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Prevalence of metabolic syndrome in beta-thalassemia major adult patients in Tanta University Hospitals

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***Abstract*---**Introduction: one of long-term complications of Beta-thalassemia major (β-TM) disease is metabolic syndrome, which has a significant influence on patients' quality of life. Objective: to investigate the prevalence of metabolic syndrome in β-thalassemia major patients in Tanta University Hospitals. Materials and methods: our study included two groups. Group I: consist of (100) adult beta-thalassemia major patients. Group II: consist of (100) sex and age matched healthy subjects as control group. Results: the present study revealed that 29% of our β-thalassemia major patients had metabolic syndrome while in control group it was 2.0%, and low high-density lipoprotein (HDL)was the most frequent positive criterion it was 86.0% in β-thalassemia major patients' group. Prevalence of hyperglycemia, abdominal obesity, hypertriglyceridemia, and hypertension in patients with thalassemia was 29, 41, 21and 7%, respectively. Prevalence of metabolic syndrome in female patient was 34.3% while in male beta thalassemia major patient it was 18.2%. the prevalence of metabolic syndrome in well chelated beta thalassemia major patient was 0.0%, while in poorly chelated patients it was 35.4%. Conclusions: this study revealed that 29% of β-thalassemia major group patients had International Diabetes Federation (IDF) criteria of metabolic syndrome and low HDL was the most frequent positive criterion. Metabolic syndrome was more prevalent in female and in poorly chelated β-thalassemia patients.

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***Keywords*---**β-thalassemia major, metabolic syndrome, prevalence, insulin resistance.

Introduction

β-thalassemia is a major public health problem in Egypt. It has been estimated that 1000 children out of 1.5 million live births are born annually with thalassemia major (el-Hashemite et al., 1997). The life expectancy and survival of these patients have increased dramatically over previous decades through introduction of regular blood transfusion therapy and iron-chelating therapies. However, repeated transfusions cause iron overload, with life-threatening complications, such as endocrine dysfunction, cardiomyopathy, liver disease and premature death (Olivieri & Brittenham, 1997). Hyperinsulinemia and insulin resistance are well documented in β-TM patients; however, its association with metabolic syndrome has not been assured (Yamagishi & Iso, 2017).

Materials and Methods

This study was carried on beta- thalassemic major patients admitted to Tanta University Hospitals in (Internal Medicine Department wards and Hematology Outpatient Clinic) for one year duration starting from March 2019 to March 2020. Our study included two groups. Group I: consist of (100) adult beta-thalassemia major patients, Group II: consist of (100) sex and age matched healthy subjects as control group.

The exclusion criteria: patient with diabetes mellitus and secondary hypertension, Adult who had any type of disability that would prevent us from measuring their weight, height, and waist circumference and Pregnant women. All patients and controls were subjected to full history taking (age, sex, disease duration, first time of blood transfusion, number of blood transfusion /year, age of splenectomy and type & duration of chelation therapy), full clinical examination and laboratory investigations; CBC, serum ferritin, complete lipid profile (Serum triglyceride (TG), Total cholesterol (Chol), High-density lipoprotein (HDL), Low-density lipoprotein (LDL)) - Fasting plasma glucose - Fasting serum insulin-. HOMA-IR The Homeostasis model assessment for Insulin Resistance model.

Metabolic syndrome definition

We used the International Diabetes Federation (IDF) consensus worldwide definition to define metabolic syndrome. According to these criteria, presence of at least three of the below components was classified as metabolic syndrome:

1. Central obesity (≥16 years: waist circumference WC ≥ 94 cm in males and ≥ 80 cm in females), which is defined for Eastern Mediterranean and Middle East population.
2. Raised triglyceride level (TG): ≥150 mg/dL.
3. Reduced High-density lipoprotein (HDL) cholesterol: < 40 mg/dL in males and < 50 mg/dL in females.
4. Raised blood pressure: systolic BP ≥ 130 mmHg or diastolic BP ≥ 85 mmHg.

