대한두경부종양학회지
제 21 권 제 2 호 2005

3D-Conformal Radiotherapy for Head and Neck Cancers at Asan Medical Center

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두경부종양에서 3차원 입체조형치료의 서울아산병원 경험

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이상욱 · 장혜숙 · 안승도 · 이병용 · 최은경 · 노영주 · 백금문 · 김종훈

= 국문초록 =

목 적 :

다양한 발생부위에서 발생한 두경부종양을 대상으로 3차원 입체조형치료를 시도하여 표적체적 내 선량균일성과 주변장기의 선량분포변화를 알아보고자 하였다.

대상 및 방법 :

1995년 1월부터 1996년 12월까지 3차원 입체조형치료를 시행 받은 38명에 분석을 시행하였다. 3차원 입체조형치료는 동일평면 또는 비동일평면상에서 4개에서 14개의 조사면 수로 시행되었다. 3차원 입체조형치료계획시 표적체적에 50~82Gy의 선량을 처방하였고, 이하선 안구, 척수, 측두하악관절 등을 보호하고자 하였다. 3차원 입체조형치료 계획을 기존의 2차원 치료계획과 비교하기 위하여 표적체적과 주변정상자기의 선량체적히스토그램, 평균선량, 표적체적 내에서 처방선량의 95~105%의 선량이 분포하는 체적을 비교하였다. 치료계획에서 실제 치료시까지 소용되는 비용효과를 비교하였다. 대상환자의 평균추적기간은 34개월이었다.

결 과 :

3차원 입체조형시료는 2차원 치료에 비해서 표적체적내 평균선량이 평균 10% 증가하였고, 주변정장기에 조사되는 방사선량이 현저히 감소됨을 관찰할 수 있었고 표적체적에 대한 등선량 곡선 분포가 우수함을 관찰할 수 있었다.

결 론 :

3차원 입체조형치료는 두경부종양에서 표적체적의 선량 균일성이 증가하였고, 주변장기의 보존이 가능할 것으로 생각되었다. 따라서 본 저자들은 3차원 입체조형치료가 두경부종양에서 국소제어율과 무질병생존율 향상에 기여할 것으로 생각하였다.

중심 단어 : 두경부종양 · 3차원 입체조형치료 · 선량체적히스토그램 · 합병증발생확률.

Introduction

Three-dimensional conformal radiotherapy (3D-CRT) is a high precision technique designed to shape the spatial distribution of high dose radiotherapy to conform to the target volume, thereby reducing the dose delivered to normal organs. Multiple coplanar and noncoplanar beams aimed towards one or multiple isocenters are used to conform high doses to the shape of the target volume in three dimensions,

*This study was supported by a grant of the National Cancer Control R&D Program 2004, Ministry of Health & Welfare, Republic of Korea (0320323-3).

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while shielding normal tissues from radiation. This technique was developed to improve the therapeutic ratio of external beam radiation therapy and to increase the probability of uncomplicated cure by radiation therapy[1]. 3D-CRT requires an integrated approach with CT-simulation[2], a 3D-RTP system, a computer-controlled accelerator equipped with a multileaf collimator (MLC) and on-line electronic portal image verification system (EPID). Utilization of this new technology is expensive, and there is significant skepticism about its impact in cancer therapy. Despite its detractors, 3D-CRT has continued to encroach on the traditional practice of external beam radiation therapy. In recent years, clinical experience with 3D-CRT has accumulated in departments of radiation oncology around the world.

Radiation therapy techniques for head and neck cancers are quite challenging, due to very complex anatomy and the surrounding of tumors by critical structures that limit the delivery of lethal doses of radiation to the target. Local failure is the major problem in the treatment of head and neck cancers, and local control has the greatest impact on survival. In most survivors, conventional radiation therapy techniques cause permanent xerostomia. 3D-CRT for head and neck cancer offers a great potential to improve survival as well as the quality of life of patients, with increased sparing of normal structures. Studies testing the feasibility of 3D-CRT for head and neck cancers showed encouraging results for improving target coverage with higher doses and increased sparing of surrounding normal structures[3-5]. Clinical trials of 3D-CRT for head and neck cancers have not been attempted, due to difficulties arising from the complex anatomy of this region and the various but unique natural history of tumors from many subsites.

