Haemoglobinopathies are common in Oman. Data from a community-based survey of the most common genetic blood disorders among Omani children has reported a prevalence rate of 2% for beta-thalassaemia trait, 0.07% for beta-thalassaemia major, 6% for sickle cell trait and 0.2% for sickle cell disease. Comparable data has also been reported in other GCC and neighboring countries.

Beta-thalassaemia major is an inherited monogenic disorder that was first described by Cooley and Lee. It is caused by a mutation at the ß-globin gene locus resulting in persistence of α-globin chain that is precipitated within erythroid precursors in the bone marrow associated with severe dyserythropoietic anaemia. The combination of early diagnosis, improvement in monitoring complications and advances in supportive therapy has enabled patients with thalassaemia major to have improved life expectancy. The cornerstone in management is life-long blood transfusion with frequent iron chelation therapy to minimize the deleterious effect of chronic iron deposition and accumulation in tissues. Despite this, these patients are prone to long-term organ dysfunction particularly the cardiovascular, hepato-biliary, endocrine and skeletal systems.

The objective of this study was to establish the spectrum and prevalence rates and times of onset of endocrine disorders in Omani transfusion-dependent beta-thalassaemia adult patients.

Methods

This cross-sectional study was conducted during the period (1st Jan to 31st Jul 2008) and dealt with Omani patients with...
transfusion-dependent homozygous beta-thalassaemia major who were consulting the adult Thalassaemia Clinic, Royal Hospital, Sultanate of Oman. It included 30 patients (15 male, 15 female), aged 16 to 32 years with median of 21 year and mean ± SD of 21.23 ± 3.42 years. Each patient was consulting the clinic at 3 monthly intervals. The diagnosis of homozygous thalassaemia was based on the characteristic haematological criteria (peripheral blood evaluation and haemoglobinopathy screening) at presentation or screening from early years of life.

The study protocol was a naturalistic observation, an integral part of routine clinical procedure through reviewing the medical records of these thalassaemic patients from the hospital computer records including the haematologists’ and endocrinologists’ clinical review as well as results of laboratory investigations. The clinical haematologists are regularly performing the management of these patients which includes supervision of blood transfusion and chelation therapy, as well as monitoring of organs’ dysfunction due to predicted iron deposition in tissues. The patients were regularly transfused with packed red cells every three weeks since early years of life, and were regularly taking iron chelator as Desferrioxamine (40 mg/kg body weight) subcutaneous infusion 5 days per week, and Deferiprone (75 mg/kg body weight) tablet daily.

For the laboratory investigations, blood samples were drawn from all patients in fasting state in the morning during their regular visits. In addition to complete blood count and serum ferritin, biochemical endocrine profiles were done to screen for any possible dysfunction. Evaluation for endocrine complications is usually performed regularly, together with other routine function profiles tests. The investigations include: pituitary-gonadal function test (FSH, LH, prolactin, estradiol in females and testosterone in males), thyroid function test (FT4 and TSH), bone profile (calcium, phosphorus, albumin, alkaline phosphatase and PTH), morning cortisol and glucose. These profiles were performed to exclude any possible hypogonadism, hypothyroidism, hypoparathyroidism, hypoadrenal cortisolism or diabetes mellitus. All the parameters were measured in the Clinical Biochemistry Laboratory, Royal Hospital. Serum FSH, LH, prolactin, estradiol in females and testosterone in males, were measured using chiluminescent microparticle immunoassay methods on Architect 2000 System (Abbott, USA). Serum calcium was measured by ion selective electrode, inorganic phosphorus by molybdenum blue, albumin by bromocresol purple, alkaline phosphatase by kinetic rate method, and glucose by timed end point hexokinase method, all on Synchron LX20 (Beckman, USA).

Laboratory evidence for hypogonadism was based on finding low FSH1 and LH with low estradiol or testosterone (hypogonadotrophic hypogonadism), or normal (but inappropriately low) FSH and LH with low estradiol or testosterone (normogonadotropic hypogonadism). Hypothyroidism was defined based on high TSH (primary) or low TSH (secondary) with low FT4. Hypoparathyroidism was diagnosed based on low corrected calcium concentration, high phosphorus and inappropriately low PTH. Diabetes mellitus was diagnosed according to the criteria of the American Diabetes Association (1997). Hypoadrenalism (hypocortisrolism) was based on finding low morning cortisol level.

