The Role of Radiation Therapy in the Treatment of Intracranial Glioma: Retrospective Analysis of 96 Cases

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Between March 1983 and December 1989, ninety-six patients with intracranial glioma were treated in the Department of Therapeutic Radiology, Kangnam St. Mary's Hospital, Catholic University Medical College. We retrospectively reviewed each case to evaluate variable factors influencing the treatment results and to develop an optimal therapy policy. Median follow-up is 57 months (range: 31~133 months). Of the 96 patients, 60 (63%) were males and 36 (37%) were females. Ages ranged from 3 to 69 years (median 42 years). The most common presenting symtoms were headeche (67%) followed by cerebral motor and sensory discrepancy (54%), nausea and vomiting (34%), seizure (19%), mental change (10%) and memory and calculation impairment (8%). Eighty five (88.5%) patients all, except 11 (11.5%) brain stem lesions, were biopsy proven intracranial glioma. The distribution by histologic type was 64 astrocytomas (75%), 4 mixed oligoastrocytomas (5%), and 17 oligodendrogliomas (20%). Fourty nine patients (58% were grade I, II histology and 36 (42%) patients were grade III, IV histology. Of the 96 patients, 64 (67%) recieved postoperative RT and 32 (33%) were treated with primary radiotherapy. Gross total resection was performed in 14 (16%) patients, subtotal resection in 29 (34%), partial resection in 21 (25%), and biopsy only in 21 (25%). Median survival time was 53 months (range 2~133 months), and 2- and, 5-year survival rate were 69%, 49% respectively. 5-year survival rate by histologic grade was grade I, 70%, grade II, 58%, grade III, 28%, and grade IV, 15%.

Multivariated analysis demonstrate that age at diagnosis ($p=0.0121$), Karnofsky performance Status (KPS) ($p=0.0002$), histologic grade ($p=0.0001$), postoperative radiation therapy ($p=0.0278$), surgical extent ($p=0.024$), cerebellar location of tumor ($p=0.0095$) were significant prognostic factors influencing on survival.

Key Words: Intracranial glioma, Radiation therapy, Prognostic factors

INTRODUCTION

Despite many contributions, some aspects of the natural history and management of the intracranial glioma have not yet been clarified. Such tumors are characterized by an extreme variability in outcome[1]. Low grade astrocytoma, a diverse group of tumor comprises up to 15% of surgically treated brain neoplasm. The biologic activity of these lesions can be quite variable. Many of these patients survived for an extended period of time[1].

However, low grade astrocytoma may develop ominous malignant characteristics, and as many as 50% of surgically treated lesions evolve into anaplastic astrocytoma or glioblastoma multiforme. At this time, there is no reliable method that can be used to predict this change in the tumor's biologic activity.

Their optimal treatment and its timing remain controversial. A number of retrospective studies have suggested a benefical role for postoperative radiation therapy in low grade astroaytomas of incompletely resected at surgery[1~3]. Yet evidence from other studies on postoperative radiation therapy is still fragmentory. In this article, we reviewed what is known about the use of radiation therapy in the treatment of low grade glioma and provided some management guide lines until more definitive answers become available.

The outcome of malignant glioma (grade III and IV) is almost uniformly fatal with 50% mortality within 6 months and 90% mortality within 1.5

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years[4]. Unfortunately, these highly malignant glioma are the most common brain tumors and account for about 50% of all primary glioma. There is abundunt evidence that malignant glioma cannot be eradicated by present available surgical and radiotherapeutic technique. Multimodality therapy for malignant gliomas -cytoreductive surgery, radiation therapy, chemotherapy- has been under investigation by cooperative group and individual institution for the past 20 years. Brain Tumor Cooperative Group (BTCG) documented that postoperative radiation alone significantly increased median survival by 150% over conventional neurosurgery and Bichlorethyl Nitrosourea (BCNU) to radiation therapy has modestly increased median survival and significantly greater long term survivor at the end of 18 months[5]. Furthermore the presence or absence of important prognostic factors may have more profound effect on outcome than treatment modality itself[6]. BTCG and Radiation Therapy Oncology Group/Eastern Cooperative Oncology Group (RTOG/ECOG) studies identified the most important prognostic factors are histologic grade, age, and performance status. Other factors such as the duration of symptoms, extent of surgical resection, the presence of speech impairment, mental status, personality change, preoperative tumor size, and tumor locations have been identified as prognostic variables in multivariate analysis[7~9].

