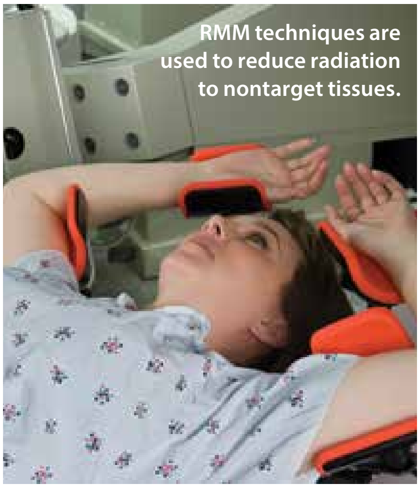
RMM techniques are used to reduce radiation to nontarget tissues.

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Respiratory motion management: Essential to radiotherapy

Bryant Furlow

As precise hypofractionated radiotherapies such as stereotactic body radiotherapy (SBRT) become widely available, managing the subtle breathing-associated movement of tumors and adjacent organs during radiotherapy is an increasingly important challenge. Technological innovations such as real-time imaging guidance (tumor tracking) can help reduce the impact of intrafraction respiratory motion on radiation dose delivery, but respiratory motion management (RMM)—particularly respiratory gating and breath hold—remains crucial to the effective implementation of treatment plans.

Radiotherapy planning involves the use of computed tomography (CT) imaging data to calculate external radiation beam paths that can deliver prescribed radiation doses to target tumors while minimizing irradiation of healthy nontarget tissues. Survival rates for patients with lung cancer might improve with radiation dose escalation, but dose escalation requires thinner margins around target tissues to avoid radiation toxicity.[1]

Imaging studies can be obtained between radiotherapy sessions to account for changes in tumor and organ size and position over time. This can allow target adjustments for subsequent dose fractions and the maintenance of narrow treatment margins.[1,2] But tumor and nontarget organ motion caused by the patient's breathing *during* radiotherapy delivery can also complicate the delivery of intended dose distributions. While anatomical changes between radiotherapy fractions appears to have a larger effect on target dose distribution in lung cancer than does intrafraction tumor motion, respiratory motion does appear to impact dose delivery and can increase radiation to nontarget tissues, potentially escalating the risk of radiation-association toxicities.[1,2] Therefore, patient treatment plans must account for respiration-associated changes in tumor position and contours, and plan for the management or minimization of respiratory motion during dose delivery.[3]

Precise dose targeting is integral to recent advances in radiotherapy techniques such as intensity-modulated radiotherapy (IMRT) and stereotactic body radiotherapy. Stereotactic radiosurgery was pioneered for the treatment of intracranial tumors; today, SBRT is used with increasing frequency as a noninvasive alternative to surgery in the treatment of solid tumors of the lung and liver to deliver therapeutic radiation doses in fewer, higher-dose fractions (*hypofractionation*) than regimens used with traditional external-beam radiotherapy.[2]

Hypofractionation's higher per-fraction radiation doses make respiratory motion a major challenge.[2,4] RMM is therefore a crucial component of treatment planning, particularly for hypofractionated radiotherapy of the breast, lungs, or liver.[2]

Two broad strategies improve dose precision when intrafraction respiratory motion is an issue: intrafraction image guidance and RMM.[3] Real-time image guidance (ie, image-guided radiotherapy [IGRT]) can provide 3-dimensional (3D) tumor tracking and accommodation of target volume motion and tumor contour deformation.[2,5] But even when tumor tracking is used, RMM techniques are also typically employed to minimize residual motion issues.[2]

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RESPIRATORY MOTION MANAGEMENT

The primary goal of RMM is to reduce respiratory motion during irradiation. Common techniques for achieving that goal include patient breath hold and respiratory gating. Foam blocks or body frames, which also ensure consistent patient position between radiotherapy treatments, are other devices used to immobilize the patient.[2,6] In SBRT of the lung or liver, abdominal compression can also be used; the upper abdomen is pushed downward using an adjustable SBRT body frame pressure plate, forcing shallow respiration and minimizing respiratory tumor motion.[2]

Both breath hold and respiratory gating function to time radiation delivery during a specific phase of respiration (expiration or inspiration/inhalation). Breath hold forces maintenance of that phase of respiration during dose delivery, with the radiation beam being held (beam off) when that phase of respiration can no longer be maintained.[2] Respiratory gating uses technology to achieve the same goal, timing beam on/off sequences to ensure that radiation is delivered during a specific phase of respiration.[2] Both RMM techniques involve pretreatment planning with time-correlated (so-called *4D*) CT image data to measure a patient's respiration. Respiratory volumes are monitored using spirometers.[2]

Inspiration-phase treatment allows better separation of lung tumor target volumes and adjacent lung nontarget tissues, reducing toxicity risks, but expiration-phase treatment appears to be more reproducible.[2,7] Inspiration-phase breath hold appears to be easier to perform for patients undergoing SBRT to the lung.[2]

Respiratory gating allows the patient to breathe freely during radiotherapy. Monitoring equipment automatically controls the beam on/off timing, using cameras or pressure sensors. Breath hold, in contrast, requires pretreatment instruction, patient practice and coaching, and close monitoring of adherence during radiation delivery. As members of the radiotherapy team, oncology nurses are responsible for ensuring patient understanding and adherence to respiratory motion management efforts.[3] In addition to such clinical tasks as monitoring patients' oxygen saturation, oncology nurses are typically responsible for pretreatment patient RMM instruction and assessment of patient comprehension and adherence to those instructions.[3]

> RMM techniques involve planning with time-correlated CT image data.

Monitoring breath hold involves more than keeping a close eye on the spirometer. Patients' stress, discomfort, or anxiety can cause them to breathe more rapidly, complicating breath-hold efforts. Verbal instructions delivered in a calm and soothing manner help create a more relaxing environment during radiotherapy.[3] ■

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