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Protocol for Stereotactic Body Radiation Therapy: Applications in Oligometastases, Radiation Oncology, CT-Simulation, Immobilisation, and Process Quality Control

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ABSTRACT: In a small number of fractions, stereotactic body radiation therapy (SBRT) applies extremely high and conformal radiation doses to clearly defined targets in the chest, abdomen, or paraspinal regions. These doses are not homogeneous and have small or no margins, which makes them ideal for treating potentially heterogeneous and physiologically moving targets. A comprehensive evaluation of objectives and resource allocation is necessary before embarking on SBRT, which demands a substantial investment of staff and equipment. The SBRT delivery system is designed to integrate and regulate all treatment phases to the highest degree feasible, ensuring accurate SBRT delivery. For assistance on how to implement each phase of SBRT, there are a variety of resources available, including as reports from the American Association of Physicists in Medicine (AAPM) Task Group, practice recommendations from the American College of Radiology (ACR), and white papers from the American Society for Radiation Oncology (ASTRO). Imaging to define the target, immobilisation, simulation, planning, motion control, alignment imaging, and beam delivery are the phases. Following the quality assurance program's guidelines, qualified staff apply the necessary equipment at each stage of the treatment delivery process utilising procedures created during deployment. Planning, allocating resources (including human and material), providing training, developing protocols, and conducting continuing quality assurance (QA) at every stage of treatment delivery are all necessary for an SBRT programme to be successfully implemented. Imaging, simulation, planning, motion management, image-guidance, and treatment administration are all parts of SBRT that can be aided by well-established tools. A good SBRT programme can be achieved by understanding and following that guidelines.

Keywords: Stereotactic Body Radiation Therapy, Radiation Oncology, CT-Simulation, Immobilisation, Quality Control

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Introduction

All the necessary resources, including qualified staff, state-of-the-art machinery, thorough training, and a system for monitoring and evaluating treatment efficacy, must be set aside for a stereotactic body radiation (SBRT) programme. Extremely high levels of confidence in the accuracy of the dose delivered are necessary for SBRT, which involves precisely identifying a target, aligning it with normal tissues on a treatment unit, designing and delivering highly conformal radiation fields—which are frequently tiny and always have high dose gradients—and maintaining this level of confidence throughout the treatment process. Training for all individuals involved, developing procedures for all aspects of SBRT, doing safety analyses, accepting and ensuring the quality of the equipment, evaluating personnel, and acquiring extra resources as needed are all necessary steps before embarking on such a programme. The seven-step process for implementing SBRT in a clinical setting is outlined in Task Group 101 of the American Association of Physicists in Medicine (AAPM). First, the program's scope, including treatment sites and clinical goals, must be established. Second, the treatment modality, dose-fractionation, and planning goals must be determined. Third, the equipment requirements must be established. Fourth, the personnel requirements must be determined. Fifth, the SBRT equipment must be accepted and commissioning. Sixth, written procedures must be established for all phases of SBRT. Finally, any relevant personnel must be trained.

Clinical Radiation Oncologist

The concept of fractionated radiation therapy to cancer patients is well-known to all radiation oncologists. SBRT, which employs a somewhat distinct body of knowledge, is the administration of big dosages in few segments. Board certification or completion of a radiation oncology residency with SBRT-specific training is required of radiation oncologists performing SBRT, according to the American College of Radiology (ACR)-ASTRO Practice Guideline for the Performance of Stereotactic Body Radiation Therapy. Among a radiation oncologist's many duties are the following: monitoring the treatment plan as a whole; advising on patient positioning; overseeing the simulation; identifying normal tissues and targets (including ways to deal with motion uncertainty); prescribing radiation doses to at-risk organs and target volumes; and attending to and supervising the treatment process.

The physician

All technical details controlling SBRT simulation and delivery are the responsibility of the medical physicist. The medical physicist has to have SBRT-specific training and be qualified by the relevant radiation therapy governing body. All parts of the system, including imaging, localisation, immobilisation, motion management, and therapy delivery systems, must be tested and put into operation before the system can be considered fully operational. High dosimetric and spatial accuracy in the transmission of tiny radiation fields should be expressly considered during commissioning. A medical physicist's responsibilities include creating comprehensive checklists for use in SBRT simulations, plans, and deliveries, and overseeing a quality control programme for the entire procedure. The medical physicist checks the patient's positioning and the prescription to make sure the delivery is done correctly and with little room for error on the day of treatment. The medical physicist stays with the patient throughout the whole procedure.

Dosimetrist

The dosimetrist, working with the radiation oncologist and the physicist, is responsible for developing a plan that meets the dose and volume constraints of that required for SBRT. The dosimetrist can assist with the patient position, immobilization, and motion management during simulation. The dosimetrist also ensures that the plan information is documented in the patient’s chart and transferred to the treatment unit, and that the therapists understand how treatment plan is to be delivered

Therapist

Radiation therapy certification and adherence to local licencing standards are essential for the therapist. Both the patient's immobilisation and the simulation, the patient's alignment before treatment, and the treatment itself are

therapist-related tasks. With the use of immobilisation devices and numerous alignment marks, the therapist must pay close attention to detail while recreating the setup.