In our institution, 3D-CRT was applied to the treatment of locally advanced head and neck cancers in a method that escalates the target dose up to 75−80Gy while sparing the function of parotid glands, orbit, brain stem, spinal cord, mandible and temporal mandibular (TM) joints. We have performed an analysis in all patients comparing the 3D-approach with the 2D-conventional approach and addressed the strengths and limitations of 3D-CRT.

Materials and Methods

1. Patients

Thirty-eight patients treated with 3D-CRT between December 1994 and December 1996, with a median follow-up of 34 months, were compared qualitatively and quantitatively with patients treated by 2D-conventional plans. Tumor sites, stages, histology, and treatment information are detailed in Table 1. Thirty-eight patients with head and neck cancers were studied. Six patients received 3D-CRT as sole radiotherapy, 30 patients as boost irradiation following conventional radiotherapy, and two patients received 3D-CRT for recurrent disease. Eleven patients received postoperative irradiation. The prescribed dose for definitive radiotherapy was 75−81Gy (median, 75Gy) to the gross tumor volume (GTV) and 50Gy to the clinical target volume (CTV). For postoperative cases, 60−65Gy (median, 65Gy) was delivered to the surgical bed for gross disease and 70Gy to the positive resection margin.

2. Procedures for 3D-CRT

In our institution, CT-simulation and 3D-planning procedures consist of 5 steps. The patient is immobilized in the supine position using a thermoplastic face mask secured to the head holder. The second step is to scan using the CT-simulator (AcQSim™ Picker Int, St. Davis, PA, USA) with 5 mm slices spaced from the vertex to the head of clavicles to define the target volumes and critical normal structures. GTV, which includes the primary tumor and apparent nodal disease or surgical bed for post-operative cases, was determined by clinical examination and imaging. CAT and MRI were performed in all patients. CTV1 includes GTV plus a 1−2cm margin with the consideration of potential local spread pathways and surrounding barriers. CTV2 includes nodal compartments with the risk of occult metastasis over 20%. Planing target volume (PTV) includes a 0.5−1cm margin around the CTV. CT-simulation images were sent to the 3D-RTP computer (Render™ PT int, Miami, FL, USA) through the DICOM format for the third step to determine the beam arrangement (e.g. coplanar and/or noncoplanar directions, number of beams, energy, size, shapes, and modifiers) and to calculate the dose. The fourth step of virtual simulation was to obtain the DRR (digitally reconstructed radiographs) from the CT simulator for field shaping for MLC or block cutting. The final step was to verify the DRR images by comparing them to the fluoroscopic images of the conventional simulator (Xematron Varian, Palo Alto, CA, USA). The final step of 3D-planning was taken the next day after full review of the 3D-RTP. 3D-CRT for head and neck cancers was delivered through 4−14beams (median, 7) and the noncoplanar multiple beams were utilized in all patients. The daily delivery of 3D-CRT was assisted by the radiotherapy management computer system (RMSTM Varian) and verified with EPID (Varian) during treatment.

3. 2D plan for the study

To better assess the relative merits of the 3D-plans, they

were compared retrospectively with conventional 2D-plans in all patients. Three slices of CT-image at various levels were used for the 2D-plan utilizing only a coplanar beam arrangement. The same tumor volumes were used for the 2D as for the 3D-plans.

