Chapter 6

A Pilot Study of Radionuclides Analysis of Human Placenta According to Different Ages

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Abstract

In this study, radionuclides Th-232, K-40, Na-22, Eu-152, Ra-226, and Bi-207 were detected in placenta samples from 24 mothers who gave birth between the ages of 20 and 49. A NaI gamma detector with an ORTEC-branded scintillator that measures 7.62 cm x 7.62 cm and has a crystalline thallium-doped yield of 2% at 0.5 MeV and 1.3% at 2 MeV was used to test radionuclides. For 86400s, the placenta samples were counted (24 hours). Using Maestro-32 software, the peak areas in the obtained spectra were captured, entered into the proper equations, and the radionuclide activity concentrations were computed as Bq/g. Th-232, K-40, Na-22, Eu-152, Ra-226, and Bi-207 activity concentrations were determined based on different ages. Th-232, K-40, Na-22, Eu-152, Ra-226, and Bi-207 activity concentrations were found, and they varied depending on the radionuclide's age. These concentrations ranged from 8.470.20 to 34.911.27 Bq/g for Ra-226, from 0.781.03 to 25.581.03 Bq/g for Th-232, from 5.100.35 and 32.371.66 Bq/g for K-40, from 4.620.66 and 14. In order to develop the methodology for a more in-depth analysis, this pilot study evaluated the capability to identify particular radionuclides in placentea samples.

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1. Introduction

The placenta is the additional embryonic tissue that arises during pregnancy between the uterine mucosa and the chorion of the progeny for the development and protection of the offspring. The organ responsible for facilitating the exchange of nutrients, oxygen, and other substances between the mother and the fetus is the placenta. Most people tend to think of this exchange as a technique to alter the location where the mother's blood and the baby' blood shift. The mother's blood does not, however, combine with that of the fetus. From the outset of pregnancy, there is chemical communication between the mother and the fetus, and these hormonal and chemical messages continue to be beneficial to the infant until birth. The nutrients and oxygen required for the development of new cell groups and tissues are carefully chosen by the placenta and transported to the fetus. The waste products that are produced are separated, though, and sent to the mother's body. Due to the extensive cellular division and differentiation that occurs during embryological development, prenatal life is regarded as the most delicate stage of human development. Because of this, exposure to any environmental toxins at this time can have serious consequences. Numerous people are exposed to environmental contaminants from numerous sources, such as radionuclides, heavy metals, organic hydrocarbons, and pesticides, as a result of rising industrial pollution and man-made or natural combustion activities around the world. It is acknowledged that these pollutants gradually worsen the public health and are particularly harmful throughout the era of growth and development. The fetus is far more vulnerable to teratogens than an adult is, even at modest exposure levels that normally do not affect the mother [1, 2]. Exposure can result in structural alterations that are permanent if it happens during organ development [3].

The environment and living things are highly at risk from radionuclides, which are radioactive materials that release ionizing radiation during the decay of active atoms [4]. The placental transmission mechanism of radioactive substances has garnered particular attention in research on the radiation load to which the human organism is exposed by the addition of radioactive nuclides.

It might be possible to see this issue from new angles by estimating some of the adverse impacts that radioactive elements might have on the fetal organism. However, it is also possible to learn more about the process by which these nuclides are incorporated into the developing organism [5]. As a result of the use of radiation, humans are exposed to radiation doses at various rates. However, humans often absorb radionuclides through inhalation, food, and water. A significant portion of the exposure from natural sources falls under a specific form of internal radiation exposure where the bronchial epithelium is exposed to alpha particles from radon's short-lived offspring [6, 7, 8]. Since the main source of natural radioactivity in soil samples is typically identified by the activity of Ra-226, Th-232, and K-40, it is crucial to identify the level of natural radioactivity in the soil [9]. Due to the fact that these radionuclides can enter people through the food chain, natural radioactive substances like Th-232, Ra-226, and K-40 can reach dangerous radiological levels in some circumstances [10]. Th-232 and Ra-226 are the radionuclides that are among them that are the most dangerous. Determining the health dangers to a developing life, such as a fetus, is crucial for this reason. Drinks, food, and breath can all introduce radium, europium, and K-40 into the body, posing both internal and external risks. According to certain research, neonates absorb more radionuclides than older children and adults. It is considered that adult fractional absorption values greater than 0.5 correlate to 100% absorption in newborns and infants. It is generally agreed that infant absorption values between 0.5 and 0.01 in adults should be increased by a factor of two. Values of 0.001 or less in adults are accepted with a ten-fold increase [11].