Administration

Proper allocation of time, money, education, and training, as well as communication, is the responsibility of SBRT's administration. It is possible to do SBRT without the necessary support, although doing so increases the probability of making mistakes.

Methods and Tools

Imaging

SBRT relies on a clearly defined target that is usually found using multimodal imaging techniques like computerised tomography (CT), magnetic resonance imaging (MRI), or positron emission tomography (PET). The patient should be scanned with the therapy immobilisation devices in situ whenever possible to provide adequate spatial quality of the multimodality images. In order to run the simulation, the collected CT scans can be combined with the pictures. Since MR relies on linear gradients for spatial encoding, it is very important to conduct a thorough evaluation of the pictures' spatial quality. It is advised against pursuing SBRT if the target or organs in danger are poorly identified, have substantial artefacts that conceal anatomy, or have substantial motion artefacts.

Immobilisation and CT-Simulation

Compared to conventional radiation, SBRT places a greater emphasis on patient immobility. Ensuring patient comfort is crucial for maintaining stability during treatments, which can be rather extensive. A variety of tools, including head and knee sponges, T-bars, and vacuum-lock bags covering the PTV, can be utilised. One way to reduce movement is to employ a respiratory compression device. A variety of total body immobilisation systems are accessible for purchase. In SBRT, the typical treatment CT-simulation isn't enough; the target's mobility in the thoracic and abdominal targets must also be evaluated. The capacity to conduct 4DCT is necessary for this. It is necessary to do imaging 5-10 cm outside of the treatment fields, or 15 cm when using non-coplanar fields. The thickness of CT slices can range from one to three millimetres. The CT simulator's quality assurance (QA) should adhere to the guidelines laid out in the Computed Tomography Simulation Process and the Report Quality Assurance for Computed-Tomography Simulators, both of which are produced by the AAPM Task Group 66. The report on the management of respiratory motion by AAPM Task Group 66 should be followed for respiratory motion management.

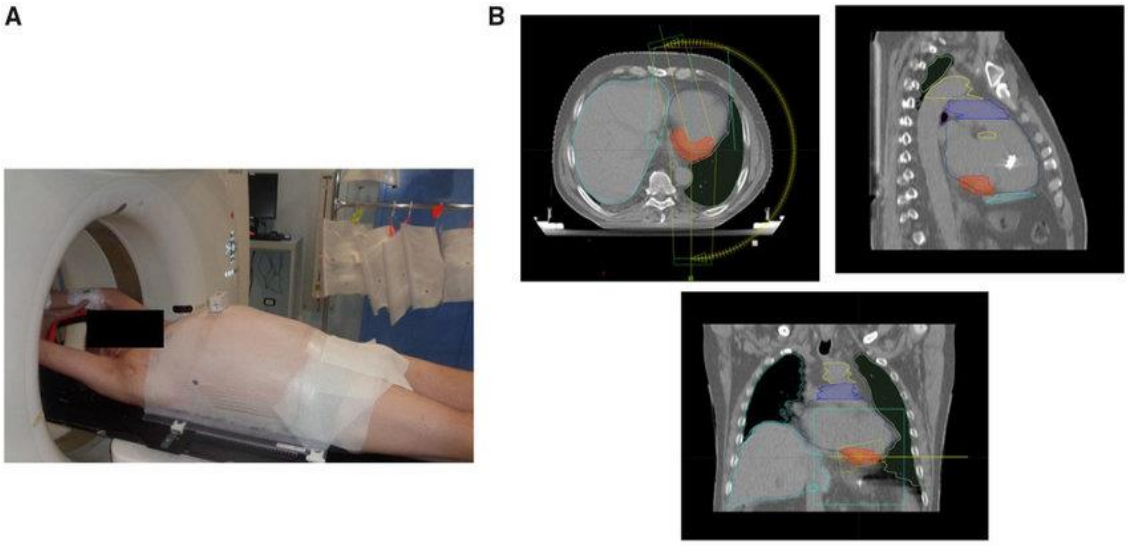

Figure 1. A) Immobilization device and CT simulation. (B) SABR treatment plan in patient with a VT diagnosis. The outlined areas represented the planning target volume (PTV) in axial, coronal, and sagittal.

These areas included the isodoses between 95% and 100% of dose prescription (25 Gy in 1 fraction) in the PTV.

