

Enhancing quality, safety and efficiency in treatment planning with health information technology (HIT) and artificial intelligence (AI)

Mary Beth Massat

Across every step of the radiation therapy process, checks are performed to ensure patient safety. From verifying the linear accelerator calculations to examining treatment plans to ensuring proper patient positioning, all members of the multidisciplinary treatment staff have a specific role in safeguarding patients as well as reporting errors and near misses.

In 2010, the American Society for Radiation Oncology (ASTRO) launched the Target Safely initiative to focus its resources on improving patient safety and reducing the potential for medical errors. A key aspect of the initiative was the 2014 development of the Radiation Oncology Incident Learning System (RO-ILS), a national medical error reporting system and patient safety database created in partnership with the American Association of Physicists in Medicine (AAPM). Target Safely also included another AAPM/ASTRO-sponsored initiative, Integrating the Healthcare Enterprise–Radiation Oncology (IHE-RO), which aims to improve the compatibility of system-to-system connections, especially among different radiation oncology

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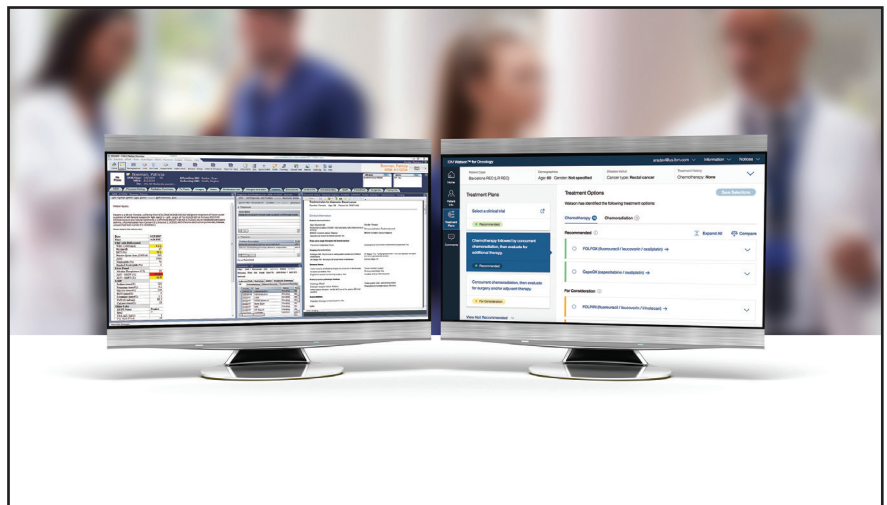


FIGURE 1. Elekta (Stockholm, Sweden) and IBM Watson Health (King of Prussia, Pennsylvania) combine the MOSAIQ oncology information system (OIS) for treatment planning and automation with artificial intelligence (AI) capabilities to provide deep learning algorithms and cognitive computing. photo/courtesy Elekta

vendors' equipment and information systems.

David Hoopes, MD, associate professor at the University of California San Diego (UCSD) School of Medicine and medical director at 4S Ranch cCare (San Diego), is one of four physicians appointed to the RO-ILS Radiation Oncology Healthcare Advisory Council (RO-HAC), the group that analyzes data from RO-ILS. Based on analyses of these data, the most common pitfalls that

can lead to a safety event or near-miss in radiation oncology departments are set-up errors, iso-center problems and suboptimal contours.

“What causes these errors really boils down to communication among the staff and the patient safety culture in the clinic,” Dr. Hoopes says. “It is important that anything that doesn’t go as it should—whether it reaches the patient and causes an incident or not—should be reported to RO-ILS.”



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Participating in a system such as RO-ILS is a big step toward improving communication, he adds. In addition to the incident being recorded in the database, it is also discussed by the treatment team.

“That discussion is a great step for improving communication,” Dr. Hoopes adds, noting that successful interdepartmental communication relies on strong physician leadership that champions open, free dialog. “When the team sees that it is a nonpunitive environment and that their ideas are taken seriously when they propose a solution, they are more likely in the future to communicate well and take care of issues the way they need to be done. So just participating in RO-ILS can help drive better communication and a culture of safety in the department.”

