

PREVALENCE OF OSTEOPOROSIS AMONG THALASSEMIC CHILDREN IN SULAIMANI

Adnan M Hasan ^a, Taha A Qaradaghi ^b
and Mohammed M Alghabsha ^c



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ABSTRACT

Background

Thalassaemia is a group of hereditary disorders and it is the most prevalent monogenetic disease in the world. Osteopenia and osteoporosis are frequent among beta-thalassaemia major patients caused by multiple factors interfere with bone remodeling.

Objective

To assess the prevalence of osteoporosis among thalassaemic children and identify factors contributed to osteoporosis in Sulaimani city\Iraq.

Patients and Methods

A cross sectional study carried out in Shaheed Dr. Hemin Hospital (Internal Teaching Hospital) in Sulaimani for period from the 1st of January to the 30th of August, 2015 on a sample of 100 patients with thalassaemia. The data were collected with direct interview and filling of a questionnaire. Selected patients were known cases of Beta thalassaemia registered in Thalassaemia center. Some information was taken from the patients and/or their parents; other information was taken from the patients files in Thalassaemia department and DXA department.

Results

Mean age of thalassaemic patients was 13.4±3.2 years. Osteoporosis was represent in 44 of thalassaemic patients and osteopenia was represent in 47 patients. A significant association between osteoporosis and thalassaemic patients with age 13-18 years (p=0.009).A significant association was observed between osteoporosis and weekly intake of dairy products (p=0.03), and weekly intake of eggs by thalassaemic patients (p=0.001).

Conclusion

Osteoporosis prevalence in thalassaemic patients in Sulaimani was lower than the reported prevalence in previous researches in Iraq and other countries.

Keywords: *Osteoporosis, Thalassaemic children, Sulaimani.*

^a Department of Pediatrics, College of Medicine, University of Sulaimani.

Correspondence: adnan.hasan@univsul.edu.iq

^b Sulaimani Interanl medicine Teaching hospital –Rheumatology section Sulaimani Health Directorate.

^c Sulaimani Pediatric Teaching Hospital, Sulaimani Health Directorate.

INTRODUCTION

Thalassaemia is a hereditary disorder of hemoglobin synthesis, and most common monogenetic disease. Beta Thalassaemia is the most common inherited single gene disorder in the world. There are 270 million carriers of thalassaemia worldwide, of which 80 million carry β -thalassaemia genes ⁽¹⁾. Iraq is one of the major centers for individuals with β -thalassaemia in the Eastern Mediterranean Region ⁽²⁾. Patients with β -thalassaemia major are susceptible to osteopenia and osteoporosis due to several factors which interfere with bone remodeling; delay in sexual maturation, hypothyroidism, diabetes mellitus, accelerated hemopoiesis with progressive marrow expansion and iron toxicity have been identified as major causes of osteoporosis among thalassaemic patients ⁽³⁾. Reduced bone mass, fractures and skeletal pain are common causes of morbidity and disability in patients with homozygous β thalassaemia. Bone abnormalities such as spinal deformities, nerve compression, scoliosis, spontaneous fractures, osteopenia and osteoporosis have also been described in patients with thalassaemia ^(4, 5).

During the last decade, presence of osteopenia and osteoporosis among well-treated thalassaemic patients had been described in different studies with high prevalence up to 50% ⁽⁶⁾. The pathogenesis of osteoporosis in thalassaemia major (TM) is complicated and differs from the pathogenesis of bone deformities characteristically found in non-transfused patients who develop bone distortion mainly because of ineffective haemopoiesis and progressive marrow expansion ⁽⁷⁾. In previous work by other authors in thalassaemic population, the lumbar spine and femoral neck bone mineral density (BMD) was lower than normal reference (10).

The aim of this study was to find out the prevalence of osteoporosis among thalassaemic children in Sulaimani and assess some factors contributing to osteoporosis.

PATIENTS AND METHODS

A cross sectional study carried out in Thalassaemia centre in Sulaimani from the 1st of January to the 30th of August, 2015. One hundred thalassaemic children regularly visiting the Thalassaemia Consultancy Clinic of Shaheed Dr. Hemin Hospital in Sulaimani for blood transfusion and clinical checking were the study population.