5. Raised Fasting plasma glucose (FPG): FPG ≥ 100 mg/dL (Martin & Thompson, 2013).

Blood sampling

Five milliliter of venous blood was withdrawn by sterile vein puncture after a 12 h overnight fasting. Four milliliter was transferred into plain tubes, allowed to clot, centrifuged for 15 min at 3000 rpm, and 1 ml was transferred into an EDTA tube for complete blood count.

Statistical analysis

Analyses were performed using SPSS version 21. Parametric quantitative data were presented by Mean ± SD, range and evaluated by student t test while non-parametric data were presented by median, Interquartile range and evaluated by Mann Whitney U test. Categorical data were presented by number and percent and assessed by the chi-square test and when it was inappropriate it was replaced by Monte Carlo Exact test. P value was considered significant at the level of <0.05 and highly significant at the level of < 0.001.

Results

Our study included two groups: Group I: consist of (100) adult beta-thalassemia major patients, Group II: consist of (100) sex and age matched healthy subjects as control group. Comparison between studied groups showed insignificant difference in age and gender. The patient group was significantly lower than control group as regard height, weight and body mass index (BMI) with (P < 0.001) (P < 0.001), (P = 0.003) respectively. This can be explained by liability of beta thalassemia major patients for impaired growth and development due to chronic anemia. , hyper metabolic state ,endocrinopathies (eg, hypogonadism with delayed puberty), typically due to excess iron deposition (Ismail, Campbell, Ibrahim, & Jones, 2006). The patient group was significantly lower than control group as regard fasting blood glucose, fasting insulin level, HOMA- IR with (P = 0.011), (P < 0.001), (P < 0.001) respectively. Hyperglycemia might be due to early impairment of β cell function and insulin resistance. Regarding total cholesterol, high density lipoprotein cholesterol was statistically significantly low in thalassemic patients when compared with normal controls (P<0.001). However, serum triglyceride, and low-density lipoprotein cholesterol levels were statistically significantly higher in our beta-thalassemia major patients when compared with the normal control group (P=0.005, P<0.001) respectively. Regarding hemoglobin, the patient group was significantly lower than control group (P<0.001). Contrary to hemoglobin, platelets and WBCs were described to be increased in the patient group of current study due to splenectomy (P < 0.001). In the current study, the patient group was significantly higher than control group regarding serum ferritin (P<0.001). (Table I)

The well chelated beta thalassemia major patient group (Serum Ferritin ≤2500) was significantly lower than poorly chelated patient group (Serum Ferritin >2500) as regard fasting blood glucose, fasting insulin level, HOMA- IR with (P = 0.022), (P = 0.001), (P = 0.002) respectively (Table II). Prevalence of underweight, normal, overweight, and obesity in beta thalassemia major patients was 29, 65, 6, and 0%, respectively; while in control group it was 14, 58, 21, and 7%, respectively. Comparison between the two-group showed that beta thalassemia major patients' group has more underweight, less overweight and no obese when compared with control group(P<0.001) (Figure I).

Prevalence of metabolic syndrome in beta thalassemia major patients' group was 29.0% while in control group it was 2.0% and low high-density lipoprotein (HDL)was the most frequent positive criterion it was 86.0% in β-thalassemia major patients' group. The patient group was significantly higher than control group as regard prevalence metabolic syndrome (P<0.001) (Figure II). Prevalence of metabolic syndrome in male beta thalassemia major patients' group was 18.2%, while in female patients group it was 34.3%. There was no statistically significant difference between the two group as regard Prevalence of metabolic syndrome (P=0.094) (Figure III).

Prevalence of metabolic syndrome in well chelated beta thalassemia major patient was 0.0%; while in poorly chelated patients it was 35.4% and low high-density lipoprotein (HDL)was the most frequent positive criterion it was 89.0%in poorly chelated beta thalassemia major patient group. Comparison between the two-group showed that well chelated patients' group was significantly lower than poorly chelated beta thalassemia major patients' group regarding prevalence metabolic syndrome (P=0.003) (Figure IV).

