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Use of artificial intelligence program in radiation therapy

Relevance: *Since 01 January 2020, the provision of radiation therapy (RT) at Almaty Oncology Center was optimized using the Visual Care Path (VCP) tool of the ARIA 15.6 oncology system, which supports the implementation of sequential and parallel mandatory procedures – from patient registration to completion of treatment.*

The purpose was *to study the impact of the implemented artificial intelligence system on RT effectiveness, safety, the share of complex RT techniques, and measure staff satisfaction and proficiency.*

Results: *The share of intensive modulated radiation therapy sessions changed from 39.3% in 2019 to 46.6% in 2020. After the implementation of VCP, timely pre-irradiation preparation of patients (centering, delineation, dose prescription) by department doctors increased from 76% to 91%, OR = 3.2; timely measurements of plans increased from 85% to 96%, OR = 4.7; the frequency of major events (the ratio of plans with errors or unsuccessful plans to the total number of plans, delineation of organs at risk and targets, dose prescription) decreased from 12% to 3%, OR = 4.5; the frequency of minor events (late notification of the patient of the treatment commencement, timely transition to the next stage of patient preparation for treatment decreased from 32% to 10%, OR = 4.5. Staff proficiency in VCP has increased by 75%. Following the anonymous survey results, 85% of staff reported a positive impact of VCP on the workflow.*

Conclusion: *The share of complex methods of RT has increased by 7.3%. The implementation of VCP significantly increased the workflow efficiency – by 3.9 times, reduced the number of major and minor events by 4.4 times. It allowed using a paperless communication with the executor's identification at each stage of RT. The new technique was also quickly adopted and favorably accepted by the staff.*

Keywords: *radiation therapy (RT), artificial intelligence, quality control, cancer, linear accelerator.*

Introduction: Radiation therapy (RT) is one of the three key methods of cancer treatment. Its role will still increase in the future due to its high efficiency and non-aggressiveness for the patient [1]. The launch of a linear accelerator at Almaty Oncology Center RT department in early April 2019 allowed reducing the queue and the average waiting time for RT for Almaty residents and treat up to 60 patients daily. Oncological informational systems are widely implemented in the treatment process [2]. This is of particular importance for accelerators used in sophisticated modern RT techniques like intensively modulated radiation therapy (IMRT, VMAT), image-guided radiation therapy (IGRT), stereotactic radiosurgery (SRS), and stereotaxic radiation therapy (SRT) [3]. In 2019, the oncological information system Visual CarePath (VCP) was installed at the RT Department of Almaty Cancer Center for RT constructing and monitoring [4]. From 01 January 2020, the department workflow was optimized using the Visual Care Path tool of ARIA 15.6 oncology system, supporting the implementation of sequential and parallel mandatory procedures – from patient registration to completion of treatment [5].

This study is especially relevant now when contactless communication between specialists, patient preparation, and conducting RT procedures are essential to ensure patient safety.

The purpose was to study the impact of the implemented artificial intelligence system on RT effectiveness, safety, the share of complex RT techniques, and measure staff satisfaction and proficiency.

Materials and Methods: A retrospective full-design study included 1110 day-hospital patients who received radiation treatment from 01 April to 31 December 2019. RT was provided using a TrueBeam STx linear accelerator, version 2.7. RT was prescribed in each case by a multidisciplinary group of physicians. The radiation method was chosen after topometric pre-irradiation preparation using "GE Optima 580" 16-slice computer tomograph, delineation of the irradiated area and critical organs, assignment and individual dosimetry planning using the Eclipse v15 program, discussion of the plan. CarePath algorithm used for patient safety and paperless communication between radiation therapists included: patient registration, import of computed tomography (CT) data, delineation of the irradiated area and surrounding organs and tissues, dose prescription, fractionation regime for irradiated organs, and restrictions for surrounding organs, discussion of dose prescription, and delineation of the irradiated area, dosimetry plan, discussion of the dosimetry plan, approval of the treatment, invitation for treatment. We compared two nine-month periods: before VCP implementation (April 2019 - December 2019) involving 535 patients,

and after VCP implementation (January 2020 - September 2020) involving 575 patients.

The patients received treatment in compliance with patient safety's ethical principles reported in the Helsinki Declaration and the GCP protocols. Quality Control plan included daily, weekly, monthly/quarterly, and yearly verification of the device performance, affecting the dose accuracy in RT. Verification by service codes – according to the rater in the Electronic Register of Cancer Patients and DAMU MED.