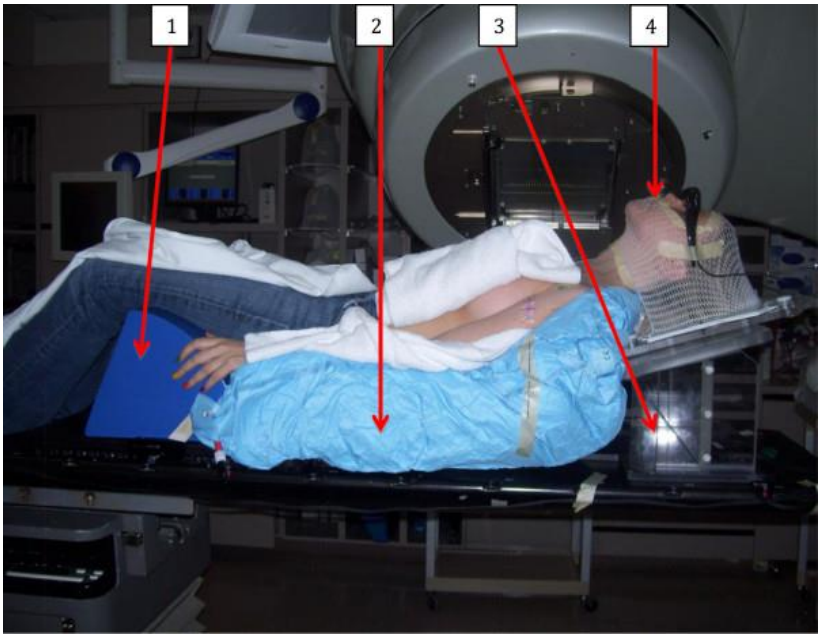

Figure 2. Presentation of the immobilisation apparatus used to simulate the patient's therapy. A hip stopper (1), a Vac-Lok (2), an inclined board (3), and a facemask (4) are all shown by arrows.

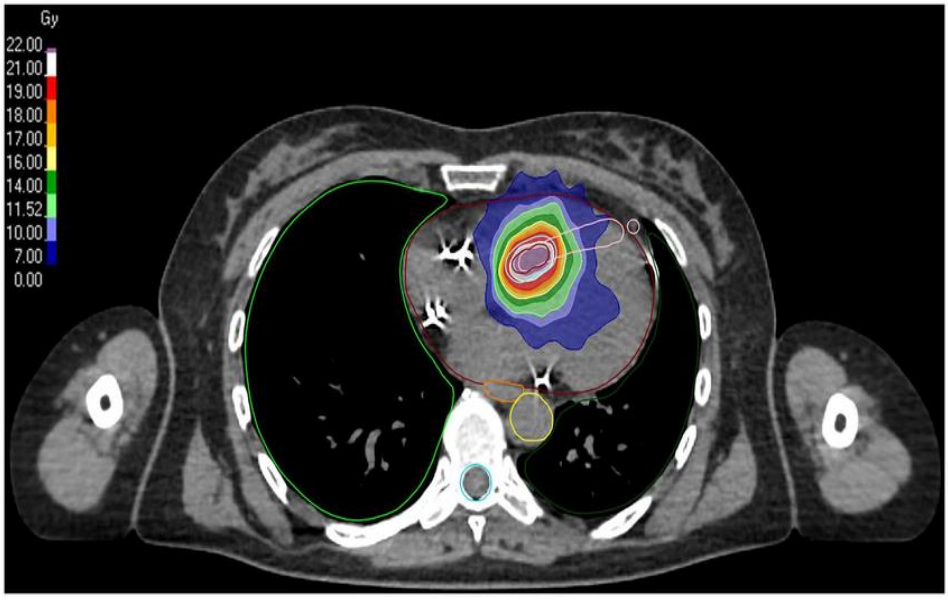

Figure 3. Treatment strategy for ventricular tachycardia (VT) that originates in the interventricular septum using stereotactic body radiation treatment (SBRT).

Making Plans

With narrow fields in heterogeneous media, the treatment planning system must reliably forecast dosage. The method for the pencil beam does not meet these requirements, and the detector's diameter should be less than half of the complete width at half maximum of the smallest beam detected. Very small sensitive volumes (~1 mm) can be utilised, or the detector response function can be deconvolved from the observations. The target definitions should be

in line with ICRU 50/62, which states that a well-defined target is one in which the clinical target volume (CTV) and the gross tumour volume (GTV) are same. The CTV's motion range is a part of the internal target volume (ITV). Additional expansion of the PTV is common, and it is typically done with asymmetric margins, making the expansion bigger in the direction of the target's motions. Planning risk volume (PRV) is similarly used to expand organs-at-risk in order to account for uncertainty and motion. Unless nearby important structures are present, a standard procedure involves using 10–12 beams with little or nonexistent margins, administering low prescription isodoses, and creating isotropic dose gradients. The recommended grid size for the dosage calculations is 2 mm. 6-10 MV beams are applicable. While higher-energy beams can be utilised selectively to make up for low-level illumination, it's important to keep in mind that these beams generate greater penumbras due to the higher-energy secondary electrons they produce. It is allowed to use intensity modulated radiation treatment (IMRT) as long as motion is minimised. The dose for the entrance should be less than 30%. Results from SBRT studies conducted by the Radiation Therapy Oncology Group (RTOG) outline limitations in treatment planning. In order to accomplish the PTV aims and the organ at risk limits, one must physically change the margins and weights of the beams, generate extremely diverse doses, and locate beams—all of which can be challenging to achieve .

