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REVIEW ARTICLE

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The Impact of Mild Iodine Deficiency on Sudanese Neonatal Parameters in Shendi Locality at River Nile State

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ABSTRACT

The habitual diets in Sudan are rich in carbohydrates, poor in marine items that contain iodine, and other micronutrients. There is spectrum of iodine deficiency severity nationwide, that affected pregnant women reproductive health and hence may be reflected in their newborn physical parameters. The study intended to examine the pregnant women perception and hence utilization of food items containing iodine and its impact on physical neonatal parameters. The study was descriptive cross-sectional hospital based, conducted in El-mek Nimir University Hospital in Shendi Locality, River Nile State, Sudan, in the period from December 2016 to February 2017. Pregnant women (n=130) in their last trimester, attending maternity unit were recruited as study population, interviewing questionnaire exploring the sociodemographic, obstetric, dietary habits, was filled. Neonatal weight, length, head circumference, weight of placenta were measured immediately after delivery. Maternal serums T_3, T_4 were also measured. The findings of the study revealed low perception of iodine importance for fetal development with (66%) of participants considered it as unimportant and (13%) of them had grade (I) thyroid goiter. The arithmetic mean of neonatal weight, length and head circumference at term were (3.1 kg), (45.6 cm), (34.3 cm) respectively. The arithmetic mean for serum T_3 is (1.33 ng/mL) which was skewed towards the upper limit of normal range and (7.96 µg/dL) for T_4.

The study demonstrated the grave impaction of mild iodine deficiency on neonatal parameters with decreasing arithmetic mean of neonatal length of (45.57±3.92 cm) compared to the international (90th Centiles) for neonatal length, at (37th weeks) of gestation, which was (50.14cm).
Key Words: Iodine, Iodized Salt, Thyroxin, Goiter, Brain development and Pregnancy.

INTRODUCTION

In Sudan there is spectrum of iodine deficiency, since it is found in marine foods chain web, and less represented in land foods spectrum. The association of poor maternal nutrition, with low birth weight and small head circumference, points to inadequate maternal nutrients intake as risk factor for mental retardation newborn mortality and morbidity increase sharply at birth weights below (2.5 kg). The iodine deficiency in the habitual diets has negative impaction on the health of mothers and outcomes of pregnancy (Crawford, 1992, Litt et al, 2005, Rees et al. 2005, Nyuar, et al, 2010). Iodine, is trace element required for human nutrition in micrograms per day (µg/day) The total amount of iodine is about (25-50 mg), in human body. About (50-70%) of it, is found in extrathyroidal tissues (Hetzel, 1989 Venturi and Venturi, 2009). Iodine is integral part of thyroxines (T_3 *and* T_4), and has many other functions (Weil, 2015). Therefore, it is crucial for brain development during fetal and childhood life, hence its deficiency is the single most important cause of avoidable mental retardation across the whole world (Peterson, 2000). The entire spectrum of (I_2) *deficiency*, that based on (I_2) *consumption* as (µg/day), whether it is mild (50–99), or moderate (20–49), or severe (< 20), affect the thyroid function of the mother and neonate, and the mental development of the child. In pregnancy there is increasing demand of iodine to (250–300 µg/day), as compared to about (200µg/day) for non-pregnant women. Severe (I_2) deficiency results in wide spectrum of disorders including cretinism. Hypothyroxinemia that affects pregnant women increases the risk of neuro developmental disorders in their children (Bernal, 1999; Stein et al 2006; Bani, 2007; Crawford et al, 2008). The WHO recommends a supplement of (250 µg/day) of (I_2) for every expectant pregnant woman, to prevent iodine deficiency during later conception and lactation. Salt fortification with (I_2) and marine's food as natural source of (I_2) is also recommended (WHO, 2007b). Developmental delays like attention deficit disorder (ADD), pervasive developmental disorders (PDD), and learning disability (LD*)* have also been related to earlier iodine deficiency (Robert and Utiger, (eds), 2006).
Iodine is strong antioxidant and enhances fertility. High (I_2) intake decreases the risk for breast cancer and compact toxic halogens (Longombe and Geelhoed, 1997; Pelletier et al, 2002; Abraham GE, 2005; Miller, 2006). Iodine deficiency disorders (IDD) refer to all of the consequences of (I_2) deficiency in a population that can be prevented by ensuring that the population has an adequate intake of iodine (WHO, 2007 a, WHO, 2007 b). While *IDD* are essentially caused by inadequate intake of iodine sufficient diets or salt, other substances known as goitrogens like thiocyanate (SCNΓ), found in millet, onions, and cassava have been pointed to as playing a role in interference with the synthesis of thyroid hormones synthesis (Osman and Fatah, 1981; Osman et al, 1983; Eltom, 1985).
Goiter prevalence, median urinary (I_2) concentration (UIC), from casual urine samples, mean serum thyroglobulin (Tg) levels, mean serum levels (T4), (T3) and thyroid-stimulating hormone (TSH) are sufficient indicators of someone (I_2) status, when considering them collectively. No single test of these can exactly and reliably diagnose iodine deficiency in specific subject with certainty (Medani, et al, 2011; Vitti, et al, 2013).

