Biological consequences of the spatial-differentiated level of the ^{131}I accumulation in sheep thyroid after Chernobyl accident

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INTRODUCTION

The aim of this work is to study the ^{131}I biological effects on sheep at different concentrations of stable iodine in the diet

The problem of the absorbed dose estimation in the sheep thyroid gland (TG) after a radiation accident at the Chernobyl NPP in the conditions of natural micronutrient deficiency is considered.

To determine the ^{131}I critical dose in the sheep TG, leading to its dysfunction and subsequent destruction, research was conducted to develop a mathematical model based on experimental and theoretical data. Modern technologies are used to model the TG area. The solution of the radiation transport equation is performed by the Monte Carlo technique, which takes into account both the γ - and β-radiation of the ^{131}I immanent source and the contribution of all secondary radiations.

MATERIALS AND METHODS

The studies were carried out on 64 sheep, divided into 10 groups based on the general clinical condition and body weight:

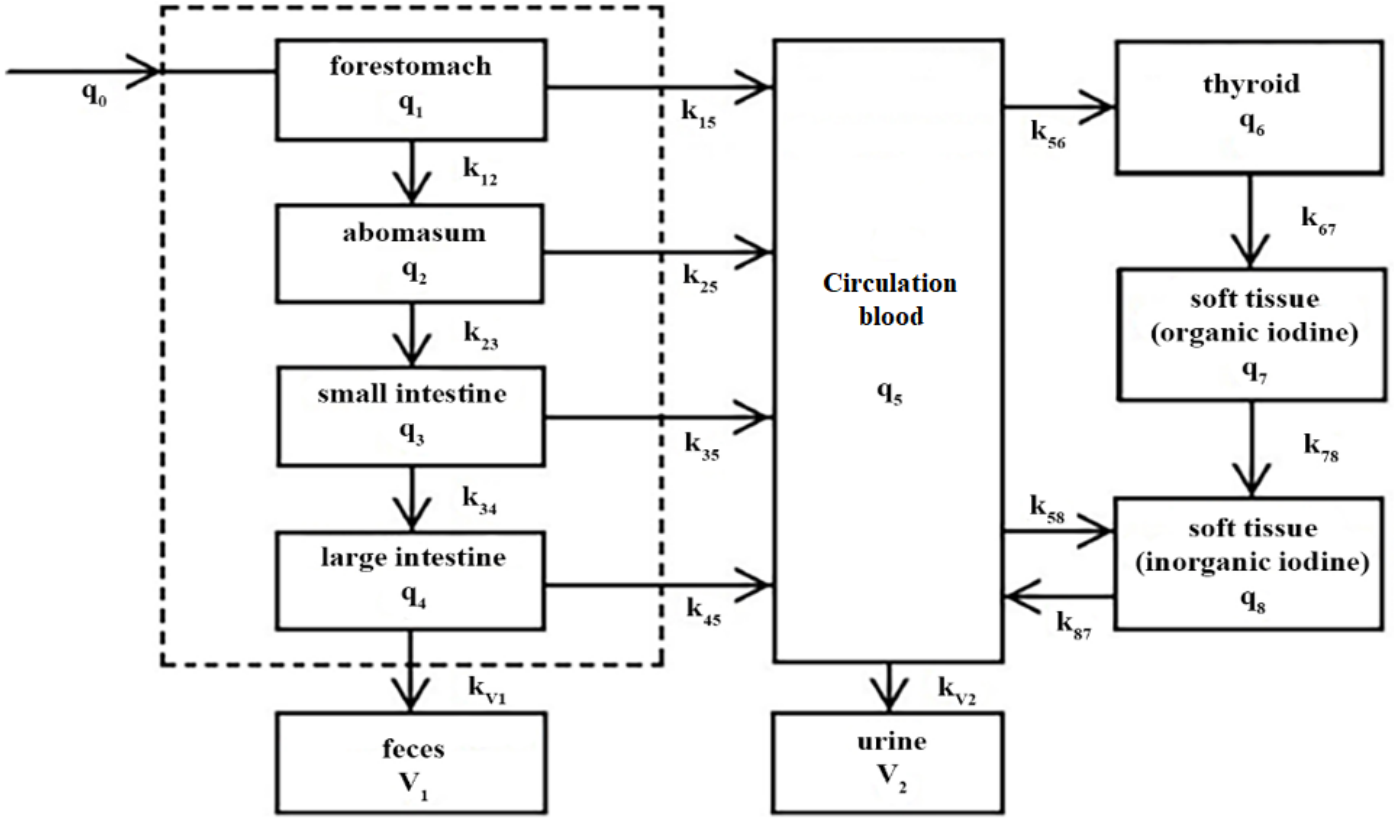
- The first 5 groups included animals from the Gomel region (32 sheep, iodine content in the daily diet was 0.08 mg/kg);