Thalassaemic patient requiring blood transfusion

(major & intermedia) aged ≤ 18 years were included. Excluded patients were those with pre-existing severe medical condition, chronic systemic administration of steroids, patients on bisphosphonate and Patients and/or their parents refused to participate.

The data were collected by the researchers through direct interview and filling a pretested questionnaire. Selected patients were known cases of Beta thalassaemia registered in Thalassaemia center. Some information was taken from the patients and/or their parents; other informations were taken from the patients files in Thalassaemia centre and radiology department. The questionnaire included the following information: type of thalassaemia, sociodemographic characteristics (age, gender and residence), amount of blood transfused per year, associated disorders (diabetes mellitus, hypothyroidism and liver diseases), surgical history (splenectomy and fractures), treatment history (chelation therapy, hormonal replacement therapy, corticosteroids, bisphosphonate and calcium with vitamin D), nutritional history (dairy products, eggs, grains, vegetables and fruits intake), vaccination history (Influenza and pneumococcal vaccines), smoking history, physical activity (whether regular or irregular), weight, height and body mass index, serum calcium, serum ferritin, DXA scan findings.

In all patients, BMD was determined using dual X-ray absorptiometry (DXA, Lunar DPX-Plus), both at the lumbar spine (L1–L4) in A-P projection and at the femoral neck. BMD was measured in radiology department of Shaheed Dr. Hemin Hospital in Sulaimani.

Osteopenia or osteoporosis was calculated according to WHO criteria, based on BMD expressed as Z-score indicating osteopenic (Z-score between -1 to -2.5 SD) and osteoporotic patients (Z-score below -2.5 SD). We considered the patients osteoporotic if they showed osteoporosis in at least one site and osteopenic if they showed osteopenia in at least one site.

Approval was taken from Sulaimani Pediatrics Teaching Hospital authority. Approval for participation was taken from patients and/or their parents.

All patients' data entered using Statistical Package for Social Sciences (SPSS) version 18. Descriptive statistics presented as (mean \pm standard deviation) and frequencies as percentages. Kolmogorov Smirnov analysis verified the normality of the data set. Multiple contingency tables conducted and appropriate statistical

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tests performed, Chi-square used for categorical variables (Fishers exact test was used when expected variables were less than 5). One way ANOVA analysis was used to compare between more than two means. In all statistical analysis, level of significance (p value) set at ≤ 0.05 .

RESULTS

A total of one hundred thalassemic patients were included in present study with mean age 13.4 ± 3.2 years. Male thalassemic patients were more than females. More than half (51%) of thalassemic patients were from urban and 49% were from rural areas; table 1

Seventy five percent of thalassemic patients had thalassaemia major and 25% of them had intermediate type. Mean blood received per year by thalassemic patients was 187.9 ± 78.1 ml/kg/year. Hemoglobin among thalassemic patients was distributed as followings; 9-10 g/dl for 3 patients, 7-9 g/dl for 75 patients and < 7 g/dl for 22 patients, table 2.

None of our patients have DM or hypothyroidism, however, 32% of the patients had liver diseases (25% had hepatitis C, 6% had liver fibrosis and 1% had hepatitis B).

Fifty two patients had splenectomy, 96.2% of them had complete splenectomy while others had partial. Fracture history was present among 26 patients; 26.9% of fractures were femoral, 19.2% leg, 15.4% in left arm, 11.5% radial fractures, 7.7% pelvic, 7.7% spinal, 3.8% arm & forearm(double fracture on same patient), 3.8% hand & leg (double fracture on same patient) and 3.8% hand fracture, table3.

Seventy two patients were taking chelation therapy, 43 irregular doses and 29 regular doses. Forty two patients were taking hormonal replacement therapy {human chorionic gonadotrophin in male &estrogen in female} and 99 of them were taking vitamin D and calcium, table 4 and figure 1.

Table 1. Sociodemographic characteristics of thalassemic patients.

Variable	No.	%
Age mean\pmSD (13.4\pm3.2 years)		
≤ 12 years	37	37.0
13-18 years	63	63.0
Total	100	100.0
Gender		
Male	52	52.0
Female	48	48.0
Total	100	100.0
Residence		
Urban	51	51.0
Rural	49	49.0
Total	100	100.0

Table 2. Thalassaemia types and Hb of thalassemic patients.