In contrast, when an assessment is made for drug- and food-based transfers, drug and nutrient transfers are explained by mechanisms such as passive, facilitated diffusion, and active transmission [12, 13]. A tentative classification of transport mechanisms across the human placenta is based on (a) primary physiological significance of transferred substances, (b) relative transfer rates, (c) true transport mechanisms, and (d) equality or inequality in distribution [14]. The absence of nucleotides in food or medicine, however, does not sufficiently explain whether or not they transfer. According to our research, certain nucleotides were transported while others were not.

By investigating the identification of specific radionuclides in placentea samples, this pilot study sought to establish the methodology such as preparation of samples and radionuclide measurements and utilized statistics analysis for a more thorough investigation. It will also serve as a reference for upcoming research.

2. Material and Method

2.1. Preparation of Samples and Making Measurements

Nearly 578 kilometers to the southeast of Turkey's capital, Ankara, lies the Mediterranean city of Kahramanmaraş, which is 568 meters above sea level. The city is situated between the 36th and 37th east meridian and the 37th and 38th north parallel. At 26 weeks, placenta samples from 24 women who gave birth between the ages of 20 and 49 were obtained in 2013 at the Sutçü Imam University (KSU) Faculty of Medicine, Department of Obstetrics and Gynecology. Donors don't reside close to any nuclear or mineral facilities, while living in the city's center. However, it's possible that the people who live in this community will eat the fish in a contaminated reservoir. After being collected, cleaned, and weighed, the samples were stored in an oven at a constant temperature of 105 °C for three weeks. The ashing operation was done at a steady temperature of 105°C to avoid the samples burning in the oven. The samples were prepared for measurements by being sieved through a 200-mesh sieve after being smashed in a mortar.

2.2. Radionuclide Measurements

Gamma ray spectrometry was used to measure the activity concentration of radionuclides in placenta samples using a 7.62 cm x 7.62 cm NaI(Tl) detector [14]. This gamma spectrometer offers an energy resolution of 8% for 662 keV and a relative counting efficiency of roughly 20%. For the accuracy of the results, it is crucial that the system efficiency calibration be completed before the measurement. Gamma sources Cs-137 (662 keV (85.1%)), Co-60 (1172 keV (99.86%), and 1332 keV (99.98%) were used for the efficiency calibration. The referenced study provides a thorough explanation of how the detector in this study was calibrated [15]. The gamma spectrum was examined using the ORTEC-provided Maestro-32 program. Every 86400 seconds, every sample was counted (24 hours). To prevent unintentional radiation exposure, the detector is encased in a lead shield. The activity concentrations of Th-232, K-40, Na-22, Eu-152, Ra-226, and Bi-207 radionuclides were computed as Bq/g using these fields in the equation shown below.

$$A = \frac{\mathrm{C}}{\varepsilon \times \gamma \times t \times m} \quad (1)$$

where m (g) is the mass of the dried and prepared samples for measurement, A (Bq/g) is the radioisotope concentration, C (counts) is the net peak area, ε is the detector efficiency, t (86400 s) is the counting time, and γ is the absolute transition probability of -decay. The difference between the areas of the peaks visible in the spectrum and the areas of the peaks determined from the BKGR (background = basic count) count is the area value, which is represented as the net peak area (C) in the equation. Figure 1 shows a picture of the experimental setup used to take the measurements.

Additionally, Figure 2 displays the spectrum for S4, including the start and end points. The nuclides used in this study's analysis were subjected to the energies displayed below.

Na-22: 511.01 keV and 1274.53 keV (Na-23 photo-peak)

Eu-152: 121.78 keV, 344.27 keV, 841.54 keV, 963.34 keV, 970.30 keV, 1314.61 keV and 1389.00 keV (Eu-151 photo-peak)

Bi-207: 569.70 keV, 1063.66 keV and 1770.23 keV (Pb-207 photo-peak)

These radioisotopes have energy in the channels where the peaks in the spectra obtained from the analysis of the samples coincide. The device's library also contains the energy of these isotopes and their peaks.

