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Comparative Study on Dose Distribution Variation in Single Direct PA Field Vs AP-PA Fields of 2D Manual Planning in the Treatment oflumbar Spinal Metastasis.

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***Abstract**: Spinal metastasis is a common manifestation in most of the cancers. Radiotherapy is the main stay of treatment to relieve the pain and other significant symptoms. To achieve good radiobiological response, it is required that target volume should cover at least 90% of given dose. Often spinal metastasis are treated with 2D manual single direct PA planning with empirical or standard depths like cervical vertebrae 3cm,thoracic vertebrae4-5cm, lumbar vertebrae 5-7 cm at most of the radiotherapy centers in developing countries . Even with cobalt 60 with appropriate 2D planning we can achieve similar disease response compared to 3D conformal planning.CT simulation images of lumbar spine were collected from 20 patients and utilized for virtual planning with help of 3D planning system. Single direct PA field plans with 5cm depth and AP/PA plans created for lumbar vertebrae and dose distributions were observed.*

In our study we observed >90% dose coverage area in Target volume(total vertebrae)1&Target volume 2(vertebral body) was 100% in AP/PA plan. In contrast , the percentage of area which is covered by >90% dose in the vertebral body is low and suboptimal in single direct PA field planning ,in which the dose heterogeneity and maximum doses were also observed as if it was observed in other studies.

***Keywords:**Radiotherapy, dose, Target volume, field,plan.*

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I. Introduction

Bone metastases may be found in up to 85% of patients dying from breast, prostate, or lung cancer and its incidence varies significantly depending on the primary site. Other primary sites with a propensity for bone metastases include thyroid, melanoma, and kidney.Patients with bone metastasis have more severe symptoms and become symptomatic earlier in the course than so patients with liver and lung metastases[1]. The most common site of bone metastasis is the axial Skelton, and spine, pelvis, and ribs are the most frequently occurring sites. The lumbar spine is the single most frequent site of bone metastasis [1].The most common level of the metastatic spinal cord compression (MSCC) involvement is in the thoracic spine (59% to 78%), followed by lumbar (16% to 33%) and cervical spine (4% to 15%), while multiple levels are involved in up to half of the patients[1] complications of bone metastases are common and occurring in up to 1/3rd of patients who develop first metastases in bones and produce high morbidity[1].Back pain is the most common presenting symptom (88% to 96%), followed by weakness (76% to 86%), sensory loss. `

In patients with bone metastasis the Overall survival depends on the primary site and the presence or absence of visceral metastases. Patients with predominant bone metastasis have longer duration of survival than patients with predominantly visceral metastasis. [1].However, patients of breast or prostate with bone metastasis may have significantly longer survival period. In patients with bone-only metastatic prostate or breast cancer, median survivals of 2 to 4 years have been reported[1].. Irrespective of the survival time, Most of these patients will often require active treatment because of pain and other associated problems and general deterioration of quality of life [1].Radiation therapy has been reported to be effective in palliating painful bone metastases, with partial pain relief seen in 80% to 90% of patients, and complete pain relief in 50% of patients. According to the literature RT can be useful in prevention and pain relief so involved bones should be treat as early as possible to prevent the morbidity, in adjuvant with good quality care and chemotherapy agents it can gives good quality and longer life especially in cancers like breast ,myeloma, prostate, thyroid, lymphoma[1,2,3,4]..

For patients with a longer life expectancy, bone-only metastases, and good performance status, a longer course of treatment (30 Gy in 10 fractions) may be more appropriate to minimize the risk of retreatment. For selected patients with a solitary bone metastasis , an even higher dose of treatment may be indicated, For

patients receiving radiotherapy for metastatic spinal cord compression (MSCC) from solid tumors, 30 Gy in 10 fractions is considered the standard of care. It is evident to achieve the good response with radiotherapy there should be at least > 90% dose distribution in the target volume and can be achieved in 3D planning and other conformal treatment options with good therapeutic ratio[1,2,3,4].

Whereas in most of the developing countries 60-70% of radiotherapy treatment centers are still depends on conventional 2D planning methods and delivering the treatment with cobalt 60 machines and simple Linac Machines even without x-ray simulators and other supportive systems with limited resources. As per general guidelines of ICRU [5]for Radiotherapy, the center of the target volume will be consider as a reference point. Because of limited resources and workload it may be practically difficult to measure the exact depth for single direct fields in spinal metastasis, And also there is no consensus in literature exactly where to prescribe the dose in vertebrae for single direct conventional planning in spinal metastases. Hence in most of the centers amongst conventional cancer treatment setups it has been in common practice to use standard depths(empirical) in manual planning to calculate treatment units depending upon area of the spine involved like cervical vertebrae-3cm depth ,thoracic vertebrae 4-5cm depth, lumbar spine 5-7cm depth depending upon patients built[2].Though some Radiation oncologists prefer AP-PA fields to lumbar spine but most of the practitioners prefer single direct field for spinal metastasis. since there are less studies on dose distribution verses benefit especially in palliative 2D planning, the importance of depth and dose distribution is less emphasized in radiotherapy of spinal metastasis[6,7,8,9].. With this back ground our aim of study is to emphasize the dose distribution variation between AP/PA plan and single direct PA plan.

