The substantiation of the quality control method for determining the radionuclide purity and the total radioactivity of radiopharmaceuticals

The quality control in the manufacture of radiopharmaceuticals has a prominent role in providing the supply of high-quality drugs for the diagnosis and treatment of patients with cancer. It has been determined that the permission to use radiopharmaceuticals directly depends on the results of the analytical control.

Aim. To reduce the time for the quality control of radiopharmaceuticals, resulting in both the radiochemical yield of the product and its specific activity. This is an important parameter in conducting diagnostic or therapeutic procedures.

Materials and methods. To optimize the process of the quality control for radiopharmaceuticals we propose to replace the following laboratory equipment: a Moleculer Mol gamma spectrometer, which monitors the radionuclide purity of radiopharmaceuticals (gamma-ray energy measurement) and a BIODEX ATOMLAB 500 preloaded device (measurement of the total radioactivity of a drug) to a radionuclide calibrator for nuclear medicine developed by domestic scientists of the Institute of Scintillation Materials and made at the "Квант" X-ray equipment plant in Kharkiv.

Results and discussion. It has been proven that the use of calibrator radiopharmaceuticals for nuclear medicine should be applied as the quality control. It has been substantiated that the calibrator of doses for nuclear medicine performs two functions simultaneously.

Conclusions. The method of optimization of the quality control of radiopharmaceuticals using the device – a radionuclide calibrator for nuclear medicine allows us to simultaneously obtain the results of the analysis by such indicators as "radionuclide purity" and "radioactivity".

Key words: quality control; radiopharmaceuticals; radionuclide calibrator for nuclear medicine; radionuclide purity; radioactivity.
Introduction. The quality control in the manufacture of radiopharmaceuticals plays an important role in providing the supply of high-quality drugs for the diagnosis and treatment of patients with cancer. The permission to use radiopharmaceuticals directly depends on the results of the analytical control [1].

The aim of the work is to reduce the time for the quality control of radiopharmaceuticals, resulting in both the radiochemical yield of the product and its specific activity. This is an important parameter in conducting diagnostic or therapeutic procedures.

Materials and methods. To optimize the process of the quality control for radiopharmaceuticals we propose to replace the following laboratory equipment: a Moleculer Mol gamma spectrometer, which monitors the radionuclide purity of radiopharmaceuticals (gamma-energy measurement) and a BIODEX ATOMLAB 500 (measurement of total radioactivity of drug) with a radionuclide calibrator for nuclear medicine developed by domestic scientists of the Institute of Scintillation Materials and made at the “Kvant” X-ray equipment plant in Kharkiv [2].

Results and discussion. Taking into account that the majority of radiopharmaceuticals have a short shelf life it is necessary to solve a difficult task – to optimize the quality control process.

Reducing the time for the quality control will increase both the radiochemical yield of the product and its specific activity, which is an important parameter for conducting diagnostic or therapeutic procedures with the use of radiopharmaceuticals.

The radionuclide calibrator proposed for nuclear medicine has smaller dimensions and weight compared to its analogs, and determines the total radioactivity of radionuclide and the radionuclide purity simultaneously [3, 4].

The radionuclide calibrator has the software that allows obtaining spectra, visualization of the radionuclide activity in the sample, as well as information concerning the presence of impurities. In addition, there is a function of printing information on paper carriers.

This equipment was used in the studies conducted in the conditions of real measurements of radioactivity and the radionuclide purity of perutecnetate eluate 99 m (99mTc) obtained from a centralized extraction generator on the experimental nuclear reactor of the Institute of Nuclear Research of the NAS of Ukraine (Fig. 1, 2).

The gamma spectra of radiopharmaceuticals were measured on the basis of Fludeoxyglucose 18F, solution for injections (FDG) and determination of the drug activity [5, 6].

The research was carried out in three batches of FDG of various activities: 20181228/184, 20181228/185 and

![Fig. 1. The gamma spectrum of the sample 99Mo + 99mTc](image)
20181229/186. The half-life was 2 h; the probability of decay via the channel was 96%. To determine the radioactivity of radiopharmaceuticals, the geometry of the data was used, the recording efficiency, and the photopic area (511 keV) were used. From these data, the calculation of radioactivity was performed according to the formula:

\[ A = \frac{S_0}{\epsilon \cdot \Omega \cdot w \cdot k \cdot c \cdot t} \]

where: A – is the activity (Bq); S0 – is the square under the peak; \( \epsilon \) – is the efficiency of recording gamma quanta with an energy of 511 keV; \( \Omega \) – is the solid angle (determined by the geometry of measurement); \( w \) – is the quantum yield (takes into account that 2 decomposition gamma rays appear per 1 decay act); \( k \) – is the coefficient that takes into account the probability of decay via the required channel (EC – 0.96); \( c \) – is the coefficient that takes into account the attenuation due to protection; \( t \) – is the measurement time (for all batches – 300 sec.).

The gamma-spectra and the results of the activity determination are shown in Fig. 3.

Using the radionuclide calibrator for nuclear medicine the results of the FDG quality control have been obtained: the gamma radiation spectrum corresponds to 511 keV in all batches studied. The total radioactivity of the sample batches: for 20181228/184 is 106 MBq, for 20181228/185 is 135 MBq and for 20181229/186 is 190 MBq.

Conclusions and prospects of further research
1. A calibrator of doses for nuclear medicine performs two functions simultaneously: it measures the total radioactivity and determines the radionuclide purity of a solution; it reduces the time for the quality control of radiopharmaceuticals.
2. This device is of domestic production; it is cheaper and easier to use than foreign analogs.
3. The optimization of the method of conducting the quality control of radiopharmaceuticals has been implemented at the All-Ukrainian Center for Radiation Surgery in the Clinical Hospital “Feofaniya” of the State Department of Affairs in accordance with the GMP requirements.

Conflict of interests: authors have no conflict of interests to declare.

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