academicJournals

Vol. 5(12), pp. 550-559, December 2013
DOI: 10.5897/IJMMS2013.0973
ISSN 2006-9723 ©2013 Academic Journals
http://www.academicjournals.org/IJMMS

International Journal of Medicine and Medical Sciences

Full Length Research Paper

Evaluation of G6PD activity and antioxidants status in jaundiced Egyptian neonates

Yasser E. Nassef [1]*, Hanan A. Fathy[2], Alaa Ali[1], Manal A. Hamed[3], Gihan A. Fathy[1]

[1]Child Health Department, National Research Centre, Dokki, Cairo, Egypt.
[2]Health Radiation Research Department, National Center for Radiation Research and Technology, Cairo, Egypt.
[3]Therapeutic Chemistry Department, National Research Center, Dokki, Cairo, Egypt.

Accepted 3 October, 2013

Jaundice with glucose-6- phosphate dehydrogenase (G6PD) deficiency is one of the most common conditions needing medical attention in newborn babies. The aim of the present study was to predict G6PD level and oxidative stress condition among Egyptian jaundiced neonates associated with G6PD deficiency. The study included 60 non-jaundiced neonates and 40 jaundiced cases with G6PD deficiency. All infants were subjected to routine hematological evaluation, total and direct serum bilirubin levels, G6PD assay and oxidative stress markers; malondialdehyde (MDA), glutathione and superoxide dismutase (SOD) levels. Out of the 40 G6PD deficient cases, 62% were males and 37% were females. 15 cases had marked G6PD enzyme deficiency and 25 cases recorded moderate deficiency. Highly increase in bilirubin level was observed in marked G6PD deficient cases than in moderate cases. Hematological indices failed to show evidence of frank hemolysis. There was no significant difference between the marked and the moderate G6PD deficient cases; regarding to the time of appearance of jaundice, frequency of using phototherapy, duration of its application, the need for exchange transfusion and the hematological indices. Oxidative stress markers revealed significant changes in G6PD deficient cases as compared to control group. Neonatal jaundice associated with G6PD deficiency is a condition associated with oxidative stress. Since G6PD deficiency seemed to be the common cause of jaundice in this study, early detection of this enzymopathy for possible jaundice control are recommended in at least preterm infants. Also screening for G6PD deficiency is recommended to define the etiology of hyperbilirubinemia.

Key words: Glucose-6- phosphate dehydrogenase, hemolysis, neonate, jaundice, antioxidants.

INTRODUCTION

Jaundice is one of the most common problems for neonates, including premature infants (Amin and Lamola, 2011). Glucose-6-phosphate-dehydrogenase (G6PD) deficiency is an important disorder of hexose mono-phosphate shunt in erythrocyte metabolism (Segel, 2004; Azma et al., 2010) that catalyses the oxidation of glucose-6-phoshate to 6-phosphogluconate; the rate limiting step of the pathway. Concomitantly, nicotinamide adenine dinucleotide phosphate (NADP) is reduced to NADPH. The NADPH, a required co-factor in many biosynthetic reactions, maintains glutathione in its reduced form. Reduced glutathione acts as a scavenger for free radicals, and thus helps reduce oxidized haemoglobin to free haemoglobin; otherwise oxidized

*Corresponding author. E-mail: yasser_nassef424@yahoo.com.

haemoglobin will precipitate as Heinze bodies. While many other body cells have other mechanisms of generating NADPH, the red blood cells rely completely on G6PD activity because it is the only source of NADPH that protects the cell against oxidative stress (Obasa et al., 2011).

Worldwide, more than 200 million people are affected with G6PD enzyme deficiency (Halmaek and Stevenson, 2002). As the disease is X-linked, all males and homozygous females inheriting the mutant allele may potentially exhibit signs and symptoms of the disease, while mildly symptoms are observed in heterozygous females (Halmaek and Stevenson, 2002; Segel, 2004). Neonatal jaundice due to G6PD deficiency may occur after exposure to oxidant agents and as a consequence hemolysis occur. But quite often, there is a mutation in the promoter site of uridyle di-phosphoglucoronyl transferase (UDPGT) which accompanies G6PD deficiency, leading to indirect hyperbilirubinemia (Halmaek and Stevenson, 2002; Segel, 2004). One of the important manifestations of this enzyme deficiency in the neonatal period is jaundice without hemolysis. This may be so serious that it can lead to kernicterus or death and also predisposes the neonate to infection (Segel, 2004; Halmaek and Stevenson, 2002; Kaplan and Hammerman, 2004).

