

# Contents of chemical elements in stomach during prenatal development: different age-dependent dynamical changes and their significance

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## Abstract

**AIM:** To observe dynamic of different chemical elements in stomach tissue during fetal development.

**METHODS:** To determine contents of the 21 chemical elements in each stomach samples from fetus aging four to ten months. The content values were compared to those from adult tissue samples, and the values for each month group were also analyzed for dynamic changes.

**RESULTS:** Three representations were found regarding the relationship between contents of the elements and ages of the fetus, including the positive correlative (K), reversely correlative (Na, Ca, P, Al, Cu, Zn, Fe, Mn, Cr, Sr, Li, Cd, Ba, Se) and irrelevant groups (Mg, Co, Ni, V, Pb, Ti).

**CONCLUSION:** The chemical elements' contents in stomach tissues were found to change dynamically with the stomach weights. The age-dependent representations for different chemical elements during the prenatal development may be of some significance for assessing development of fetal stomach and some chemical elements. The data may be helpful for the nutritional balance of fetus and mothers during prenatal development and even the perinatal stages.

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## INTRODUCTION

Embryonic stomach develops from the caudal side of foregut, and then the primitive stomach expands towards abdomen. With its enlargement, a 90 degrees clockwise rotation occurs around its major axis, giving the rise to the shape similar to the adult stomach. During the prenatal development, stomach is one of the fast growing organs, and all nutritious elements for the growth are supplied by mother through the placenta. The stomach is mainly for digestion of food and absorption of

nutrients, so its development and functional maturation after birth is important for its adaptability to the changing nutrient intaking way. In this article, we reported the dynamics contents of 21 chemical elements in gastric tissues during the development of fetal stomach.

## MATERIALS AND METHODS

### Materials

The fetuses were 4-10 months old (every 4 weeks are one month), all begin from countryside of Henan Province. Those gland 10 months old were obtained through unexpected abortion and those with shorter pregnancies were collected after the induced abortion. No case of the abortion could be attributed to environmental pollution, or their maternal health or nutrition problems. The stomach was taken from the fetus, using redistilled water, and then dried in an oven at 70-80 °C. The samples were crushed into powder and kept in the desiccator for use. Stainless steel scalpel and Teflon scissors were used during the sample processing, and contamination was avoided in the whole course.

### Methods

Se was measured using the method of 2,3 - di-aminonaphthalene fluorescence, with a fluorescence spectrometer (Model MPF-4, Hitachi). The other elements were detected using the method of ICP-AES<sup>[1]</sup>, with a sequential plasma emission spectrometer (ICP-2070 Barid Company's Model). All reagents employed were of commercial reagent-grade quality. Quality control was carried out by national first grade references including ox liver powder (ESA-1) and the pork (GBW08552). Statistical computations were conducted using the soft package SPSS 10.0.

### Analysis data of adult

All data of adults were taken from the literature<sup>[2]</sup>, covering reference parameters from the 100 persons (68 men, 32 women, 31.3 ± 1.0 years old) 4 provinces in South and Northern China. The original values, presumed to contain 71.6 % of water, were converts into those by dry weight.

## RESULTS

### Contents of constant elements in fetal stomach

Table 1 showed the contents of six constant elements of stomach of fetus aging 4-10 month, with that of K increasing with age, the values of Na, Ca, P, and Al were found to decrease with the fetus age, but the change for Mg was not significant. Contents of K, Na, Ca, P, Al and Mg in stomach tissues from fetus 10 month-old were 112.4 %, 60.6 %, 53.3 %, 78.0 %, 44.3 %, 86.1 % respectively of those from fetus 4 month-old. This indicates that the gastric tissues at embryo stages, contain more K than those at later pregnancy, and that Na, Ca, P, Al and Mg are higher in the embryonic stomach. In addition, K, Na, Ca and Mg contents were higher in the fetal stomach than in the adult samples.

