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Future of Multidisciplinary Team in the Context of Adaptive Therapy

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The implementation and early adoption of online adaptive radiotherapy (oART) has required the presence of clinicians, physicists and radiation therapists (RTT) at the treatment console. The impact on each of them is unique to their profession and must be considered for safe and efficient implementation. In the short term future, widespread adoption will depend on the development of innovative workflows, and rethinking of traditional roles and responsibilities may be required. For the future, technologies such as artificial intelligence promise to change the workflow significantly in terms of speed, automation and decision-making. However, overall communication within the team will persist in being one of the most important aspects.

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Introduction

The multidisciplinary team of clinicians (radiation oncologists, clinical oncologist), medical physicists (healthcare scientist) and radiation therapists (radiographers, RTT), the key professionals in the planning and delivery of radiotherapy, have been instrumental in the development and implementation of new technologies in radiotherapy.^{1–6} Adaptive external beam radiotherapy (ART), a treatment approach initially postulated in the 1990's, is currently again under intense investigation in part driven by new technologies that combine online, high resolution MR or CT imaging with real-time, adaptive, planning and delivery systems. The core principle of ART is a feedback loop using information gained at the time of treatment to adapt the original plan/treatment.⁷ This process has progressed from using images to replan the treatment offline,^{8–11} to providing a library of plans for use online,^{12–14} to now replanning treatment online and eventually inline planning (replanning during treatment delivery).¹⁵ The importance of engagement of all members of the team

has been illustrated by the successful implementation at each stage.

In the offline situation, although the pressure is less compared to online because of the patient not remaining on the bed, there needs to be sufficient time to replan and introduce the new plan with enough remaining treatment fractions to be of benefit. One approach is to prospectively schedule replanning,¹⁶ however this may involve replanning when not necessary or not planning at the optimum time for that patient. To perform replanning effectively, a triggering process is essential. The radiographer (RTT) as the professional acquiring the images is best placed to escalate cases for replanning, likely to be due to weight loss, tumor progression or regression or other systematic change over time after initial imaging and treatment planning.^{17–21} Evaluation of the images is then required to estimate the potential benefit of replanning which involves physicists/dosimetrist and clinicians, and if approved, the replanning process including the introduction of the new plan on treatment, with appropriate quality assurance. This process is time consuming because all steps of the original planning process are performed with the engagement of all professionals at each stage, similar to starting a new patient on treatment.

An alternate online adaptive strategy, creating a library of plans, is resource intensive at the planning stage with 3 to 5 reference images acquired or modeled, contoured and planned, involving an increase in clinician and dosimetrist/physicist time.^{22–25} A decision needs to be made before each fraction regarding which plan to use. This may require the clinician to be present at the time of treatment, although studies have shown that this can equally be performed by a trained RTT^{26,27} (Fig. 1).