The objective of our study was to evaluate optimal radiation therapy policy and important prognostic variables in intracranial glioma by retrospective analysis of 96 cases treated between 1983 and 1989.

MATERIALS AND METHODS

We retrospectively reviewed 96 patients of intracranial glioma treated at Kangnam St. Mary's Hospital between March 1983 and December 1989. Survival data were available for all patients and survival time was calculated from the time of pathologic diagnosis to the close of this study, July 1992.

1. Patients and Tumor Characteristics

The 96 patients consisted of 60 males (63%) and 36 females (37%). Ages ranged from 3 to 69 years (median age: 42 years). The most common presenting symptoms were headach (67%) followed by cerebral motor sensory discrepancy (54%), nausea and vomiting (34%), seizure (19%), mental change (10%), and memory and calculation impairment (8%). Distribution of site of involvement were frontal lobe 27 (28%), temporal lobe 29 (30%), parietal lobe 31 (32%), occipital lobe 10 (10%), brain stem 12 (13%), and cerebellum 15 (16%) (Fig. 1). Multiple lobes or sites involvement were common. In summary, there were 65 (68%) supratentorial tumors and 31 (32%) infratentorial tumors. Performance status, using karnofsky scale, were assigned to each patient after initial patient evaluation. There were 67 patients with KPS >70, 21 patients with KPS 60~50, and 8 patients with KPS 10~40. Histologic grade of tumors are variously defined according to Kernohan's classification or the three-tiered classification system of Ringertz and Berger. Therefore, we have much difficulty in uniform histologic grading due to different classification systems used. There were 49 grade I, II tumor (58%) and 36 grade III, IV tumor (42%). The distribution of histologic types was 64 (75%) astrocytomas, 4 (5%) mixed oligoastrocytomas, and 17 (20%) oligodendroglioma. Table 1 summarizes the patient and tumor characteristics.

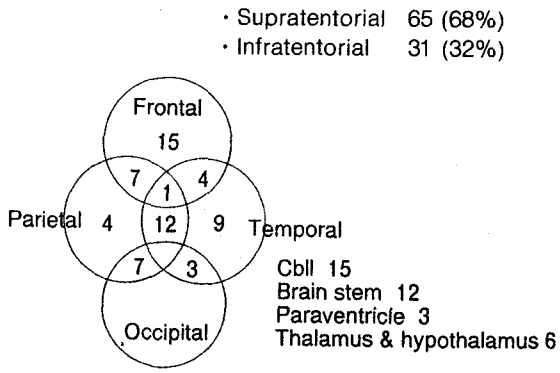

Fig. 1. Sites of involvement.

2. Treatment

1) Surgery

The extent of operation was determined from information in the surgeon's operation record and postoperative radiological studies, if available. Surgical extent was gross total resection in 14 (16%), subtotal resection in 29 (34%), partial resection in 21 (25%) and biopsy only in 21 (25%).

2) Radiation Therapy

Sixty four (67%) of 96 patients received postoperative radiation therapy and 32 patients (33%) were treated with primary radiation therapy using 6 MV photon. The dose to the tumor bed ranged from 5.4 Gy to 64.8 Gy. Only 8 (9%) patients received less than 4000 cGy, whereas 15 (18%) patients

Table 1. Patient and Tumor Characteristics (%)

Age		3~69 (median : 42)
Sex	Male	60 (63)
	Female	36 (37)
Performance Status		
	KPS>70	67 (70)
	50<kps<60	21 (22)
Presenting Symtom		
	Headache	64 (67)
	Cb Motor/Sensory	52 (54)
	Nausea/Vomiting	33 (34)
	Seizure	18 (19)
Pathology		
	Astrocytoma	64 (75)
	Oligodendrogliom	17 (20)
	Mixed oligoastrocytoma	4 (5)
Tumor Grade		
	Grade I	29 (34)
	Grade II	20 (24)
	Group III	22 (26)
	Grade IV	14 (16)

KPS: Karnofsky performance Status.

