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# Electronic charting of radiation therapy planning and treatment: Report of Task Group 262

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## Abstract

While most Radiation Oncology clinics have adopted electronic charting in one form or another, no consensus document exists that provides guidelines for safe and effective use of the Radiation Oncology electronic medical records (RO-EMR). Task Group 262 was formed to provide these guidelines as well as to provide recommendations to vendors for improving electronic charting functionality in future. Guidelines are provided in the following areas: Implementation and training for the RO-EMR, acceptance testing and quality assurance (QA) of the RO-EMR, use of the RO-EMR as an information repository, use of the RO-EMR as a workflow manager, electronic charting for brachytherapy and nonstandard treatments, and information technology (IT) considerations associated with the

**Abbreviations:** AAPM, American Association of Physicists in Medicine; API, Application programming interface; ASTRO, American Society for Radiation Oncology; CIED, Cardiovascular Implantable Electronic Device; DIBH, Deep inspiration breath-hold technique; DICOM, Digital Imaging and Communications in Medicine; DNR, Do not resuscitate; DR, Disaster recovery; DRR, Digitally reconstructed radiograph; DVH, Dose-volume histogram; EMR, Electronic medical record; EOT, End of treatment; ERP, Enterprise resource planning; FIESTA, Format, Input, Efficacy, Scope Traceability, and Accessibility; H&P, History and physical; HA, High availability; HDR, High-dose rate brachytherapy; H-EMR, Hospital EMR (EpicTM, for example); HITECH, Health Information Technology for Economic and Clinical Health; IEC, International Electrotechnical Commission; IGRT, Image-guided radiation therapy; IHE, Integrating the Healthcare Enterprise; IMRT, Intensity-modulated radiation therapy; IS, Information systems; IT, Information technology; LDR, Low dose rate; OAR, Organ-at-risk; OIS, Oncology information system; OR, Operating room; P&P, Policies and procedures; QA, Quality assurance; R&V, Record and verify; RO-EMR, Radiation Oncology Electronic Medical Record; RT-PACS, Radiotherapy picture archiving and communication system; SBRT, Stereotactic Body Radiation Therapy; SIB, Simultaneous integrated boost; SQL, Structured Query Language; SSN, Social security number; TMS, Treatment management system; TPS, Treatment planning system; VMAT, Volumetric-modulated arc therapy; VPN, Virtual private network.

RO-EMR. The report was based on a literature search by the task group, an extensive survey of task group members on their respective RO-EMR practices, an AAPM membership survey on electronic charting, as well as group consensus.

**KEYWORDS**
care path, chart check, checklist, electronic approval, electronic charting, electronic document, electronic medical records, EMR, implementation committee, IT infrastructure, prescription, quality assurance, radiation oncology, treatment history, workflow design, written directive

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## 1 | INTRODUCTION

Electronic medical record (EMR) usage has increased significantly since the Health Information Technology for Economic and Clinical Health (HITECH) Act in 2009.[1,2] Many studies have shown the effectiveness of the EMR in reducing errors and increasing efficiency.[3-10] As different medical specialties would have their own challenges in adopting information technology into their specific clinical practices, it is important for each individual specialty to define their own standards and guidelines. Adoption and maintenance of the Radiation Oncology electronic medical record (RO-EMR) requires significant effort and presents unique challenges compared to other EMR systems as related in a number of publications and presentations. Benedetti presented a comprehensive overview of the transition of a Radiation Oncology clinic from paper to electronic charting for both external beam therapy and brachytherapy.[11] Kirkpatrick et al. discussed their institution's clinical experience implementing RO-EMR including a discussion of the interplay between the RO-EMR and the more general hospital electronic medical record (H-EMR).[12] Both experiences are common in that a multidisciplinary team is formed which focuses on management of documentation and workflow with investment in hardware and software, and an increased reliance on IT support. Colonias et al discussed the development and integration of an EHR system, including the design of modules for information acquisition, tracking, and analysis.[13] Weeks and Coleman discuss the electronic medical record and its part in Radiation Oncology, noting that while Radiation Oncology adopted computerization early through computerized treatment planning systems, EMR adoption "struggled with overcoming legal and communication continuity concerns" which contributed to the adoption of RO-EMR systems after computerized treatment planning had progressed.[14] Mechalakos and Dieterich discuss radiation oncology electronic charting within the larger context of quality and safety.[15] Additional reports on in-house and commercial system development utilization are available.[16-19] Although focusing primarily on the record and verify (R&V) system, IAEA HHR No.7[20] and IEC 62274ED.1.0[21] provide a comprehensive list of tests. While the aforementioned publications discuss various aspects of the RO-EMR from different perspectives, a synthesis of overall clinical guidelines is lacking. Electronic charting has been shown to improve the quality and safety of patient care as well as efficiency of workflow,[12,22,23] so if the system is properly configured to meet the needs of the clinic while providing safe care, the gains in efficiency and safety can offset the costs and effort of configuration. Facilities and committees adopting a new RO-EMR system would benefit from a set of guidelines from those who have implemented various RO-EMR systems and overcome many of its challenges. Therefore, a task group dedicated to the electronic charting for external beam radiation therapy and brachytherapy was created.

The "electronic chart" is broadly defined as the electronic analog of the traditional "paper chart" and the RO-EMR replaces the traditional "paper chart" that was specifically used in Radiation Oncology which was passed between different members of the clinical team (medical physicists, dosimetrists, radiation therapists, radiation oncologists, nurses, support staff) as needed. Clinics typically purchase an RO-EMR system from one of the vendors of such systems and it is often part of a larger system called the Oncology Information System (OIS) which includes the R&V system which sends and receives treatment data to and from the treatment machine.

The goal of the task group was to create basic guidance on the radiation oncology electronic charting process that includes recommendations for management of the system configuration, interfacing with the hospital EMR system, and basic quality assurance (QA) associated with implementation and maintenance of a RO-EMR. The scope of this report includes those facets of electronic charting (i.e., prescription, treatment planning, QA documents, treatment planning workflow, task lists, and billing to name a few) related to external beam radiotherapy for linac-based systems that typically employ one of the commercially available RO-EMR solutions, as well as for brachytherapy treatment, and for "nonstandard" delivery systems from the electronic charting perspective such as Tomotherapy, CyberKnife, etc which may not be compatible with the commercial systems typically used by linac-based practices but may offer custom solutions. Items such as clinic appointments and follow-up scheduling are beyond the scope of this task group, except as they relate to the planning and delivery process. Explicit guidance on treatment delivery systems and record and verify (R&V) systems, even though they may be part of the same software suite as the electronic chart, is also beyond the scope of this report, except in areas where the R&V system communicates with the electronic chart, for example in transferring the treatment record.

Conversion to electronic charting or between different systems requires the time and effort of a dedicated committee, as each document is evaluated and converted and workflows are restructured. In addition, adequate time is required to train staff. A committee directing such a transition will invariably encounter roadblocks along the way in which potential advantages of the system can become disadvantages if not managed properly. Potential challenges can be avoided or handled more expediently if the committee and the clinic are prepared for them. For example, insufficiently consolidated storage of patient records, even though they can be accessed from anywhere, can cause confusion. Inadequate training or an overly granular electronic

workflow manager can cause inefficiency and disrupt workflow. Also, the electronic approval system may be troublesome if it is overly restrictive or not sufficiently adaptable. Most importantly, the transition to electronic charting fundamentally alters the workflow, communication, and QA paradigms of the clinic. Guidance can help a facility's committee identify a suitable RO-EMR system, transition and implement it in a way that supports efficiency, and does not compromise patient safety due to excessive confusion, ineffective workflows, inadequate/incorrect documentation, or poor communication.

## 1.1 | Charges of the task group

The charges of task group 262 are as follows:

1. To provide guidance in the administration, design, and implementation of electronic charting for simulation, planning, and treatment using external beam radiotherapy and brachytherapy.
2. To provide guidance in maintaining safe clinical processes and communication when designing an electronic charting system—both during the transition to the new system and once the system is implemented.
3. To provide guidance in implementation and management of electronic charting in the context of other systems in the clinic and other programs in the hospital (billing, IT, medical records).
4. To provide a list of desired features for a robust electronic charting system and warn of potential pitfalls based on accumulated clinical experience.

## 1.2 | Methods and materials

An extensive literature search on electronic charting found that data on good clinical practice in electronic charting for radiation oncology were scarce. Therefore, in order to formulate consensus guidelines for this report, the task group carried out two surveys of current clinical practice:

1. TG 262 member survey: A survey of task group members on their RO-EMR practice (12 respondents)
2. AAPM member survey: A survey of the AAPM membership on their RO-EMR practice (421 respondents)

The two surveys are briefly described below.

### 1.2.1 | TG 262 member survey

The TG 262 member survey consisted of 150 questions developed by task group members. The format of the survey included both open-end and multiple-choice questions. A total of 12 respondents (three from community centers, eight from academic centers, and one from a government center) completed the survey and results were collected and summarized.

The task group members were evenly divided between the two major commercially available systems at the time (ARIA™, Varian Medical System, Palo Alto, CA and MOSAIQ™, Elekta, Sunnyvale, CA). Respondents reported having between 2 and 22 linear accelerators in their clinics, and all provide a range of brachytherapy and nonstandard treatments.

### 1.2.2 | AAPM member survey

The most relevant questions from the TG 262 member survey were selected and adapted for a survey of AAPM membership on their RO-EMR practice. Question formats were made more consistent with only sparse-free response questions to ensure brevity. Responses from 421 AAPM members (including task group members) were received. The AAPM membership survey was divided into six subsections:

1. Demographics
2. Implementation and QA
3. Information Storage and management
4. Workflow
5. Brachytherapy and nonstandard treatment devices
6. IT infrastructure

Survey respondents were divided between small clinics (<50 pts/day- 45%), medium clinics (51–100 pts/day-31%), and large clinics (>100 pts/day- 24%). Most respondents (98%) used one of the two major commercially available charting systems in use at the time of the survey (ARIA™, MOSAIQ™). The rest used either in-house systems or other commercial systems (LANTIS™, Oncochart™, IKnowMed™). Respondents were from the United States (89%), Canada (4%), and other countries (4%). Forty-seven of 50 states were represented by at least one respondent; Alaska, Hawaii, and Nebraska did not have respondents. The five states with the most respondents were California (30), Texas (24), Florida (23), New York (20), and Pennsylvania (20).

Results of the surveys were collated and reviewed by the task group members. Task group members were divided into subgroups aligned with the subsections of this report. These subgroups independently formulated recommendations related to their topic based on survey results, available literature if any, and group consensus. The full list of recommendations was then reviewed by a panel consisting of the leaders of each of the individual subgroups in a face-to-face meeting.

### 1.3 | Structure of this report

The report presents recommendations of each of the subgroups, followed by a list of recommendations to the vendors developed by the panel of subgroup leads.

Rather than providing detailed instructions for configuration and use of existing RO-EMR systems, the task group provides general guidelines for configuration and management in key areas of the RO-EMR experience. This is primarily for two reasons:

1. The scope of the task group is too large and detailed recommendations for various software systems would make the report excessively long.
2. Commercial electronic charting systems do not share a consistent configuration except that they contain functionality for storing information and managing workflow. These systems are constantly changing and an overly specific report at this stage of their development would have a higher chance of becoming obsolete within a few years.

Each section consists of an introduction followed by recommendations with brief explanations and supporting documentation. The exception is Section 7 on Brachytherapy and Nonstandard Devices, which describes an application of electronic charting that is not as developed as that for external beam therapy. This section begins with a broader birds-eye view narrative of the topic followed by a list of specific recommendations. Specific recommendations in the body of the report are in boldface and Section 2 lists a summary of all the recommendations for quick reference.

The focus of this report is the Radiation Oncology electronic medical record (RO-EMR) which has two primary functions: storing information related to the patient's treatment and managing workflow within the radiation therapy department. Many clinics and hospitals also use a separate Hospital Electronic Medical Record (H-EMR) which is not dedicated to radiation oncology. H-EMRs are beyond the scope of this report.

## 2 | SUMMARY OF RECOMMENDATIONS

This section summarizes the recommendations of the task group for quick reference. Please refer to the body of the report for discussion and rationale of each recommendation.

### 2.1 | Implementation

1. Form a multidisciplinary committee to manage the implementation of the electronic chart.
2. The implementation committee should include representatives from all stakeholders.
3. The committee should consist of five and 10 members based on clinic size, with possible exceptions for larger institutions. Hospital networks sharing an RO-EMR should make sure there is representation from satellite sites such that any differences in workflow are taken into account.
4. Having a physician champion is highly recommended. Having a project manager is also highly recommended.
5. The implementation committee should clearly define the goals of the RO-EMR system and milestones in the implementation process at the outset and allocate sufficient time for each.
6. Protected time for committee members and adherence to upfront deadlines is recommended for a timely rollout and proper implementation.
7. The committees should create a list of priorities for their systems gleaned from a variety of resources to present to vendors when choosing a system.
8. A test environment should be maintained for the implementation and for ongoing testing.
9. A carefully designed and time-limited pilot or transition period between charting systems is recommended for successful implementation of a new RO-EMR. The transition period should be no longer than 6 months.
10. “Champions” should be identified for initial training to facilitate a smooth transition.
11. Competency assessment upon the completion of training should be considered to ensure all staff have the knowledge to efficiently and effectively use the new electronic charting system.
12. Ongoing training by the training team should be considered when new staff are onboarded, during software upgrades, and during introduction of new technology.

### 2.2 | Acceptance testing and QA

1. A vendor representative should be present for the initial use of the system to troubleshoot any early issues associated with clinical implementation.
2. Use of the system should be monitored by the implementation team during the initial clinical rollout. Any issues raised by users should be addressed by the team in consultation with the vendor.
3. After implementation of the RO-EMR is completed, an RO-EMR management committee should be formed to manage the system and perform requested amendments.
4. Establish a QA program to determine if the RO-EMR is up to date with clinical developments and to determine when improvements can be implemented.

5. In addition to developing a QA program for the management and maintenance of information and workflows, it is essential to develop a QA and QC program to test the interconnectivity between the RO-EMR and other systems within the facility, including H-EMR, treatment planning system (TPS), delivery systems, and other supporting information systems.
6. Automation and standardization should be leveraged to the extent possible in the electronic charting system as an error prevention tool.

## 2.3 | Information management

1. User group rights in the RO-EMR should be configured to the extent possible to reflect the approval rights paradigm of the clinic and regulatory requirements.
2. Only attending physicians should be given rights to approve prescriptions. Editing rights without approval should be offered as sparingly as possible to satisfy regulations but enough to not disrupt the clinical workflow.
3. Plan documentation in the RO-EMR should be consistent with treatment and be updated any time a plan is revised, prior to the next treatment.
4. RO-EMR software may have built-in features to inhibit treatment if an embedded prescription is amended after treatment commences. Users should take advantage of these functionalities when possible and practical.
5. When designing documents for the electronic chart and choosing a native storage format, the implementation committee should consider the format, input, efficacy, scope, traceability, and accessibility (FIESTA) of the document.
6. When possible, chart elements should be stored using native storage functionalities of the system.
7. Forms, or structured documents designed for the RO-EMR system, should be used for consistency whenever possible.
8. Document repositories in RO-EMR systems should be configured consistently for all users such that documents are easily identifiable and categorized appropriately to prevent errors.
9. Documents should be sorted and categorized consistently if possible. Clutter should be minimized and the number of documents should be minimized.
10. Avoid using free-text notes “for lack of a better place.”
11. It is the responsibility of all users to use the chart consistently with respect to entry of information, both in terms of where and how the information is entered. Redundancy should be minimized.
12. To the extent possible, consistency in documentation entry should be enforced.
13. Electronic signatures should be used where clinically appropriate and be sufficiently secure to adhere to local regulations. They should be easily accessible for audits by regulators, credentialing bodies, billing compliance personnel, and other entities.
14. When choosing a signature format, the most efficient method that satisfies regulatory requirements should be used.
15. To the extent possible, forcing functions should be employed to enforce proper practice in completing documents.
16. Simulation orders should clearly reflect site-specific procedures and avoid superfluous information.
17. Users should take advantage of the capabilities for prescribing that are provided by the RO-EMR.
18. The task group recommends that vendors and clinics join to make prescriptions “smarter” by making prescription parameters sufficiently flexible, capitalizing on the ability to mine data in an electronic prescription, and by checking the prescription for self-consistency and against the treatment plan.
19. An explicit prescription check should be performed as the first part of a chart checking process.
20. Treatment plan documentation should be accessible for easy internal review as well as documentation for outside institutions or departments when requested.
21. Checklists and similar tools within the RO-EMR should be used to provide a systematic and comprehensive approach to ensure standardized patient care, thereby decreasing errors and improving patient workflows.
22. The RO-EMR should be used to communicate special circumstances including but not limited to pregnancy, prior radiation, radiation-sensitive implanted medical devices, allergies, and infectious diseases.
23. Special circumstances should be documented using forms where possible to ensure consistency.
24. A system should be put in place to capture and appropriately document incomplete treatment sessions or courses on documentation in the RO-EMR, either automatically or manually via standard QA checks.
25. The treatment history of the RO-EMR should be checked for accuracy in the event of an incomplete treatment.
26. A process should be in place to detect save-back failures (the failure of treatment records to be saved back to the RO-EMR history) of the treatment history.
27. Changes in the treatment course such as early completion of treatment should be documented with a valid attending physician signature if they deviate from the prescription as originally written.
28. A department should have procedures for using the RO-EMR for emergency and urgent cases in an efficient, safe, and consistent way.
29. Chart reviews (plan checks, weekly chart checks, end of treatment checks, etc) should be documented electronically in the RO-EMR.

30. A clear procedure should be in place for preparation and transmission of patient records to outside institutions.

## 2.4 | Workflow and communication

1. The committee should establish process maps before configuring the workflow manager.
2. When designing the workflow, the committee should consider the following for each task: Who, What, When, How, Why, hard or soft stop, and possible risks.
3. Documentation such as checklists should be linked by the system to workflow tasks when possible.
4. Safety barriers should be established to prevent simulation without completion of an accurate simulation order.
5. The institution should incorporate prescription entry as one of the workflow tasks; consider when it should be entered initially, and the proper time frame to finally approve it.
6. If a third-party prescription application is utilized, a system of checks needs to ensure the consistency of information and proper data transfer with the primary RO-EMR to prevent possible discrepancies between two different systems.
7. When the RO-EMR is used for billing purposes, automated charge capture should be used if available.
8. Formalizing the process of releasing workflow management tools (discussion by RO-EMR management committee, pilot and formal release with proper notification) is recommended to prevent potential errors or unanticipated clinical inefficiencies.
9. Clinics should utilize task completion metrics and feedback from different clinical groups to refine RO-EMR workflows as part of ongoing QA.
10. The clinic should establish clear consensus on the channels for transfer of specific types of time-sensitive information and enforce its use.
11. Implementation committees should focus on known lapses in communication in the workflow development phase to ensure that the clinical workflow design is robust against these sort of unexpected changes in care.
12. “Handoffs” and “handshakes” should be clearly identified for different types of communication
13. User interfaces should be standardized within the same user group.

