Task Group 315: Medical Physics Practice Guideline (MPPG) For Plan and Chart Review in External Beam Radiotherapy and Brachytherapy

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I. Introduction

Task group (TG) 40 report [1], published in 1994, established the foundation of comprehensive quality assurance (QA) for radiation therapy. Most current medical physics practices in radiation therapy stem from this report. With the advancement of radiation therapy in the past two decades, several additional QA reports have been published [2-4], each addressing one specific aspect of QA topics covered in TG 40. A recently published TG 275 [5] provided evidence-based recommendations on physics plan and chart review for radiation therapy based on a survey of AAPM members and failure mode and effect analyses (FMEA). In parallel with TG 275, the purpose of this report is to provide specific checklist during plan/chart review for dosimetrists, medical physicists, and therapists based on minimum practice standards. Since radiation therapy is a coordinated team effort, this report also clarifies the responsibilities of each team member (radiation oncologists, medical physicists, dosimetrists, and therapists). The differences between this MPPG and TG 275 are elaborated the last section of this report.

A patient chart typically consists of many types of documents, including diagnostic reports, consultation reports, simulation documents, treatment plan reports, daily treatment records, and on-treatment visit reports. With the advent of electronic medical records (EMR), many clinical reports reside in a general hospital EMR system, while other radiation-related technical reports may reside in a radiation specific EMR system. One integrated EMR system is ideal; but currently not feasible because hospital EMR systems are generally incapable of sending radiation treatment plans to the treatment equipment and recording radiation treatment parameters automatically, both of which are critical for radiation therapy. The purpose of having a patient chart reviewed by different team members at multiple time points throughout the course of

treatment (e.g. prior to treatment (initial), during treatment (weekly), and at the end-of-treatment (final) is to ensure accurate and precise radiation treatment planning and delivery. To accomplish these tasks, one of the most important documents of a radiation therapy-related patient chart is the treatment plan report, along with other supporting documents for treatment delivery.

Treatment plans for radiation oncology consist of two major components: a clinical element and a technical element. The clinical component of a treatment plan includes the intent of radiation treatment (definitive, adjuvant, or salvage), radiation dosage, fractionation scheme, and anatomic contours that are delineated either to receive the prescribed treatment doses or to be protected from a specific tolerance dose. The technical component of a treatment plan includes the details of patient positioning along with the immobilization devices, placement of radiation beams, and the aperture shapes of radiation beams (designed either manually or by computer optimization) to achieve highly conformal radiation dose distributions to the treatment target volumes while protecting the critical organs.

1. Scope

This MPPG report is focused on the technical component of a treatment plan, referred to as the treatment plan in subsequent sections. The goal of this MPPG is to provide essential checklist items for medical physicists who conduct plan/chart reviews according to the minimum acceptable safe standards.

The purpose of a new (initial) plan/chart review is to ensure compliance with the prescription,

no clinically significant deviations are present, and that all information necessary for the therapists to deliver the treatment has been provided. Significant deviations in the plan/chart include errors, inconsistencies, or ambiguities, which may cause confusion for the team and potentially resulting in treatment errors. A recent publication [6] from the Radiation Oncology Incident Learning System (RO-ILS) reported that 33% of reported events occur during the processes of treatment planning and pretreatment review/verification. Mitigation of these hazards is best accomplished by catching errors as far upstream as possible and including multiple layers of plan check/review. The possibility of an error propagating through to the patient can further be minimized by using a standardized treatment plan document, a consistency check from the planners, and a pretreatment check by radiation therapists.

The purpose of weekly on-treatment (weekly) chart review is to verify that the prescription is being fulfilled. If for clinical reasons, the prescription is altered, medical physicists are responsible for ensuring that the modified prescription is followed accordingly. At the end-of-treatment (final) chart check, medical physicists are responsible for ensuring that all technical documents for that patient are signed/approved and that the treatment course is completed. If for clinical reasons or patients' decisions, the treatment course is not completed, a radiation oncologist should document the specific reason in the chart. This MPPG provides essential checklists for medical physicists to utilize while carrying out the responsibilities of initial, weekly, and final chart review.