To date, more than 480 facilities nationwide have joined RO-ILS. To further encourage participation, RO-ILS provides reports of aggregated data and in-depth case examinations to all ASTRO members and the public. These reports include free continuing medical education (CME) credits.

“RO-ILS continues to grow and add new practices,” says Dr. Hoopes. “Certainly our goal is to continue growing, and while we would love to have all facilities nationally participate, we have facilities from almost every state.”

One technology-related area that Dr. Hoopes would like to see improved is the development of software modules

to help connect treatment planning systems or oncology-specific electronic medical records (EMRs) to RO-ILS. Currently, reporting to RO-ILS involves a separate system. In the future, Dr. Hoopes says enabling connectivity could simplify error reporting by allowing for automatic population of patient and treatment information to the incident learning system.

The ability to perform high-quality, electronic peer review is another area where Dr. Hoopes sees a gap in technology. His hope is that vendors will create a module allowing peer review to be part of treatment planning system. “While many departments do peer review, it is inefficient,” he says.

Education and Training

Safety in radiation oncology is not a new topic, but interest has resurged as its link to payment and accreditation has grown. Many clinics are now putting more resources toward accreditation programs from ACR, ASTRO or the American College of Radiation Oncology (ACRO).

In light of this increased focus, one group from the University of Washington (Seattle) examined the education and training that residents received regarding patient safety and quality improvement in radiation therapy. According to lead author Matthew Spraker, MD, PhD, who is now assistant professor of radiation on-

ology at Washington University School of Medicine (St. Louis, MO), the study found that residents are not exposed to training in patient safety and quality improvement programs, including incident learning programs, even though physicians and physicists are expected to assume leadership roles in these areas.¹

“Radiation oncology residents are not being trained to lead these credentialing programs,” says Dr. Spraker. “On top of that, they reported that they don’t feel that they are prepared in this specific respect.”

In a follow-up survey of directors of radiation oncology and medical physics residency programs accredited by the Accreditation Council for Graduate Medical Education (ACGME), Dr. Spraker and co-authors reported that most directors believe residents are adequately exposed to patient safety and quality improvement tools.² However, this perception differs from the results of Dr. Spraker’s prior study and other independent studies.

There were several interesting takeaways from the program directors’ responses, says Dr. Spraker. Many programs don’t have educators experienced in designing curricula to address patient safety and quality improvement. Residents undergo a grueling curriculum to learn how to manage all cancers and, therefore, many program directors are concerned about the time and resources to build these concepts into the curricu-



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lum, even if they have the expertise.

"This is where technology can help," Dr. Spraker says, whether it be the development of educational tools, such as online collaboration or webinars, or incident learning simulation programs.

"There is also a growing understanding of how information technology is designed and how software interfaces can lead to errors," explains Dr. Spraker, noting that it comes down to human factor engineering.

Human factor engineering is the science behind identifying and addressing safety issues that arise from the interaction of people and technology. It encompasses how systems and equipment are designed so human errors don't lead to a patient safety event.

"The idea is for industry to think about how the system works and the tools that it provides, so as people are working under certain constraints, the equipment does not contribute to errors or failures," Dr. Spraker says.

To further identify the root causes of errors, Dr. Spraker and colleagues from the University of Washington examined 300 randomly selected event reports from the international ILS, Safety in Radiation Oncology (SAFRON). Communication and human behaviors were the most common errors impacting all events; however, poor human factor en-

gineering contributed to more high-risk than low-risk events.³

"Workflow is key," Dr. Spraker says. "When designing these systems, industry needs to spend time with the people using the technology and interacting with how it is used in the clinic."

Artificial Intelligence and Machine Learning

While incident reporting is an important tool for evaluating the root cause of safety-critical events and near misses, it is voluntary and post-incident. Artificial intelligence (AI) and, more specifically machine learning (ML), may help facilities identify these events pre-incident.