Literature evaluations should be conducted at the right time since our understanding of normal tissue tolerances at large fractional doses is always changing. All aspects of the treatment plan, including the dosage, the prescription isodose line, the fraction count, and the overall treatment delivery time, must be meticulously documented in the patient's medical record. Metrics like the conformance number, heterogeneity index, and heterogeneity index should be used to evaluate target coverage. It is important to document the rate of dose falloff, which includes metrics like the ratio of the 50% dose volume to the PTV volume, significant areas of high dose beyond the PTV, and dose to organs-at-risk. By utilising a picture of the patient taken on the treatment unit, image-guided therapy positions the patient relative to the treatment volume. Imaging methods can include CBCT, planar MV, planar kV, or a mix of these. As a stand-in for actual tumour location, the imaging ought to do satisfactorily. For instance, while imaging the bony anatomy planarly, it is important to position the PTV spatially relative to the bone anatomy. Next, imaging of the soft tissues, including cone beam computed tomography (CBCT), should be employed. To substitute for the tumour, radiopaque markers might be placed in close proximity to it .

Remember that the patient is considered a rigid-body in both the simulation and treatment phases, and that this assumption underpins the treatment plan and alignment. This assumption is almost always partially or completely disproven for image-guided alignments performed outside of the skull. A larger discrepancy between the intended and actual dosages, as well as a more challenging fusion, are consequences of a more serious assumption violation. Due to the fact that the rigid body assumption is not completely accurate, it is crucial to give more weight to the parts that are nearest to the treatment volume when assessing the fusion, and less weight to the regions that are farther away. Refer to the AAPM Task Group 179 report, Quality Assurance for Image-Guided Radiation Therapy Utilising CT-based Technologies, for guidelines on how to use CT for image guiding. After the patient is properly positioned, a second set of images can be obtained to check if they are within the acceptable range. If that's the case, we can start treating you. In that case, it's possible to start over. Any movement during therapy should prompt re-imaging, therefore the patient must be closely followed. Imaging techniques such as CBCT, fluoroscopy, and gated radiography can evaluate respiratory motion. The picture includes a time-averaged range of motion that is close to the ITV because CBCT acquisition periods are about one minute .

Infrared reflectors placed on the skin can be optically tracked to allow for patient monitoring. When using reflectors to track a patient's posture, it's best to set them on a solid anatomical landmark. The reflectors work best when placed on regions of highest motion if they are to be used to track the movement of the respiratory system. Alignment and monitoring are both made possible by commercially available optical surface tracking systems. Embedded markers can be followed with radiofrequency. Note that regardless of the mechanism chosen, external tracking is just a stand-in for the actual location and motion of the internal targets. Treatment can begin once the patient is properly oriented, confirmed, measured for motion, and monitored. The less time a patient has to walk around during treatment, the better. However, for shorter treatments, the patient's position must be closely monitored to ensure that the correct dose is administered; otherwise, a substantial portion of the dose could be administered incorrectly if the patient moves.

The medical accelerator treatment unit has to be up to code with the AAPM Task Group 142 Report on Quality Assurance.

Risk prevention

Small, potentially moving targets, frequently in close proximity to potentially dangerous organs, must be administered strong doses with steep radiation gradients in SBRT. Therefore, SBRT carries a higher risk than conventional radiation. There are two parts to reducing this risk: process QA and equipment QA. The AAPM Task Groups that were mentioned earlier can be used to accomplish equipment QA. The report from Task Group 142 details the process of ensuring the safety of medical accelerators. Planning system quality assurance is the subject of Task Group reports. While Task Group 179 focuses on CT-based image-guided alignment, Task Group 66 ensures the quality of CT simulators. An outstanding SBRT report is provided by Task Group 101. Standards for SBRT execution are outlined in the ASTRO/ACR practice guidelines. There is a great deal of information in the appendices to the ASTRO white paper that explains quality and safety concerns. Dosimetric precision and end-to-end alignment testing is a crucial part of quality assurance. From computed tomography (CT) scans, target definition, treatment planning, alignment, and administration, the complete treatment process is carried out by a phantom in this test. This procedure checks the device in every way to find out how well it can provide the treatment in terms of both position and dosage. An SBRT type phantom is available at the Radiological Physics Centre (MD Anderson Cancer Centre, Houston TX) and can be used as a last check before treating patients. It provides an impartial evaluation of the skills required to model, plan, align, and administer an SBRT treatment .

Assurance of Process Quality

The focus of process QA is on the patient, not the machinery. Patient assessment, medication administration, immobilisation, modelling, preparation, transmission of treatment data, alignment, administration, and monitoring are all parts of it. Formalising and standardising the process through the development of written procedures based on checklists helps decrease the chance of error by eliminating potential "non-standard" processes. Ongoing review is a crucial part of any quality assurance process to ensure it is still meeting goals and if there are any modifications that maintain the program's safety over time. These assessments are necessary since technology evolves over time. Successes and failures can be revealed and systems can be improved by ongoing patient follow-up .