The results were analyzed and numerical data presented as mean ± SD with median and range. The prevalence rate of endocrinopathy was calculated as single or multiple endocrine organ involvement. The statistical difference in serum ferritin between the different groups of patients with or without endocrinopathies was assessed using unpaired student’s t test. The statistical significance was assigned for p<0.050.

Results

The prevalence rates of endocrinopathies/endocrine disorders are shown in Table 1. Hypogonadism was reported in 22 (73.3%) patients (13 female, 9 male). Low FSH ≤ 1.5 U/L (median, range; 0.6, 0.1-1.5 U/L) and low LH ≤ 1.5 U/L (0.3, 0.1-1.1 U/L) with low estradiol <100 nmol/L (6 patients <77 nmol/L, 1 patient 88 nmol/L) in females, and low testosterone <9.0 nmol/L (0.9, 0.3-2.2 nmol/L) in males, indicative of hypogonadotrophic hypogonadism was noted in 15 (50.0%) patients (7 female, 8 male). On the other hand, normal (but inappropriately low) level of FSH (3.6, 2.6-7.4 U/L) and LH (2.6, 2.3-15.0 U/L) with low estradiol (43, 37-88 nmol/L) in females and low testosterone (6.9 nmol/L in the only one male) indicative of normogonadotropic hypogonadism was noted in 7 (23.3%) patients (6 female, 1 male).

Primary hypothyroidism was present in only 1 (3.3%) female patient who had high TSH and low FT4. There was no evidence of secondary hypothyroidism. Hypoparathyroidism was found in 3 (10.0%) patients (2 female, 1 male) who were presented with low corrected calcium of < 2.1 mmol/L (median, range; 1.42, 1.34-1.45 mmol/L), high inorganic phosphorus of > 1.4 mmol/L (2.87, 2.47-3.3 mmol/L) and inappropriately low PTH (1.3, 1.3-1.7 µg/L). Diabetes mellitus with fasting glucose ≥ 7.0 mmol/L (12.5, 8.0-24.2 mmol/L) was noted in 8 (26.7%) patients (2 female, 6 male). Six patients (1 female, 5 male) had severe hyperglycaemia and
were treated by insulin, and two patients (both males) had records of presentation with ketoacidosis. Morning cortisol levels for all patients were within the reference range (250-550 nmol/L) and no patient showed suspicion of hypocortisolism or hypoadrenal cortical function.

Table 2 shows the prevalence of endocrinopathy according to the number of endocrine disorders (hypogonadism, hypothyroidism, hypoparathyroidism or diabetes mellitus). Certain patients had more than one endocrine disorder. Accordingly, 8 (26.7%) patients had no endocrine disorder, 12 (40.0%) had one disorder, 8 (26.7%) had 2 disorders, and 2 (6.7%) had 3 endocrine disorders. There was no significant difference (p>0.050) in mean serum ferritin in thalassaemic patients with or without endocrinopathy (Table 1), regardless of the number of endocrine glands involved (Table 2).

In concern with therapy, thalassaemics with hypogonadism were on oestrogen-progesteron combination therapy as oral contraceptive pills with Proglyton tablets (in females), and monthly testosterone injection (in males). The single thalassaemic patient with hypothyroidism was placed on L-thyroxine therapy. Thalassaemics with hypoparathyroidism were on daily maintenance dose of vitamin D, alfa.1.calcidol and calcium carbonate supplement. Of the 8 diabetics, 6 were treated by insulin and 2 were on oral hypoglycaemic drugs.