Thyroid gland that is enlarged is known as goiter. The *WHO* criteria for classification of goiter, divide it into three categories:-

1. *Grade 0*, no palpable or visible goiter.
2. *Grade I*, mass in the neck consistent with an enlarged thyroid that is palpable but not visible when the neck is in normal position and moves upward in the neck as the subject swallows.
3. *Grade II*, a swelling in the neck, which is visible when the neck is in normal position and is consistent with an enlarged thyroid when the neck is palpated. The sum of grades I and II estimates

the total goiter prevalence in certain community. Worldwide, there are nearly (2) billion people with *IDDs*. (Peterson, 2000; WHO, 2007b).

IDDs still considered a public health problem throughout urban and rural areas in the Sudan and iodine in sufficiency seems to be the major etiological factor (Izzeldin et al, 2009).

The overall prevalence of goitre in Shendi, which is situated on the east bank of the River Nile (150 km) Northeast of Khartoum and has population of about (269,440), was (18%). The goiter was more prevalent among age group (31-45) which represent (43, 5%) of population who had goiter. Also a high prevalence among female than male with a ratio of (3:1) was observed. (Elmanssury, 2013). *IDD* is associated with poor socioeconomic development and political instability and civil conflicts as it is clear in countries such as Central African Republic and Democratic Republic of Congo and western and Southern Sudan. (Peterson S, 2000).

Rationale of the Study

Since Shendi Locality is considered as suffering from mild iodine deficiency, due to scarcity of the rich source of iodine, like marine's food items There is a special need to know the impact of mild iodine deficiency on neonatal health as well as assessment of the general awareness of the nutritional importance of using iodized salt in household (Crawford et al, 2008).

This study aimed to investigate the effect of mild iodine deficiency disorders on neonatal parameters such as weight, length and head circumference as well as maturity and placental weight.

General Objective

To assess the pregnant women perception, utilization and hence their body status of iodine, and its impact on physical neonatal parameters.

Specific objectives

The specific objectives of this study include the study of:-

1. To investigate the perception of iodine significant for fetal development by women and hence its consumption during pregnancy.
2. To demonstrate the effect of maternal serum thyroxin level on fetal birth weight, length, head circumference and placental weight.
3. To study the effect of maternal thyroxin level on fetal maturity.

Subjects and methods

The study is descriptive cross sectional hospital based study carried out in Shendi Locality at River Nile State in Sudan. One hundred and thirty (n=130) healthy pregnant women in their last trimester, attending maternity unit in El –mek Nimir University Hospital in Shendi, for delivery were recruited from December 2016 to February 2017 to the study. Women with multiple pregnancies and chronic illnesses were excluded.

