Conformal therapy techniques combine good patient immobilization to minimize the PTV margin around the CTV coupled with the use of multiple, intensity modulated, non-coplanar beams to reduce treated volume margin beyond the PTV. In the thorax and abdomen, the PTV remains relatively large, largely due to respiratory induced organ motion. The reduction in the PTV margin, achieved by minimizing the effects of organ motion due to respiration, may be as great as the reduction in the treated volume margin gained by using conformal therapy techniques.

Determination of the respiratory cycle or diaphragm position may be inferred by employing an apparatus that measures changes in chest or abdomen position (impedance plethysmography) or pressure (pneumotachometry) using a sensor such as a belt attached to the patient. This approach may have calibration problems caused variation of the tightness of the belt between treatments or slippage that occurs during treatment. If the device is in the beam, radiation damage to the device or loss of skin sparing may occur. Video techniques, employing multiple cameras, allow measurement of chest position while overcoming the calibration and skin sparing problems of the belt systems. Monitors may be used to characterize a patient's respiratory mechanics by placing a sensor in the patient's mouth, clamping the nose and instructing the patient to breathe normally through the mouth. One such device collects data at a rate of 100 times per second, employing a capnograph which measures CO_2 using an infrared sensor capnograph and measures airway pressure using a differential pressure pneumotachometer.

Gating at full exhalation is the most effective for eliminating respiratory induced motion because the diaphragm position is most reproducible at this point. Investigators have reported

elimination of 80-90% of diaphragmatic movement. Gating at full inhalation, although less reproducible, may prove to be advantageous because there is maximal separation of the target volume from other normal structures. Reproducibility of the diaphragm position may be improved by using biofeedback circuitry.

Gating involves a trade-off between elimination of respiratory motion and duty cycle (i.e. fraction of time that the radiation beam is on). Duty cycle may be improved by breath holding. One system forcibly prevents a patient from breathing for short periods at a time. An alternate method relies on the patient to hold his breath.

A linear accelerator must be capable of turning on and off rapidly in response to gating signals. One approach is to modify the accelerator's trigger circuit so that during "beam off" sequences electrons are injected out of phase into the wave guide, suppressing x-ray production. Attention must be paid to beam dosimetry because degradation in beam flatness, symmetry and dosimeter calibration is possible. CT, MRI and simulator images obtained for treatment planning must be acquired at the same point in the respiratory cycle at which radiation treatments are delivered.

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EDUCATIONAL OBJECTIVES

Understand the role of respiratory gating in conformal radiotherapy.

Identify the optimal gating technique.

Understand the linear accelerator and treatment planning image acquisition requirements.