Variable	No.	%
Thalassaemia types		
Major	75	75.0
Intermedia	25	25.0
Total	100	100.0
Hb cut off		
9-10g/dl	3	3.0
7-9g/dl	75	75.0
<7g/dl	22	22.0
Total	100	100.0

Table 3. History of splenectomy and fractures of thalassemic patients.

Variable	No.	%
Splenectomy		
Yes	52	52.0
No	48	48.0
Total	100	100.0
Splenectomy types		
Partial	2	3.8
Complete	50	96.2
Total	52	100.0
Fracture history		
Yes	26	26.0
No	74	74.0
Total	100	100.0
Fracture sites		
Femur	7	26.9
Leg	5	19.2
Pelvic	2	7.7
Left arm	4	15.4
Radius	3	11.5
Arm and forearm-double	1	3.8
Spinal	2	7.7
Hand and leg-double	1	3.8
Hand	1	3.8
Total	26	100.0

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Table 4. Treatment history of thalassemic patients.

Variable	No.	%
Chelation therapy		
Yes	72	72.0
No	28	28.0
Total	100	100.0
Chelation therapy regularity		
Regular	29	40.3
Irregular	43	59.7
Total	72	100.0

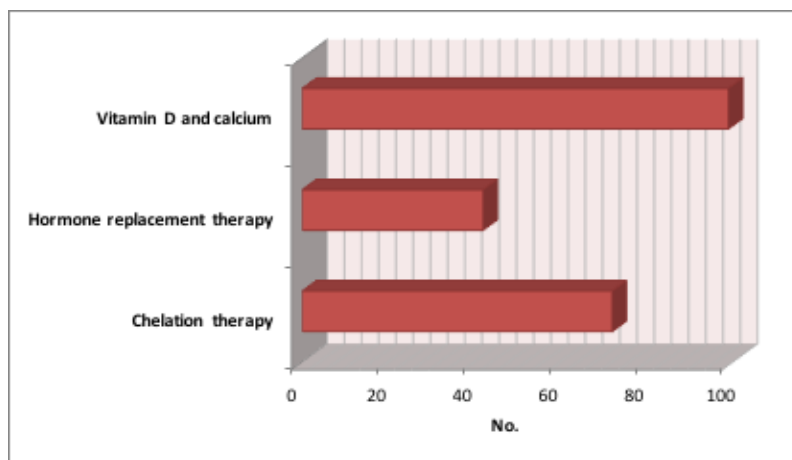


Figure 1. Treatment of thalassemic patients.

Fifty seven of thalassemic patients were taking dairy products daily, 36 were taking eggs daily, 30 were taking vegetables and fruits daily and 80 were taking grains daily, table 5.

Fifty three patients had received influenza vaccine and 11 patients had received pneumococcal vaccine. Only five patients had smoking history and 12 patients only had regular physical activity history, table 6.

Mean BMI of thalassemic patients was $16.6 \pm 2.4 \text{ Kg/m}^2$, 37 of them were underweight (normal between 5th & 95th percentile). Mean calcium level of thalassemic patients was $9.5 \pm 0.7 \text{ mg/dl}$ (normal range $8.6-10 \text{ mg/dl}$), 4 of them had low calcium and 4 of them had high calcium, while 92 thalassemic patients had normal calcium level. Mean ferritin level of thalassemic patients was $1920.2 \pm 2707 \text{ Mg/L}$ (normal range (male 30-40 female 15-150 Mg/L)), 2 of them had low ferritin level, 20 of them had normal ferritin level and 78 of them had high ferritin level. All these findings were shown in table 7.

Osteoporosis was represented by 44 of thalassemic patients, osteopenia was represented by 47 of thalassemic patients and normal DXA findings were represented by 9 of thalassemic patients. All these findings were shown in table 8.

There was a significant association between osteoporosis and thalassemic patients with age 13-18 years ($p=0.009$). No significant association was observed between patients with different DXA scan findings regarding gender and residence of thalassemic patients ($p>0.05$). All these findings were shown in table 9 and figure 2

No significant association was observed between patients with different DXA scan findings regarding thalassemic characteristics ($p>0.05$). All these findings were shown in table 10.