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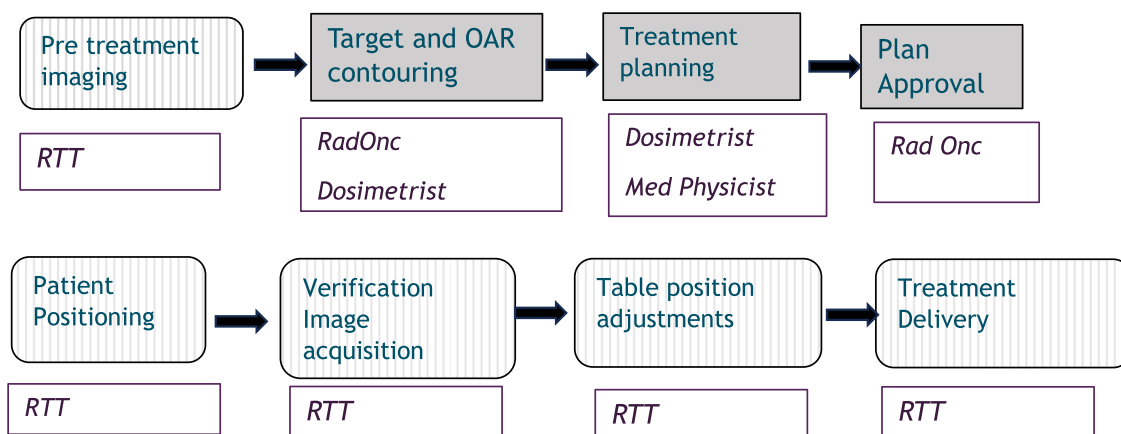
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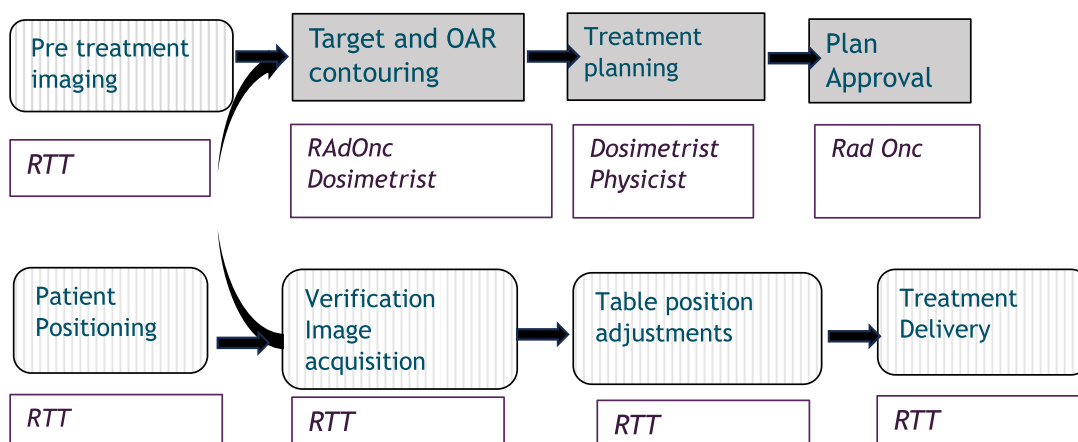
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(a) Conventional Radiotherapy