**Contents of essential elements in fetal stomach**

Table 2 showed the contents of ten essential elements of stomach of fetus at the ages of 4-10 months. A tendency of age-dependent reduction was observed for all of 10 trace

elements, with the changes of Cu, Zn, Fe, Mn, Cr, Se and being more pronounced, and Cu, Zn, Fe, Mn, Cr, Sr, Se, Co, Ni, V contents in fetal stomach age of 10 month were 67.5 %, 38.8 %, 69.8 %, 78.0 %, 54.6 %, 95.8 %, 72.7 %, 99.0 %,

**Table 1** Contents of constant elements in fetal stomachs, with comparison to those in adult<sup>[2]</sup> (μg/g dry weight)

Age (mon)	4	5	6	7	8	9	10	Adult
K	7995.7 2309.1(6)	8148.9 2783.7(19)	8712.2 1969.6(14)	8583.1 1405.1(9)	8838.4 1731.5(7)	9091.5 2308.9(6)	8987.2 894.2(5)	5193.7 1457.7
Na	13237.5 1540.3(6)	11255.8 2096.0(19)	10708.8 2718.0(14)	9368.1 2112.5(9)	7859.1 2433.1(7)	9673.3 1855.6(6)	8023.6 1853.8(5)	4894.4 1626.8
Ca	972.7 60.3(6)	676.1 191.9(19)	704.5 147.3(14)	662.6 110.4(9)	699.4 243.8(7)	575.5 103.7(6)	518.8 159.0(5)	89.7 47.5
Mg	591.8 203.3(6)	589.5 155.6(19)	627.4 99.6(14)	622.7 91.9(9)	648.1 71.5(7)	519.7 96.5(6)	509.8 84.6(5)	494.0 159.7
P	7850.8 2113.8(6)	7668.5 1092.0(19)	7029.8 969.1(14)	6213.7 946.3(9)	6117.3 752.4(7)	6216.3 722.9(6)	6122.4 312.9(5)	
Al	12.922 8.947(6)	14.486 5.794(19)	14.152 8.620(14)	14.792 8.608(9)	10.786 4.513(7)	10.096 7.342(6)	5.722 5.208(5)	

Data in the upper row for each element is average mean, those in the lower is standard deviation with the case numbers in bracket. Case number of adult is 100.

**Table 2** Contents of essential elements in fetal stomachs, with comparison to those in adult<sup>[2]</sup> (μg/g dry weight)

Month-age	4	5	6	7	8	9	10	Adult
Cu	47.33 13.95(6)	37.26 14.74(19)	38.98 9.02(14)	37.67 16.44(9)	38.28 17.42(7)	27.65 8.53(6)	32.20 8.43(5)	4.95 1.52
Zn	310.7 38.8(6)	311.1 124.6(19)	279.6 50.3(14)	215.2 44.7(9)	150.6 81.2(7)	136.0 34.9(6)	120.5 12.6(5)	71.87 15.42
Fe	765.1 188.5(6)	677.0 257.3(19)	550.9 158.1(14)	503.1 147.4(9)	559.8 98.9(7)	530.1 260.0(6)	534.3 131.3(5)	138.6 61.4
Mn	3.266 0.797(6)	2.849 0.881(19)	2.833 1.015(14)	2.918 0.934(9)	3.068 0.859(7)	2.370 0.387(6)	2.547 0.512(5)	2.440 1.116
Se	- 0.042(2)	0.565 0.186(10)	0.553 0.161(9)	0.539 0.240(7)	0.471 0.089(6)	0.468 0.137(5)		
Co	0.575 0.380(6)	0.613 0.292(19)	0.711 0.320(14)	0.709 0.547(9)	0.648 0.259(7)	0.595 0.229(6)	0.569 0.188(5)	0.060 0.377
Cr	0.595 0.291(6)	0.565 0.309(19)	0.513 0.396(14)	0.510 0.397(9)	0.359 0.241(7)	0.302 0.154(6)	0.325 0.181(5)	3.958 6.511
Ni	0.511 0.254(6)	0.898 1.551(19)	0.517 0.584(14)	0.483 0.302(9)	0.780 0.293(7)	0.530 0.426(6)	0.211 0.096(5)	0.662 0.556
Sr	1.231 0.554(6)	0.785 0.394(19)	0.922 0.502(14)	0.735 0.238(9)	0.651 0.236(7)	0.374 0.170(6)	0.564 0.178(5)	
V	0.707 0.521(6)	0.500 0.386(19)	0.702 0.524(14)	0.581 0.170(9)	0.640 0.261(7)	0.556 0.413(6)	0.327 0.173(5)	

**Table 3** Contents of harmful elements in fetal stomachs, with comparison to those in adult<sup>[2]</sup> (μg/g dry weight)

