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Research Article

TEMPORAL LOBE SPARING RADIOTHERAPY OF PITUITARY TUMOURS: A PROSPECTIVE STUDY

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ABSTRACT

Purpose: This study was undertaken to compare three modalities of radiotherapy in pituitary tumours in terms of temporal lobe sparing and target volume coverage so as to choose the best modality for the treatment.

Methods and Materials: A total number of 22 patients were included in the study and after CT simulation, all three treatment plans were generated for all the patients. Plans were compared based on DVH characteristics and PTV coverage and OAR sparing were compared among various other parameters. The plan best optimized was chosen for treatment delivery.

Results: 3DCRT, IMRT and VMAT resulted in equally optimal PTV coverage but the VMAT plans were the best in sparing temporal lobes and other OARs. The temporal lobe sparing was trending towards significance though it could not attain statistical significance. This was attributed to difference in plan optimization methods when comparing with other studies.

Conclusion: In our study VMAT showed better sparing of temporal lobes and other OARs while offering equivalent PTV coverage in comparison to IMRT and 3DCRT.

INTRODUCTION

Radiation therapy is a very effective modality for the treatment of pituitary adenomas. Unlike surgery, radiation therapy does not provide a very rapid relief from signs and symptoms, decompression or hormonal normalization, but with time, the endpoint is almost as good as surgery with lower morbidity. Radiation therapy is most commonly used in cases of residual disease after surgery or disease recurrence after tumour excision. It's used as the sole treatment modality in patients who are inoperable or those who refuse surgery.

Based on the data obtained from a large number of retrospective case studies, it is found that radiotherapy provides a 10-year control rate of 85% to 95% in pituitary adenomas [1].

Investigators at the Princess Margaret Hospital reviewed 145 patients with secretory pituitary adenomas who had undergone radiotherapy.[2] After a follow up of 10 years, they found a progression free survival of 96%.The investigators thus concluded that radiotherapy is the highly effective modality to arrest the growth of the pituitary adenomas. Pituitary adenomas may be treated with different conformal radiotherapy modalities. The most commonly used techniques at present are 3DCRT, IMRT, and stereotactic radiotherapy.

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Treatment with charged particles e.g. proton beams is slowly emerging.

Traditionally pituitary adenomas were treated with two opposing lateral wedge fields with one anterior or vertex field. This approach has been discontinued because it results in very high dose to the temporal lobes. It can be tackled by using couch rotation, such that the beams enter from a superior lateral angle. If tumour is spherical, use of a double arc method using 110-degree arcs, with 30-degree wedge providing an optimum coverage.

This was associated with a good tumour control but the tradeoff was the significant normal tissue toxicity. The critical organs in the radiation field are eyeballs, optic nerve and chiasm, brainstem, temporal lobes, cochlea, hippocampus.

One solution to this was the use of conformal radiotherapy delivered by techniques such as 3D conformal radiotherapy (3DCRT), intensity modulated radiotherapy (IMRT) and volumetric modulated arc therapy (VMAT).

Various studies have shown that VMAT could offer better sparing of OARs in pituitary adenomas and also at other treatment sites in the body.

In this prospective study, we have compared the three different modalities of conformal radiotherapy namely 3DCRT, IMRT and VMAT in the treatment of pituitary adenomas, and have attempted to find out the modality that offers the best sparing of the temporal lobes and treatment target volume coverage and also other OARs and treatment parameters.

METHODS AND MATERIALS

A total of 22 patients were included in the study. Of these, 5 were secretory type. Remaining 17 were non-secretory. Out of the total 22 cases studied, 21 cases were operated surgically, before referring them for radiotherapy. One patient did not undergo surgery because of patients' denial for surgery.

Patients were immobilized using thermoplastic mask and a pituitary board. Axial CT images were obtained with a maximum slice separation 3mm with 1mm reconstruction throughout the volume. Postoperative T1 contrast MRI images were taken and the CT-MRI image fusion was done.

