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Reconstruction of organ dose for Japanese nuclear workers and reanalysis of cancer mortality risk for J-EPISODE 1991-2010

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Background

Japanese Epidemiological Study on Low-Dose Radiation Effects (J-EPISODE) has been conducted since 1990 and analysed health effects in association with photon exposure assessed in $H_p(10)$. However, it is under way to estimate cancer morbidity and mortality risk evaluated in organ absorbed dose.

Aim

To reconstruct organ dose during 1957 to 2010, and reanalyse cancer mortality risk of the fifth J-EPISODE analysis 1991-2010.

Materials and methods

The reconstruction method of organ dose principally followed the approach adopted in the IARC 15-Country Collaborative Study, which conducted experiments on dosimeter response to photon exposure for three types of dosimeter; old film dosimeter, multi-element film dosimeter and thermoluminescence dosimeter (TLD). Usage of dosimeters in Japan developed from those to glass badge (GB), electronic personal dosimeter (EPD) or optically stimulated luminescence (OSL) dosimeter in around 2000.

Therefore, dosimeter response data under combinations of a specific photon energy (119 keV, 207 keV and 662 keV) and a specific geometry (antero-posterior geometry and isotropic geometry) were experimented in the same way of the IARC study for GB, EPD and OSL dosimeter.

Conversion coefficients from recorded dose to organ dose were reconstructed using these data on dosimeter response as well as coefficients from kerma to organ dose for each year and site where workers were exposed to photon, followed by reconstruction of organ dose for colon, lung and red born marrow during 1957 to 2010.

Results

Organ absorbed dose for several tissue/organs were calculated for each participant during 1957 to 2010. Then, Poisson regression method was applied for estimating ERR (Excess Relative Risk) for cancer death.

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What is J-EPISODE 1991-2010?

- ✓ A cohort study on health effects for Japanese nuclear workers
- ✓ Cohort size 204,103 male, mean cumulative dose 13.9 mSv in $H_p(10)$
- ✓ All cancer death excl. leukaemia: 7,929 and leuk. (excl. CLL): 207
- ✓ Suggested smoking as a confounder

Aim

- ✓ To construct conversion coefficients from dosimeter readings to organ absorbed dose for photon exposure in working conditions.
- ✓ To reanalyze cancer mortality risk for J-EPISODE 1991-2010 using organ absorbed dose.

What was the preliminary result of reanalysis of cancer risk using organ absorbed dose?

1. Temporarily converted individual dosimeter reading of $H_p(10)$ to organ dose, considering dosimeter type, facility type of work place and exposed period.
   Mean cumulative dose: Colon 11.0 mGy, Lung 11.5 mGy, Red bone marrow (RBM) 10.1 mGy

2. Temporarily reanalyzed cancer mortality risk for all cancers, lung and leukaemia. Applied colon dose for estimating all cancers, lung dose for lung cancer, and RBM dose for leuk.

3. Applied Poisson regression LNT model for stratified data;
   Attained age: every 5 years, Region: 8
   Calendar year: 1991-94, 1995-99, 2000-04, 2005-10
   Dose: <5, 5- , 10- , 20- , 50- , 100+ (mGy or mSv)
   Lag: 2 years for leuk. and 10 years for others

End point	Dose	ERR and 90% CI		
All cancers excl. leukaemia	$H_p(10)$	1.20 Sv^{-1}	0.43	1.96
	Colon	1.24 Gy^{-1}	0.27	2.21
Lung cancer	$H_p(10)$	3.15 Sv^{-1}	1.34	4.96
	Lung	3.98 Gy^{-1}	1.74	6.22
Leukaemia (excl. CLL)	$H_p(10)$	-0.27 Sv^{-1}	-4.07	3.52
	RBM	-1.57 Gy^{-1}	-6.32	3.18

4. Result:
   Due to change of dose unit from Sv to Gy, the mean dose value apparently decreased, and consequently the slope angle of the estimated LNT line increased.

Conclusion :

- ✓ Results of reconstruction of organ dose and preliminary reanalysis were consistent with the previous studies.
- ✓ Dosimeter response data are usable for other cohort studies.
- ✓ Further reanalysis will be conducted using organ dose.
- ✓ New cohort has started which will utilize;
  - ➢ Organ absorbed dose.
  - ➢ Cancer incidence data from National Cancer Registry which became available in 2019.
  - ➢ Lifestyle questionnaire survey including smoking, eating habits, cancer history, CT history, and so on, conducted for all participants in 2015-19.

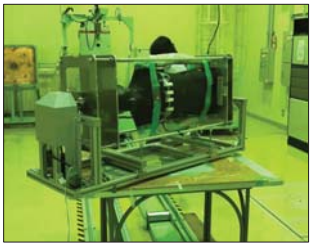
How was organ absorbed dose reconstructed?

1. Followed the approach of the IARC 15-country collaborative study [1,2].

2. Assumed the working environment of photon exposure received by workers as same as the IARC study;
   Energy distribution
   100-300 keV : 300-3000 keV = 10 : 90 for NPP
   = 20 : 80 for other facilities
   Geometry distribution
   Antero-posterior (AP) : Isotropic (ISO) = 50 : 50

3. Obtained the data of dosimeter response (Sv/Gy), readings per air kerma, by dosimeter type.
   Made use of response data of the IARC study for film badge (FB) and thermoluminescence dosimeter (TLD).

4. Newly experimented at Japan Atomic Energy Agency calibration laboratories in the same way as IARC study for recently used personal dosimeter types in Japan; glass badge (GB), electronic personal dosimeter (EPD) and optically stimulated luminescence dosimeter (LB [Luminess badge]) [3].
   Mean energy of the source: 119, 207 and 662 keV
   Geometry: AP and ISO estimated from ROT(θ)

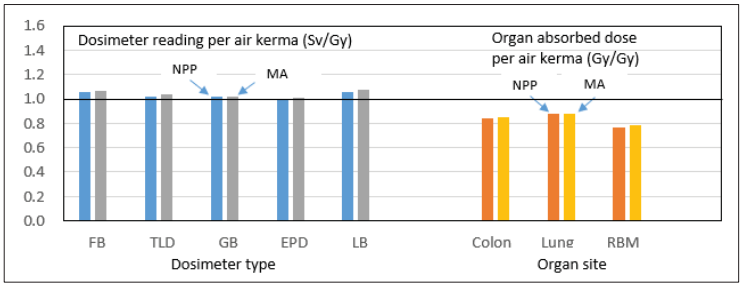


Device to simulate rotational geometry with angle to source

Simulation of isotropic (ISO) irradiation

5. Developed the conversion coefficients from air kerma to organ absorbed dose for Japanese adult male voxel phantom.

6. Result:



- The dosimeter responses were close to 1, regardless of dosimeter type.
- The conversion coefficients from air kerma to organ absorbed dose were approximately 0.8.

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