## 2.5 | Brachytherapy and nonstandard devices

1. If mobile devices are not permitted in the OR, a paper-written directive may be used, which should be scanned into the RO-EMR in a timely manner after the completion of the procedure. The scanned electronic document should be stored in a consistent location and with clear labeling in the RO-EMR.
2. For an electronic-written directive, the history of the written directive should be easily accessible to users of the RO-EMR. Historical versions (which should be saved within the RO-EMR) should include the date, time, and electronic signature of the directive. Any changes or amendments to the written directive should follow regulations and be documented appropriately.
3. Each Radiation Oncology Department should develop policies and procedures (P&Ps) defining how electronic signatures are to be validated.
4. The availability, cost, and functionality of the RO-EMR connectivity software should be assessed for existing nonstandard devices and prior to purchase of new nonstandard devices and brachytherapy afterloaders.
5. The RO-EMR implementation committee should include representatives from all stakeholders *working with the nonstandard devices*.
6. For all devices, the prescription should be entered and signed in a similar method as for standard devices.
7. For all prescriptions, the applicable federal, state, and local regulations pertaining to the written directive should be followed. Note that paper format for the written directive is typically used when electronic records are not available, such as in the OR, or when regulators still require paper documentation
8. Plan documentation should be exported as file and imported into the RO-EMR. If this is not possible and documentation is needed, then it can be printed and scanned.

## 2.6 | IT Infrastructure and management

1. Discussions regarding the IT infrastructure should include members of the clinical team as well as medical physicists since they will be responsible for highlighting the needs of the practice.
2. Medical physicists should familiarize themselves with the terminology, technical concepts, and main issues regarding the architecture and management of the IT infrastructure.
3. While the task group does not recommend that the medical physicists assume primary responsibility for the IT infrastructure and support for the RO-EMR, it is important that medical physicists be part of the ongoing decision-making process.
4. Clinical needs, institutional restrictions, and constraints need to be clearly defined when building the IT infrastructure for the RO-EMR environment.
5. Disaster recovery, and when possible, high availability solutions are essential when designing failover processes for the RO-EMR.

6. Clinics should have a system and processes for disaster recovery (i.e., backups) as well as processes to validate those backups. A monitoring system is also recommended, either automated or manual, to verify that the backup process took place.
7. Each practice should determine the amount of downtime that the clinic can accept and implement a HA and/or DR solution that meets those needs.
8. Mobile device connectivity must be secure. Users must evaluate mobile platforms for compatibility with all accessible electronic chart functions. If a mobile devise is used for image review, the screen size and resolution must be appropriate.
9. Manual or automated processes should be in place to monitor the growth of the RO-EMR database and ancillary storage devices and warn the IT team that more space is needed.
10. Usage and storage capacity should be monitored on a real-time basis to warn the administrators of near capacity storage and provide time to amend system.
11. Clinical teams need to be aware of information security threats and work with both the department/institutional IT teams and the vendor to mitigate this risk.
12. It is important that the medical physicists partner with institutional and departments IT teams as well as vendors to mitigate the risks and prevent data breaches in radiotherapy both to maintain adequate security and to protect the integrity of the RO-EMR system.
13. The Clinical team should consider including a test environment as part of the RO-EMR environment deployment and design strategy.
14. Dual monitor setup should be a minimum standard with adequate screen resolution to support all of the RO-EMR functionalities as specified by the vendor.
15. Members of the clinical team should become familiar with and partner with IT team members to develop application services that optimize the connectivity among systems as well as data collection and analytics from the RO-EMR environment and other information systems.
16. Clinical team users should be familiar with the robustness and potential risk of running database queries on clinical production systems.

### 2.7 | Challenges and future improvements for both users and vendors

1. The task group recommends a continued focus on automation.
2. The task group recommends that checklist functionality be enhanced.
3. The task group recommends that approval mechanisms be enhanced, including consideration of more granular approval mechanisms such as approval at the field level of a document or template.
4. The task group recommends that online interactive versions of their software be available for testing and training.
5. Configuration of document repositories should be flexible and customizable so that clinics can display the documents in a way that works best for them.
6. The task group recommends that communication tools within the electronic chart be enhanced based on input from industry experts, clinicians, and researchers.
7. The task group recommends that flexibility of workflow managers should be increased to adapt more easily to the wide range of workflows in practice. Workflows should be more efficient by more tightly integrating the virtual task in the workflow with the work in the system that it represents.
8. The task group recommends that tools be made available to acknowledge communications electronically.
9. The RO-EMR should allow for the concurrent use of different workspaces and minimize the need to open an excessive number of windows.
10. Communication between the RO-EMR and H-EMR as well as between RO-EMR systems and nonstandard systems should be improved.
11. Vendors should design the RO-EMR database in a standard database format such as Structured Query Language (SQL). Users should be provided with information of the database structure and access to the database for data analysis and data mining. A feature-rich API should be available.
12. Databases should be sufficiently robust to queries.
13. Vendors not currently pursuing modules and components to support interfaces with nonstandard systems should consider doing so, or alternatively provide the user information on their interface module so that users could develop their own interfaces.

## 3 | IMPLEMENTATION OF THE RO-EMR

The first and arguably the most important step in successful RO-EMR deployment is the configuration of the RO-EMR system for the clinic. A carefully structured implementation is essential to maximizing the benefits in efficiency and safety afforded by the RO-EMR system as well as to ensuring acceptance of the new system by clinicians and other stakeholders. A number of references describe implementations at various institutions,[11-13,16-19] and the TG 262 member survey and AAPM member survey undertaken by this task group provide a glimpse of the current practices in the community.

This section provides recommendations for safe and efficient implementation of an electronic charting system. It is accepted that this task group was initially motivated by the sometimes onerous and challenging transitions of task group members from paper to electronic charting. It is also accepted that the majority of institutions have transitioned from paper charting to electronic charting at the time this report is released. However, the task group believes these guidelines remain relevant. Many institutions switch systems or have to adopt a second RO-EMR at one of their clinics. Also, groups may choose to overhaul their existing RO-EMR system and need a structured roadmap for the process.

## 3.1 | Committee team and size

**The task group recommends that a multidisciplinary committee be formed to manage the implementation of the electronic chart**. A dedicated committee for the implementation of an electronic chart spreads ownership of the chosen RO-EMR system and engages all stakeholders to efficiently work together to more rapidly implement its proper setup and ensure training of all necessary colleagues.[11]

**The task group recommends that the implementation committee include representatives from all stakeholders**. Team representation may include members from the relevant subspecialties: physicists, therapists, dosimetrists, nurses, MDs, residents, administrators, IT, vendor, engineers, and those who work with nonstandard devices. Everyone should have a clearly defined role in the committee, primarily as the representative of their particular clinical subspecialty or as an administrative or vendor representative. Finally, a multidisciplinary team is more likely to include institution-wide priorities and goals from the onset and increase satisfaction.

The number of team members depends on the size of the clinic. Some clinics commonly have some staff members serve multiple roles; for example, nurses in a smaller clinic may perform follow-up visits and participate in certain aspects of the simulation process, whereas residents in a larger clinic may be involved in these duties. Representation from these areas should be proportional to the clinic size. **The task group recommends a committee size of between five and 10 members; larger institutions (i.e., those with broader clinical teams including residents, dedicated radiation oncology IT, and others who expand the pool of representation required on the committee) may require larger committees to manage the workload. Hospital networks sharing an RO-EMR should make sure there is representation from satellite sites such that any differences in workflow are taken into account**.

The committee should gather input from the various clinical groups through their representatives on the implementation committee, including ancillary staff who might not be responsible for task completion but still are critical to the process. This broad input has been shown to facilitate increased compliance from the team and quick adoption of the system.[18]

**Having a physician champion is highly recommended**. **Having a project manager is also highly recommended**. The physician champion can play a vital role in "buy-in" from the clinic and the project manager can keep the team on schedule and monitor the need for resources as the implementation progresses. The Medical Physics Leadership Academy has provided training on project management at past meetings.

## 3.2 | Definition of goals and milestones of the RO-EMR system

**The implementation committee should clearly define the goals of the RO-EMR system and milestones in the implementation process at the outset and allocate sufficient time for each.** The task group suggests the following milestones for consideration when formulating an implementation plan. Not all may be relevant to all clinics.

- Definition of roles and responsibilities for members
- Formulation of a timeline. The implementation team should provide periodic updates to the relevant administrative bodies and clinical leads through the process. The schedule of these updates should be included in the timeline and correspond with scheduled milestone dates.
- Definition of goals for the RO-EMR system: A discussion by team members on the expectations for the RO-EMR in consultation with the clinical stakeholders can provide a framework on which to move forward with the design and transition. Some general goals and expectations may include:

**a.** Expectations for ease of use in various procedures
**b.** Comprehensive information storage with easy accessibility
**c.** A clinically efficient workflow which minimizes redundancy except where needed for quality assurance and distills the number of steps to complete each task to the minimum required with extraneous steps removed
**d.** A robust IT infrastructure which maintains sufficient uptime and provides adequate disaster recovery such that the clinical operations are not significantly affected and patient information (data) is not jeopardized. The clinic should decide on a maximum acceptable downtime and design/invest in an IT infrastructure to provide that.

**e.** Adequate support for users—this should be prescribed by the required response time at different hours of the day (during treatment, after treatment, and weekends) and for different clinical activities (simulation, treatment planning, treatment, status checks, QA checks, etc).
**f.** A well-planned transition with well-defined start and endpoints and stages clearly mapped out. A feedback mechanism should be in place such that superusers and champions can monitor progress and make changes if necessary.
**g.** Appropriate level of training—the required training will differ depending on role. A program should be designed such that each member of the clinical team is trained on the basic components of the RO-EMR as well as provided more detailed training on the specific components relevant to their workflow. Training should also be provided for updates to the system as they pertain to different members of the clinical team. Finally, retraining/refresher training should be considered for those who may not use the system for a given period of time, for example 6 months or 1 year.

- Choice of RO-EMR system
- Configuration of the test environment for end-to-end tests and pilot studies
- Configuration of the IT infrastructure, including backup and disaster recovery, consistent with the goals of IT infrastructure robustness defined above
- Creation of user groups and assignment of security roles (see Section 5.1.1). Information storage regarding user rights assignment
- Demarcation between hospital H-EMR and RO-EMR—what documents will be stored in each? How will the two systems communicate?
- Design of forms (refer to the design guidance provided in Section 4. Information Storage)
- Configuration of the workflow management software, if any (refer to the workflow guidance provided in Section 5—Workflow management)
- Establishment of procedures for ad hoc events that are not part of the standard workflow such as replanning due to treatment-related changes or chart rounds, bolus placement, etc
- Establishment of communication channels for clinically relevant information
- Configuration of the billing infrastructure, if it exists
- Writing procedures and making them easily available everywhere the RO-EMR is accessed.
- Delegation of superusers/champions for support and training
- Planning of training for initial rollout and transition period
- Formulation of ongoing QA policies and procedures—see Section 4
- Delegation of a team to manage ongoing chart maintenance/modifications/upgrades—see Section 4

## 3.3 | Project timelines and protected time

**Protected time for committee members and adherence to upfront deadlines are recommended for a timely rollout and proper implementation**. Time should be available for meetings of the implementation team and work between meetings. The task group recommends 10–20% protected time for RO-EMR design as a reasonable goal for clinical members of the implementation team. The bulk of the effort at surveyed clinics was spent on the areas of the development of processes and configuration of the RO-EMR.

An estimate of percent effort required for the five major phases of RO-EMR design based on the AAPM survey is given in Table 1. This can be used as a starting point for planning the transition roadmap. Implementation times depend on department size and resources, among other factors. Also given is a rough estimate of the range of time to budget for each step based on results of the TG 262 and AAPM surveys.

## 3.4 | Resources for comparison of charting systems

When assessing which charting system is appropriate for a particular clinic, a variety of resources should be considered and used. Table 2 summarizes factors that can drive RO-EMR selection. **The task group recommends that implementation committees create a list of priorities for their systems gleaned from a variety of resources to present to vendors when choosing a system**.

When visiting another facility to observe their RO-EMR system, it is helpful to have questions prepared. Some applicable questions adapted from the AAPM member survey are provided in Appendix B.

**TABLE 1** Estimate of percent effort for various steps in the RO-EMR implementation timeline

| Tasks | Average % of total time (duration of effort) | Estimated time to budget (months) |
|---|---|---|
| Software selection | 10% | 1–4 |
| Process Development | 30% | 4–6 |
| Configuration | 25% | 3–4 |
| Training | 20% | 1–3 |
| Go live | 15% | 1–2 |

**TABLE 2** Factors that can drive RO-EMR selection ranked by prevalence in the AAPM member survey

| Method | Percentages |
|---|---|
| RO-EMR already in use as our record and verify system | 23% |
| Vendor presentations at your facility | 21% |
| Consulting with colleagues in other clinics | 16% |
| Visiting other clinics | 13% |
| Conversation with vendors during national meetings (e.g., ASTRO, AAPM, etc.) | 13% |
| Virtual or testing system provided by the vendor to your institution | 10% |
| Other / unknown | 4% |

## 3.5 | Test environment

**The task group recommends that a test environment be maintained for the implementation and for ongoing testing.** Having access to a test environment during RO-EMR configuration and prior to the installation of the clinical system is common and provides a platform to test configurations, test documents, and workflows, and to provide initial and ongoing training. It is equally valuable in the implementation process and for ongoing management for the same reasons.

## 3.6 | Pilot or transition period

**A carefully designed and time-limited pilot or transition period between charting systems is recommended, when possible, for successful implementation of a new RO-EMR**. Although a transition period is not mandatory, the consensus of the task group is that a set time frame be established for this process to keep the clinic on task with regard to phasing out the old system. Furthermore, additional resources such as champions and superusers can be more easily allocated for a definite time period rather than in an open-ended transition. In the survey of AAPM members, those most satisfied with the initial transition from paper to electronic charting had an average transition period of 6 months and those either satisfied or neutral had average transition periods of approximately 10 months. Longer transition periods were not as common and were associated with lower overall satisfaction with the transition. **The task group recommends a transition period no longer than 6 months when changing from one system to another (whether paper to electronic or electronic to electronic)**. If the old and new systems are independent of each other (such as would have been the case if transitioning from paper), transitions should be organized in such a way that users know which system to use in which circumstance. For example, a subset of physicians could be chosen to adopt the new system during the transition period to work out the "kinks"—this is more of a pilot type transition. The transition period, if there is one, should not be used if it creates more disruption than a clean break from the old system. If a transition period is impossible, then adequate training and preparation as well as appropriate support after go-live is critical for success.

## 3.7 | Transition and Training

**"Champions" should be identified for initial training to facilitate a smooth transition.** The training team should include representatives from each clinical group, preferably a subgroup of the implementation committee. The training process begins with the vendor preinstallation as well as during the installation of the electronic charting system. Subsequently, the champions are the key individuals that continue the training process to support staff collaboratively. **Competency assessment upon the completion of training should be considered to ensure all staff have the knowledge to efficiently and effectively use the new electronic charting system**.

**Ongoing training by the training team should be considered when new staff are onboarded, during software upgrades, and during introduction of new technology, or when a significant deviation has occurred and led to an unexpected result**.[13,19,24]

## 3.8 | Ease of transition and "buy-in"

Support is critical for a successful implementation.[25] The task group has identified three critical components necessary for a successful transition. First is the importance of a detailed project plan which needs to be communicated to the entire department to ensure buy-in throughout all phases of conversion to a new system. Second, there needs to be champions or superusers who utilize the new system first, as cited above. By having these champions use the new system first, most if not all patient workflow processes will be familiar to the other clinical staff members when it is their turn to use it. Lastly, it is imperative to have a clear process for addressing concerns or enhancements of workflows as the clinical staff uses the new system.

# 4 | ACCEPTANCE TESTING AND QA OF THE RO-EMR

Periodic QA of electronic charting is not standardized as of the writing of this report. Therefore, the task group

recommends the following guidelines for acceptance testing and ongoing QA of the RO-EMR.

## 4.1 | Acceptance testing and commissioning

Radiotherapy departments are becoming more and more complex with potentially many connected systems comprising the suite of clinical software and potentially interfacing with the RO-EMR. In addition, replacing or upgrading an existing system is a complex process because the patient treatment process should experience minimal interruption while a safe and smooth transition from the old system is carried out. Acceptance testing and commissioning is therefore recommended for the RO-EMR as with any major clinical system. IAEA HHR No.7[20] and IEC 62274ED.1.0[21] provide a comprehensive test list for R&Vs, some of which are also relevant to RO-EMR systems. The task group has created a list of recommended acceptance criteria adapted from the IAEA and IEC recommendations with additional items specific to document repositories and workflow managers. These criteria are listed in Appendix A.

Commissioning of RO-EMR systems does not occur in the same sense as it would for a treatment machine or treatment planning system. One does not gather data to enter into the system in the same sense that one measures depth dose and profiles for a treatment planning system. The RO-EMR is configured for use and much of this task group applies to that process. Therefore, we recommend that users refer to the guidelines in this report for configuration.

As recommended for R&V systems in the IAEA and IEC reports, **it is recommended by the task group that a vendor representative be present for the initial use of the system to troubleshoot any early issues associated with clinical implementation. It is also recommended that the use of the system be monitored by the implementation team during the initial clinical rollout and that any issues raised by users be addressed by the team in consultation with the vendor**.

## 4.2 | Ongoing management of the system

**After implementation of the RO-EMR is completed, the task group recommends that an RO-EMR management committee composed of clinical stakeholders be formed to manage the system**. The group should have well-defined roles and responsibilities and meet periodically. This RO-EMR management group should be responsible for approving and implementing modifications to the RO-EMR system, updating written policies and procedures, addressing concerns/suggestions, and for ongoing user management, such as activation/deactivation of user accounts, and verification of appropriate training.

## 4.3 | QA program

**The task group recommends that a QA program be established to determine if the RO-EMR is up to date with clinical developments and to determine when improvements can be implemented**.

Ongoing QA is essential to ensure that the RO-EMR system is still serving the needs of an evolving clinic. To ensure that the RO-EMR remains current and is functioning optimally, we recommend that a set of predefined use cases across the range of treatment techniques be reviewed at least yearly to determine the following:

- Are general policies and procedures for access and use of the RO-EMR being observed?
- Are existing forms up to date with respect to clinical processes?
- Are new forms required for new processes?
- Are there forms that should be retired?
- Are forms being used as per policies and procedures, that is, are they being filled in properly, are they being signed by appropriate personnel, and are they being reviewed if necessary?
- Is the workflow manager up to date with respect to current clinical practices?
- Are there new clinical processes requiring integration into the workflow manager?
- Are there any processes in the workflow manager that should be refined or retired? (See Section 6.8.)
- Is the workflow manager being used properly as per policies and procedures, that is, what is the compliance rate of electronic task completion? Are appropriate personnel interacting with workflow tasks in the system?
- Have any near misses or adverse events been reported in the hospital incident reporting system related to the RO-EMR or are there changes to the RO-EMR that can help prevent one?

Assessment of the aforementioned situations is consistent with recommendations of credentialing bodies to review policies and procedures each year and can be considered part of the ongoing review process.[26]

There are also some special circumstances when ad hoc QA should be implemented[18]:

- Software/hardware updates of the RO-EMR system—basic functionality tests should be performed (see Section 4.4)
- Introduction of new technology—basic accessibility and functionality tests should be performed and workflows should be assessed

- Any modification of network infrastructure—basic accessibility and functionality tests should be performed
- In response to a significant adverse event or near miss

**In addition to developing a QA program for the management and maintenance of information and workflows, it is essential to develop a QA and QC program to test the interconnectivity between the RO-EMR and other systems within the facility, including H-EMR, Treatment Planning System (TPS), delivery systems, and other supporting information systems**. The process of developing and implementing a connectivity QA and QC program has been well outlined and described by Siochi et al. in the upcoming report of TG 201, "Quality Management of External Beam Therapy Data Transfer." Their recommendation follows the TG 100 approach,[27] and provides a framework that each facility can follow to perform their own safety and risk evaluation, which in turn will guide the selection process of the necessary connectivity QA and QC tests as well as their corresponding frequency. As part of TG 201 framework, they highlight that a first step is for each facility to map and understand their IT infrastructure, IT and IS configuration and corresponding system dependencies. Then, in order to perform the risk analysis, they proposed the utilization of two tools: Data Transfer Matrices and Fault Tree Analysis. Providing a full description of the risk analysis, connectivity, and data transfer tests is beyond the scope of this task group. However, it is important to emphasize the need of developing an interconnectivity QA and QC program when implementing a RO-EMR and TG 201 provides a baseline of tests that at minimum should be performed annually and for any upgrades of the system.

