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Research Article

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Cyberknife treatment for different types of tumor

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Abstract

CyberKnife radiosurgery is a frameless, image guided robotic stereotactic radiosurgical system (IGR-SRS) which uses potent, ablative radiation dose with limited treatment volume. The main aim of this study is to provide knowledge of this treatment for different types of tumor. To deliver radiation treatment from multiple angles, with real time target tracking through a combined orthogonal radiograph imaging and optic motion tracking system cyberKnife is a new and advanced technique. Radiation is delivered to the tumor within a predetermined range, for this an object recognition computer algorithm and a fudicial marker placed within a tumor. CyberKnife treatment cost USD 6,800 (Indian Rupees approx. 4,89,000). In this review you will get idea about different types of tumor get treated with cyberKnife radiosurgery (SRS). CyberKnife have submillimeter accuracy in metastatic brain tumor. By giving appropriate tracking method for stage I lung cancer and lung oligometastases stereotactic radiotherapy is an efficient treatment. So, at well-defined tumor sites cyberKnife is a new stereotactic body radiation therapy which delivers high dose of radiation in short period of time. For head and neck tumor treatment cyberKnife is most widely used. This treatment is helpful for adrenal gland tumor and prostate tumor, spinal metastases.

Keywords: CyberKnife, Stereotactic Radiosurgery, Stereotactic body Radiotherapy.

1. Introduction

CyberKnife it is a stereotactic radiosurgery (SRS) that is radiation therapy in which incision (cuts) are not made on body, only radiation beam is used. These radiations particularly focus on small area of the body by using high power of energy. Because of some health and age problem SRS is mostly use for those patients who have very high risk for microsurgery. SRS treatment can minimize damage to the other healthy tissue so basically it is target specific, that's why it is highly recommended for different types of tumor. This cyberKnife utilizes an approach that is SRS/SBRT (stereotactic body radiation therapy) which uses a novel 3D co-ordinate system and it gives very accurate radiotherapy plan with highly advanced image. Stereotactic body radiation therapy it utilizes 3D co-ordinate system. CyberKnife have benefits above SBRT because they are able to be tracking the coordinates in real time although the head of the accelerators realigns itself for helping the fluctuation in the target position [01]. The choice of method in real time tracking use to measure tumor position which is largely independent of the choice of method to realign the beam. So, these two aspects of technique can be developed separately. On the characteristics of tumor motion both tumor measurement and beam alignment methods are depend.

2. Material and Method

High tech of SBRT: This noninvasive treatment is use for that patient who have inoperable or surgically complex tumour. A tumour we called as inoperable because of having very small and complex shape. By using this cyberKnife system we can be provided simply new treatment by using radiation to the tumour patient. CyberKnife can requires only five or fewer outpatient procedure, which give high-dose radiation to the tumour cells [02].

Dr. Lars Leksell, a Swedish neurosurgeon, in early 1950's he developed concept of radiosurgery. They have developed a new device for radiosurgery by using approximately 201 number of pencil-type Co-60 source which focused on the region of abnormal tissue. Gamma knife is a system in which these all sources were spherically distributed in a helmet around the skull, which is fitted around the skull. By using this system, they can deliver spherical dose focused around the target volume, with minimal dose to the

surrounding normal cell. But we can use Gamma Knife only outside the head, instead of new generation of Gamma Knife can able to treat tumour up to C2 vertebra level [03].

Procedure of Cyberknife

Multidisciplinary team has been assessed the patient and then treatment procedure starts. Steps involve in these processes are given below:

- Setup of treatment
- Planning of treatment
- Delivery of treatment

Every procedure has been given by same day or else it will take different days. In this treatment patient don't have any compulsion to be stay at hospital or they don't need an acute care environment when program has devised. In between therapy planning patient can be able to come home. Patient CT scan can be done by using iodinated dye comparison with the mask in place (custom-fit plastic mask is created for patient). In the treatment planning application CT information has incorporated and then with the goal of pictures reconstructed demonstrating various patient places have connect so the computer can analyse 3D distance in which lesions has situated. For the planning of this treatment we need clinical expertise of the radiation oncologist and physicist, so they can handle the high-speed computers foe ascertain the quantity, dose and radiation ray goal pattern.