Table 2. Treatment Modality

	Surgery				Total (%)
	Biopsy	Partial	Subtotal	Total	
RT	14	14	23	9	60 (71)
RT+ChemoTx	7	7	6	5	25 (29)
Total (%)	21 (25)	21 (25)	29 (34)	14 (15)	

RT: Radiation Therapy ChemoTx: Chemotherapy

received between 40 Gy and 50 Gy, 53 (62%) patients received 50 Gy to 60 Gy and 9 (11%) patients received 60 Gy more. We used the conventional fractionation of 180 cGy/day, 5 fraction/week schedule forty (42%) patients were treated with partial brain irradiation, encompassing the gross tumor with a 2~3 cm safety margin. The remaining 56 (58%) patients received whole brain irradiation and then additional boost volume irradiations. The dose delivered to the whole brain ranged from 5.4 to 45 Gy and dose for the additional boost volume were in the range 51.1 Gy to 69.6 Gy.

3) Chemotherapy

Nitrosourea based chemotherapy was used in 25 patients (26%), as an adjuvant to surgery and radiation, or as a palliation at the time of recurrence. Many complicated chemotherapy protocols were used, depending on the physicians trends and these specific regimens were not analyzed separately. Table 2 displayed the treatment modality.

3. Statistical Consideration

The end point of this study was length of survival from date of pathologic diagnosis. Survival was estimated by the Kaplan-Meier method. Statistical survival differences were tested with a Log-rank test and Wilcoxon Ranked Sum test. To examine the possible prognostic value of each independent variable separately, Cox regression multivariated analysis was performed.

RESULT

1. Survival

The Kaplan-Meier survival estimate showed a median survival time of 53 months (range: 2~133 months) (Fig. 2). Two- and 5-year survival rates were 69%, and 49% respectively.

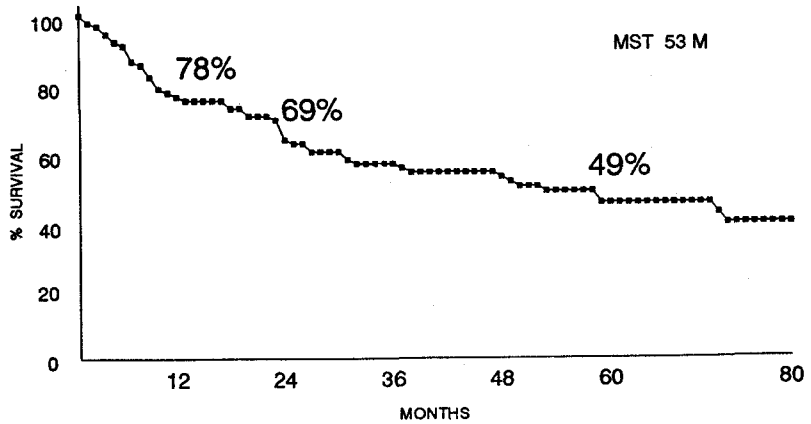

Fig. 2. Overall survival curve.

Table 3. Influences of Prognostic Factors on Survival Time

Prognostic Factors	p-value	Survival Correlation (+/−)†
Age	0.0121	(+)
Mael	0.7728	(−)
Cell Location	0.0095	(+)
Histologic Subtype*	0.9534	(−)
Histologic Grade	0.0001	(+)
Location‡	0.0897	(+/−)
Surgical Extent	0.05	(+)
RT Dose	0.5566	(−)
RT Field**	0.2827	(−)
Combined ChemoTx	0.0197	(+)
Treatment Modality	0.0261	(+)
Postoperative RT	0.0635	(+/−)
KPS	0.0002	(+)

*Astrocytoma, Oligodendroglioma, Mixed Oligoastrocytoma
‡Supratentorial Tumor, Infratentorial Tumor
**Whole Brain RT, Partial Brain RT
†(+): Significant, (−): Insignificant

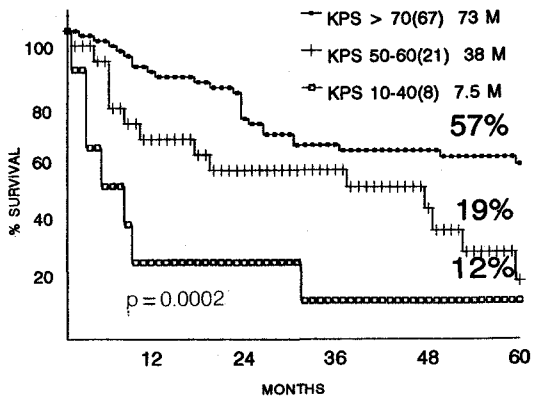

Fig. 3. Survival as a function of KPS at the time of initial TX.

