RO•ILS® RADIATION ONCOLOGY INCIDENT LEARNING SYSTEM

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CLARITY PSO

A Patient Safety Organization

RO-ILS CASE STUDY 21

CONTOURING COMPLEXITY – Navigating the *Breath* of Multiple CT scans in Radiation Therapy Planning

Introduction

Contouring target volumes and organs-at-risk (OARs) is a cornerstone of modern radiation therapy treatment planning. For target(s) and OAR(s) delineation, the patient must undergo a planning simulation, which most commonly involves a computed tomography (CT) scan in the treatment position with use of customized immobilization devices for setup reproducibility. CT-based treatment planning emerged as a standard of care in the early 2000s and since then the number and types of CT scans acquired at simulation has steadily increased, especially for complex cases in which motion management is important. For example, patients with left sided breast cancer may undergo both a free-breathing CT scan and a deep inspiration breath-hold (DIBH) scan in order to quantify the displacement of the heart away from the treatment field(s) for that particular patient. In patients with intrathoracic tumors, a 4D CT scan is generally obtained, resulting in 10 scans corresponding to each phase of the respiratory cycle (0%-90% at 10% intervals), as well as an average scan, and a maximum intensity projection scan. If significant motion of the target is observed on the 4D CT scan, the treatment team may decide to obtain additional scans such as a DIBH or end exhalation breath hold scan. These represent but a few examples of the myriad of unique CT image data sets that are often acquired at CT simulation and underscore the importance of effective communication so that all members of the team are aware of how and when each scan is used for treatment planning purposes.

Event Overview

A patient with lung cancer underwent treatment planning for stereotactic body radiation therapy. Based on significant tumor motion shown on the 4DCT, the intent was to treat the patient with DIBH gating. However, the radiation oncologist contoured the target volumes on the free-breathing CT scan instead of the DIBH scan. As a result, treatment planning was done on the incorrect image data set and the contouring error was discovered on physics second check prior to the patient initiating treatment.

Contributing Factors

- Multiple CT image data sets available for contouring.
- Each CT data set may not have been labeled accurately.
- Lack of documentation as to which CT data set should be used for planning.
- Staff labeling the CT data sets and documenting the notes may not have had adequate training on these more complicated simulations.

Lessons Learned/Mitigation Strategies

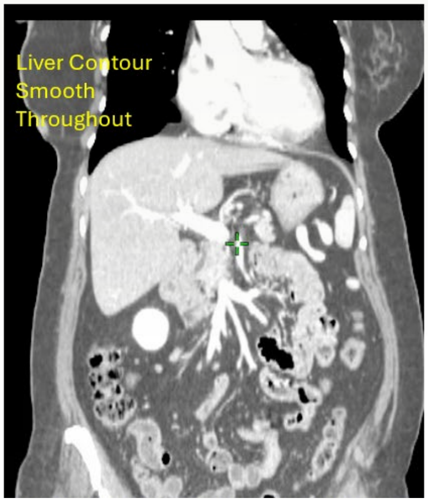
1. **Simulation documentation:** When multiple image sets are acquired at CT simulation, it is important to clearly document which scans were acquired, and to clarify the primary image set to be used for planning as early as possible in the process. Simulation therapists and all others involved in the process of labeling and reading images need to be trained on a well-defined policy for naming conventions.
    a. This process can begin at CT simulation where each image set obtained should be labeled as clearly as possible using a standardized nomenclature as determined by the facility. Examples of possible nomenclature are provided below.
        i. 4DCT: CT_0, CT_10, CT_20, etc. for each phase of the breathing cycle; CT_ave (average scan), and CT_MIP (maximum intensity projection)
        ii. Free-breathing CT scan: CT_FB
        iii. Deep inspiration breath-hold: CT_DIBH
        iv. End exhalation breath-hold: CT_EEBH
    b. Ideally, the simulation directive would also specify which scan the physician would like to use for radiation treatment planning. If feasible, having the treating physician and/or a physicist present at simulation can help clarify which scan should be used for planning.

2. **Exporting scans to the treatment planning system**: All CT simulation image data sets that may be used in planning should be sent to the treatment planning system clearly labeled. Exporting all scans eliminates the problem of the wrong scan being selected for export; especially as physicists/physicians may not be available at the time of simulation at all practices to provide clinician expertise on which will be used for planning. Auto-sending all scans is efficient, which will be particularly important for patients that need rapid turnaround. However, practices should be aware that sending all scans does not eliminate the possibility that the wrong scan is drawn on and prepared for treatment planning. This can be mitigated by clear labeling and a physician note on which scan is intended for planning purposes.

3. **Importing scans into the treatment planning system**: Communication from simulation to dosimetry and from dosimetry to the physician is critical to using the intended data set for planning and treatment.
    a. After the import is completed, staff should confirm that scan names have not been altered during the process – which may occur depending on vendor products and interoperability.
    b. If the simulation note states which scan should be used for treatment planning, then the dosimetrist should label that image set clearly with a standard notation such as "_RTP" (radiation treatment planning). For example, if the physician wishes to contour on the DIBH scan, then the scan should be labeled CT_DIBH_RTP.
    c. If it is unclear which scan should be used for planning, the dosimetrist should confirm with the radiation oncologist prior to beginning work.
    d. The structure set (list of target volumes and OAR contours) should only be placed on the final scan (e.g., "RTP") used for planning to help avoid confusion when the physician starts contouring.
    e. The radiation oncologist should confirm that they are interacting with the correct data set.

4. **Recognizing characteristic differences between free-breathing and breath-hold scans**: Even when all of the above steps are followed, it is still possible that a scan is mislabeled as a free-breathing CT scan or that a physician contours on the wrong scan, particularly if the structure set is placed on all scans and not just the "RTP" scan.
    a. While low on the hierarchy of effectiveness, staff may benefit from increased training/awareness of how free-breathing scans look different from breath-hold scans. One key difference is that on breath-hold scans, the edges of structures that move significantly with respiration, such as the liver, will have a crisp appearance whereas there will be artifact (blurring) in this region on an average scan, and blurring or "disjointedness" of the structure and edge on the average scan. This is highlighted in the figure below comparing a DIBH scan versus the average scan for a patient undergoing liver stereotactic body radiation therapy.

DIBH Scan



Average Scan

Conclusion

The once routine practice of simulation and treatment planning is becoming increasingly complex with the advent of ever-advancing technologies. This often involves acquiring multiple scans at the time of CT simulation to provide a treatment plan that is optimized for maximum tumor control and minimal dose to OARs. The optimal approach (free-breathing vs. breath-hold) for an individual patient is sometimes unclear until the time of radiation planning, when the target is visualized in relation to the OARs, and this can necessitate the acquisition of multiple image sets at the time of simulation. As seen in the case example above, this can lead to multiple error pathways culminating in contouring and/or treatment planning on the incorrect scan. This particular event underscores the importance of practices establishing a well-defined process for acquiring and labeling multiple CT data sets at simulation, coupled with a multi-step verification process that includes clear documentation so that the correct scan is employed at time of treatment planning.

SAFETY CHECK

- How does your practice promote effective communication between the treatment team as to which simulation scan is used for treatment planning?
- At your practice, is it feasible to have a physician or physicist present for all simulations that entail complex procedures such as respiratory gating?
- What is your practice's protocol regarding sending all image data sets acquired at time of simulation to the treatment planning system?