Table 5. Nutritional history of thalassemic patients.

Variable	No.	%
Dairy products		
Daily	57	57.0
Weekly	43	43.0
Total	100	100.0
Eggs		
Daily	36	36.0
Weekly	64	64.0
Total	72	100.0
Vegetables and fruits		
Daily	30	30.0
Weekly	70	70.0
Total	100	100.0
Grains		
Daily	80	80.0
Weekly	20	20.0
Total	100	100.0

Table 6. Immunization, smoking and physical activity history of thalassemic patients.

Variable	No.	%
Influenza vaccine		
Yes	53	53.0
No	47	47.0
Total	100	100.0
Pneumococcal vaccine		
Yes	11	11.0
No	89	89.0
Total	100	100.0
Smoking history		
Yes	5	5.0
No	95	95.0
Total	100	100.0
History of physical activity		
Regular	12	12.0
Irregular or none	88	88.0
Total	100	100.0

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Table 7. BMI, Calcium and Ferritin of thalassemic patients.

Variable	No.	%
BMI mean±SD (16.6±2.4 Kg/m²)		
Underweight	37	37.0
Normal	63	63.0
Total	100	100.0
Calcium mean±SD (9.5±0.7 mg/dl)		
Low	4	4.0
Normal	92	92.0
High	4	4.0
Total	100	100.0
Ferritin mean±SD (1920.2±2707 ng/L)		
Low	2	2.0
Normal	20	20.0
High	78	78.0
Total	100	100.0

Table 8. DXA scan findings of thalassemic patients.

Variable	No.	%
DEXA scan findings		
Normal	9	9.0
Osteopenia	47	47.0
Osteoporosis	44	44.0
Total	100	100.0

Table 9. Distribution of sociodemographic characteristics according to DXA scan findings.

Variable	Normal		Osteopenia		Osteoporosis		χ ²	P
	No.	%	No.	%	No.	%		
Age								
≤ 12 years	5	13.5	23	62.2	9	24.3	9.3	0.009
13-18 years	4	6.3	24	38.1	35	55.6		
Gender								
Male	8	15.4	22	42.3	22	42.3	5.4*	0.06
Female	1	2.1	25	52.1	22	45.8		
Residence								
Urban	5	9.8	24	47.1	22	43.1	0.09*	0.9
Rural	4	8.2	23	46.9	22	44.9		

*Fishers exact test.

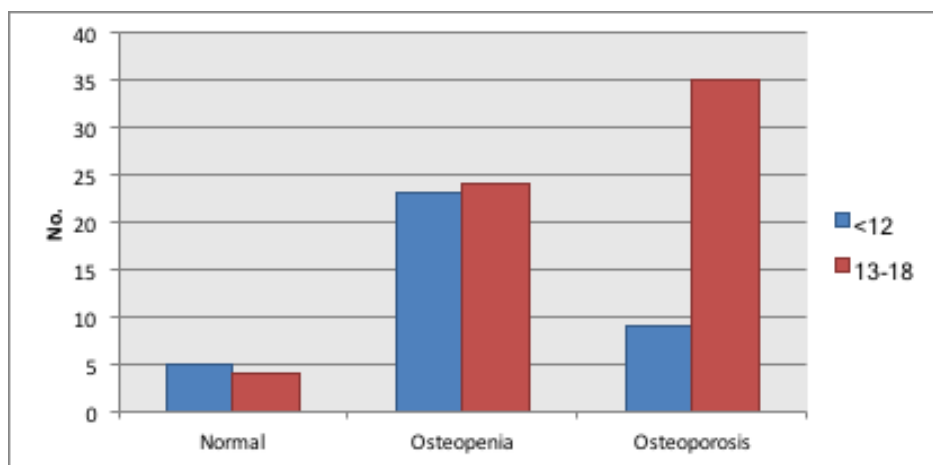


Figure 2. Age distribution according to DXA findings.