II. Material And Method

In this study we utilized CT simulation images of lumbar spine of randomly chosen 20 patients who were treated for different cancers in our department and virtual plans were generated.

2.1Volume of interest

In each patient 4-5 vertebrae were contoured as Target volume1 and vertebral bodies contoured as Target volume 2 since it is most important part involved in fractures and cord compressions in lumbar spine.Single direct PA field and AP/PA fields created with 5mm margin on either side of vertebrae and up to intervertebral discs as upper and lower margins of field.

2.2Planning approach:

Treatment MUs were calculated in ARYA 2D planning system with help of field sizes at 5cm depth in SSD, 300/# schedule and at isocenter depth in AP/PA 150/150 cgy weightage with 6MV energy. For each patient MUs were calculated at 5 cm depth as standard (empirical)practicing depth in single direct PA plan, and isocenter depth in AP/PA field separately. Field size and MUs were entered in 3D planning system at prescribed depth and doses were calculated separately for single direct PA plan and in AP/PA plan without any changes, likewise Comparative virtual plans were generated for each patient with the help of 3D images and 3D planning system. For each patient 2 virtual plans were generated one for single direct and another for AP/PA plan, likewise 40 plans were generated. Dose coverage observed and noted.Cumulative dose volume histograms(DVH) were generated for each plan .Minimum, maximum and mean doses and percentage of area covered by >90% of given doses in Target volume1 and Target volume2 were collected.

III. Results

Dose distributions of two different plans- single direct posterior field and AP/PA field plan in Target volume1(complete vertebrae) of Lumbar spine are shown in table 1 and since the vertebral body-Target volume2 is the key part in the vertebrae its doses coverage is shown in table 2.Minimum doses in all single posterior field plans were significantly lower while maximum doses were significantly higher than AP/PA field plan. AP/PA fields achieved the intended dose ranges and homogeneity for target volume in lumbar spine.

Table .1.The Mean Percentage of Minimum, Maximum and Mean Target Volume 1(total vertebrae) doses±standard deviation for all plans of Lumbar spine

1. Mean dose (range) %± SD in Lumbar spine(Target volume 1)			
		5cm depth field	AP/PA field
1	Minimum	75.5 (63.4-84.4) ±5.7	87.3 (79.5-95) ±5.3
2	maximum	119.8 (110.8-122.6) ±3.2	109.7(101.3-116.1) ±4.1
3	mean	95.3 (79.8-102.5)	103.2 (97-107.6)

		±5.8	±2.6

Table.2.The Mean Percentage of Minimum, Maximum and MeanTarget Volume 2(Vertebral Body) Doses ±Standard Deviation for all Plans of Lumbar Spine

Table.2.Mean dose (range) %± SD in Lumbar spine (target volume 2)			
	Doses	5cm depth single direct PA field	AP/PA Field
1	Minimum Dose	75.9 63.9-84.5 5.7	91.6 79.6-98 4.8
2	Maximum dose	102.0 91.5-109.1 4.9	106.9 99.8-111.6 3.1
3	Mean dose	89.45 74.9-96.1 5.65	102.5 96.4-106.8 2.6

Table .3 percentage of vertebral body(target volume 2) covered by >90% of Prescribed dose in lumbar spine

	Doses	At 5cm depth PA field	AP/PA Plan
1	Mean	48.12	99.8
2	Min-Max	0-89	97-100
3	SD	28.676	0.75

