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Urinary iodine concentration: a biochemical parameter for assessing the iodine status

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Abstract

Iodine is a micronutrient, which is essential for the synthesis of thyroid hormones. Thyroid hormones play a major role in the development of different functional components in different stages of life. The relationship between iodine intake level of a population and occurrences of thyroid disorders U-shaped with an increase from both low and high iodine intake. Iodine deficiency disorders (IDDs) are a major health problem worldwide in all age groups, but infants, school children, and pregnant and lactating women are vulnerable. During pregnancy and lactation, the fetus and infants are sensitive to maternal iodine intake. Even mild iodine deficiency may lead to irreversible brain damage during this period. A main cause of IDDs of neonates and infants is maternal iodine deficiency. Universal salt iodization strategy has been initiated by the World Health Organization and United Nation International Children Emergency Fund by the year 1993 for correction and prevention of iodine deficiency. Excessive iodine causes hypothyroidism, iodine-induced hyperthyroidism and autoimmune thyroid diseases. Iodine deficiency and excessive iodine, both cause goiter. There are many indicators for assessing the IDDs, such as measurement of thyroid size by palpation or ultrasonography, serum thyroid stimulating hormone, and thyroglobulin but these are less sensitive, costly and sometimes interpretation is difficult. Urinary iodine concentration (UIC) is a well-accepted, cost-efficient, and easily obtainable indicator of iodine status. Since the majority of iodine absorbed by the body is excreted in the urine, it is considered a sensitive marker of current iodine intake and can reflect recent changes in iodine status. Iodine requirements are greatly increased during pregnancy and lactation, owing to metabolic changes. During intrauterine life, maternal iodine is the only source of iodine for a fetus. UIC determines the iodine status of pregnant and lactating women. Breast milk is the only source of iodine for exclusively breastfed neonates and infants. Breast milk iodine concentration can be determined by UIC. UIC predicts the adverse health consequences of excessive iodine intake such as goiter, hypothyroidism, and hyperthyroidism. This review presents that iodine status in different groups of a population can be determined by UIC which will be helpful in assessing the iodine status in a community, finding out the cause of thyroid disorders, to predict the risk of adverse health effects of iodine deficiency and excessive iodine, and in making plan for iodine supplementation.

Key words: urinary iodine concentration, breast milk iodine concentration, iodine status.

Background

Iodine is a micronutrient which is essential for the synthesis of thyroid hormones.[1,2] Thyroid hormones play a major role in the development of different functional components in different stages of life. The relationship between iodine the iodine intake level of a population and occurrence of thyroid disor-

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ders U-shaped with an increase from both low and high iodine intake.[3] An estimated 35% of the world's population has insufficient iodine intake and continues to live at risk for iodine deficiency and associated iodine deficiency disorders (IDDs).[4] Iodine deficiency poses a threat throughout the life and has been associated with mental impairment and goiter in older children and adults and complications with pregnancy, including stillbirth and congenital abnormalities.[5] During pregnancy and lactation, the fetus and infants are sensitive to maternal iodine.[6] Inadequate iodine intake during pregnancy may lead to irreversible fetal brain damage.[7] Infants are very sensitive to iodine deficiency because of their high demand and low storage of iodine.[1,8] Even mild iodine deficiency may lead to irreversible brain damage during this period.[2,8]

Universal salt iodization strategy has been initiated by World Health Organization (WHO) and United Nation International Children Emergency Fund (UNICEF) by the year 1993 for correction and prevention of iodine deficiency.[9] Excessive iodine causes hypothyroidism, iodine-induced hyperthyroidism and autoimmune thyroid diseases. Iodine deficiency and iodine excess both cause goiter.[10-13] There are many indicators for assessing the IDDs such as measurement of thyroid size by palpation or ultrasonography, serum thyroid stimulating hormone and thyroglobulin but these are less sensitive, costly, and sometimes interpretation is difficult.