2. The charges of this MPPG

(1) To define roles of a dosimetrist, therapists, a physicist in training, and a qualified medical physicist as they pertain to the treatment plan/chart review process for external beam radiotherapy (EBRT) and brachytherapy.

(2) To define essential checklist items for initial, weekly and final plan/chart review.

(3) To make recommendations on the timing of the initial, weekly, and final plan/chart review, especially for special procedures (e.g. TBI, stereotactic body radiotherapy, and brachytherapy).

This MPPG considers typical treatment plans in radiotherapy, including the most frequently used external beam radiotherapy (C-arm linear accelerators) using photons and electrons (excluding proton plans) and the most frequently practiced brachytherapy procedures, such as high dose rate (HDR) brachytherapy for gynecological treatments. It is not feasible for this MPPG to cover every procedure or situation, and as such, the medical physicist should collaborate with other members of the department to establish and document appropriate procedures for those falling outside of this work. Working with radiation oncologists, medical physicists are responsible for confirming a patient-specific high-quality plan is developed; however, the quality of a treatment plan is ultimately the radiation oncologist's responsibility. This MPPG does not expound on the aspect of plan quality metrics.

II. Definition

The following terms will be used throughout this report. Their definitions are generally understood by the radiation oncology community. For others who are not familiar with these terms, the definitions are provided below.

QMP: For the purpose of providing radiation oncology therapy clinical professional services, a Qualified Medical Physicist is an individual who is competent to practice independently in the subfield of therapeutic medical physics. The ACR strongly recommends that the individual be board certified. Individual who is not board certified but is licensed by the state, or documented by home institution as passing the institution's competency requirement are also considered as QMP. This definition is more aligned with the ACR definition [7] to be more encompassing than the AAPM definition of QMP [8].

AU: Authorized Users are radiation oncologists who are authorized to utilize a high dose rate (HDR) brachytherapy unit and are required by the Nuclear Regulatory Commission (NRC) and agreement states to be present at the treatment console during high dose rate (HDR) brachytherapy treatments.

AMP: Authorized Medical Physicists are individuals who are listed on the HDR license of brachytherapy and are required by the NRC and the agreement States to be present at the treatment console during brachytherapy treatments. For States that require a license to practice medical physics, licensed medical physicists are AMP.

Prescription: Following the guideline of American Society of Radiation Oncology (ASTRO) on the prescription [9], a Radiation Oncologist should provide the following minimum information in the written prescription for external beam radiation: anatomic site, delivery technique including photon/electron, energy, total dose, number of fractions, and the percent isodose line

that is used for normalization to a specific point or to a specific volume. If IGRT is applicable, the prescription should specify the alignment method (e.g. bone or soft tissue) and the frequency of IGRT applications.

Written directive: Used for brachytherapy plans, similar to the prescription in EBRT plans defined above, a Radiation Oncologist should provide the following minimum information in the written prescription: anatomic site, isotope, activities, total dose, number of fractions, and the percent isodose line that is used for normalization to a specific point or to a specific volume.

Clinical Plan: A radiation oncologist should provide the following in a clinical component of a treatment plan: instructions to the planners on how to create the planning target volume (PTV), if desired, total dose, fractionation scheme, and dose limits to the organs at risk (OARs), if they are different from the institutional established standard tolerances, as indicated in ACR guidelines [10, 11].

Chart: All of the documents that accompany a patient-specific radiation treatment, including: treatment prescription, treatment plan (clinical and technical plans), treatment delivery parameters, recorded treatment deliveries, and image guided radiotherapy (IGRT) images.

Plan: The technical component of a treatment plan, consists of the total dose, fractionation scheme, energy, treatment method, treatment parameters, and the isodose line that is used for normalization and dose statistics.

EBRT: External Beam Radiation Therapy

CT: Computed Tomography, which is acquired during simulation and used for treatment planning.