Many studies conducted in the Mediterranean area and some Asian regions confirmed that G6PD deficiency is a common cause of severe jaundice in the neonatal period (Tanphaichitr et al., 2003), in which jaundice was seen without hemolysis (Slusher et al., 2000; Madan et al., 2001). Neonatal jaundice (NJ) is associated also with a condition of oxidative stress (Dahiya et al., 2006). Antioxidant activity in the serum of term neonates is lower than that of adults. It is still lower in preterm and low birth weight babies as compared to term babies (Sullivan and Newton, 1988). Red blood cells are extremely susceptible to lipid peroxidation since they are rich in unsaturated membrane lipids and are rich supply of oxygen (Jain, 1989). Neonatal erythrocyte membrane is more susceptible to oxidative damage due to its predominant pro-oxidant potential (Jain, 1989). Bilirubin is a sensitizer of singlet oxygen production. It behaves as an antioxidant especially the albumin bound fraction stress (Dahiya et al., 2006).

Severe neonatal jaundice is seldom associated with mortality when closely monitored, but portends significant long-term risks in settings where hospitals are ill-equipped to provide phototherapy or exchange blood transfusion (Badens et al., 2001). Early detection of the at-risk populations helps in prevention of morbidity associated with the disease. Newborn screening for the disease has been implemented and incorporated into the screening program in many countries (Kaplan and Hammerman, 2004).

This study aimed to evaluate G6PD activity, hematological indices (hemoglobin level, percentages of reticulocytes, heamatocrite and anemia levels; Hb < 11 g/dl) as well as oxidative stress markers (malondialdehyde, glutathione and superoxide dismutase) among jaundiced Egyptian neonates with moderate and marked G6PD deficiency.

MATERIALS AND METHODS

Patients

This study included 100 infants (within 15 days of life), 40 with neonatal jaundice and 60 jaundice free cases. The patients were randomly selected from Abu Elreash Children Hospital, Cairo University (2011 to 2012). All neonatal jaundice was defined by a peak serum bilirubin level of ≥ 15 mg/dl. Neonatal jaundiced patients were selected in this study according to the severity of G6PD deficiency. Marked cases were classified as G6PD < 10% of the lower limit of normal activity, while moderate G6PD deficient cases were classified as G6PD activity between 10 and 60%. All cases of the study were subjected to full history taking, physical examination, routine hematological evaluation (hemoglobin level, percentages of reticulocytes, heamatocrite and anemia levels; Hb < 11 g/dl), total and direct serum bilirubin levels, glucose-6-phosphate dehydrogenase activity and oxidative stress markers; malondialdehyde (MDA), glutathione and superoxide dismutase (SOD).

Exclusion criteria

Direct Coomb's test was done to exclude cases of isoimmune hemolysis. The excluding criteria were; term neonates with a total bilirubin less than 15 mg/dl, preterm newborns with a total bilirubin less than 10 mg/dl and direct hyperbilirubinemia (direct to total bilirubin ratio more than 20%). In summary, we excluded cases of physiological jaundice, jaundice cases without G6PD deficiency and direct hyperbilirubinemia (> 25 mg/dl; cases of intrahepatic cholestasis).

Ethics

Informed consents were taken from the parents of the selected groups according to guideline of Medical Ethical Committee of National Research Centre, Dokki, Cairo, Egypt.

Biochemical assays

Derived data included age, sex, total, direct and indirect bilirubin, hemoglobin, reticulocyte count, direct Coombs test, G6PD level, type of treatment (phototherapy and blood exchange transfusion) and the antioxidant markers. All cases of the study were screened for G6PD deficiency by a qualitative enzyme assay using the methemoglobin reduction test (Sampavat et al., 2001). This test is based on the principle of reduction of methemoglobin by G6PD activity of the red blood cells. The rate of reduction is proportional to the G6PD activity of the red cells under test. During screening method the color of the test sample is compared visually to the reference controls in order to arrive at the diagnostic conclusion.

G6PD deficiency in erythrocytes was carried out by a quantitative

kinetic assay (RANDOX Laboratories Limited, Crumlin, Co. Antrim, United Kingdom, BT294QY) if G6PD deficiency was provisionally diagnosed by qualitative assay. The enzyme activity was determined by measuring the rate of reduction of NADP to NADPH at 340 nm. Glucose-6-phosphate dehydrogenase activity was calculated in relation to erythrocyte count. Results were interpreted as the percentage of normal G6PD activity. Enzyme activity less than 10% of the lower limit of normal activity was classified as severe deficiency, whereas the activity between 10 and 60% was classified as mild to moderate deficiency. Reference range according to manufacturer was 120 to 240 nm/RBC in million (Ainoon et al., 2003).

