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Scientific Article

Implementation of a Novel Chart Rounds Application to Facilitate Peer Review in a Virtual Academic Environment

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Purpose: Peer review in the form of chart rounds is a critical component of quality assurance and safety in radiation therapy treatments. Radiation therapy departments have undergone significant changes that impose challenges to meaningful review, including institutional growth and increasing use of virtual environment. We discuss the implementation of a novel chart rounds (NCR) format and application adapted to modern peer review needs at a single high-volume multisite National Cancer Institute designated cancer center.

Methods and Materials: A working group was created to improve upon the prior institutional chart rounds format (standard chart rounds or SCR). Using a novel in-house application and format redesign, an NCR was created and implemented to accomplish stated goals. Data regarding the SCR and NCR system were then extracted for review.

Results: SCR consisted of 2- 90-minute weekly sessions held to review plans across all disease sites, review of 49 plans per hour on average. NCR uses 1-hour long sessions divided by disease site, enabling additional time to be spent per patient (11 plans per hour on average) and more robust discussion. The NCR application is able to automate a list of plans requiring peer review from the institutional treatment planning system. The novel application incorporates features that enable efficient and accurate review of plans in the virtual setting across multiple sites. A systematic scoring system is integrated into the application to record feedback. Over 5 months of use of the NCR, 1160 plans have been reviewed with 143 scored as requiring minor changes, 32 requiring major changes and 307 with comments. Major changes triggered treatment replan. Feedback from scoring is incorporated into physician workflow to ensure changes are addressed.

Conclusion: The presented NCR format and application enables standardized and highly reliable peer review of radiation therapy plans that is robust across a variety of complex planning scenarios and could be implemented globally.

Introduction

Peer review is a critical component of quality assurance and safety in radiation therapy treatments.[1-5] Peer review has been shown to improve the identification of errors in

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radiation treatment planning including clinical course, prescriptions, contours, and dosimetry.[5-8] The majority of radiation therapy programs across the United States have employed a form of peer review known as "chart rounds" to assess plan quality and safety. Chart rounds generally consists of meetings during which members of the treatment team review all aspects of radiation therapy treatment plans listed above.[1]

Despite its widespread use, there is significant variability in the format, delivery, and efficacy of chart rounds across institutions. The *American Society for Radiation Oncology (ASTRO)* attempted to remedy this by publishing a white paper discussing the importance of peer review and providing some guidance for peer review efforts in 2013.[9] Since this time health care and radiation therapy departments have undergone significant changes, including institutional growth, increase in use of virtual environment following the COVID-19 pandemic, and changes in resident learning techniques.[10-17] Here, we discuss our institutional experience with chart rounds and the implementation of a new chart rounds application to adapt to modern radiation therapy departmental needs and multiple use scenarios.

Methods and Materials

In June 2021 an NCR application was proposed at a single high-volume multisite National Cancer Institute designated comprehensive cancer center to address the evolving work and educational environment. A working group, including radiation oncology physicians, residents, physicists, and dosimetrists, was created to discuss the format and delivery of the SCR and critical components for the proposed NCR application. NCR application format and goals are listed in Table 1.

After delineation of goals, the NCR application was created by a physicist at our institution. It was written in C++ using the Visualization Toolkit (VTK). Before every chart rounds session, SQLite is used to query our institutional treatment planning software for all plans reviewed by an MD since the prior session. The SQLite query extracts all relevant patient data. VTK allows the display of images, segmentations, doses, and other data in the proprietary format. The proprietary format is designed for efficiency through optimization techniques. The functions and visualization modules are custom-made with the goal of rapidly assessing plan quality. The application software was disclosed to the Office of Technology Transfer at our institution.

Following development, the application was tested by select providers to evaluate functionality. The NCR format and application was implemented institution-wide in May 2022. Following initial operation, the application was further customized to address any challenges with real-world use. Data regarding the SCR and NCR systems were then extracted for review.

Table 1 Goals for Novel Chart Rounds Application and Format

Novel Chart Rounds Goals
1. Divide by disease site(s) assisted by the application and standardization of treatment plan elements.
2. Sift through data from the institutional treatment planning system to automate a list of plans requiring peer review.
3. Standardize a scoring system within application to record plans requiring major or minor changes following peer review.
4. Incorporate customizable features to facilitate disease-specific peer review needs.
5. Record review feedback within application.
6. Create mechanism for timely and reliable relay of critical feedback to treating providers.
7. Enable education for medical physics and clinical radiation oncology residents during and outside of chart rounds activities.
8. Facilitate future research through creation of an automated growing, searchable archive of cases.

