyme level between patients and control groups is shown in table 3. Mann Whitney U test showed that median human cytochrome enzyme level was significantly higher in patient than in control group and P= 0.014.

Calculation the best cutoff, of human cytochrome enzyme, value that identifies patients group:

Presence of a wide significant difference in enzyme level in both groups, suggests a possibility of a value that predicts patient group. For this purpose a receiver operator characteristic curve (ROC) analysis was performed. This test showed that a value of ≥ 87.554 is a perfect cutoff to segregate groups into patients and controls as shown in table 4.

The specificity of the test was 75 %, sensitivity was 50%, positive predictive value (PPV) was 87.5 %, and negative predictive value (NPV) was 30%. The accuracy of the test was 68.1 % (it is very close to 0.7). The test was significant with a P-value of 0.014. These results are shown in table 5.

Correlation of human cytochrome enzyme with other variables in control group, the BMI, FSH, LH, estradiole and testosterone is shown in table 6. A significant positive correlation was found between human cytochrome enzyme and LH, whereas, no significant correlation was found between human cytochrome enzyme and the rest of other variables.

A significant positive correlation was found between human cytochrome enzyme, FSH and LH.

No significant correlation was found with other variables, age, BMI, estradiol and testosterone. These results shown in table 7.

A comparison was made between patients and control groups and the results were as shown in table 8 were as following:

Mean FSH and mean Estradiol are significantly higher in patient group than in control group (p=0.042, p=0.066 respectivly). The p-value of LHcan be considered a border line significant value being very close to 0.01. Mean LH p=0.094 and mean testosterone p=0.832 are not significantly different.

DISCUSSION:

Aromatase enzyme, which converts testosterone to E2, is highly expressed in peripheral fat tissue and any increase in aromatase activity is thought to result in increased E2 production, which inhibits secretion of FSH and LH from the pituitary gland (10).

The extraglandular aromatization of circulating androgen precursors is the major source of estrogen in all men. Importantly in men the testes account at most for 15% of circulating estrogens, while the remaining 85% is due to peripheral aromatization of circulating androgen precursors in different tissues (11), these are from adipose tissue, brain, skin, and the endothelium. Also it has been demonstrated that testicular androgen precursors contribute more to the total amount of circulating estradiol than adrenal androgens (12). These extragonadal sites of estrogen biosynthesis lack the ability to synthesize C19 precursors from cholesterol so, their estrogen-producing activity totally depends on the availability of these circulating C19 androgenic steroids (13). On the other hand, the estrogen synthesized within these extragonadal compartments may be also locally active in a paracrine or intracranial fashion (14). It is clearly that with more adipose tissue, the associated increase in adipose aromatase activity dominates any effect of the polymorphisms on intrinsic aromatase activity (15). It is known, that aromatase is a specific marker of the undifferentiated adipose mesenchymal cell phenotype, but it is less expressed in mature adipocytes. Thus, factors that stimulate adipocyte differentiation, such as Peroxisome proliferator-activated receptor gamma (PPARγ) agonists could also lead to the down regulation of aromatase gene and a reduction in aromatase activity (16). It is well known, if there are more adipocytes, there could be more aromatase activity even with reduced production of estrogen per fat cell.

The results of the present study demonstrated clearly that obesity may contributes to the decline in fertility rate among the studied patient group. As far as the hormones level are concerned, the FSH was significantly higher in patient group than in control group (the high difference in FSH because our patients are infertile), this result does not agree with results reported by other investigators (17), who showed no statistically significant relationships between (BMI) and FSH hormone. Also reported by another study a lower FSH level in obese patients (1).