Interviewing questionnaire was filled and body mass index (BMI) for each participant women was calculated. (3 millimeters) blood samples were collected in plain containers, allowed for one hour, clotting at temperature of (25℃). Serum was then separated in the main hospital laboratory by centrifugation at (4000) round per minute for (10 minutes). Sera were stored at (80 ℃) below zero in blood bank refrigerator for analysis. Neonatal parameters, weight, length, head circumference weight of placenta were measured immediately after delivery. Measurement of total T_3 was done using ST AIA-PACK TT3,for quantitative in vitro measurement of total T_3 , using enzyme immunoassay on TOSOH II AIA System Analyzers. The systems perform all sample and reagent handling operations automatically; reading the rate of fluorescence produced by the reaction and automatically converts it to T_3 concentration in ng/ml. The reference interval for T_3 is (0.79 to 1.58ng/mL) or (1.22 to 2.43 nmol/L). The conversion to SI units of nmol/L may be made using the following equation: nmol T_3/L = ngT_3/mL ×1.5. The above stated procedure was also used for total T_4 .The reference interval T_4 is (4.9 to 11.0 µg/dL) or (63.2 to 141.9 nmol/L). The conversion to SI units of (nmol/L) may be made using the following equation: (nmol T_4/L = µg/dL ×12.9). All collected data is analyzed using SPSS 16.0 for windows, Pearson Chi-Square test was used for categorical data with

p - value >0.05 as significant. Analysis of variance (ANOVA) was used for continuous data and the statistical results were presented as means ± SEMs.

RESULTS

Table 1. Socio demographic analysis.

	Frequency	Percent (%)
Residency distribution (n=130)		
Inside Shendi	38	29.0
Outside Shendi	92	71.0
Total	130	100.0
Age group categories (years) (n=130)		
<20	15	11.5
20-25	44	33.8
26-30	38	29.2
31-35	16	12.3
36-40	17	13.1
Total	130	100.0
Level of education (n=126)		
No formal education	8	6.3
Primary	40	31.7
Secondary	39	31.0
University	39	31.0
Total	126	100.0
Monthly family income in SDG (n=129)		
Less than 1000	12	9.3
1000-2000	103	79.8
Above 2000	14	10.9
Total	129	100.0

The study group represented middle class society of Shendi
Locality, with acceptable level of education

Table 2. Knowledge and attitude towards iodine.

	Frequency	Percent (%)
Perception of iodine importance for fetal development (n=130)		
Yes	30	23.1
No	86	66.2
Don't know	14	10.8
Total	130	100.0
Type of salt used at home (n=130)		
Iodized	90	69.2
Uniodized	35	26.9
Don't know	5	3.8
Total	130	100.0

In spite of the availability of iodized salt, there was low recognition of its importance

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Table 3. Level of education versus iodine perception.

Level of education		Iodine perception			Total
		Yes	No	Don't know	
No formal	Count	0	8	0	8
	% within level of education	0.0%	100.0%	0.0%	100.0%
Primary	Count	6	29	4	39
	% within level of education	15.4%	74.4%	10.3%	100.0%
Secondary	Count	9	23	7	39
	% within level of education	23.1%	59.0%	17.9%	100.0%
University	Count	15	21	3	39
	% within level of education	38.5%	53.8%	7.7%	100.0%
Total	Count	30	81	14	125
	% within level of education	24.0%	64.8%	11.2%	100.0%

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	12.486	6	0.05
Likelihood Ratio	14.562	6	0.02
Linear-by-Linear Association	3.974	1	0.04
N of Valid Cases	125		

Chi-Square Test

There was strong association between levels of education, and iodine perception, with statistically positive *P* value.

Table 4. Categories of thyroid goiter grading (n=129).

	Frequency	Percent (%)
Grade (0)	112	86.8
Grade (I)	17	13.2
Grade (II)	0	0.0
Total	129	100.0

The prevalence of thyroid goiter (13.2%) pointed to the problem of iodine deficiency

Table 5. Arithmetic means of neonates parameters (Mean ±SD).

	N	Mean	Std. Deviation
Neonatal weight (kg)	129	3.09	0.57
Neonatal length (cm)	127	45.57	3.92
Neonatal head circumference (cm)	127	34.29	3.69
Weight of placenta (kg)	127	0.7614	0.55

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The mean of neonates' length (45.57cm) was less than international standard (49.1cm)

Table 6. Categories of maternal serum T_3 (ng /mL) & T_4 (µg/dL).