## 4.4 | Software Upgrades

Software upgrades require extensive preplanning because they may also involve the record and verify system and the TPS in addition to the RO-EMR. Therefore, upgrade preparation for the RO-EMR may occur in concert with preparation for upgrades of other components of the OIS. Database migrations may be a part of the upgrade which can fundamentally affect clinical processes plus multiple vendors may be involved. Finally, upgrades often take place on a constrained schedule (such as over a weekend), consequently detailed preparation well in advance of the upgrade is essential.[15] A detailed description of the upgrade process for the OIS in general is beyond the scope of this task group; however, for the RO-EMR in particular:

1. Training should be performed for all clinical stakeholders in all new and modified features.
2. A test system should be used to
   a. evaluate new features
   b. test basic functionality of the information storage system—can documents be created, opened, edited, closed? Can document templates, questionnaires, and checklists be created and implemented properly?
   c. test basic functionality of the workflow manager—can tasks and workflows be created and implemented as they are in the clinic
   d. test the integrity of migrated information (documents, data tags, etc) if the upgrade involves a database migration
   e. confirm connectivity with other systems (see recommendations for interconnectivity tests above)
   f. test accessibility of information by members of the clinical team.
3. Standard QA of the RO-EMR described in Section 4.3 should be performed.
4. The RO-EMR workflow manager can be used during the upgrade to guide specific processes such as patient data review. For example, if the upgrade involves the record and verify system, one of the steps in the upgrade workflow could be the moding up of the patient plan at the treatment machine.
5. Documentation of upgrade tests for patients on treatment can be stored in the RO-EMR via a patient note, completion of a task, or completion of a questionnaire or checklist. This documentation can be reviewed as an audit of the upgrade process, for example therapists can be instructed to confirm the presence of upgrade check documentation for all patients prior to the first treatment after the upgrade, plus this documentation can be reviewed in subsequent weekly chart checks by therapists and by medical physicists.

As stated earlier, upgrades of the RO-EMR do not typically occur in a vacuum and are often part of a larger OIS upgrade. We have only focused on the RO-EMR here in terms of what to check and how the system can be used to document checks. More comprehensive recommendations can be found in the literature.[15]

## 4.5 | Automation and standardization

**Automation and standardization should be leveraged to the extent possible in the electronic charting system as an error prevention tool.** This can be accomplished through the use of templates, document indexing, statistical process control via customizable reporting tools that come with the system or through an application programming interface (API), and protocols

such as checklists or questionnaires. Independent double check systems for ease of performing physics QA should also be considered. Forcing functions[27] or hard stops within the electronic chart should be used when possible. Lastly, to aid in error prevention, the administrator of the RO-EMR system should if possible automate notifications of outstanding, unscheduled, or unapproved items to ensure adequate compliance and take advantage of the reporting systems of the RO-EMR to the fullest extent possible.

Automation should also be utilized to minimize manual data entry and transcription of information. Redundancy should be minimized (see Section 5.1.5); if possible, it is ideal if data are entered once and visible in multiple modules rather than expecting users to maintain and enforce consistency of redundant entries.

## 5 | INFORMATION MANAGEMENT

Patient documentation usually is used for one or more of the following purposes: a record of treatment decisions (e.g., plan) or status (e.g., weekly physician's note) for future review and for charge capture, reference for future use by other sites that may provide additional treatment, and for reviews by accreditation or legal/regulatory agencies. Typical types of documentation found in RO-EMR systems are listed in Table 3. An important consideration in the design of forms is how data are entered and how it is stored in the system. Regarding data entry, consideration should be given to whether the form is templated (i.e., all users see the same blank form) or not, that is how much guidance/restriction that the user encounters in filling out the form. Should only certain values be allowed? What functionalities exist within the system to enforce limitations in what can be entered? Is free text required for certain types of information?

Regarding storage, consideration should be given to whether the data entered into the form are queriable. Queriable data can be used to create reports or to populate other parts of the chart (e.g., patient name, ID, and diagnosis). Data that are entered in a templated fashion may not necessarily be queriable due to limitations of that form, the template may simply serve to guide the data entry. Therefore, templating and queriability should both be considered independently when designing forms, since one does not necessarily imply the other. Templating is desirable in terms of the format of the form being consistent, while queriability/minability is desirable in terms of how data are entered and stored on the form.

Table 4, which is a snapshot of current practices, reflects the variety of ways in which RO-EMR documentation elements are utilized.

Documentation plays an important role in charge capture, external chart requests, and error investigation. A common practice is to automatically capture charge codes using an electronic task tied to an activity capture system. Most descriptions of radiotherapy errors rely directly on the documentation record of the prescription, plan, and treatment.[28]

### 5.1 | Matched user group rights and approval rights

**User group rights in the RO-EMR should be configured to the extent possible to reflect the approval rights paradigm of the clinic and regulatory requirements.** Write access to documents requiring approval such as the prescription can be managed by user rights assignment. These rights are commonly administered through the creation of user groups within the RO-EMR system. In creating these groups, the implementation committee should carefully consider the roles and responsibilities of the different clinical team members, so groups with different editing and approval roles are separated to the greatest extent possible. Editing rights of prescriptions and other such documents should be structured such that they are available only to those whose responsibilities are to edit these documents and no more. This setup leverages the approval power of the system to enforce the roles and responsibilities of the clinical team.

Practices vary as to which users can “touch” a prescription and a variety of workflows are possible for the prescription process. **The task group recommends that only attending physicians be given rights to**

**TABLE 3** Types of documentation

| Type | Method | Examples |
|---|---|---|
| Parameters | Direct input and display through the RO-EMR graphical user interface | Demographic information, planned couch coordinates, actual couch coordinates |
| Template form | Embedded word processing document | Treatment summary, physics consult, simulation document |
| Free text document | Embedded word processing document | Consult, treatment plan document |
| Checklist | Native format in the RO-EMR | Weekly chart check |
| Questionnaire | Native format in the RO-EMR with stored data elements | Physicist plan checks |

**TABLE 4** Documentation categories and examples of elements currently seen in practice

| Document Categories | Examples |
|---|---|
| Patient demographics | Typically the patient's full name, date of birth, gender, address, and phone number. It may additionally include doctor information and SSN, legal guardian, emergency contact information, DNR, and health insurance information. |
| Diagnosis | One or more ICD−10 codes. |
| Consult note | Typically contains diagnostic imaging evaluation, lab test results, history and physical evaluation, leading to an impression, plan, and informed consent. |
| Simulation Order | Instructions from the physician as to site, desired immobilization, orientation, etc., necessary to carry out the simulation. May also contain prescription and imaging information that aids in assignment of a treatment unit. |
| Prescription / Directive | Dose per fraction, number and frequency of fractions, total dose, energy, modality, imaging, dose constraints, special instructions. |
| Treatment Planning Directive | Treatment planning information that may not be explicitly indicated on the prescription such as planning goals. This may or may not be signed. |
| Simulation document | Setup instructions (e.g., immobilization) and photos, bolus, imaging parameters (number of slices, kV, mAs, slice thickness), special notes (e.g., bladder full/empty, Gating/DIBH notes), contrast media. |
| Physics Consults | In vivo dosimetry, Cardiovascular Implantable Electronic Device (CIED) dose calculation and risk assessment,[58] pregnancy, prior radiation assessment, image fusion reports, gating/DIBH notes, discussion with patient/MD. |
| Previous treatment | Commonly obtained in pdf format (DICOM RT files are also sent when requested but these are not normally stored in the RO-EMR). |
| Treatment plan | PDF, scanned signed PDF, or the electronic version in the EMR. |
| Patient QA forms | Physics initial chart check, therapist initial chart check and pre-treatment check (timeout), weekly chart checks by physics and radiation therapy. Checklists are often used for this purpose. |
| Patient specific dosimetry | Patient dosimetry verification: independent dose calculations, in vivo measurements, portal dosimetry with or without the patient, film and chamber measurements, or diode/chamber array measurements. |
| Daily Treatment Record | In addition to the electronic record of treatment that should be maintained by the RO-EMR via the treatment history, there may also exist a manually recorded document stored in the RO-EMR that can be reconciled with the RO-EMR history as part of a QA process. |
| Unplanned issues | On-treatment items, missed appointments, machine failures, incomplete treatments. |
| Imaging/IGRT | Imaging studies with shift/matching data may be stored in the RO-EMR |
| Image Review | This is usually handled through data elements within the RO-EMR. |
| End of Treatment notes | This could be an electronically generated form. |
| Weekly on-treatment visits and follow up notes | These could also be forms and may go into the hospital EMR and/or the RO-EMR. |
| Non-patient QA forms | This includes periodic machine QA. Most institutions do not store this information in their RO-EMR, although it may be convenient to have non-patient periodic imaging tests associated with a fictitious patient for easy test retrieval. Most modern machines require IGRT imager QA (kV, MV and cone-beam CT (CBCT)) on a daily basis and these images may be part of a QA patient stored in the RO-EMR. |
| Patient reported outcomes | Quality of life patient questionnaires. |
| Other | Allergy alerts, on treatment alerts that appear at the console for a particular patient, ad hoc treatment notes, etc. |

**approve prescriptions and that editing rights without approval be offered as sparingly as possible to satisfy regulations but enough to not disrupt the clinical workflow**. For example, medical residents should have editing rights as it is a necessary part of their training but not approval rights.

TG 262 identified lack of consistency between the printed plan documentation and the treatment when a change is made to a treatment plan as a vulnerability. **The task group recommends that plan documentation in the RO-EMR be consistent with treatment and be updated any time a plan is revised, prior to the next treatment**. If changes are made to any treatment parameters, doses, or approvals, the documentation should be updated to reflect that since it is consulted at treatment, status checks, and weekly chart checks. **RO-EMR software may have built-in features to inhibit treatment if an embedded prescription is amended after treatment commences, and the task group recommends that users take advantage of these functionalities when possible and practical**.

## 5.2 | Document design and storage: Format, input, efficacy, scope, traceability, and accessibility (FIESTA)

**When designing documents for the electronic chart and choosing a native storage format, the implementation committee should consider the format, input, efficacy, scope, traceability, and accessibility (FIESTA) of the document.** These elements are summarized in Table 5. *Format* refers to how easy a document is to read. *Input* refers to how data are entered into a document. It should be automated to the fullest extent possible. Note that macros are sometimes disabled due to security restrictions put in place by the institution which may inhibit certain kinds of automation of input. RO-EMR systems also may have built-in tools which can be customized for information entry such as vital sign assessments or checklists.

*Efficacy* alludes to how the information fits into the workflow management system or, in the case of vital patient-specific information such as a CIED or bolus, how the information can be stored so as to be easily detected during the standard workflow—for example, a particular type of form may be attached to a task in the workflow manager making it easy to fill in without excessive clicking. *Scope* refers to how the document is grouped with respect to other documents in the system. Documents that are usually accessed together such as a prescription and a plan are easier to use if they are in the same part of the system rather than in different parts. *Traceability* refers to whether previous versions are saved (not overwritten) and can be reviewed. This is useful for comparison to previous versions when modifications are made for root cause analyses. Finally, *accessibility* refers to how easy a document is to access after it is completed and how quickly it can be made available for writing, particularly important in high throughput environments like the treatment machine.

**When possible, chart elements should be stored using native storage functionalities of the system.** RO-EMR information formats include simple data formats like parameter lists and checklists. They also include free-text formats like internal messaging that do not enforce an entry format. There are also structured documents and imported documents in formats such as PDF and MS Word. **Forms, or structured documents designed for the RO-EMR system, should be used for consistency whenever possible**.

## 5.3 | Document repositories

**Document repositories in RO-EMR systems should be configured consistently for all users such that documents are easily identifiable and categorized appropriately to prevent errors.** Electronic document repositories within the RO-EMR may not be optimally designed and may become cluttered if no enough features are available to categorize and compartmentalize them. This may lead to errors; for example, a prescription from an earlier course may be opened if the sorting of the documents is not immediately apparent to the user. **The task group recommends that documents be sorted and categorized consistently if possible and that clutter be minimized and the number of documents should be minimized**. Clutter reduction strategies include moving forms that may not be necessary for access during treatment and not required by regulators into ancillary storage such as on a secure server. Short of that, at least the ancillary forms can be sequestered from the main clinical document repository. In such a scenario, it is important that all staff be aware of the location of these documents via the electronic chart documentation and that clinically necessary documents remain within the main clinical repository.

## 5.4 | Free-text notes

Free-text notes are a valuable resource in the RO-EMR and can be used by clinical personnel for ad hoc entries.

**It is recommended that use of free-text note or journaling functionality be avoided except for ad**

**TABLE 5** Elements of document design

| Element | Definition | Example |
|---|---|---|
| **F** ormat | Ease of reading | Appropriate font, clear wording, lean content |
| **I** nput | How data is entered | Use of dropdowns, radio buttons, etc, minimization of free text |
| **E** fficacy | How document fits into the workflow of the clinic | Is data minable, does the form appear automatically when it is needed such as a checklist attached to a task, etc.? |
| **S** cope | How the document is grouped with respect to other documents | Are prescription and plan stored together? Are documents needed by therapists grouped for easy and quick access? |
| **T** raceability | Are early version retrievable? | Early versions of a prescriptions, plans, etc, are useful for determining what changes are made. |
| **A** ccessibility | How easy a document is to access | Is the number of clicks to access a document excessisve? Are documents needed when a patient is on the table quickly accessible? |

**hoc entries**. Free-text notes are not easily minable and not consistently entered. In addition, they often need to be consulted for important information that actually does belong there, such as changes in treatment for a particular fraction. Therefore, efforts should be made to find a "home" for standard information elements so that free-text notes are only used for ad hoc entries during treatment and not unnecessarily cluttered.

## 5.5 | Consistent entry of information

**It is the responsibility of all users to use the chart consistently with respect to entry of information, both in terms of where and how the information is entered. Redundancy should be minimized, that is the same data should not have to reside in different parts of the chart such that consistency needs to be maintained.** Inconsistent information entry makes errors more likely due to failed communication. QA checks such as initial chart checks or weekly checks may not easily detect these errors. For example, the prescription may call for gating or bolus to be used, requiring the reviewer to navigate to and check the consistency of settings in multiple locations of the electronic chart, which can be challenging. If consistency of usage is good and not unnecessarily redundant, the check is more efficient and workflow delays can be avoided. In addition, according to the white paper by TG 201, standard nomenclature is essential.[29] **To the extent possible, consistency in documentation entry should be enforced**.

## 5.6 | Electronic signatures

**Electronic signatures should be used where clinically appropriate and be sufficiently secure to adhere to local regulations. They should be easily accessible for audits by regulators, credentialing bodies, billing compliance personnel, and other entities**.

Each Radiation Oncology Department should develop policies and procedures (P&Ps) defining how electronic signatures are to be validated. Electronic signatures were addressed by Public Law 106–229 (the "Electronic Signatures in Global and National Commerce Act") in 2000.[30] Electronic signatures are more robust than paper signatures as future editing may invalidate the signature, although this should be verified by the user. **When choosing a signature format, the most efficient method that satisfies regulatory requirements should be used**.

A locked document can be disruptive to workflow, especially when documents have to be reapproved for small changes such as typographical errors. Documents requiring signatures should be designed in such a way that the need for reapprovals is minimized. For example, less sensitive information that does not have to be signed that currently resides on a signed document can be moved to an unsigned document. **To the extent possible, forcing functions should be employed to enforce proper practice in completing documents**. For example, it may be possible to inhibit saving a document unless all required elements are entered. However, this kind of functionality is often not available or restricted in its use by local IT policies that prohibit macros and user compliance has to be relied upon.

## 5.7 | Simulation orders

**Simulation orders should clearly reflect site-specific procedures and avoid superfluous information.** Any special concerns related to a particular patient should be indicated in the simulation order and communicated to the simulation staff ahead of the time.

Postsimulation, simulation documents which include patient setup description and photographs, and maybe additional isocenter coordinate information when applicable, should be uploaded and later reviewed by appropriate sim staff for correctness and completeness in the RO-EMR.

## 5.8 | Prescription

**Users should take advantage of the capabilities for prescribing that are provided by the RO-EMR**. ASTRO (American Society for Radiation Oncology) has provided guidance on items to include to improve standardization of dose prescriptions.[31]

Dose-volume constraints can be considered as part of the prescription or as a separate document of intent to ensure that treatment planning obtains the complete information to begin the plan, thus limiting the need for unnecessary communication or revision downstream. These constraints can be explicitly stated or standard department constraints can be referenced with explicit exceptions listed for the particular case. Any modification to constraints will result in a prescription modification if the document is approved. Institutional standards for personalized dose constraints alleviate this inefficiency by requiring explicit documentation of constraints which differ from the institutional norm.

Common failure modes associated with the prescription fall into three general categories:

1. Incomplete information and typographical errors
2. Mismatches between the prescription and the treatment plan
3. Changes to the prescription that are not communicated to the clinic

**The task group recommends that vendors and clinics join to make prescriptions "smarter" by making prescription parameters sufficiently flexible, capitalizing on the ability to mine data in an electronic prescription, and by checking the prescription for self-consistency and against the treatment plan**.

Flexibility in electronic prescriptions not only refers to allowing flexibility in existing fields but allowing for custom fields in the electronic prescription. Missing information can be managed by introducing forcing functions into the prescription that require entry of mandatory elements. The task group believes that confirmation of the internal consistency of the prescription and consistency between the prescription and the plan are crucial in the prevention of errors and that software should be developed to provide this check. Currently, there are some commercial systems with this functionality. However, there is still work to be done to make electronic prescriptions flexible enough to be suited to a variety of clinical workflows.

**The task group recommends that an explicit prescription check be performed as the first part of a chart checking process**. The check should include a thorough review of the prescription as well as a check of concordance between the prescription and the treatment plan. This "prescription first" policy should be reinforced and documented as part of the QA process, for example if there is a checklist, an explicit check of the prescription should be first.

## 5.9 | Treatment plan documentation

**Treatment plan documentation should be accessible for easy internal review as well as documentation for outside institutions or departments when requested.** A TPS may offer a short-form and long-form report for treatment plan documentation or users can create their own forms using scripting. Sparseness of documentation must be considered against the need to easily access the treatment plan information by different members of the clinical team. Treatment plan documentation should be designed to adhere to all applicable regulatory requirements (such as state or local laws and any requirements of certifying bodies), and easily provide access to necessary information for plan review by physics (weekly checks, end of treatment (EOT) checks), therapists, and physicians (chart rounds, status checks). In addition, a version suitable for export to outside institutions or for review by other departments should be available but could be compiled when such requests are made (see Section 5.16).

## 5.10 | Checklists

**Checklists and similar tools within the RO-EMR should be used to provide a systematic and comprehensive approach to ensure standardized patient care, thereby decreasing errors and improving patient workflows**. Checklists are a valuable safety tool for Radiation Oncology[32] and can interlock downstream actions; for example, a treatment can be prevented until the checklist is signed. In addition, checklists will ensure a consistent process is followed. Checklist design cannot be taken lightly, a poor checklist can lead to "checklist fatigue" or miss crucial elements. The task group recommends that implementation committees and RO-EMR management committees refer to the AAPM Medical Physics Practice Guideline on development, implementation, use, and maintenance of safety checklists when designing checklists for their RO-EMR system [33]

Radiation therapists frequently use checklists for the pretreatment time-out when they ensure that the correct patient is being treated with the correct plan and setup. TG 262 recommends that a consistent and efficient method be chosen at the institution to document time-outs, preferably using existing functionalities of the system suited to that purpose.

