DISTRIBUTION OF SOME ELEMENTS IN HUMAN HAIR AND ORGANS DETERMINED BY NAA

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ABSTRACT

Twenty four male autopsies were obtained from Shanghai. The samples of liver, lung, kidney cortex, brain and scalp hair were collected from the autopsies. The elements As, Br, Ca, Cd, Cl, Co, Cr, Cu, Fe, Hg, Mg, Mn, Na, Rb, S, Se and Zn were determined by neutron activation analysis (NAA). The present study provides the elemental levels of different tissues for normal male adults. The distribution pattern of elements was discussed. Great difference on distribution of some elements in different tissues was observed.

Keywords: Trace elements Human hair Internal organs NAA

1 INTRODUCTION

Physiological roles of trace elements in a living body have attracted interest of many researchers. In recent years, the research of trace elements was also developed rapidly in China. For example, Chinese doctors have found Keshan disease (a local epidemic) is related to lack of selenium in local environment, and resulted in methods for curing the disease[1]. In order to learn the relation between trace elements and diseases, many researchers determined various trace elements in hair of normal persons and patients[2,3]. Obviously, it is important to learn the correlation of elemental levels between human hair and internal organs, and the distribution pattern of elements in human body. The correlation of elements has been described in our article[4]. In this paper, the elements As, Br, Ca, Cd, Cl, Co, Cr, Cu, Fe, Hg, Mg, Mn, Na, Rb, S, Se and Zn in liver, lung, kidney cortex, brain and hair from Chinese autopsies were determined by NAA and their distribution pattern was discussed.

2 EXPERIMENTAL

2.1 Collection and preparation of samples

Twenty four autopsies, whose ages ranged from 35 to 60 years, were obtained from Shanghai Institute of Forensic Medicine. The samples of liver, lung, kidney cortex,

brain and scalp hair were collected within 48 hours after accident death of persons who were proven in good health before the accidents. The liver samples were collected from the superior half of the organs, lung samples from the lower half of the right ones, kidney samples from the outer cortex of the left ones, brain samples from the left part of cerebral cortex and hair from the occipital region. After collection the soft tissues were stored in a freezer at temperature below –30°C. They were cut into 1–2 cm cubes with titanium knives and homogenized in teflon containers by the brittle fracture in liquid nitrogen. Then freeze–dried and grounded into fine powder. Hair samples were washed with acetone and water several times, then dried and homogenized by brittle fracture technique. The dry powder samples were stored in closed plastic bottles at room temperature.

The mean ratio of dry and wet weight for liver, lung, kidney, brain and hair are 0.298, 0.210, 0.206, 0.248 and 0.930, respectively.

2.2 Radiochemical neutron activation analysis (RNAA)

The elements As, Cd, Cu, Hg and Zn were determined by RNAA. A simple group separation scheme based on extraction was developed for this work[5]. Samples of 100–200mg dry weight were sealed into polyethylene bags and irradiated in a swimming pool type reactor with a thermal neutron flux of 1×10^{13} n · cm^{-2} · s^{-1} for 44 hours. After a cooling period of 1–3 days, the samples were digested with H_2SO_4 and HNO_3 in teflon bombs at 150°C for 4 hours. The elements Cu and Hg were extracted with $Zn(DDC)_2$ (Zinc diethyl–dithio–carbamate), and As, Cd and Zn were extracted with MIBK (methylisobutyl ketone) from H_2SO_4 and KI media. The elements can be extracted from strong mineral acids quantitatively, and separated into two groups which are suitable for measurement of gamma ray spectrometry.

The activities of ^{76}As, ^{115}Cd, ^{64}Cu, ^{197}Hg and ^{65}Zn were measured by an Ortec Ge(Li) detector coupled to a CANBERRA S–80 4096 channel pulse height analyzer. Three samples were prepared and analyzed for each case.

2.3 Instrumental neutron activation analysis (INAA)

The elements Br, Ca, Cl, Co, Cr, Fe, Mg, Mn, Na, Rb, S and Se were determined

Table 1

The conditions of experiments for INAA

Neutron flux ($n \cdot cm^{-2} \cdot s^{-1}$)	Irradiation time	Cooling time	Counting time (s)	Group of nuclides
8×10^{11}	60 s	5 s	60	^{77m}Se
5×10^{11}	8 min	60 s	400	^{80}Br, ^{49}Ca, ^{38}Cl, ^{66}Cu ^{27}Mg, ^{56}Mn, ^{24}Na, ^{37}S
1×10^{12}	50 h	2–3 weeks	3600	^{60}Co, ^{51}Cr, ^{59}Fe ^{203}Hg, ^{86}Rb, ^{65}Zn

by INAA, Cu, Hg and Zn in brain were also determined by the method. Samples of 100

mg were sealed into polyethylene bags. Chemical standard samples were prepared by dropping appropriate solution on clean filter paper and sealed into polyethylene