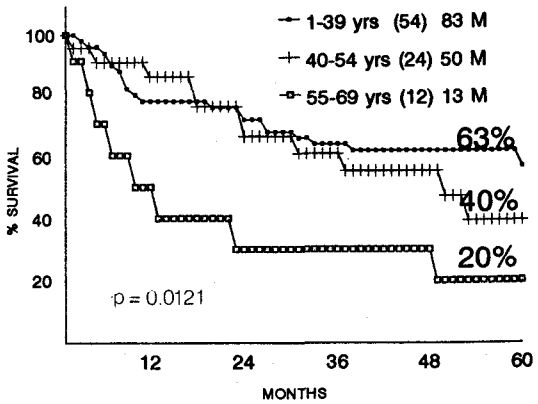

Fig. 4. Survival as a function of age at Dx.

2. Prognostic Factor

A total of 13 possible prognostic factors were analyzed for their association with survival time. The influences of prognostic factors on survival time are summarized in Table 3. Age at diagnosis, KPS status at the time of initial treatment, cerebellar location, histologic grade, surgical extent, treatment modality, and postoperative RT were statistically significant variables in multivariate analysis. Sex, histologic subtype (astrocytoma vs oligodendroglioma), and total radiation dose were not associated with survival. The remaining variables such as RT field (Whole brain RT vs Partial Brain

RT), tumor site (supratentorial vs infratentorial) were marginally significant.

Age at diagnosis was a significant independent variable (Fig. 4). Median survival time was 83 months for patients less than 18 years old, 50 months for patients 40 to 54 years old, and 13 months for patients over 55 years old ($p=0.0121$).

KPS at the time of initial treatment was a significant independent factor (Fig. 3). Patients with greater physical activity lived longer. Median survival time in three performance categories were as follows: KPS 100~70 for 51 months, KPS 60~50 for 34 months, and KPS 10~40 for 12 months ($p=0.0002$). Five year survival rate for KPS 100~70 and KPS 60~50 were 59%, and 19% respectively. None of the patient with KPS 10~40 survived beyond 5 years.

Cerebellum located tumor had significantly longer survival than any other hemispheric site (Fig. 5). Cerebellar located tumor had 2-year and 5-year survival rates of 93% and 79%, respectively, with median survival not reached. But median survival for the remaining hemispheric tumor was 41.7 months. Two- and 5-year survival were 65%, and 43%, respectively ($p=0.0095$). In view of unique histopathologic features and a uniformly favorable clinical course with pilocytic astrocytoma of cerebellum, these were estabilished as a special histological subgroup. In our 15 cerebellar located tumor, 11 were pilocytic astrocytoma.

Histologic grade of tumor was a significant independent variable (Fig. 6). Median survival time was as follows: grade I, 76 months, grade II, 60 months, grade III, 20 months, grade IV, 13 months ($p=0.0001$).

There was no statistically significant difference in survival according to histologic type (Fig. 7, $p=0.9534$). Although median survival for oligodendroglioma was substantially longer than astrocytoma (60 months vs 38 months), it did not reach statistical significance when long term survival was considered (5-year survival rate 49% for astrocytoma vs 55% for oligodendroglioma).

Extent of surgical resection was a significant independent prognostic factor (Fig. 8). Patients with gross total resection lived significantly longer than these with partial resection and/or subtotal resection. Patients with any degree of resection lived significantly longer than those undergoing biopsy only ($p=0.05$).