- The 6–10th groups (32 sheep; 0.43 mg/kg) – from the Vladimir region.

Tests for iodine content in feed and water were performed in the Belarusian Institute of Experimental Veterinary Medicine. (Minsk, 1989).

For sheep 1–3rd , 6–8th groups (9 sheep in the group) once peroral the ^{131}I was injected with activity: for the 1st and 6th groups 3 μCi, for the 2nd and 7th 15 μCi, from the 3rd and 8th – 72 μCi per capita.

The ^{131}I metabolism in a sheep body (compartmental model)



Transfer coefficients k_{ij} for a compartmental model of ^{131}I metabolism in sheep obtained uses experimental data, day^{-1}

k_{12}	k_{23}	k_{34}	k_{V1}	k_{15}	k_{25}	k_{35}	k_{45}	k_{56}	k_{67}	k_{78}	k_{85}	k_{58}	k_{V2}
1,2	27,0	8,0	2,0	0,15	0,15	0,30	0,15	0,41	0,07	0,13	4,3	4,3	0,6

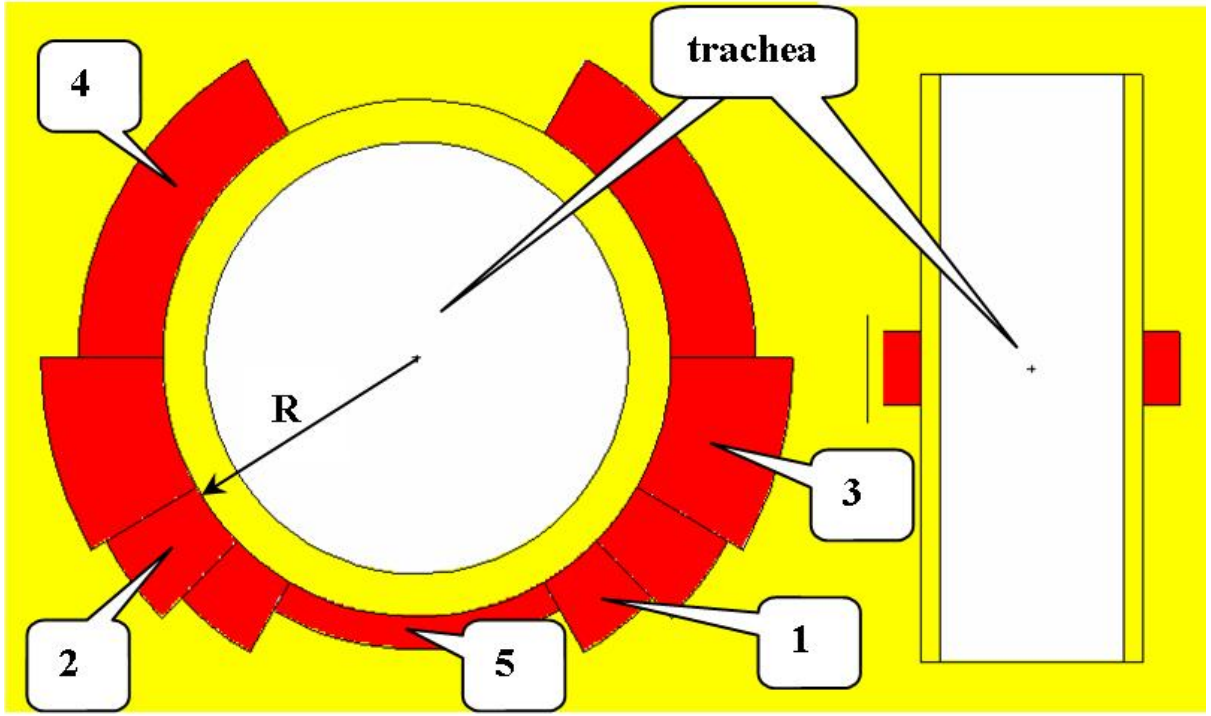
CALCULATION

Calculation of the ^{131}I radiation field characteristics was carried out by means of the MCNP5 code. The cattle thyroid gland is modeled by a two-dimensional axisymmetric body composed of nine segments, which are obtained by axial and radial cylindric sections.

The TG tissue with density ~ 1.03 g/cm^3 besides four main elements include the next ones: Na, P, S, Cl, K and I. Iodine activity is distributed uniformly in the TG volume.

№	External radius, cm	Height, cm
1	1,65	1,15
2	1,70	1,50
3	1,80	1,65
4	1,65	1,15
5	1,25	0,35

The table contains dimensions of TG cylindrical layers



Radial (left) and axial section of the TG computational model (not to scale; received by visualization of the MCNP5 code input).

RESULTS AND DISCUSSION

Precise calculations were carried out for:

a) β-radiation transport in TG accompanied by production secondary radiation and its further transport taking into account all processes, including generation and transport of bremsstrahlung, Auger electrons, etc.;

b) transport of ^{131}I inherent γ-radiation, taking into account generation and transport of X-ray and fluorescent radiations, etc.