(b) Offline Adaptive Radiotherapy

Radiotherapy



(c) Library of plans

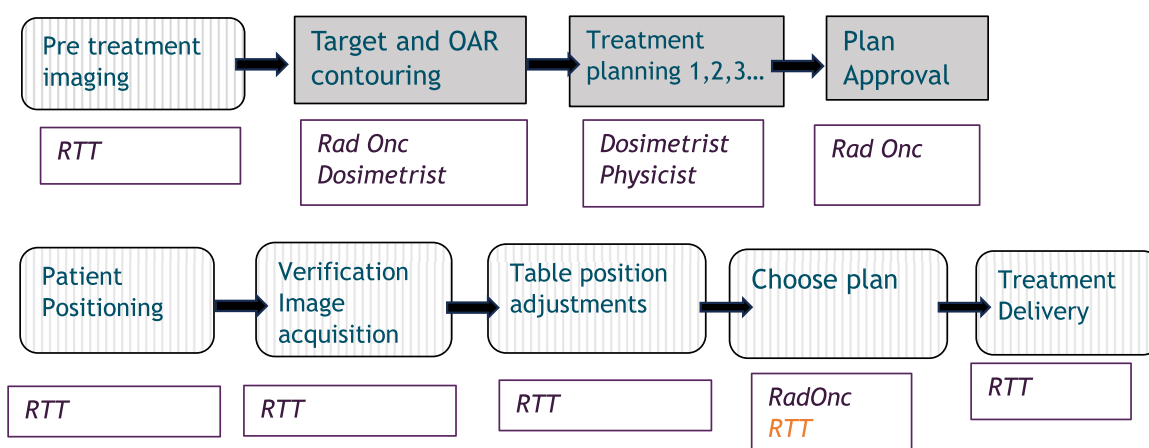
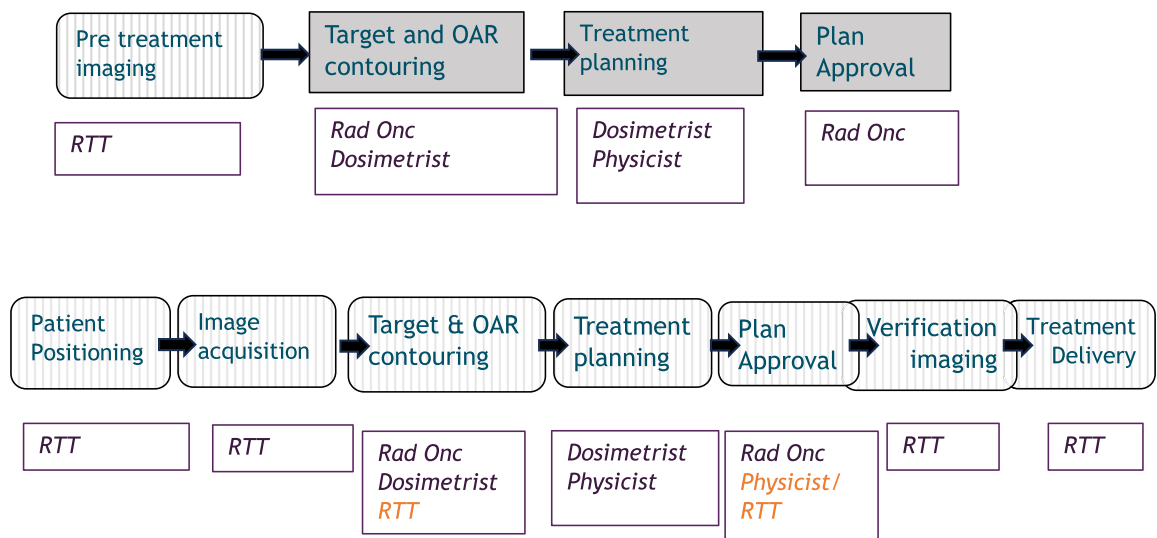
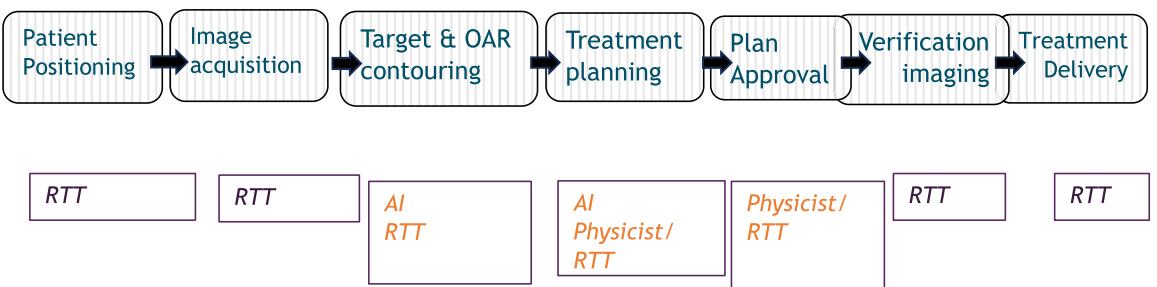


Figure 1 Radiotherapy Pathway for (a) Conventional radiotherapy (b) Offline adaptive radiotherapy (c) Using Library of Plans (d) Current online adaptive radiotherapy (e) Future adaptive radiotherapy.

(d) Online adaptive



(e) Future



Key

Patent not required.

RTT - Radiation technologist/Radiation therapist

Orange Text- task with delegation/training

AI- Artificial intelligence

Figure 1 continued

Both of the above scenarios involve a sequential workflow ie, from pretreatment, to planning and treatment delivery with the tasks performed by each professional and passed from 1 stage to the next, culminating in image guided treatment delivery. Online adaptive radiotherapy (oART), by enabling real time replanning and delivery, has dramatically changed this conventional workflow by currently requiring the presence of all professions at the time of treatment delivery. While initially necessary for demonstrating the feasibility and advantages of online adaptation, this model is not sustainable long-term in the context of widespread adoption of adaptive radiotherapy. Again, studies suggest that trained RTTs can perform some of these tasks, reducing the need for clinicians and medical physicists to be present.²⁸⁻³⁰ Training

of RTTs for such new tasks is potentially time consuming but can be regarded an investment in long-term workforce diversity and efficiency. It involves input from all professionals with audit to be effective. A balance is required between the number of staff to be trained and the number of patients treated to maintain competency. A low number of staff or patients is likely to mean the presence of a clinician is still required.