Urinary iodine concentration (UIC) is a well-accepted, cost-efficient, and easily obtainable indicator of iodine status.[4] Since the majority of iodine absorbed by the body is excreted in the urine,[14] it is considered a sensitive marker of current iodine intake and can reflect recent changes in iodine status.[15] Iodine requirements are greatly increased during pregnancy and lactation, owing to metabolic changes.[16-19] During intrauterine life, maternal iodine is the only source of iodine for a fetus. UIC determines the iodine status of pregnant and lactating women.[5,20] Breast milk is the only source of iodine for exclusively breastfed neonates and infants. Breast milk iodine concentration (BMIC) can be determined by UIC.[21] UIC predicts the adverse health consequences of excessive iodine intake such as goiter, hypothyroidism, hyperthyroidism.[9]

This review aimed to show iodine status in different groups of a population, which can be determined by UIC, which will be helpful in assessing the iodine status in a community, to find out the cause of thyroid disorders, to predict the risk of adverse health effects of iodine deficiency and excess iodine, and in making plan for iodine supplementation.

Urinary iodine

Most of the iodine absorbed by the body is excreted in urine.[14] Therefore, UIC is a sensitive marker for current iodine intake and can reflect recent changes in iodine status.[15] However, this indicator does not provide direct information about the thyroid function.[20] Iodine concentration in the morning or other casual urine specimens from children or adults provide an adequate assessment of a population iodine nutrition, provided a sufficient number of specimens is collected, and 24 hours' sample is not necessary.[9] A casual sample is taken in adequate number within a population accurately reflects 24 hours' collection.[22] Median casual UIC, expressed in μg/L is currently the most practical biochemical indicator for assessing community iodine nutrition. It is more useful and much simpler than measuring 24 hours' sample or urinary iodine/ creatinine ratio.[23] Urinary iodine/ creatinine ratio is not reliable, particularly when protein intake is decreased.[9] The minimum iodine concentration for iodine sufficiency is 100 μg/L, which corresponds roughly to a daily iodine intake of 150 μg in an adult.[9]

Iodine status determined by UIC

An estimated 35% of the world's population has insufficient iodine intake and continues to live at risk for iodine deficiency and associated IDDs.[4] UIC is the prime indicator of a person's nutritional iodine status; it is the primary variable used to measure the

success of iodine supplementation in a population.[24] In 1990, urinary iodine was presented as an effective biochemical indicator to assess recent dietary iodine intake, and a median urinary iodine level of 50 µg/L or less was proposed for classifying iodine deficiency along with a series of values to establish the degree of urgency for its correction (important, urgent or critical).[25] In a consultation held in 1992, the cut-off value for iodine deficiency was raised to a median UIC lower than 100 µg/L and severity was classified as mild, moderate or severe.[26,27]

UIC and iodine status of school children or adults[9,26,27]

According to current recommendations produced by the WHO, UNICEF and International Council for Control of Iodine Deficiency Disorders (ICCIDD), the median UIC 100-199 µg/L in samples from school children or adults indicate adequate iodine intake and optimal iodine nutrition and UIC <100 µg/L indicates iodine insufficiency[9] (Table 1). This recommendation was made on the basis of the assumption that the threshold of 100 µg/L would allow values <50 µg/L (moderate deficiency) in no more than 20% of the population. Some participants at a meeting in 1999 convened by WHO to revise the indicators felt that 20% represented an unacceptably high number of people, and the group considered raising the threshold for the median above the current value of 100 µg/L.[9] It appeared, however, that this concern was not scientifically based, because no hard data were available on the frequency of concentrations of urinary iodine <50 µg/L in populations where the median urinary is >100 µg/L. On the basis of UIC, severity of iodine deficiency was classified mild (UIC 50-99 µg/L), moderate (UIC 20-99 µg/L), severe (UIC <20 µg/L)[26,27] (Table1). The major epidemiological consequence of iodine excess is iodine-induced hyperthyroidism.[28,29]

In 2001, cut-off values for urinary iodine that are indicative of a more than adequate or excessive iodine intake were first introduced.[9] UIC ≥300 µg/L are considered excessive iodine intake and should be discouraged in order to avoid possible adverse health consequences, including hyperthyroidism and autoimmune thyroid diseases. Furthermore, in populations characterized by long-standing iodine deficiency with rapid increases in iodine intake, median values for urinary iodine above 200 µg/L in adults are not recommended because of the risk of iodine-induced hyperthyroidism.[9] A systematic review and meta-analysis among the school-aged children was shown that iodine deficiency and iodine excess both have risk of development of goiter.[10] In those studies, they compared the prevalence of goiter among the different UIC groups based on the WHO classification and they found that there was a U-shaped association between UIC and goiter prevalence, with higher prevalence observed at UIC values <20 µg/L and >200 µg/L.[10] So, UIC is a promising biomarker for predicting goiter among school-aged children.