Table 10. Distribution of thalassaemia characteristics according to DXA scan findings

Variable	Normal		Osteopenia		Osteoporosis		χ^2	P
	No.	%	No.	%	No.	%		
Thalassaemia type								
Major	6	8.0	39	52.0	30	40.0	3.0	0.2
Intermedia	3	12.0	8	32.0	14	56.0		
Hb cut off								
9-10 mg/dl	0	-	1	33.3	2	66.7	3.6*	0.4
7-9 mg/dl	6	8.0	39	52.0	30	40.0		
<7 mg/dl	3	13.6	7	31.8	12	54.5		

*Fishers exact test.

No significant association was observed between patients with different DXA scan findings regarding splenectomy and fracture history of thalassemic patients ($p>0.05$). All these findings were shown in table 11.

No significant association was observed between patients with different DXA scan findings regarding treatment of thalassemic patients ($p>0.05$). All these findings were shown in table 12.

A significant association was observed between osteoporosis and weekly intake of dairy products and eggs by thalassemic patients. No significant association was observed between patients with different DXA scan findings regarding fruits and grains intake ($p>0.05$). All these findings were shown in table 13.

No significant association was observed between patients with different DXA scan findings regarding influenza vaccine, pneumococcal vaccination, smoking history, and physical activity ($p>0.05$). All these findings were shown in table 14.

No significant association was observed between patients with different DXA scan findings regarding BMI, Calcium and Ferritin means ($p>0.05$). All these findings were shown in table 15.

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Table 11. Distribution of splenectomy and fracture history according to DXA scan findings.

Variable	Normal		Osteopenia		Osteoporosis		χ^2	P
	No.	%	No.	%	No.	%		
Splenectomy								
Yes	3	5.8	25	48.1	24	46.2	1.3*	0.4
No	6	12.5	22	45.8	20	41.7		
Splenectomy types								
Partial	0	-	1	50.0	1	50.0	0.1*	0.9
Complete	2	5.9	25	49.0	23	45.1		
Fracture history								
Yes	3	11.5	10	38.5	13	50.0	1.08	0.5
No	6	8.1	37	50.0	31	41.9		
Fracture sites								
Femur	0	-	1	14.3	6	85.7		
Leg	1	20.0	3	60.0	1	20.0		
Pelvic	0	-	2	100.0	0	-		
Left arm	0	-	1	25.0	3	75.0	24.1*	0.08
Radius	1	33.3	1	33.3	1	33.3		
Arm andforarm forearm	1	100.0	0	-	0	-		
Spinal	0	-	0	-	2	100.0		
Hand and leg	0	-	1	100.0	0	-		
Hand	0	-	1	100.0	0	-		

*Fishers exact test.

Table 12. Distribution of treatment according to DXA scan findings.

Variable	Normal		Osteopenia		Osteoporosis		χ^2	P
	No.	%	No.	%	No.	%		
Chelation therapy								
Yes	7	9.7	34	47.2	31	43.1	0.2	0.9
No	2	7.1	13	46.4	13	46.4		
Chelation therapy regularity								
Regular	2	6.9	18	62.1	9	31.0	4.2*	0.1
Irregular	5	11.6	16	37.2	22	51.2		
Hormone replacement therapy								
Yes	3	7.1	18	42.9	21	50.0	1.1	0.5
No	6	10.3	29	50.0	23	39.7		

*Fishers exact test.

Table 13. Distribution of nutritional history according to DXA scan findings.

Variable	Normal		Osteopenia		Osteoporosis		χ^2	P
	No.	%	No.	%	No.	%		
Dairy products								
Daily	7	12.3	31	54.4	19	33.3	6.5	0.03
Weekly	2	4.7	16	37.2	25	58.1		
Eggs								
Daily	5	13.9	24	66.7	7	19.4	13.8	0.001
Weekly	4	6.3	23	35.9	37	57.8		
Vegetables and fruits								
Daily	3	10.0	16	53.3	11	36.7	0.9	0.6
Weekly	6	8.6	31	44.3	33	47.1		
Grains								
Daily	7	8.8	35	43.8	38	47.5	2.0	0.3
Weekly	2	10.0	12	60.0	6	30.0		

Table 14. Distribution of immunization, smoking and physical activity history according to DXA scan findings.