Table 5: Parameters of ROC analysis

Interpretation	Value	Parameter
Considered positive	≥87.608	Cutoff
Poor	50 %	Sensitivity
Good	75 %	Specificity
Good	87.5 %	PPV
Poor	30 %	NPV
Although being Poor , it is very close to 0.7	68.1% (0.681)	Accuracy (AUC)
Significant	0.014	P-value

Table 6: Correlation between human cytochrome enzyme and other variables in control group

P-value	*R-value*	Variables
0.777	0.068	**BMI**
0.980	-0.006	**FSH (IU/L)**
0.003	0.623	**LH (IU/L)**
0.458	-0.176	**Estradiol (Pg./ml)**
0.427	-0.188	**Testosterone (ng/ml)**

Table 7: Correlation between human cytochrome enzyme and other variables in patients group

P-value	*R-value*	variables
0.359	-0.111	**Age (yr.)**
0.977	-0.003	**BMI**
<0.001	0.660	**FSH (IU/L)**
<0.001	0.582	**LH (IU/L)**
0.432	-0.095	**Estradiol (Pg./ml)**
0.602	-0.063	**Testosterone (ng/ml)**

Table 8: Mean serum hormone levels in patients and control group)

P-value	Maximum	Minimum	SE	Mean	Groups	Hormone
	7.50	1.29	0.39	3.63	**Control**	**FSH (IU/L)**
0.042	40.40	0.77	0.80	6.76	**Patients**	
	40.40	0.77	0.64	6.06	**Total**	
	5.73	2.00	0.24	3.21	**Control**	**LH (IU/L)**
0.094	22.51	1.37	0.39	4.48	**Patients**	
	22.51	1.37	0.32	4.19	**Total**	
	71.07	0.50	3.35	14.75	**Control**	**Estradiol (Pg./ml)**
0.066	42.42	5.06	1.03	19.64	**Patients**	
	71.07	0.50	1.11	18.55	**Total**	
	6.35	1.56	0.32	3.53	**Control**	**Testosterone (ng/ml)**
0.832	5.82	0.51	0.14	3.46	**Patients**	
	6.35	0.51	0.13	3.47	**Total**	

The mean LH was not significantly different in patient group than in control group, but it seems to be slightly higher than in the controls. (MacDonald et al.) (17) demonstrated that LH does not seem to be affected by (BMI) in men. A study (18), showed that there was no significant correlation explored between (BMI) and LH level, whereas another study (19), found that (BMI) significantly influenced LH value. (Qin D D, et al.) (20) claimed that obesity can reduce the level of LH. Mean estradiol was higher in patient group than in control group, although the difference was not significant, but it gives an indication that there is an association between (BMI) and an increase in this hormone. In males E2 is derived mainly from intratesticular and peripheral aromatization of the C19 androgens (androstenedione, testosterone) by aromatase, a product of the CYP191 gene. CYP 19A1 is a single copy gene located on chromosome 15 q 21.2 (21). It is believed that any increase in estrogens in obese males is owing to increased conversion of testicular and adrenal androgens due to the increase in available aromatase enzyme in the fatty tissue (22). Another study (17), stated that the levels of estradiol generally appear unaffected by (BMI), but a few studies (23) have suggested slightly higher levels with increasing (BMI).

The reduced pituitary function or hypogonadotropic hypogonadism in obese men is likely multifactorial. (Schneider G, et al.) (23) stated that in obese men both estrone and estradiol are increased due to increased peripheral aromatization of androgens. Estrogens have a negative effect on the hypothalamus that alters the gonadotropin-releasing hormone GnRH pulses and suppresses gonadotropin, FSH and LH secretion (24). Such a role for estradiol is also confirmed, showing an increase in gonadotropins and sex steroid production after the administration of aromatase inhibitors to obese men (21).

A statistically significant association was observed between (BMI) and estradiol (18, 25). (Egwurugwu et al.) (26), demonstrated significant and positive correlations between (BMI) and serum concentrations of progesterone and estradiol. Increase in (BMI) was associated with increase in serum levels of E2 and progesterone. (Roth, M. Y.) (27), clearly expressed that high levels of estrogens in obese males result from the increased conversion of androgens into estrogens due to the high bioavailability of the aromatase enzyme.