Month-age	4	5	6	7	8	9	10	Adult
Li	0.707 0.903(6)	0.720 0.328(19)	0.699 0.374(14)	0.653 0.318(9)	0.567 0.189(7)	0.479 0.258(6)	0.383 0.165(5)	
Cd	0.266 0.357(6)	0.197 0.189(19)	0.129 0.080(14)	0.128 0.070(9)	0.103 0.065(7)	0.108 0.053(6)	0.081 0.039(5)	0.835 0.553
Pb	1.091 0.607(6)	0.882 0.565(19)	0.881 1.245(14)	0.851 0.578(9)	0.879 0.948(7)	0.884 0.461(6)	0.835 0.370(5)	0.426 0.356
Ba	2.542 1.214(6)	1.361 0.789(19)	1.055 0.447(14)	0.911 0.770(9)	1.053 1.445(7)	0.415 0.183(6)	0.705 0.228(5)	
Ti	0.347 0.154(6)	0.567 0.298(19)	0.474 0.275(14)	0.497 0.286(9)	0.543 0.353(7)	0.533 0.385(6)	0.419 0.290(5)	

41.3 % and 46.3 % respectively of that of 4 month. This indicates that the embryonic stomachs contain more essential elements than the fetal stomach. In comparison to the adult tissues, the gastric samples from fetuses aging 10 months contain more Cu, Zn, Fe and Co, less Cr and Ni, but the Mn content was similar. There were no analytical datum of Se, Sr, V in stomach of China Reference Person.

### **Contents of harmful elements in fetal stomach and comparison with those in adult**

Table 3 showed the contents of five harmful elements of stomach of fetus ageing 4-10 months. Except Ti, other elements reduced with the fetal development. Li, Cd, Ba, Pb and Ti contents in fetal stomach at the age of 10 month were 54.2 %, 30.5 %, 27.8 %, 78.2 % and 120.7 % respectively of those at the age of 4 month. In comparison to the published data for the adult group<sup>[2]</sup>, the stomach tissue in fetuses at the age of 10 month contained less Cd and more Pb.

### **Change regulation of contents of chemical elements in Fetus' stomach and its significance**

Table 4 showed the stomach weights of fetuses from 4 to 10 months. The data in agreement with those reported elsewhere<sup>[3]</sup>. The stomach weight was positively correlative the age ( $r=0.961$ ,  $P=0.001$ ). Table 5 showed the relation between contents of 21 elements and the age of fetus, with both parameters positively correlative for K, negatively correlative for 14 elements and statistically independent for the remaining elements.

**Table 4** Stomach weights of fetus aging from 4 to 10 months

Month-age	4	5	6	7	8	9	10
Weight (gram)	0.35 0.12(6)	0.94 0.45(19)	1.73 0.64(14)	3.17 0.74(9)	4.20 1.19(7)	5.41 0.76(6)	8.93 2.10(5)
Fixed ratio (%)	100	268.6	494.3	905.7	1200.0	1545.7	2551.4
Circular ratio (%)	-	268.6	184.0	183.2	132.5	128.8	165.1

The data in the upper row was average mean, that in the lower row was standard deviation, with the case number in bracket.

$$\text{Fixed ratio} = \frac{\text{stomach weight of fetus age of } i \text{ month}}{\text{stomach weight of fetus age of } i \text{ month}} \times 100 \%;$$

$$\text{Circular ratio} = \frac{\text{stomach weight of fetus age of } j \text{ month}}{\text{stomach weight of fetus age of } i \text{ month}} \times 100 \%;$$

( $i=4,5...10$ ;  $j=i+1$ ,  $j_{\max}=10$ )

**Table 5** Relation between elements' contents and age of fetus

Remarkable positive relativity (Pearson r)	Remarkable negative relativity (Pearson r)		Unobvious relativity (Pearson r)
K(0.9301) <sup>b</sup>	Na(-0.8815) <sup>b</sup>	Mn(-0.7364) <sup>a</sup>	Mg(-0.5265)
	Ca(-0.9222) <sup>b</sup>	Cr(-0.9515) <sup>b</sup>	Co(-0.1858)
	P (-0.7221) <sup>a</sup>	Sr(-0.8734) <sup>b</sup>	Ni(-0.4872)
	Al(-0.7983) <sup>a</sup>	Li(-0.9419) <sup>b</sup>	V(-0.6348)
	Cu(-0.8259) <sup>a</sup>	Cd(-0.9051) <sup>b</sup>	Pb(-0.0002)
	Zn(-0.9700) <sup>a</sup>	Ba(-0.8369) <sup>b</sup>	Ti(0.2161)
	Fe(-0.7883) <sup>a</sup>	Se(-0.9648) <sup>b</sup>	

<sup>a</sup> $P<0.05$ , <sup>b</sup> $P<0.01$ .