Total and direct bilirubin was measured by the method of Doumas et al. (1973), where bilirubin reacted with diazotized sulfanilic acid in the presence of caffeine with final azo-pigment product. The developed colour was read at 546 nm. Indirect bilirubin is calculated from the total and direct bilirubin.

Lipid peroxide was determined as malondialdehyde. Malondialdehyde is an unstable compound that decomposed to form a complex series of reactive carbonyl compounds. Polyunsaturated fatty acid peroxides the generated malondialdehyde (MDA) which has been used as an indicator of lipid peroxidation process. MDA concentration was calculated using the extinction coefficient value $1.56 < 105\ M^{-1}\ cm^{-1}$ and the developed colour was read at 535 nm by the method of Buege and Aust (1978).

Glutathione was estimated by the method of Beutler et al. (1963). The method is based on the development of a relatively stable yellow colour when 5,5' dithiobis-2- nitrobenzoic acid (DTNB) is added to sulfhydryl compounds. The reaction colour was read at 412 nm.

SOD was estimated by the method of Nishikimi et al. (1972). SOD determination is based on the oxidation of nicotinamide adenine dinucleotide reduced form (NADH) (mediated by superoxide radical) through a free radical chain of reactions involving thiol oxidation and univalent O_2 reduction. The following increase in absorbance was read at 560 nm using molar extinction coefficient of NADH (6.22×10^3).

Statistical analysis

Data was expressed as mean ± standard deviation (SD) of 60 control individuals and 40 neonatal jaundice children (15 marked and 25 moderate cases). Analysis of data was carried out by independent t-test, SPSS for windows version 11.0 Software Computer Program accompanied with least significance difference between groups at $p < 0.05$.

RESULTS

In the present study, 40 cases of neonatal jaundice with G6PD deficiency were studied and compared with 60 normal cases. A total number of 100 cases divided into 65 males and 35 females. Female to male ratio in jaundiced neonatal cases were represented by 3:5, while in normal cases were represented by 1:2, respectively. In comparison between normal and G6PD deficiency groups, the results revealed significant difference ($p < 0.01$) between consanguinity and gestational age (Table 1). Neonatal jaundiced with G6PD deficiency cases were identified by serum bilirubin level of ≥ 15 mg/dl where it represented by 40% with a ratio of 62% in male and 37% in female (Table 1). In case of laboratory findings, G6PD level in jaundiced neonates with G6PD deficiency was highly significantly ($p < 0.0001$) decreased by 49% in male and 65% in female as compared with normal cases. Total serum bilirubin recorded highly significant increase ($p < 0.0001$) by 6 folds in G6PD deficiency cases as compared to normal cases, while indirect and direct bilirubin recorded significant increase ($p < 0.0001$) by 8 and 6 folds, respectively. Hemoglobin levels, hematocrite values and reticulocytes count did not record significant changes between normal and neonatal jaundiced with G6PD deficiency cases (Figure 1).

In comparison between marked and moderate G6PD deficient neonatal jaundiced groups, there were no significant differences between sex distribution, gestational age and time of appearance of jaundice. Frequency distribution of kernicterus, duration of phototherapy and number of cases requiring exchange transfusion were significantly higher in marked G6PD deficient neonatal jaundiced cases than in moderate cases ($p < 0.05$). Marked G6PD deficient cases represented a ratio of 37% of all neonatal jaundice, while 62% of moderate G6PD deficient cases were reported (Table 2).