IGRT: Image-Guided Radiation Therapy, utilizing imaging, including Cone Beam CT (CBCT), kilo-voltage (KV) or mega-voltage (MV) image pairs, for accurate patient alignment during radiation treatments.

4D-CT: Multiple sets of CT scans obtained during regular respiration cycles, to obtain image datasets that can be used to determine tumor/normal organ motions, and to create a better representation of the tumor/normal organs by creating an internal target volume (ITV) or an average CT for treatment planning purposes.

Initial Plan/Chart Check: The same as the new plan/chart check, applied to any plan that is either a new or has significant dosimetric changes.

Weekly Chart Review: The same as the on-treatment chart check.

Final Chart Review: The same as the end-of-treatment chart check.

III. Expectations and Responsibilities

1. External Beam Radiation Therapy

In compliance with the American College of Radiology (ACR) practice guideline [10], radiation oncologists are responsible for the delineation of the tumor volumes, including the gross tumor volume (GTV) and clinical target volume (CTV). For the internal target volume (ITV) and planning target volume (PTV), radiation oncologists can either create these target volumes, or provide a written instruction to the planners on how to create ITV and PTV volumes from the contoured GTV and CTV volumes. Radiation oncologists are responsible for reviewing and approving contours of all target volumes and OARs. Any OARs that are not clearly discernible

on the planning images should be delineated by radiation oncologists. Upon approval of all targeted volumes and OARs, radiation oncologists should provide detailed written instructions to the planner about the desired dose-volume coverage to the targeted volumes and dose limits to clinically relevant OARs (sometimes referred to as dose constraints) [8, 9]. The primary responsibility of a planner is to create a treatment plan in accordance to these dose constraints provided by a radiation oncologist.

In the event that the prescription must be changed during planning, the radiation oncologist should document the change in writing [12]. Some institutions may require a physicist to check the plan quality (which, as mentioned previously, is not in the scope of this MPPG) before the radiation oncologist's approval. Before plan approval, some institutions may have a physicist check important planning parameters such as the removal of the CT couch (or insertion of a couch model), isocenter coordinates, normalization methods, and calculation point placements, in an attempt to catch errors early in the planning process. Other institutions use a quality checklist for the planner to perform a self-check or use a computer program to perform a plan consistency check to eliminate obvious errors, which will be further discussed in Section V. Ultimately, the treatment plan must be approved by a radiation oncologist.

After plan approval, a planner will assemble all necessary information pertinent to the delivery of the plan, such as the creation of digitally reconstructed radiographs (DRRs), setup beams, source to skin surface distance (SSD) parameters, and the key treatment table parameters, when appropriate. Furthermore, a comprehensive treatment plan report is generated. This plan report

is the basis for all levels of plan review by both physicists and therapists. This report can also be used for peer review, billing purposes, and even for patients, who may request this document when transferring care or for re-treatment considerations. The recommended documentation for this plan report is detailed in Section IV. In addition to the plan report, a planner is responsible for transferring the treatment delivery parameters to a Record and Verify (R&V) system, if the R&V system has a separate database from the treatment planning system. The information that is transferred may include additional shifts from the initial isocenter (or reference point) set during simulation, modification of patient external contours (e.g. add bolus on specific region), all essential treatment parameters for each field, and images (DRRs, reference images) associated with the treatment isocenter. This information is essential for radiation therapists to perform accurate treatment delivery for each patient.

Therapists are responsible for positioning the patient for treatment, according to the simulation report, setup instruction, and treatment plan document. To ensure precise patient positioning, radiation therapists must confirm all essential information is available, approved, and consistent. Prior to each treatment, therapists must set up patients with patient-specific devices or patient-specific settings of a reusable immobilization device. A recommended checklist for therapists is discussed in Section V. 1c and listed in Table 5.