While giving the therapy, patient on the treatment table should lies face upward and could fitted with the right immobilization device. When the true therapy starts, there is a imaging program which give digital x- rays of tumor location and patient position. Now this information is forward to the arm and we could use maneuver the LINAC into suitable position. So, at different places around the individual the robot goes and retarget the LINAC when the treatment is going on. A little radiation beam has delivered at every place. To finish this procedure at 50-300 distinct places around the individual this replicated [04].

Figure 1: cyberKnife Machine

Cyberknife for different types of tumour

Metastatic brain tumor: Significant cause of morbidity and mortality is metastatic brain tumor which is the most common intracranial neoplasms in adult. From various primary sites is 9.6% overall incidence rate of brain metastases was observed. But the highest rate of brain metastases that is 19.9% is from lung cancer. Recent improvement is seen in brain metastases treatment by using magnetic resonance imaging (MRI) for detection of small metastases and improvement in systemic therapies so survival rate is also longer. When the treatment is given to patient should be fitted with thermoplastic mask in the supine position. In the contrast MRI CT images of 1mm slice thickness is fused. When the enhanced lesion observes by contrast-enhanced MRI the clinical target volume CTV is Using the Multiplan inverse treatment- planning algorithm (Accuracy Inc) plan will generate. defined. By adding margin 1mm to CTV, planning target volume (PTV) is generate. To treat 79 lesions SRS with median dose of 24 Gy (range, 20-25 Gy) prescribed to D90 (radiation dose has received by 90% of the PTV). To treat 30 lesions three fraction SRT with a median dose of 30 Gy (range 18-36 Gy) prescribed to D90. As compared to SRS tumor volume is greater in SRS. Because of patient movement target get displaced which is automatically corrected. CyberKnife have submillimeter accuracy [05].

Intracranial malignancy has brain metastases is a common type which is derived from the transfer of tumor cells outside the central nervous system to the brain tissue. With an onset age of 50 to 70 year old,Lu Emerson and Eichler was stated that brain metastases were reported to occur in 20 to 40 % in cancer patients [06].

lung Tumor

Patients with inoperable primary or metastatic lung cancer in that cyberKnife stereotactic treatment allowing for minimally invasive treatment with satisfactory results. Case study was done in between January and December at 2013 in which ninety-five patients (100 lung tumors) was treated by SBRT using cyberKnife. They get best result with small lesions. Even though instead of gold seeds coils may also be used. On the probability of local control fiducial marker (these are gold seeds or stainless-steel screw) don't have a significant impact. By giving appropriate tracking method for stage I lung cancer and lung oligometastases stereotactic radiotherapy is an efficient treatment [07]. Achievement of satisfactory local control and low toxicity rate in inoperable early stage primary lung cancer patient by cyberKnife lung SBRT which allows for real time tumor tracking and risk adapted fractionation [08]. The delivery of ablative dose of radiation by cyberKnife, while decreasing radiation related comorbidity by providing superior targeting and respiratory motion compensation [09].

Hepatic tumor

The sixth most common cancer worldwide is hepatocellular carcinoma. In 2012, according to GLOBCAN it has estimated that around 745,517 deaths were result of HCC (hepatocellular carcinoma) [10]. Combining synchronous tracking guide and fiducial marker tracking which can control the precision within 1mm and realize precise therapy which is the advantage of CK- SBRT [11].

