IGRT with Helical Tomotherapy – Effort and Benefit in Clinical Routine

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Introduction

The idea of using imaging methods prior to daily radiotherapy is not really a new one. But there has been a remarkable trend and awareness for this aspect of high precision radiotherapy in the recent years [1, 5, 20]. The rationale of image-guidance is using daily images acquired in treatment position in order to visualize daily setup errors and organ variations [4, 10]. The renaissance of image-guidance is probably associated with three circumstances [11]: first, highly individualized dose distributions that can be achieved with IMRT require high precision positioning, otherwise there is a high risk of "missing targets with high precision" [6, 7, 16]. The increased use of portal imaging devices and the resulting experience with interfractional variations are probably the second reason. Third, modern technology allows the integration of modern imaging devices, fast image acquisition, matching and position correction on a daily base. Daily ct-imaging can be performed either with an in room ct-scanner on rails, kilovoltage or megavoltage cone beam ct or megavoltage fan beam ct [8, 9, 12, 15, 17, 18]. Each of these modalities seem to have certain advantages and drawbacks. They all have a huge impact upon clinical practice in common. This includes costs, time effort, required manpower and reduced patient throughput. Another common aspect is the fact that despite of several advantages in terms of consequences upon positioning and dose distributions the benefit concerning treatmeant outcome, local control, long term toxicity or survival could not yet be shown [2, 13, 14]. This work intends to describe the trade off between effort and benefit in the daily routine of helical tomotherapy.

Methods and Materials

Between July 2006 and February 2007 100 patients were treated with helical tomotherapy in the University hospital of Heidelberg. This very heterogenous group of patients was composed of the following tumor entities: head-and-neck tumors (n = 19), prostate cancer (n = 14), gastrointestinal tumors (n = 13), breast cancer (n = 12), multiple metastases (n = 11), spinal re-irradiation (n = 7), radiosurgery (n = 5), malignant pleural mesothelioma (n = 4), sarkoma (n = 4), lung cancer (n = 3), thoracic tumors (other than lung) (n = 3), skin malignancies (n = 2), whole abdominal irradiation for ovarian cancer (n = 2), craniospinal axis treatment (n = 1). In 98% of the 2187 fractions a pretreatment megavoltage ct scan was performed. After matching with the kilovoltage planning ct scan corrections for translations and roll were done.

Results

Helical tomotherapy and daily image-guidance with megavoltage ct could be introduced fast and successfully into daily clinical routine. For the described tumor entities average time on table was 24.6 minutes, average treatment time 10.6 minutes. Table 1 shows the treatment times for the 5 most common tumor sites. With an average time of 5 minutes for uploading of patient plans and patient positioning, image guidance produced an extra time effort of 9 minutes per fraction. This included chosing ct-scan area, performing ct-scan, image registration and matching, checking corrected images in all planes and several slices plus manual corrections and position correction.

Treatment was terminated due to tumor progression once. 11 times enormous rectal filling in prostate cancer patients that could not be sufficiently corrected by table movements was detected and treatment was performed after sending the patient to the bathroom.

Figure 1 shows the dose distribution of a patient with malignant paraganglioma with vertebral body infiltration. Tomotherapy could produce steep dose gradients around the spinal cord and image guidance allowed safe application of this aggressive treatment regimen.

Discussion

Besides excellent dose distributions for the various indications there are some characteristics inherent in this technique that must be considered. This method of course requires more time than conventional radiotherapy. Additional 9 minutes for daily image guidance must be calculated and have a major impact on the number of patients that can be treated on one machine. In our institution an average time of 24.6 minutes was needed for the first 100 patients resulting in 16 to 20 patients during a one-shift working day.

Key Words: IGRT · Helical tomotherapy · IMRT · Megavoltage CT

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Table 1. Average treatment and radiation times for the most frequent tumor sites.

Tumor	Number of patients	Number of fractions	Mean time on table	Mean radiation time
head-and-neck	19	413	23.2 min	8.5 min
prostate	14	441	20.7 min	6.2 min
gastrointestinal	13	260	24.9 min	8.0 min
breast	12	313	24.4 nin	13.2 min
spinal reirradiation	7	127	19.1 min	6.1 min
total	100	2187	24.6 min	10.6 min