## **DISCUSSION**

Embryo's development is a special stage in human life. It can be divided into the embryo, fetus and neonate stage. There are respective characteristics during each stage. Main character of fetus is that embryo differentiates into different organs for

fetal development and storage for material and energy. Neonate characteristic is the adaptation of outer-environment of womb, and fetal metabolism changes from anabolism to catabolism. These characters are extremely easy to be interfered by environment, different dangers happen in different stages, and this is one of reasons that changes happen in the later stage of fetus appear after birth<sup>[4]</sup>. At present, there is very deficient knowledge to the variety of the chemical elements and understanding of their physiological function in the special changes that happen in the stage of fetus, it is helpful to solve these problems through dynamic observation of chemical elements of fetal tissues.

In this article, the correlation analysis between chemical elements in stomach and fetal age indicates that elements that are positively correlative with age in per gram stomach tissue increases with the development of the stomach, and elements' contents in fetus are lower than neonate; 14 elements that are reversely correlative with age in per gram stomach tissue reduce notably with the development of the stomach, and the elements contents in fetus are higher than neonate; 6 elements that are statistically independent with age in stomach of fetus may be basically unanimous of those of neonate. These results may be of some significance for studying the relation between elements and stomach development and physiological function.

In eleven essential elements that have datum of "China reference person", there are eight elements' contents of stomach of fetus higher than those of adult. For example, Ca of fetus stomach is 5.8 times of the adult's, Cu is 6.5 times, Fe is 3.8 times, and Zn is 1.7 times. It is well known that Ca, Cu, Fe, Zn are the elements that are easy to be lack and affect on the organs' development, cause a lot of physiology biochemical pathological changes and health problems in neonate, infant and children<sup>[5-9]</sup>, the character that there are higher contents in the stage of fetus not only reflects the material' storage function of fetus, but also reveals the regulation of "adaptation to outer-environment of womb" after birth. The contaminative trace elements' contents are remarkably lower than adult (Cr, Ni), such as Cr content in stomach of adult is 12.2 times of that of fetus, this indicates that the increase of this kind of elements' contents in adult is closely related with environment<sup>[2]</sup>. Harmful elements like Cd and Pb, their contents decrease with the increase of age, for example, the contents of Cd of stomach of fetus 10 month age is 30.45 % of that of fetus 4 month age, and the content of Pb of children over 7 is 37.5 % that of the neonate, which indicates that the content of Cd, Pb doesn't bring harm to fetus, and the accumulations of Cd, Pb in body of children result from environmental pollution, bad living and sanitary custom *et al*<sup>[8, 10-20]</sup>, this can consult for environmental monitoring.

Our series study of 21 elements contents' dynamics in other tissues of fetus (liver, kidney, brain, heart, lung, spleen), the same to stomach, majority of 21 elements' contents in per gram tissue remarkably reduce with the fetal age, the decreasing rate is especially large before birth. This common character of elements' change in different tissues indicates the sensitivities to these elements deficiency in the stage of neonate and infant, if the supply of this kind of elements from mother-environmental system is insufficient, it may bring nutritional lack of this kind of elements. Intervene experiment shows that it will take good effects on fetus and infant development with this kind of elements supplement singly to pregnant women<sup>[21-25]</sup>, however, supplement with Ca, Fe, Zn jointly to pregnant women, the mean values of the weight and height of their baby at birth are largest than other groups, this indicates that Ca, Fe, Zn supplement to pregnant woman is benefit for fetus and infant development<sup>[26-28]</sup>. Our study not only provides basis for adjusting and controlling nutrition of neonate, infant and pregnant and breast-feeding

woman, at the same time, furthermore can offer physiological foundation for focus viewpoint that some diseases of adult originate from fetus<sup>[29-32]</sup>.

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