4. Quantitative and qualitative comparison between 3D-plan and 2D-plan

Dose volume histograms (DVHs) of targets and critical

Table 1. Case summary

Case	Age/Sex	Site	Histology	Stage	Surgery	Total dose Gy/fx	3DCRT dose Gy/fx
1	M/74	NPC	SCC	T4N0	Biopsy	76.4/39	26.0 / 13
2	M/51	NPC	SCC	T2N2	Biopsy	75.6/42	16.2 / 9
3	M/14	NPC	Undiff	T3N2	Biopsy	72.0/40	16.2 / 9
4	M/59	NPC	P/D	T4N0	Biopsy	79.4/43	20.0 / 10
5	M/34	NPC	Undiff	T4N2	Biopsy	72.4/39	22.0 / 11
6	F/34	NPC	Undiff	T4N2	Biopsy	75.4/38	25.0 / 10
7	F/55	NPC	SCC	T4N2	Biopsy	74.4/43	15.0 / 10(BID)
8	M/43	NPC	P/D	T4N0	Biopsy	75.6/42	25.2 / 14
9	M/48	NPC	SCC	T4N0	Biopsy	75.4/41	16.0 / 8
10	M/55	NPC	SCC	T4N3	Biopsy	74.4/39	15.0 / 6
11	F/59	NPC	SCC	T3N2	Biopsy	78.4/42	19.0 / 8
12	F/66	NPC	Undiff	T3N2	Biopsy	74.4/39	15.0 / 6
13	F/60	NPC	Undiff	T4N2	Biopsy	74.4/39	15.0 / 6
14	M/40	NC	ACC	T4N0	Excision	64.0/32	64.0 / 32
15	M/47	PNS	SCC	T3N0	Resection	70.2/39	70.2 / 39
16	M/53	PNS	SCC	T3N0	Biopsy	76.0/38	76.0 / 38
17	M/69	PNS	SCC	T3N0	Biopsy	76.4/35	76.4 / 35
18	F/67	PNS	SCC	T4N0	Biopsy	74.4/40	6.0 / 3
19	M/60	PNS	SCC	T3N0	Biopsy	76.8/40	10.8 / 6
19	M/60	PNS	SCC	T3N0	Biopsy	76.8/40	10.8 / 6
20	M/35	NC	Undiff	T4N0	Biopsy	74.8/41	19.0 / 9f
21	F/40	PNS	Schwannoma		Resection	64.8/36	14.4 / 8
22	F/26	PNS	RMS	II	Resection	50.6/25	20.0 / 8
19	M/60	PNS	SCC	T3N0	Biopsy	76.8/40	10.8 / 6
20	M/35	NC	Undiff	T4N0	Biopsy	74.8/41	19.0 / 9f
21	F/40	PNS	Schwannoma		Resection	64.8/36	14.4 / 8
22	F/26	PNS	RMS	II	Resection	50.6/25	20.0 / 8
23	M/60	OC	SCC	Rec	Biopsy	103.8/56	30.0 / 15
24	M/18	OC	Muco	T4N1	Excision	65.0/36	14.4 / 8
25	M/70	OP	SCC	T3N0	Biopsy	81.3/45	21.6 / 12
26	F/65	OC	ACC	T4N0	Resection	69.4/38	19.0 / 11
27	M/56	OC	SCC	T2N1	Resection	74.4/40	24.0 / 12
28	F/83	OC	SCC	T2N0	Resection	76.8/40	21.0 / 7
29	M/66	HP	SCC	T4N2	Biopsy	74.8/41	10.0 / 5
30	M/9	HP	RMS	III	Excision	41.4/23	41.4 / 23
31	F/14	PG	Muco	T2N0	Resection	64.8/36	14.4 / 8
32	M/62	PG	Adenosq	T4N2	Resection	66.4/38	16.0 / 8
33	F/28	PG	Muco	T2N0	Resection	60.0/30	15.0 / 3
34	M/47	EAC	SCC	T3N0	Biopsy	70.4/ 38	25.4 / 13
35	F/44	EAC	ACC	T3N0	Resection	66.4/ 36	16.0 / 8
36	M/56	EAC	Adenosq	T4N0	Resection	66.6/ 37	66.6 / 37
37	M/86	Neck	SCC	Rec	Biopsy	57.8/ 31	37.8 / 21
38	M/58	Neck	SCC	TXN3	Biopsy	71.0/ 42	26.0 / 14

NPC : nasopharyngeal cancer, NC : nasal cavity tumor, PNS : paranasal sinus tumor, OC : oral cavity cancer, OP : oropharyngeal cancer, HP : hypopharyngeal cancer, PG : parotid gland tumor, Rec : recurrent disease, EAC : external auditory canal cancer, SCC : squamous cell carcinoma, P/D : poorly differentiated cancer, ACC : adenoid cystic carcinoma, RMS : rhabdomyosarcoma, Muco : mucoepidermoid carcinoma, Rec : recurrent disease

normal structures were computed for each case of 3D- and 2D-plan, and the data of doses and volumes in the targets and critical normal structures were analyzed to assess the differences between the plans. The dose homogeneity in the target was assessed using the mean, minimum and maximum doses in the target. Target coverage was assessed as the percentage of the volume receiving 95−105% (V95−105) of the prescribed dose in the planning target volume (PTV). The dose conformity of PTV was assessed as the percent dose irradiating 95% of the PTV (D95) and the percent dose of the remaining 5% of the PTV (D5).