2.3. Statistics

Table 1's results are all provided as average-error values (x-error). For the statistical analysis of various ages and radionuclide activity concentrations, the IBM SPSS 22 program was employed. The link between various ages and radioactive activity concentrations was examined using Pearson correlation analysis. The range of the correlation coefficient is from -1 to +1. A negative correlation, on the other hand, is defined as one of the variable pairs rising while the other declines, and it is defined as the correlation coefficient taking values between 0 and -1. A positive correlation, which ranges from 0 to 1, indicates that the two variables change in tandem. Additionally, whether negative or positive, the connection is stronger the closer the correlation coefficient is to +1 or -1. Table 2 provides the correlation coefficients between the various factors.

3. Results and Discussion

Table 1 lists the radionuclide concentrations found in the tissues of the human placenta. As seen from Table 1 and Figure 3, the radionuclide activity concentrations measured in placenta samples are varied in between 34.91±1.27 8.47±0.20 Bq/g for Ra-226, between 25.58±1.03 and 0.78±1.03 Bq/g for Th-232, between 32.37±1.66 and 5.10±0.35 Bq/g for K-40, between 14.36±1.09 and 4.62±0.66 Bq/g for Eu-152, between 18.92±0.80 and 1.50±0.07 Bq/g for Na-22 and between 28.47±0.11 and 1.05±0.20 Bq/g for Bi-207. Also, the net mass of the placenta samples are tabulated at the same table.

As seen from Table 1 and Figure 3, Ra-226 was detected in all of the placenta samples in "all different ages". The highest Ra-226 value measured

34.91 Bq/g in the 30 age ~~group~~ (S11), while the lowest value measured 8.47 Bq/g in the 31 years old (S12). Th-232 radionuclide could not be detected in samples S20, S21, S23, S31, S34, S39 and S40. However, the highest amount of Th-232 was measured as 25.58 Bq/g in the 36 years old (S17) and the lowest Th-232 amount was measured in the 49 years old (S24). K-40 radionuclide could not be detected in the placenta samples S23, S24, S26, S29, S33, S35, S36, S39 and S41. However, the highest amount measured to be 32.37 Bq/g in the 25 years old (S6), while the lowest amount was measured as 5.10 Bq/g in the 34 years old (S15). The Eu-152 radionuclide was detected in all placental samples. The highest concentration of Eu-152 was measured as 14.36 Bq/g in the sample no. S5 (24 years old) and the lowest amount of Eu-152 was measured as 4.62 Bq/g in the sample S17, that is, in the 36 years old. Na-22 radionuclide could not be detected in placental samples coded S7, S17, S18, S19 and S24. For all that, while the highest Na-22 radionuclide concentration was determined as 18.92 Bq/g in the S11 coded sample, the lowest Na-22 amount was measured as 1.50 Bq/g in the S13 coded sample. Finally, in only one sample (S17), the radionuclide Bi-207 could not be measured. The highest Bi-207 radionuclide concentration was measured to be 28.47 Bq/g in the sample numbered S19, and the lowest Bi-207 radionuclide amount was also detected in the S24 coded sample as 1.05 Bq/g.

The amount of each radionucloid versus age can be seen at Figure 3. Although there is no significant correlation with age, the variation trend of each nucleoid is similar when all age groups are taken into account.

4. Conclusion

The placenta formed by the extraembryonic tissue that develops between the baby's chorion and the uterine mucosa during pregnancy for the development and protection of the embryo/fetus.It provides nutrition, development, respiration and excretion of the embryo/fetus.During the development of the embryo, it secretes different hormones. The placenta, which acts as a lung from time to time, takes over kidney function from time to time. Therefore, the placenta performs a multifunctional task [12, 13] (web 1). Radionuclide activity concentrations of Th-232, K-40, Na-22, Eu-152, Ra-226 and Bi-207 were measured in placenta tissue samples taken from a total of 24 pregnant women aged 20 to 49 years. The radionuclide activity concentrations are varied in between 34.91±1.27 and 8.47±0.20 Bq/g for Ra-226, between 25.58±1.03 and 0.78±1.03 Bq/g for Th-232, between 32.37±1.66 and 5.10±0.35 Bq/g for K-40, between 14.36±1.09 and 4.62±0.66 Bq/g for Eu-152, between 18.92±0.80 and 1.50±0.07