## 5.11 | Special circumstances

**The RO-EMR should be used to communicate special circumstances including but not limited to pregnancy, prior radiation, radiation-sensitive implanted medical devices, allergies, and infectious diseases**. Special circumstances can have a critical impact on clinical decisions or effective infection control for other patients and clinical staff. To ensure no treatment proceeds in ignorance of such circumstances, they should be documented consistently in the RO-EMR. Policies and procedures for the RO-EMR should explicitly address each special circumstance to ensure roles and responsibilities are clearly defined. Dedicated workflows are also recommended (General RO-EMR workflow design is discussed in Section 6). **The task group recommends that special circumstances be documented using forms where possible to ensure consistency**. Consistency must be maintained with the H-EMR if this information is also contained there, therefore automated transfer of this information is recommended when available.

This information should be easily noticeable, especially given that it is not common and therefore unless there is a prompt for the reader of the chart to look for it, it will easily be overlooked. Important items that need to be managed prior to treatment such as pregnancy tests should be in a checklist, while items that need to be checked daily should be in a document that is accessed daily such as setup instructions or in a machine alert mechanism if one is available in the RO-EMR. This is an example of efficacy and of accessibility described in Section 5.2, it is extra important that vital patient

information be detectible within the normal workflow—users should not be solely expected to check for this kind of information in a part of the chart that is not usually accessed routinely.

## 5.12 | Incomplete treatment sessions or courses

**A system should be put in place to capture and appropriately document incomplete treatment sessions or courses in the RO-EMR, either automatically or manually via standard QA checks**. This scenario is a potential safety issue where patients could receive less than the prescribed dose. About 97% of AAPM survey respondents document incomplete treatments, more than 85% document missed appointments, and more than half document machine failures in the RO-EMR. RO-EMR design can help simplify and standardize documentation for deviations from the appointment schedule.

**The task group recommends that the treatment history of the RO-EMR be checked for accuracy in the event of an incomplete treatment.** This is in addition to any checks which may be performed as part of the weekly chart check of the RO-EMR treatment history. Notes should be added to the RO-EMR for missed appointments and machine failures as well, since a missed treatment may cause confusion downstream that is more likely to be resolved if this information is readily available.

When an external beam treatment is administered under the direction of a treatment management system (TMS), a record of that treatment is saved back to the TMS under normal conditions. A "save-back failure" is a failure to save the record, thus leaving the TMS with an incorrect number of delivered treatments and potentially leading to overtreatment if not detected and corrected. A clinic using an RO-EMR may choose to rely on the saved history from the treatment management system as the history of record of the patient. Therefore, **a process should be in place to detect save-back failures of the treatment history**.

## 5.13 | Treatment course changes

**Changes in the treatment course such as early completion of treatment should be documented with a valid attending physician signature if they deviate from the prescription as originally written.** The course of a treatment often changes due to unexpected changes in clinical condition of the patient, new findings, or other reasons. Often it is not appropriate to modify the prescription to indicate these changes as it represents the intent of the treating physician. For example, if a course of treatment is completed early due to deteriorating clinical condition, it may not be deemed appropriate to modify the prescription because the prescription represents the intended treatment. In that case, a note in the chart may be more appropriate. Another example is the case of a patient being prescribed twice daily treatment and missing one of the treatments on one day due to unforeseen circumstances. In cases such as these in which there is a change requested by the physician that deviates from the prescription without an overall change in treatment intent, the physician should document this deviation in a signed note and add it to the RO-EMR.

Transfers of the patient between treatment machines should be documented. Permanent transfers to machines that are dosimetrically equivalent, where dosimetric equivalence implies that delivery of the same plan will produce the same dose distribution, should be annotated in the treatment plan document to avoid confusion by the treatment team even though there is no significant change in the dose delivered. Temporary transfers to a dosimetrically equivalent machine can be annotated as a free-text note. Transfers to nondosimetrically equivalent machines will require review by medical physics and the need for a new plan is dependent on the change in delivered dose due to the transfer. A detailed discussion of dosimetric equivalence in the context of machine transfers is beyond the scope of this task group. The treatment machine ID for each delivery should be saved in the treatment history which may at first glance obviate the need for annotation; however, these annotations can minimize confusion and be helpful to the treatment team. Even if machines are dosimetrically equivalent, there is still some work needing to be done for transfers such as possibly reimaging and recapturing couch coordinates. Specialized workflows can be designed for machine transfers or campus transfers in larger institutions to help standardize the process (see Section 7 for a discussion on workflows).

## 5.14 | Emergency and urgent cases

**A department should have procedures for using the RO-EMR for emergency and urgent cases in an efficient, safe, and consistent way.** The approach to documentation for clinically emergent cases such as cord compressions or bleeding, which are often treated with simple single or parallel opposed fields, is more varied than that for planned cases with electronic documents, electronic forms, and paper printouts all in clinical use. Since this process is typically carried out on a short timescale and often also outside regular treatment hours, forms and workflows should be designed such that all of the efficiency tools of the electronic chart can be exploited as much as possible. Short forms with only the necessary information can be designed.

### 5.15 | Chart reviews

**Chart reviews (plan checks, weekly chart checks, end of treatment checks, etc) should be documented electronically in the RO-EMR**. They are an essential step in the routine QA process and touch all subspecialties: physicists, dosimetrists, physicians, therapists, nurses, and others. These chart reviews are also reviewed by regulators. Therefore, it would be advisable that documentation of the particular review be easily accessible within the chart. Review could be represented by a task completion or a signed checklist if a checklist is part of the process, or both. The association of the review with a username is advisable, a scanned document with a signature does not take advantage of the data mining capabilities of the system. An electronic signature within the system is preferable.

### 5.16 | Preparation and transmission of patient records

**A clear procedure should be in place for preparation and transmission of patient records to outside institutions**. This process is more complex for an electronic chart due to the decentralization of relevant data and often involves DICOM elements. The process for sending chart documents should be easy to complete by administrative staff who often prepare these transfers. DICOM transfers should be handled or supervised by medical physics personnel. External record requests should be considered when configuring documentation formats: are patient documents stored in such a way that they can be easily exported, as pdfs for example, and transmitted to another facility? The task group recommends that a plan printout or comparable summary be sent with DICOM data to confirm the completeness of the DICOM dataset. Also, the final treatment summary must be reviewed prior to sending the information to ensure that the treatment course corresponds to the plan information being sent and that no changes are missed in the transmission that are not reflected in the documentation which was created prior to treatment.

## 6 | WORKFLOW DESIGN AND COMMUNICATION IN THE RO-EMR

In the days of paper charting, passing of the chart from one group to another guided the workflow. In RO-EMR systems, workflow managers provide clinical team members with the status of the patient in the planning and treatment process as well as triggering the successive steps in the workflow. In the RO-EMR, a "workflow" is basically a process map represented as a sequence of "tasks" that are to be completed to represent the progression of patient care.

Figure 1 is a hypothetical RO-EMR workflow represented as a task sequence. The red and yellow symbols between tasks demonstrate potential hard stops (red) or soft stops (yellow) installed in the workflow. A hard stop is a mechanism to stop the workflow from moving forward if the previous task is not completed accordingly in the RO-EMR. The stopping mechanism can be manual or automatic, depending on the software capability. A soft stop gives the user the option

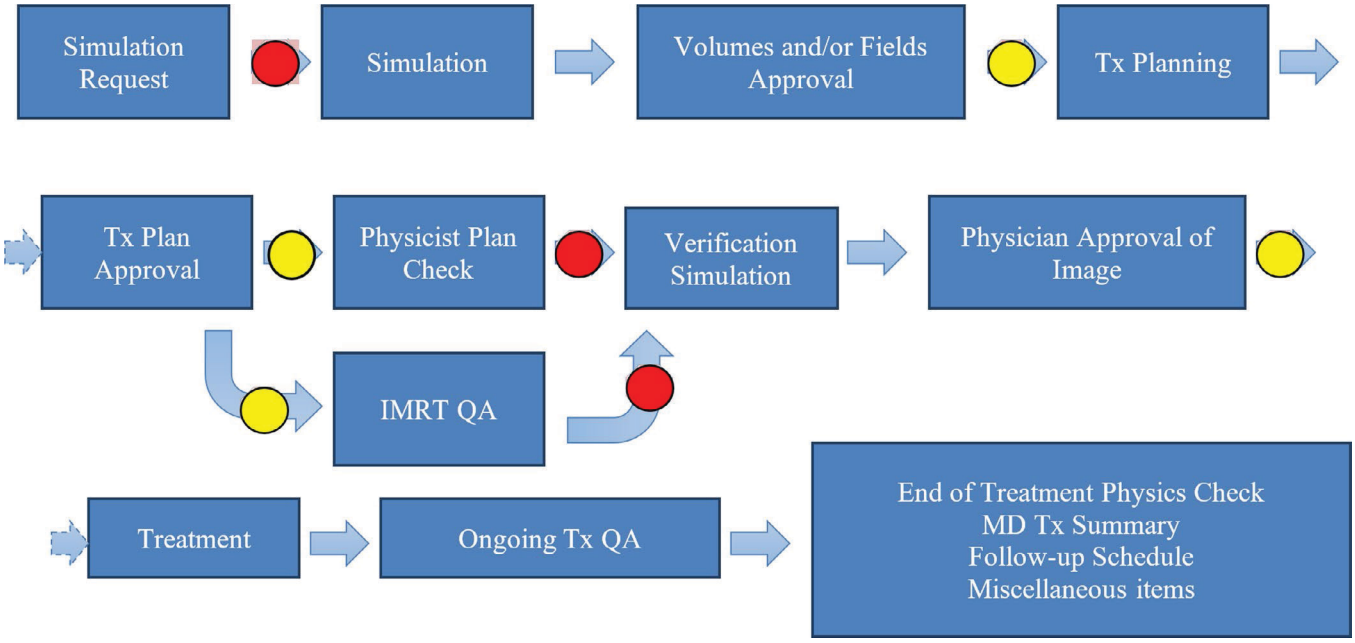



**FIGURE 1** Sample RO-EMR workflow flow chart. Hard stop, red symbol sign; IMRT, intensity-modulated radiation therapy; MD, physician; QA, quality assurance; Soft stop, yellow symbol, Tx: treatment

to stop but does not force the stop using the functionality of the system. If there is neither a hard nor soft stop, the workflow will proceed without any interruption or warning from the system. Certain documents (not shown in diagram) may be associated with each of the tasks such as a simulation order with the simulation step, a prescription and treatment plan with the treatment planning step, a checklist with the Physicist Plan Check task, etc…

Workflows inherently act as a form of communication. For example, when one task is completed, RO-EMR systems trigger the next task in the workflow and the person responsible for that task is alerted that it is their turn in the chain. If a change is made in a patient's plan of care midstream, for example if a replan is requested due to a new finding, the workflow design has to be agile enough to move that change forward and notify the appropriate personnel. Therefore, *workflow design is fundamentally linked to communication in the clinic* and that concept should not be lost on the implementation committee when they design the various workflows for the RO-EMR.

In this Section, we present recommendations for design of workflows using the RO-EMR. We then touch on some specific key documents as they pertain to the workflow such as the simulation order and checklists. We then discuss proper communication in the clinic and its relation to a smooth workflow. Finally, we touch upon the importance of standard configuration of user interfaces and their importance in the execution of an efficient workflow.

## 6.1 | Connecting tasks to form a workflow

**The committee should establish process maps before configuring the workflow manager.** Process maps should be constructed to chart serial and parallel events in the clinical workflow. These process maps can in turn feed the configuration of workflow management systems.[18,34]

The most skeletal workflow should support handoff between the various groups in the clinical process. At least one task from each of the groups should be included in the baseline or skeleton list as a starting point to move the chart from each group to the next. The individual groups can then add additional steps within their section of the workflow, thus building the workflow into something clinically usable. A task sequence for a particular workflow can be built by.

1. Entering a primary task for each section to pass the chart from one section to the next
2. Adding tasks to the baseline task list in each section if additional passing is required within that section

Figure 2a,b illustrates how a task sequence can be developed. A baseline task list (2a) is followed by team-specific tasks which are provided by each team based on their internal workflow (2b).

## 6.2 | Creating tasks for the workflow

**When designing the workflow, the committee should consider the following for each task: Who, What, When, How, Why, hard or soft stop, and possible risks**.

- *Who*—Who should perform this task? Do they have the appropriate rights?
- *What*—What information element, if any, will be used to document this task? Is there a checklist to be completed? Is this a document to be filled and/or approved?
- *When*—What time interval should this task be given for completion? Does this task happen sequentially after a previous task? Does this step prevent the next task from occurring? Can this task be performed in parallel to other tasks?
- *How*—How can the completion of a particular task be confirmed (electronic approval of a document, completion of a task or checklist item, signature on paper to be scanned or imported, etc.)?
- *Hard or soft stop*—Should an incomplete task create a hard stop or soft stop to the following task?
- *Possible risks*—Are there other possible errors that could happen but not yet included in the workflow design?

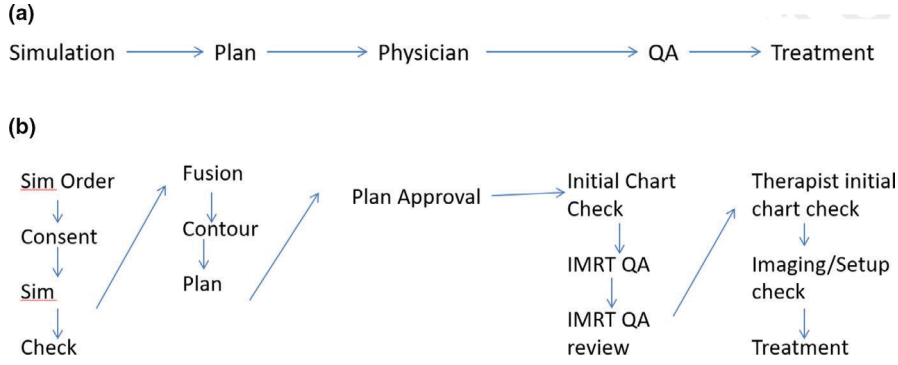



**FIGURE 2** Evolution of a task sequence. Figure 2a shows the baseline task sequence and Figure 2b shows the team specific tasks that replace the baseline sequence in each of the baseline categories

## 6.3 | Linkage of documents with workflow tasks

**Documentation such as checklists should be linked by the system to workflow tasks when possible.** Documentation, where appropriate, provides proof of what had been done in the task, rather than only a record of the completion of a task item. Therefore, documentation is often linked to certain workflow tasks.[34] Documentation could be in different formats depending on workflow design. For example, a checklist may be attached to an electronic task for physics initial chart check. Another example of documentation linked to a workflow task could be a scanned consent document in the consenting task. A completed scheduled task item that is linked to a workflow task could also be useful in confirming and documenting the completion of a task item, although having an attached form is preferable if possible.

## 6.4 | Simulation orders in the workflow

**Safety barriers should be established to prevent simulation without completion of an accurate simulation order.** The simulation order often serves as the initial source of information for the clinical team and provides the intended treatment for the patient. Accuracy of the simulation order is essential for a smooth simulation process and for avoiding unnecessary resource reallocation downstream in the planning process. For example, information such as previous treatment is valuable when assigning treatment planning resources, as nonplanned cases matching to a previously treated area may require a special physics consultation during the simulation to set the isocenter and define the fields. When simulating for stereotactic radiosurgery, the simulation order should state the correct number of lesions (if known) which aids in allocating planning resources and scheduling adequate time on the treatment machine.

The simulation order often involves the synthesis of information from a variety of sources, many of which may be stored on the H-EMR. This often leads to a debate concerning where the simulation order should reside. The H-EMR may also have more robust features for control of data entry such as required fields, more robust approval mechanisms, and more connectivity to other departments. More streamlined connectivity between the H-EMR and RO-EMR (i.e., any synchronization functionality which eliminates the need to manually transfer certain documents between the two systems) is always advantageous and the document could be synthesized in either of the systems and reside in one or both systems.

Built-in features of the RO-EMR may aid in the enforcement of an accurate, complete, and signed simulation order. There are a number of ways in which clinics currently enforce completion of the simulation order. A time-out procedure or checklist is commonly used as a template in the RO-EMR. Crucial steps in the simulation workflow such as completion of the sim order can be incorporated into the automated workflow manager.

## 6.5 | Prescription entry in the workflow

**The institution should incorporate prescription entry as one of the workflow tasks; consider when it should be entered initially, and the proper time frame to finally approve it.** Prescription entry serves as a basis for treatment planning to begin and is an important task in the workflow management. While at times the treatment beam energy or technique could be flexible and may only be finalized after a computerized treatment plan is done in the treatment planning system, the planner has a critical need to know the physician's intent to begin and efficiently proceed through the planning process.

**If a third-party prescription application is utilized, a system of checks needs to ensure the consistency of information and proper data transfer with the primary RO-EMR to prevent possible discrepancies between two different systems.** The prescription should be easily accessible by the clinical team. Maintaining a copy of the prescription that is not automatically updated introduces risk of there being two different versions of the prescription. This sort of redundancy should be avoided.

## 6.6 | Incorporating automated charge capture in workflows

**When the RO-EMR is used for billing purposes, automated charge capture should be used if available**. The committee should take this functionality into consideration when configuring workflow managers. Forms should be designed such that billing compliance can be easily verified. Utilizing automated charge capture helps to ensure billing charges are correct as they are tied to a specific task completion activity.

## 6.7 | Formalizing the release of workflows into the clinic

**Formalizing the process of releasing workflows (discussion by RO-EMR management committee,**

**pilot and formal release with proper notification) is recommended to prevent potential errors or unanticipated clinical inefficiencies**. Workflow management tools fundamentally affect the functioning of the clinic. As discussed, they should be configured to mirror the sequence of serial and parallel tasks in a clinical process. Therefore, formalizing the development, release, and modification of these tools is recommended to ensure adequate vetting and testing prior to release. Workflows that are poorly designed can cause potentially serious delays in the clinic. Like documents, workflows should be carefully designed by the implementation committee, tested, piloted if possible with a small subset of clinical cases, and approved prior to general release.[13,18,34]

## 6.8 | Ongoing refinement of workflows

**Clinics should utilize task completion metrics and feedback from different clinical groups to refine RO-EMR workflows as part of ongoing QA.** As described in Section 4: QA of the RO-EMR, workflow refinement is one of the tasks recommended for ongoing QA of the RO-EMR. A combination of feedback from various groups[18,19] using workflows as well as analysis of task completion metrics provides valuable information in determining if the workflow is serving the clinic and not the other way around. Recommended task completion metrics include percent task completion at each step and the bottleneck for completion for each task (potentially indicating that an individual or a group may need more training).

## 6.9 | Consistency in communication

In the same way that consistency is essential in information entry, consistency in communication within the RO-EMR is essential. Clinics rely on the RO-EMR to communicate time-sensitive information regarding the patient from one group of staff member to another. When the channels of communication are inconsistent, some vital information may not reach its intended audience in the necessary time frame. **The clinic should establish clear consensus on the channels for transfer of specific types of time-sensitive information and enforce its use**. For example, if a change is requested in chart rounds, the change has to be communicated to treatment planning consistently because an electronic system has no paper chart to pass the information which would initiate the requested change. In addition, the therapists must be notified that a revision of the treatment plan is in process.

Flaws in communication were identified by the task group, particularly when changes were made to a patient's chart after the patient began treatment. Similarly, the communication of changes in treatment parameters (such as discontinuation of bolus) remains a concern. **The task group recommends that implementation committees focus on known lapses in communication in the workflow development phase to ensure that the clinical workflow design is robust against these sorts of unexpected changes in care**. Stops in the process and/or forcing functions to compel notification are helpful here.