Treatment of Oligometastases with Stereotactic Body Radiation

It was formerly believed that patients with confirmed distant metastases from solid tumours had an incurable disease that required only palliative care. The concept of "oligometastases" was developed to describe specific locations where cancer has spread, allowing for the reduction of the overall disease load to a manageable number of localised lesions that may respond well to treatment. A new approach to radiation oncology, stereotactic body radiation therapy (SBRT) precisely targets tumours with a high dosage of radiation utilising a single or small number of fractions. Recent developments in imaging guidance, treatment planning and delivery, and patient and tumour immobilisation have led to SBRT. Several prospective and retrospective trials demonstrated encouraging outcomes for local tumour management and, in a small subset of patients, survival. The paper delves into the technical, clinical, and radiobiologic details of SBRT for different anatomical locations .

Oligometastases, which refer to metastases to a single or limited organ, are becoming more common as a result of advancements in the early detection of distant disease locations. Surgical removal of metastases from certain body parts increases survival rates for some individuals. For instance, despite a lack of clarity regarding the benefits of resection and suitable selection criteria in patients who develop metastases, surgical resection became the standard approach for patients with oligometastatic lung cancer. It is challenging to pick the most suitable individuals for local therapy. The idea behind focusing on a single organ for metastases is that, if the main malignancy and regional nodes are under control, any one or very few metastases in that organ can be cured. Within this context, radiation may play a part in the regional management of oligometastatic localised cancer. While morphological and functional imaging methods have come a long way in the last decade, oligometastatic situations are becoming increasingly common during follow-up. Due to its reduced rate of morbidity, lower costs, and the possibility of administering ablative treatments on an outpatient basis, highly conformal radiation therapy, like stereotactic body radiation therapy (SBRT), also called stereotactic ablative radiotherapy (SABR), may end up being a less invasive and more effective alternative

to surgery as metastasis foci become smaller. New technological advancements are presently taking place in the field of radiotherapy. Modern advancements in technology are honing the "ballistic" method to precisely target organs and tissues while minimising damage to nearby healthy tissues and organs. This is achieved through the use of three main techniques: (a) radiation therapy that is intensity-modulated, such as volumetric modulation arc therapy or similar rotational approaches; (b) radiation therapy that is delivered by robotic arms, like the CyberKnife Robotic Radiosurgery System (Accuray Inc., Sunnyvale, CA); and (c) radiation therapy that uses protons and other hadrons to achieve high linear energy transfer. More and more evidence is pointing to SBRT as a safe and effective method for local management of several metastasized areas. In this overview and discussion, preclinical evidence, clinical experience, and obstacles are explored .

Choice of Patient

Criteria for SBRT selection in the treatment of oligometastatic cancer are still very important. The indications for SBRT are similar to metastasectomy in general, however there are no limitations regarding the treatment's feasibility in patients who are not surgical candidates. The following criteria have been specified in several studies as SBRT eligibility for oligometastatic cancer: a small number of metastases (one to five), a small tumour diameter (four cm), a primary tumour that has been locally managed, and the absence of other metastatic locations. Additional, more recent suggestions for selection criteria to provide SBRT to patients with different types of oligometastatic tumours include: a well-controlled primary, favourable histology, limited metastatic disease, metastases that appear metachronous, good performance status (PS), and a young age. Patients who are eligible for SBRT in clinical practice are typically those who have not been candidates for surgery because to age or PS, or who have already undergone many lines of systemic therapy, and for whom the toxicity of local therapies should be minimised.

The Science Behind SBRT

One commonality between treatment delivery units is the ability to use image-guided therapy to confirm the tumor's or target volume's location before treatment is delivered. One example of a 3D volume imaging modality that can be used for this image-guided therapy is cone beam computed tomography (CT). Using invasive fiduciary markers either inside the tumour or very near to it is necessary for two-dimensional imaging. The planning target volume can be decreased with the help of these image-guided methods, which significantly decrease treatment setup error by utilising the tumour as a fiducial (frameless SBRT). There are a number of cone beam CT integrated therapy devices available for purchase right now. There is no clear winner among various treatment delivery units; rather, each has its advantages and disadvantages. The treatment delivery unit is less crucial than the SBRT team's training and expertise .

SBRT's Radiobiology

The typical standard for radiation has always been 1.8- to 2.0-Gy fractionation, which results in longer treatment periods. This is because fraction sizes have a greater impact on normal tissue effects than acute effects. The mitotic death of cancer cells produces a tumoricidal effect at fractionally small doses, which simultaneously allows normal tissues to recover from late sublethal injury. New evidence suggests that at increasing fraction doses, a separate mechanism involving microvascular damage starts to significantly impact the tumour cell kill, adding a new method of radiation-induced damage to SBRT. This mechanism works in addition to direct cytotoxicity. Microvascular disruption and tissue death are outcomes of endothelial apoptosis. So, while hypo-fractionated irradiation could potentially increase late toxicity risks from a radiobiologic standpoint, SBRT techniques mitigate this risk by minimising the amount of normal tissue exposed to high doses. The rationale behind this is that SBRT techniques are highly precise, unlike conventional radiotherapy that typically uses fraction sizes ranging from 1.8 to 2.0 Gy, which results in longer treatment times. The mitotic death of cancer cells produces a tumoricidal effect at fractionally small doses, which simultaneously allows normal tissues to recover from late sublethal injury. New evidence suggests that at increasing fraction doses, a separate mechanism involving microvascular damage starts to significantly impact the tumour cell kill, adding a new method of radiation-induced damage to SBRT. This mechanism works in addition to direct cytotoxicity. Microvascular disruption and tissue death are outcomes of endothelial apoptosis. So, while hypofractionated irradiation might increase radiobiologic concerns about late damage, SBRT approaches mitigate these worries by minimising the amount of healthy tissue exposed to high doses.

