Quality control in radiotherapy of brain tumors

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SYSTEM OF QUALITY CONTROL

The idea of quality control and quality assurance was first introduced into industry, including all necessary planned and accepted procedures, providing precise and permanent functioning of the system, according to accepted standards. Quality control program was introduced into medicine in 1976 on suggestion of the World Health Organization - WHO. The basic aim was the control of accepted treatment programs, their improvement and optimization to enable proper and high quality treatment of patients.

Acceptance and quality control realization should make possible that chances for cure of patients of the same stage and type of disease do not depend on the place and team conducting the therapy. Also, treatment planned in this way should provide designing of methods of treatment and adequate equipment, which are safe both for patients and the staff as well (1).

In recent decades, radiotherapy is rapidly developing not only because of the introduction of new, contemporary technologies, but also because of the most modern approach in development of the quality control system. General quality control system is introduced, covering all aspects during treatment process, from the time of presentation, diagnosis, histological finding, treatment to follow-up of patients. It is about complex quality control system, which includes clinical, physical and technical aspects of quality control. Clinical aspects include basic data on patient, disease type, staging and planned treatment according to accepted therapeutic protocols, treatment results and continual patients' follow-up after completion of treatment. Physical aspects include available equipment, dosimetry, isodose distribution planned to dosimetric protocols and both international and local regulations and technical aspects comprise precision of application of the planned therapeutic program - positioning of a patient and irradiation beam, checking of geometric parameters and the beam modifiers, protection precision (2,3,4). For the purpose of follow-up of applied regulations and comparison of results standardization has been made and acceptance of the international recommendations for planning, conducting and control of therapeutic programs - ISO 9000, ICRU Report 50, ICRU Report 62, Quality Assurance in radiotherapy program (5,6,7).

CLINICAL ASPECTS OF QUALITY CONTROL

Primary brain tumors are the most frequent solid tumors in children with 20% of all malignant diseases in childhood, while the incidence in adults is low (1.5%). Nevertheless, the importance of quality control in radiotherapy is essential both in children and in adults, regarding risk for late sequelae, as well as possible physical, neurological and cognitive deficits with unsatisfied quality of life.

Whenever possible, radical tumor dose should be applied in radiotherapeutic treatment of the central nervous system tumor. Determination of irradiation fields is conditioned by histopathological type of the tumor and malignancy grade. Applied irradiation dose also depends on the age, histopathological type, malignancy grade and extension of the surgical procedure. The most frequently applied irradiation technique are cranial and craniospinal technique, requiring precision in planning and conducting of the program of irradiation technique (6). Cranial irradiation should include whole brain or, more often local techniques with different safety areas depending on the tumor type. These irradiation techniques are also applied in some stages of acute lymphoblastic leukemia, as well as in adults.

PHYSICAL ASPECTS OF QUALITY CONTROL

Physical aspect of quality control comprises available equipment, dosimetric determination of the beam quality parameters, absorbed dose, isodose planning according to dosimetry protocols and both international and local regulations (9). In order to use a certain radiotherapeutic device in every day use for treating patients, it should function correctly and according to producer's recommendations and have stable determined physical characteristics of the irradiation beam. Both these aspects are mutually conditioned and connected, having common aim - to enable daily precise application of the planned therapeutic dose.

Quality control aspect in cranial and craniospinal radiotherapy is especially important for follow-up of effects at the field separation level. Problem of the field separation has been known for long time in the radiotherapy planning. The aim in radiotherapy is to achieve dose uniformity at separation level, making adequate choice of the irradiation technique, dose distribution, and precisely giving irradiation treatment.

In craniospinal radiotherapy this refers to separation between cranial and spinal fields, and separation of the spinal fields. Many authors have analyzed this problem and tried to find optimal solution that will satisfy all required demands. Numerous studies have shown that any deviation from stated separation intensifies effect of overdosing or underdosing in the function of separation area and intensity.

TECHNICAL ASPECTS OF QUALITY CONTROL

Technical aspects of quality control refers to correct functioning of radiotherapeutic megavoltage machines, and correct conducting of all procedures related to immediate realization of radiotherapeutic treatment (10). In cranial and craniospinal radiotherapy this, in the first place, refers to checking of reproducibility of patient's positioning to irradiation plan, positioning of the fields and fields' angle, then distance control, protecting blocks, compensators, wedge filters and equipment for immobilization during the treatment.