Gross tumour volume (GTV), which included solid and cystic tumour elements, was outlined according to standard departmental protocols using clinical, imaging, and surgical information. CTV was same as GTV due to pathologically benign nature of these tumours and a 5mm margin was added to CTV for defining the PTV. The dose prescribed was 45 to 54 Gy at 1.8Gy per fraction.

For all these patients' 3DCRT, IMRT and VMAT plans were generated. Sliding-window IMRT plans was generated for comparison with VMAT and 3D-CRT plans. All were normalized so that 95% of the planning target volume (PTV) received at least 100% of the dose. VMAT was delivered using one or two clockwise and counter clockwise arcs (Rapid arc, Varian medical systems, Switzerland), with a dose rate of 600MU/min. Planning was done using Eclipse version 10.0.28. Calculations were done using AAA algorithm for 3D-CRT and IMRT, version 10.0.28. Calculations for rapid arc were done using PRO algorithm version 10.0.28. The multi-leaf collimator (MLC) used was having 120 leaves or 60 pairs of leaves. All treatments were delivered using clinac ix.

All plans were evaluated for acceptable target coverage, homogeneity and Conformity.

Doses to organs at risk (OARs) and the number of monitor units and delivery time were also compared.

The data was collected and statistical analysis was done using one-way ANOVA. The mean values for each parameter were determined along with the standard deviation. All statistical analysis was carried out at 95% confidence interval for mean and p value <0.05 was considered as significant.

RESULTS

The values were obtained for volume receiving 95% of the prescribed dose in all the three treatment plans and the statistical comparison showed equivalent mean values for V95.

The mean dose received by the right and left temporal lobes showed lower Dmean for VMAT plans though not statistically significant.

The Dmax i.e. dose received by 2% of the PTV and Dmin i.e. dose received by 98% of the PTV were also computed and the results translated in better sparing of temporal lobes in terms of total dose and also regions of high dose depositions.

DISCUSSION

V95% refers to the volume receiving 95% of the prescribed dose and it is a measure of PTV coverage. Our results have shown that V95% is almost equal among all the three radiation modalities used. This shows that all the three radiation techniques offered optimum PTV coverage and thus other factors may be taken into consideration while choosing the best-optimized plan.

Gerhard *et al*. evaluated intensity-modulated radiotherapy for stereotactic radio-surgery in pituitary adenoma patients. [3] He studied ten patients with pituitary adenomas and compared 3D conformal radiotherapy with IMRT. IMRT showed much better target coverage compared to the other conformal modality.

Table 1 Comparison of V95%(cc) values among 3DCRT, IMRT and VMAT plans

		Mean	Std. Deviatior	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
V95% (cc)	3DCRT	33.84	14.42	3.22	27.09	40.59	9.312	68.06
	IMRT	33.71	14.12	3.15	27.10	40.32	9.35	66.64
	VMAT	33.90	14.07	3.14	27.31	40.48	9.39	65.01

Table 2 Comparison of TEMPORAL LOBE Dmean values among 3DCRT, IMRT and VMAT plans in sellar and suprasellar brain tumours

		Mean	Std. Dev	Std. Error	95% Confidence Interval for Mean		Min.	Max.
					Lower Bound	Upper Bound		
RIGHT TEMPORAL LOBE Dmean	3DCRT	2078.24	858.39	191.94	1676.50	2479.98	555.9	3829.1
	IMRT	1805.24	738.27	165.08	1459.71	2150.76	340.5	3325.5
	VMAT	1897.38	700.95	156.73	1569.32	2225.43	555.9	2940.8

Table 3 Comparison of TEMPORAL LOBE Dmax values among 3DCRT, IMRT and VMAT plans in sellar and suprasellar brain tumours

		Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
RIGHT TEMPORAL LOBE Dmax	3DCRT	4733.29	278.61	62.30	4602.89	4863.68	3982.4	5200.3
	IMRT	4407.37	446.20	99.77	4198.54	4616.20	3013.1	4861.9
	VMAT	4306.50	412.10	92.14	4113.63	4499.37	3028.1	4752.9
LEFT TEMPORAL LOBE Dmean	3DCRT	2197.24	800.47	178.99	1822.6	2571.87	984.1	3898.1
	IMRT	1868.16	642.75	143.72	1567.34	2168.98	908.0	3389.4
	VMAT	2160.69	954.74	213.48	1713.85	2607.52	111.4	3898.1