SBRT BY SITE

For publications on arguments published in indexed journals, a MEDLINE search was performed in conjunction with reference checking. Our analysis did not include studies that met the following criteria: (a) had a small number of patients (less than seven), (b) had a diverse population, or (c) had a relatively short duration of follow-up (less than 10 months).

Lung Oligometastases

As SBRT can achieve high rates of tumour control with relatively little harm, lung metastases likely serve as an example of the possible benefit that can be achieved. At one year, the local control probability ranges from 70% to 100% for solitary or few lung metastases (defined as fewer than three or five, depending on the selection criteria). With a variety of fractionation schedules and delivery modalities, the recommended physiologically effective doses in the majority of series are 100 Gy. While some reports used a single fraction of SBRT, the majority of studies used multiple fractions (ranging from three to ten). The lack of randomised trials and the inclusion of patients with highly varied clinical characteristics in most phase I-II studies makes it difficult to appropriately assess survival estimates and the actual influence on patients' clinical outcomes when utilising SBRT for lung metastases. The 2-year weighted overall survival (OS) rate estimate from the largest studies was 54.5%, according to a recent review by Siva et al., with higher rates in selected series (e.g., 84% OS at 2 years in Norihisa et al.) and lower rates (e.g., 39% in a multi-institutional trial with nonsurgical unselected patients) compared to smaller studies. The study found that over 40% of patients had two metastases, nearly 30% had tumours with a volume of 10 cc or more, the median tumour volume was 4.2 cc, and nearly 29 percent had received more than one prior line of chemotherapy. Although not consistently documented, the median survival periods varied from 11.3 months in the pioneering Swedish group's experience. It lasted up to 42.8 months in a group of 61 carefully chosen patients, most of whom had just one metastasis from their original lung tumour. Typically, trials reported 1-2 or 1-3 synchronous lung metastases, while there was anecdotal evidence of patients with 1-5 tumours. The most common clinical finding was the spread of cancer to more than one lung. Optimal outcomes are likely to be attained in patients who have a generally favourable tumour volume presentation, have undergone no or few prior chemotherapy cycles, and do not have any extrathoracic metastatic disease, according to the current data. Additionally, following SBRT, a large number of patients were given chemotherapy or other local therapies, which improved disease control following systemic progression, according to certain studies. Here, SBRT has the potential to significantly slow progression, and the progression-free survival (PFS) interval seems to be an important endpoint for bigger trials involving this group of patients in the future. The comparison of SBRT with surgical metastasectomy results is an obvious next step after initial experience. Patients afflicted with a single metastasis had an OS rate of 70% at 2 years and 36% at 5 years, according to data from the International Registry of Lung Metastases. Most patients referred for SBRT are considered inoperable due to medical comorbidities that can significantly impact their OS outcome; this makes it difficult to compare OS data using SBRT with data from historical surgical series. Another reason is the different clinical characteristics of the patients. When compared to other alternative therapies, SBRT appears to have the same or lower rates of acute toxicity. The incidence of adverse effects was minimal in a study conducted by Siva et al. Grade 3 toxicity occurred at a rate of 2.6% in a series of fractionated radiosurgery and 4% in a series of hypofractionated radiation. Because most reports are retroactive and toxicity data is inadequate, it is probable that there are no grade 1-2 toxicity scores. There was one death due to oesophageal necrosis in a tumour that was positioned in the centre, and the toxicity rate was generally higher when treating lesions in that area. There is a dearth of published evidence on late toxicity, making evaluation challenging. One well-known radiological finding following SBRT is radiation-induced lung injury, which includes radiation pneumonitis and radiation fibrosis; however, there is no direct link between these findings with clinical or functional respiratory parameters. The lung is the principal organ at risk. In patients with one or a small number of lung metastases (five or fewer), SBRT is a viable alternative to surgery due to its high local control rates, potential survival benefits, and lack of significant side effects. However, there is currently not enough evidence to confirm the optimal tumour selection parameters, fractionation schedules, and radiation therapy techniques. The most common minimum ablation technique is radiofrequency ablation (RFA). Despite the heterogeneity of the patient cohort, which made direct comparison of survival outcomes difficult, a prospective multicenter trial found that RFA produced encouraging results in terms of overall survival and cancer-specific survival. The local control rate was 88% in both the primary and metastatic lesions. Optimal candidates for RFA treatment include small tumours (3-5 cm) and those on the periphery. Pneumothorax is the most common consequence, occurring in 28% of cases. Pain (14% of patients)

and pleural effusion (14% of patients) are further side effects. On a global scale, RFA shows promise in certain individuals; nevertheless, trials are necessary to evaluate its efficacy in comparison to other local ablative treatment options .