The irradiated volume of critical normal structures was computed as a function of dose. Since the traditional 2D-plan and 3D-plan were both designed to keep the spinal cord within tolerance, the variations between the plans was small and of no clinical significance. For the mandible, ipsilateral and contralateral parotid glands and TM joint, the mean dose in the 80% of volume irradiated was computed and normalized to the prescription dose. For the eye and brain stem, the maximum dose in the 5% of volume irradiated was computed.

The normal tissue complication probability (NTCP) was calculated by Lyman's model[6-8] using the parameters data given by Burman[9-11]. This model has three parameters that characterize the dose response : TD_{50}, the tolerance dose for 50% complications for uniform irradiation to the whole organ ; n, a parameter that represents the volume effect ; and m, a parameter that represents the steepness of the dose response curve. For non-uniform irradiation, the inhomogeneous dose volume histogram is reduced to a uniform equivalent using an effective volume calculation[8]. NTCP is then obtained by evaluating the error function for a volume equal to the effective volume, and a dose equal to the peak dose to the organ. The parameters used to calculate NTCP are given in Table 3.

NTCP was calculated as

$$NTCP = 1/\sqrt{2\pi} \int_{-\infty}^{t} \exp(-t^2/2)dt$$

$$t = (D - TD_{50}(V))/(m * TD_{50}(V))$$

$$TD_{50}(V) = TD_{50}(1) * V^{n}$$

$$V = V_{eff}/V_{ref}$$

$$V_{eff} = \sum (D_i/D_m)^{1/n} * V_i$$

D_m: reference dose
TD_{50}: tolerance dose in 5 yrs
V: partial volume
n, m: tissue-specific parameter
D_i: dose element
V_i: volume element

To evaluate the practical utilization and the cost benefit of the 3D-CRT technique, the planning and delivery procedures were compared to those of conventional 2D-radiotheapy for head and neck cancers.

Results

1. Dose homogeneity

The 3D-plans improved the dose homogeneity to the target volume at all sites of head and neck cancers (Fig. 1, Table 2). The 3D-plan increased the mean dose to the target by an average of 10%, decreased the maximum dose to the target by an average of 10%, and decreased the minimum dose by an average of 22%. The 3D-plan markedly reduced the mean dose to normal structures, including the parotid gland, eye, brain stem, mandible and TM joint (Fig. 2A, B). Since the traditional 2D-plan and 3D-plan were designed to keep the spinal cord within tolerance, the variations between the two plans were small and of no clinical significance.

2. Target coverage

The 3D-plans improved target coverage at all sites of head

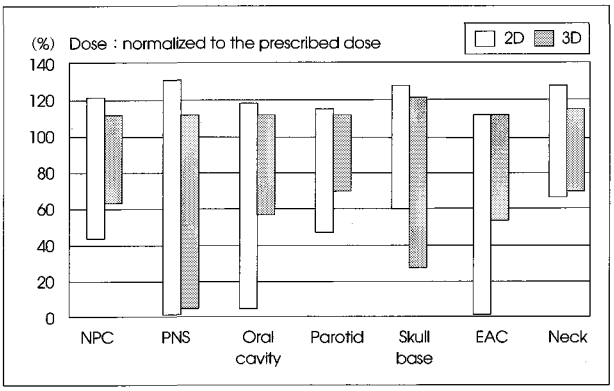

Fig. 1. Target coverage (maximum, mean, minimum dose). Radiation dose was normalized to the prescription dose.

Table 2. Dose conformity index in target (3D/2D)

Organ (number of patients)	Dmin	Dmax	Dmean	V95−105	D95	D05
NP(13)	58 /35.9	110.8/108.9	95.6/95	96.3/90.5	98.7/96.9	3.2/ 6.1
PNS(9)	6.7/ 1.1	109.3/109.7	93.3/84.8	91.6/97.0	92.1/97.0	9.6/13.0
Oral/Pharynx(8)	56 / 7.3	106.7/109.1	93.8/94.2	95.5/92.4	96.9/92.4	3.6/21.0
Parotid(3)	64.8/46.0	107.5/107.9	96.0/91.3	95.1/ 99.2	97.3/99.2	2.2/ 8.2
EAC(3)	51.7/ 4.2	107.5/105.8	94.6/84.0	95.4/90.8	96.4/90.8	7.2/17.0
Neck(2)	65.2/61.4	110.6/117.5	96.0/87.2	97.7/94.4	96.1/94.4	14.3/19.0