Plan/chart review consists of reviewing the treatment plan and/or report, relevant documentation such as setup instructions, and daily treatment records to ensure accuracy, consistency, and clarity. Reviews should occur at multiple time points during the treatment process: initially, weekly, and at the conclusion of treatment (final) during the course of treatments.

(a) Initial Plan/Chart Check

A QMP is responsible for an initial plan/chart check. It is a good practice to perform the initial check prior to the first treatment. The essential checklist for the initial check is discussed in Section V.1b and listed in Table 4. The majority of the DICOM data are transferred via network; however, some information may need to be entered manually. During the initial check, it is important to focus on these elements due to the higher risk of human error. Certain treatment parameters may be automatically checked (see Section VI). We recommend all radiation dose relevant components and critical verification imaging parameters in treatment fields be approved and locked after the initial check to avoid any accidental alterations during the treatment course. Treatments should not be allowed to proceed if the approval status is revoked.

If the initial check is completed by a QMP-designated physicist, then a QMP must complete an initial check prior to the delivery of 10% of the prescribed dose or prior to the third treatment, whichever comes first. The QMP-designated physicists must be someone who is a trained medical physics resident, or other physicist who is supervised by a QMP. The QMP must document the competency the designated physicists on plan and chart review of each specific EBRT treatment modality (i.e. conventional EBRT, SBRT, and SRS). For emergency treatments occurring after hours, an on-call QMP may be contacted to review the treatment plan remotely. For institutions that do not have an on-call QMP, a radiation oncologist may conduct the secondary initial check and a QMP shall check the plan on the next business day, or prior to the treatment on the next business day if additional fractions are prescribed.

(b) Weekly Chart Review

The purpose of weekly chart review is to conduct a systematic review of recorded treatment delivery data, including any overrides, incomplete treatments, any unusual isocenter shifts after the initial image verification, the status of verification image approval, and documentation of SSDs. If daily image guidance is indicated in the prescription, weekly chart reviews should check whether the frequency of image guidance is followed and that the shifts after IGRT are within a reasonable range. A specific weekly chart checklist is discussed in Section V. 1d and listed in Table 8. Any dosimetric changes in a treatment plan should be considered as a new plan, and a new report of the modified plan should be created. For example, a change in daily fraction dose requires a new report to document on the changes of monitor units (MUs). The modified plan should undergo an initial plan/chart check. Weekly chart reviews should be completed within a window of every five treatment fractions. If a treatment course is five fractions or less, the institution should consider developing a process to ensure at least one weekly chart review is conducted during the course of treatment, ideally near the beginning of the course. For single fraction treatment, a weekly chart check can be omitted, but the chart should be reviewed by a QMP within one business day of treatment completion.

Weekly chart reviews should be completed by a QMP or their trained designees, which may include dosimetrists, medical physics residents, and other physicists. When a designee completes the weekly chart review, the QMP must co-sign the document, indicating that the designees are under the supervision of the QMP. It is recommended, when possible, that QMPs and/or their designees conduct the weekly chart reviews on an alternating basis, so that the same person does not check the chart for the entire treatment course.

(c) Final Chart Review

The purpose of final chart review is to review all treatment delivery parameters and documents to ensure that the treatment prescriptions have been fulfilled accurately and all pertinent technical documents are signed and approved. The final chart review should be completed by a QMP within five business days of the patient's last delivered fraction [7]. For single fraction treatment course, we recommend completing the final chart review on the same day of the treatment or no later than the next business day, if the weekly chart review is omitted.

2. Brachytherapy - HDR

There is a broad scope of procedures encompassed within the brachytherapy realm. As an example, this MPPG examines a common high dose rate (HDR) brachytherapy for gynecology cancer. The plan/chart check procedure developed for this procedure may be extended to other more complicated brachytherapy treatments or procedures.

The initial check for HDR should be performed by an AMP. In situations where an AMP is in a solo practice, an AMP designated team member (either a therapist, a dosimetrit, or an AU) who is trained for the HDR procedure may complete the initial plan/chart check if the HDR plan was created by the solo AMP.