Oligometastases of the liver Over the last 10–15 years, a large body of clinical evidence has documented the safety and effectiveness of SBRT in a variety of patient groups with non-lung metastases. Metastasis from colorectal cancer (CRC) often occurs in the liver. The results demonstrate that some patients can achieve long-term survival after surgical removal of small liver metastases. Unfortunately, approximately 10%–20% of patients with metastatic CRC are good candidates for surgical resection due to the technical difficulty of the procedure. A range of ablative treatments have been developed for use in certain individuals who have a small number of liver metastases and are not good candidates for surgery. Percutaneous ethanol injection, RFA, and transarterial chemoembolization are the most common methods. All of these options have significant restrictions and varying degrees of invasiveness, but they are significantly less invasive than surgery. There is a wide range in the 5-year survival rate (14%-55%), according to retrospective evaluations using RFA for liver metastases from CRC. A history of radiation-induced liver illness, which manifests 4–8 weeks after radiation treatment, cast doubt on the liver's radiosensitivity and made it difficult to acquire the radiation doses needed to remove large tumours. SBRT offers a noninvasive way to target liver metastases locally, minimising radiation exposure to healthy tissue and increasing the likelihood of successful tumour management with minimal side effects. Several retrospective experiments have shown that the local control rate that can be achieved with SBRT ranges from 57% to 100%. But most research only followed participants for a short period of time—about 18 months at most. The use of SBRT to treat liver metastases has been the subject of multiple published prospective studies. Results from published trials show promise and confirm that a small but considerable fraction of oligometastatic patients may benefit from intensifying local therapy with higher radiation doses using SBRT. This is despite the relatively short follow-up duration of 18 months in the majority of series.

Lymph Nodes with Metastatic Isolation

Conventional radiotherapy's local control rate in cases of limited or isolated lymph node metastases is seldom documented in the literature. SBRT does not take the role of chemotherapy, although it can enhance its effects on metastatic lymph nodes and specific areas of gross disease. While there has been a great deal of variation in the fractionation and dosage schedules, preliminary results from a few new series show promise for the local control rate. Dose escalation may provide higher efficacy without prohibitive damage since metastatic lymph nodes are treated in tiny quantities. Multiple series' lower disease-free survival rates could be accounted for by large variations in patient populations with respect to many factors, most notably the behaviour of the original tumour and the load of microscopic systemic disease beyond the irradiation target. To summarise, while it is true that the majority of patients who get SBRT for lymph nodes metastases will eventually experience failure at other sites, the local control that is achieved during this initial therapy can be crucial for maintaining quality of life and postponing the need for additional systemic treatments. Tolerance dosage evaluation to the vascular wall around the lymph node target, particularly with ablative doses, is an intriguing problem that will undoubtedly involve patients with long-term survival rates .

Adrenal Gland Metastases

Although several non-adrenal primary tumours can metastasise to the adrenal glands, non-small cell lung cancer (NSCLC) is the most common. When compared to nonsurgical treatments such as RFA, chemical ablation, arterial embolisation, blend embolisation, radioembolization, external beam radiation, and cryoablation, resection of clinically isolated adrenal metastases has generally shown longer median survival and overall survival times. represents and contrasts the features of the published SBRT studies for adrenal metastases. Overall, there is a dearth of published research on SBRT's effectiveness in treating adrenal gland metastases, and this could lead to critiques about the lack of information on local control and dose fractionation. However, researchers should be encouraged to conduct more clinical trials to optimise local control and assess any possible advantage to PFS, given the good tolerability and encouraging clinical data .

Metastases in the Spine

Despite the lack of prospective research beyond retrospective analyses and phase I-II trials, spinal radiosurgery has demonstrated efficacy in treating spinal metastases in appropriately chosen individuals. After considering the follow-up of each trial, it has been found that 80% of presentations are successfully managed locally using imaging and/or

pain treatment. In a recent analysis, Sahgal et al. pointed out that, while the rates of control are encouraging, it is impossible to draw any strong conclusions due to the overall absence of actuarial data. When it comes to pain control, there are no randomised trials that compare stereotactic radiotherapy with conventional radiotherapy. Another problem is that with traditional treatments, local control is usually evaluated primarily on clinical benefit, not imaging. Additionally, stereotactic radiation can be used as a retreatment for areas that have already been irradiated. The outcomes in pain control are similar to those in patients who have not been treated before. draws on a number of research papers, one of which discusses the efficacy of stereotactic radiation on spinal tumours. With a worldwide follow-up time of a few months, direct comparison is impossible due to the various dose prescription regimens, total doses, and fractional doses. Due to the fact that SBRT works by treating only the target region, which means that areas near the spinal cord are often underdosed, the procedure's hallmark pattern of failure following SBRT for spinal metastases is typical of SBRT. A common site of failure is the epidural space. According to Chang et al., eight out of seventeen failures in this area were found in seventy-four tumours. There is an increased likelihood of recurrence in the back portion of the spinal column. Optimal target contouring is still up for discussion, however some series use MRI to shape the entire vertebral body while others contour just the tumour. In order to reduce the extent of surgery, which can be confined to epidural decompression and fixation, Sahgal et al. reported that SBRT can also be safely applied in the postoperative environment .