Dmin : % of minimum dose in PTV, Dmax : % of maximum dose in PTV, Dmean : % of prescribed dose, V95−105 : % of volume receiving 95−105% of the prescribed dose in PTV, D95 : % of dose that 95% of PTV was irradiated, D5 : % of dose that 5% of PTV was irradiated

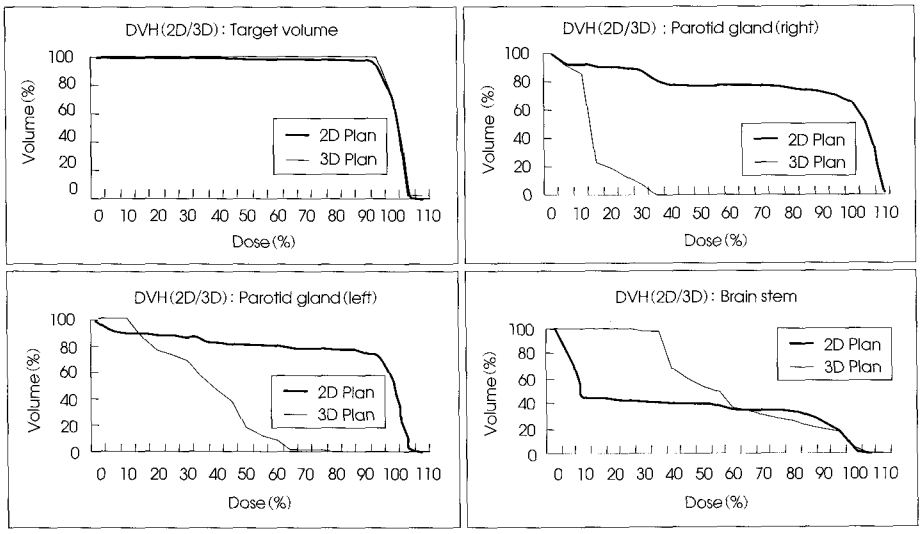

Fig. 2. Dose volume histograms(DVHs) in a patient with nasopharyngeal carcinoma, for the target, right parotid gland, left parotid gland and brain stem.

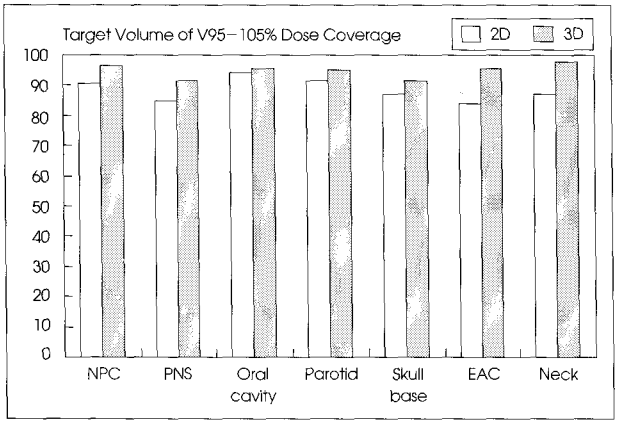

Fig. 3. Target volume of 95-105% isodose coverage(V95-105). Percent volume receiving 95-105% isodose of the prescribed dose in the planning target volume.

and neck cancers (Fig. 3, Table 2). V95-105 was increased by an average of 7% in the 3D-plan compared with the 2D-plan.

3. Dose conformity

The dose conformity of PTV was assessed as the percent dose in the 95% of the PTV irradiated (D95) and the percent dose in the remaining 5% of the PTV (D5). For D95, the variation between the 3D- and 2D-plans was small, since both were designed to cover the PTV. In contrast, D5 showed a dramatic difference between the two plans (Table 2) at all sites of head and neck cancers. The 3D-plan reduced the D5 by 30-85 % (average, 50%) compared with the 2D-plan. D5 appears to be a good index for the dose conformity at PTV.

4. Parotid sparing

For the ipsilateral parotid gland, the mean dose in the 80% of volume irradiated was computed and normalized to the prescription dose (Fig. 4). In all patients except those with external auditory canal cancer, the 3D-plan reduced the mean dose to the ipsilateral parotid gland dramatically. The opposite parotid gland was excluded from the beam direction in the 3D-plan, whereas about 50% of the opposite parotid gland was shielded during the 2D-plan. All patients were assessed for xerostomia during follow-up. Only three patients with nasopharyngeal cancer complained of mild xerostomia. One patient with nasopharyngeal cancer developed brain necrosis at the bilateral temporal lobe where 60 Gy was delivered with the 2D-approach. However, no patient in this study experienced a complication related to the brain stem, eye, mandible or TM joint.