Bq/g for Na-22 and between 28.47±0.11 and 1.05±0.20 Bq/g for Bi-207. Statistical analysis was performed for the correlation between Th-232, K-40, Na-22, Eu-152, Ra-226 and Bi-207 radionuclide activity concentrations and different ages. But, no statistically significant correlation was determined between different ages and radionuclide activity concentrations. The data obtained could not be compared since it is unclear from the literature whether radionuclide activity concentration measurements are done in human placental tissues. Due to the fact that it has not yet been established whether the mothers have radionuclides it is unclear whether the radionuclide activity concentrations measured in Table 1 and Figure 3 are harmful to human health. The human body contains radioisotopes in its natural state. It's not just K-40; other isotopes include I-129, uranium, thorium, carbon, polonium, etc. Radiological examinations of placentas that belonged to both the mothers and the fetuses were carried out. There were no additional evaluations or measurements of the mother.

In addition, the tendency of each nucleotide to decrease and increase in all different ages is similar to each other although there are different sources of radionuclides. This pilot study intended to establish the methods, such as sample preparation and radionuclide measurements, and used statistical analysis for a more in-depth investigation by looking into the identification of individual radionuclides in placentea samples. It will also be used as a source for future studies.

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Table 1. The radionuclide activity concentrations measured as Bq/g in placenta samples (mean ±error, n=3).

Samples	Age	Ra-226	Th-232	K-40	Eu-152	Na-22	Bi-207	Mass (kg)
S1	20	14.72±0.44	BDL	13.47±0.26	9.30±0.98	11.14±0.44	18.81±0.72	0,0780
S2	21	26.60±1.03	BDL	20.84±2.51	8.81±0.77	10.08±0.65	13.54±0.09	0,0760
S3	22	22.45±0.80	13.33±0.94	10.17±0.90	7.71±1.09	11.24±0.39	14.40±0.08	0,0784
S4	23	22.69±0.70	BDL	BDL	8.48±0.75	4.83±0.05	6.47±0.32	0,0835
S5	24	29.70±0.99	20.96±0.83	BDL	14.36±1.09	11.30±0.30	23.35±0.87	0,0789
S6	25	16.75±0.61	13.87±0.65	32.37±1.66	10.08±1.03	17.68±0.62	22.71±0.73	0,0713
S7	26	23.47±0.85	9.30±0.49	BDL	6.73±0.60	BDL	4.83±0.32	0,0868
S8	27	13.78±0.55	3.98±0.47	30.73±0.44	10.39±0.83	2.94±0.06	12.33±0.38	0,0799
S9	28	22.55±0.63	21.97±1.45	21.41±1.81	12.07±1.04	12.39±0.29	19.69±0.14	0,0704
S10	29	17.31±0.71	20.26±0.97	BDL	7.23±0.73	4.57±0.06	16.92±0.20	0,0793
S11	30	34.91±1.27	16.74±0.55	18.88±1.74	12.97±0.98	18.92±0.80	3.02±0.10	0,0701
S12	31	8.47±0.20	BDL	6.72±0.22	8.52±0.76	9.64±0.50	13.07±0.30	0,0741
S13	32	13.79±0.46	6.70±1.75	30.00±1.26	3.86±0.59	1.50±0.07	18.72±0.95	0,0803
S14	33	19.53±0.65	13.26±0.61	BDL	8.88±0.66	8.41±0.30	4.00±0.53	0,0789
S15	34	24.16±0.63	BDL	5.10±0.35	9.14±0.77	12.51±0.52	21.18±1.15	0,0739
S16	35	16.80±0.62	8.59±0.51	BDL	5.48±0.50	5.87±0.17	1.89±0.18	0,0749
S17	36	22.43±0.84	25.58±1.03	BDL	4.62±0.66	BDL	4.84±0.61	0,0500
S18	37	13.04±0.54	21.80±1.23	5.61±0.97	9.69±0.77	BDL	BDL	0,0743
S19	38	25.90±0.89	6.41±0.58	19.09±2.12	14.33±0.96	BDL	28.47±0.11	0,0748
S20	39	23.60±0.75	BDL	BDL	7.26±0.78	8.18±0.06	8.34±0.20	0,0707
S21	40	16.74±0.51	24.23±1.54	14.11±0.32	13.40±1.22	7.41±0.29	8.13±0.58	0,0626
S22	41	21.21±0.85	10.84±0.41	BDL	8.78±0.89	10.45±0.30	15.18±0.67	0,0742
S23	42	16.10±0.61	BDL	14.49±0.72	13.13±0.86	9.18±0.28	25.30±0.36	0,0764
S24	49	23.07±0.85	0.78±1.03	29.85±0.98	10.67±0.91	BDL	1.05±0.20	0,0731