As the number of platforms to deliver adaptive radiotherapy increases, the process will become more streamlined and efficient, in part driven by advances in artificial intelligence and machine learning as well as requiring shifts in the roles and responsibilities of clinicians, physicists and radiographers. The impact this has on the team, currently and in the

future will be discussed including roles and responsibilities, communication and education.

Current Impact

The implementation and early adoption of oART has required the presence of clinician, physicists, and radiographers at the treatment console (Fig. 1). The impact on each professional in the adaptive workflow is unique, important and essential for successful, safe implementation.

Clinicians have tumor boards, multidisciplinary clinics and other responsibilities that have them outside of the radiation oncology department. Their daily schedules are not well designed for protracted periods of time at the treatment machine. In particular, fractionated treatment where their presence is required each day becomes onerous. Currently, the clinician's main responsibilities in the oART workflow are to participate in the decision about whether a replan is needed and, if so, recontour the relevant targets and OARs in real-time and approve the final replan prior to treatment delivery.^{15,31} Recontouring for adaption is different to initial contouring for the reference plan. The latter requires a holistic view of the patient and treatment objectives; incorporation of prior diagnostic imaging and clinical exam, and often discussion with colleagues, including radiologists, about image interpretation and relevant target volumes. At recontouring, the purpose is rather to reproduce the original clinical intent, considering anatomical changes that occur from day to day. The reference contours can provide a valuable starting point for recontouring to speed the process and convey important, patient-specific information if the most responsible clinician cannot be present. Nevertheless, ensuring consistent and reproducible contours during fractionated oART is challenging, particularly with time pressure and if done by different clinicians from 1 day to the next. Clinician peer review of contours before treatment, now commonly practiced to assure adherence to guidelines and detect errors, can improve consistency³²⁻³⁴ but is impractical in the current oART workflow. A team discussion of patients undergoing oART before the treatment series starts is important for ensuring that all clinicians, physicists and RTTs have a full understanding of the patient and plan-specific objectives for each case.

Similarly, for the physicist, being present at time of treatment requires a time commitment. Performing the planning under time pressure and whilst being observed is also a change in practice.³⁵ To create an acceptable plan online requires the conventional target goals and organs at risk (OAR) constraints. Any compromises made on the reference plan need to be carefully considered in light of the daily anatomy because if more favorable, the original compromises may not be required. There is also the challenge of performing quality assurance (QA) process online, a task that is usually performed independently offline, although it may be simpler because the process has been already executed for the reference plan. As with other new technologies for example intensity modulated radiotherapy (IMRT) the QA can be streamlined with experience.

The RTT roles in patient preparation set-up, image acquisition, registration and verification remain similar as conventional radiotherapy but the complication of protracted on-bed time can create the potential for motion, increase patient discomfort and increase the complexity of verification.^{31,36,37} With the ability to adapt available, the emphasis may move away from reproducibility, where it has already been demonstrated that aligning carefully to tattoos does not improve the patient positioning, and towards patient comfort.^{38,39} Although the patient may have previously experienced conventional radiation treatment, they may require more information regarding the adaptive process and why treatments may differ from day to day, such as why treatment takes longer on 1 day compared to another, or why so many images are required. Improved patient information has been shown to have an impact on satisfaction and potentially outcome.