Arithmetic means of serum, T_3 (ng /mL) and T_4 (µg/dL) (Mean ±SD)			
	N	**Mean**	**Std. Deviation**
Serum T3	100	1.33	0.30
Serum T4	100	7.98	1.45
	Frequency		**Percent (%)**
Serum T_3 (ng /mL) categories of pregnant women (n=100)			
≤ 0.79	2		2.0
0.79-1.58	79		79.0
≥ 1.58	19		19.0
Total	100		100.0
Serum T_4 (µg/dL) categories of pregnant women (n=100)			
4.9-11	98		98.0
≥ 11	2		2.0
Total	100		100.0

There was more variation and abnormality of T_3 thanT_4

DISCUSSION

It is obvious from Table (1) that the participating pregnant women (n=130) generally represent the middle class society in Shendi Locality with acceptable access to anti natal care. Two thirds of the study group was from rural backgrounds (71%). They had moderate education level .The family income and the educational level had their impaction on the perception and consumption of food items during pregnancy.

Regarding the age groups of the participating women, (11.5%) of them were under (20) years of age, reflecting the bad social culture of teenage girl marriage and it's devastating consequences as suffering during pregnancy and low neonatal birth weight out comes as depicted in Table (1).

The participating pregnant women perception of iodine importance for the proper fetal development was very low. Only (23%) acknowledged it, (66%) consider it as unimportant, and (11%) do not know its effects, as heighted in Table (2). There was strong association between educational level, and positive iodine perception, with statistically significant *P* value of (0.05) by Pearson Chi-Square, (0.02) by Likelihood Ratio and (0.04) by Linear-by-Linear Association as appeared in Table (3). This does not agree with the general perception of iodine for the thyroid gland function which is good (63%) as demonstrated by (Elmanssury, 2013). This result demonstrates clearly the superficial popular misunderstanding of *IDD*, as represented only by thyroid goiter, which is actually the ice berg of the problem. Iodine deficiency associated neuro developmental disorder and others were clearly underestimated. Although (70%) of women claimed the availability of the iodized salt in their homes, as in Table (2). There was concern of the rational use and the iodine amount in some locally available salt. The iodized salt is available in the local markets in many different brands. Iodine is labile and reactive and it is affected by temperature, humidity and sun light. Therefore proper seal packing is important, which largely doesn't exist for local brands.

Malaria was usually incriminated as confounding factor for adverse pregnancy outcomes, especially in association with low birth weight and preterm delivery.

In the study group, (84%) had no malaria during their pregnancy course; whereas (11.5%) had it once and only (1.5%) had malaria four times or more. The provision of electricity in rural area as well as the combined artisunate therapy for malaria had led to dramatic reduction in malaria cases nationwide. Nutritional factors are more significant ones affecting pregnancy outcomes (Sudan Malaria Treatment Protocol, 2017).

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As thyroid goiter was considered a valid indicator regarding chronicity of iodine deficiency in specific society. In the study group (13%) had grade (I) goiter as seen Table (4). Therefore, the prevalence of goiter in the study group was less than what figured out by (Elmanssury, 2013), who found the overall prevalence of goitre (18%) among the population surveyed in Shendi locality It was also less compared to that pointed out by (Medani et al, 2011) while estimated the overall prevalence of all types of goiter by (22 %). There was no association between residency and grades of thyroid goiter with statistically insignificant *P* value of (0.57) by Pearson Chi-Square, (0.77) by Likelihood Ratio and (0.57) by Linear-by-Linear Association .This might reflect the changing culture of society towards adopting domestic use of iodized salt due to availability of iodized salt in local groceries and the positive effects of health education campaign in the media and health facilities, but extreme cautious should be exerted in generalizing such results.