While preliminary evidence suggests that SBRT may be an effective method for treating spinal metastases, this approach is still in its experimental phase and needs to be further studied in a controlled setting. In recent times, there have been multiple reports of innovative and effective ablation treatment techniques for the treatment of bone metastases. Radiofrequency ablation (RFA), cryoablation, microwave ablation, and laser ablation are all part of this category. Rosenthal and Callstrom recently reviewed the literature on minimally invasive procedures and found that RFA and cryoablation had the highest number of studies. Criteria for selecting patients for SBRT are comparable. Though the findings of the two studies differ due to factors such as patient selection, the level of anaesthesia, and the degree of tumour eradication, RFA is beneficial in lowering pain from skeletal metastatic illness, as shown in two multicentric trials. In the study conducted by Goetz et al., up to 95% of patients reported pain improvement, while the American College of Radiology Imaging Network found a 14-point reduction in pain at the 3-month mark. Among the side effects were neuropathic pain, worsening of pain, and broken bones. Five percent of cases worldwide were found to have category 3 toxicity. Although these findings necessitate additional testing, they suggest that RFA may be competitive with SBRT in certain instances. There is a lack of clinical data on cryoablation, although it may be an alternative to RFA.

The Affordability

We must evaluate SBRT's cost-effectiveness in addition to its efficacy since it is being employed in more and more clinical settings. It is possible to increase the likelihood of tumour control with SBRT by using dose-adaptive radiation therapy, which incorporates image guiding, high-precision dose administration, more precise target definition with improved anatomical and biological imaging, and the ability to verify dose throughout treatment. A lot of people are worried about the worth of this technical advancement, and it comes at a higher price. However, shorter treatment durations can help reduce some of the financial burden of investing in state-of-the-art radiation oncology equipment and resources. Loss of time and economic output due to treatment-related and cancer-related illness and mortality are examples of the indirect costs of cancer care that can be reduced with better tumour management, less toxicity, and fewer treatment rounds. In 2010, indirect mortality costs accounted for 53% of cancer care expenditures, while indirect morbidity costs accounted for 8%, according to the US National Institutes of Health. Hence, there is hope for significant direct and indirect cost reductions due to developments in radiation therapy. Although it is assumed that SBRT would be more cost-effective for most health systems compared to other treatments involving anaesthesia and/or hospitalisation, there is a lack of specific data in the literature that addresses this matter. Recent publication by Sher et al. of a cost-effectiveness analysis of SBRT vs. RFA for patients with medically inoperable, early-stage NSCLC stands out among the most intriguing studies .

CONCLUSION

The role of radiation therapy for metastatic disease has changed from symptom palliation to potentially curative purpose, as demonstrated in specific patient settings, including promising data from oligometastases. This shift is due to the more extensive prescription of SBRT and SABR, which led to preliminary published results. There is still much debate about whether harsh treatments like metastasectomy or SBRT are acceptable for oligometastatic patients, especially since the benefits to survival have not been proven. With the exception of a small number of patients, intensive local therapies did not consistently result in significantly prolonged survival periods. In addition, multiple surgical series have criticised an artefact of patient selection: doctors use assumed benefit calculations based on comparisons with inadequately described survival projections from other patients who have advanced disease. Exploring SBRT dose escalation to optimise local control may be helpful in the subset of patients with a single metastasis. Life expectancy and toxicity should be carefully considered when evaluating the selection criteria for SBRT in situations with multiple metastases, particularly when more than one organ is implicated. Important questions that remain include: (a) when should chemotherapy be administered, (b) how can radiation oncologists determine the optimal target while minimising risk to other microscopic disease foci, and (c) what is the true boundary between palliative and hypothetical curative intent therapy in oligometastatic patients? There has to be extensive investigation into the use of new medicines in conjunction with SBRT due to the high likelihood of distant progression in these individuals. Given this history and reasoning, it is time to suggest high-dose SBRT prospective trials to determine its efficacy in a subset of oligometastatic cancer patients. Comprehensive Treatment of Oligometastatic Tumours is a global randomised phase II controlled trial that is actively recruiting participants (NCT01446744). This study aims to evaluate SBRT at ablative dosages in comparison to standard radiotherapy and chemotherapy as they are currently practiced. Clinicians eagerly await the findings of this and other prospective randomised trials to determine the true effect of SBRT on overall survival and quality of life outcomes for patients with oligometastatic disease .

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