PET-CT IN ONCOLOGICAL PATIENTS WITH OCCUPATIONAL EXPOSURE TO IONIZING RADIATION

Mikhail V. OSIPOV*
Andrey V. VAZHENIN**, Anna I. KUZNETSOVA**, Irina A. AKSENOVA**,
Daria A. VAZHENINA**, Mikhail E. SOKOLNIKOV*

*Southern Urals Biophysics Institute, Ozyorsk, Russia
**Chelyabinsk Regional Clinical Center of Oncology and Nuclear Medicine, Chelyabinsk, Russia

Introduction

Exposure to Ionizing Radiation of population: man-made sources

Occupational exposure of nuclear workers

PET-CT - a dual source of radiation exposure of patients

Repeated PET-CT increase the cumulative dose

How do these factors impact on cancer risk during next few years after PET-CT examination?

Objective

- estimate the dose and exposure levels of Ozyorsk patients subject to PET-CT

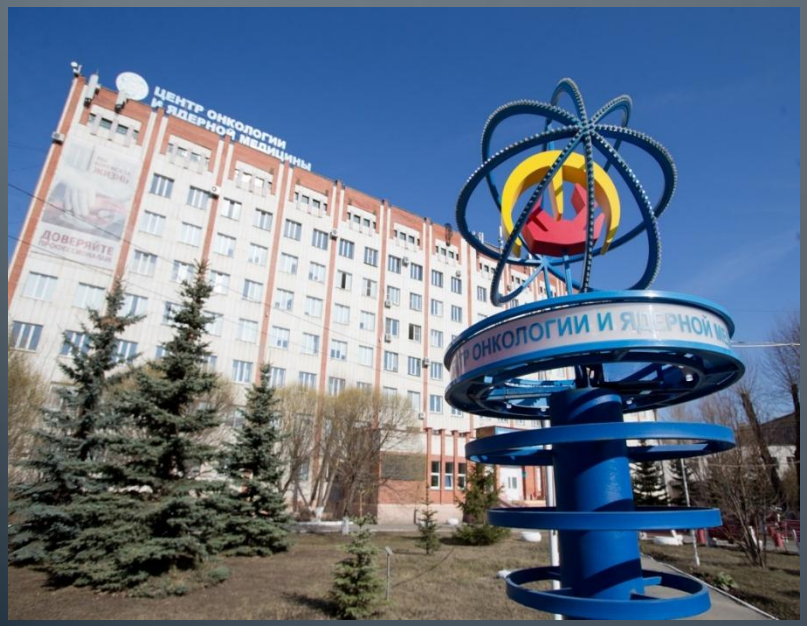
- estimate the dose from occupational exposure of patients who were Mayak PA employee

- update vital status and cause of death of patients

- evaluate possible risk factors

Material

- Data from Chelyabinsk Regional Center of Oncology and Nuclear Medicine
- 651 archived protocols of PET-CT of 347 patients from Ozyorsk
- Age, sex, clinical diagnosis, stage of malignancy, number of repeated examinations, 18-FDG activity and effective dose were recorded



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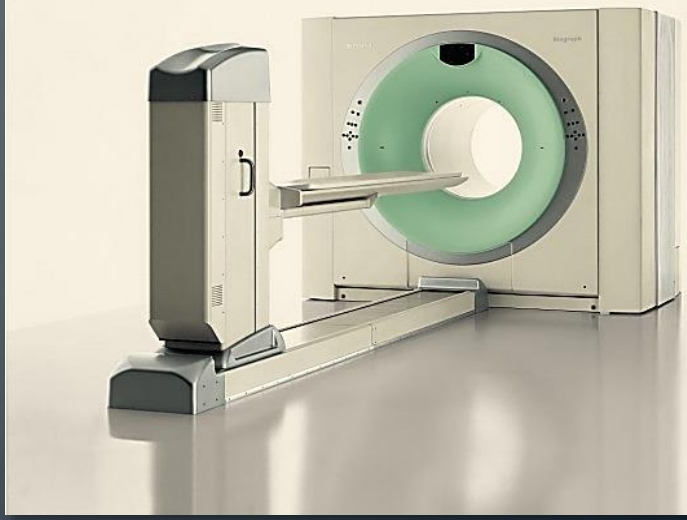

Method

Retrospective follow-up study. Patients followed from 2010 to the middle of 2019 or to the date of death or the date of last known information

