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Karbala International Journal of Modern Science 2 (2016) 104–112
http://www.journals.elsevier.com/karbala-international-journal-of-modern-science/

Influence of various parameters on the levels of arsenic in washed scalp hair from Karbala, Iraq by using ICP-OES technique

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Received 1 November 2015; revised 15 February 2016; accepted 16 February 2016
Available online 28 April 2016

Abstract

The use of unconventional biological materials as biomarkers in trace element studies has increased in terms of published research studies. In the present study, human scalp hair samples (n = 65) were used to be a possible biomarker for the arsenic level in the human body as no study has been published in Karbala city, Iraq yet. The level of arsenic was determined by inductively coupled plasma optical emission spectrometry (ICP-OES). The validity, precision and accuracy of the methodology were evaluated using a "pooled" sample and certified reference materials, respectively. The validation methods provided acceptable levels of precision and accuracy with lower range of RSD (1.1%) and acceptable range of elemental recovery (97.72%), respectively. The influence of various factors including health status, gender, smoking activity, interaction, individual's age and drinking water on arsenic levels in washed scalp hair was investigated using the analysis of covariance (ANCOVA), analysis of variance (ANOVA), F-test and a two-tailed pooled t-test. The arsenic levels in washed scalp hair of breast cancer patients (8.270 ± 4.345 mg/km) were significantly increased when compared with healthy individuals (6.266 ± 1.892 mg/km) ($p < 0.05$). It was found that the levels of As were significantly higher in washed scalp hair of males (12.395 ± 6.243 mg/kg) than those for females (7.637 ± 4.234 mg/kg) ($P < 0.05$). Hair of smokers (16.078 ± 4.245 mg/kg) was significantly contained more As than hair of non-smokers (6.532 ± 2.817 mg/kg). The levels of As in the age group (over 40 year) are significantly different when compared with the two remaining groups (under 20 year, and 20–40 year). The value of correlation coefficient ($r = 0.907$, $p < 0.001$) was indicated that there is significant positive correlation between the arsenic level in the scalp hair and the arsenic level in the drinking water.

Keywords: Human scalp hair; ICP-OES; Breast cancer; Karbala

1. Introduction

In the last few decades, human scalp hair and nails (finger & toe) have widely been used as a good biomarker in the assessment of exposure to various pollutants in occupational and/or environmental settings, and in terms of assessing the metabolic state of humans, for essential and toxic trace elements [1–3]. Hair and nail tissues were found to have several advantages namely: non-invasive materials, easily sampled and potentially represent a long-term growth material. In addition, several trace elements may accumulate in hair and nail tissues over a time frame of

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Peer review under responsibility of University of Kerbala.

http://dx.doi.org/10.1016/j.kijoms.2016.02.004

2–18 months. These advantages may provide useful data in determining the health status of an individual over long periods, as the tissues remain isolated from other metabolic activities in the human body [4,5]. The use of human hair and nails as an excellent tool to assess changes in our bodies has received a great deal of attention for a few decades and become successful in different applications [6,7]. The concentration of trace elements is homeostatically regulated when the health status of individuals is under normal conditions (healthy individuals) [8]. There are accumulating evidences that the metabolism of several trace elements is altered in cancer, and may play significant roles in the pathogenesis and progress of this disease [9]. Many studies have previously discussed the relationship between trace elements and cancer for patients by comparing them with healthy individuals [10–12].

Arsenic, similar to other elements, can become toxic if its concentration in the human body is too high. A level of 1–3 mg/kg As is enough to be lethal in a human adult [13]. The toxicity of arsenic is strongly related to its oxidation state and chemical form [14]. It was found that inorganic arsenic is suggested to be more toxic than organic forms in terms of human health [15]. Most cases of arsenic-induced toxicity in humans are due to natural exposure to inorganic arsenic via air, water, soil, dust and food [16,17]. In the last centuries, the use of arsenical compounds was increased, namely: in pigments, dyes, preservatives of animal hides, glass manufacture, agricultural pesticides, and various pharmaceutical substances [18]. Chronic arsenic exposure has been suggested to have etiologic roles in diabetes development, cancer, neoplastic, cardiovascular, endocrine and neurodevelopmental disorders [19,20]. The previous studies have indicated that an elevated risk of cancers persists even decades after exposure has ceased [21–23]. A proportion of studies further displayed that As_2O_3 also prevents many other hematologic malignancies and solid tumors such as neuroblastoma, breast cancer, liver cancer, gastric cancer, lung cancer, esophageal cancer, cervical cancer and so on [24]. One study in India has indicated that excessive use of mineral fertilisers and pesticides has led to water and soil contamination, affecting farming. This study has referred that cancer mortality is directly correlated with gender and farming [25]. Arsenic trioxide is effective in treating promyelocytic leukemia, and laboratory studies establish that arsenic trioxide reasons apoptosis of human breast cancer cells [26]. The main aim of this study is to investigate whether there is any possible link between arsenic and the onset of breast cancer by using washed scalp hair as a biomarker. This can be used (i) to evaluate if any possible arsenic relationships exist between healthy individuals and those with human health conditions, such as smoking activity and breast cancer; (ii) to investigate whether factors like gender and age may affect the arsenic concentrations in washed scalp hair of the individuals under study; and (iii) to evaluate whether the environmental sample (water) makes any significant contribution to the arsenic levels of the selected tissue in this study.

2. Materials and methods

In the present study, the concentrated nitric acid (Aristar® 65%) was used for digestion procedure, whereas, the pure acetone and de-ionised water (DDW; 18.2 MΩ) were used for washing method and dilution, respectively.

2.1. Study population

Human scalp hair samples were collected from individuals resident in Karbala which is a city in Iraq located about 100 km south west of Baghdad. The participants were clearly informed of all the study procedures before signing the informed consent form. Generally, volunteers were interviewed at the time of sampling to obtain some general information about their health status, lifestyle, typical diet and smoking habits. In total, 65 samples were collected from healthy individuals (n = 32) and breast cancer patients (n = 33) in relation to different forms of smoking (none, and active), varying in gender (male and female) and age. In addition, some individuals provided either one or two type of samples, namely scalp hair and fingernails (n = 5). This then enabled an examination of any significant differences and whether a possible relationship between the levels of arsenic between these media existed. Moreover, environmental samples (domestic water, n = 15) were chosen in order to assess whether this media makes any significant

Table 1
Demographic characteristics of study populations from Kerbala city, Iraq.

Type of sample	Health status		Gender		Smoking activity	
Scalp hair	Healthy	Breast cancer	Male	Female	Smoker	Non-Smoker
	32	33	17	48	16	49
Fingernail	5					
Water	15					