The timeliness of the task completion was measured to evaluate the efficacy. Doctors of the department ensured timely pre-irradiation preparation of patients (centering, delineation, dose prescription). Medical physicists ensured timely preparation of treatment plans. The patient safety was evaluated by the likelihood of unexpected events (major and minor). The frequency of major events (ratio of inaccuracy or unsuccessful plans, delineating organs at risk and targets, dose prescription) was measured. The frequency of minor errors (late notification of the patient of the treatment commencement, the transition to the next stage of patient preparation for treatment) was measured. Events identified during validation of the dose distribution plans were also considered. The degree of proficiency in the system and the staff satisfaction level were measured during a survey three months after the VCP implementation. Data before and after the VCP implementation was compared using the Pearson chi-square test ($\chi 2$) and the odds ratio (OR).

Results and Discussion:

All patients underwent high-tech RT (see Table 1 for details).

Table 1 – Number of patients and RT services with the use of the linear accelerator

Service	Nine months of 2019		Nine months of 2020	
Conformal radio therapy	6510	335	6482	305
Intensive modulated radiation therapy (IMRT, VMAT)	4208	190	5644	270
Stereotactic radiation therapy\radiosurgery	14	6	45	12
Image-guided radiation therapy for selected tumors (IGRT)	9171	524	8740	553
Pre-irradiation topometric preparation-centering	644	556	611	580
Manufacturing a special fixation mask for radiotherapy	75	73	97	94
Selection of individual radiation therapy regimen	565	516	634	578
Individual dosimetry planning	565	508	650	579

The average number of services per patient in nine months of 2019 and 2020 was changing as follows: conformal radiation therapy – 19.4 and 21.3, IMRT, VMAT – 22.1 and 20.9 sessions, IGRT – 17.5 and 15.8 sessions on average, respectively. The share of more complex RT techniques grew with experience. Thus, the share of IMRT sessions changed from 39.3% in 2019 to 46.6% in 2020.

Timely pre-irradiation preparation of patients (centering, delineation, dose prescription) by department doctors after the implementation of VCP increased from 76% to 91% ($\chi 2=14.8$, $p=0.01$, OR=3.2 95% CI (1.8-6.3)). Timely measurements of plans after the implementation of VCP increased from 85% to 96% ($\chi 2=12.3$, $p=0.01$, OR=4.7 CI (1.9-12.9)). The frequency of major events (the ratio of erroneous or unsuccessful plans, delineation of organs at risk and targets, dose prescription) after the implementation of VCP decreased from 12% to 3% ($\chi 2=9.4$, $p=0.01$, OR=4.5 CI (1.7-14.4)). The frequency of minor events (late notification of the patient of the treatment commencement, timely transition to the next stage of patient preparation for treatment) after the implementation of VCP decreased from 32% to 10% ($\chi 2=26.8$, $p=0.01$, OR=4.5 CI (2.5-8.3)). Staff proficiency in VCP has increased by 75%. Following the anonymous survey results, 85% of staff reported a positive impact of VCP on the workflow. Before the VCP implementation, treatment plans were discussed occasionally; now, it is mandatory to approve the treatment plan after discussion with a digital signature.

The clinical operation apparatus's settings and preparation, including measuring all radiation characteristics, processing, and introduction into the dosimetry planning system and data verification, were completed before 01 April 2019. The starting point for implementation was 01 January 2020, when all radiation therapy participants have mastered and began to use the VCP model with a chart of sequential and parallel events from registration to completion of treatment.

A shortcoming of this research is the absence of comparison with other institutions in Kazakhstan. In the world literature, we have found only a study by N. Kovalchuk et al. They reported an increase in simulation order and treatment prescription for VCP by 35.2%, an increase in compliance with treatment planning with the use of VCP by 20.3%, and a decrease in the number of "near-misses" using VCP by 69.8% compared to baseline data. 94% of survey responders thought that VCP improved the patient care workflow by prompting staff to complete their tasks in time and improved the department organization level, and 81% of responders thought that the introduction of VCP improved the interdisciplinary communication in the department [4]. Our study provided comparable data.

Conclusion: The implementation of VCP has significantly increased the workflow efficiency (by 3.9 times), reduced the number of major and minor events (by 4.4 times), increased the share of complex RT techniques (by 7.3%). VCP technique was quickly adopted and favorably accepted by the staff. It allowed a transfer to pa-

perless communication and identification of the implementer of each stage of RT. We recommend a wide use of VCP in RT departments.