## 6.10 | "Handoffs" and "handshakes"

**"Handoffs" and "handshakes" should be clearly identified for different types of communication.** By "handoff," the task group means a transfer of work from one user to another that does not require confirmation. Examples include the passing of the plan from physician to physics at the conclusion of contouring. The physician does not check that the information was received and relies on the workflow manager to convey it. A "handshake" is more rigorous and requires confirmation from the receiving party. An example could be the reduction of fractions from the treatment course (prescription modification). The physician should confirm that the information was received by the intended party, whether it be physics staff, therapy staff, or both.

The task group would like to note that handoffs and handshakes within the RO-EMR system by no means obviate verbal communication which can serve as confirmation as well as provide clarification when it is needed. These handoffs and handshakes can be thought of as the systemic means of communication within the RO-EMR which can initiate a more detailed verbal communication. The RO-EMR should not substitute effective verbal communication currently in place but rather efficiently support it.

## 6.11 | Standardization of user interfaces

**User interfaces should be standardized within the same user group.** A customizable RO-EMR user interface by staff type would be appropriate and aid in easy access to the necessary items/menus for individual users. It would also facilitate a more efficient workflow and facilitate training. An admin user, typically a department Information Technology/Information Systems (IT/IS) personnel, should be able to configure RO-EMR layouts based on the user staff type.

# 7 | BRACHYTHERAPY AND NONSTANDARD DEVICES

Brachytherapy and nonstandard devices such as Tomotherapy (Accuray Inc., Tomotherapy Inc., Madison,

WI), CyberKnife (Accuray Inc., Accuray Corporate HQ, Sunnyvale CA), Gamma Knife (Elekta AB, Stockholm, Sweden), and Viewray (Viewray Technologies, Inc., Mountain View, CA) share core characteristics in their limited connectivity to the RO-EMR. Brachytherapy and other nonstandard devices do not have the same standard workflows as external beam radiotherapy, and consequently make universal application of an electronic chart complex. In this section, we will describe the current state of electronic charting for these systems and make suggestions about the future environments and directions that the RO-EMR may migrate into. We then provide recommendations on how to design the RO-EMR for nonstandard devices in each connectivity category such that it closely replicates the standard RO-EMR chart while not creating undue burden for the clinic.

## 7.1 | Definitions of RO-EMR connectivity categories

### 7.1.1 | Standalone

Standalone devices are devices which do not connect to RO-EMR at all. Examples of standalone devices at the time of this report are:

- Intraoperative devices located outside the Radiation Therapy Department (operating room (OR), Nuclear Medicine Floor): electron linacs, kV devices including electronic brachytherapy, low-dose rate (LDR) prostate seed implants, orthovoltage devices, and nuclear medicine ablative procedures handled by radiation therapy departments.
- Devices located within the Radiation Therapy Department, but with no connectivity to EMR or for which connectivity modules have not been purchased: noncommunicative HDR afterloaders, Gamma Knife, non-C-arm linacs, and new devices for which connectivity modules have not yet been developed.
- Third-party software systems or devices such as MIM Symphony LDR (MIM Software Inc, Cleveland, OH), Oncentra seed (Elekta AB, Stockholm, Sweden), or Variseed (Varian, Palo Alto, CA) when used in the OR for LDR brachytherapy procedures. iPads (Apple Inc., Cupertino CA) are routinely used to remotely perform Therasphere[35] or COMS[36] eye plaque calculations. These instruments can be used either in the RO department or outside (e.g., Interventional Radiology, operating room (OR)).

### 7.1.2 | Limited connectivity

Devices with limited connectivity have connectivity modules available to connect to most commercial RO-EMR systems but are not part of the R&V functionality of the RO-EMR. These connectivity modules are developed by device manufacturers, RO-EMR vendors, or third-party vendors. A typical connectivity module allows for the bidirectional flow of information. In the RO-EMR-to-Device direction, patient demographics flows to the connected device, and scheduled treatment plans are made available to the machine for delivery. In the device-to-RO-EMR direction, the treatment data are automatically recorded back to the EMR after each delivered fraction. Other data such as setup images may be part of data transfer in this direction as well.

### 7.1.3 | Full connectivity

Full connectivity occurs when the device is driven by the RO-EMR exactly like current C-arm linacs. The recommendations in the other sections of this task group report apply to these devices. In the case of fully connected HDR afterloaders, the special considerations regarding the written directive are discussed in Section 7.2.1.

## 7.2 | Shortcomings

In some systems, the patient can be scheduled, queued, treated, and recorded all within the use of the RO-EMR. With other vendor combinations, such interplay between RO-EMR and delivery system does not exist. Some vendors currently are not pursuing modules or components to allow this connection to happen at all. However, allowing nonstandard devices to lag technologically hinders the workflow and efficiency of the process. For some combinations of RO-EMR and devices, creating connectivity requires the purchase of an extra license or module. This is costly in some clinics and a financial burden that prohibits its implementation.

For some device/RO-EMR combinations, partial connectivity is established. The issues with partial connectivity can be multifaceted, depending on the equipment being used. Some nonstandard devices such as CyberKnife lack a way to incorporate and record shifts from the treatment imaging into the RO-EMR; others such as low-dose rate (LDR) brachytherapy lack a method of handling dose tracking and accumulation even in a simplistic way. Some nonstandard devices cannot handle complex patient situations such as multiple courses or sites. A lack of dose tracking can be a significant issue with certain systems, particularly if the course or plan has changed over the course of a patient's treatment and there is no way to modify or edit the information on the third-party system.

Furthermore, the workflow for procedures using nonstandard devices can significantly differ from standard devices, and also be more varied across clinics.

This variability results in difficulty customizing the available workflow tools for these devices. Even the clinical space needed for moving to an electronic environment can be difficult due to the number of extra computers and monitors needed—this is not unique to brachytherapy but may be more extreme. A suggested minimum of two separate RO-EMR workstations (e.g., for concurrent usage by different clinical team members), plus the treatment computers, and potentially a planning system requires significant console area space.

Another hurdle to implementation of electronic recording of patient treatments in the realm of brachytherapy is the acceptance of electronic documentation by regulatory bodies. While this was discussed previously, the AAPM member survey indicated numerous times that regulators (e.g., one respondent mentioned an NRC audit) were not accepting electronic signatures. The work-around to the clinic was to print the electronic prescription/written directive, have the physician sign it, then scan back into the RO-EMR system for storage. Concerns over complying with regulators and HIPAA are still valid.

One of the largest concerns found in the AAPM member survey regarding an all-electronic environment was the inability to treat the patient if the network went down or if there was a communication failure.[37] For conventional linear accelerators, if the machine or network goes down before the plan has been transferred from planning system to device, the procedure is usually just to remove the patient from the table and have them wait until the connection is restored. In the case of HDR brachytherapy, a patient may be sedated and have uncomfortable applicators in place. During intraoperative radiation therapy (IORT), the patient may be anesthetized and have an open surgical procedure occurring. In the case of HDR, one way of mitigating this potential risk is to test the connectivity between the afterloader and planning system during daily QA. The planning system may also have a method for transferring the plan to the afterloader via USB drive.

## 7.3 | Brachytherapy-specific challenges

### 7.3.1 | Requirements of written directive

Part of the complexity in adopting electronic charting in brachytherapy is the requirements of a written directive. In the United States, facilities agree to follow the regulations in 10 CFR 35 and all state and local regulations. The written directive is covered in 10 CFR 35.40. Figures 3 and 4 show an example of an electronic-written directive in ARIA and MOSAIQ, respectively, each containing the five required components of radionuclide, treatment site, dose per fraction, number of fractions, and total dose. However, unlike a typical radiotherapy EMR, it does not control any devices or treatment delivery in most cases, and therefore exists to fulfill regulatory requirements only.

Limited access to the inter-departmental RO-EMR systems can be a barrier to using an electronic-written directive. Examples include brachytherapy procedures taking place in procedure rooms outside the radiation oncology department, such as interventional radiology or an OR. Access to the RO-EMR may be limited to one (or a few) shared workstation(s) running Citrix or remote desktop applications. Additionally, **many hospitals prohibit the use of mobile devices in the OR, effectively preventing access to the RO-EMR. In these circumstances, a paper-written directive may be used, which should be scanned into the RO-EMR in a timely manner after the completion of the procedure. The scanned electronic document should be stored in a consistent location and with clear labeling in the RO-EMR**. Figure 5 shows an example of a paper-written directive. Once the document is scanned into the RO-EMR, the original document may be discarded in a HIPAA-compliant manner.

Figure 6 shows an example for an unsealed source. 10 CFR 35.40(b)(6) stipulates that the written directive may be amended before the formal completion of the procedure. **For an electronic-written directive, the**

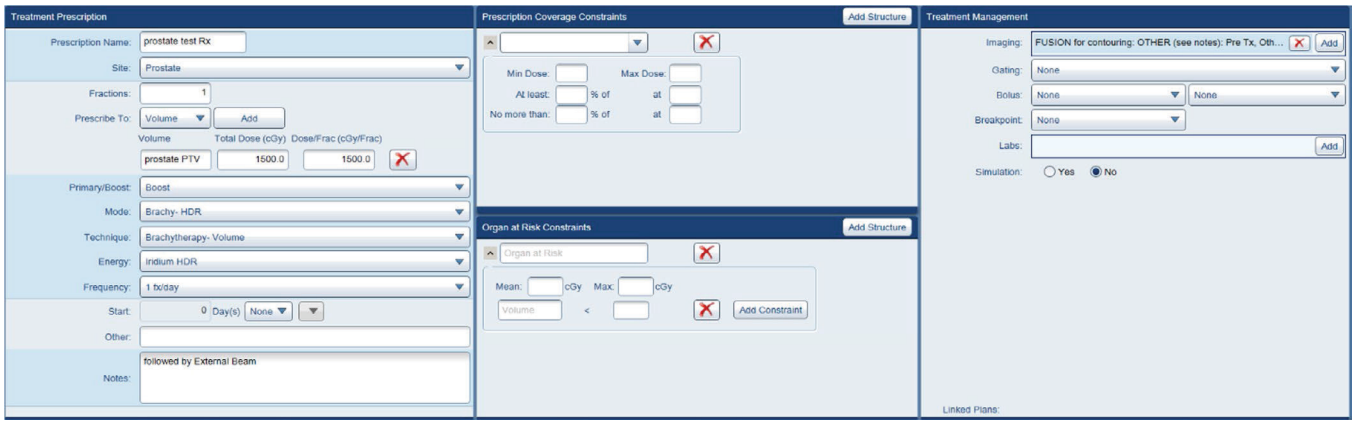



**FIGURE 3** Sample screenshot of a written directive for high dose rate brachytherapy in ARIA

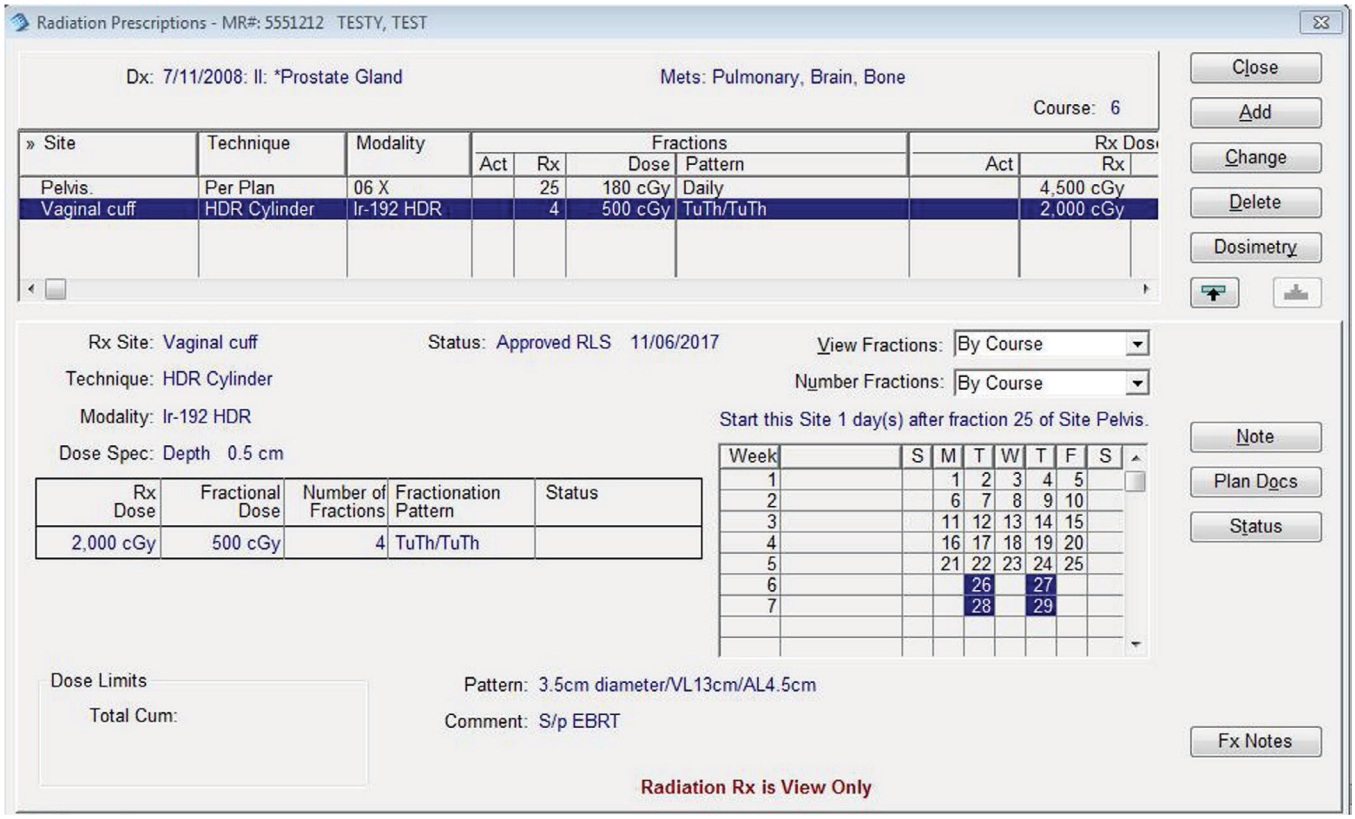



**FIGURE 4** Example of a written directive for High dose rate brachytherapy in MOSAIQ

**history of the written directive should be easily accessible to users of the RO-EMR. Historical versions (which should be saved within the RO-EMR) should include the date, time, and electronic signature of the directive. Any changes or amendments to the written directive should follow regulations and be documented appropriately**. While 10 CFR 35.40 does not require applicator information to be part of the written directive, including the information as best as the RO-EMR prescription field allows is an added safety feature. With regard to other components of the written directive, ASTRO has published a white paper with recommendations for the standardization of radiation treatment prescriptions.[31] In general, regulations and guidelines published by regulatory agencies such as the NRC in the United States take precedence over AAPM or ASTRO society recommendations.

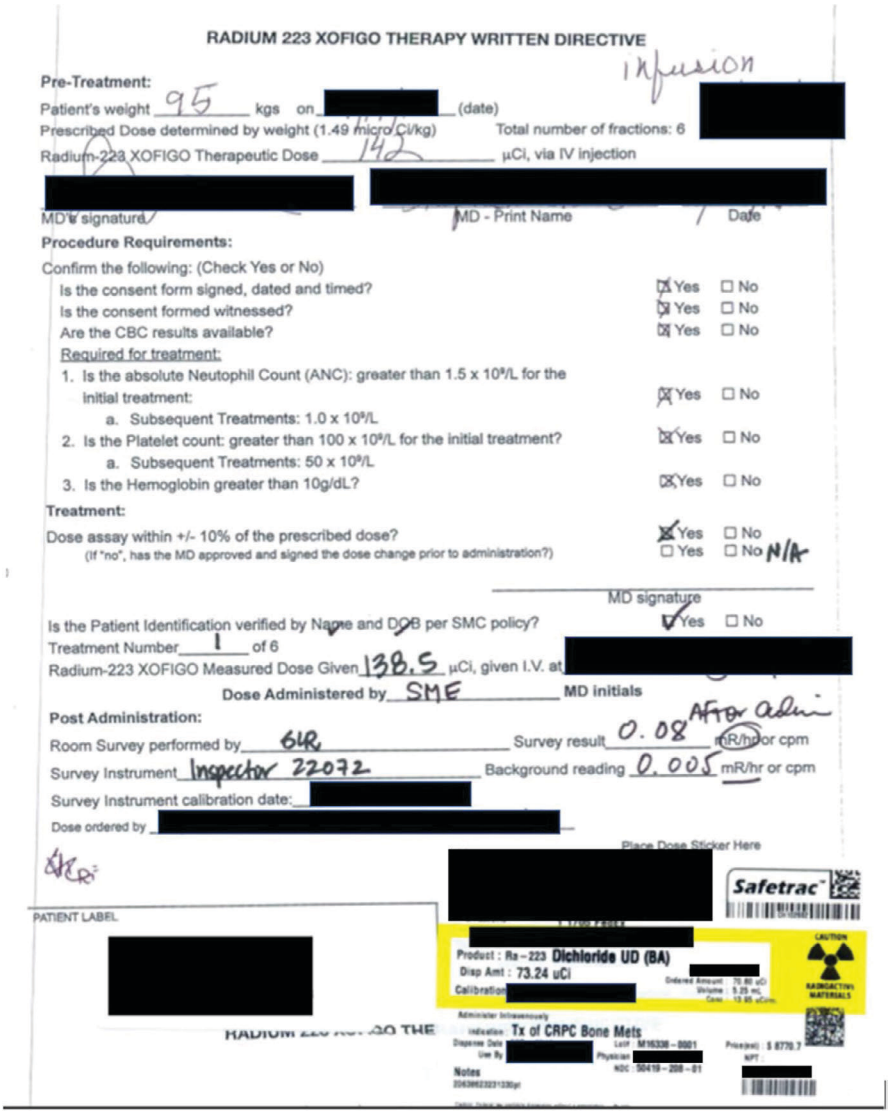
### 7.3.2 | Guidance on electronic signatures specific to brachytherapy

As described in Section 6.6, in the United States, the Electronic Signatures in Global and National Commerce Act (Public Law 106–229 from June 30, 2000) defines which types of electronic signatures "may not be denied legal effect."[30] The Report of the NRC Advisory Committee on the Medical Uses of Isotopes for Electronic Signatures from April 16, 2012 specifically endorses the NRC to accept as compliant any electronic signatures following the guidance of Public Law 106–229.[38] It has been the experience of some members that the NRC has accepted electronic signatures but the physicist should discuss with local regulators prior to implementation. **Each Radiation Oncology Department should develop policies and procedures (P&Ps) defining how electronic signatures are to be validated**.[39] This is of particular interest in brachytherapy treatments because of slowly changing rules and regulations for these types of procedures. It is recommended that those developing a brachytherapy RO-EMR work with local regulators and inspectors to alleviate any potential concerns.