BDL:Below Detection Limit

Table 2. Correlation Coefficients

Correlation	N	p	r	results
Age*Ra-226	24	0.690	-0.086	Relationship weak, not significant
Age*Th-232	17	0.749	-0.084	Relationship weak, not significant
Age*K-40	15	0.969	-0.011	Relationship weak, not significant
Age*Eu-152	24	0.589	0.116	Relationship weak, not significant
Age*Na-22	19	0.526	-0.155	Relationship weak, not significant
Age*Bi-207	23	0.421	-0.176	Relationship weak, not significant

Fig. 1. Experimental set up.

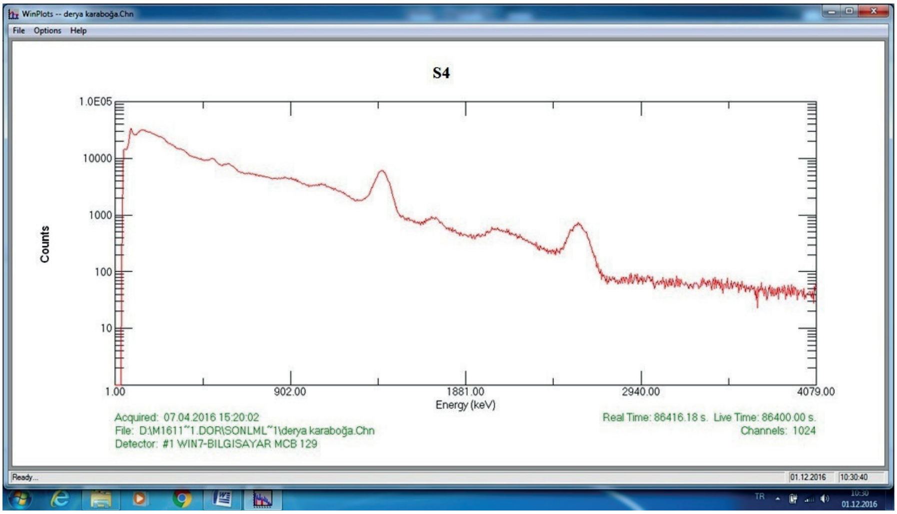

Fig. 2. The spectrum for S4 sample

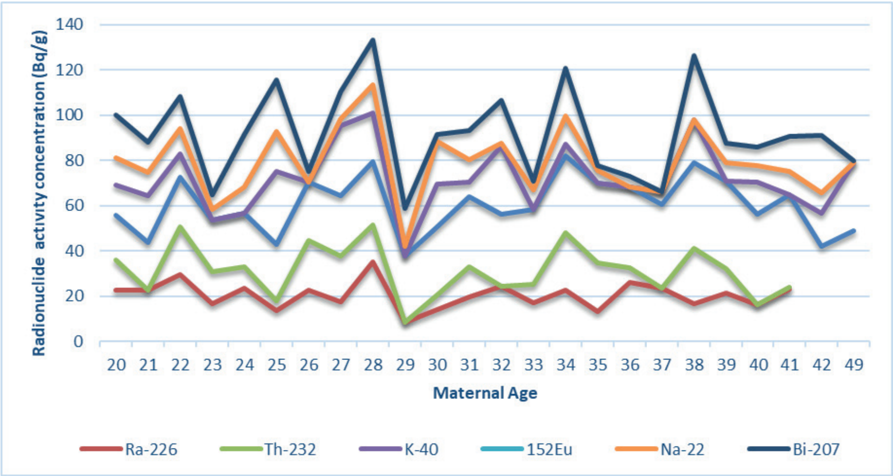

Fig. 3. Variation of each radionuclide according to different ages

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