Table 2

The analytical results for standard reference materials (mg/kg)

Element	IAEA H-8 (Horse kidney)		NIES-5 (Human hair)		NBS-1573 (Tomato leaves)	
	This work	Certified values	This work	Certified values	This work	Certified values
As	0.022±0.002	0.021±0.003	0.062±0.006		0.223±0.015	0.27±0.05
Cd	194.5±5.6	189±2.4	0.19±0.02	(0.20)	2.92±0.08	(3)
Hg	1.00±0.12	0.91±0.12	4.47±0.38	(4.4)	0.085±0.002	(0.1)
Cu	30.2±1.14	31.3±1.7	15.8±0.47	16.3±1.2	11.3±2.4	11±1
Zn	186±3.5	193±6	158.3±7.3	169±10	66.2±13.9	62±6
Br	105±2	104±11.4	97.9±1.0	(90)		
Cl	10040±210	12600±1800	261.4±5.2	(250)		
Mn	5.68±0.52	5.73±0.28	5.19±0.25	5.2±0.3		
Mg	761±66	818±91	233±5	208±10		
Na	9225±387	9600±298	27.8±0.7	26±1		
S	10120±3800	(9000)	41300±2300	(41600)		
Se	4.65±0.46	4.67±1.0	1.48±0.06	(1.4)		
Ca	890±123	924±203				
Co	0.115±0.040	(0.13)			0.58±0.05	(0.6)
Fe	295.4±3.2	265±15.1			652±76	690±25
Rb	20.3±0.5	22.2±0.8			16.4±0.8	16.5±0.1
Cr					4.11±0.46	4.5±0.5

bags. The samples and standards were irradiated in a swimming pool reactor or a MNSR reactor. Table 1 shows the irradiation, cooling and counting times for three groups of nuclides. The activities were measured as stated above. The reliability for both RNAA and INAA was checked by analysis of reference materials Horse Kidney IAEA H-8, Tomato Leave NBS 1573 and Human Hair NIES-5. The analytical results were shown in table 2, they are in good agreement with the certified values[5,6].

3 RESULTS AND DISCUSSION

Table 3 shows the analytical results of 17 elements. In this table, the number of specimens (*N*), arithmetic mean (AM) and standard deviation (SD) are reported for each element in each tissue.

As, Cd, Hg, Cu, Se and Zn are important elements for human health. We paid attention to the individual differences of these elemental levels in different persons. In general, the individual differences of As, Hg and Cd are greater than that of Cu, Se and Zn. The relative standard deviation (SD/AM) can reflect the individual difference. Great relative standard deviation indicates great individual difference. For example, the relative standard deviations of Cd in hair, kidney, liver and lung are 70%, 64%, 62% and 68%, respectively, but corresponding values for Zn are only 20%, 38%, 26% and 20%.

The arithmetic means of elemental contents in each tissue are shown in Fig.1. The