**Table 1: Prevalence of endocrinopathies in 30 homozygous beta-thalassaemic patients***

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hypogonadism</th>
<th>Hypoparathyroidism</th>
<th>Hypothyroidism</th>
<th>Diabetes Mellitus</th>
<th>No Endocrinopathy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HypoGonadotrophic</td>
<td>NormoGonadotrophic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. (M/F)</td>
<td>15 (8/7)</td>
<td>7 (1/6)</td>
<td>3 (1/2)</td>
<td>1 (0/1)**</td>
<td>8 (6/2)</td>
</tr>
<tr>
<td>Prevalence</td>
<td>50%</td>
<td>23.3%</td>
<td>10.0%</td>
<td>3.3%</td>
<td>26.7%</td>
</tr>
<tr>
<td>Age at Diagnosis (years)</td>
<td>17.5±4.96</td>
<td>18.57±2.76</td>
<td>17.0±3.6</td>
<td>15</td>
<td>17.6±2.1</td>
</tr>
<tr>
<td>Median</td>
<td>16.0</td>
<td>19.0</td>
<td>16</td>
<td>-</td>
<td>17.5</td>
</tr>
<tr>
<td>Range</td>
<td>13-32</td>
<td>15-22</td>
<td>14-21</td>
<td>-</td>
<td>15-21</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>21.0±3.48</td>
<td>21.57±3.82</td>
<td>22.3±4.1</td>
<td>16</td>
<td>21.5±2.39</td>
</tr>
<tr>
<td>Median</td>
<td>21.0</td>
<td>23.0</td>
<td>19.0</td>
<td>-</td>
<td>21.0</td>
</tr>
<tr>
<td>Ferritin (µg/L)</td>
<td>5794±3413</td>
<td>7726±2620</td>
<td>5348±2038</td>
<td>4950</td>
<td>6445±3979</td>
</tr>
<tr>
<td>Median</td>
<td>6030</td>
<td>7424</td>
<td>5744</td>
<td>-</td>
<td>6257</td>
</tr>
<tr>
<td>Range</td>
<td>568-4318</td>
<td>4318-12473</td>
<td>3933-7951</td>
<td>-</td>
<td>1576-12540</td>
</tr>
<tr>
<td>Significance of difference in Ferritin (P)**</td>
<td>0.838</td>
<td>0.191</td>
<td>0.812</td>
<td>-</td>
<td>0.618</td>
</tr>
</tbody>
</table>

* : no patient had hypocortisolism
** : only one patient had hypothyroidism, statistical data are not presented
*** : significance of difference in ferritin in comparison with patients without endocrinopathy
Table 2: Prevalence of endocrinopathies according to the number of disorders in 30 homozygous beta-thalassaemic patients

<table>
<thead>
<tr>
<th>Parameter</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. (M/F)</td>
<td>8 (6/2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prevalence (%)</td>
<td>26.7%</td>
<td>40%</td>
<td>26.7%</td>
<td>6.7%</td>
</tr>
<tr>
<td>Age at Study (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>20.0±2.6</td>
<td>21.6±3.0</td>
<td>21.4±4.4</td>
<td>24.0±4.2</td>
</tr>
<tr>
<td>Median</td>
<td>20.0</td>
<td>22.0</td>
<td>20.5</td>
<td>24.0</td>
</tr>
<tr>
<td>Range</td>
<td>17-24</td>
<td>17-28</td>
<td>18-32</td>
<td>21-27</td>
</tr>
<tr>
<td>Ferritin (µg/L)</td>
<td>5647±3663</td>
<td>6825±2661</td>
<td>6425±3638</td>
<td>4640±1001</td>
</tr>
<tr>
<td>Median</td>
<td>5014</td>
<td>7166</td>
<td>6257</td>
<td>4640</td>
</tr>
<tr>
<td>Range</td>
<td>865-11809</td>
<td>3248-12473</td>
<td>568-12540</td>
<td>3933-5348</td>
</tr>
<tr>
<td>Significance of difference in Ferritin (P)***</td>
<td></td>
<td>0.390</td>
<td>0.609</td>
<td></td>
</tr>
</tbody>
</table>

* : endocrinopathies included: hypogonadism, hypoparathyroidism, hypothyroidism, diabetes mellitus
** : only two patients had 3 endocrinopathies, data of significance in ferritin is not applicable
*** : significance of difference in ferritin in comparison with patients without endocrinopathy

Discussion

Patients with beta-thalassaemia major are prone to metabolic complications, including endocrine dysfunction which can occur as single or multiple endocrine glands' involvement. Although the actual mechanism is not definitive, however, the most likely explanation is related to iron overload and its burden, in addition to lipid peroxidation, oxidative stress and free radicals release.13

In the current report, high prevalence of endocrine abnormalities was observed in beta-thalassaemic patients, which is in agreement with the reports by several authors.14, 15, 16 Hypogonadism was the most frequent endocrine disorder, with 73.3% patients being affected (50% hypogonadotrophic and 23.3% normogonadotrophic). In term of sex, out of 15 females, 13 were affected, and out of 15 males, 9 were affected. All of our patients are in the second or third decade of life (median 21 years, range 16-32 years), which had raised the risk of involvement. It has been reported that the pituitary-gonadal axis is very sensitive to iron deposition leading to hypofunction of these glands, particularly in the form of secondary hypogonadism, which is rarely reversible even with iron chelation therapy.17 In comparison with others, hypogonadism has been reported from 17% to 69%, and in another study up to 62% in boys and 75% in girls with beta-thalassaemia major.14, 18, 19 Hormone replacement therapy is recommended, however the age of initiation and dosage should be balanced with coexistence of other organs’ dysfunction particularly heart, liver and skeletal systems.20 In our patients, the affected females were on oestrogen-progesteron combination therapy as oral contraceptive pills with Proglyton tablets, and affected males were on monthly testosterone injection, as replacement therapy. Other possible causes of hypogonadism include associated liver disorder, chronic hypoxia, diabetes mellitus, free radicle oxidative stresses, and zinc deficiency.21