Comparing between the severity of enzyme activity, male with marked G6PD deficient cases recorded significant decrease in G6PD by 63% as compared to normal value, while male with moderate G6PD deficient patients showed significant decrease by 45%. Male with marked G6PD deficient cases recorded significant decrease in G6PD level by 33% less than moderate cases (Figure 2). In case of female, marked cases showed decrease in G6PD level by 72%, while moderate cases showed decrease by 57% comparing with normal group. Female with marked G6PD deficient cases showed significant decrease in G6PD level by 35% less than moderate cases (Figure 2). Total and indirect bilirubin levels in marked G6PD deficient jaundiced patients recorded highly significant increase ($p < 0.0001$) by 7 and 10 folds, respectively, while in moderate cases, it was highly significantly increased by 5 and 7 folds, respectively as compared to the normal group. The direct bilirubin level recorded significant increase by 7 folds in the marked cases and 5 folds in the moderate cases. Hemoglobin levels, hematocrite values and reticulocytes count insignificantly decreased in marked and moderate cases as compared to normal cases (Figure 2). The marked G6PD deficient cases showed higher levels of total (40%) and indirect (57%) bilirubin than in moderate cases. Lower levels of direct bilirubin (36%) was observed in marked G6PD deficient cases than in moderate cases. Hemoglobin, hematocrite and reticulocytes levels recorded insignificant changes between marked and moderate G6PD deficient cases (Figure 2).

As regard to the oxidative stress markers, MDA

Table 1. Clinical findings in Egyptian jaundiced neonates with G6PD deficiency level versus normal cases.

Items		Neonatal jaundice with G6PD deficiency n=40		Normal cases n=60	
		n	%	n	%
Sex	Male	25	62	40	66
	Female	15	37	20	33
Consanguinity		22*	55	18	30
Previous history NJ		12	30	15	25
Gestational age	Full-term	32	80	54	90
	Pre-term	8*	20	6	10
Birth weights (kg)		3.55±0.60		3.60± 0.72	
Appearance of Jaundice (days)		3.22±1.30		-	
Icterogenic agents		14	35	-	
Kernicterus		8	20	-	-
% of anemia according to age (Hb < 11 g/dl)		24	60	12	20
No of cases receiving phototherapy		40	100	-	-
Duration of phototherapy		6.33±1.54		-	
Exchange transfusion		28	70	-	-

Neonatal jaundice with G6PD deficiency was defined by a peak serum bilirubin level of ≥ 15 mg/dl and G6PD < 10% of the lower limit of normal activity. (*) is the significance value at $p < 0.01$.

recorded significant elevation in both moderate (65%) and marked (100.24%) G6PD deficient neonatal jaundice cases as compared to normal cases. Marked G6PD deficient neonatal jaundice group showed elevation in MDA level by 21% more than the moderate cases (Table 3). Glutathione level recorded a significant decrease in both moderate and marked G6PD deficient jaundiced cases by 44 and 60%, respectively. In marked cases, the glutathione level decreased by 29% than in the moderate cases. SOD enzyme activity showed increase in its level by 67% in moderate G6PD deficient jaundiced cases, while in marked cases it increased by 96%. SOD was increased by 17% in marked than in moderate G6PD deficient neonatal jaundice patients (Table 3).

DISCUSSION

The prevalence of G6PD deficiency varies from one geographical zone to another and between ethnic populations (Cladera et al., 1997; Jennifer et al., 2005). As Egypt lies in a special geographic situation at the meeting of the three continents with different ethnic groups, the incidence of G6PD deficiency varies widely in different localities. Genetic heterogeneity has been discovered in different Mediterranean populations. As many as 19 variants were found in Egypt, still the Mediterranean variant of the enzyme deficiency is considered the most prevalent in Egypt (Kamal et al., 1967). The high rate of consanguineous marriage in some populations may well have influenced the genetic makeup and resulted in the propagation of such deleterious genes (Cappellini et al., 2008). In a recent study on Gaza Palestinian population, there were three variants; G6PD Mediterranean, G6PD A- (in particular c.202A/c.376G) and G6PD Cairo. The identification of prevalent G6PD variants will permit development of specifically targeted rapid molecular assays to facilitate their screening (Sirdah et al., 2012).

In this study, the G6PD deficiency for females was 37% while that of males was 62% with a ratio 3:5. A ratio of