Discussions

Beta-thalassemia major (β-TM), is one type of a hemoglobinopathies leading to chronic hemolytic anemia (Weatherall, 2004). β- thalassemia major is a common disease in Mediterranean countries, Southeast Asia, the Indian subcontinent and the Middle East (El-Beshlawy et al., 1999). As in many Mediterranean countries, β-thalassemia is a major public health problem in Egypt. The position of Egypt in the center of the Middle East, contiguous with the Mediterranean countries, has facilitated genetic admixture of Egyptians with several populations of diverse geographic and ethnic origins (Thuret et al., 2010).

The life expectancy and survival of these patients have increased dramatically over previous decades through introduction of regular blood transfusion therapy and iron-chelating therapies (Olivieri & Brittenham, 1997). However, repeated transfusions cause iron overload, with life-threatening complications, such as endocrine dysfunction, cardiomyopathy, liver disease and, ultimately, premature death. In the absence of transfusion, patients with beta-thalassemia major die within the first five years of life, and even with transfusions, only 50–65% of patients live beyond the age of 35 years in high-income countries (Saki et al., 2019). While β-thalassemia major patients' survival has improved, there are growing concerns about long-term complications of this disease and its related therapies. Hyperinsulinemia and insulin resistance are well documented in β-TM patients; however, its association with metabolic syndrome has not been assured. Therefore, we aimed to investigate the prevalence of metabolic syndrome in beta-thalassemia major patients (Yamagishi & Iso, 2017).

This study was carried out on 100 adult beta-thalassemia major patients and 100 healthy individuals of matched age and sex as controls. In the present study height, weight and body mass index (BMI) were significantly lower in the thalassemia group compared to the control group ($P < 0.001$, $P< 0.001$, $p = 0.003$) respectively; while waist circumference was significantly higher in the thalassemia group compared to the control group ($P < 0.001$). This can be explained by liability of beta thalassemia major patients for impaired growth and development. In agreement with these results, Saki F, et al (Saki et al., 2019) demonstrated that height, weight and BMI were significantly lower in the thalassemia group compared to the control group ($P < 0.001$). While Gozashti MH, et al (Gozashti, Hasanzadeh, & Mashrouteh, 2014) found that waist circumference was significantly lower in the thalassemia group compared to the control group ($P < 0.001$). In the present study the median (IQR) of fasting blood glucose was 89.5 (35) (mg/dL) in β-thalassemic patient group while in control group it was 87 (10.75) (mg/dL), The patient group was significant higher than control group regarding fasting blood glucose (P=0.011). In beta-thalassemia major patients, hyperglycemia might be due to early impairment of β cell function and insulin resistance. Iron overload and chronic hepatitis C (HCV) could play a significant role in this regard (Khalifa et al., 2004).

In agreement with these results, Shams S, et al (Shams et al., 2010) revealed that the serum glucose concentration was significantly higher in the patients than in the controls (P=0.000) . In disagreement with our results, Suvarna J, et al (Suvarna, Ingle, & Deshmukh, 2006) found that there was no significant difference between the fasting plasma glucose of cases and the controls. In our study, the median (IQR) of fasting insulin level was 8 (11.375) (mlU/mL) in patient group while in control group it was 5.75 (4) (mlU/mL), The patient group was significantly higher than control group regarding fasting insulin level ($P<0.001$).

In line with our results, Suvarna J, et al (Suvarna et al., 2006) in their study of insulin resistance and beta cell function in chronically transfused patients of thalassemia major found that fasting plasma insulin was significantly higher in cases as compared to the controls ($P = 0.004$); this occurs as the initial insult is insulin resistance compensated by hyperinsulinemia, related to liver dysfunction (due to iron deposition), that may interfere with insulin's ability to suppress hepatic glucose uptake. Also, at the level of the muscle, iron deposits may decrease glucose uptake (Loebstein et al., 1998).