Optimal application of the physical and technical parameters control program provides permanent control and confirmation of dosimetry stability of the radiotherapy machine, what, with control clinical parameters enables adequate planning and application of the therapeutic plan of treatment.

All three aspects of quality control are mutually connected and have common aim to provide correct, reproducible irradiation with planned total tumor doses according to intracranial localization, histological type and grade, age and performance status.

CRANIAL RADIOTHERAPY

Aim of the cranial irradiation is whole brain irradiation, with or without irradiation of complete intracranial subarachnoid space. For the first option target volume must include subarachnoid space around optical nerve, what
practically means inclusion of orbit top. Also, the fields must include cribiform plate and temporal pit. Hypodosing of the cribiform region has been considered the most common cause of the supratentorial relapse in the patients with medulloblastoma. Lower limit of the field is at the level of the second cervical vertebra in order to provide homogeneous distribution at the level of peripherally localized subarachnoid space. Apart from application in the patients with certain primary brain tumors and brain metastases, this technique is applied in high-risk stages of acute lymphoblastic leukemia, which means prophyactic or therapeutic teleradiotherapy in neuroleukemia.

Cranial radiotherapy using local techniques is indicated in astrocytoma, oligodendroglioma, ganglioglioma, hemangioblastoma, some benign tumors and vascular malformations as well. Safety margins include borders of radiation fields 2cm out of macroscopic tumor on imaging findings (CT, MRI) in low-grade gliomas, but 5-7cm in high-grade gliomas.

CRANIOSPINAL RADIOTHERAPY

Craniospinal technique is necessary for majority of pediatric brain tumors that have tendency of dissemination through liquor - supratentorial PNET, medulloblastoma, infratentorial and high-grade supratentorial ependymomas, germ cell tumors, pinealoblastoma, hirudoci plexus carcinoma. Aim is to irradiate complete subarachnoid space, both cranial and spinal one. Cranial field corresponds to previously described and spinal should include spinal cord up to S2 vertebra. Cranium and proximal part of cervical cord up to C4 vertebra are irradiated from two opposite parallel fields using wedge filters in many centers, including our Institute as well. Vertebral axis is irradiated with one or more directs fields. Lower edge of the spinal field is planned on the basis of MRI examination, as well as lower edge of S2, or lower level of rectal bag. Dose is focused on front surface of C7 and L5 vertebral bodies. Quality control algorithm applied at all levels of planned cranial and craniospinal radiotherapy has been accepted in contemporary radiotherapy approach. After precise defining of target volume, in accordance to the international recommendations, the field localization is determined on a patient - simulation and immobilization, according to isodose plan. Then start irradiation treatment and the first positioning with "checking" film - gammagraph on the therapy machine. Quality control should be necessarily one during irradiation treatment, in relation to all relevant technical parameters of the quality control: fields positioning with the cranial field precision control, protection checking of critical locations (eyes, cribiform plate, temporal pits), precision of craniospinal and spinal crossing. Then, control of patient's positioning, checking of geometric parameters, beam modifiers and planned protections. Planned radiotherapy program is individually conducted for every patient, in accordance with accepted and already mentioned internationals regulations and recommendations in radiotherapy.

ABSORBED TUMOR DOSE AND FRACTIONATION SCHEDULE

For the majority of pediatric brain tumors conventional fractionation is recommended with daily doses from 1.8 to 2.0Gy and total absorbed dose of 50 to 55Gy. Prophyactic doses in craniospinal technique are from 30Gy to 40Gy, daily fractions are about 1.5Gy. All irradiation fields are given every day, five days per week. There are a few exceptions for some patients. For patients with minimal neurological deficits and satisfied performance status teleradiotherapy used to be conventional with radical total doses range 55-60Gy, or hypofractionated with 30Gy in 10 fractions. On the other hand, hypofractionated regimens such as 18Gy in three fractions or 12Gy in two fractions or 20Gy in five fraction are recommended particularly for patients with neurological deficits, bad performance status and minimal expectancy for longer survival.

CONCLUSION

Radiotherapy techniques for brain tumors are complex and require precision in planning and giving radiotherapy programs. Continual application of quality control should enable achieving better treatment results with minimizing risk for late treatment-related complications. Introduction of uniform and precise parameters for the therapy planning, dose determining and patients control, makes possible for optimal follow-up and comparison of treatment results between different therapeutic centers.

SELECTED REFERENCES