A comparison of creatinine concentration with ^{40}K radioactivity in spot urine

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1. Introduction

The assessment of internal exposure dose usually is performed by in-vivo bioassay and in-vitro bioassay methods. The in-vivo bioassay method measures the human body directly whereas the in-vitro bioassay which analyzes urine or feces etc. provides a measure of the amount radioactive material excreted from the body. Especially, analyzing spot urine sample from internally contaminated person provides an early estimation of internal contamination [1]. It is possible to internal contamination in radiopharmaceutical production process because it uses unsealed radioactive source. Normally 24 hour urine collection is used for assessing the internal contamination. However, this method has limitation in the radiopharmaceutical production process because in this field very short half life radionuclides are used. Furthermore, 24 hour urine collection is technically difficult to carry out and inconvenience for subjects. Also the result of 24 hour urine may vary from collection date [2].

The spot urine assessment has large uncertainty that some spot urine concentrated or some spot urine diluted. Hence, it needs to apply normalization method for minimizing result of measurement the spot urine. In radiation emergency, specific gravity method was proposed [1] which method use portable density meter for measuring density of urine and then normalization.

The creatinine test recommend by ICRP (1968) and IAEA (1999) is the most common method for urine normalization. However, the creatinine result was various which depends upon sex, age, race and health conditions [1]. Thus it needs to supplementary method for urine normalization.

Natural potassium has isotopes those are K-39, K-40 and K-41, in the percentages of 93.08, 0.0118 and 6.91, respectively. Especially, the K-40 emits relatively high energy (1.46 MeV gamma ray) with a half life of $1.248 \times 10^9\ y$. The potassium is an essential element in human which works as homeostatic regulation. Thus human body contains specific amount of the potassium and then excreted regularly. And then K-40 is measurable in urine sample using HPGe detector.

The purpose of this study is to estimate the variability of spot urine normalization method for assessing the internal exposure dose of hospital workers who work related with radiopharmaceutical produce.

2. Methods and Results

2.1 Urine collection

Spot urine samples which were voided after work were collected every time of 6 males. The subject's work type is related with radiopharmaceutical production. The subject's height range is 165-178 cm (average, 171 cm), and weight range is 52-85 kg (average, 67.5 kg). Measuring spot urine sample and then collected the spot samples which were accumulated for one-day (24hr) was measured. The radiopharmaceutical related worker uses very short half radionuclide such as F-18, I-123, Tl-210 and so on. This is the reason why the spot urine sample was measured for assessing internal dosimetry.

2.2 K-40 activity analysis using HPGe gamma spectroscopy

K-40 emits a gamma photon of 1.46 MeV and then K-40 radioactivity in urine sample was measured by high purity Germanium (HPGe) detector (relative efficiency: 30%, GC-3018, CANBERRA, CT). The spot urine was inserted into 90 mL U8 bottle and then mass was measured. The gamma spectroscopy results were converted to unit on Bq/kg that considered sample mass. After measuring each spot urine sample, collected samples which were accumulated spot urines during one day were measured.

2.3 Creatinine concentration analysis

The concentration of creatinine in urine samples was measured using clinical chemistry analyzer (COBAS C501, ROCHE). This equipment could measure the creatinine concentration in small amount of sample (2-50 μL/ test). The creatinine was measured separately for each spot urine sample and collected urine sample (24hr urine). The creatinine unit is normally used in mg/dL. Following previous studies, normal creatinine range is wide. For example, creatinine guideline range in World Health Organization (WHO) is 30-300 mg/dL., Needleman et al. (1992) suggested 170 mg/dL, Bader et al. (2012) suggested 137 mg/dL and Landry et al. (2011) suggested daily excretion mass such as 500-

2,000 mg per day. This value was modified to 33-133 mg/dL which value was considered as daily excretion volume (1,500 mL).

2.4 Comparing activity of K-40 and Creatinine concentration in Urine samples

Fig. 1 indicated relation with K-40 activity and creatinine concentration of urine samples. As a result, the creatinine is 60-285 mg/dL which value meets WHO guideline reference range then this result is possible to assess the spot urine sample. However, the creatinine could be changed by density of urine. Hence it is important to decide whether concentrated or not.

Average value of K-40 activity is 105 Bq/kg and concentration of creatinine is 146 mg/dL. As K-40 activity increased, the creatinine in urine also increased (0.3 mg/L per 1 Bq of K-40). Using this result, it is possible to consider not only the creatinine but also K-40 activity when spot urine activity measurement. It is expected that the uncertainty could be reduced.

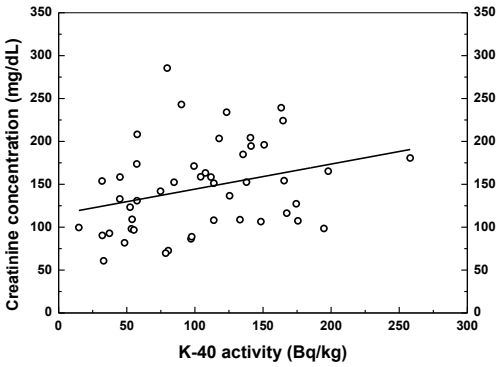

Fig. 1. Relationship of K-40 activity (Bq/kg) and creatinine concentration in urine samples (mg/dL).

K-40 activity and creatinine in urine samples were indicated in fig. 2. Box plots with horizontal bars indicate median values, boxes indicate the 25th and 75th centiles, error bars indicate the maximum and minimum, and symbols in the box indicate average values. T-test was performed for comparing with the creatinine and K-40 activity (p-value < 0.05). As a result, the creatinine and K-40 activity should be indicated similar values in spot urine sample measurement.

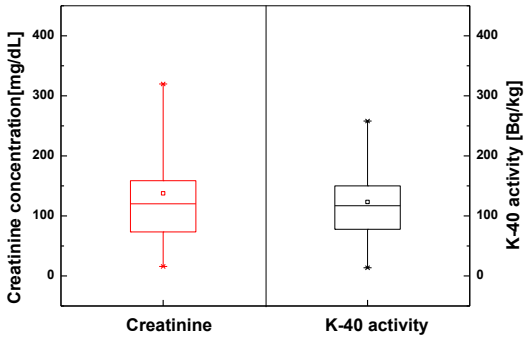

Fig. 2. Box plot for comparing with creatinine concentration and ^{40}K activity in urine sample.

3. Conclusions and discussion

The use of creatinine as normalization of spot urine samples for internal dosimetry is possible to reduce level of uncertainty. However, creatinine range is wide which means the creatinine is not exactly correct reference value for normalization. Or some malfunction in creatininee analysis, it need to another supplementary method for normalization for adequately assessing the activity in spot urine samples. In this study, the result of gamma spectroscopy and the creatinine analysis was in direct proportion. Therefore measuring/comparing with creatinine and K-40 activity could applicable to complement method for creatinine normalization in spot urine analysis.

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