UIC of pregnant and lactating women, and children aged <2 years[5,9,20,30]

Iodine requirements are greatly increased during pregnancy and lactation, owing to metabolic changes.[16-19] During pregnancy, maternal thyroid hormone (thyroxin) production is unregulated and the transfer of thyroxin and iodine from the mother to the fetus is essential for proper brain development and thyroid function in the fetus.[18] Although, the rate of production of thyroid hormone returns to normal during lactation, iodine requirements remain elevated, as the breastfeeding mother provides the nursing infant with its sole source of iodine while the infant is exclusively breastfed.[20] Epidemiologic criteria for assessing iodine nutrition based on median UIC in pregnant and lactating women were first published in 2007.[5,20] Similar criteria was established for children aged <2 years, who were also at a high risk of iodine deficiency because of the continuing high iodine demands that were necessary for supporting brain and thyroid development.[9,30] The median UIC used to assess iodine nutrition among pregnant and lactating women, and children aged <2 years are presented in Table 2 and 3.

Table 1. Iodine nutrition based on median UIC in school children (6 years and above) or adults[9,26,27]

Median urinary iodine, µg/L	Iodine intake	Iodine status
<20	Insufficient	Severe iodine deficiency
20-49	Insufficient	Moderate iodine deficiency
50-99	Insufficient	Mild iodine deficiency
100-199	Adequate	Adequate iodine nutrition
200-299	Above requirements	May pose a slight risk of iodine-induced hyperthyroidism and autoimmune thyroid diseases
≥300	Excessive	Risk of iodine-induced hyperthyroidism and autoimmune thyroid diseases

Table 2. Iodine nutrition based on median UIC in pregnant women[5,20]

Median urinary iodine, µg/L	Iodine intake
<150	Insufficient
150-249	Adequate
250-499	Above requirements
≥500	Excessive

Table 3. Iodine nutrition based on median UIC in lactating women and children aged <2 years[9,30]

Median urinary iodine, µg/L	Iodine intake
<100	Insufficient
≥100	Adequate

Relation of UIC to BMIC

Iodine is essential for normal growth, mental development and survival for infants.[31] IDDs are a major health problem worldwide in all age groups, but infants, school children, and pregnant and lactating women are vulnerable.[5] During pregnancy and lactation, the fetus and infants are sensitive to maternal iodine intake and an adequate iodine concentration in breast milk is essential for optimal growth and neurological development.[6] Breast milk is the only source of iodine for exclusively breastfed infants. The BMIC of lactating mothers can vary somewhat from day to day and even within a given day due to irregular iodine intake and dilution effect by increasing volume.[32] The mean BMIC is reported as ranging from 5.4 to 2170 µg/L (median 62 µg/L) in worldwide studies.[33] A review on BMIC reported a wide range of iodine concentration (13-155 µg/L) among the women living in areas with varying levels of iodine intake.[6] The optimum BMIC is supposed to be 64-178 µg/L.[34] The minimum recommended BMIC is 50 µg/L.[32] Routine measurement of BMIC is difficult due to social and religious barriers. UIC can predict the BMIC.[21,35] According to the United States National Health and Nutrition Examination Survey, in areas with iodine

sufficiency, BMIC positively correlated with UIC.[35] This was also found in a study of lactating mothers in Bangladesh.[21] In China, in an area of iodine excess, Liu et al found that BMIC was positively correlated with UIC in lactating women.[36] Many other studies on lactating women reported that the BMIC was positively correlated with UIC.[21,37] Molla et al reported that BMIC was positively correlated with UIC but BMIC of mildly iodine deficient mothers was below the level of the optimum range.[21] It indicated that BMIC of iodine sufficient lactating women was normal but lactating women of low UIC was a risk of low BMIC. Low UIC, expressed in µg/L for lactating mothers can be taken as an indicator of low BMIC.[34]

Conclusion

Iodine status in different groups of population in a community can be determined by UIC. UIC is a biomarker for predicting adverse health consequences of both low and excessive iodine intake. UIC can also be used as an indicator of BMIC.

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