This MPPG suggests an essential brachytherapy checklist for a new plan/chart checks in Section V.2. In practice, some institutions generate a new plan for every fraction. The new plan is checked again, which can be considered as the weekly chart review. In institutions where the same brachytherapy plan is delivered over multiple fractions, the AMP should complete a weekly chart review within a window of every 5 fractions, similar to those conducted for EBRT. If an institution decides not complete weekly chart reviews on a brachytherapy procedure because a new plan is created each fraction, a QMP should review a treatment procedure document after each treatment to ensure the treatment record, pre- and post-radiation surveys, and documentation of the presence of appropriate clinical personnel (an AU) is completed.

The final chart review should be performed at the end of the treatment course. The guidelines are the same as for EBRT. The AMP should check the accuracy of all treatment delivery parameters and documents to ensure the AUs' directives have been fulfilled accurately and that all pertinent technical documents are signed and approved. It is recommended the final chart review be completed by an AMP at the day of final treatment, or no later than the next business day.

IV. Essential Content of a Treatment Plan Document

A treatment plan report should be generated after the radiation oncologist (or AMP)'s review and approval of the treatment plan. This report allows careful preservation of the treatment plan stored in a central location, either in the hospital EMR system or radiation oncology specific medical record system (Record and Verify System) along with other treatment-related

documents. For purpose of patient care, the treatment plan report can be easily readable by all caretakers as well as the patients themselves, who are not familiar with (or do not have access to) the treatment planning system or a DICOM program.

1. External Beam Plan Document

The treatment plan report is often in a file format, such as PDF, where modification is restricted. A treatment plan report should display information in a consistent manner from patient to patient by standardizing the components, order, and the specific displays (i.e. isodose lines appearing at standard levels and colors). For the prescription, it is recommended to include the anatomic site name and laterality, total dose, number of fraction, and the percent isodose line that is used for normalizing to a specific point or to a specific volume (see Table 3) according to the prescription guideline from American Society of Radiation Oncology (ASTRO) [9]. Nomenclature such as beam names should be standardized and designed to reduce confusion and improve safety. For organ names and tumor volume names, it is recommended to use the established nomenclature standard described by TG 263 [13]. We recommend including at least one isodose image for each of the three orthogonal planes at isocenter or in the middle of the target(s) with isodose lines shown in absolute dose and including the prescription dose level(s).

The second column in Table 1 shows the various components of a treatment plan report for external beam and brachytherapy plans. Optional elements should be considered depending on specific institutional workflow, clinical practice, or billing requirements. The components of the

treatment plan report should be reconsidered when implementing new technology, e.g. proton therapy. A treatment plan report must demonstrate that the prescription is being fulfilled. The documentation should clearly convey how the plan fulfills the specific radiation oncologist intent. Setup information including documentation of immobilization devices is important for reproducible treatments. If setup information is not documented elsewhere, it should be included in the treatment plan report.

2. Brachytherapy (HDR) Plan Document

A brachytherapy (HDR) plan document should follow the same order as the EBRT plan document. The Third column in Table 1 shows the various components of a HDR plan report. Optional elements should be considered depending on specific institutional workflow, clinical practice, or billing requirements. The major differences in documents between EBRT and brachytherapy plans are on the sections of plan summary and beam eye views. For brachytherapy plans, it is of utmost importance to examine the reconstruction view of each catheter and/or source position(s), including orientation (for example, tip verses catheter end). It should be noted that the verification of the reconstruction may not be fully possible with a printout alone but likely requires a review with the TPS.