## 7.4 | Additional recommendations

### 7.4.1 | RO-EMR connectivity software and new nonstandard devices

**The availability, cost, and functionality of the RO-EMR connectivity software should be assessed for existing nonstandard devices and prior to purchase of new nonstandard devices and brachytherapy afterloaders**. This assessment should dictate the design of the RO-EMR for these devices. Hospital IT should be consulted regarding the server needs, firewall and


RADIUM 223 XOFIGO THERAPY WRITTEN DIRECTIVE

Pre-Treatment:

Patient's weight 95 kgs on [redacted] (date)

Prescribed Dose determined by weight (1.49 micro Ci/kg) Total number of fractions: 6

Radium-223 XOFIGO Therapeutic Dose 143 µCi, via IV injection

[redacted]

MD's signature MD - Print Name Date

Procedure Requirements:

Confirm the following: (Check Yes or No)

Is the consent form signed, dated and timed? ☒ Yes ☐ No

Is the consent formed witnessed? ☒ Yes ☐ No

Are the CBC results available? ☒ Yes ☐ No

Required for treatment:

1. Is the absolute Neutophil Count (ANC): greater than 1.5 x $10^9$/L for the initial treatment: ☒ Yes ☐ No
   a. Subsequent Treatments: 1.0 x $10^9$/L
2. Is the Platelet count: greater than 100 x $10^9$/L for the initial treatment? ☒ Yes ☐ No
   a. Subsequent Treatments: 50 x $10^9$/L
3. Is the Hemoglobin greater than 10g/dL? ☒ Yes ☐ No

Treatment:

Dose assay within +/- 10% of the prescribed dose? ☒ Yes ☐ No

(If "no", has the MD approved and signed the dose change prior to administration?) ☐ Yes ☐ No N/A

MD signature

Is the Patient Identification verified by Name and DOB per SMC policy? ☑ Yes ☐ No

Treatment Number 1 of 6

Radium-223 XOFIGO Measured Dose Given 138.5 µCi, given I.V. at [redacted]

Dose Administered by SME MD initials

Post Administration:

Room Survey performed by GR Survey result 0.08 mR/hr or cpm

Survey Instrument Inspector 22072 Background reading 0.005 mR/hr or cpm

Survey Instrument calibration date: [redacted]

Dose ordered by [redacted]

Place Dose Sticker Here

[redacted] Safetrac

PATIENT LABEL [redacted]

Product : Ra-223 Dichloride UD (BA)

Disp Amt : 73.24 uCi

Calibration [redacted]

Indication Tx of CRPC Bone Mets

Notes

**FIGURE 5** Sample written directive for an unsealed source in a standalone procedure. The written directive is later scanned into the RO-EMR

security settings, backup capabilities and other considerations falling under the IT department responsibility. Some technologies require "send and query access" to remote servers. In community clinics and free-standing clinics, the medical physicist may have to take on these IT responsibilities.

### 7.4.2 | Stakeholders working with the nonstandard devices on RO-EMR implementation committee

**The RO-EMR implementation committee should include representatives from all stakeholders *working with the nonstandard devices***. Committee members should identify areas in which functionality and use of nonstandard devices can be kept identical or as closely aligned as possible with the external beam chart. The committee should include individuals knowledgeable about the rules and requirements for the technology in that state such as a qualified medical physicist and/or a radiation safety officer.

The AAPM member survey asked about which elements of the chart modality for nonstandard devices were handled as paper only, scanned paper, or electronic (results shown in Figure 7). Given that less than 10% of chart elements for nonstandard device were paper only, a clear opportunity exists to standardize RO-EMR chart design across modalities with the only changes being scanned paper versus electronic chart elements.

### 7.4.3 | Prescription entry for nonstandard devices

**For all devices, the prescription should be entered and signed in a similar method as for standard devices**.

***For all prescriptions, the applicable federal, state, and local regulations pertaining to the***

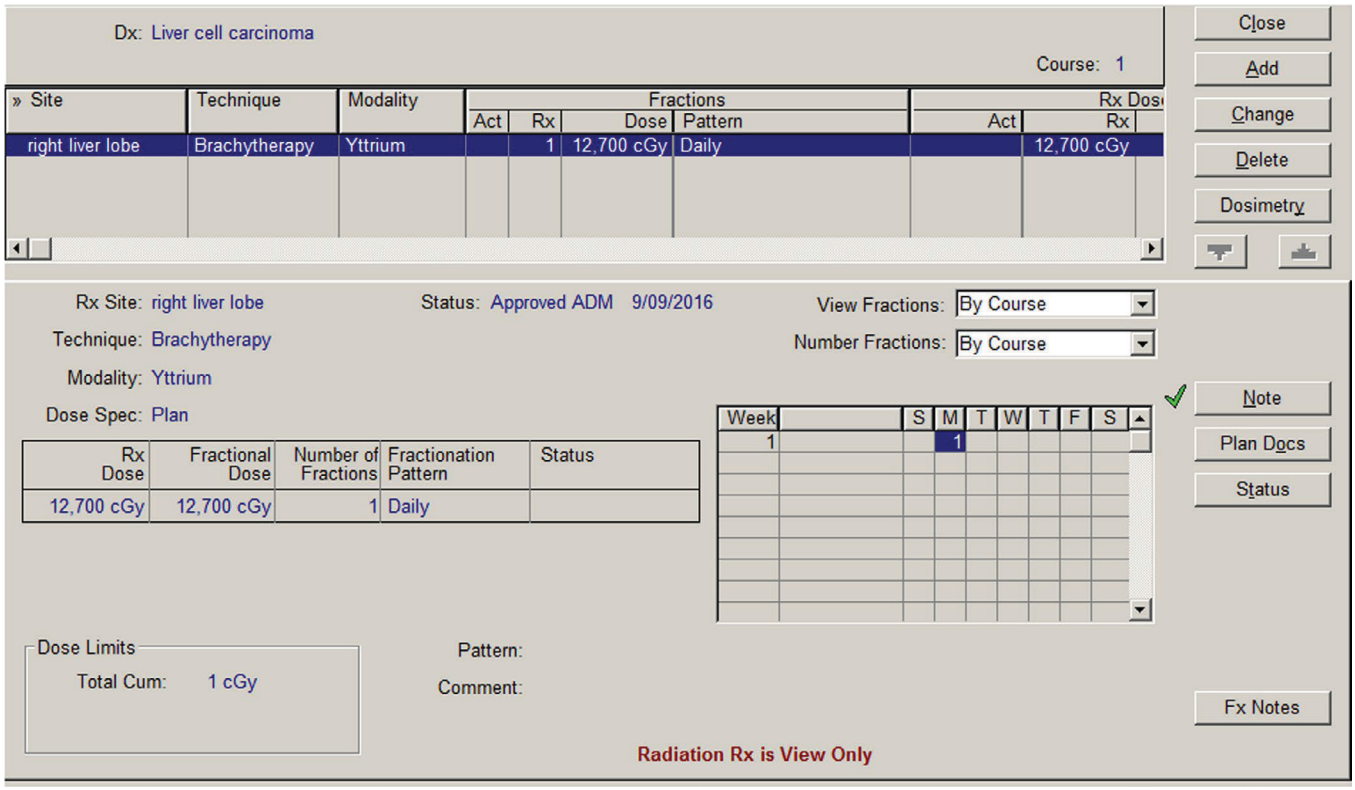
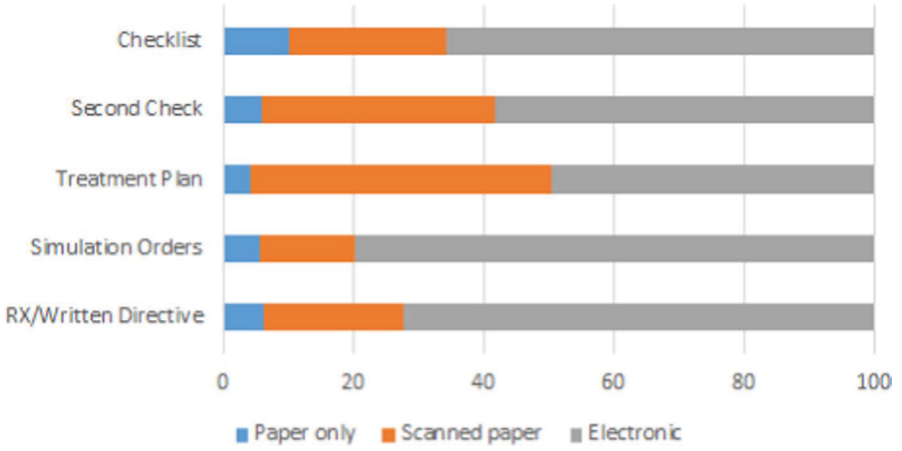



**FIGURE 6** Example of a written directive for an unsealed source in MOSAIQ

**FIGURE 7** Format of chart elements for brachytherapy and non-standard treatments from AAPM survey results




***written directive should be followed. Note that paper format for the written directive is typically used when electronic records are not available, such as in the OR, or when regulators still require paper documentation***.

### 7.4.4 | Plan documentation and documentation of billable activities

Two general methods are commonly used for handling plan documentation and depend on the need for print documentation. **Plan documentation should be exported as file and imported into the RO-EMR. If this is not possible and documentation is needed, then it can be printed and scanned**. The electronic signature functions of the RO-EMR can be used for plan documentation approval. For treatment plans that cannot be readily saved to a shared drive, or in situations such as an OR environment where a paper printout is essential for documentation, the treatment plan document is later scanned into the RO-EMR.

**Documentation for billable activities associated with nonstandard devices should also be considered.** When designing the RO-EMR for these devices, the implementation team should consider the associated billable activities and determine if adequate documentation exists in the proposed RO-EMR design.

# 8 | IT INFRASTRUCTURE AND DATA MANAGEMENT

IT infrastructure and data management processes form the backbone of the RO-EMR system. Additionally, modern RO-EMR environments do not work in isolation; rather they are one piece of a network of multiple systems in charge of managing patient care in a radiotherapy practice. Modern RO-EMR systems also contribute to information management and exchange with other hospital information systems. Understanding the connectivity between all the systems involved in a radiotherapy practice as well as the IT infrastructure are fundamental requirements for providing high-quality and safe patient care.

Using published evidence as well as the data collected by our two surveys, TG 262 developed the recommendations in this section on best practices for management of IT infrastructure which supports the RO-EMR environment. It is important to emphasize that both surveys have a relatively equal distribution of the two primary types of environments: the single-vendor environment (i.e., delivery, treatment planning, and RO-EMR environment are from the ***same*** vendor; 52.4% in the AAPM member survey) and the multi-vendor environment (i.e., delivery, planning, and RO-EMR environment are from **different** vendors; 47.6% from the AAPM member survey). Therefore, recommendations driven by the survey data are not biased toward a specific type of environment, and could apply to institutions that would like to pursue or already have either a single- or multi-vendor environment.

## 8.1 | IT infrastructure

IT infrastructure refers to "the composite hardware, software, network resources and services required for the existence, operation and management of an enterprise IT environment. It allows an organization to deliver IT solutions and services to its employees, partners and/or customers and is usually internal to an organization and deployed within owned facilities."[40] In order to provide an overall structure for the recommendations as well as a framework to facilitate future discussions, we divided the IT infrastructure into the following four domains:

- **Peopleware** (the human role in software and hardware development and interaction)[41,42]**:**
  a. Network, database, and system administrators
  b. Developers
  c. Designers
  d. Generic end-users with access to any IT appliance or service for maintenance and support
- **Hardware Infrastructure:**
  a. Physical and/or Virtual servers
  b. Server connectivity
  c. Internet connectivity
  d. Firewall and security
  e. Cloud-based deployment
  f. High availability and redundant systems
  g. Networking
  h. Data backup systems and processes
  i. Performance
  j. Test environments
  k. Mobile Device Connectivity
- Software supporting IT infrastructure:
  a. Enterprise resource planning (ERP)
  b. Productivity applications
  c. Operating system
  d. Database management system (DBMS)
  e. Communications protocols
  f. Antivirus software
  g. Compilers
  h. Other development tools
- Application Services:
  a. Reporting
  b. Mining and data analytics
  c. Data and information exchange with other hospital-based systems and devices

This report primarily focused on peopleware, hardware, and application services. Software supporting the IT infrastructure beyond the actual RO-EMR software covered by this report is essential but outside the scope of this task group.

## 8.2 | Peopleware and management strategies

### 8.2.1 | Team members

Implementation, deployment, maintenance, and everyday clinical operations of the IT Infrastructure require the collaboration of the following three main groups: (1) Clinical Practice (i.e., medical physicists, therapists, dosimetrists, and/or physicians), (2) Department or Institutional IT, and (3) Vendor. Siochi et al.[43] emphasize the importance of medical physicists and/ or representatives of the clinical team partnering with equipment service engineers, vendors, RO IT staff, and hospital or clinic IT staff. They argue that reliance on just the IT staff alone is not sufficient, since they do not fully understand the critical needs of the RO-EMR environment as well as the needs of the practice.

As the management and needs of the RO-EMR environment become more complex, the role of the institutional IT team will be highly valuable in order to

maintain a secure, effective, and safe IT infrastructure. However, **the task group recommends that members of the clinical team as well as medical physicists participate in the discussion regarding the IT infrastructure, since they will be responsible for highlighting the needs of the practice**. Inadequate collaboration between medical physics and institutional IT has caused frustration among practices when a lack of harmonization exists between the needs of the institutional IT team and the clinical team.

### 8.2.2 | Familiarity with terminology, technical concepts, architecture, and management of the IT infrastructure

**Medical physicists should familiarize themselves with the terminology, technical concepts, and main issues regarding the architecture and management of the IT infrastructure.** This is especially important when no radiation oncology-specific IT support exists. Historically, the role of medical physics in radiotherapy has been focused on the management of the radiotherapy clinical processes and systems and the medical physicist was often the IT person in the department. As modern treatment planning and delivery systems become more complex and connectivity outside the department becomes more prevalent, the role of the medical physicist increasingly requires specialization in the IT domain.

There is continuing debate concerning the level of involvement of medical physicists in the IT domain.[44] However, both surveys show that practices frequently rely on medical physicists to take a lead role in some or all the aspects of the RO-EMR environment. **While the task group does not recommend that the medical physicist assume primary responsibility for the IT infrastructure and support for the RO-EMR, it is important that medical physicists be part of the ongoing decision-making process**. Therefore, medical physicists should become familiar with some of the terminology and concepts related to the IT infrastructure and data management, so they can have meaningful and constructive conversations with both the department/institutional IT teams and the vendor. The four IT infrastructure domains described above provide a high level set of topics that medical physicists, involved in the management of their RO-EMR IT infrastructure, could use as a training checklist to become more knowledgeable in the areas of IT infrastructure and data management. The local IT representative can recommend training resources that best suit the IT infrastructure being used in the clinic if desired.

## 8.3 | Hardware infrastructure type and design

### 8.3.1 | Clinical needs, institutional restrictions, and constraints

**Clinical needs, institutional restrictions, and constraints need to be clearly defined when building the IT infrastructure for the RO-EMR environment.** There are primarily four architectural models for RO-EMR IT infrastructures: thick clients only (e.g., conventional desktop PC software deployment), remote virtual clients only (e.g., Citrix managed by the institution), combination of institutional thick and remote virtual clients, and cloud based (both RO-EMR database and remote virtual servers are managed by the vendor).

These can be deployed via servers in the department, servers on institutional supported networks, and servers on remote locations. The pros and cons of thick clients versus virtual environments like Citrix or cloud based is given in Table 6.

Each model has its own clinical and economic advantages and disadvantages; thus it is important that each practice collaborates with their departmental/institutional IT teams as well as the vendor to clearly define the needs and restrictions on each of the four IT infrastructure domains.[45] What is best for a specific practice will depend on many factors, which include economic restrictions, IT infrastructure support, treatment delivery and planning systems, and specific clinical needs.

### 8.3.2 | Deployment and design

There are a variety of deployment strategies for an RO-EMR system that are highly dependent on the resources that each practice has available to them. Therefore, the task group does not feel that it would be appropriate to recommend any one type of deployment over another. The most common RO-EMR environment deployment as seen by the task group surveys was a combination of thick clients and a virtual deployment (i.e., Citrix). Using this hybrid approach, users have access to the system through either a thick client or through an application virtualization process like Citrix. A hybrid approach has two main benefits: it provides a balance between a cost-effective and efficient system deployment provided by the application virtualization process, and it also maintains a fallback system in case the virtual deployment fails. However, hybrid deployments tend to be more costly. The stability and efficient accessibility of the RO-EMR environment through the virtual deployment (i.e., Citrix) is highly

**TABLE 6** Comparison of Thick Clients vs Citrix vs hybrid systems

| Client Type | Pros | Cons |
|---|---|---|
| Thick Client | • If one thick client breaks, it does not affect the rest of the environment.<br>• Easier to implement.<br>• Generally better performance for things like contouring. | • Expensive to maintain during upgrades.<br>• Requires a very robust network.<br>• May require "non-standard" hardware on end-user desktops.<br>• Uniform system security standard may be more challenging |
| Virtual Environment (i.e. Citrix, cloud based[a]) | • Cost Effective.<br>• Easy to maintain during upgrades.<br>• Lower system requirements on end-user desktops. | • Highly dependent on infrastructure.<br>• Single point of failure in the absence of adequate redundancy, ie with no alternatives, a failure (network outage for example) can cut off access to the RO-EMR.<br>• Very complex to implement.<br>• Slow access |
| Hybrid: Thick Clients and Virtual Environment | • Provides the most flexibility on accessing the application. | • Highest cost solution.<br>• Most complex solution.<br>• Hardest to maintain. |

[a]Note: Cloud-based environments introduce another level of complexity since the vendor is taking ownership of the infrastructure and corresponding maintenance, data security and uptime. So it is important that the practice/group is aware, understands and agrees with the vendor's roles and responsibilities for supporting the virtual environment.

dependent on the specifications of the infrastructure sustaining the virtualization process. The task group did not learn of any patient-related incidents or near misses directly caused by the utilization of Citrix and its downtime. However, some reported slow access to RO-EMR environment or a down network.

## 8.4 | Database architecture

Relying on centralized hospital or institutional-based IT infrastructure models is becoming a more common approach. Most clinics rely on the institutional IT infrastructure model, which provides a designated group of resources and people to maintain the infrastructure. The most common deployment encountered was through institutional servers, followed by a hybrid approach (i.e., combination of institutional and department data centers as well as cloud-based systems), and cloud based only.

Some of the institutional IT teams may lack a full understanding of the relevance of the systems in radiation oncology which may lead to disharmony between the clinical needs of the department and the priorities of the IT group supporting the infrastructure. This issue emphasizes the need for a constant dialogue as well as direct involvement of the members of the clinical team on everyday decisions regarding the IT infrastructure. Early communication could resolve potential issues and minimize delays. Most importantly, mutual understanding and respect between the medical physicist and the IT representative regarding each other's roles, responsibilities, and expertise is essential to a productive partnership in the management of the RO-EMR system and its infrastructure.

### 8.4.1 | Disaster recovery (DR) and high availability (HA) solutions

**Disaster recovery, and when possible, high availability solutions are essential when designing failover processes for the RO-EMR.** A common concern among users is the loss of clinical data due to catastrophic failure or corruption of the system. Modern RO-EMR environments and corresponding IT infrastructures offer multiple solutions to mitigate that risk. Among these solutions, it is important to differentiate between two main concepts: high availability and disaster recovery. High availability (HA) is the measurement of a system's ability to remain accessible in the event of a system component failure. Disaster recovery (DR) is the process by which a system is restored to a previous acceptable state and is more commonly known as a "backup." While they both increase overall availability, "high availability" refers to the retaining of the service and "disaster recovery" to the retaining of the data. During implementation of disaster recovery solutions, a slight loss of service for a specified duration occurs while the disaster recovery plan is executed, and the system is restored.[46] **The task group recommends that clinics have a system and processes for disaster recovery (i.e., backups) as well as processes to validate those backups. A monitoring system is also recommended, either automated or manual, to verify that the backup process took place**.

Since HA solutions add an additional cost to the overall IT infrastructure architecture, HA solutions are still not commonly adopted in the field of Radiation Oncology. More investigation is needed regarding the value of adopting HA solutions as part of an IT infrastructure for an RO-EMR environment. Continuity of care is essential, therefore **each practice should**

**determine the amount of downtime that the clinic can accept and implement a HA and/or DR solution that meets those needs**.