The present study exhibited that the mean testosterone was not significantly different in patient group than in control group, a negative significant correlation was found between human cytochrome enzyme and this hormone. This result seems to be different from other studies in which obese tissue leads to the lowering of the male hormone, testosterone, which directly affects fertility. Majority of studies which investigate the effect of obesity on testosterone reported decreased levels. This reduction is may be at least in part caused by the decreasing in the sex hormone binding globulin (SHBG) levels that will influence the half-life of testosterone (28). Whether the reduction in testosterone levels is adequate to exert a biological effect, influencing spermatogenesis, is a subject of debate.

The increasing in the number and size of adipocytes is associated with obesity. Many proposed mechanisms to explain the effect of obesity on male fertility focus on the influence of abnormal levels of adipose derived hormones and adipokines related to reproductive organs and hormones on fertility. Subcutaneous fat, intra-abdominal fat and total body fat may be associated with low levels of testosterone in males, and most obese males looking for infertility treatment present with a decreased in the testosterone ratio to estrogen (29, 30), this decrease is explained by over activity of the human cytochrome enzyme, which is exist at high levels in the white adipose tissue and, there for, is responsible for a key step in the biosynthesis of estrogens.

Receiver operating characteristic (ROC) curve analysis was used to calculate cut off values of variables because of the presence of wide significant differences in enzyme level in both groups.

REFERENCES

1. Hammoud, A. O., Gibson, M., Peterson C. M., et al. "Obesity and male reproductive potential". J. Androl. 2006; 27, 619–626.
2. Cheng, J. Y. & Ng, E. M. "Body mass index, physical activity and erectile dysfunction: an U-shaped relationship from population based study". Int. J. Obes. 2007; 31, 1571–1578.
3. Globerman, H., Shen-Orr, Z., Karnieli, E., et al." Inhibin B in men with severe obesity and after weight reduction following gastroplasty". Endocr. Res. 2005;31, 17–26.