The immediate outcome of pregnancy, celebrated by the family, their relatives and friends is the delivery of neonate, who cried immediately with no obvious congenital deformity. At that happiest moment of arrival of new family member, no one paid attention to his or her physical parameters, which affect the future life. In the study group, the immediate pregnancy outcome showed relative predominance of female sex of (54.6%) as opposed to male of (45.4%), and (96%) are mature, whereas only (4%) are immature, which was compatible with global standards of (4%) as maximum rate of prematurity (Villar et al, 2014). The weights of (66%) of neonates at birth were found between (2.5 and 3.5 kg). (9%) of delivered neonates failed to achieve weight greater than (2.5 kg), and hence were considered as underweight. This rate is higher compared to less than (5%) as adopted WHO standard (Villar et al, 2014). Of great concern, the pregnant women under (20) years of age who compromised (11.5 %) of pregnant women had the highest percentage of neonatal underweight of (20%). The arithmetic means of neonatal *weight*, *length* and *head circumference* at term in this study were (3.09 ± 0.57 kg), (45.6 ± 3.92 cm), (34.3 ± 3.69 cm) respectively, these figures, with exception of length, were in agreement with those for Kenya and Oman projected in the International standards for newborn *weight*, *length*, and *head circumference* by gestational age and sex: the Newborn Cross-Sectional Study of the INTERGROWTH-21st Project. The figures for Kenya were (3.3±0.4 kg), (49·1± 1.8 cm), (34·2±1.2 cm), and for Oman were (3.1±0.4 kg), (49·0 ±1.8 cm), (33·6± 1.1 cm) respectively. These two countries are similar to Sudan both geographically, and demographically. Those neonatal parameters, also lagged behind the international 90th Centiles for neonatal weight, length, and head circumference at 37th weeks of gestation, which were (3.45 kg), (50.14 cm) and (34.63cm), respectively (Villar et al, 2014). The figures projected in this study were also compatible with those published by (El-Samani et al, 2016), in their study of predictors of the mean birth weight and risk factors of low birth weight among full-term, singleton babies born in an urban setting in Khartoum in the Sudan as regard to the mean birth weight was (3.1±0.471 kg) and the prevalence of low birth weight was (9.2%), with more prevalence of low birth weight in mothers younger than (20 years) of age.

The discrepancy of mean fetal length might reflect the prevalence of mild iodine deficiency in Shendi locality, since linear growth was more affected by iodine deficiency, than weight (Medani et al, 2011).

In Table (5), the arithmetic mean of placental weights was (761.4 ±55 gram). It was higher than the arithmetic mean obtained by (Thompson et al, 2007). In the study of placental weights in Norway from the Medical Birth Registry of Norway, that was (626) gram for (37) weeks of gestational age. It was also higher than what was demonstrated by (El-Samani et al, 2016) of (571±118 gram). The difference in the means of placental weights might partially be due to the method of weighting that exclude the membranes and the umbilical cord from placental weight in Norway, where they were included in the current study. The guidelines of the Norwegian Society of Obstetrics and Gynaecology recommended 'the placenta should preferably be weighed without the cord and membranes. In recent years, birth weight, sometimes in conjunction with placental weight, had been associated with the development of a series of diseases later in life. Associations had been observed of placental size to pregnancy outcomes and early mortality, morbidity and even the development of

diseases in adult life. Placenta is connected to the developing fetal cardiovascular system (Thompson et al, 2007).

In Sudanese traditional cultural heritage, there was perception of the placenta as part of the offspring future; therefore, it had been honored by burying it either inside the family home or in yards for praying and religious events.

The most important function of the thyroid gland is the production of thyroxine (T_4 and T_3). In humans, the ratio of (T_4 to T_3) released into the blood is between (14:1) and (20:1). In Table (6) the arithmetic mean is (1.33 ng/ml), which was skewed towards the upper limit of normal range, that is (0.79 to 1.58 ng/mL), there were (2%) who had (T_3) value less than the normal range value and (19%) had (T_3) above it.

The situation concerning (T_4) was different, with arithmetic mean of (7.96) in the middle of the reference interval for (T_4), which is (4.9 to 11.0 µg/dL), with (98%) within the reference interval and only (2%) above it.

This might indicate increasing peripheral conversion of (T_4 to T_3), with more unregulated production of (T_3) and hyperstimulation of thyroid gland by TSH, and less production of (T_3) and more (T_4) inside the gland. This might be the first feature of iodine deficiency that leads ultimately to thyroid goiter and failure with overt hypothyroidism later in life.

CONCLUSION

The study demonstrated the existence of mild iodine deficiency in Shendi Locality, as in the previous studies with goiter prevalence rate of (13%). It also revealed the serious impaction of it on neonatal parameters with decreasing mean neonatal length of (45.57±3.92cm).

Recommendation

Up scaling of salt iodization should have special priority in national antenatal care, children and women health policy (Sudan Federal Ministry of Health, 2016).

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