Cancer death was used as the event. Odds ratio (OR) was considered as the ratio of probability of an event occurred to the probability of its non-occurrence (1):

$$OR = P/(1 - P) \qquad (1)$$

Logistic regression was used for the analysis. A multifactorial analysis has been applied using direct (subsequent) adding of parameters to the model based on 0.05 significance level (2):

$$P(y_i \neq 0|x_i) = exp(\beta_0 + x_i \beta_i) / (1 + exp(\beta_0 + x_i \beta_i)) \qquad (2)$$

The model testing has been performed using LRT at 95% level of significance

Results

Table 1: Distribution of patients by age of 1st PET-CT and gender

Age category	Male,%	Female,%	Both gender,%
19-29	6.0%	0.5%	2.9%
30-39	8.7%	7.6%	8.1%
40-49	9.4%	17.7%	14.1%
50-59	30.9%	23.7%	26.8%
60-69	30.2%	37.9%	34.6%
70-79	12.1%	9.6%	10.7%
80+	2.7%	3.0%	2.9%
Total	100.0%	100.0%	100.0%

42.9% males and 57.1% females were examined between 2010 and 2019
Expected lifetime among Russian population: males 68,5 females 78,5 years (2019)

Results

Table 2: Distribution of patients by vital status, sex and occurrence of occupational exposure

Vital status	Male	Female	Both gender	Worker*
Alive	39.6%	48.5%	44.7%	8.1%
Dead	57.1%	46.9%	51.4%	13.3%
Lost	3.4%	4.6%	3.9%	0.2%
Total	100.0%	100.0%	100.0%	21.6%

* Percent of those with given vital status

Results

Table 3: Proportion (%) of PET-CT, effective dose from PET-component (ED_{FDG}), CT-component (ED_{CT}), total effective dose due to PET-CT (ED_{SUM}) and effective dose from professional exposure (ED_{WRK}) at the end of follow-up by number of examinations (Ex)

Ex.	%	ED_{FDG}*	ED_{CT}*	ED_{SUM}*	ED_{WRK}**
1	64.6	7.3 (0.1)	15.7(0.5)	22.2 (0.5)	19.1 (8.3)
2	19.0	14.6 (0.3)	30.8 (1.3)	46.9 (1.4)	19.5 (10.6)
3-5	12.1	25.8 (1.4)	61.3 (6.3)	92.3 (6.5)	6.4 (5.7)
6-12	4.3	56.6 (7.0)	131.0 (25.8)	180.7 (34.6)	8.4 (7.2)
Total	100%	12.6 (0.6)	27.8(1.8)	41.2 (2.3)	17.7 (5.8)

* mean cumulative ED to the end of follow-up, mSv with standard deviation (in brackets)

** External cumulative dose for nuclear workers with non-zero exposure (64%)

Results

Table 4: Logistic regression modeling results comparison at 95% CI

Risk factor	z	P(z)	β_i	z	P(z)	β_i
	Model A			Model B		
β_0 (const.)	-2.54	0.011	-2.08	-1.86	0.06	-1.74
X_1	-2.36	0.018	-0.78	-1.95	0.05	-0.68
X_2	3.29	0.001	0.04	2.79	0.005	0.04
X_3	2.61	0.009	0.31	2.72	0.007	0.33
X_4	-	-	-	0.99	0.324	0.42*
X_5	-	-	-	-0.88	0.378	-0.24
LR*	LR $\chi2(3)=21.7$ p=0.0001			LR $\chi2(5)=23.6$ p=0.003		

X1 = gender; X2 = age at 1st PET CT; X3 = malignant tumor stage; X4 = professional exposure; X5 = repeated PET CT

* exp(X_4)=1,57 p=0.324

Resume

- 347 Ozersk patients were examined on PET-CT from 2010 to 2019
- average follow-up period 2.7 years (up to 9 years)
- average number of PET-CT examinations: 2
- the average PET-CT cumulative dose: 41.3 mSv
- 21,6% of patients were employees of the Mayak PA
- Professional exposure resulted in 17.7 mSv average cumulative dose
- No significant effect of radiation dose on cancer death for given period in the study group

Discussion

How to improve the results of the study?