In disagreement with our results Shams S, et al (Shams et al., 2010) found that there was no significant difference between the serum insulin level of cases and controls (P=0.215). Also, the study made by Abdulsada SH et al. (Abdulsada, Farag, Kamil, Abdul-Rudha, & Hussein, 2017) show that insulin and β-cell function decreased significantly in serum of β-thalassemia patients when compared with that of the control group, this due to iron excess and its related oxidative stress can mediate apoptosis of pancreatic islet cells resulting in decreased insulin secretory capacity.

In our study, the median (IQR) of HOMA- IR was 1.7 (4.85) in patient group while in control group it was 1.2 (0.8), The patient group was significantly higher than control group regarding HOMA- IR ($P<0.001$). Bhat KG, et al (Bhat & Periasamy, 2014) found that the insulin resistance index was higher in cases compared to controls and the difference was highly significant. Also the study performed by Suvarna J, et al (Suvarna et al., 2006) , Shams S, et al (Shams et al., 2010) reported that Insulin resistance index (IRI) was significantly higher in cases compared to controls .

An increase in fasting serum glucose and insulin resistance index accompanied with normoinsulinemia suggests some degree of insulin resistance and relative pancreatic failure, because normally the islet cells should produce more insulin to overcome hyperglycemia. It is likely that an elevated level of iron and ferritin cause iron toxicity in the liver and pancreas and insulin dysregulation, due to hepatic and pancreatic dysfunction, which is most likely the cause of impaired glucose metabolism in our patients (Shams et al., 2010). We found that total cholesterol, high density lipoprotein cholesterol was statistically significantly low in thalassemic patients when compared with normal controls ($P<0.001$). However, serum triglyceride, and low-density lipoprotein cholesterol levels were statistically significantly higher in our beta-thalassemia major patients when compared with the normal control group ($P=0.005$, $P<0.001$) respectively.

Our results are in agreement with the results obtained by Mario et al. (Maioli et al., 1997) who reported that thalassemic patients had higher TG and LDL concentrations compared with controls. They explained their results by the reduction in extra hepatic lipolytic activity, which could account for the rise in circulating TG in thalassemic patients. There are some clues that iron overload, steatosis, and chronic viral infections from repeated hemotransfusions may induce hepatic acute phase response, which is associated with an enhanced LDL secretion. Also, Shalev et al. (Shalev, Kapelushnik, Moser, Knobler, & Tamary, 2007) who stated that the mechanism of hypocholesterolemia in thalassemia major includes increased erythropoietic activity, resulting in increased cholesterol requirements and liver injury due to iron overload. In addition, increased uptake of LDL by macrophages and histiocytes of the reticuloendothelial system is the main determinant of low plasma cholesterol levels in patients with beta - thalassemia major.

In the current study, the median (IQR) of serum ferritin was 7735 (7683.5) (ng/mL) in patient group while in control group it was 60 (27.95) (ng/mL). The patient group was significantly higher than control group regarding serum ferritin ($P<0.001$). This is comparable with previous studies where reported ferritin level was 3682 ± 1693 ng/mL Kandhari et al., 2005 (AESSOPOS & FARMAKIS, 2005) and 3225 ± 1594 ng/ mL (Munir et al., 2013) (Pinto & Forni, 2020). Increased intestinal iron absorption, repeated blood transfusions, peripheral hemolysis and ineffective erythropoiesis are unavoidably linked to iron accumulation within different organs like liver, kidney, heart and endocrine glands (Ayyash & Sirdah, 2018).

In our study the median (IQR) of hemoglobin was 7.6 (2) (g/dL) in patient group while in control group it was 12.05 (2) (g/dL), The patient group was significantly lower than control group regarding hemoglobin level ($P<0.001$). That is also in line with previous studies Ayyash et al., (Ayyash & Sirdah, 2018) the mean Hb in thalassemia patient it was (7.4 ± 0.8 g/dL and 7.36 ± 1.57 g/dL) in the males and females βTM patients, respectively while in control it was (13.9 ± 0.7 g/dL and 12. 6 ± 1.2 g/dL).