Table 1 describes goals for novel chart rounds format and application delineated by chart rounds working group.

Standard Chart Rounds

Before incorporation of the novel chart rounds (NCR) application, institutional chart rounds (standard chart rounds or SCR) consisted of weekly department-wide sessions. The department consists of 7 distinct treating sites participating in review. One physics faculty compiled a list of new radiation therapy treatment starts taken from the treatment planning software, ARIA/Eclipse. These cases were then manually entered into an application which extracted information from the treatment planning software during the chart rounds session. This preparatory process required one full workday per week.

Providers were split into 2 chart rounds groups consisting of a variety of disease site experts, thus a variety of radiation therapy cases. The 2 simultaneous virtual 90-minute chart rounds meetings were held weekly at the same time on Friday mornings. Clinical radiation oncology residents led the chart rounds groups using the software. The application was able to pull basic information from the treatment planning software including the patient narrative and prescription document, the CT simulation with overlying isodose lines, and the dose volume histogram for review of OARs. Educational discussion for medical physics and clinical radiation oncology residents was encouraged but was limited due to time constraints.

Table 2 Standard Chart Rounds Challenges and Solutions

Challenges with *Standard* Chart Rounds	Solutions with *Novel* Chart Rounds
1. Manual case input resulting in duplicate cases, missed cases and excessive time.	1. Automated code allows fast and more accurate input of new treatment start cases into chart rounds application.
2. Enlarging hospital system unable to review all new cases within 90 minutes between 2 chart rounds groups weekly.	2. Separation into 6 disease site specific chart rounds with 60 minutes for each disease site weekly.
3. Chart rounds application with glitches resulting in slow and error-prone case review.	3. Novel application created with fewer glitches delaying case review.
4. Difficult to quickly identify unmet clinical goals.	4. Novel application is able to flag important information for plan review, including unmet clinical goals.
5. Lack of standardized review of plan evaluation items.	5. Standardized scoring system created to record feedback from peer review.
6. Manual recording of commentary regarding problematic plans.	6. Standardized scoring system is recorded within application as a required component of each review.
7. Lack of system to ensure problematic plans are addressed by providers.	7. Feedback from scoring is incorporated into physician workflow to ensure changes are addressed.
8. Lack of productive educational discussions for faculty and residents.	8. Increase in time available to spend on each plan encourages discussion.

Table 2 describes challenges with standard chart rounds, as well as solutions with novel chart rounds format and application.

One medical dosimetrist in each meeting group was tasked with recording all concerns with treatment plans. These comments were compiled into an email that was distributed to the entire department. Plans requiring changes were manually included in the following week's chart rounds to ensure comments were addressed.

The standard chart rounds format posed multiple challenges outlined in Table 2.

Results

Novel Chart Rounds

SCR consisted of 2 weekly 90-minute chart rounds sessions to review all sites. NCR uses 6 weekly disease site specific sessions of 1-hour duration held virtually, enabling faculty and residents to spend more time reviewing each plan. Disease site sessions, also known as workgroups, include central nervous system/pediatrics, gastrointestinal/sarcoma, breast, genitourinary/gynecology, head and neck/skin/lymphoma, and stereotactic body radiation therapy/thorax. With the NCR format, 11 plans per hour are reviewed on average compared with 49 plans per hour with the SCR format in the 5 months preceding NCR implementation. Additionally, there has been more robust discussion among faculty and residents due to minimal time constraint and increased attendance. In the 6 months preceding implementation of the NCR, on average 26 participants total were in attendance for each SCR session weekly, including 13 physician faculty, 7 physician residents, 3 physicists, and 2 dosimetrists. In the initial 6 months of use of the NCR, the average number of participants for each disease site included: 19 (breast), 13 (central nervous system/pediatrics), 16 (gastrointestinal/sarcoma), 23 (genitourinary/ gynecology), 21 (SBRT/thorax), and 16 (head and neck/skin/lymphoma).

SCR required manual creation of patient lists for plan review, resulting in up to 20% of plans being missed or excluded. Notably, plans treated with 3D conformal radiation therapy with palliative intent were excluded. The NCR application allows automation of the list of plans requiring peer review from the treatment planning system. Plans chosen are the new radiation treatment starts for the upcoming week. All plans are reviewed in NCR, regardless of modality or treatment intent.

