THE PROBLEMS AND PERSPECTIVES OF MEGAVOLTAGE PHOTON BEAM RADIOTHERAPY IN UKRAINE

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Global trends of technological improvements in external beam radiation therapy (EBRT) demand accelerate structural and technological reforming the physical and technical service of radiation oncology in Ukraine. Conditions for overcome its technological backwardness are defined for existing level of equipment and staffing.

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1. INTRODUCTION

The international growth of cancer cases and lack of available treatment become a global problem of humanity. According to recent ESTRO-HERO analysis a 16.1% increase of new cancer patients until 2025 is predicted [1]. Depending on the type of cancer near 50...60% of patients need radiation treatment [2]. But for countries with low and middle income (LMIC) this task is complicated by lack of financial resources and worse conditions for maintenance of sophisticated radiotherapy equipment [3-5].

The main types of mega-voltage radiotherapy equipment currently are medical 6...18 MeV linacs and $Co-60$ machines. According to actual data of IAEA DIRAC Database there are more than 11300 linacs and near 2260 $Co-60$ machines in use worldwide. For high developed regions (North America and Western Europe) the average ratio "linacs vs $Co-60$ machines" is 96% to 4%, for Eastern Europe and North Asia – 56% to 44%, respectively.

Comparative analysis of EBRT equipment in Ukraine and surrounding countries indicates that East European countries – members of EU demonstrate better ratio "linacs vs $Co-60$ machines" with trend to total elimination of use of $Co-60$ machines. But in Ukraine as well as Russian Federation and Kazakhstan the obsolete $Co-60$ machines still are the main type of equipment for EBRT (Fig.1). Understanding of problem of urgent replacement of $Co-60$ machines changed qualitative ratio in favour of linacs. Especially this process is successful in Turkey (Fig.2).

Ukraine continues to show slow growth rates of equipment for EBRT. In 2015 operation of the outdated equipment continued, and only 3 new linacs were installed, mainly in the private centers. However, this statistic only shows changes in the

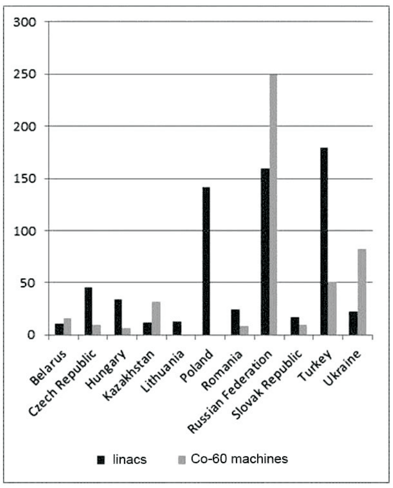

Fig.1. *Comparison number of linacs vs cobalt machines in Ukraine and surrounding countries (IAEA DIRAC, 2015)*

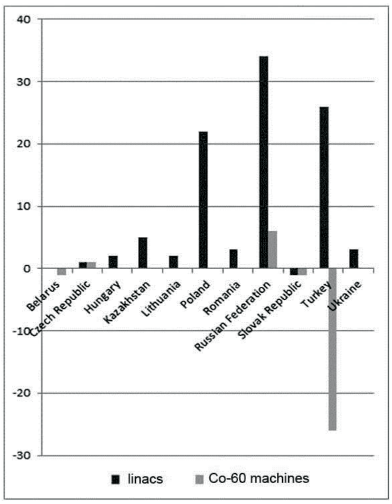

Fig.2. *Installation (+) and uninstallation (-) of EBRT equipment in Ukraine and surrounding countries (IAEA DIRAC, 2015)*

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number of devices for EBRT, but not their quality. So, most of the devices in Ukraine only allows to carry out traditional or conformal radiation therapy.

2. EBRT PHOTON BEAMS

Many specialists in medical radiation physics as well as radiation oncologists currently discuss problem of effective use of EBRT equipment and its optimal choice for certain clinical needs [6-8]. Of course linacs allow form more sharp high energy photon beams than $Co-60$ machines. Depth dose distribution of linac beams is more safe for superficial tissues and preferable for treatment of deep cancers (Fig.3).