Contrary to RBCs, platelets and WBCs were described to be increased in the patient group of current study due to splenectomy. The median (IQR) of Platelet was 572.500 (333.25) (x103/mm3) in patient group while in control group it was 250 (134.45) (x103/mm3),The patient group was significant higher than control group regarding platelet (P<0.001), while the median (IQR) of white blood cells was 11.285 (8.84) (x103/mm3) in patient group while in control group it was 5.925 (3.003) (x103/mm3) ,The patient group was significant higher than control group regarding white blood cells (P<0.001) which is also in cohort with previous studies (Munir et al, Ayyash et al.,) (Ayyash & Sirdah, 2018; Pinto & Forni, 2020).

In our study, Prevalence of underweight, normal, overweight, and obesity beta thalassemia major patients was 29, 65, 6, and 0%, respectively; while in control group it was 14, 58, 21, and 7%, respectively. Comparison between the two-group showed that beta thalassemia major patients' group has more underweight, less over weight and no obese when compared with control group (P <0.001). Our results are in agreement with the results obtained by Ali A et al. (Asadi-Pooya & Karamifar, 2004))who showed that patients with thalassemia major have low BMI, a common finding in these patients especially when they were older than 10 years of age. It is in agreement with Abdulsada SH et al. (Abdulsada et al., 2017), who stated that BMI decrease in patients group compared with healthy people.

The present study revealed that 29% of our β- thalassemia major patients had metabolic syndrome while in control group it was 2.0%, and low HDL was the most frequent positive criterion it was 86.0% inpatient group. Prevalence of hyperglycemia, abdominal obesity, hypertriglyceridemia, and hypertension in patients with thalassemia was 29, 41,21and 7%, respectively. The present study showed that metabolic syndrome was more prevalent in females; Prevalence of metabolic syndrome in female patient it was 34.3% while in male beta thalassemia major patient was 18.2%.

Our results are in agreement with the results obtained by Saki F, et al (Saki et al., 2019) which show that 22% of his β- thalassemia major patients had metabolic syndrome while in control group it was 2.0% , and low HDL was the most frequent positive criterion it was 90.0% inpatient group. Prevalence of hyperglycemia, abdominal obesity, hypertriglyceridemia, and hypertension in patients with thalassemia was 32, 32, 23and 4%, respectively. In disagree with our result Gozashti MH, et al (Gozashti et al., 2014) revealed that prevalence of metabolic syndrome in minor β-TM patients was lower than that in the normal population, and they proposed that minor thalassemia might act as a protective factor for metabolic syndrome.

The present study showed that prevalence of metabolic syndrome in well chelated beta thalassemia major patient was 0.0%, while in poorly chelated patients it was 35.4% and low HDL was the most frequent positive criterion it was 89.0% in poorly chelated beta thalassemia major patient. Our results are in agreement with Datz C, et al (Datz, Felder, Niederseer, & Aigner, 2013) who stated that Serum ferritin was positively associated with BMI, visceral fat mass, serum glucose levels and insulin sensitivity, blood pressure, the MetS and also related to cholesterol levels.

Conclusions

This study revealed that 29% of β-thalassemia major group patients had IDF criteria of metabolic syndrome and low HDL was the most frequent positive criterion. Metabolic syndrome was more prevalent in female patients. Prevalence of metabolic syndrome in well chelated beta thalassemia major patient was 0.0%, while in poorly chelated patients it was 35.4%.