### 8.4.2 | Mobile device connectivity

**Mobile device connectivity must be secure. Users must evaluate mobile platforms for compatibility with all accessible electronic chart functions. If a mobile devise is used for image review, the screen size and resolution must be appropriate.** Mobile technologies are becoming a common solution in health-care systems, providing new models for caregivers and patients.[47] Given this demand, mobile device connectivity will require the implementation of new infrastructure that supports this new deployment model. How this trend will affect the area of radiation oncology remains to be seen. The main concern is information security. The task group found that institutions that provide mobile device connectivity use a secure virtual private network (VPN) connection and Citrix to deploy the application on mobile devices. The field is slowly moving in the direction of data portability from mobile devices, which will require IT infrastructure to support it.

### 8.4.3 | Electronic storage capacity

**Manual or automated processes should be in place to monitor the growth of the RO-EMR database and ancillary storage devices and warn the IT team that more space is needed.** TG 262 members identified this issue as a common failure mode, given that some TG members' RO-EMR systems stopped clinical operations when the RO-EMR database or ancillary storage devices (e.g., imaging storage) did not have sufficient space. **The task group recommends monitoring the usage and storage capacity on a real-time basis to warn the administrators of near capacity storage and provide time to amend system**. Clinics should request recommendations or requirements from vendors on the necessary storage overhead needed to function properly so appropriate limits can be monitored.

### 8.4.4 | Information security threats

**Clinical teams need to be aware of information security threats and work with both the department/institutional IT teams and the vendor to mitigate this risk.** Information security is quickly becoming a relevant concern in the health industry. According to the Office of Civil Rights, there were 253 breaches in the health-care industry in 2015, affecting 500 individuals or more with a combined loss of over 112 million records.[48] A very tangible example occurred at MedStar Health systems, where all information systems were shutdown due to a ransomware attack, causing radiotherapy treatment delays for 2 days.[49] Even though radiation oncology is a small section of the overall health industry, the reality is that all systems including RO-EMR environments and radiotherapy systems are exposed to this risk. Either the IT team alone or IT team working with medical physicists are responsible for secure access to the information in the RO-EMR environment. The responsibilities of medical physicists are extending beyond monitoring the quality and safety of the treatment delivery and now include the monitoring of the safety of the patient information and systems against information security threats, including cyber attacks. Since this new responsibility requires a new set of knowledge, **it is important that the medical physicist partner with institutional and departments IT teams as well as vendors to mitigate the risks and prevent data breaches in radiotherapy both to maintain adequate security and to protect the integrity of the RO-EMR system**. Most clinics maintain either secure access through network logging in privileges, secure access provided within the RO-EMR software itself, or a combination of both. The effectiveness of these preventive measurements will most likely be dependent on each institution's infrastructure and staff culture around information security.

*Information security good practices and strategies for RO-EMR Environments:*

- From the IT Infrastructure:
  a. Keeping patch level current.
  b. Monitoring system performance closely with an automated tool for system abnormalities.
- From the System Administration:
  a. Use a personal account for daily activities (i.e., email, web browsing, administrative tasks) and a service account with the minimum level of permissions for system maintenance activities.
- From the individual user safety practices:
  a. Only use local administrative permissions when required. Do not run as administrator at all times.
  b. Use complex passwords and a password vault (i.e., Keypass, Lastpass, 1Password).

### 8.4.5 | Test environment

**The Clinical Team should consider including a test environment as part of the RO-EMR environment deployment and design strategy.** The RO-EMR test environment allows users to test upgrades preclinically. Test environments are also very useful during the initial phases of implementation of an RO-EMR environment, and can be used for validating workflows and system configurations, testing connectivity, data migrations, as well as preclinical deployment training. Even though

a test environment adds additional cost to the overall RO-EMR environment implementation and continuous maintenance of both systems, this test component has been proven to be very valuable to all surveyed practices and minimizes the likelihood of issues with the RO-EMR environment during the implementation of upgrades and new features. It affords users the opportunity to test new workflows, scripts, and functionalities prior to their release into the clinic.

### 8.4.6 | Electronic screen space (dual monitor setup)

Adequate screen space in the electronic environment is analogous to adequate desk or tabletop space in the paper environment. The clinical team should consider the available electronic screen space for all users and all clinical contexts. The need to scroll or rearrange windows should be minimized (this may be due to inadequate resolution settings which should be verified with the vendor initially and with each upgrade); information just off the screen may be missed and lead to error. **The task group recommends that a dual monitor setup be the minimum standard with adequate screen resolution to support all of the RO-EMR functionalities as specified by the vendor**. Information in the RO-EMR environment workflow is distributed among several systems and applications and necessitates several open windows. For example, information from treatment planning systems, hospital EMRs, radiology imaging reviewing systems, among many others, are needed throughout the radiation oncology workflow. In addition, certain busy environments such as the treatment machine cannot afford to take the time to move between various subsystems required for appropriate information access.

### 8.4.7 | Application services

**Members of the clinical team should become familiar with and partner with IT team members to develop application services that optimize the connectivity among systems as well as facilitating the collection of data and analytics from the RO-EMR environment and other information systems**. Several radiation oncology practices are part of a hospital or a bigger cancer care center, and thus they have a basic need to exchange information between the radiation oncology department and other departments within or outside the main hospital or cancer center. The task group has identified a need for better and more efficient mechanisms for information exchange. Robust connectivity will require continuous discussion and direct support from both institutional IT groups and vendors with feedback and guidance from the clinical team.

In the era of "Big data analytics," the community must continue analyzing and learning from the information gathered by the RO-EMR environment and continue developing tools to access and retrieve data from the system. These tools can be a combination of vendor-provided and in-house developed tools. The task group notes that practices are using the tools provided by the vendors but lack the knowledge and resources to implement more sophisticated data mining strategies. A whole section issue on the Red Journal (www.redjournal.org/issues Volume 95, Issue 3, July 2016) is dedicated to providing a review on the topic of Big Data in Radiation Oncology[50,51]

### 8.4.8 | Risk of running database queries on clinical production systems

**Clinical team users should be familiar with the robustness and potential risk of running database queries on clinical production systems.** TG 262 members recognized that performing RO-EMR database queries without considering the potential load on the system can potentially bring down the whole system. Therefore, clinical team members should become familiar with the risk introduced when running both vendor-provided as well as custom queries. Additional disk space can potentially be added to a RO-EMR to be utilized as scratch space or virtual memory in support of running large queries, but at the cost of performance. Depending on the external storage interface being utilized, this could be orders of magnitude slower than main storage and memory. In addition, the option of running queries in the background typically requires a database administrator. It should be noted that for large queries, this may be suboptimal depending on how soon the data are needed as the query may not be completed in time. Also, not all vendor database systems currently support this.

*Potential risk of running database queries on clinical production systems and mitigation strategies*:

- Risks:
  a. Running an unbounded or complex query can result in all system resources being consumed by the query. This would result in a system outage and potential impact to patient care.
  b. Running any kind of query that can potentially write to the database may circumvent application controls that provide patient safety.
- Mitigation Strategies:
  a. Using vendor supplied query/reporting/analytics.
  b. Using vendor supplied applications for data manipulations.
  c. Replicating the production database to nonproduction infrastructure.

d. Automatically scheduling mining tasks to run outside of clinic hours
e. Setting low priority for data mining tasks

# 9 | CHALLENGES AND FUTURE IMPROVEMENTS FOR BOTH USERS AND VENDORS

TG 262 is composed of individuals who have had extensive involvement with the configuration and maintenance of electronic charting systems, and the task group has collected data on the practices in the medical physics community. Based on this body of knowledge, we present suggestions to vendors for future enhancements to RO-EMR software to improve the user experience and optimize efficiency and safety.

## 9.1 | Continued focus on automation

**The task group recommends a continued focus on automation.** Several studies have shown that automation in the RO department reduces the error rate.[52,53] Automation is useful in avoiding unnecessary delays and more importantly in preventing errors arising from manual repetitive processes. Some desired automation functions are listed below:

- Prompts for comment for incomplete treatments and overrides
- Automated notifications for certain events such as delivered dose disparity with prescription.
- Notifications should be configurable and include email functionality

One of the by-products of automation is that staff may become increasingly reliant on the computers and gradually lose their awareness of the treatment process that has been automated. Clinics should be aware of potential failure modes associated with each new automation feature introduced. A review of associated QA procedures should always accompany the introduction of a new automated feature and the potential failure modes should be accounted for in subsequent checks.

## 9.2 | Checklist functionality

One of the most important tools to improve patient safety is the use of checklists.[32,33] Paper checklists, if well designed, are easy to use and review. While electronic checklists offer functionality that go above and beyond paper checklist functionality, such as the use of a checklist for forcing function or interlock, the implementation in RO-EMRs is currently still suboptimal and warrants improvement.

### 9.2.1 | Multiuser checklists

**The task group recommends that checklist functionality be enhanced.** Many checklists used clinically in high-stakes procedures such as pretreatment checklists for SRS, SBRT, or brachytherapy are multiuser due to the interdisciplinary nature of patient care. Users signing off the checklists typically include physicists, dosimetrists, physicians, nurses, radiation therapists, and administrative staff. Because there is currently no RO-EMR implementation of a multiuser checklist that offers the same level of functionality, ease of use, and signature recognition that could match a paper checklist, we request vendors to add a multiuser checklist with functionality comparable to a paper checklist.

## 9.3 | More granular approval mechanisms

**The task group recommends that approval mechanisms be enhanced, including consideration of more granular approval mechanisms such as approval at the field level of a document or template.** One common complaint among RO-EMR users is that document reapproval is needed for even the smallest of modifications since approvals only occur at the document level. A more granular approval functionality that allows for approval of certain easily identifiable fields of a form while leaving other fields editable will allow for more versatile document configuration and possible consolidation of information and less clutter. This allows for flexibility in editing while still protecting vital clinical elements.

## 9.4 | Vendor sandbox

**The task group recommends that online interactive versions of their software be available for testing and training.** A “vendor sandbox” is a space in which users can test software prior to purchasing to determine whether it best suits their clinic. It can also serve as an online interactive training resource for users that have already purchased the product that highlights the safety and efficiency elements of the software. While TG 262 recommends that users have a test system to validate upgrades, an online testing area would make a valuable evaluation and training tool.

## 9.5 | More flexibility in structure and filtering of document repositories

**Configuration of document repositories should be flexible and customizable so that clinics can display the documents in a way that works best for them.**

Paper charts were very flexible when it came to organizing documents and RO-EMRs may not translate that flexibility as well. Often documents for multiple courses are in the same repository and are sometimes not easy to distinguish since they are largely represented by text descriptors. Filtering has to be done by clicking radio buttons or checkboxes. Sorting is available but can be error prone, for example if a dosimetrist accidentally sorts the documents in reverse chronological order and plans based on an old prescription. More flexibility in structuring document repositories would be helpful and would be a worthwhile QA step. More attention to the appearance and structure of the document list and how documents are tiered would provide users with the flexibility to construct their document lists the way that works best for them. Also, the added ability to associate documents using different tags or keywords would be of benefit.

## 9.6 | Stronger communication tools

**The task group recommends that communication tools within the electronic chart be enhanced based on input from industry experts, clinicians, and researchers.** RO-EMR systems have started to provide some features to use as a communication tool among clinicians and their patients such as integrated email, instant messaging, pop-up warning messages etc. However, many clinicians are still experiencing communication barriers when they are using suboptimal communication tools in RO-EMR system. Communication is a key element for patient safety and high-quality care. Ineffective communication costs US hospitals an estimated $12 billion annually.[54] Stronger tools for communication and meaningful use of RO-EMR should be developed and improved by the vendor, based on cooperative work of informatics professionals, clinicians, and researchers. TG 262 requests that vendors consider making the following communication tools available within the system: integrated email, instant messaging, and internal video meeting tools for collaborative review of the chart without having to launch an external application. One unfortunate consequence of electronic charting is that it is no longer necessary to be physically present to review a chart or a treatment plan together. While this is a plus for efficiency due to ease of access, it can have the unintended consequence of reducing face-to-face interaction in the clinic. Communication tools should be available to easily facilitate one-on-one communication.

## 9.7 | Greater flexibility and efficiency in workflow managers

**The task group recommends that flexibility of workflow managers should be increased to adapt more easily to the wide range of workflows in practice. Workflows should be more efficient by more tightly integrating the virtual task in the workflow with the work in the system that it represents.** Greater flexibility for assignment of work and collection of statistics from the workflow managers could streamline the workflow process and its subsequent analysis for internal and external reports, respectively. A workflow manager, through its enumeration of necessary tasks in the clinical process, can provide important information on the frequency of certain clinical processes for departmental statistics. For example, the number of end of treatment checks can be determined by counting the corresponding tasks completed in the manager. Although this report can be configured by IT in many cases, an easier procedure so that the user can compile this report themselves would be beneficial. Other reports include number of plans per planner, completion metrics for treatment plans, and statistics for on-time performance of tasks in the workflow. In addition, certain tasks may be done by rotating staff and the reassignment of resources to these kinds of tasks would be too burdensome every time a new person rotated onto that team. For example, end of treatment checks may be performed by a team and not the planner who planned the case. Therefore, assignment of a person to the end of treatment task may be difficult since it is not known who will be on the team when it becomes available. The option to collect and monitor for the tasks themselves regardless of resource would add welcome flexibility to the system.

In addition, more flexibility in the way that visual workflow management tools work would be helpful. For example, medical physics workflows can involve recurrent replans and checks. Facilitating that sort of looping workflow with appropriate decision path functionality would be helpful.

A common complaint regarding workflow managers is the disconnect between the task that needs to be completed and the associated workflow task item. For example, a physician approves volumes and then has to complete a virtual task that says the volumes are approved. The same goes for plan approval. Virtual tasks are not completely without links; for example a task may hyperlink to the workspace where the work is done if the workspace is within the RO-EMR ecosystem. Additional integration of the virtual tasks in the workflow and completion of the work they are supposed to represent would enhance efficiency.

## 9.8 | Handshake functionality and acknowledgment

**The task group recommends that tools be made available to acknowledge communications electronically.** "Handshake" functionality (see Section 6.10) should be available such that requests for change will send back

a confirmation when all of the receiving parties have acknowledged that the information has been received, or a warning is sent when it has not. We have provided examples of issues that can occur due in the RO-EMR environment; for example, changes in chart rounds not being communicated to physics or to the machine. One way to mitigate this issue would be to introduce communication tools that require verification of receipt within the system. Then, when ad hoc events require an atypical "passing of the chart," a receipt system, such as an automated email sent upon receipt for example, is in place to ensure that the workflow is still moving forward. These requests for receipts should be configurable.

## 9.9 | Concurrent use of different workspaces and custom views

**The RO-EMR should allow for the concurrent use of different workspaces and minimize the need to open an excessive number of windows. The creation of custom views should be possible.** During chart review, chart checks, weekly checks, and end of treatment (EOT) review, several elements of the charts need to be checked against each other for consistency. A RO-EMR system should allow the user to see multiple workspaces for the same patient concurrently, and allow the use of dual monitor viewing of tabs or windows within the RO-EMR to do so. Many clinics have adopted digital "whiteboards" showing the current status of patients, MDs, or dosimetrists. More or this type of functionality and/or closer integration with external whiteboards would be a welcome feature.

RO-EMR systems generally allow some customization of certain interfaces; however, going farther by providing tools to design custom views that can access certain database elements would increase flexibility. For example, a clinic may want to see certain specific elements of the chart for a weekly chart check on one place rather than clicking through tabs or opening multiple workspaces. Some clinics create their own whiteboards using the API of the RO-EMR to fill in the gaps between what is available in the system vs what is needed in the clinic. A custom workspace design module would be a welcome addition and allow more flexibility within the system.

## 9.10 | Improved connectivity with H-EMR and nonstandard systems

**Communication between the RO-EMR and H-EMR as well as between RO-EMR systems and nonstandard systems should be improved.** Effective communication between the RO-EMR and H-EMR has a number of advantages, including elimination of the need for transcribing information between the two systems, real-time availability of Radiation Oncology data in the hospital system, and the inclusion of Radiation Oncology data in the permanent part of the health record in a common database which is useful for abstraction of data and comparable effectiveness research.[55] A recent AAPM education session covered important points about data transfer between the two major electronic charting systems (ARIA and MOSAIQ) and Epic[56,57] and data transfer is addressed more generally in the report of AAPM Task Group 201. The utility of automated transfers is clear; however, there are still obstacles to effective transfer of information for all clinical scenarios, and improvement and further standardization of communication between these systems is still needed.

Enhanced connectivity between nonstandard systems and RO-EMR systems would be a benefit to the community. It would further promote centralization of chart elements, especially for those patients receiving multimodality treatments. A centralized treatment history and accumulated dose can help enhance safety features to prevent overtreatment in one modality due to insufficient familiarity with the dose given via the other modality.

## 9.11 | RO-EMR in standard database format with access—API functionality

**Vendors should design the RO-EMR database in a standard database format such as Structured Query Language (SQL). Users should be provided with information of the database structure and access to the database for data analysis and data mining. A feature-rich API should be provided**. The power of EMR implementation in general is in the promise of easier access to data for data mining. In contrast to any study involving paper charts, which typically involves administrative assistants spending many hours pulling data from paper charts and entering them in a single-purpose research database, a comprehensive electronic patient database could facilitate automation of the data collection task through scripted database queries. Vendors could facilitate this process by designing the database in a standard database format and providing tools for the database users to mine their clinic data.

A feature-rich API would allow users to more safely query the database and potentially automating certain repetitive actions in the RO-EMR—this would facilitate the creation of custom software for the clinic.

## 9.12 | Databases should be sufficiently robust to queries.

**Databases should be sufficiently robust to queries.** If feasible, vendors should offer a means to expand

working memory to ensure clinical functionality is not compromised by large database queries. This may include allowing the end-users to install additional RAM or external hard drives to accommodate the extra load.

### 9.13 | Provision of optional interfaces for nonstandard systems

**Vendors not currently pursuing modules and components to support interfaces with nonstandard systems should consider doing so, or alternatively provide the user information on their interface module so that users could develop their own interfaces**. For nonstandard devices and brachytherapy devices, connectivity modules are not always available or are too costly. Vendors should support user capability to develop custom connectivity modules by providing interface information and some database write-access that does not compromise data integrity or compromise patient safety.

## 10 | DISCUSSION

The RO-EMR is the fundamental means of information storage in the clinic and often workflow management as well. The electronic chart should be configured and managed to optimize efficiency and maximize safety. Electronic charts for radiation oncology differ from other departments in fundamental ways and therefore require specific guidelines for their use beyond what general charting guidelines can offer. It is in this context that TG 262 was convened. With the increasing pace and complexity of modern Radiation Oncology departments, optimization of chart usage becomes more and more essential.

The collective experience of the task group members provided the foundation for building consensus recommendations. The operative word is “consensus” since there was no extensive body of literature on the subject at the writing of this report. Therefore, we relied on an exhaustive survey of task group members and a more general survey of the medical physics community to provide our recommendations rather than consolidating already existing recommendations, which is a common practice for many task groups.

TG 262 group decided that the recommendations should be general for two reasons. First, since electronic charting software is constantly evolving, finely detailed reports now carry the risk of becoming quickly obsolete. Second, the scope of these systems in the context of our charges, particularly the inclusion of external beam therapy, brachytherapy, and nonstandard treatment devices would be excessively resource-intensive and make for an excessively large document if recommendations were not sufficiently general. We stress that we are not advocating or providing recommendations for any one particular system. We have strived to remain sufficiently neutral such that our recommendations can be applied to all systems.

Users of a new RO-EMR system face a challenging task, whether they be a small private clinic or a large academic facility when initially configuring the system. There are different forms of information storage available and not everything has to be an electronic document. The format, input, efficacy, scope, traceability, and accessibility (“FIESTA”, see Section 5.1) should be considered and characterized for each type of information storage available to pick the best mode of information storage for each particular clinical form. Clinics should rely on feedback from users and periodic QA to constantly update the charting system.

