Respiratory Gating in Radiation Therapy Without Adequate Breath-Holds

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Radiation Therapy

Radiation Therapy refers to the treatment of cancer through the delivery of high-energy radiation to cancerous sites. This can be either curative or palliative in nature; and can work in tandem with chemotherapy and surgery.

Diagnostic images are obtained to determine location and extent of the tumor, with subsequent lesion biopsy to determine if tumor is cancerous.

A set dose of radiation is prescribed by an oncologist. A medical dosimetrist determines the frequency of the doses to create a daily treatment. plan.

A CT simulation scan is created, in order to determine the patient position that will remain consistent throughout the course if their treatment.

(Long et al., 2016)

Quality assurance tests are completed before treatment begins to verify that the planned dose will be the same as the dose that is delivered

(Jaroš et al., 2020).

Respiratory Gating

Respiration creates movement in the thoracic and upper abdominal areas. During Radiation Therapy treatments, this movement can result in the target areas exiting the treatment areas and healthy tissue entering the area.

Respiratory gating minimizes this issue by requiring the patient the hold their breath during treatment delivery.

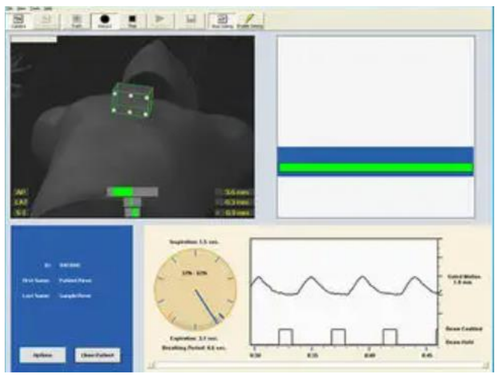

Figure 1. Varian Respiratory Gating System Interface. Adapted from “Magnitude, Impact, and Management of Respiration-induced Target Motion in Radiotherapy Treatment: A Comprehensive Review,” by S.A. Yoganathan, K.J. Maria Das, A. Agarwal, and S. Kumar, 2017, Journal of Medical Physics, 42(3), p. 107. Copyright 2017 by Journal of Medical Physics

Respiratory Gating Procedure

Respiratory Gaiting is then monitored through either chest or abdominal wall motion by an optical system with an infrared light source, a marker block attached externally and, camera.

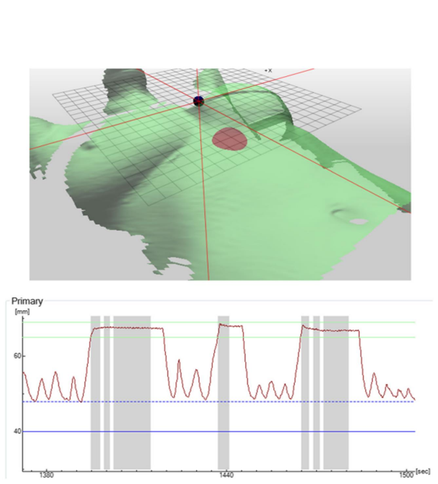

Figure 2. DIBH monitoring. Top: A breathing spot (red) on the patient surface (green) is monitored. Bottom: The breathing curve with three breath holds, covering 7 individual beams (indicated using the grey bars). From “Recent advanced in Surface Guided Radiation Therapy,” by P. Freislederer, M. Kügele, M. Öllers, A. Öllers, T. Sauer, C. Bert, D. Giantsoudi, S. Corradini, and V. Batista, 2020, *Radiation Oncology,* 15(1), p. 6. Copyright 2020 by BioMed Central

Generally a deep inspiration breath-hold (DIBH),is utilized. This is meant to hold the target area still. For breasts treatments, this also serves to keep the treatment area as far as possible from the heart (Yoganathan et al., 2017).

Only when the breath is held to the predetermined volume can treatment be delivered.

Patient communication and cooperation is imperative. Patient’s respiration is monitored by therapists who instruct the patient the appropriate time and duration of breath hold.

The gating system detects when respiratory motion resumes and ceases radiation treatment.

25-50% of breast treatments will utilize respiratory gating in some form (Anastasi et al., 2020).

Respiratory gating is also commonly utilized in lung, liver, and pancreas treatments.

Case Study

55-year-old female self palpated a lump on the right breast. This prompted mammogram and ultrasound studies which confirmed an irregular mass in that area. A biopsy conducted of the right breast demonstrated an invasive carcinoma.

Patient began receiving chemotherapy followed by a bilateral mastectomy with immediate reconstruction to follow.

The patient was described as having an excellent response to chemotherapy, owing a large part to the mastectomy .

The cancer had spread to the right internal mammary nodal chain. Recommendations were made to begin therapy treatment of the right chest wall, axilla, supraclavicular lymph node region, and the right internal mammary lymph nodes (Kemmerer, 2021).

Treatment Plan

A total of 5000 cGy was prescribed to be delivered in 200 cGy fraction. The treatment was to be daily five times a week for a total of 25 fractions.

DIBH was ordered.

CT imaging and reconstructive images were created to determine treatment angles.

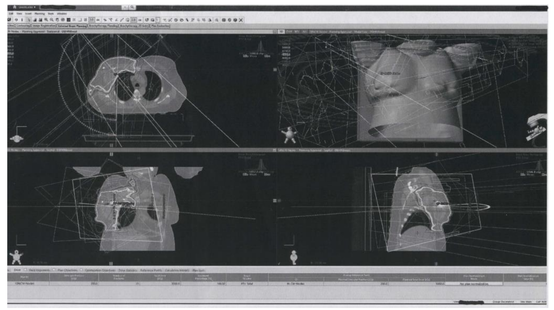

Figure 3. Treatment planning reconstruction. From “Oncology Consultation Notes/Treatment Plan,” by E.J. Kemmerer, 2021

Cone-beam CT (CBCT) imaging was ordered daily(Kemmerer, 2021). CBCT is completed before treatment delivery begins to make sure the patient is in the same position they were in for simulation.

Simulation

CT simulation was completed with the patient in a supine breast board.

Respiratory gating capacity was determined to be sufficient.

Treatment

During treatment, radiation therapists noted that the patient had great difficulty holding their breath for the determined amount of time. This led to multiple disruptions to beam on/off time.

Concern significantly increased when inadequate breath holds continued for multiple days. The apprehension was related to the multiple times that the treatment beam was turned on/off potentially having a negative effect on the patient’s outcome. There could be unintentional irradiation to healthy tissue while bypassing the targeted areas. Longer treatment times were also a consequence.

The patient’s treatment continued as planned with no modifications barring a short interruption in treatment due to an infection of the left breast.

At the conclusion of treatment, it was found that the carcinoma was reacting as expected with a reduction in size. No negative effects were noted due to the inability of the patient to maintain an adequate breath hold.

Conclusion

It was found that the patient’s inability to adequately hold their breath during the duration of treatment did not have a negative effect on their outcome.

Negative effects were seen on patient treatment times. This had a negative effect on patient outflow and disrupted other patient’s treatment time schedules.

Care that was delivered to the patient was adequate, with multiple strategies proposed as ways to decrease patient treatment times in response to inadequate breath-hold abilities.

Respiratory gating is a rapidly growing practice with the main barrier being financial constraints (Anastasi et al., 2020).

Installing a display monitor within the patient’s view that displays the patient’s respiratory waveforms has shown to be an effective way to increase patient compliance during gating treatments (Mohammad et al., 2018).

Prediction-based respiratory gating systems are coming to the market. These use algorithms to predict when the patient’s breathing cycle will be in the optimal range (Johno et al., 2018).

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