Radiation accompanied by surgery significantly prolonged survival more than radiation alone (Fig. 9, $p=0.0278$). Median survival increased from 24

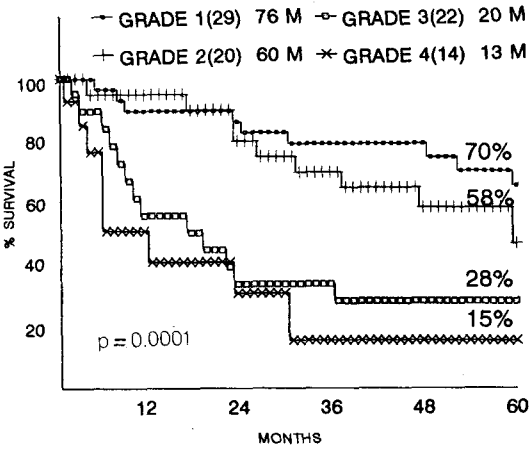

Fig. 6. Survival as a function of the tumor grade.

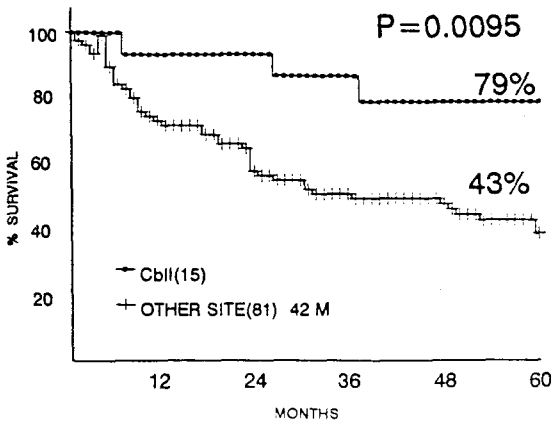

Fig. 5. Survival as a function of tumor location.

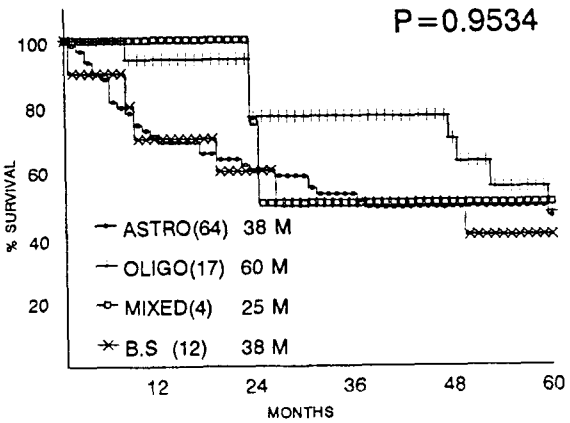

Fig. 7. Survival as a function of histologic Dx.

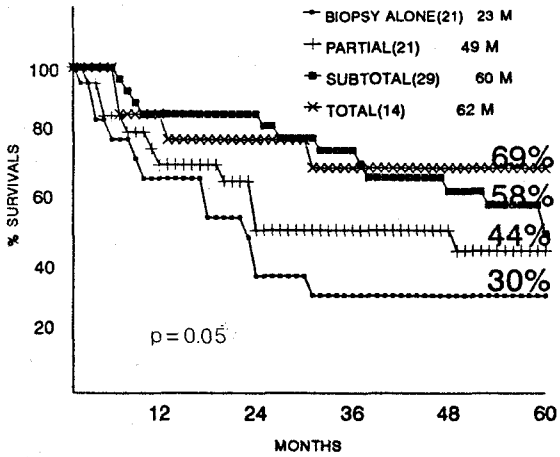

Fig. 8. Survival as a function of surgical resection.

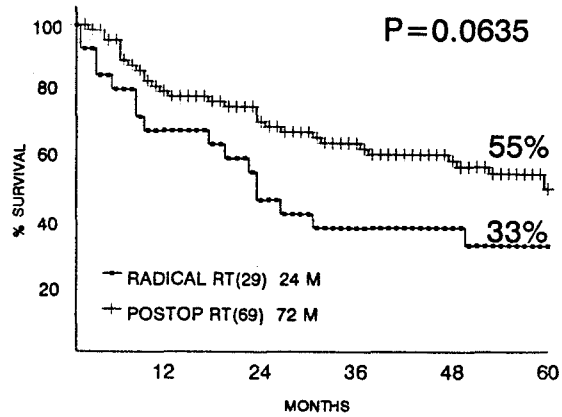

Fig. 9. Survival as a function of treatment modality.

months for radiation alone group to 72 months for the surgery and RT combined group.