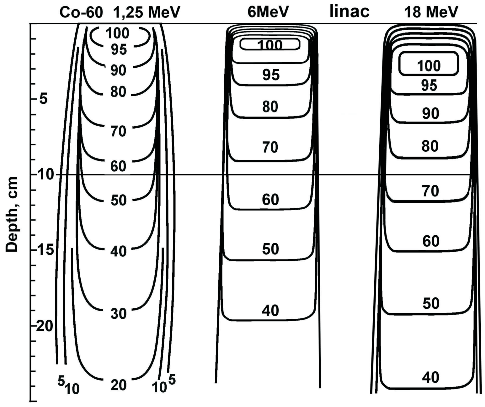

Fig.3. *Comparison of photon beams percentage depth dose distribution in water*

To determine the appropriateness of the choice of a long term linac to gamma device, was held analysis of changes in the ionizing radiation beam parameters within 5 years (approximately equal to the period of halving the activity of the most common sources in a gamma devices - $Co-60$). Information about the parameters Clinac 600C, given in Table, was obtained as a result of carried out within 5 years of parameters control (daily, quarterly and annual).

Dose distribution and geometrical parameters of a linac photon beam are well reproduced during long operational time. Our 2015 annual experimental examination of Varian Clinac 600C beam depth dose distribution performed with use of PTW water phantom and 31010 ionization chamber(Fig.4).

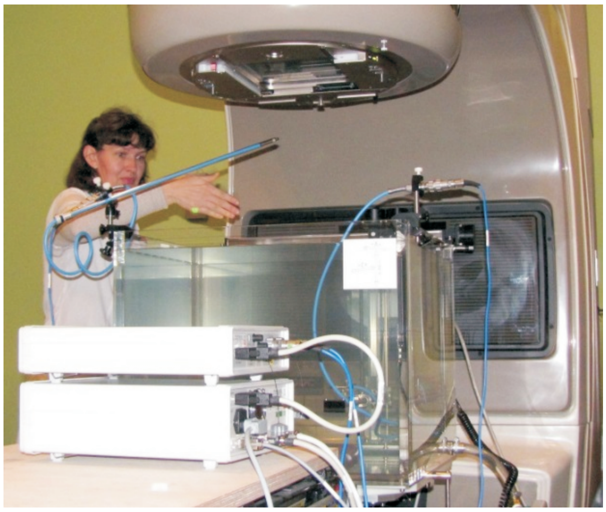

Fig.4. *Experimental estimation of Varian Clinac 600C beam depth dose distribution in PTW water phantom*

Statistic of dosimetry parameters Varian Clinac 600C

Monitored parameter	**Average values over the year**				
Year	2011	2012	2013	2014	2015[4]
MU price[1], cGy/MU	0.996	0.991	0.988	0.995	1.000
Dose rate (rep rate 320 MU/min), MU/min	312	307	295	314	320
Field symmetry (TRN/RDL)	0.01/0.02	0.03/0.02	0.04/0.02	0.01/0.03	0.03/0.04
Amplitude of the absorbed dose values at the minimum and maximum dose rate[2], %	1.9%	1.9%	2.0%	2.0%	0.1%
The coincidence of prices 1 MU with a predetermined in planning system, %	0.4%	0.9%	1.2%	0.5%	0%
Number of completed repair and adjustment work during the year[3]	7	8	10	12	10

1 – at standard conditions: SSD $100\,cm$, $10\times10\,cm$ *field, the ionization chamber depth* $15\,mm$*; setpoint according to the planning system -* $1\,Gy/MU$*;*

2 – due to the nonlinearity of the total absorbed dose at different dose rates;

3 – relating to beam parameters;

4 – close to ideal parameter values demonstrate getting the engineering group have enough experience in the linac maintenance.

It proved that measured dose profiles confirm predefined ideal dose distributions very well even after 5 years of intensive use (Fig.5). During the same time the $Co-60$ source of our ROCUS-AM machine lost half of its initial activity and must be replaced.

Medical linacs as totally electronic generators of treatment beams are safer and easily integrated with computerized control systems (Fig.6). At the same time medical linacs require very qualified technical staff, more strict and specific conditions of use.

The newest $Co-60$ machines are equipped by multi leaf collimators (just the same as in linacs) and must be integrated into general network of EBRT department [6]. So use of these machines already is not as simple as in past. Even the cost of the new $Co-60$ machines is close to the cost of 6 MeV linacs [9].