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Tables

Table (I): general characteristics and the biochemical studies of beta thalassemia major patients and their healthy controls

Variables		Group I Patients (n=100)	Group II Control (n=100)	Test	P-value
Age (years)	Median (IQR)	26 (8)	26 (9.75)	Mann Whitney test U =4351.5	0.112
Gender	Male	33 (33%)	30 (30%)	Chi square test X^2=0.209	0.648
	Female	67 (67%)	70 (70%)		
Height (cm)	Mean ± SD	160.1 ± 5.98	165.8 ± 4.22	*Student t-test t =7.886*	<0.001*
	Min. – Max.	147 – 173	158 – 177		
Weight (kg)	Median (IQR)	55 (13.75)	63 (12.75)	Mann Whitney test U = 2498.0	<0.001*
Body Mass Index (BMI) (kg/m2)	Median (IQR)	22.1 (5.6)	22.65 (4.55)	*Mann Whitney test U =3777.5*	0.003*
Waist circumference (cm)	Mean ± SD	*81.6 ± 4.52*	*78.3 ± 5.65*	*Student t-test t =4.509*	<0.001*
	Min. – Max.	*73 – 95*	*66 – 98*		
Systolic blood pressure (SBP) (mmHg)	Median (IQR)	100 (15)	110 (10)	*Mann Whitney test U = 2748.5*	<0.001*
Diastolic blood pressure (DBP) (mmHg)	Median (IQR)	70 (20)	75 (10)	*Mann Whitney test U= 3440.0*	<0.001*
Fasting blood glucose (FBG) (mg/dL)	Median (IQR)	89.5 (35)	87 (10.75)	*Mann Whitney test U= 3957.5*	0.011*
Fasting insulin level (mlU/mL)	Median (IQR)	8 (11.375)	5.75 (4)	*Mann Whitney test U= 3034.5*	<0.001*
Homeostasis model assessment for insulin resistance (HOMA- IR)	Median (IQR)	1.7 (4.85)	1.2 (0.8)	*Mann Whitney test U = 3039.5*	<0.001*
Triglyceride (TG) (mg/dL)	Median (IQR)	111.5 (38.75)	110 (39.5)	*Mann Whitney test = 3844.5*	0.005*
High density lipoprotein	Median (IQR)	31 (11)	40 (15)	*Mann Whitney test*	<0.001*

(HDL) (mg/dL)				*U =1852.0*	
Total cholesterol (mg/dL	Median (IQR)	103 (34.75)	145 (33.5)	*Mann Whitney test U = 959.5*	<0.001*
Low density lipoprotein (LDL) (mg/dL)	Median (IQR)	55 (14.25)	44 (10.75)	*Mann Whitney test U = 3068.0*	<0.001*
Hemoglobin (Hb) (g/dL)	Median (IQR)	7.6 (2)	12.05(2)	*Mann Whitney test U = 0.000*	<0.001*
Platelets (x10³/mm³)	Median (IQR)	572.500 (333.25)	250 (134.45)	*Mann Whitney test U =255.5*	<0.001*
White blood cells (WBCs) (x10³/mm³)	Median (IQR)	11.285 (8.84)	5.925 (3.003)	*Mann Whitney test U =1360.0*	<0.001*
Ferritin (ng/mL)	Median (IQR)	7735 (7683.5)	60 (27.95)	*Mann Whitney test U =0.000*	<0.001*

*P≤ 0.05 (statistically significant), ≤0.001 (highly significant).

Table (II): general characteristics and the biochemical studies of well chelated and poor chelated beta thalassemia major patients

Variables		Well chelated (Serum Ferritin ≤2500) (n=18)	Poor chelated (Serum Ferritin >2500) (n=82)	Test	P-value
Age (years)	Median (IQR)	23 (7.25)	26 (8)	Mann Whitney test U=629.5	0.060
Height (cm)	Mean ± SD	161.3 ± 5.78	159.8 ± 6.02	Student t-test t=0.946	0.346
	Min. – Max.	148 – 172	147 – 173		
Weight (kg)	Median (IQR)	52.5 (16)	55 (13.25)	Mann Whitney test U=630.5	0.334
Body Mass Index (BMI) (kg/m2)	Median (IQR)	19.95 (5.35)	22.5 (5.375)	Mann Whitney test U=546.0	0.085
Systolic blood pressure (SBP) (mmHg)	Median (IQR)	100 (21.25)	100 (15)	Mann Whitney test U=649.0	0.416
Diastolic blood pressure (DBP)	Median (IQR)	70 (20)	70 (20)	Mann Whitney test	0.685