Table 4 Comparison of TEMPORAL LOBE Dmin values among 3DCRT, IMRT and VMAT plans in sellar and suprasellar brain tumours

		Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
RIGHT TEMPORAL LOBE Dmin	3DCRT	55.70	42.82	9.57	35.66	75.74	18.2	186.1
	IMRT	136.53	243.89	54.53	22.38	250.67	22.2	931.4
	VMAT	232.54	351.40	78.57	68.08	397.00	31.5	1248.9
LEFT TEMPORAL LOBE Dmin	3DCRT	59.82	42.33	9.46	40.01	79.63	17.5	165.4
	IMRT	153.96	250.81	56.08	36.57	271.34	27.9	1010.0
	VMAT	210.66	334.44	74.78	54.13	367.19	21.9	1257.5

The sparing of the temporal lobe was almost equal in both the modalities with no significant benefit with IMRT. Circular collimators gave better results as compared to the multileaf collimators.

So though the author has found a better coverage of PTV with IMRT in his case series, in our study, no such advantage was found with any of the modality in particular and all three techniques offered almost equal PTV coverage.

Fogliata *et al* compared VMAT with 5-7 field fixed field IMRT.[4] He studied five acoustic neuromas, five meningiomas and two patients with pituitary adenomas. He found almost equal PTV coverage with VMAT having slight advantage over IMRT. Lagerwaard *et al* [5] also demostrated that equal PTV coverage was seen with single arc VMAT and dynamic conformal arcs. He compared single arc VMAT with five non-coplanar dynamic conformal arcs and a single dynamic conformal arc. [5] On analysis of the plans, PTV coverage was found to be similar between the three plans.

So different authors have compared the PTV coverage with different modalities and have found them to offer nearly the same coverage with marginal edge with one modality or the other. This can be explained by the differences in optimization of the treatment plans and thus these are bound to vary from study to study.

Also the types of collimators used and also the tumour morphology and target volumes also govern the variations in PTV coverage in different institutional studies.

Among the organs at risk, in our study VMAT showed relative sparing of temporal lobes and it was trending towards statistical significance. The further optimization or the use of micro collimators could have achieved a statistically significant sparing of temporal lobes.

Fogliata *et al* compared VMAT with 5-7 field fixed field IMRT.[4] He studied five acoustic neuromas, five meningiomas and two patients with pituitary adenomas. IMRT was better in sparing the temporal lobes as compared to VMAT. [4]

A study was undertaken to compare volumetric-modulated arc radiotherapy with conventional fixed field IMRT in the patients with pituitary adenoma. [6] Ten patients were included in the study and for each patient, four plans were generated: fixed five-Field IMRT, seven-Fields IMRT, single arc VMAT and double arc VMAT. The radiation dose prescribed was 45 Gy in 25 fractions. Dose volume histograms were used to study the different plans and comparing various parameters. VMAT plans were significantly superior in sparing of the organs at risk and also they used lesser monitor units and thus lesser treatment time.

Our results were also similar to this study in depicting better sparing of temporal lobes with VMAT, compared to IMRT. This clearly shows that when there is a critical organ in the close vicinity of the tumour, it can be relatively spared using VMAT. These results are also similar to the results obtained in the studies done by Preeti K Parihar *et al* [7] with respect to temporal lobe sparing.

In our study, the advantage for temporal lobe was observed with VMAT, though it did not achieve statistical significance. This difference in the results could be due to different techniques of plan optimization, use of 120 leaves collimator, different dose constraints and different anatomy and morphology of the tumour and relationship of the GTV with respect to the organs at risk. Similar studies with larger patient cohort and use of more homogenous optimization methods and standard hardware may be necessary in future to establish the supremacy of VMAT in the treatment of pituitary tumours.

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