Although one of the major changes for the RTT is the presence of the large number of staff in the control room when the treatment is being delivered, working online in the presence of colleagues will impact all staff and will be experienced differently by each individual.³⁵ The impact of different communication and learning styles is an aspect that should not be underestimated. Communication skills in radiotherapy have often focused on patient staff communication^{37,40,41} but we could potentially learn from other settings, such as the aviation industry or emergency medicine, where hierarchical relations exist for example between the pilot and co-pilot; consultant and junior doctors, nonetheless effective communication in both directions between participants is essential. Hierarchical relationships will likely be present between senior and junior staff in the case of oART but there may be also less distinct or acknowledged hierarchical relationships present between professionals. Poor communication and incivility in particular, have been shown to adversely impact the individual team member and the entire team and care of the patient.⁴²⁻⁴⁴ To create a positive culture, evidence suggests 3 core needs are important for individuals:

- i. Autonomy—the need to have control over their work lives, and to be able to act consistently with their values.
- ii. Belonging—the need to be connected to, cared for, and caring of others around them at work, and to feel valued, respected and supported.
- iii. Contribution—the need to experience effectiveness in what they do and deliver valued outcomes.

In clinical handover situations, a communication tool called SBAR (situation, background, assessment, and recommendation) was demonstrated to improve communication. Clear role definition and standardized, formal communication processes empower individuals to engage in discussions that mitigate hierarchy and facilitate psychological safety.⁴⁵ Individuals will also differ regarding learning styles and experiencing conscious thought, which affects motor control.⁴⁶ Although these aspects may seem unrelated to the

oART workflow, it may affect the cognitive performance of an individual including how an individual reacts to being spoken to, or processes information, whilst performing a task. Minimizing interruptions are particularly important because of their potential of introducing serious errors. Procedures such as check lists and no interruption zones can reduce the risk of such events, but a strong local safety culture is possibly the most important factor.⁴⁷ In summary, at the time of treatment, respect for each role, clear guidance for responsibilities and mutual trust will ensure the oART process is smooth.

Effective team communication is also required between each fraction. Contouring difficulties or strategies to improve accuracy and speed should be passed onto the next person. Compromises made during planning, for example underdosing of the target to ensure that organs at risk (OAR) are within constraints, will need to be passed to the team the next day. As mentioned above handover logs or notes are important.³¹

While the current excitement about oART is focused on external beam treatment, there are well established, real-time, adaptive brachytherapy workflows that illustrate the importance of a multidisciplinary, team-based approach and can inform the development of future external beam workflows. For example, cervical cancer patients treated with MR-guided brachytherapy may receive 3-4 treatment fractions after external beam radiotherapy, with MR imaging, contouring and planning immediately before each fraction to account for tumor regression and day-to-day changes in tumor and normal tissue position and shape. All members of the interdisciplinary radiation treatment team are usually present throughout the entire procedure and contribute in different ways to plan development and plan quality. Clinicians have primary responsibility for inserting the brachytherapy applicator and contouring images acquired after insertion. However, preplanning by physicists before the first insertion can inform the choice of catheter position and depth, while RTTs often play important roles during the procedure such as real-time ultrasound imaging. Clinicians, physicists and RTTs are crucial in treatment plan evaluation, optimization, approval and delivery. Key learnings of relevance to online external beam ART include the importance of a strong culture of communication, mutual respect and team learning to foster individual and programmatic competencies.⁴⁷

Short Term Future

The future widespread adoption of oART will depend on innovative, efficient and safe workflows that appropriately engage all members of the multidisciplinary treatment team. It will require rethinking transitional roles and responsibilities to maintain the necessary competencies, while incorporating treatment adaptation into the workday without requiring individuals to relinquish other important responsibilities. In particular, some of the tasks currently performed by clinicians and physicists can be delegated to the RTT.³⁶

It will be important for clinicians to ensure that the original intent of treatment is maintained throughout, including continued oversight of replan contours and replan approval.