Resource allocation for implementation is important, and different clinics have reported different levels of resource allocation for their implementation teams. Clinics should read this report to get a sense of the breadth of tasks required of the implementation team and plan accordingly, given the experience of their RO and IT teams and limitations of their clinic. Adequate protection for implementation time is essential for the best user experience, because insufficient resource allocation for chart configuration will lead to issues with efficiency, workflow, and possibly safety down the line. All stakeholders should have representatives in the implementation process to the extent possible, and goals and deadlines should be set and monitored closely. It is easy to become bogged down in overly speculative details that delay rollout when the better course in certain instances may be to decide on a functional starting point for the chart and make changes based on feedback down the road. The ideal prescription form will likely not be the first one, no matter how much time is spent making minor modifications.

The need for champions to provide support in the transition process and beyond cannot be understated. Champions from the different stakeholder groups and end-user groups not only foster satisfaction but also foster compliance. Compliance is essential for a smooth workflow in the RO-EMR. Physician champions as well as administrative support are essential to provide encouragement and incentive to users as there will always be resistance to change. This is a lesson learned in hindsight by many, and it is best to make that clear in the beginning.

Since the primary purposes of the electronic chart are to store information in an easily accessible way and to drive workflow, periodic QA should primarily address whether those goals are being met and no new goals need to be added. A team entrusted with management of the system in the context of a living and evolving clinic should be periodically assessing whether the chart is optimized for efficiency and safety for the clinic in its current state. This should be the basis of the ongoing QA program. The level of review should be realistic,

so it does not unnecessarily overburden the team and potentially lead to no QA at all.

There are many documents and forms to consider in the configuration of RO-EMR systems. That is one reason that the recommended QA includes a review of the current documents to see which are out of date. This minimizes unnecessary signatures and duplication of data. Also, discussion of the interactive connection between documents and workflow managers in the electronic system should be part of the equation. A home should be found for each type of information, and the temptation to use free text for things other than ad hoc notes should be avoided.

Workflow managers play a critical role in the RO-EMR ecosystem. These workflow managers must be optimized for efficiency so they do not unnecessarily slow down the workflow. However, not everything needs a task, and each clinical group in the workflow should determine which items or tasks they need to add to the system so it works best for them. Workflow managers can also enhance the collection of statistics for the clinic as a task can not only drive the workflow but also act as a "token" for a certain clinical process (such as IMRT QA or an end of treatment check). The frequency of that process can be determined by counting the number of a specific task that are completed, in progress, or planned.

The use of the RO-EMR for nonstandard systems and for brachytherapy is not as developed as it is for external beam therapy. Many nonstandard systems do not have interfaces into RO-EMR systems, and it becomes difficult to consolidate treatment information for patients receiving multimodality therapy that may include external beam and brachytherapy for example. We have provided guidelines for electronic charting of these systems in their existing state as well as guidelines for their development in future. We also believe that the template laid down for external beam therapy provides a usable framework for the development of nonstandard charting systems.

The collaboration between medical physics and IT is essential for effective and safe chart maintenance. IT and medical physics are essential core team members in the maintenance and management of the system. Adequate network availability and disaster recovery resources are essential because a network or systems failure can potentially cripple the clinic not only through the disabling of the R&V system but also through the unavailability of the chart. Network failures may affect patient treatments and lead to inaccuracies in the treatment record if an adequate system for catching failures to save the treatment history in the RO-EMR ("save-back failures") is not in place. A redundant system for recording patient history should at least be in place if an automated system is not available. An assessment of whether current IT resources are adequate for an ongoing monitoring of hardware and software needs at the time of installation is an important first step. A slow chart is unacceptable in a fast-paced clinic.

Finally, in the effort to maximize the potential for an electronic system to enhance efficiency and safety and to maximize flexibility, we have provided general suggestions for ongoing enhancement of systems. Vendors should consider adding automation and enhancement of information storage and approval capability, more flexibility in existing functionalities such as checklists, and sufficient computing power (or prioritizing mechanisms) for analyses to ensure that electronic charting keeps pace with clinical complexity.

## CONFLICT OF INTEREST

The members of the AAPM Task Group 262 listed below disclose the following potential conflict(s) of interest related to subject matter or materials presented in this document. S. Yaddanapudi has received speaker fees from Elekta for a Gamma Knife presentation, not related to this work. V. Harwalkar, L Hong, S. Sutlief, J. Hanley, L. Fong de los Santos, M. Parry, S. Fontenla, S. Merkel, and S. Richardson have nothing to disclose. G. Kim provides consulting services for Varian Medical Systems related to the clinical use of Varian Products, which is unrelated to the content of the TG (HyperArc SRS technique). S. Dieterich has received research funding from Varian which is unrelated to the content of the TG (4D imaging studies in companion animals at the Vet School). J. Huang has received honoraria from Elekta for presenting in their user meetings in 2018 and 2019 about brachytherapy. J. Mechalakos was named on a research grant with Varian medical systems unrelated to the contents of this report.

## REFERENCES

1. Health Information Technology for Economic and Clinical Health (HITECH) Act (https://www.hhs.gov/sites/default/files/ocr/privacy/hipaa/understanding/coveredentities/hitechact.pdf) Enforcement Interim Final Rule. Section 13410(d).
2. Jha AK, DesRoches CM, Campbell EG, et al. Use of electronic health records in U.S. hospitals. *N Engl J Med*. 2009;360:1628-1638.
3. Jha AK, DesRoches CM, Kralovec PD, Joshi MS. A progress report on electronic health records in US hospitals. *Health Aff*. 2010;29:1951-1957.
4. Devaraj S, Kohli R. Information technology payoff in the healthcare industry: a longitudinal study. *J Manag Inform Syst*. 2000;16:41-67.
5. Devaraj S, Ow TT, Kohli R. Examining the impact of information technology and patient flow on healthcare performance: a Theory of Swift and Even Flow (TSEF) perspective. *J Oper Manag*. 2013;31:181-192.
6. Menachemi N, Burkhardt J, Shewchuk R, Burke D, Brooks RG. Hospital information technology and positive financial performance: a different approach to finding an ROI. *J Healthc Manag*. 2006;51:40-58.
7. Buntin MB, Burke MF, Hoaglin MC, Blumenthal D. The benefits of health information technology: a review of the recent literature shows predominantly positive results. *Health Aff (Millwood)*. 2011;30:464-471.

8. Jones SS, Rudin RS, Perry T, Shekelle PG. Health information technology: an updated systematic review with a focus on meaningful use. *Ann Intern Med*. 2014;160:48-54.
9. Atasoy H, Greenwood BN, McCullough JS. The digitization of patient care: a review of the effects of electronic health records on health care quality and utilization. *Annu Rev Public Health*. 2018;40:487-500.
10. Reis ZSN, Maia TA, Marcolino MS, Becerra-Posada F, Novillo-Ortiz D, Ribeiro ALP. Is there evidence of cost benefits of electronic medical records, standards, or interoperability in hospital information systems? overview of systematic reviews. *JMIR Med Inform*. 2017;5:e26.
11. Benedetti L. Clinical Implementation of Electronic Charting. https://vimeo.com/90160027 Accessed 2013.
12. Kirkpatrick JP, Light KL, Walker RM, et al. Implementing and integrating a clinically driven electronic medical record for radiation oncology in a large medical enterprise. *Front Ooncol*. 2013;3:69.
13. Colonias A, Parda DS, Karlovits S, et al. A radiation oncology based electronic health record in an integrated radiation oncology network. *J Radiat Oncol Inform*. 2011;3:3-11.
14. Weeks A, Coleman AM. Electronic charting and image management. In: Washington CM, Leaver D, Trad M, eds. *Principles and practice of radiation therapy*. St. Louis, Missouri: Elsevier; 2021:484-496.
15. Mechalakos J, Dieterich S. Quality and the electronic medical record in radiation oncology. In: Dicker AP, ed. *Quality and safety in radiation oncology*. Williams TR: Ford EC Springer Publishing Company; 2016:287-296.
16. Fraass BA, McShan DL, Matrone GM, Weaver TA, Lewis JD, Kessler ML. A computer-controlled conformal radiotherapy system. IV: Electronic chart. *Int J Radiat Oncol Biol Phys*. 1995;33:1181-1194.
17. Han Y, Huh SJ, Ju SG, et al. Impact of an electronic chart on the staff workload in a radiation oncology department. *Jpn J Clin Oncol*. 2005;35:470-474.
18. Kovalchuk N, Russo GA, Shin JY, Kachnic LA. Optimizing efficiency and safety in a radiation oncology department through the use of ARIA 11 Visual Care Path. *Pract Radiat Oncol*. 2015;5:295-303.
19. Nowlan AW, Sutter AI, Fox TH, Johnstone PA. The electronification of the radiation oncology treatment cycle: the promises and pitfalls of a digital department. *J Am College Radiol JACR*. 2004;1:270-276.
20. Record and Verify Systems for Radiation Treatment of Cancer: Acceptance Testing, Commissioning and Quality Control. Vienna; 2013.
21. (IEC) IEC. International Electrotechnical Commission, Medical Electrical Equipment, Safety of Radiotherapy Record and Verify Systems. Geneva; 2005.
22. Shen X, Dicker AP, Doyle L, Showalter TN, Harrison AS, DesHarnais SI. Pilot study of meaningful use of electronic health records in radiation oncology. *J Ooncol Pract Am Soc Clin Oncol*. 2012;8:219-223.
23. Shen X, Dicker AP, Doyle L, Showalter TN, Harrison AS, DesHarnais SI. Pilot study of meaningful use of electronic health records in radiation oncology. *J Oncol Pract Am Soc Clin Oncol*. 2012;8:219-223.
24. Patton GA, Gaffney DK, Moeller JH. Facilitation of radiotherapeutic error by computerized record and verify systems. *Int J Radiat Oncol Biol Phys*. 2003;56:50-57.
25. Kotter JP. Leading change: why transformation efforts fail. *Harv Bus Rev* (Harvard Business School Publishing). 1995;59-67.
26. Radiology ACo. Radiation Oncology Practice Accreditation Program Requirements. 2017.
27. Huq MS, Fraass BA, Dunscombe PB, et al. The report of Task Group 100 of the AAPM: application of risk analysis methods to radiation therapy quality management. *Med Phys*. 2016;43:4209-4262.
28. Amols HI. New technologies in radiation therapy: ensuring patient safety, radiation safety and regulatory issues in radiation oncology. *Health Phys*. 2008;95:658-665.
29. Siochi RA, Balter P, Bloch CD, et al. A rapid communication from the AAPM Task Group 201: recommendations for the QA of external beam radiotherapy data transfer. AAPM TG 201: quality assurance of external beam radiotherapy data transfer. *J Appl Clin Med Phys Am College Med Phys*. 2011;12:3479.
30. An act to facilitate the use of electronic records and signatures in interstate or foreign commerce., Vol. Public Law 106-229 (Government Publishing Office (US)) 2000.
31. Evans SB, Fraass BA, Berner P, et al. Standardizing dose prescriptions: an ASTRO white paper. *Pract Radiat Oncol*. 2016;6(6):e369-e381. https://doi.org/10.1016/j.prro.2016.08.007
32. Gawande A. *The checklist manifesto: how to get things right*. New York: Metropolitan Books, Henry Holt and Co.; 2009.
33. Fong de Los Santos LE, Evans S, et al. Medical Physics Practice Guideline 4.a: development, implementation, use and maintenance of safety checklists. *J Appl Clin Med Phys Am College Med Phys*. 2015;16:5431.
34. Albuquerque KV, Miller AA, Roeske JC. Implementation of electronic checklists in an oncology medical record: initial clinical experience. *Elect Health Rec Oncol*. 2011;7:222-226.
35. Yttrium-90 Microsphere Brachytherapy Sources and Devices -TheraSphere® and SIR-Spheres®-Licensing Guidance; 2016.
36. Design and methods of a clinical trial for a rare condition: The collaborative ocular melanoma study. Controlled Clinical Trials. 1993;14(5): 362-391. https://doi.org/10.1016/0197-2456(93)90052-f.
37. RO-ILS RO-ILS Case Study 8- IT Permissions Disrupt HDR Delivery. PSO C. 2021; https://www.astro.org/ASTRO/media/ASTRO/Patient%20Care%20and%20Research/PDFs/ROILS_Case08.pdf
38. The Report of the NRC Advisory Committee on the Medical Uses of Isotopes for Electronic Signatures. 2012; https://www.nrc.gov/docs/ML1218/ML12185A145.pdf
39. Kroger L Personal communication 2018.
40. IT Infrastructure: What Does IT Infrastructure Mean? (May 12, 2020) Definition from technopedia.com. https://www.techopedia.com/definition/29199/it-infrastructure
41. Lorenzi NM, Riley RT. *Managing Technological Change: Organizational Aspects of Health Informatics (2nd Edition)*. 10. New York, N.Y.: Springer-Verlag; 1995.155–157.
42. Gremy F. Hardware, software, peopleware, subjectivity - A philosophical promenade. *Meth Inf Med*. 2005;44:352-358.
43. Siochi RA, Balter P, Bloch CD, et al. Information technology resource management in radiation oncology. *J Appl Clin Med Phys*. 2009;10:16-35.
44. Siochi RAC, Brack CD, Orton CG. The chief information technology officer in a radiation oncology department should be a medical physicist. *Med Phys*. 2009;36:3863-3865.
45. Fong de los Santos LE, Herman MG. Radiation oncology information systems and clinical practice compatibility: workflow evaluation and comprehensive assessment. *Pract Radiat Oncol*. 2012;2:e155-e164.
46. Microsoft. High Availability and Disaster Recovery (Middleware) - a Technical Reference Guide for Designing Mission - Critical Middleware Solutions. https://technet/ Microsoft/ com/en-us/library/hh393522(v=sql.110).aspx Accessed 2016.
47. Steinhubl SR, Muse ED, Topol EJ. The emerging field of mobile health. *Sci Transl Med*. 2015;7(283):283rv3. https://doi.org/10.1126/scitranslmed.aaa3487
48. Munro D. Data Breaches In Healthcare Totaled Over 112 Million Records. In 2015. http://www.forbes.com/sites/danmunro/2015/12/31/data-breaches-in-healthcare-total-over-112-million-records-in-2015/#4cb0afc97fd5 Accessed 2015.

49. Woodrow CJ. MedStar Health turns away patients after likely ransomware cyberattack. In The Washington Post; 2016.
50. Benedict SH, El Naqa I, Klein EE. Introduction to big data in radiation oncology: exploring opportunities for research, quality assessment, and clinical care. *Int J Radiat Oncol Biol Phys*. 2016;95:871-872.
51. Benedict SH, Hoffman K, Martel MK, et al. Overview of the american society for radiation oncology-national institutes of health-American association of physicists in medicine workshop 2015: exploring opportunities for radiation oncology in the era of big data. *Int J Radiat Oncol Biol Phys*. 2016;95:873-879.
52. Macklis RM, Meier T, Weinhous MS. Error rates in clinical radiotherapy. *J Clin Oncol Off J Am Soc Clin Oncol*. 1998;16:551-556.
53. Fraass BA, Lash KL, Matrone GM, et al. The impact of treatment complexity and computer-control delivery technology on treatment delivery errors. *Int J Radiat Oncol Biol Phys*. 1998;42:651-659.
54. Agarwal R, Sands DZ, Schneider JD. Quantifying the economic impact of communication inefficiencies in U.S. hospitals. *J Healthc Manag*. 2010;55:265-281.
55. Russo GA. When electronic health records (EHRs) talk, everyone can win: our experience creating a software link between hospital and radiation oncology EHRs. *Int J Radiat Oncol Biol Phys*. 2016;94:206-207.
56. Surucu M. Practical considerations for ARIA and Epic EMR integration. http://www.aapm.org/education/VL/vl.asp?id=12283 Accessed December 3, 2017.
57. Yu U. Practical considerations for MOSAIQ and Epic EMR integration. http://www.aapm.org/education/VL/vl.asp?id=12284 Accessed December 3, 2017.
58. Sabater S, Montero A, López Fernández T, et al. Management of patients with implanted cardiac devices during radiotherapy: results of a Spanish survey in radiation oncology departments. *Clin Transl Oncol*. 2018;20(12):1577-1581. https://doi.org/10.1007/s12094-018-1893-5

## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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## APPENDIX

### A.1 | ACCEPTANCE CRITERIA FOR A NEW RO-EMR SYSTEM

The task group has created a list of recommended acceptance criteria adapted from the IAEA[20] and IEC[21] recommendations with additional items specific to document repositories and workflow managers. These criteria are listed here.

1. All values of radiation quantities displayed shall include units.
2. Display of date and time should be unambiguous. Timestamps shall be assigned correctly.
3. Means shall be provided to prevent unauthorized changes to RO-EMR data. Check by creating test users with different rights levels and verify that data are locked according to specified authorization.
4. Connect the RO-EMR to the network and confirm that access is limited to authorized users.
5. If there is an electronic prescription workspace, confirm that parameters are transferred correctly to the treatment planning system, treatment machine, and any other system connected to it.
6. Treatment history cannot be modified except by an authorized user. If treatment data are modified, it should be apparent by a visual indicator.
7. Means shall be provided to back up data. Standardizing the backup process is highly desirable.
8. Means shall be provided to archive data. Standardizing the archive process is highly desirable.
9. Confirm that transfer of history from the treatment machine to the RO-EMR is correct and means exist to warn the user if such transfer does not take place.
10. Test the document repository by creating and saving a range of document types supported by the system.
11. Test the workflow management system by running a range of sample clinical workflows with test users.
12. Examine user task lists for completeness and correctness using mock tasks. Test interplay between user task list and workflow manager (task status update correctly regardless of where they are edited, etc., tasks that are autocompleted function properly, etc)
13. Stress test the system to determine whether there is appropriate IT infrastructure for anticipated clinical load.
14. Test that all forcing functions work properly (e.g., inhibiting treatment if a linked prescription is unapproved)

## APPENDIX

### B.1 | SAMPLE QUESTIONS FOR CLINIC VISITATIONS

The following questions may be helpful when visiting a clinic to gather information on electronic charting:

1. How many patients are treated per day?
2. Was a committee formed to transition? Who was represented? How often did you meet?
3. How long did it take the committee to configure the chart and how long was a hybrid system in place?
4. How was training administered for staff?
5. What were the major challenges of implementation? Of training?

6. What do you consider the most effective features on your RO-EMR for preventing errors?
7. In what form is the prescription or written directive stored? Other documents?
8. How are MD approvals recorded? Physics approvals?
9. How is workflow managed? What specific tasks are included in your RO-EMR workflow manager?
10. What barriers to efficiency or communication have you experienced with your current RO-EMR workflow?
11. Have you experienced any QA issues related to the RO-EMR that you can share? How did you mitigate them?
12. Who maintains the RO-EMR? How are changes made?
13. Do you use the RO-EMR for brachytherapy or other nonstandard treatments? How is it used differently for these treatments?
14. How is your RO-EMR system deployed? Locally? Remote servers? Both?
15. How is your RO-EMR accessed?
16. How many licenses are needed for each user type?
17. Which aspects of your process live in the H-EMR and why?
18. Do you have a test system?
19. How is your RO-EMR backed up?
20. Does your RO-EMR interface with other systems in the clinic, such as the H-EMR? How are these interfaces structured?
21. How well would you rate your RO-EMR system in the following categories?
    a. Implementation
    b. Training
    c. Communication
    d. Information/Documents
    e. Workflow
22. What questions do you wish you had asked when first purchasing your system?
23. Are there additional functions you wish were available or are there existing functionalities you wish worked better?