- Enlarge the period of follow-up (44.7% alive)
- Calculate the organ absorbed dose due to PET-CT
- Use the absorbed dose for nuclear workers
- The dose from previous CT performed outside the Center of Oncology
- Data on radiotherapy and chemotherapy

Conclusions

Exposure to PET-CT exceeds the levels of professional external exposure of nuclear workers of the Mayak PA

The odds ratio of death from cancer is increased with the age of 1st examination and the stage of malignancy

Among the study group, additional radiation dose due to repeated PET-CT was not associated with cancer mortality during given follow-up period

For oncological patients, short survival period may be a reason for radiation risk underestimation

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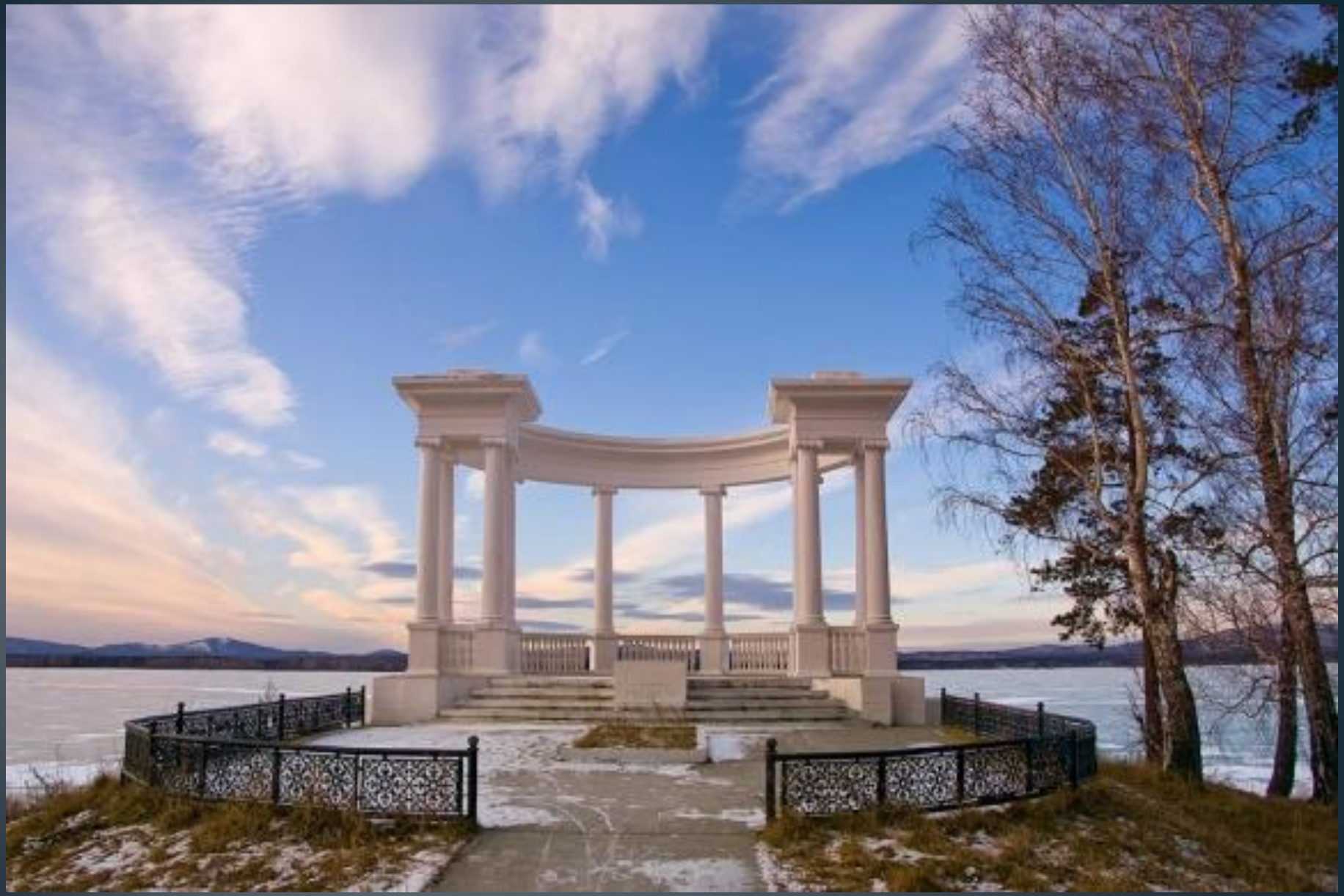
Thank you for your attention!



Ozyorsk, Chelyabinsk Region, Russia
E-mail: ferrum76@mail.ru