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Image-guided Radiation Therapy:
Respiratory Gating

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Image-guided Radiation Therapy: Respiratory Gating

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As technology for radiation therapy image guidance, planning and treatment delivery has improved, the role of the radiation therapist in managing intrafraction motion has become increasingly critical. Methods to manage the effects of respiratory motion on tumors and organs also have improved, providing the opportunity to more precisely plan and deliver consistent radiation treatments to anatomical areas affected by respiration and to maximize dose distribution. This article discusses motion management and respiratory gating techniques.

After completing the article, the reader should be able to:

- Describe various techniques of treatment planning for intrafraction motion and how to account for motion in planning.
- Explain the types of motion management systems and methods.
- Discuss how respiratory motion affects treatment planning and delivery.
- List quality assurance recommendations for motion management imaging and airflow management equipment.
- Describe how to use gating with advanced radiation delivery modalities.
- Explain how to manage respiratory motion for specific organs.

In the past few years, new technology has provided radiation oncology with additional tools to verify patient setup positions, which has improved treatment plans.[1-3] Technological advances in image-guided radiation therapy (IGRT) have helped motion management become a reality for many daily radiation treatments. Intrafraction motion occurs during a treatment fraction and includes respiratory, cardiac, musculoskeletal and peristaltic motion.[4]

Radiation oncology teams now control respiratory motion with new motion management technologies; however, several factors still affect tumor motion within the patient. Tumor size, location, local attachments and the patient's breathing patterns can directly affect tumor motion in the thoracic, abdominal and pelvic regions.[4] This constant motion throughout treatment delivery can cause the tumor or microscopic disease to move outside the treatment field or penumbra region, resulting in underdosed areas of the planning target volume (PTV) (see **Figure 1** and **Box**) and leading to marginal recurrences.[5]

Respiratory gating helps limit treatment delivery to preset periods within a patient's breathing cycle, which facilitates increased dose delivery to the PTV and limits dose to surrounding normal tissue and critical structures.[6,7] There are several ways to manage respiratory motion, including monitoring external respiration with infrared cameras, tracking internal fiducial markers with imaging and software, and limiting respiratory motion with breath holds or compression. This article discusses various respiratory gating techniques in detail.

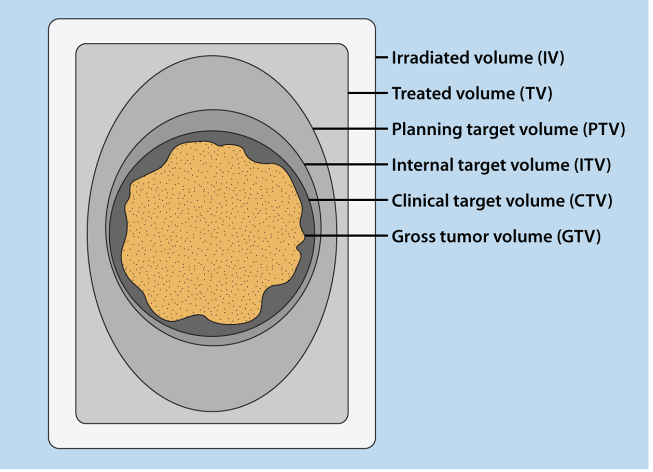

Figure 1. *Volumes used for radiation treatment planning. The gross tumor volume (GTV) includes the palpable or visible tumor. The clinical target volume (CTV) includes the tumor and presumed microscopic spread. The internal target volume (ITV) consists of the CTV and an internal margin built into the treatment plan. The planning target volume (PTV) includes the CTV and margins that account for geometric uncertainties. The treated volume represents the minimum target dose that adequately covers the PTV plus an additional margin to cover limitations in treatment technique. The irradiated volume contains tissue that receives a significant amount of the prescribed dose.*

Box

Tumor Volumes

Gross tumor volume (GTV)	Consists of the gross demonstrable tumor, including the primary mass, any metastasis and lymphadenopathy. The GTV is determined by visual or palpable assessment and through diagnostic imaging. If the tumor has been resected, an outline of the tumor volume from preoperative images can be substituted.
Clinical target volume (CTV)	Includes the demonstrable tumor and any area of presumed malignancy. The CTV represents the true extent of the tumor location; no other cancerous cells are identified or presumed to be outside this volume. Radiation doses to this area must be adequate to achieve treatment goals.
Internal target volume (ITV)	Compensates for any changes to the CTV during therapy due to physiologic movement and variations in target position, shape and size. This volume includes the CTV and an internal margin built into the plan.
Planning target volume (PTV)	Includes the CTV and margins accounting for geometric uncertainties in treatment setup, beam quality and consistency, and patient movement. This volume also must represent the organs at risk, emphasizing the need to minimize doses to these areas. Precision in contouring both the tumor and the dose-limiting structures is very important. Although it is difficult to reproduce an exact contour, the radiation oncologist must be diligent when contouring all volumes.
Treated volume	Represents the minimum target dose that adequately covers the PTV. The treated volume includes an additional margin to cover limitations of the treatment technique.
Irradiated volume	The largest of all volumes, containing tissue that receives a significant amount of the prescribed dose. A significant dose is sometimes defined as approximately 50% of the prescribed target dose. Conformal techniques have decreased the size of irradiated volumes over the years, but it is still important to document dose to critical structures within this volume.

Adapted from International Commission on Radiation Units & Measurements. Prescribing, Recording, and Reporting Photon Beam Therapy. *Bethesda, MD; International Commission on Radiation Units & Measurements; 1993 and 1999. ICRU Report 50 and ICRU Report 62 (Supplement to ICRU Report 50).*