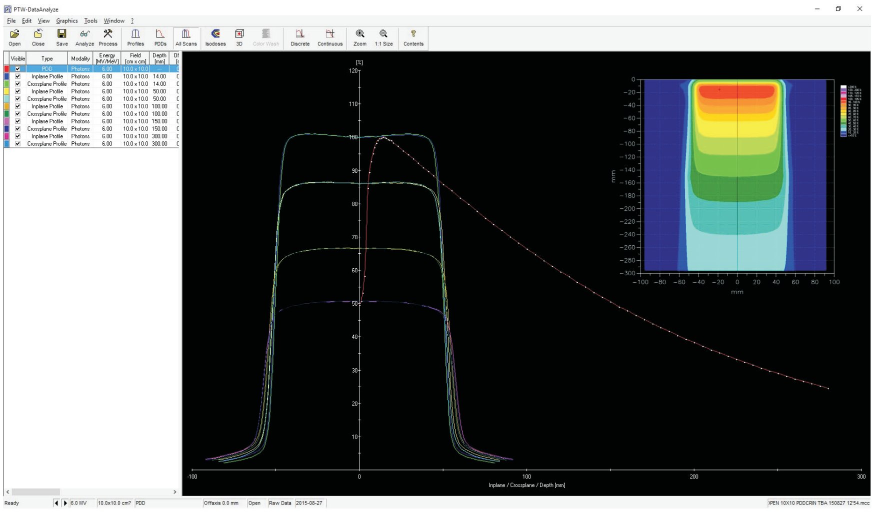

Fig.5. *Results of measurements of Varian Clinac 600C beam depth dose distribution*

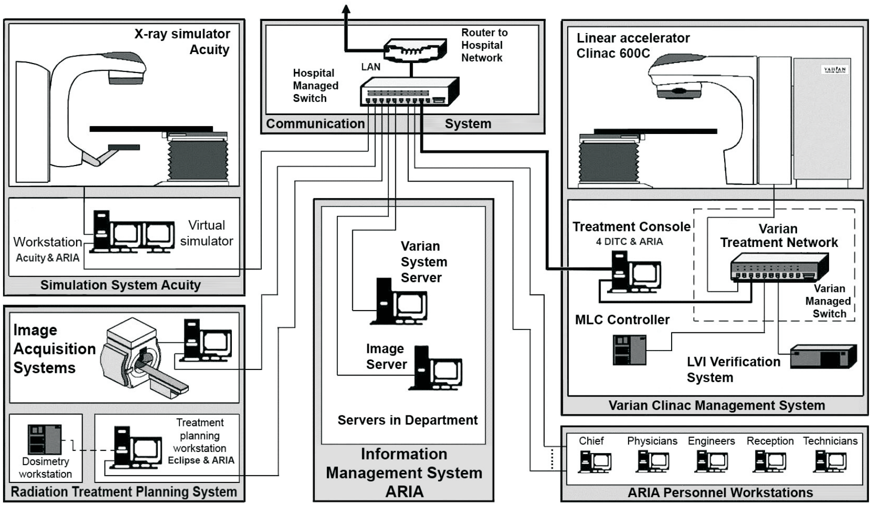

Fig.6. *Technical structure of the typical linac-based radiotherapy department accepted to use at Grigoriev Institute for Medical Radiology NAMS of Ukraine*

3. CONCLUSIONS

Based on these data we can conclude that the use of linac is a more appropriate approach in the selection of equipment for radiotherapy, as the beam dosimetric parameters depend largely on the quality of the unit's settings; at the same time, the operation of the linear accelerator requires much more careful maintenance. The prescribed dose at the same time is guaranteed to be in the range of $\pm 3\%$, which is included in the allowable amount of deviation required by the IAEA. Development of customized protocols QA of linac beam output parameters in Ukraine will improve the quality of patient exposure.

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ПРОБЛЕМЫ И ПЕРСПЕКТИВЫ ЛУЧЕВОЙ РАДИОТЕРАПИИ В УКРАИНЕ

В. П. Старенький, Л. Л. Васильев, И. О. Самофалов

Глобальные тенденции технологических усовершенствований внешней радиационной лучевой терапии (EBRT) требуют ускорения структурных и технологических преобразований физического и технического обслуживания радиационной онкологии в Украине. Условия для уменьшения ее технической отсталости определены для существующего уровня оборудования и укомплектования персоналом.

ПРОБЛЕМИ І ПЕРСПЕКТИВИ ПРОМЕНЕВОЇ РАДІОТЕРАПІЇ В УКРАЇНІ

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Глобальні тенденції технологічних удосконалень зовнішньої радіаційної променевої терапії (EBRT) вимагають прискорення структурних і технологічних перетворень фізичного і технічного обслуговування радіаційної онкології в Україні. Умови для зменшення її технічної відсталості визначені для існуючого рівня обладнання і укомплектування персоналом.