Deshan Yang, PhD, associate professor of radiation oncology and primary investigator in the Laboratory of Medical Imaging and Health Informatics at Washington University School of Medicine (St. Louis), has been exploring the use of machine learning in medical physics and radiation oncology. He is the recipient of a National Institutes of Health grant to develop an automated health information technology (HIT) system to improve patient safety, treatment quality and working efficiency in radiation therapy.

Dr. Yang believes that HIT and machine learning can help improve the overall quality and safety in the day-to-

day workflow of medical physicists.

"By using technology to help us work more accurately and efficiently in performing daily quality checks and verifying the patient treatment plan, the hope is that we can improve the overall quality and safety of patient care," he says.

Dr. Yang is examining three types of data with HIT: patient data (tumor location, dose and prescription); image data (target and critical structures); and the treatment plan data (how good is the plan and can it be better).

"We are developing a rules-based logic solution for medical physicists that can perform the same tasks as a human but do it automatically, more accurately and more quickly," Dr. Yang explains.

It's not that radiation therapy is not safe, rather safety comes at a high price: the time and cost of the human worker. Yet, he says safety doesn't always equate to quality. Medical physicists often have a heavy workload, and Dr. Yang's goal is to develop a system that would create new workflow efficiencies so they could focus more on quality.

"If we can have a computer-based system take care of the more basic safety-related work, that would give us more time to focus on increasing the quality of the treatment," he says. "Efficiency leads to better quality care. There is always room to improve a plan, but that comes at a



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cost of time, and that is the problem we face in our daily workflow.”

Adds Dr. Yang: “The burning question is, ‘What will be the expected and acceptable treatment plan for a particular patient [and] is there room for improvement?’”

That’s where AI and ML can make an impact (**Figure 1**). By examining the patients treated—their treatment plan, dose distributions and the anatomic images used for planning and to contour critical structures—and using an ML model, it is possible to have a better knowledge-based understanding of the entire treatment plan, including the relationship of the patient anatomy to the previously approved treatment plan.

“We can use this technology to compare a new patient’s anatomy to the machine learning model and help predict the quality of the new treatment plan and radiation dose distribution,” Dr. Yang explains. “Then, we have a knowledge base and empirical ground truth to compare for the dose volume histogram matrix.”

Dr. Hoopes also sees potential for AI and ML to help analyze the data from RO-ILS, particularly as the incident database continues to grow.

“Radiation therapy involves complex workflows and volumes of data,” he says. “It will be difficult over time for

humans to review every event. So we’ll need to build machine learning algorithms to help us through this process.”

Dr. Spraker agrees that ML can help by also comparing reported incidents with patient-specific features in an EMR. He cites an abstract from ASTRO 2016 that explored trigger indicators in oncology information systems (OIS) and EMRs to help identify safety-critical events. The study queried the OIS with 10 indicators over four years and correlated with the facility’s ILS to find patients with reported high-grade, near-miss safety events. The study authors reported a significant correlation between the panel of indicators and safety-critical events. Future efforts will revolve around the development of an ML algorithm to refine indicator selection to find specific combinations of trigger indicators and safety-critical events.⁴

“We can use machine learning to find correlations between features in the patient’s EMR and incidents in the clinic,” Dr. Spraker says. “If we have a model, then triggers can be identified in the EMR that, for example, notify the user that similar patients had three incident reports.” This may enable the ability to identify a potential incident before it occurs.

Dr. Yang posits that medical physicists will soon have new tools to help

predict treatment plan quality. “I believe that in five years, auto segmentation of normal structures in medical images and, at some level auto treatment planning, will be ready for the clinic,” he says.

If clinics can reduce the time needed for treatment planning and concurrently develop a better plan, then the potential to treat patients the same day as developing their treatment plan could become a reality. Yet, Dr. Yang cautions that benchmarks are needed to qualitatively measure the use of AI and ML in treatment planning. Without this, it will be difficult to quantitate the usefulness of these new tools.

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