The NCR application is an organized, searchable database of cases. Plans can be queried by prescription, diagnosis, workgroup, and other characteristics (Appendix E1 and Video E1). When a plan is chosen for review, the prescription document is easily viewed. Cases can be separated into favorites lists, project groups and similar cases (Appendix E1 and Video E1). Representative images of the NCR application can be viewed in Fig. 1.

The novel application incorporates features that enable the efficient and accurate review of radiation plans in the virtual setting across multiple sites. Features include incorporation of 4D scans for visualization of motion for thoracic and abdominal cases; incorporation of MRI registrations for central nervous system cases; ability to view composite plans for boost and reirradiation cases. Met clinical goals are indicated with green color, while unmet clinical goals are flagged as red color. Unmet

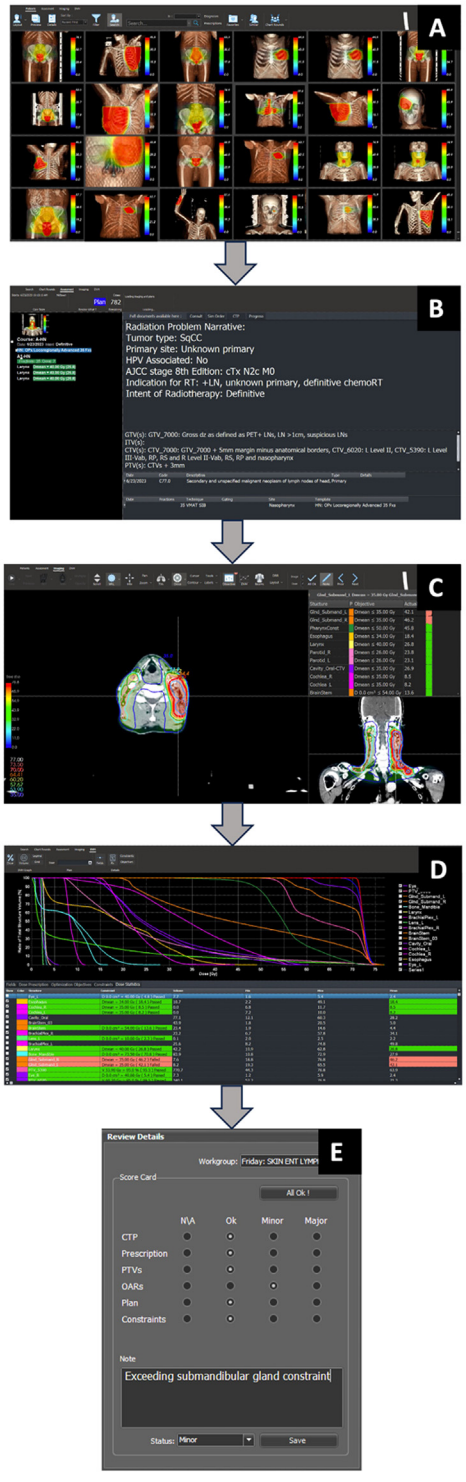

Figure 1 Demonstrates key steps of the novel chart rounds (NCR) application. (A) Demonstrates the home screen with the ability to visualize patients requiring peer review and searchable function of application, including by diagnosis, prescription, workgroup and favorite list. (B) Demonstrates diagnosis, radiation problem narrative, prescription, radiation technique, and target volume definitions. (C) Demonstrates review of imaging, contours, isodose lines, and clinical goals. Constraints that are achieved are highlighted in green. (D) Demonstrates dose-volume histogram review. (E) Demonstrates standardized scoring card within the novel chart rounds application that must be completed for each plan that is reviewed.

clinical goals include plans that do not meet target coverage goals or exceed organ-at-risk (OAR) constraints. Segmentation is checked against a model of learned previous cases, resulting in abnormally shaped structures (OARs, volumes) to be automatically marked (Fig. 2).

The NCR contains a standardized scoring card within the application (Fig. 1). The scoring card allows rating of the clinical treatment plan, prescription, target volumes, OAR constraints, and overall plan. Plans are scored as requiring no changes, minor changes, or major changes. Plans scored as requiring major changes indicate that the treatment should be stopped until the peer-review feedback is addressed. Plans scored as requiring minor changes indicate that there may be concerns with the plan, however the treatment does not need to be urgently stopped to address these. There is an opportunity to add comments regarding each plan and score.