4. Simpson ER, Mahendroo MS, Means GD, at el. "Aromatase cytochrome P450, the enzyme responsible for estrogen biosynthesis". Endocrine Reviews 1994; 15, 342–355.
5. Simpson ER."Aromatase: biologic relevance of tissue specific expression". Semin Reprod Med. 2004; 22:11–23.
6. Francisco Urbanos, Juan Fernandez-Baeza & Bruno Chaudret. "Selective aromatization of the A ring of steroids through demethylation by an Soc., Chem. Commun. 1991; 1739-1741.
7. Swan, S. H., Elkin, E. P. & Fenster, L. "The question of declining sperm density revisited: an analysis of 101 studies published 1934– 1996. Environ. Health Perspect. 2000; 108, 961–966.
8. Hofny, E. R., Ali, M.E., Abdel-Hafez, H.Z., et al. "Semen parameters and hormonal profile in obese fertile and infertile males". Fertil. Steril. 2010; 94, 581-4.
9. Aggerholm, A. S., Thulstrup, A. M., Toft, G., et al. "Is overweight a risk factor for reduced semen quality and altered serum sex hormone profile?" Fertil. Steril. 2008; 90, 619–626.
10. Padubidri, VG; Daftary, SN, eds. "Shaw's Textbook of Gynaecology". 2011; (15th ed.). p. 201.
11. L. Gennari, R. Nuti, & J. P. Bilezikian, "Aromatase activity and bone homeostasis in men," Journal of Clinical Endocrinology and Metabolism, 2004; vol. 89, no. 12, pp. 5898–5907.
12. W. de Ronde, H. A. P. Pols, J. P. T. M.et al."The importance of oestrogens in males," Clinical Endocrinology, (2003) vol. 58, no. 5, pp. 529–542.
13. E. Simpson, M. Jones, S. Davis, et al. "Do intracrine mechanisms regulate aromatase expression?" Journal of Steroid Biochemistry and Molecular Biology, 1999; vol. 69, no. 1–6, pp. 447–452
14. F. Labrie, A. Bélanger, L. Cusan, et al "Physiological changes in dehydroepia- ndrosterone are not reflected by serum levels of active androgens and estrogens but of their metabolites: intracrinology," Journal of Clinical Endocrinology and Metabolism, 1997; vol. 82, no. 8, pp. 2403–2409.
15. T. Yanase, Y. M. Mu, Y. Nishi, et al. "Regulation of aromatase by nuclear receptors," Journal of Steroid Biochemistry and Molecular Biology, 2001; vol.79, no. 1–5, pp. 187–192.
16. Y. M. Mu, T. Yanase, Y. Nishi, et al. "Combined treatment with specific Ligands for PPARγ:RXR nuclear receptor system markedly inhibits th expression of cytochrome P450arom in human granulosa cancer cells," Molecular and Cellular Endocrinology, 2001; vol.181, no. 1–2, pp.239–248.
17. MacDonald AA, Herbison GP, Showell M, et al. "The impact of body mass index on semen parameters and reproductive hormones in human males: a systematic review with meta-analysis". Hum Reprod Update, 2010; 16(3):293–311.
18. Hajshafiha, M., Ghareaghaji, R., Sadeghi-Bazargani, H at el. "Association of body mass index with some fertility markers among male partners of infertile couples".Int. J. Gen. Med 2013; 6, 447-451.
19. Al-Ali, B.M., Gutschi, T., Pummer, K., at el. "Body mass index has no impact on sperm quality but on reproductive hormones levels". Andrologia.2014; 46(2), 106–111.
20. Qin DD, Yuan W, Zhou WJ, et al. "Do reproductive hormones explain the association between body mass index and semen quality?" Asian J Androl. 2007; 9(6):827–34.
21. Bulun SE, Sebastian S, Takayama K. at el. "The human CYP19 (Aromatase P450) gene: update on physiologic roles and genomic organization of promoters". J Steroid Biochem Mol Biol. 2003; 86:219– 224.
22. De Boer H, Verschoor L, Ruinemans-Koerts J, at el."Letrozole normalizes serum testosterone in severely obese men with hypogonadotropic hypogonadism". Diabetes Obes Metab 2005; 7 (3) 211- 215.
23. Schneider G, Kirschner MA, Berkowitz R.at el. "Increased.estrogen production in obese men". J Clin Endocrinol Metab.1979; 48 (4) 633-638.
24. Akingbemi BT." Estrogen regulation of testicular function". Reprod Biol Endocrinol .2005; 3: 51.
25. Pauli, E.M., Legro, R.S., Demers, L.M., at el. "Diminished paternity and gonadal function with increasing obesity in men". Fertil Steril. 2008; 90(2):346-51.
26. Egwurugwu1, J.N., Nwafor, A., Chike, C.P.R., at el. "The relationship between body mass index, semen and sex hormones in adult male". Nig. J. Physiol. Sci. 2011; 26, 29 –34.
27. Roth, M. Y., Amory, J. K. & Page, S. T. "Treatment of male infertility secondary to morbid obesity". Nat. Clin. Pract. Endocrinol. Metab. 2008; 4, 415–419.
28. Foresta C, Di Mambro A, Pagan C, at el." Insulin-like factor 3 as a marker of testicular function in obese men". Clin Endocrinol. 2009; 7,422-426.
29. Tsai, E. C., Matsumoto, A. M., Fujimoto, w. Y. et al. "Association of bioavailable, free, and total testosterone with insulin resistance: influence of sex hormone-binding globulin and body fat". Diabetes Care. 2004; 27, 861–868.
30. Strain, G. W. "Mild hypogonadotropic hypogonadism in obese men". Metabolism. 1982; 31, 871–87