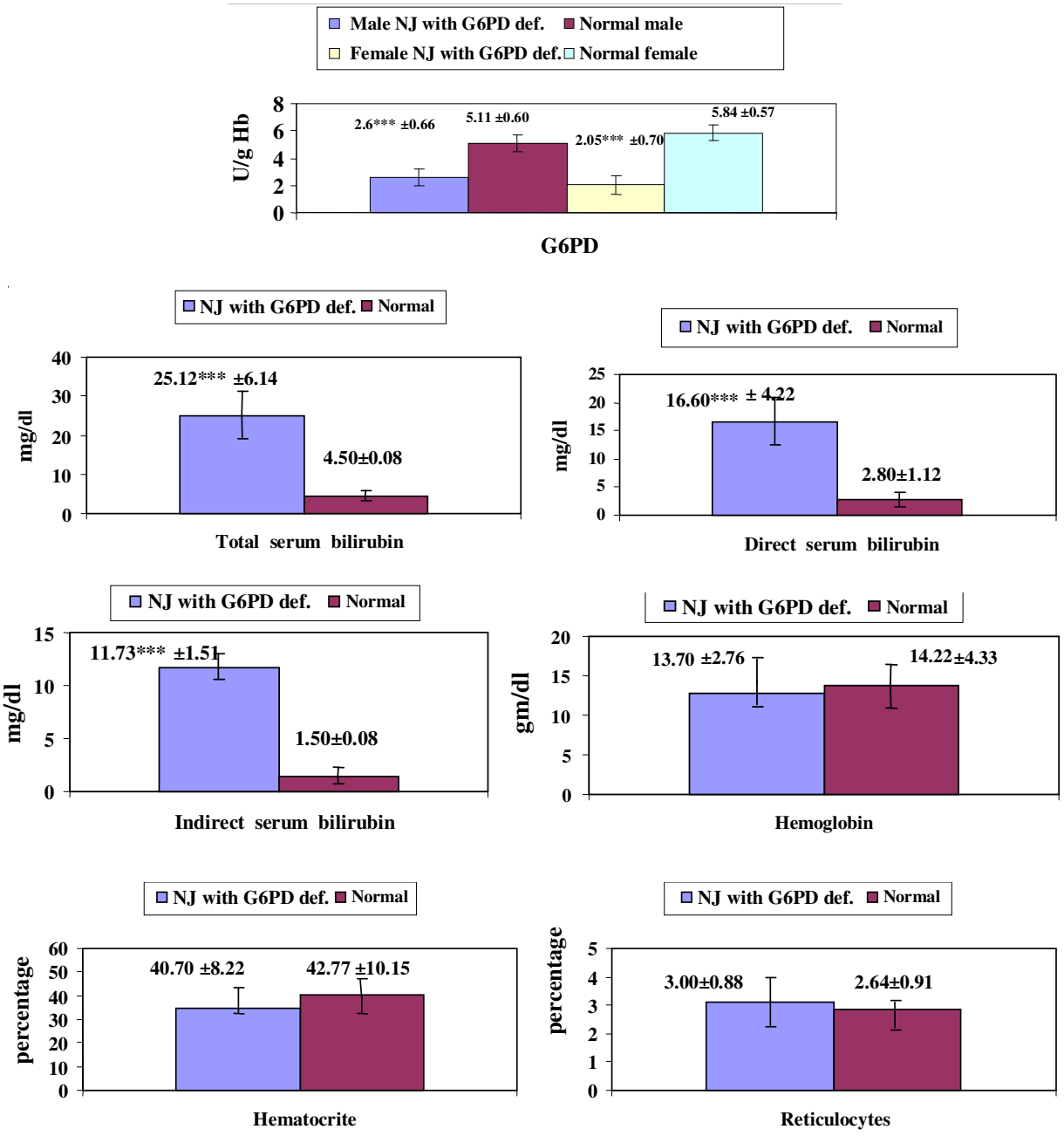

Figure 1. Comparison of biochemical parameters among healthy infants and neonatal jaundice with G6PD deficiency cases. (***) is the significance level at $p < 0.0001$ as compared to normal cases. All neonatal jaundice with G6PD deficiency was defined by a peak serum bilirubin level of ≥ 15 mg/dl and G6PD < 10% of the lower limit of normal activity.

3:1 was found in a study done in India (Iranqour et al., 2003) on 53 cases with G6PD deficiency associated with NJ. This non significant difference between males and females within the prevalence of G6PD deficiency of the jaundiced infants of the present study goes in agreement with previous studies done by Sampavat et al. (2001) and Weng et al. (2003). This is consistent with the X-linked recessive inheritance of G6PD deficiency which makes it more prevalent in males (Maxwell, 1981). This is not surprising because one would expect affected males to have lower levels of the enzyme than the females in view of the fact that the defect is X-linked recessive (Egesie et

Table 2. Clinical findings in Egyptian jaundiced neonates with moderate and marked G6PD deficient levels.