Energy dissipation was monitored up to 1 keV, integral (energy) dose dispersion was throughout < 0.1 %. The main result of calculations was the "conversion coefficient" from ^{131}I activity (uniformly distributed in TG) to the average absorbed dose in TG (for these conditions of irradiation):

^{131}I ($T_{1/2}$ = 8,02 day) – $2{,}34 \cdot 10^{-12}$ Gy/s on 1 Bq

RESULTS AND DISCUSSION

The accumulation of dose in thyroid of sheep

№ groups	Stable iodine content in the diet, mg / kg	The activity of one-time injected ^{131}I, μCi	Dose TG, Gy
1	0,08	3	40
2		15	220
3		72	820
6	0,43	3	21
7		15	70
8		72	200

Signs of severe chronic radiation sickness in ruminants under the influence of incorporated radionuclides of iodine

- the first 3 days-high dose rate of gamma radiation in the thyroid gland-up to 12 R/h;
- in a relatively short period - from 3 to 5 days-acute thyroiditis in the form of painful swelling of the submandibular space;
- after 10-15 days-hair loss (epilation) in the area of the thyroid gland;
- after 1-1.5 months - a sharp decrease in the level of thyroxine blood serum, a decrease in volume of the thyroid gland, total necrosis of the parenchyma.

- decreasing level of thyroid hormones;
- increasing of concentration of autoantibodies in the blood serumin the thyroid gland;
- disruption of parenchyma and atrophy of the thyroid gland;
- mucous degeneration of perinephric and pericardial adipose tissue;
- general depression;
- increased mortality.

CONCLUSION

In animals with low levels of iodine nutrition, a large capture of the isotope by the TG was noted, which provided larger (2–5 times) doses. This circumstance causes more serious functional and pathological disorders of the thyroid gland sheep in the territories of the Ukrainian and Belarusian Polesie, endemic for the content stable iodine.

Thank your for attention!