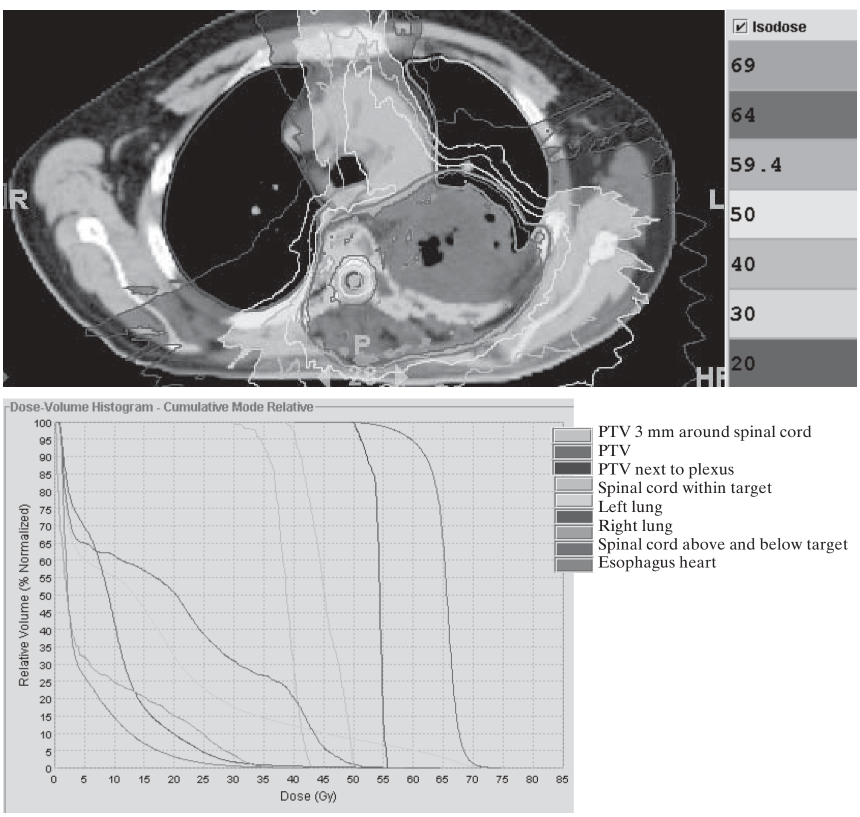

Figure 1. Dose distribution and DVH of a helical tomotherapy plan for a patient with malignant paraganglioma with vertebral body infiltration. Image guidance allowed safe application of this plan with narrow safety margins.

Daily ct scanning produces an extra dose to the patient of 1–2 cGy. For 35 fraction this means additional 0.35 to 0.7 Gy.

The second issue that helical tomotherapy achieves higher quality of dose distribution on a daily basis at the cost of higher manpower and investments. The cost effectiveness of this treatment therefore depends on the local reimbursement system.

Advantages of the system are:

1.) Daily visualization of postion accuracy gives valuable information about the quality of different immobilization devices.

2.) Systematic and random setup errors can be recognized easily and corrected instantly. Interfractional variation of positioning accuracy, organ position or filling can be compensated in three different ways. First and most important by correction of translations and roll. Second repositioning if not correctable misplacements are detected. Third reacting to stomach, bladder and rectal filling by postponing therapy until optimal circumstances are achieved. By these instant reactions the full possibilities of steep dose gradients and individualized dose distributions can be safely used.

3.) The decribed methods allow the treatment of patients when high precision radiotherapy is needed and exact immobilization is not possible. Reasons might be heavy pain for instance in vertebral metastases, severe obesity, neurological impairment or claustrophobia.

4.) Another issue is that daily imaging allows treatment with an "open eye". Changes in tumor geometry – shrinking or progress – can be seen early and consequences upon dose distributions can be calculated. In case of non responding tumor and growth during radiotherapy treatment can be terminated before severe side effects are produced without benefit. In addition, changes next to the tumor like opening of atelectasis or changes of effusions can be seen early. Loss of weight and hereby resulting changes in anatomy and proximity of organs at risk can be visualized and its effect upon dose distribution assessed.

5.) All these advantages taken together open possibilites for so called dose guided radiotherapy [3]. Image acquisition and dose recalculation enable the detection of differences in dose distribution either of too high dose to organs at risk or underdosage to the target. In a second step the remaining fractions can be performed with adapted plans to the changed anatomy and dose differences can be compensated [19].

Conclusions

The High Art Tomotherapy system with its integrated megavoltage ct allows daily image guidance with an extra need of time of 9 minutes per fraction. With a careful selection of patients that benefit from daily image guidance the advantages of this technique clearly overweigh the drawbacks of increased time and manpower. Daily positioning errors and interfractional variation can be recognized and corrected easily and therefore treatment precision can be increased. This allows the radiation oncologist to take full advantage of the possibilities of steep dose gradients and highly individualized dose distributions.

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