(mmHg)				U=694.5	
Waist circumference (cm)	Mean ± SD	79.8 ± 4.00	81.9 ± 4.56	Student t-test t=1.822	0.071
	Min. – Max.	74 – 86	73 – 95		
Fasting blood glucose (FBG)	Median (IQR)	86.5 (9.5)	92.5 (38)	Mann Whitney test U=483.0	0.022*
Fasting insulin level	Median (IQR)	5.5 (4.125)	8.5 (15.625)	Mann Whitney test U=354.5	0.001*
Homeostasis model assessment for insulin resistance (HOMA IR)	Median (IQR)	1.35 (0.9)	1.7 (5.7)	Mann Whitney test U=396.5	0.002*
Triglyceride (mg/dL)	Median (IQR)	103 (22.5)	117.5 (53.25)	Mann Whitney test U=412.0	0.003*
High density lipoprotein (HDL) (mg/dL)	Median (IQR)	32 (27.5)	31 (11)	Mann Whitney test U=713.0	0.822
Total cholesterol (mg/dL)	Median (IQR)	104 (55.75)	103 (30)	Mann Whitney test U=710.5	0.805
Low density lipoprotein (LDL) (mg/dL	Median (IQR)	50.5 (28)	55 (22.75)	Mann Whitney test U=692.0	0.680
Hemoglobin (Hb) (g/dL)	Median (IQR)	7.85 (2.325)	7.6 (1.925)	Mann Whitney test U=679.5	0.599
Platelets (x 10^3)	Median (IQR)	504 (266.5)	650.5 (338.25)	Mann Whitney test U=558.0	0.106
White blood cells (WBCs) (x 10^3)	Median (IQR)	13.45 (8.8675)	10.5 (8.05)	Mann Whitney test U=556.0	0.102
Ferritin (ng/mL)	Median (IQR)	2365 (218.75)	8784.5 (5970)	Mann Whitney test U=00.0	<0.001*
Type of chelator	Deferasirox (n= 54)	0 (0.0%)	54 (65.9%)	Chi square test x2=25.769	<0.001*
	Deferasirox +Deferoxamine (n= 46)	18 (100.0%)	28 (34.1%)		

*P≤ 0.05 (statistically significant), ≤0.001 (highly significant)

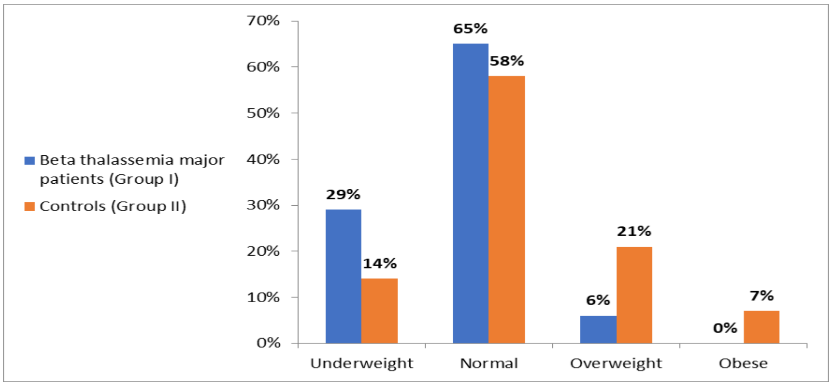

Figure (I): WHO body mass index (BMI) categories in the beta thalassemia major patients and controls group