V: Recommended Checklist items During Plan and Chart Review

1. External Beam Plans and Charts

a. Checklist for Planners

As mentioned in Section III, the primary responsibility of a planner is to create a treatment plan in accordance with the treatment prescription and other written instructions provided by a radiation oncologist. In addition, a planner must assemble necessary information for the therapists to deliver the plan, including isocenter shifts, IGRT reference images, and cross-verification parameters (e.g. SSDs, table positions, etc.). To assist a planner, it is recommended that a planer conducts a self-check during planning or after the plan is completed. The self-check items are listed in Table 2. Once the plan is approved by a radiation oncologist, it is recommended that a planner creates a plan report following a standard format established by each local institution. The recommended components of a treatment plan report are listed in Table 1. The final section in Table 2 lists checklist items that are essential for therapists to deliver the plan. The optional items listed in Table 2 can be added to the planner's checklist, depending on the preference of the local institution and practice.

b. Initial Plan/Chart Checklist for Physicists

A treatment prescription (and/or written directive) from a radiation oncologist is the foundation for any new treatment, and thus it is recommended that the treatment prescription be standardized, clear and concise, and follows the prescription guideline from American Society of Radiation Oncology (ASTRO) [7]. The essential items to be included in the prescription are listed in Table 3. During new plan/chart review, a QMP should ensure that these items are documented in the prescription and are consistent with the corresponding treatment plan report. Upon reviewing the plan report, it is recommended that a QMP follows checklist in Table 4. In the treatment plan, the isocenter or the initial reference point

that was marked during CT simulation must agree with the skin marks on the patient since this is the starting point of treatment plan and delivery including any additional shifts required during the planning process. A recent publication [5] from Radiation Oncology Incident Learning System (RO-ILS) reported that a potential systematic error in 15% of reported events was a wrong isocenter, which could have originated from the initial isocenter marked on the patient skin mismatching the isocenter that was sent for treatment planning. Therefore, this MPPG recommended that a photo documenting the initial alignment point marked on the patient skin be added in the R&V system, which can assist therapists to identify the alignment point (sometimes, it referred to as the laser alignment point). Furthermore, this MPPG also recommend documenting the agreement between the coordinates or location of the initial isocenter sent to the treatment planning system and the initial alignment on the patient skin markers. For example, for institutions that implement the virtual simulation (identify the iso-center after completion of planning CT acquisition) one can acquire an additional single slice axial CT scan after acquisition of the planning CT. This single slice image should contain three radio-opaque markers that are placed on the skin where three laser points intersected. A planner should then verify the initial isocenter (or reference point) matched with points marked on the patient skin.

Optional items included in Table 4 can be added to the checklist depending on the specific practice of each institution. A QMP should ensure that essential information from the treatment plan report are correctly transferred into the R&V system and approved by assigned responsible teams. The last section in Table 4 lists the essential checklist items. The

optional items in this section of Table 4 can be added to the checklist depending on the specific practice of each institution.

c. Initial Plan/Chart Checklist for Therapists

Prior to any new treatment, therapists should conduct a new plan/chart review to confirm all essential information is available, approved, and consistent. The importance of therapists conducting an initial check is well demonstrated [14]. A recommended checklist for therapists is listed in Table 5. Optional items in Table 5 can be added to the checklist depending on the specific practice of each institution.

d. Weekly Chart Review Checklist

A recommended checklist for weekly chart check is listed in Table 8. The optional items listed in Table 8 can be added to the checklist depending on the specific practice of each institution. After completion of the weekly chart review, we recommend that a formal report to be generated to document the date of the weekly chart review, the treatment site, accumulated dose, number of fractions delivered to date, and other checklist items listed in Table 8. For a new plan or a modified plan that has dosimetric impact, the first on-treatment chart check should also include a quick check on plan quality, which serves as another level of assessment to ensure that there are no gross errors in the plan.

e. Final Chart Review Checklist

A QMP should conduct a final chart checks to ensure the treatment prescriptions and/or written directive have been fulfilled accurately and all pertinent documents are signed and approved. A recommended checklist for final review is listed in Table 9. It is recommended to generate a formal document to report the date of the final chart check, the treatment site, total dose, and total number of fractions delivered in accordance to the prescription. This recommendation is compliant with ACR practice guideline[7]. If the prescribed treatment course was not completed, a comment should be added in the existing prescription, or a separate note or document. This document and the existing prescription should be stated on the final dictation by the radiation oncologist.