Table 3. Normal tissue end points and tolerance parameters

Organ	n	m	TD5	TD50	Endpoint
Brain stem	0.16	0.14	50	65	Necrosis/infarction
Parotid	0.70	0.18	32	46	Xerostomia
Eye	0.20	0.19	45	65	Blindness
TM joint	0.07	0.10	60	72	Marked limitation of joint function

n, m : tissue specific parameters, TD_5 : dose to whole organ or reference volume that would lead to a complication probability of 5 percent, TD_{50} : dose to whole organ or reference volume that would lead to a complication probability of 50 percent

5. Normal tissue complication probability(NTCP)

NTCP was calculated for the parotid gland, eye, brain stem and TM joint, and the 3D-plan was found to reduce NTCP compared with the 2D-plan (Table 4). For nasopharyngeal cancers, the 3D-plan reduced the NTCP of the parotid gland and TM joint to about 50% of that of the 2D-plan.

6. 3D-planning and 3D-CRT delivery time

Time spent during the CT simulation was similar to that for the comprehensive conventional simulation procedure. It took about 20-30minutes to prepare the immobilization

Table 4. Normal Tissue Complication Probability (NTCP) in Head and Neck Cancers (3D/2D)

Organ	Parotid		Eye		Brain stem	TM joint	
	Ipsilat. 3D/2D	Contralat. 3D/2D	Ipsilat. 3D/2D	Contralat. 3D/2D		Ipsilat. 3D/2D	Contralat. 3D/2D
Nasopharynx	0.16/0.37	0.17/0.30	0.0/0.0	0.0/0.0	0.19/0.22	0.14/0.29	0.18/0.24
Oropharynx	0.16/0.18	0.16/0.17	0.18/0.18	0.18/0.18	0.16/0.17	0.16/0.18	0.12/0.17
PNS	0.17/0.18	0.15/0.16	0.20/0.19	0.18/0.18	0.17/0.18	0.19/0.19	0.11/0.12
Parotid	0.16/0.15	0.0/ 0.17	0.0/0.0	0.0/0.0	0.15/0.16	0.13/0.13	0.19/0.19
EAC	0.27/0.21	0.16/0.16	0.0/0.0	0.0/0.0	0.17/0.18	0.12/0.13	0.19/0.19
Neck	0.18/ 0.25	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0	0.0/0.0	0.18/0.18

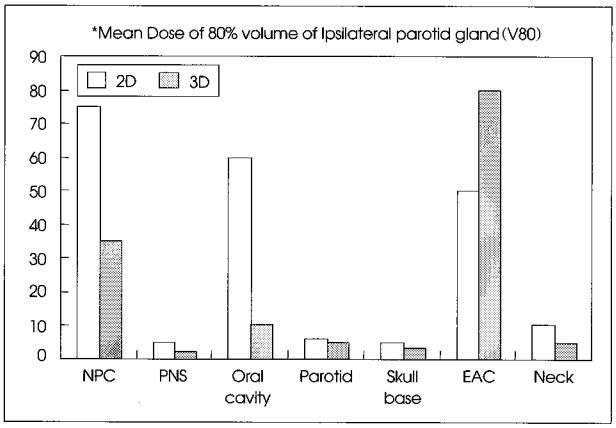

Fig. 4. Mean dose in the 80% of the volume of the irradiated ipsilateral parotid gland (V 80). Mean dose was normalized to the prescription dose.

device, 10−20minutes for scanning (12 seconds/slice, 40−60slices) and 30−60minutes to contour the target and normal critical structures. For the 3D-plan, 4−14beams (median, 7beams) were arranged, and in all patients noncoplanar beams were utilized and computer planning took 2−5hours. As more experience accumulated, planning time for 3D-CRT decreased, but it still took about 2−3 times longer than the 2D-plan. The delivery of 3D-CRT assisted by RMS^{TM} took 10−40minutes, and the delivery process became less time consuming as we gained more experience.