However, this will not necessarily require clinicians to be physically present at the treatment console. Technology solutions that enable remote access, controlled delegation of responsibility and decision support tools with thresholds for contour and plan acceptability and triggers for escalation could be used in place of the clinician being present, similar to IGRT traffic light protocols. A culture of mutual respect, trust and communication will be essential for success. One foreseeable challenge will be ensuring timely response from clinicians when escalation is triggered, if not immediately present and otherwise involved in activities from which they cannot immediately disengage. We must also be mindful that interruptions can increase the risk of errors in care.⁴⁷

To further ease the burden of oART on clinicians, while capitalizing on the talent and skill of those already present, contouring tasks can be delegated to RTTs after appropriate training and assessment to ensure competency. Studies have shown that RTTs can perform target and OAR contouring for oART in place of clinicians for patients receiving radiotherapy for prostate cancer.^{28,30} Successful training programs have involved offline and online cases and practices with evaluation of contours, including reviewing and editing contours where necessary and a direct comparison using similarity metrics. With training and experience, equivalence in contouring between clinicians and RTTs has been demonstrated. It will be important to expand this model to tumor types beyond prostate cancer, where contouring can be more complicated and take more time.³² Many centers have incorporated RTT led segmentation of gastrointestinal organs at risk for adaptive pancreatic cancer treatments.⁴⁸ The level of training required for the RTTs to perform the planning will vary internationally because of the variation in planning and dosimetry skills for RTTs. In the UK for example although dosimetry and planning are core skills for undergraduate programs, dosimetry has been identified as a training need required for adaptive radiotherapy.⁴⁹ In the Netherlands, Canada and Australia however RTTs routinely undertake dosimetry. RTTs in the United States do not have any dosimetry experience; and some centers have a separate dosimetrist come to the machine for adaptive cases. Although the physicist may feel some of their skills regarding dosimetry are reduced, the expertise to oversee the technical challenges in a treatment plan and make decisions on feasibility/acceptability of a plan will remain.

Depending on the treatment platform the decision to adapt or treat with the current plan may need to be made. The process for this decision to be passed to the RTT will be similar for planning with thresholds required for replanning. However, if the clinician will be required for contouring, then they will need to be present which negates the benefit in this situation.

Long Term Future

The future of the MDT in the context of oART will depend on how oART is implemented. There are 2 lines of thought, the first is oART to be available for all patients and the second oART will only be used when necessary and efforts will

be made to distinguish between patients and/or fractions that require oART. Factors such as capital investment, staff resources and speed of workflow will affect the path chosen. Also, different tariff schedules will influence “adoption of adaptation.” There is no distinct adaptive therapy charge in the United States; which means that billing is done based on each plan that is changed. This could lead to an additional 20-30 plan charges if conventional patients are treated with adaptive therapy; which would nearly double the cost of treatment. However the the question arises, will evidence of benefit be required? Similar discussions were made regarding IMRT in the early 2000’s with a call for evidence base prior to widespread implementation.⁵⁰ Yet, IMRT is now routine for most indications. oART is currently under intense investigation but evidence from Phase III clinical trials to determine clinical benefit is expected to take considerable time to collect. These clinical trials typically don’t focus on the cost of oART and will not address the wide range of possible clinical scenarios. To study the effect of different workflows, there is an opportunity for large registration studies and databases to fill the gap, for example the Momentum study.⁵¹ In radiotherapy, relationships between dose and clinical outcomes with respect to tumor control and toxicity have been defined for many treatments. These relationships possibly can be used to provide surrogate evidence to support investing in adaptive treatment in some patient populations.

If there is a decision to be made regarding the use of oART, this could be made per tumour site, patient and /or per fraction. Per tumor site is logistically the simplest approach and reduces the need for a decision prior to planning or treatment but the resources must be in place to accommodate all patients with that disease. This would require coordination in the MDT to ensure that the priorities for investment and equipment will be aligned with the department needs.

If the decision is to be made for the individual patient, this would need to be decided prior to planning to ensure that the patient is booked to receive treatment on the appropriate treatment platform and the correct scanning parameters and positioning devices are used. Whether there would be sufficient information available prior to planning to make the decision, for example from diagnostic imaging, may be unlikely. Some investigations have attempted to predict the benefit of oART⁵²⁻⁵⁴ for an individual patient but this process may be difficult to implement routinely.