2. Brachytherapy Plans/ Charts

a. Initial Plan/Chart Checklist for Physicists

As discussed in Section III 2, during HDR planning, the accuracy of image co-registration, applicator specification and placement, catheter reconstruction, and catheter channel parameters (such as indexing/ length and the appropriate identification of the first dwell positions) are important parameters to verify before transferring the treatment data to the treatment console. We recommend each new plan be checked by an AMP listed on the HDR license, using the checklist provided in Table 6.

b. Initial Plan/Chart Checklist for Therapists

Prior to each treatment, we recommend that therapists (or an AMP if a therapist is not involved in the procedure) conduct a pre-treatment check following Table 7. The

checklist can serve as a part of the treatment procedure document and be signed by an AMP and an authorized radiation oncologist, who are present during the treatment.

c. Weekly Chart Review Checklist

Weekly chart review for brachytherapy plans is only required when the same brachytherapy plan is delivered over multiple fractions. The applicable items are listed in the second column in Table 8.

d. Final Chart Review Checklist

Similar to external beam, an AMP should conduct the final chart reviews to ensure the treatment prescriptions and/or written directive have been fulfilled accurately and all pertinent documents are signed and approved. A recommended checklist for final review for brachytherapy plans is the same as the EBRT plans as listed in Table 9. If the prescribed treatment course was not completed, a comment (or a note) should be added in the prescription and approved by the radiation oncologist.

VI: Computer-aided Plan/Check and Automation

Some vendors and individual institutions have developed computer programs to automatically check various parts of a patient plan or chart [15-20]. These programs are effective in checking simple logistic requirements and numerical consistency. For example, a computer program can check whether prescriptions or portal images are approved by radiation oncologists[21], and whether radiation treatment parameters are in agreement with the planned parameters [20] . A comprehensive literature review about computer-aided plan/chart check can

be found in TG275 [5]. Due to significant variations in workflows among different clinical practices, these programs cannot completely replace the function of a physicist in the process of the plan and chart review. Computer programs, however, can assist in certain areas of plan/chart review. For example, vendor-provided programs [22, 23] can assist with checking whether plan DVHs meet clinical requirements, but these programs cannot substitute careful examinations of three dimensional dose distributions on planning images.

With automation, plan document components recommended in Table 1 can be easily standardized and implemented. Most items listed in Table 2 can be checked automatically to avoid errors in the upstream during treatment planning, but items such as whether bolus is applied appropriately and whether contours of normal/critical structures are completed and accurate will still rely on human judgment and experiences. Some items in Table 3 can be extracted from treatment plan documents, but items such as CBCT frequency, IGRT alignment structures, and special motion management techniques vary from patient to patient, requiring human judgment and discretion. While a majority of the items listed in Table 4 can be checked by computer programs, items such as whether the isocenter of a plan (if no isocenter shift) matches with isocenter markers on the patient's skin, beam clearance, and anatomy structure density override, still need human attention. Computer-aided programs can provide an alert list for initial and weekly plan/chart review, calling for special attention to certain missing or mismatched items, therefore can help streamline the whole process.

Before implementing computer-aided check programs, it is the responsibility of a QMP to rigorously validate them to avoid potential systematic errors. With increasing use of artificial intelligence and sophisticated statistical machine learning tools in the medical physics field, more commercial computer-aided plan/chart review programs are expected to be available

clinically in the near future. The combination of computer-aided and human plan/chart review will significantly improve the effectiveness of this vital process while improving safety and quality of our patient care.