Items		Neonatal jaundice with moderate G6PD deficient cases n=25		Neonatal jaundice with marked G6PD deficient cases n=15	
		n	%	n	%
Sex	Male	20	80	12	80
	Female	5	20	3	20
Gestational age	Full-term	20	80	12	80
	Pre-term	5	20	3	20
Appearance of Jaundice (days)		4.66±2.17		3.73±1.22	
Kernicterus		4	26	6	24
% of anemia according to age (Hb < 11 g/dl)		10	40	12	80
Duration of phototherapy		3.22±0.91		4.11±1.30	
Exchange transfusion		15	60	12	80

Neonatal jaundice with G6PD deficiency was defined by a peak serum bilirubin level of ≥ 15 mg/dl. Marked G6PD deficient cases are classified as severe deficiency of G6PD<10% of the lower limit of normal activity. Moderate G6PD deficient cases are classified as G6PD activity between 10 and 60%. No significant differences regards sex distribution, gestational age, time of appearance of jaundice, duration of phototherapy and number of cases requiring exchange transfusion.

al., 2008). However, the process of lyonisation is complex and involves random inactivation of an X-chromosome (Egesie et al., 2008). In some instances, more of the maternally derived or paternally derived chromosome may escape inactivation and even a small advantage of one set of clones over the other would result in marked disparity between the number of normal and deficient cells. As a result, affected females can show extremely low levels of the enzyme (Pai, 1980; Edwards, 2002).

However, because not all G6PD deficient infants become jaundiced there have been additional factors that play a role in jaundice like genes determine variation in bilirubin elimination (Kaplan et al., 2007). An interaction between G6PD deficiency and promoter polymorphism for the gene encoding the bilirubin conjugation enzyme has been implicated in the pathogenesis of hyperbilirubinemia in G6PD deficient infants. Also, decrease bilirubin elimination in hepatocytes play a major role (Kaplan and Hammerman, 2009; Edwards et al., 2002).

Unidentified environmental or exogenous factors exposing the infants to oxidant injury such as infection or the application of dyes or powder to the umbilicus may also play a role in the prevalence of NJ associated with G6PD deficiency (Beutler, 1994). In this study, these potentially hemolytic factors were only excluded by history taking as out of the 40 G6PD deficiency cases (35%) gave history of exposure to icterogenic agents for example, sulpha powder applied to the umbilicus. This agrees with other reports who have documented that neonatal hyperbilirubinemia were significantly more prevalent among G6PD deficiency infants often with no apparent cause and even when all known triggers of hemolysis have been eliminated (Jallohs et al., 2005; Ahmadi and Ghazizadel, 2008). So, G6PD deficiency acts as an independent icterogenic factor and will increase the proportion of infants developing significant NJ in the absence of other causes (Ho et al., 2007). In contrast, a number of studies conducted over Nigeria infants declared a direct association between exposure to icterogenic agents and severe NJ and kernicterus in G6PD deficient infants (Owa, 1989).

As regards gestational age, the frequency distribution of preterm was significantly higher within G6PD deficient group compared to the non deficient group. There was also a significant higher incidence of G6PD deficiency within the preterm infants compared to the frequency among the full-term infants. This agrees with previous studies that declared a statistically significant inverse relationship between the percentage of G6PD deficiency and gestational age in NJ (Costa et al., 2008). This may be explained by the exaggerated hepatic immaturity that contributes to the greater prevalence, severity and duration of neonatal jaundice in late preterm infants (Watchko, 2010). In addition, instability of the enzyme particularly evident in the preterm jaundiced infants contributes to the jaundice severity (Bender et al., 2007).

In the present study, total peak serum bilirubin level was significantly higher among G6PD deficient group compared to non deficient group. In agreement with the