Fig.1.AP/PA Planning –dose coverage

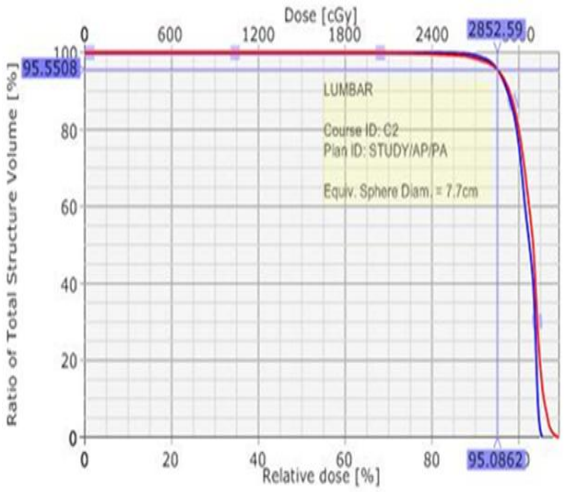
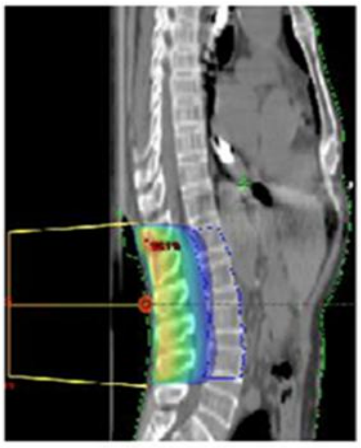
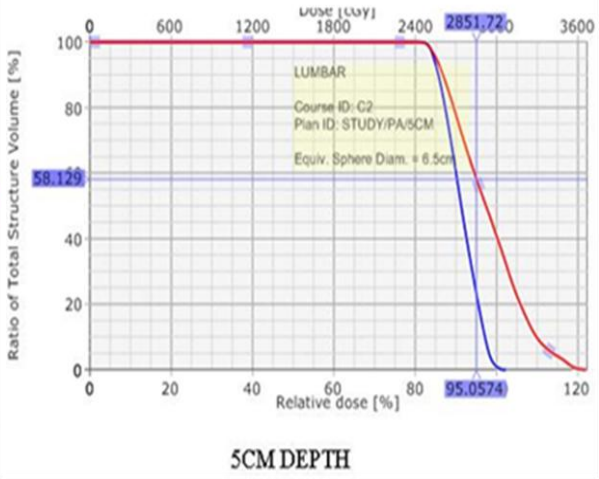


Fig.2. AP/PA Planning-DVH



5CM DEPTH

Fig.3. single direct PA plan doses



5CM DEPTH

Fig.4.single direct PA plan –DVH(Dose volume histogram)

IV. Discussion

Radiotherapy is the main stay of treatment for spinal bone metastasis for pain relief and to prevent fracture and progression of early lesions.The homogenous dose distribution in target volume plays significant role in treatment outcome .Factors like depth, photon energy, field size, portals mainly determine the dose distribution variations. As per ICRU report, homogeneous dose within 95% to 107% of the prescribed dose is recommended for the target volume[5], a variation of ± 10% from the prescribed dose is widely used in clinical practice. Hence in our study we collected data on the dose distributions in AP/PA field plan and single direct PA field plan at 5cm depth prescription which is being in practice for 2D manual planning for Lumbar spinal bone metastasis on cobalt and 6mv machines [2,4]., we also verified and compared the dose outcomes between these two planning. In AP/PA planning mean percentage of maximum doses was 109.7(101.3-116.1)±4.1table .1,which is less than single direct plan. Mean percentage of mean doses for target volume1 (total vertebrae) was103.2% (97-107.6)±2.6% table.1and its>90% dose coverage area in Target volume(total vertebrae)1&Target volume 2(vertebral body) was 100% in AP/PA plan table.3 and Fig.1,2. In contrast, the percentage of area which is covered by >90% dose in the vertebral body which is the key part in the vertebrae for fractures and card compression is low and suboptimal in single direct PA field planning Fig.3,4 and table.3 ,in which the dose heterogeneity and maximum doses were also observed as if it was observed in other studies[7].The maximum doses were high but they are within normal tissue tolerance range at palliative doses. Suboptimal doses may be helpful for temporary pain relief[1] but not useful to stop the disease progress.

To achieve the intended doses in single direct field it is necessary to calculate the exact depth of vertebrae.. Our results were comparable to other study results.According to the study done by FundagulAndic, Turkey, parallel opposed AP/PA field did achieve the intended dose ranges with homogenous dose distribution and with reasonable doses to medulla spinalis, esophagus and intestines [6,7,8,9,10].Studies investigating the relationship between radiotherapy technique and treatment outcome [6,7,8,9,10].would provide important information, particularly for patients with long life-expectancies.

V.Conclusion

Good dose distribution is the prerequisite to achieve required optimum response in Radiotherapy. Conditions like cabreast, prostate, myeloma, thyroid with solitary metastasis to bone will respond to radiotherapy along with other chemotherapy treatment and can gives good quality life for 2-4 years in contrast to common belief. Though it may not be absolute error freecalculation method finally AP/PA field 2D planning is advisable and effective palliative procedure than single direct PA field plan with 5cm depth for Lumbar spinal metastasis.

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