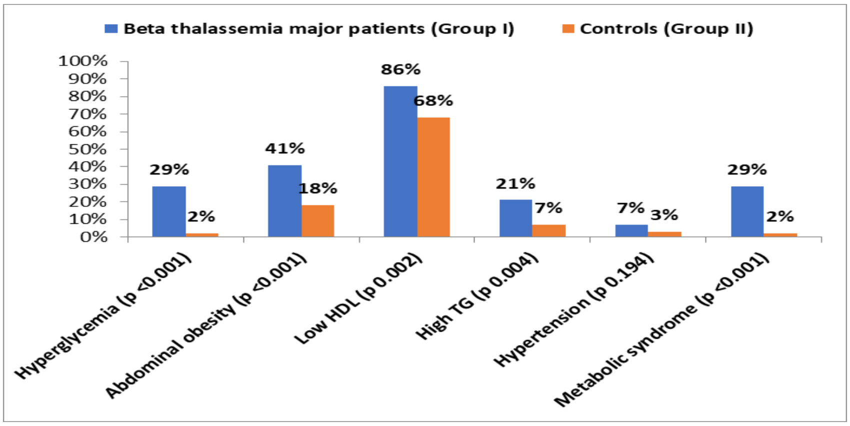

Figure (II): Frequency of positive International Diabetes Federation (IDF) criteria of metabolic syndrome comparisons between beta thalassemia patients and their controls

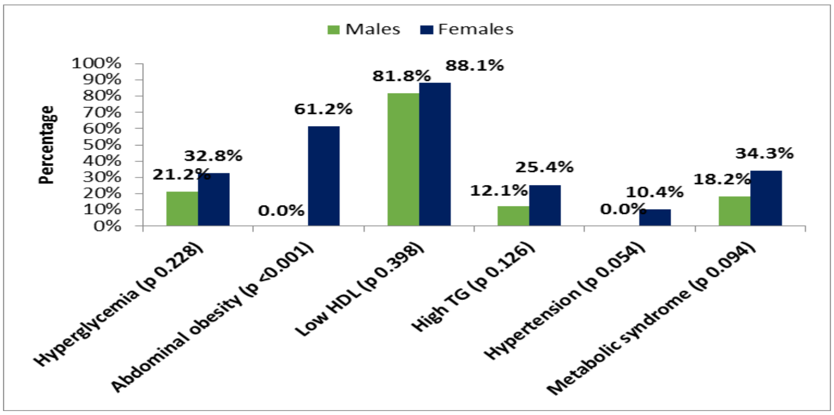

Figure (III): Frequency of positive International Diabetes Federation criteria of metabolic syndrome comparisons between males and females in beta thalassemia patients

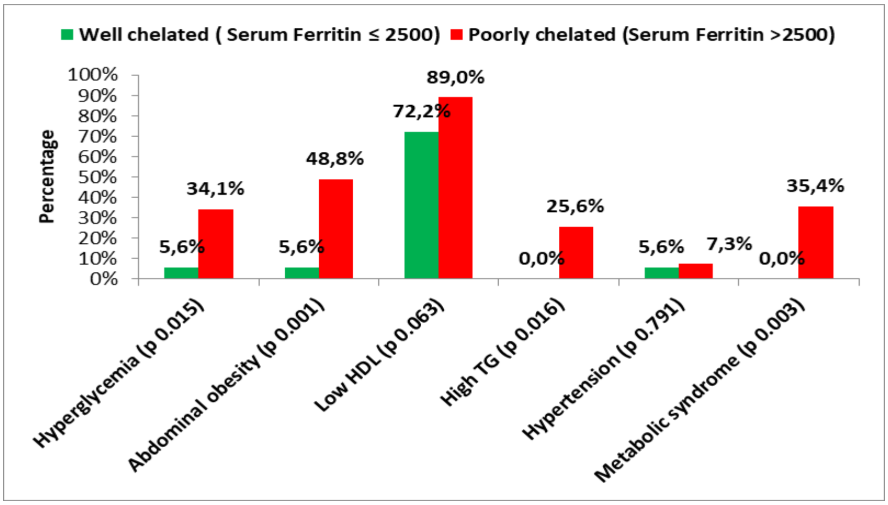

Figure (IV): Frequency of positive International Diabetes Federation (IDF) criteria of metabolic syndrome in well chelated and poorly chelated beta thalassemia major patients