Chemotherapy combined with the radiation therapy had a significant negative effect on the survival (p=0.0197). The beneficial effect of combined BCNU chemotherapy on survival has recently been well documented. But our study did not confirm the value of chemotherapy.

No improvement in survival was noted with increasing dose of radiation (p=0.5566). The dose ranges were less than 40 Gy, 40~50 Gy, 50~60 Gy, above 60 Gy and no significant difference in survival could be found among any of these subgroup. Infratentorial tumor had a longer survival tendency than supratentorial tumor, but it was only a marginally significant statistic difference (p=0.0897).

Regarding the irradiated volume, multivariate analysis did not show a strong association between patient survival and radiation volume (WBRT vs PBRT). Patient treated with PBRT had relativel yonger median survival than patients treated with WBRT (72 months vs 48 months), but statistical significance could not be confirmed (p=0.2827).

DISCUSSION

Our study was a retrospective analysis in which treatment subgroups were not similar in important characteristics (e.g., age, Karnofsky score, surgical extent, location of lesion, RT dose and field size). We had no uniform pathologic classification system and no simultaneous control group of patients who are not treated with radiation therapy. Therefore we have much difficulty with definitive statements of the role of radiation therapy in intracranial glioma. With these limitations in mind, we reviewed the previous literature, and our result, in an attempt to discover whether there is any trend that can provide us with at least some general guideline until a more rigorous study is carried out.

Low grade gliomas are clinically, radiologically, and pathologically diverse group of CNS neoplasm. Opinion for the management of low grade glioma range from observation to surgery plus postoperative radiation therapy. Proponents of observation argue for the benign course of the disease as well as both the lack of proven benefit and potential morbidity of therapy, particulary radiation therapy[10,11].

The rationale for treating incompletly resected, well differentiated astrocytoma with radiation therapy was be that of destroying undetected anaplastic foci, as has already been suggested in a pathologic study on retarding the occurence and decreasing the incidence of malignant transformation[11]. Improved results associated with radiation therapy have been noted in other series, where average 5 year survival rate of 20% were noted with surgery alone, compared to about 50% with surgery and postoperative radiation therapy[12~14]. In our study, 39 patients who underwent at least partial resection of tumor along with postoperative radiation therapy had 59% of 5 year survival rate. That was comparable to the results in previous reports. The errorneous conclusion can be drawn that patients with low grade astrocytoma who have undergone total removal of their tumors do not require postoperative radiation therapy. Sheline[15] reported that patients who underwent total removal of the tumor had 5 and 10 year survival rates of 100% and 90% respectively. A closer

scrutiny of Sheline's data reveals that the group with tumor resection were made up primarily of young patients with cerebellar pilocytic astrocytoma. By Shaw's data, patients with pilocytic astrocytomas also did well with gross total or radical subtotal resection alone, in sharp contrast to the comparable group of patients with ordinary astrocytoma or mixed oligoastrocytomas, whose outcome was poor (5 and 10 year survival rate 52% and 21% respectively)[12,16]. In our 15 cerebellar located tumor, pilocytic astrocytoma were in 11 patients. Eight patients among them had undergone gross total or subtotal resection. They showed an excellent 5 year survival rate of 89%. These observations support the notion that pilocytic astrocytoma are focal, well demarcated lesions amenable to cure with surgical removal and for the most part do not undergo malignant transformation, whereas ordinary astrocytoma or mixed oligoastrocytoma is usually infiltrative, difficulty to extirpate surgically, and require adjuvant therapy such as irradiation.

Treatment volume and total dose in low grade glioma are a matter of discussion. Regarding the volume to be irradiated, multivariate analysis did not show any association between patient survival and radiation volume. An earlier series describing the outcome of irradiated patients with low grade glioma found a negative influence of whole brain irradiation on survival[17]. For these reasons, plus potentially negative sequalae of whole brain irradiation on the intellectual function in glioma patients.