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ТҰЖЫРЫМ

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Сәулелік терапияда жасанды интеллект программасын қолдану

Өзектілігі: *2020 жылғы 1 қаңтардан бастап Алматы Онкологиялық орталығында ARIA 15.6 онкологиялық жүйесінің Visual Care Path (VCP) құралының көмегімен пациентті тіркеуден бастап емдеу аяқталғанға дейін ж дәйекті және параллель оқиғаларды міндетті түрде орындай отырып, сәулелік терапияның (ЖТ) жұмыс процесін оңтайландыру жүргізілді.*

Зерттеудің мақсаты: *жасанды интеллект жүйесін енгізудің сәулелік терапия процедураларының тиімділігі мен қауіпсіздігіне әсерін, сәулелік терапияның күрделі әдістерінің үлесін зерттеу, сонымен қатар жүйеге иелік ету және қызметкерлердің қанағаттану деңгейін өлшеу.*

Нәтижелері: *Бөлімшеде жүргізілетін қарқынды-модуляцияланған сәулелік терапия сеанстарының үлесі 2019 жылғы 39,3% - дан 2020 жылы 46,6% - ға дейін өсті. VCP енгізілгеннен кейін бөлімше дәрігерлерінің пациенттерді сәуле алды дайындауды уақтылы орындауы (орталықтандыру, контурлау, доза нұсқамасы) 76% – дан 91% – ға дейін (МҚ=3,2), жоспарларды есептеуді уақтылы орындауы – 85% - дан 96% - ға дейін (МҚ=4,7), елеулі оқиғалардың жиілігі (қателері бар немесе сәтсіз жоспарлары бар жоспарлардың үлесі, қауіп органдары мен нысаналарды контурлау, доза нұсқамасы) 12% - дан 3% - ға дейін (МҚ=4,5) төмендеді, Елеулі емес оқиғалардың жиілігі (науқасқа емді бастау жайлы ақпаратты уақытылы хабарламау, емдеу үрдісінің келесі этапына уақытылы өту) - 32% - дан 10% - ға дейін (МҚ=4,5). Қызметкерлердің VCP иелену деңгейі 75% - ға өсті. Анонимді сауалнаманың нәтижесінде бөлім қызметкерлерінің 85% - ы VCP-нің жұмыс процесіне жағымды әсер ететінін атап өтті.*

Қорытынды: *VCP-ді енгізу жұмыс процесінің тиімділігін 3,9 есеге арттырды, оқиғалар саны 4,4 есеге азайды, сәулелік терапияның күрделі әдістерінің үлестік салмағының 7,3% -ға өсу байқалады. Бұл әдісті қызметкерлер тез меңгерді және жақсы қабылданды. Бұл сәулелік емдеудің әр кезеңінің орындаушысын анықтай отырып, қағазсыз байланыс түріне көшуге мүмкіндік берді. Сондықтан, біз VCP-ді сәулелік терапия бөлімшелерінде кеңінен қолдануға кеңес береміз.*

Түйінді сөздер: *Сәулелік терапия, жасанды интеллект, сапа бақылауы, қатерлі ісік, сызықты үдеткіш.*

АННОТАЦИЯ

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Использование программы искусственного интеллекта в лучевой терапии

Актуальность: *С 1 января 2020 года в Алматинском онкологическом центре была проведена оптимизация рабочего процесса лучевой терапии (ЛТ) при помощи инструмента Visual Care Path (VCP) онкологической системы ARIA 15.6 с обязательным выполнением последовательных и параллельных событий от регистрации пациента до завершения лечения.*

Цель исследования: *изучить влияние внедрения системы искусственного интеллекта на эффективность и безопасность процедур ЛТ, долю сложных методик ЛТ, а также измерить уровень владения системой и удовлетворённости персонала.*

Результаты: *Доля сеансов интенсивно-модулированной лучевой терапии, проводимой в отделении, выросла с 39,3% в 2019 году до 46,6% в 2020 году. После внедрения VCP своевременное выполнение предлучевой подготовки пациентов (центрация, оконтуривание, предписание дозы) врачами отделения возросло с 76% до 91% (ОШ=3,2), своевременное выполнение расчета планов – с 85% до 96% (ОШ=4,7), частота серьезных событий (доля планов с ошибками или неудачных планов, оконтуривание органов риска и мишеней, предписание дозы) снизилась с 12% до 3% (ОШ=4,5), частота несущественных событий (несвоевременное уведомление пациента о начале лечения, своевременный переход на следующий этап подготовки пациента к лечению) – с 32% до 10% (ОШ=4,5). Степень владения VCP персоналом выросла на 75%. По результатам анонимного анкетирования, 85% персонала отметили благоприятное воздействие VCP на рабочий процесс.*

Заключение: *Внедрение VCP достоверно повысило эффективность рабочего процесса в 3,9 раза, уменьшило количество событий в 4,4 раза, повышение на 7,3% удельного веса сложных методик лучевой терапии. Данная методика была быстро изучена и благоприятно воспринята персоналом. Это позволило перейти на безбумажный вид коммуникации с идентификацией исполнителя каждого этапа лучевого лечения. Мы рекомендуем повсеместное использование VCP в отделениях лучевой терапии.*

Ключевые слова: *Лучевая терапия, искусственный интеллект, контроль качества, рак, линейный ускоритель.*