Primary hypothyroidism was observed in only one patient (3.3%) of our thalassaemics, who was placed on L-thyroxine replacement therapy following diagnosis. It seems that hypothyroidism is a rare complication in Omani thalassaemics and its prevalence was lower than that reported by others. This is comparable to another cohort study which reported low prevalence of hypothyroidism of 4.0% in beta-thalassaemia, although 26.9% of their patients with normal thyroid function showed an exaggerated TSH response to TRH test.22 However, in a recent survey, a high prevalence of primary overt hypothyroidism was present in 16% of beta-thalassaemic patients.23 The disorder is mostly due to iron deposition in the thyroids. However, the thyroid pituitary axis seems to be less sensitive to iron deposition damage than gonadal and GH axis. Hence, secondary hypothyroidism is rare in thalassaemic patients, which was not observed in our series, as also in other reports.22, 24 In studies with low prevalence of overt hypothyroidism, mild thyroid dysfunctions were more common as reported in 12.5% of patients.22 In our series, mild thyroid dysfunction (subclinical hypothyroidism) was also reported only in one patient (3.3%).

Disturbance of calcium homeostasis is also known in thalassaemia major that could be due to hypoparathyroidism, vitamin D deficiency, bone marrow expansion or chronic liver involvement. Three thalassaemic patients (10.0%) in our series
had evidence of primary hypoparathyroidism, of whom 2 had two additional endocrinopathy and 1 had another endocrinopathy. In comparison with others, a prevalence of hypoparathyroidism from 3.6% to 13.5% had been reported. In a similar study in Saudi Arabia, Aleem et al. reported hypoparathyroidism in 20% of the 40 thalassaemic patients reviewed. Also, high prevalence for hypocalcaemia of 41% has been observed by Najafipour et al. Although, hypoparathyroidism was reported to be more common in males with male/female ratio of 4:1, however in our series it was observed more in females with a ratio of 1:2. Periodic assessment of bone profile in addition to vitamin D status is recommended and maintenance of normal serum calcium is important to avoid the risk of arrhythmias particularly in the presence of cardiomyopathy. Our thalassaemic patients who had hypoparathyroidism were on daily maintenance dose of vitamin D, alfa 1.calcidol and calcium carbonate supplement. Osteopenia is more common in thalassaemics with its prevalence reported to be 45-51%. Diabetes mellitus was observed in 8 (26.7%) patients, of whom 6 patients (5 male, 1 female) had severe hyperglycaemia and were treated by insulin. Among the mechanisms involved for precipitating diabetes mellitus, iron overload in the pancreatic beta-cells leading to pancreatic dysfunction is the most likely one. Other contributing factors include insulin resistance, liver dysfunction, genetic predisposition or family history of diabetes. Studies had reported prevalence of diabetes mellitus in beta-thalassaemic patients to range up to 24%. Diabetes appears to be unusual in beta-thalassaemias of less than 16 years old. In our thalassaemias, a state of hypocortisolism was not noted and there was no clinical suspicion for the involvement of ACTH or adrenal gland. Reports have indicated that iron deposition may occur in the adrenals particularly in the zona glomeruloza and only when this is severe, it will interfere with its function.

Finally, in the thalassaemic patients reviewed, no relationship between serum ferritin level and development of endocrinopathy was observed. There was no significant difference in mean ferritin in thalassaemic patients with or without endocrinopathy, as well as in patients without or with one or more endocrinopathy. There is contradiction between the different studies, with some revealing a positive relationship while others did not.

Conclusion

There is high prevalence of certain endocrine disorders among Omani adult homozygous beta-thalassaemic patients. This signifies the importance of therapeutic intervention and medical awareness for their development which necessitates the importance of frequent follow-up and monitoring for early detection and replacement therapy. No relationship between serum ferritin level and development of endocrinopathy was noted.

References