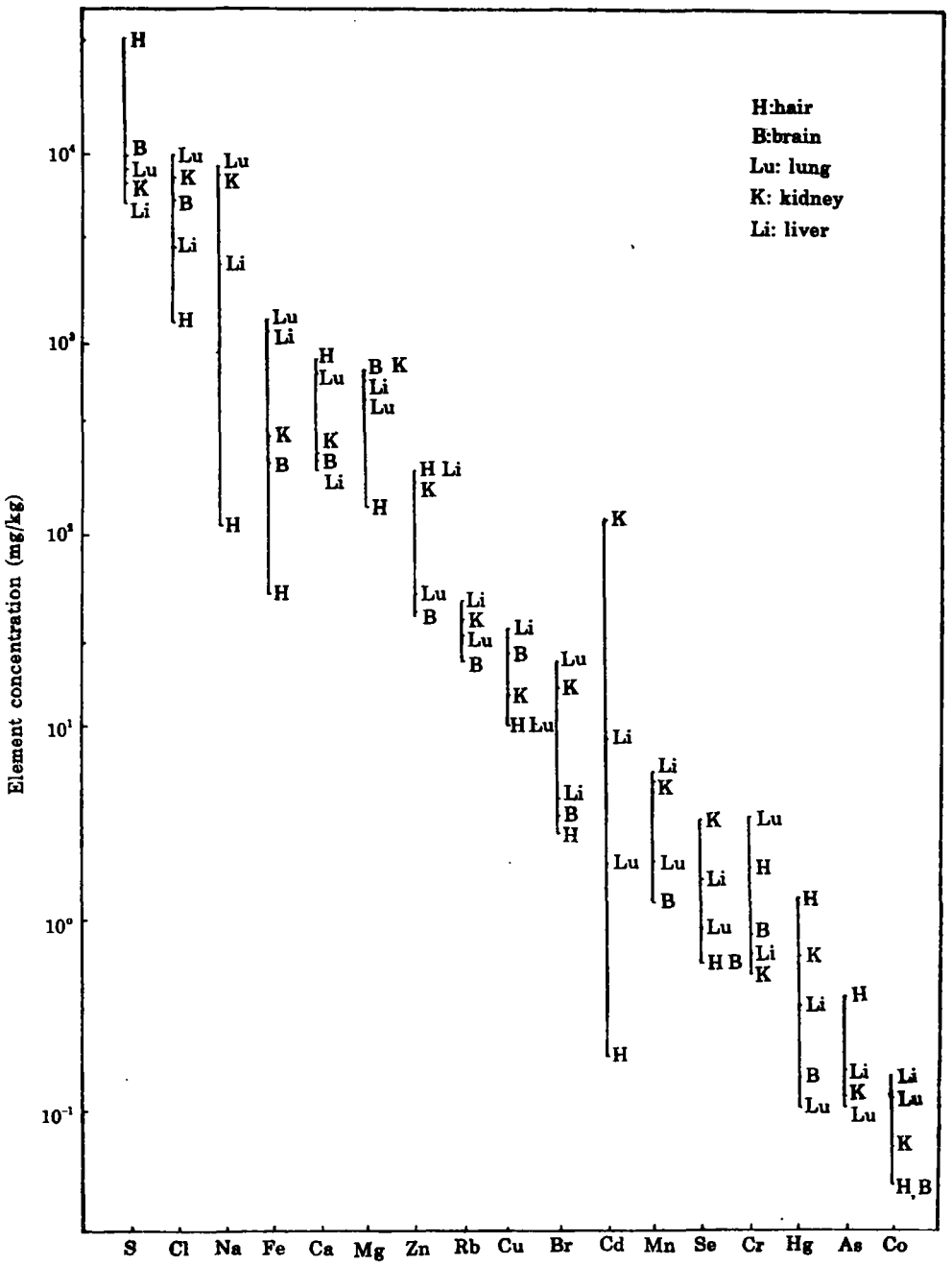

Fig. 1 The comparison of 17 elemental levels in human hair and internal organs

elemental concentrations decrease from left to right in the figure. For some elements great differences are observed in different tissues. The greatest difference was found to be Cd in different tissues, its concentration in kidney is almost 500-fold greater than that in hair. The toxic element Cd is mainly excreted through kidney, so the element

can be accumulated in kidney. Great differences between hair and internal organs are also observed for Fe. Iron concentration in blood is high, and blood content in each tissue is different, so distribution of Fe is not homogeneous in human body. For other elements, such as Cu and Zn, only small differences were found in different tissues.

Table 3

The analytical results of 17 elements in hair and internal organs (in mg/kg dry weight)

Element	Hair			Kidney			Liver			Lung			Brain		
	N	AM	SD	*N*	AM	SD	*N*	AM	SD	N	AM	SD	N	AM	SD
S	11	41800	11200	8	7600	2700	10	5800	1500	6	8600	2500	21	9800	3700
Cl	11	1430	630	11	8050	3050	10	3540	1070	11	10700	1350	23	6420	830
Na	11	110	120	11	8200	1900	11	2800	1000	11	9200	2000			
Fe	10	54.1	25.6	11	345	141	11	1160	1210	11	1250	280	20	224	35
Ca	10	846	498	5	292	177	5	217	103	10	689	688	16	255	146
Mg	9	131	32	11	681	116	10	616	98	11	480	85	23	700	102
Zn	24	207	43	24	188	72	24	210	55	24	55.0	11.2	20	41.3	5.6
Rb				11	37.5	7.6	11	44.3	15.2	11	30.4	4.6	20	22.2	7.0
Cu	24	10.1	2.1	24	13.4	3.4	24	34.1	13.6	24	9.79	3.77	23	25.8	6.9
Br	11	2.93	1.28	11	16.0	4.5	11	4.33	1.10	10	22.8	4.9	19	3.27	1.16
Cd	24	0.20	0.14	24	116	74	24	8.6	5.3	24	1.90	1.30	-		
Mn	11	4.37	2.22	11	5.07	1.03	11	5.83	1.52	10	1.97	1.07	23	1.16	0.43
Se	24	0.62	0.24	24	3.65	0.82	24	1.45	0.38	24	0.90	0.26	23	0.569	0.170
Cr	11	1.83	0.86	6	0.50	0.30	7	0.645	0.369	11	3.74	2.24	20	0.80	0.53
Hg	24	1.18	0.55	24	0.62	0.46	24	0.37	0.26	24	0.10	0.04	18	0.166	0.080
As	24	0.40	0.22	24	0.11	0.06	24	0.16	0.11	24	0.10	0.07			
Co	9	0.037	0.010	11	0.061	0.015	11	0.155	0.056	11	0.107	0.067	20	0.0351	0.0063

This paper provides the elemental levels for normal male adults in local area. We intend to extend our research on the trace elemental levels to pathological cases, and the elemental levels of normal persons will be used as reference values.

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