As mentioned above the decision per fraction requires close discussion and coordination with the MDT and requires a decision support system with thresholds for plan acceptability and triggers for escalation. The importance of standardization of clinical goals for the uptake of automation has been identified.⁵⁵ Currently, adaption is driven by anatomical variations but in the future biologic adaptation and dosimetric adaptation (re-planning only when the delivered target dose falls below a predefined threshold or an OAR dose exceeds a predefined threshold) may be considerations. Two forms of ART may well evolve: one that propagates the intent of the clinician, albeit more accurately, the other that modifies the treatment intent based on response metrics.⁵⁶ The responsibility of the former could be delegated by the

clinician to RTT/Physicists, but the latter would remain the clinician’s responsibility.

The potential for major change in the context of the MDT and the widespread implementation of oART is artificial intelligence (AI), which has the potential to improve speed, utilize automation and assist with decision making.⁵⁷ AI has already shown benefit through automation of contouring and plan optimization in the offline setting but is not yet in mainstream practice.^{58,59} The process of implementing AI will impact the MDT with the RTT as the professional responsible for the delivery of radiotherapy having a major role in the implementation.⁵⁹ Subsequent to implementation, the AI tools will shift roles and responsibilities among the core members of the MDT team and likely reduce the time required for clinician and physicists as well as decreasing time on bed for the patient. However, clinicians will remain intimately involved in identifying target and OARs, treatment plan review and approval and in the medical management of patients, including the management of significant side effects. Peer review, advocated as best practice, and the place on oART, as mentioned above, is another aspect to be considered with the availability of AI.

Automation brings alongside the perceived risk of losing skills, which has been articulated by dosimetrists. For all the MDT, consideration of technology models maybe appropriate to overcome any perceived barriers to implementation.⁵⁵ Four factors can determine how well new technology is embraced in the workplace (performance expectancy, effort expectancy, social influence, and facilitating conditions).⁶⁰ Dosimetrists perceived that the introduction, or increased use, of automation would involve increased effort. In other words, dosimetrists held an “effort expectancy” prior to implementation of automation. Methods taken to reduce this perception would improve uptake.

However, these approaches are mimicking the offline process which may be unnecessary and simple sanity checks could suffice. In the case of the implementation of IMRT, the QA process was streamlined significantly.^{61,62} If this is the case in oART, then it seems likely that the RTT could, with AI, deliver oART without the presence of physicists and clinician. Human interaction remains necessary, not only because of the patient aspects, but because of the need of some form of validation process. To ensure the MDT is confident about assuming overall responsibility, a robust process of oART workflows should be created which can then be transferred to the individual patients. However, some human decisions for example intent to increase the target in an area more at risk, is difficult to convey in an automatic system and a process where this sort of information can be transferred will be essential. This also applies in the case where multiple clinicians are contouring. In summary the communication between the MDT remains essential and the process can evolve pending on technology available.

One of the greatest potential changes in workflow because of the availability of adaption is likely to be the elimination of the need for a reference image and plan. The possibility of using the diagnostic image as a reference image is already being explored.⁶³ The implementation of simulation free

treatments will reduce the resources in pretreatment and may shift the staff from pretreatment to online treatment with an increased need for dosimetry experience. In the future, the benefit of a reference plan is questionable, particularly with hypo-fractionation.

Education for the future will change for all professions in terms of learning to work with automation, systems, and trust, and understanding the process. If the RTT is to take on new skills, these need to be included in undergraduate and postgraduate education programs. The education of RTT may include sub-specialization for example certification for high-level tasks, ie, contouring of target volumes for a specific indication.

Conclusion

For a strong future of implementation of innovative radiotherapy all member of the MDT must play a part.⁶⁴ The clinician to determine clinical need and benefit, the physicists in terms of driving technology innovation, the RTT in terms of creating patient acceptable, safe and efficient treatment delivery. Maintaining and creating a safe culture of effective communication between professions to adapt to the new technology is essential for successful implementation and to realize patient benefit.

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