Variable	Normal		Abnormal finding		χ^2	P
	No.	%	No.	%		
Influenza vaccine						
Risk	5	9.6	47	34.6	0.5*	0.9
No risk	4	8.5	44	61.7		
Pneumococcal vaccine						
Risk	1	9.1	10	36.4	0.6*	0.8
No risk	8	9.0	81	48.3		
Smoking history						
Risk	0	-	5	-	0.6*	0.4
No risk	9	9.5	86	49.5		
History of physical activity						
Regular	2	16.7	10	58.3	0.2	0.3
Irregular	7	8.0	81	45.5		

*Fishers exact test.

Table 15. Distribution of blood infusion, calcium, ferritin and BMI means according to DXA scan findings.

DXA scan findings	Blood/year	Calcium	Ferritin	BMI
	Mean±SD	mg\dl	Mg\l	
Normal	200.6±98.9	9.4±0.4	1229.4±990.7	15.8±2.6
Osteopenia	199.8±61.5	9.5±0.4	2060±3193.9	16.6±2.5
Osteoporosis	173±87.8	9.4±0.9	1914±2383.9	16.6±2.1
ANOVA (P value)	0.2	0.7	0.7	0.6

DISCUSSION

Prevention and early diagnosis of osteoporosis is so valuable as it is a progressive disease. Unbalanced turnover with more resorptive phase which is associated with decreased bone marrow density of thalassaemic patients continued although hemoglobin normalization, iron chelation therapy and hormone replacement ⁽¹¹⁾.

Present study revealed that prevalence of osteoporosis among thalassaemic patients was 44% and osteopenia prevalence was 47%. This finding is close to results of Al-Khero KN and Salih MM study in Iraq (2013) ⁽¹²⁾ which found prevalence of osteoporosis among thalassaemic patients as 50% and that of osteopenia as 36.5%. Our finding regarding osteoporosis is lower than that found by Al-Jadir SM, et al study in northern Iraq(mosul) (2012) ⁽¹³⁾ as 76.5% osteoporosis and 9.4% osteopenia. Osteoporosis prevalence among our patients was also lower than prevalence reported by Hashemieh M, et al study in Iran (2014) ⁽³⁾ as 65.6%. In addition to other cross-sectional studies that indicated the prevalence of osteoporosis to be 52- 96% among thalassaemic Patients ^(14, 15). This difference might be attributed to small sample size in present study and difference dietary intake. Many previous literatures had shown that several factors are included in the pathogenesis of osteopenia/osteoporosis among thalassaemia, as primary disease, itself leading to bone marrow expansion and several secondary factors, such as hormonal insufficiency, high iron level, desferrioxamine toxicity, low levels of calcium, zinc and vitamin D, hypothyroidism, hypoparathyroidism, diabetes mellitus, hypogonadism and low physical activity. These factors affect by inhibiting the osteoblast activation and/or increasing the osteoclastic function, which in turn lead to bone loss and osteoporosis ⁽³⁾.

Studying sociodemographic characteristics of

thalassaemic patients found that 63% of them were in adolescent age. This is close to results of Abdulwahid DA and Hassan MK study in southern Iraq (Basra) (2012) ⁽¹⁶⁾ which found that 56% of studied thalassaemic children were adolescents. There was a significant association between increased age of thalassaemic patients and osteoporosis (p=0.009). This is consistent with results of Al-Jadir SM, et al study in northern Iraq (mosul) (2012) ⁽¹³⁾ which reported that the bony disorder in thalassaemic patients increased with age (bone pain, carpo pedal spasm, osteoporosis). Male thalassaemic patients were more than females with predominance of urban resident patients. These findings agreed with results of Al-Badry BJ and Al-Tamemi MB study in southern Iraq (Thiqar) (2014) ⁽¹⁷⁾ which found predominance of male gender with prevalent urban resident thalassaemic patients.

Three quarters of thalassaemic patients in current study had Beta thalassaemia major and one quarter of them had Beta thalassaemia intermedia. This distribution is similar to that described by Shawky RM and Kamal TM study in Egypt (2012) ⁽¹⁸⁾. Patients whose anemia is not so severe as to necessitate regular transfusions are said to have thalassaemia intermedia. It represents up to one-fourth of Beta-thalassaemia patients ⁽¹⁹⁾. The hemoglobin in more than two thirds (75) of studied thalassaemic patients was 7-9 mg/dl. This finding agreed with results of Al-HakeimHK, et al study in Iraq (2009) ⁽²⁰⁾.