In May 2011 and June 2015 patients with HCC with extrahepatic metastasis or vascular or bile duct invasion was enrolled. To treat each lesion, they used cyberKnife. Assessment of trends of tumor markers including alpha fetoprotein (AFP), proteins, produced by vitamin K absence II (PIVKAII) wasdone. With Fishers exact test and logistic regression model prognostic factor for tumor response and tumor marker was evaluated. Kaplan- Meier method and multivariate analysis was performed to evaluate survival rate, and which is done by using Cox proportional hazards model [12].

Head and neck tumor

Including whole body surgery, intracranial and extracranial surgery as well as benign and malignant tumor cyberKnife treatment is used. For head and neck cancer treatment cyberKnife treatment is also widely used. Outcomes of cyberKnife radiotherapy for head and neck cancer comprising 275 patients studied during 2000 to 2016 this data was evaluated with total of 5 articles included for extraction. For this cancer they get outcomes from cyberKnife treatment was assayed on locoregional tumor control, overall survival rate at 1 and 2-year, median survival rate, median follow up period and development of major complication during the period of follow up. Good locoregional tumor control, with absence of distant metastatic progression in majority of cases of previously irradiated head and neck cancer with or without concurrent chemotherapy, cyberKnife was found good treatment. From first year to second year the overall survival rate was found to be decrease except study conducted by Kawaguchi et al which is 78.8% at 2 years give good survival rate. Due to the low sample size in study this increase in survival rate in the aforementioned study can see. 43.33% was mean survival rate in the 2 years. Other stereotactic radiotherapy methods like image modulated radiotherapy other than this cyberKnife was found to be more survival rate. Due to limitations of anesthesia and surgical outcomes radiotherapy for the management of cancer were used as one of the best methods of management in 20th century. In the following years overall survival rate for patient receiving radiotherapy is increased. For oropharyngeal and hypopharyngeal carcinoma management radiotherapy is not used as primary treatment strategy due to rate of tumor control and lower morbidity compared with surgical therapy [13].

The occurrence of distant metastatic progression limits by cyberKnife treatment and thereby increasing the overall survival rate [14].

Adrenal Tumor

In primary tumors of lung, liver, renal, colorectal, lymphoma the adrenal glamd is the commonest metastatic site [15]. Through surgery based comprehensive therapy adrenal tumor are mostly treated. Timely diagnosis and treatment often prevent through the diverse and atypical clinical manifestation. Treatment efficacy affect by some patient age, tumor metastasis, contradiction to surgery and relapse. As a result, for adrenal tumor radiation therapy plays important role. Overcoming the dosage limitation of conventional radiotherapy and improving control rate stereotactic radiotherapy allow tumor treatment with high dosage and low fractionation. For the treatment of adrenal tumor they used cyberKnife therapy in 26 patients between March 2009 and 2012 in hospital. The goal is to check safety and efficacy. With the range and dosage of radiation, radiation injury is the main factor limiting dosage. To lower incidence of radiation injury cyberKnife is precise and reduce radiation exposure range and dosage of neighboring healthy tissue and vital organ. Kidney, stomach, pancreas, intestines are automatically adjacent to adrenal gland. Therefore, with special precision delivery of high dose of radiation is important. Strict dose radiation was made to accommodate the vital organ, during the formulation of treatment plan for patient. As a result, after treatment only one patient developed acute radiation injury. Fatigue and gastrointestinal discomfort are most common adverse reaction. Result shows Superior short-term efficacy with lower toxicity cyberKnife is safe for treating adrenal tumors [16].

A case of a patient who underwent initial surgical resection for a locally advanced lung adenocarcinoma and subsequently developed an early, biopsy-proven, oligometastatic recurrence in the adrenal gland was reported. For the adrenal metastases he taken

chemotherapy and SABR using cyberKnife and is in remission 7 years after treatment with no late toxicity. For adrenal metastases fractionated SABR is an attractive noninvasive alternative to surgery [17].