Selection of total dose is a more controvertial issue. In Shaw's report of one Mayo Clinic series, the survival rate among patients who recieved radiation of 5300 cGy or more was significant better than that of patients who recieved less than 5300 cGy or surgery alone (68% vs 47% vs 32% 5 year survival rate)[16]. The current policy is to deliver dose of 55~55 Gy (1.8~2.0 Gy per day) on limited volume as determined by CT or MRT imaging.

Currently three prospective randomized worldwide trials are in progress. They have been designed to help define the role of postoperative radiation therapy for patient with supratentorial low grade glioma, and to characterize and dose-response relationship as well[19].

Recently the grim picture of malignant glioma has improved with the advent of a vigorous multimodality therapy aimed at reducing tumor burden[21]. The Brain Tumor Cooperative group is a pioneer for malignant glioma in systematic multi-institutional randomized clinical trials since the 1960s. In the BTCG 6901 study, median survival time following resection alone without postoperative RT or chemothekrapy was only 14 weeks while postoperative RT improved the median survival to at least 36 weeks ($p=0.0001$)[5]. According to our results, the median survival time for the postoperative group was 19.5 months, which was remarkable longer than that of multi-institutional study. It may be partly explained that our study included a relatively larger proportion of anaplastic astrocytoma than glioblastoma multiforme.

A large number of prospective trials have evaluated the combination chemotherapy and radiation therapy in patient with malignant glioma. By result of BTCG trial 7201 and 7501, BCNU plus radiation therapy has modestly increased median survival and has a definitive advantage in long term survival (median survivaltime 50 weeks, 24% 18 months survival rate for BCNU plus RT)[22]. The advantage of adjuvant chemotherapy seems greatest for patients under 60 years of age and with good performance status (KPS>70) by the RTOG-ECOG study. Elderly patient with poor function benefit little from chemotherapy[7]. Our results did not confirm the previously mentioned survival benefit of chemotherapy. This may simply reflect the diverse chemotherapy protocol used not as an adjuvant to RT or surgery, but as a palliative in poor prognostic patient with recurrence, progressive disease, or incomplete surgical resection. In view of the modest gains produced by adjuvant chemotherapy, a carefully designed treatment approach is needed in the furture.

It is clear that many prognostic variables in combination influence survival at least as much as does combination multimodality therapy. BTCG and RTOG/ECOG studies found that certain patient and tumor characteristics influence outcome[7]. Prognostic variables, in order of importance, were age, histologic grade, initial performance status, duration of symptom, surgical extent, occurrence of seizure, initial neurologic symptoms, and possibly tumor location. Our study also demonstrated that age, initial performance status, histologic grade, surgical extent and tumor location were statistically significant variables by multivariated analysis.

In the present study, we had much difficulty in determining histologic grade due to different classification systems used. Therefore, this study suffered from a bias induced by nonuniformity of classification systems. Although currently used three tiered classification showed an excellent

overall correlation between grade and outcome, emphasis is placed on the need for a commonly accepted classification system that will not only confirm prognosis but allow intercomparision of different clinical trails[16].

Numorous clinical trials have analyzed the relationship between extent of tumor resection and survival time. Walter et al[5] noted that patients with either total or subtotal tumor resection had longer survival time than patients undergiong biopsy only. Similar finding have been reported by RTOG[23]. However, other studies failed to identify the extent of resection as an independent prognostic factor. Inconsistent result of previous studies may be partially explained by their emphasis on degree of resection rather than residual tumor volume, which is more prognostically important, but which requires postoperative CT scan[24]. This discrepancy highlights the need for careful studies using modern imaging studies to assess the amount of postoperative residual tumor. In our study, extent of resection was a significant prognostic factor. We determined extent of resection from information of surgeons' operative records and posroperative CT scan if available. The most convincing study supporting the use of cytoreductive surgery was published by Wood et al[9]. They found that tumor area remaining after surgery, and after the completion of radiation therapy, was an independent prognostic factor, but there was no correlation between survival and preoperative tumor area, or the amount of tumor removed.