About one third (32%) of thalassaemic patients in our study had history of liver diseases (HC, B and fibrosis). This finding is consistent with results of Ardalan FA, et al study in Iran (2004) ⁽²¹⁾ which concluded that marked liver iron overload and HCV infection in thalassaemic patients have potentiating effect on hepatic fibrogenesis. HCV is responsible for 80–90% of post-transfusional cases of hepatitis in patients who have received blood

transfusion(s) prior to the introduction of routine blood products screening in 1990. More than 75% of HCV infections become chronic and up to 20–30% progress to cirrhosis ⁽²¹⁾.

Present study showed that more than half of studied thalassemic patients had done splenectomy (96.2% complete splenectomy). This finding is close to results of Salih AM study in Kirkuk-Iraq (2013) ⁽²²⁾. Packed cell transfusions in thalassaemia had improved the survival rate but transfusions also had side effects of iron overload and so iron-chelating agents are given concurrently with recurrent blood transfusion ⁽²²⁾. Less than one-third of thalassemic patients in present study had fracture history, commonly femoral fractures. This finding agreed with results of Pasanagoudar PL in India (2001) ⁽²³⁾ which reported that fractures were more common in under transfused patients than in well-transfused patients. This difference, however, was not statistically significant. The severe osteoporosis found in some patients with multiple fractures suggested that these fractures could be related to severity of the bone disease, which is multi-factorial, rather than related to hemoglobin levels only ⁽²³⁾.

Chelation therapy was the common treatment for 72% of thalassemic patients in this study, although, it was irregular for more than half of thalassemic patients. This is similar to results of Shah N, et al study in India (2010) ⁽²⁴⁾ that reported 67% of thalassemic children on chelation therapy with low proportion of them who were regularly on treatment.

More than half of thalassemic patients were taking dairy products and grains daily, while less than half of them were taking eggs and vegetables daily. There was a significant association between weekly intakes of dairy products and eggs by thalassemic patients with osteoporosis ($p < 0.05$). These findings agreed with results of Fung EB, et al study in USA (2012) ⁽²⁵⁾ which found that patients with thalassaemia have reduced intake of many key nutrients. Dietary inadequacy proved the need for nutritional monitoring to determine which high risk patients for nutritional deficiency. Transfusional iron overload is the most common cause of death caused by cardiac failure ⁽²⁶⁾.

The longevity of thalassemic patients was increased as chelation therapy improved but they exhibit high morbidity with incomplete growth, low immunity, high oxidative stress and low bone mineralization and others that all associated with nutritional status ⁽²⁷⁾. Currently

it has been found that body mass index and body fat of thalassemic patients was related to bone growth and density ⁽²⁸⁾. Previous study reported that more than half of regularly transfused patients with thalassaemia had deficient circulating levels of vitamin A, C, D and selenium ⁽²⁹⁾. However, there is a need to more studies on the contribution of dietary intake and nutritional deficiencies on thalassaemia.

No significant association was observed in present study between influenza vaccination and osteoporosis among thalassemic patients ($p=0.9$). This is inconsistent with reports of Liungman P study in Sweden (2012) ⁽³⁰⁾ that found risk of some vaccines use among Immuno compromised patients. Osteoporosis was not associated significantly with smoking history ($p=0.4$). The smoking has a risky effect on bone health as it inhibit the metabolism of hormones, lowering body weight, affect vitamin D levels, decreasing calcium absorption, and increases oxidative stress thus affecting bone resorption and formation, leading to osteoporosis. Moreover, smokers had 25% increases in fracture risk probability and are nearly twice as likely to experience hip fractures. Smoking also retards bone healing after operations ⁽⁶⁾.

Less than half (37) of thalassemic patients in present study were underweight and most of them had normal calcium level but 78% of them had high serum ferritin level. These findings agreed with results of Bashir FY and Sadoon OA study in Iraq (2010) ⁽³¹⁾.

Limitations of the study: Small sample size without controls, selection bias, lack of serum vitamin D level.

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