Prostate Tumor

In developed countries justifies the increasing interest in new radiotherapy technologies for the high incidence of prostate cancer patient (pcp). Stereotactic ablative radiotherapy (SABR) is a safe and effective treatment for low and intermediate risk prostate cancer patient. Patient failure in inclusion of T2 patient and low percentage of intermediate risk patient permit us the assumption that this procedure could be utilized in the treatment of most advanced cases [18]. Patients with low intermediate risk prostate cancer treated to 35-40 GY as most study included [19].

Spinal Tumor

Treatment options are limited to spinal cord metastases. On metastases location, systemic disease, functional capacities and life expectancy this factor are depends for the treatment of intramedullary spinal cord metastases (SCIM). EBRT, open surgery, chemotherapy, hormonal therapy, and more recently SRS these are more common treatment for SCIM [20]. In patient who underwent separation surgery for metastatic epidural spinal cord compression (MESCC) they sought to compare local tumor control after conventionally fractionated image- guided intensity-modulated radiotherapy versus adjuvant CyberKnife stereotactic body radiotherapy. Patient with MESCC hybrid surgery-radiosurgery therapy is safe and effective treatment option [21].

Breast Tumor

To access the feasibility of cyberKnife accelerated partial breast irradiation on 20 evaluable patients of 29 eligible, followed for 2 years, this pilot study was designed. Acute/ sub-acute toxicity was the primary endpoint; late toxicity and the cosmetic result were the secondary endpoints. During the period of observation mild side effects were recorded. From the start of the radiotherapy up to two years cosmetic evaluation e=were performed by three observers. Progressively increase patient's evaluation from 65% to 85% of excellent rating; to that of external observer this trend was similar. With mild acute and late toxicity and very good cosmetic result, these preliminary results showed the safe feasibility of cyberKnife accelerated partial breast irradiation in early breast cancer [22]. Decrease in quality of life experienced by breast cancer patient with metastatic disease is due to spinal metastasis which is associated with significant symptoms, risk, alteration of structure related to morbidity, hematopoietic function of spine and weight bearing [23]. Followed by a boost of 10-16 Gy for a total of 6-6.5 weeks a conventional whole breast irradiation consists of 45-50 Gy to the whole breast. Delivery of 42 to 42.5 Gy in 3-4 week with larger dose of radiation given daily over a shorter time period by hypofractionated whole breast radiation regimens. Whole breast irradiation delivered after lumpectomy & local recurrence rate decreases by 50-60% shown by randomized control trials [24].

Acoustic Neuroma

For all brain tumors vestibular schwannoma accounts for 6-10% and histologically it is benign tumor, from the sheath of cranial nerve VIII it is commonly arise. Optical indication for each individual should be determined on the basis of size and location of the tumor, hearing level and patient age and the visible treatment option for vestibular schwannomas determined by observation, microsurgery and radiation therapy [25].

The treatment of sporadic vestibular schwannomas and neurofibromatosis type 2 yielding satisfactory growth control and preservation of hearing, facial, trigeminal nerve function cyberKnife has been shown effectiveness [26].

Pancreatic Tumor

In the united states it is fourth leading cause of cancer mortality in men and women. For early stage pancreatic cancer surgical resection remains the only curative therapeutic moiety [27]. For patient who may benefit from a shorter period of interruption of chemotherapy to control micro- metastatic disease & provide quicker relief from pain and allow the potential for dose escalation with reduce side effects so the short duration of SBRT is an attractive feature [28]. In terms of treatment time, satisfactory overall survival rate and loco regional control means that an effective option for inoperable pancreatic cancer which are the advantage of SBRT [29].

3. Conclusion

In our series we represent the cyberKnife radiosurgery treatment for different types of tumors with safety and good result. Which utilize the 3D co-ordinate system with advanced image enhancement? It is used to treat conditions throughout the body including prostate, lung, brain, head and neck, liver, adrenal gland, spinal tumor and can be alternative to surgery or for patient who are inoperable or surgically complex tumor. CyberKnife treatment are typically performed in 1-5 sessions. This system helped thousands of cancer patients and has more than two decades of proof.

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