In the most recent 5 months of use the NCR, 1160 plans have been reviewed with 143 scored as requiring minor changes, 32 requiring major changes and 307 with comments. Disease site specific data are listed in Table 3. All major changes triggered replan and often included vital OARs exceeding constraints, need to expand target coverage, alterations to patient set-up, and inclusion of prior radiation dose. Feedback from scoring is incorporated into physician workflow to ensure changes are addressed. Physician response time is expected to be within 24 hours. Plans that require further discussion or changes are not marked as completed and are reviewed again at the following week's chart rounds session.

Discussion

Chart rounds is a vital component of peer review for radiation therapy departments. With changes in the work environment including enlarging institutions, remote settings, and increasing need for standardization, it is prudent to improve upon current chart rounds processes. Our experience creating an NCR format and application to meet these needs is the first reported in the literature. It enables efficient and highly reliable peer review of radiation therapy plans for a multitude of complex planning scenarios. This NCR process can be replicated at other institutions.

While other institutions have improved peer review through the use of automated tools,[1] early peer review,[4] virtual format,[18] disease site specific,[18-20] and standardized scoring system,[21] this is the first report of the creation

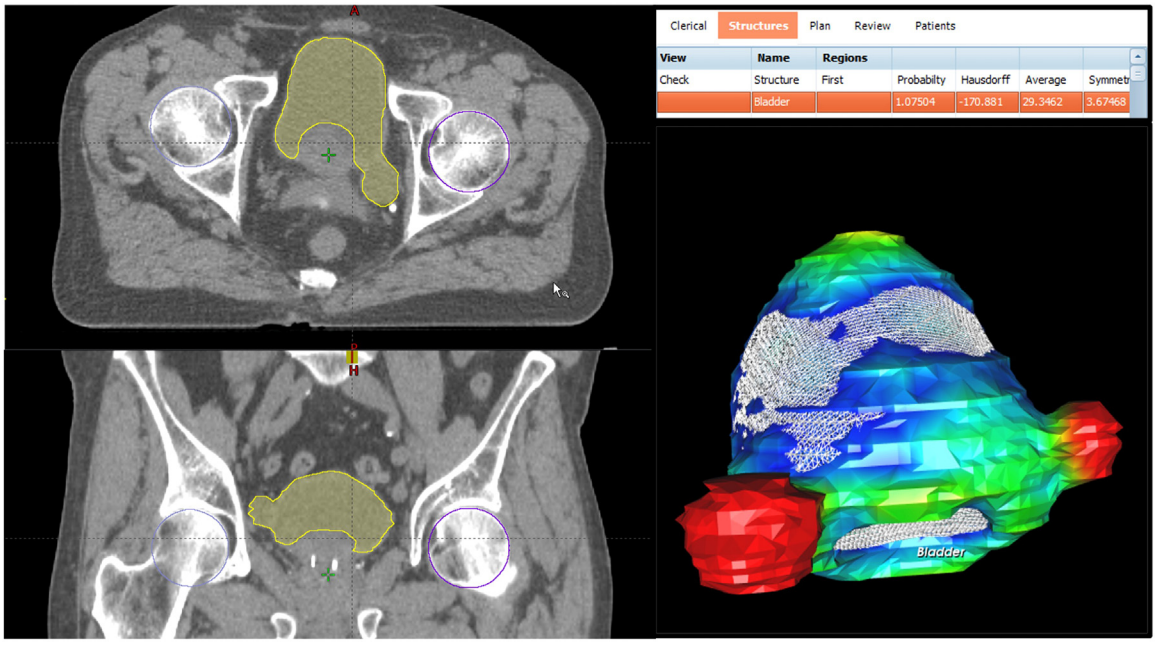

Figure 2 Demonstrates the use of segmentation to assess accuracy of structures. This abnormal bladder shape is automatically marked. Segmentation is checked against a model of learned previous cases.

and implementation of novel application and format which include all of these features. However, as the stated changes were made concurrently, it is difficult to discern whether the improvements in plan review were due to the NCR application, disease site format, or both. We are further limited by the retrospective single institution nature of this experience. Because of the inability to record major changes, minor changes, or treatment delays in the SCR system, we are unable to quantitatively compare plan changes made in the SCR and NCR systems.

The NCR has many notable benefits, compared with the SCR system. The use of automation to import new radiation treatment plans into the chart rounds application allows physics faculty to focus efforts on other tasks. Reduced application glitches allow streamlined chart rounds experience and minimal time spent troubleshooting. Automatic flagging of unmet clinical goals within the application enables efficient recognition of plan issues. To ease the implementation of the NCR application and format, our institution allows access to the application software upon request. However, software customization may be necessary to match individual institutional practices."