VII: Discussion

The primary goal of this MPPG is to provide essential checklist items for medical physicists who conduct plan/chart reviews according to the minimum practice standards. The plan/chart review process, particularly the initial plan review process, is critical to prevent errors and to ensure smooth patient care. Thus this process should have multiple layers and take collective efforts of the entire department, in addition to the physics check/review. This MPPG, therefore, also recommends therapists conduct the initial plan/chart check prior to any new treatment. The initial plan/chart checklist for the therapists overlapped with the checklist of initial plan/chart check for the physicists on the important items, such as the prescriptions and location of the iso-center. In addition to act as an additional layer of the safety check, another purpose of checklist for therapists is to ensure the presence of important documents and the associated authorizations and approval, according to the rules of ACR and other regulatory agencies, thus preventing potential interruptions of patient care. This MPPG invited American Society of Radiologic Technologists to review the report and obtained the endorsement from the society.

To catch errors upstream, this MPPG recommends a self-consistent checklist for planners and the use of standard documentation of a plan. Since the planners are often dosimetrists, this MPPG also reach out to the American Association of Medical Dosimetrists (AAMD) for their input and

endorsement of self-consistent checklist and standard documentation. There are some debates about whether a standard documentation is necessary if everyone has an access to the treatment planning system to review the plan comprehensively. Given the complexity of a treatment planning system, a planner typically accesses numerous treatment planning parameters through many sub-windows and panels, therefore, we believe that not everyone has the skill and confidence level as a planner in the use of a treatment planning system. A standard plan document displays all key information of a plan in a consistent order and straightforward format, facilitating those who are not familiar with the treatment planning system to grasp the content of a plan, including patients themselves.

From the perspective of minimum practice standards, this MPPG is different from TG 275 [5] although the underlining principles are the same. Within this task group, we included two members from TG 275, who provided a valuable link between TG 275 and this MPPG. Based on TG 275 and practice experiences of the task group members, which included academic and community practices using different Record & Verify systems and treatment planning systems, the recommended initial plan/chart checklist for physicists has about 50% - accordance of the example checklist (Table 1c from TG 275). Some items in the example checklist of TG 275, such as physician directives for simulation procedures, treatment prescriptions with respect to the standard of care/clinical guideline, are not included in the recommended checklist of this MPPG because we believe these items are beyond the training and responsibility of a medical physicist. This view is supported by ACR guideline for 3D external beam radiation planning and conformal therapy[10]. Furthermore, the accuracy of contours of tumor volumes and normal tissue volumes is predominant in 3D and IMRT planning and is the responsibilities of radiation oncologists per

ACR guideline[10]. To improve patient care workflow, it is a good practice for each planner to conduct a sanity check of all contours to avoid replanning. This sanity check (included in Table 2 of planner checklist) is to detect gross errors such as skip slides, miss labels of contours, an illogical relationship among GTV, CTV, ITV and PTV, stray voxels, to name a few. According to the guideline of ATSRO [9], this MPPG recommends each local institution establishes its own standard format of a treatment prescription for both EBRT and brachytherapy. Medical physicists can provide supports to radiation oncologists to adhere to the ASTRO guideline. The accuracy and completeness of a prescription are again beyond the clinical training and responsibility of a medical physicist. Some items in the checklist of this MPPG are not in the checklist of TG 275, including items such as the patient name and medical record numbers, and item such as all beams associated with the same iso-center (for single iso-center plans). The weekly and final chart review checklists from this MPPG are mostly in agreement of recommendation of TG 275. For institutions that desire to conduct more comprehensive and thorough plan/chart review and have the required resources, they are encouraged to develop their own checklists that combines checklists from TG 275 and this MPPG and more.

The scope of this MPPG is limited to most frequently used external beam radiotherapy (C-arm linear accelerators) and most frequently used brachytherapy (for gynecological treatments). The recommended checklists can be extended to other external beam modalities such as proton beam radiotherapy, Cyberknife, and Tomotherapy while taking account for unique applications of these modalities.

VIII: Summary

This MPPG provides lists of the essential checklist items, according to the minimum practice standards, for medical physicists, dosimetrists, and therapists to follow when conducting plan/chart reviews. The report also provides essential components to include in a treatment plan report, provides minimum personnel qualifications for those completing plan/chart review, and provides appropriate timelines for when to complete plan / chart reviews.

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