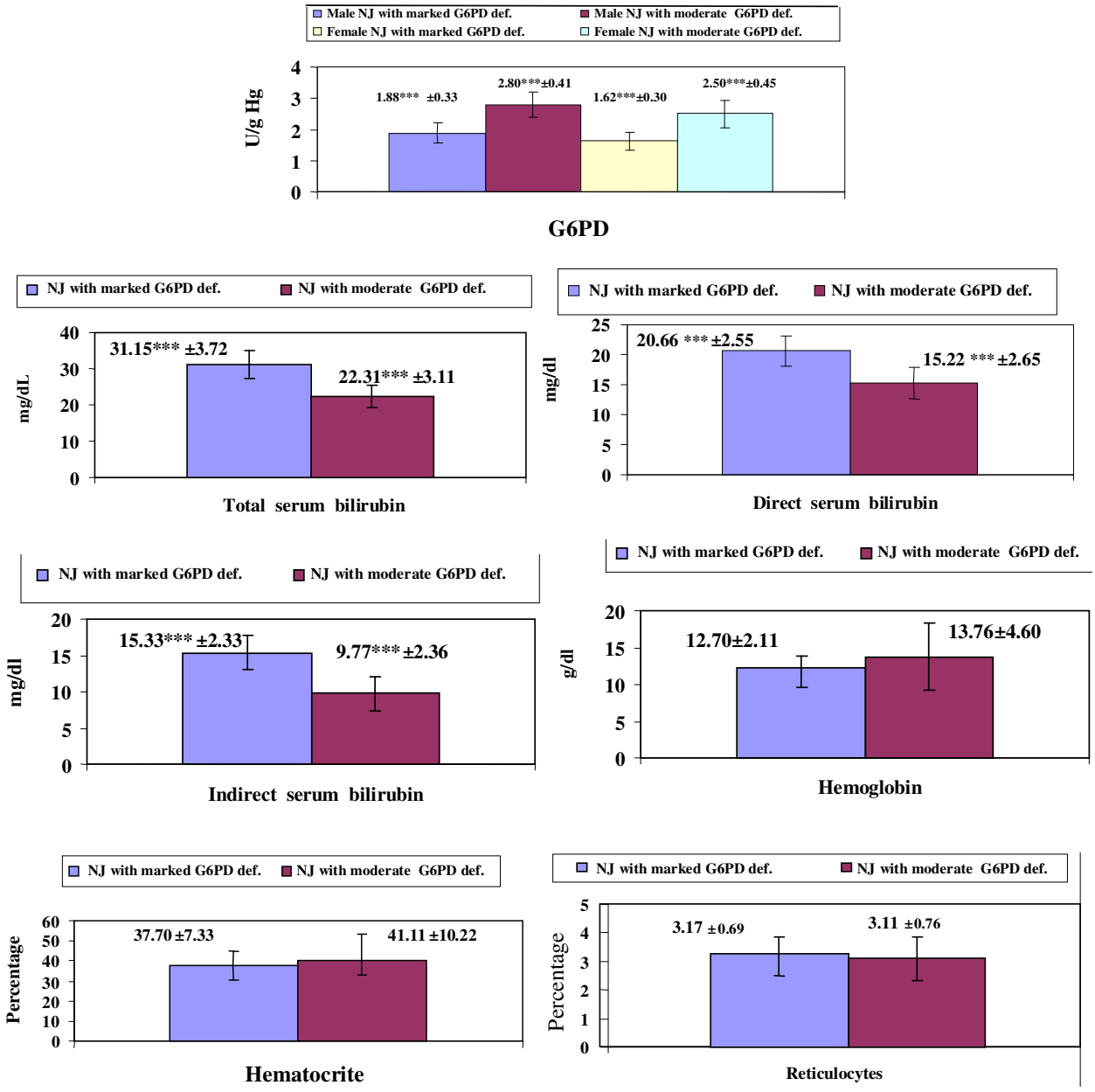

Figure 2. Comparison of biochemical parameters in jaundiced neonates with marked and moderate G6PD deficient levels. (***) is the significance level at $p < 0.0001$ as compared to normal cases. Marked G6PD deficient cases are classified as severe deficiency of G6PD <10% of the lower limit of normal activity. Moderate G6PD deficient cases are classified as G6PD activity between 10 and 60% of the lower limit of normal activity.

present results, several studies reported that the maximal total serum bilirubin levels were significantly higher among G6PD deficient jaundiced neonates when compared with G6PD normal icteric neonates (Kaplan et al., 2004; Atay et al., 2006; Bhutani et al., 2013). In the present study, out of the 40 G6PD deficient cases 8 cases developed kernicterus (20%). This is in agreement with several studies, where G6PD deficient jaundiced cases developed kernicterus (Katar, 2007; Burke et al., 2009). In contrast, other studies reported that G6PD deficiency neonates have not been associated with kernicterus (Gandapur et al., 2002; Loys et al., 2005). So in certain populations, hyperbilirubinemia secondary to G6PD deficiency results in an increased rate of

Table 3. Oxidative stress markers in Egyptian neonatal jaundice cases with marked and moderate G6PD deficient levels.