The absolute number of participants per session decreased in NCR as a result of cases and participants being split among 6 chart rounds sessions. These smaller settings ensure that more disease site experts can attend, and more time is spent per patient plan, strengthening plan evaluation. We were previously unable to review 3D palliative plans in-depth, however all plans are fully reviewed in the NCR system. Additional time results in robust discussion between faculty and residents that may enhance the educational value of chart rounds. However, faculty and residents are not exposed to disease sites outside their own, possibly resulting in diminishing knowledge of field trends. Additionally, there is an increased burden on residents and faculty who treat multiple sites, as they may be required to attend multiple chart rounds meetings. At our institution, faculty are not mandated to attend all chart rounds meetings where their cases are presented, as the standardized format of plan review ensures all cases are appropriately reviewed and feedback is delivered.

A formalized scoring system within the NCR application ensures that all plans undergo a systematic review and avoids errors resulting from manual recording of peer review discussion (SCR). This enables data driven peer review tracking to identify areas for quality improvement. However, completion of score cards in the NCR application takes additional time per plan. While feedback from scoring cards is forwarded to physicians, if the physician is unavailable (vacation, conference, family leave) there may be delay before feedback is forwarded to the covering provider. This may result in a holdup in appropriate changes being made to plans.

The NCR application serves benefits outside of standard peer review. It can be used outside of the chart rounds environment for educational and research purposes. All new plans are incorporated into the application resulting in a searchable database of cases. Challenging cases can be marked as such and reviewed at a later time by interested residents, dosimetrists, or physicists. Contouring and treatment planning of rare and complex cases that residents have not previously encountered can be

Table 3 Disease Site Chart Rounds

Disease Site Chart Rounds	Plans reviewed per session *Median (min, max)*	Plans with major changes per session *Median (min, max)*	Plans with minor changes per session *Median (min, max)*	Plans with comments per session *Median (min, max)*	Total plans reviewed	Total plans with major changes	Total plans with minor changes	Total plans with comments
SBRT/THORAX	12 (4, 18)	0 (0, 2)	1 (0, 2)	3 (0, 7)	177	10	16	41
BREAST	15 (9, 23)	0 (0, 2)	2 (0, 4)	4 (1, 10)	311	11	36	78
PEDS/CNS	13 (5, 21)	0 (0, 3)	1 (0, 3)	2 (0, 7)	255	5	23	46
ENT/SKIN/LYMPHOMA	8 (1, 15)	0 (0, 1)	2 (0, 9)	5 (0, 9)	148	3	35	75
GI/SARCOMA	4 (1, 8)	0 (0, 0)	1 (0, 4)	2 (0, 4)	84	0	19	36
GU/GYN	13 (2, 22)	0 (0, 2)	0 (0, 6)	1 (0, 6)	185	3	14	31
ALL SITES	11 (1, 23)	0 (0, 3)	1 (0. 9)	3 (0, 10)	1160	32	143	307

Abbreviations: CNS = central nervous system; ENT = head and neck; GI = gastrointestinal; GU = genitourinary; GYN = gynecology; PEDS = pediatrics; SBRT = stereotactic body radiation therapy.
This table describes the average number of plans reviewed, scored as requiring major or minor changes, and plans with comments per 1-hour session. Additionally, the total number of plans reviewed, plans scored as requiring major or minor changes, or plans with comments over a 5-month period is listed.

facilitated by a search of the institution's prior peer reviewed cases. This database also serves as a resource for large-scale institutional research projects.

Though we mainly describe the benefits of NCR in the setting of an expanding academic institution, there are obvious benefits that may allow for enhanced peer review beyond local, national and international borders. Expansion of this tool beyond our institution could serve to enhance radiation therapy programs in resource poor settings (low-middle income countries, rural/remote departments) where robust peer review programs are difficult to initiate. The NCR application may be used in this setting to review challenging cases virtually with experts on a national or international level.[22,23] Adaptations may be necessary to account for resource limitations, reduced specialization, and increased time limitations in these environments. Future studies may help to elucidate this further.

Conclusion

Novel chart rounds processes are required to adapt to modern use scenarios. An NCR format and application was created at a single high-volume multisite academic center in the United States. The NCR demonstrates efficacy across a variety of different planning scenarios. This process may be replicated at institutions worldwide to enable high quality radiation treatments.

Disclosures

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.adro.2023.101406.

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