Discussion

The logistics of 3D-CRT for head and neck cancer offer a great potential for reducing the degree of xerostomia and avoiding major complications of the surrounding critical structures. In addition, this technique can escalate the target dose to improve both local control and cure rate. In our institution, 3D-CRT was applied to head and neck cancers to escalate the target dose to 75−80Gy while sparing the function of the parotid glands, orbit, brain stem, spinal cord, mandible and TM joints. All patients in our study showed improved dose homogeneity and target coverage with the 3D-plan compared with the 2D-plan. The 3D-CRT plan increased the mean dose to the target by an average of 10%, decreased the maximum dose to the target by an average of 10%, and decreased the minimum dose by an average of 22%. The 3D-plan also markedly reduced the mean dose to the normal structures, including the parotid gland, eyeball, brain stem, mandible and TM joint. We found that the 3D-plans improved the target coverage at all sites of head and neck cancer and that the V95−105 was increased by an average of 7% in the 3D-plan compared with the 2D-plan. The 3D-plan has been reported to increase the mean dose to the tumor volume by an average of 13% over 2D planning[4]. In 39 patients with advanced stage malignant tumors of the paranasal sinuses, 3D-CRT was found to preserve critical structures unaffected by tumor invasion and achieve generally expected local control rates[12].

In our study, the dose conformity of PTV was assessed with dose statistics, such as the percent of dose in the 95% of the PTV irradiated (D_{95}) and the percent of dose in the remaining 5% of the PTV (D_5). For D_{95}, the variation between the 3D-CRT and 2D-plans was small, since both plans were designed to cover the PTV. In contrast, D_5 showed dramatic differences between the two plans at all sites of head and neck cancer. The 3D-plan reduced the D_5 by 30−85% (average, 50%) compared with the 2D-plan, suggesting that D_5 is a good index for the dose conformity at PTV. It has been shown that an average of 22% of the target volume is underdosed at a 95% isodose level for the 2D-plan compared with 7% for the 3D-plan[4], and that an average of 1.8% of the target volume was underdosed within a 95% isodose level for the 3D plans compared with 18.8% for the 2D plans[3]. Taken together, these findings suggest that the target volume coverage of 3D-CRT was superior to that of the 2D plan.

In this study, one patient with nasopharyngeal cancer developed brain necrosis at the bilateral temporal lobes where 60Gy was delivered with 2D-approach. No patient in this study, however, experienced a complication related to the brain stem, eye, mandible or TM joint. The 3D approach con-

siderably reduced the NTCP of the parotid gland, eyeball, brain stem and TM joint. For nasopharyngeal cancer, the 3D-plan reduced the NTCP of the parotid gland and TM joint to about 50% of that of the 2D-plan. The opposite parotid gland was excluded from the beam direction in the 3D-plan, whereas about 50% of the opposite parotid gland was shielded during the 2D-plan. Only three patients, each with nasopharyngeal cancer, complained of mild xerostomia during follow-up. Hakuka et al[5]. reported that the mean dose to the opposite parotid was 3.9Gy for the 3D plans versus 28.9Gy for the conventional plans, and only 2/12 patients had complained of dry mouth with a minimum follow-up of 4 months. Eisbruch et al[13]. reported that parotid gland sparing in patients treated with bilateral head and neck irradiation was feasible using a 3D conformal approach, with all of 15 patients having no or mild xerostomia shortly following the completion of radiation therapy. In our study, the mean dose in the 80% of volume irradiated for the ipsilateral parotid gland was computed and normalized to the prescription dose. In all patients, except for those with external auditory canal cancer and parotid gland cancer, the 3D-plan dramatically reduced the mean dose to the ipsilateral parotid gland.

Time spent for CT simulation was similar to that for the comprehensive conventional simulation procedure. Since a median of 7beams (range, 4−14beams) were arranged for 3D-CRT of head and neck cancers and noncoplanar beams were utilized for all patients, the computer planning time was 2−3 fold longer than for the 2D-plan. The delivery of 3D-CRT assisted by RMS™ took 10−40minutes, and the delivery process became less time consuming as more experience was gained.

In assessing the strengths and limitations of 3D-CRT for head and neck cancers, we conclude that this technique can deliver higher and more homogenous doses to the target while sparing normal structures and organs of interest. We observed that 3D-CRT provided much improved quality of life for head and neck cancer patients by reducing the risk of xerostomia, and improved local control by escalating the target dose. Implementation of a 3D-CRT plan, however, is very difficult because the usual PTV of head and neck cancer patients includes bilateral neck nodes. Starting of a 3D-CRT plan should make it possible to reduce complications of normal tissues.

KEY WORDS : Head and neck cancer · 3D-conformal radiotherapy · DVH · NTCP.

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