The question of optimal radiation volume for treatment of malignant glioma is a subject of debate. The BTCG has reported no statistically significant difference in survival between those patients treated with 60.2 Gy of WBI compared to those receieved 43 Gy whole brain irradiation (WBI) followed by 17.2 Gy on the cone down boost volume. Payne et al[25] also reported that use of limited field irradiation does not appear to have compromised final result. When we reviewed the treatment of malignant glioma with limited external beam field vs WBI, there was no significant difference in median or 5 year survival. Furthermore, although not as well documented, long term survivors with whole brain dose 60 Gy frequently show deficits involving short term memory or cognitive function[6]. In the present study, multivariate analysis did not show a survival benefit of whole brain irradiation over partial brain irradiation ($p=0.2827$). Since WBI is unfortunately, we could not carry out a long term follow up of possible adverse effect of WBI.

The optimal dose for conventional fractionation radiation therapy for malignant glioma also has been controvertial. A RTOG/ECOG study compares 60 Gy whole brain to 60 Gy whole brain plus boost 10 Gy. They did not find significant improvement in survival in high dose RT[7]. But Salaza et al[26] found that an increase in median survival was significant with a 7500 cGy median dose. Whether their improved survival can be maintained up to 5 years remains to be seen. In our study we could not confirm a distinct dose-response relationship. This may simply reflect the narrow range of dose used and a small number of patients at each dose level (53 patient recieved 50~60 Gy, only 9 patient recieved more than 60 Gy). Patients receiving over 60 Gy showed longer median survival than that of patients with under 40 Gy (53 months vs 32 months). But high dose RT could not alter long term survival (5 year SR 44% for patient >60 Gy vs 45% for patient <40 Gy).

Recently, the radiation oncologist has been faced two distinct problems in the managenment of intracranial glioma. First, generally available external beam treatment can not control the bulky portion of tumors. This may be due to inherent radioresistent properties in this tumors. Second, even finest focal therapy will fail in the significant portion of patient who have extensive infiltrative disease.

It is clear that continued large scale prospective trials are required to examine new treatment approaches in the most definitive manner.

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=국문초록=

뇌 교종 96예에 대한 방사선치료 성적의 후향적 분석

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1983년 3월부터 1989년 12월까지 가톨릭의과대학 강남성모병원 치료방사선과에서 뇌교종으로 방사선치료를 받은 환자 96명을 대상으로 방사선치료 성적 및 생존률에 영향을 미치는 예후인자들의 후향적 분석조사를 실시하였다. 대상환자의 연령분포는 3세에서 69세였으며(중앙값 42세), 남녀비는 60:36이었고, 임상주증상은 두통 및(67%) 운동신경 마비(54%)였다. 조직학적 진단방법 및 수술은 생검 21명(22%), 부분절제 21명(22%), 아전절제 29명(30%), 전절제 14명(15%)이였고, 뇌간을 침습한 환자 12명중 11명은 조직검사를 시행하지 않았다. 조직학적 분류는 성상세포종이 64명(75%)으로 가장 많았고, 희돌기교세포종이 17명(20%), 혼합형이 4명(5%)였다. 조직학적 등급에 따른 구분은 49명이 grade I, II 종양(58%)이였으며, 36명이 grade III, IV 종양(42%)이였다. 전체 96명 중 64명(67%)이 수술과 방사선 치료를 병행하였고, 32명(33%)이 방사선단독 요법으로 치료하였으며, 25명(26%)의 환자에서 화학요법을 병행하였다.

전체환자의 평균 생존기간은 53개월이었고, 2년 및 5년 생존률이 각각 69%, 49%이였다. 조직학적 등급에 의한 생존률은 grade I 종양의 5년 생존률이 70%였고, grade II, III, IV 종양이 각각 58%, 28%, 15%였다.

연령, 조직학적 등급 및 분류, Karnofsky performance status(KPS), 침습부위, 수술적 제거 여부 및 제거정도, 방사선치료선량, 방사선조사야, 화학요법 병행 여부에 따라 생존률을 분석한 결과 연령($p=0.0121$), KPS($p=0.0002$), 조직학적 등급($p=0.0001$), 수술적 제거($p=0.0240$)가 유의한 예후인자로 분석되었으며, 통계학적으로 유의하지는 않았지만 천막하병소가 천막상부 병소에 비해, 부분조사가 전뇌조사에 비해 높은 생존률을 보이는 매개변수로 분석되었다.