Parameter	Normal	Neonatal jaundice with moderate G6PD deficient	Neonatal jaundice with marked G6PD deficient
MDA (nM/gHb)	4.11±0.62	6.78±0.56*	8.23±0.66*[a]
		+65%	+100.24%
			+21%
Glutathione (M/gHb)	31.12±5.35	17.45±3.23*	12.45±4.56*[a]
		-44%	-60%
			-29%
SOD (EU/gHb)	1411.56±325.22	2356.45±411.22*	2765.23±512.45*[a]
		+67%	+96%
			+17%

Neonatal jaundice with G6PD deficiency was defined by a peak serum bilirubin level of ≥ 15 mg/dl. Marked G6PD deficient cases are classified as severe deficiency of G6PD < 10% of the lower limit of normal activity. Moderate G6PD deficient cases are classified as G6PD activity between 10 and 60%. * is the level of significance at $p < 0.001$ as compared to control, [a] is the level of significance at $p < 0.001$ as compared to moderate neonatal cases. Values between brackets are percentages change over normal group. Values between parentheses are percentages change over moderate neonatal group.

kernicterus and death whereas in other population this has not been observed. This may reflect genetic mutations specific to different ethnic groups (Kaplan et al., 2004).

In this study, comparing between jaundiced neonatal and normal cases as well as marked and moderate G6PD deficiency groups regarding to the hemoglobin levels, hematocrite values, reticulocytic counts and percentages of anemia according to age, the results revealed no significant difference. So, these hematological indices and the ratio of direct to total bilirubin level (> 0.2) failed to show evidence of frank hemolysis between two groups of G6PD deficient and normal cases and between marked and moderate G6PD deficient cases. These results are in line with several studies based on hematological indices that could not demonstrate evidence of acute hemolysis in G6PD deficient jaundiced cases (Jennifer et al., 2005).

In the present study, the absence of frank anemia in G6PD deficient infants with NJ supports the role of deficiency of G6PD in hepatocytes not in red cells (Jallohs et al., 2005). This confirms that the cause of jaundice in icteric newborns is not only the hemolysis, but also the concomitant mutation that led to a decrease in the activities of G6PD and uridine diphosphate glucuronyltransferase (UDPGT); an enzyme that transforms bilirubin into water-soluble and excretable metabolites (Halmaek and Stevenson, 2002; Segal, 2004).

The frequency of using phototherapy in the present study was high and the duration of its application was relatively along within the G6PD deficient jaundiced neonates. In addition, the duration of phototherapy and frequency of exchange transfusion were not significantly different in group of marked G6PD deficiency when compared to the group of moderate deficiency. These results were in agreement with Jennifer et al. (2005) and Atay et al. (2006) who reported that the use of phototherapy and exchange transfusion was not significantly different between G6PD deficient icteric neonates and G6PD normal icteric neonates. In contrast, other studies reported that phototherapy and exchange transfusion were more prevalent in G6PD deficient jaundiced neonates than in other icteric neonates (Iranpour et al., 2003 and Kaplan et al., 2004).

Concerning oxidative stress markers, it has been reported in literatures that jaundice produced an oxidative stress as demonstrated by decrease in the cellular level of glutathione (Turgut et al., 2004). A rise in MDA level was also observed in neonatal jaundice (Dahiya et al., 2006) and could be due to increase generation of reactive oxygen species (ROS), since bilirubin acts as a sensitizer singlet oxygen production. The energy is thus gained and subsequently transferred to molecular oxygen, thereby generating singlet oxygen and other ROS. These oxygen species, in turn, can oxidize many other important biomolecules including membrane lipids as well as bilirubin itself (Dahiya et al., 2006). The oxidative stress associated with jaundice can be counteracted by increase in the antioxidant response as evidenced by increase in SOD. The antioxidant defense is highly stressed and less developed in infants (Dani et

al., 2004) and by generating ROS, it leads to their increased consumption.

Conclusions

Our study showed an incidence of hyperbilirubinemia, G6PD-deficiency and oxidative stress biomarkers changes among jaundiced newborns in Egypt. Among jaundiced cases, the enzyme deficiency is more prevalent in female than male. The frequency distribution preterm of gestational age was significantly higher within G6PD deficient group than non deficient group. Heamatological parameters were not affected by jaundice or by G6PD deficiencies. Exchange transfusion rate was 70% in the G6PD-deficient groups. Since glucose-6-phosphate dehydrogenase deficiency seems to be the common cause of jaundice in this study, early detection of this enzymopathy for possible jaundice control are recommended in at least preterm infants. Also screening for G6PD deficiency is recommended to define the etiology of hyperbilirubinemia and to give the newborn's family information concerning hemolytic crisis prevention.

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