Preliminary Experience of CyberKnife® Treatment of Lung Metastasis: The Question about Real Clinical Benefit

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Objective: *Evaluate the effectiveness of radiotherapy plan and physical parameters including local tumor response and clinical outcome of lung metastasis in patients who received CyberKnife® treatment at Ramathibodi Hospital.*
Material and Method: *Six cases with twenty lesions of lung metastasis patients were evaluated for tumor response after having received CyberKnife® treatment. The prescribed radiation dose was calculated approximately to biological equivalent dose (BED) around 60 to100 gray (Gy_{10}). The response of each lesion to treatment was evaluated from roentgenographic study during follow-up period along with adverse event, status of patients, and disease.*
Results: *At the third month after treatment, roentgenographic partial response (PR, 50% decrease in size) was demonstrated in eight lesions and stable disease (SD, unchanged size) in eight lesions with no complete response (CR, disappearance of tumor) detected. Progressive disease (PD, 25% increase in size) of six treated lesions was detected during the follow-up period. At the time of report, two patients were alive and still received palliative chemotherapy, two patients died from uncontrolled progressive metastases and failed palliative chemotherapy, and two patients lost follow-up after progressive metastases with unknown surviving status. No severe adverse event was observed. The treatment planning parameters demonstrated borderline of radiation dose homogeneity, and conformality coverage of the target volume.*
Conclusion: *This preliminary report aimed to provide the idea of choosing the appropriate lung metastasis patient to receive CyberKnife® treatment that must strictly clarify the real clinical benefit of each selected case to achieve the best outcome from this special treatment procedure.*

Keywords: *CyberKnife®, Stereotactic body radiotherapy, Lung metastasis*

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Lung metastasis is a common problem for advanced malignant disease whose management relies mostly on systemic treatment with a regimen based on the primary malignant site while radiotherapy has a limited or no role of treatment. With the innovation of radiotherapy, stereotactic body radiotherapy (SBRT) has been applied to treat lung metastasis due to its ability to provide multiple radiation beams to conform high dose radiation at target volume. This can improve local control of each lesion while radiotherapy complication can be controlled by a limited dose to surrounding normal tissues. CyberKnife® is the linear accelerator 6 megavoltage (MV) modern frameless mounted on the robotic manipulator, image-guided by a pair of orthogonal x-ray sources and imaging panels, stereotactic radiotherapy system that can deliver multiple radiation beams from multiple angles directly to the target volume with very high dose radiation while sparing radiation dose effectively from surrounding normal tissues. When combined with the fiducial (gold seeds) markers and respiratory cycle tracking (Synchrony) system, CyberKnife® is suitable for improving local control rate of malignant pulmonary lesion[1]. The report of CyberKnife® treatment experience for primary inoperable non-small cell lung cancer in Ramathibodi Hospital has provided the effectiveness of treatment plan and local tumor controlled without severe adverse event. It leads the idea to apply this modality as the aggressive local treatment for lung metastasis disease[2]. However, the natural history and prognosis of metastatic disease are so different from primary lung cancer. Thus, the

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question about real benefit of CyberKnife® treatment in this status of disease needs to be answered.

There were two objectives of the present study. The first was to evaluate the effectiveness of radiotherapy plan and physical parameters of CyberKnife® treatment in lung metastasis patients, whereas the second was to evaluate the local tumor response along with the adverse event from treatment, and also to find out whether CyberKnife® could provide benefit in clinical outcome for this group of patients.

Material and Method

The present study was approved by the ethic clearance committee on human rights related to researches involving human subjects, Mahidol University; protocol number ID 09-55-20.

Prepared process for eligible patients

CyberKnife® has been settled down in Ramathibodi Hospital since 2008 and began to treat lung metastasis in 2009 by modifying the radiotherapy regimen from primary lung cancer protocol[2]. The treatment was considered by each radiation oncologist's opinion, mostly for the patient who could not tolerate, failed, or refused standard systemic treatment at that moment with aiming to stop local tumor growth and expecting to receive further standard treatment for any metastases in the future if the patient's clinical status could be available. The patient and family must acknowledge that this treatment was neither for curative intent nor for the standard palliative treatment in this condition of disease. If possible, the treated lesion(s) should be limited at the maximum diameter of 4 cm and less than four lesions treated at the same time to avoid severe adverse events. The patient would be evaluated for an understanding of regular breath cycle and breath holding controlled as a part of CyberKnife® treatment planning protocol. All of the processes and details of treatment planning and schedule were proceeded in the same pattern as the primary non-small cell lung cancer treatment protocol[2].

Radiotherapy planning delivery and definitions

The detail of tumor (gross tumor volume [GTV], clinical target volume [CTV], planning target volume [PTV]) and organs at risks contouring was proceeded from the same protocol as primary lung cancer treatment[2]. The non-isocentric inverse-planning algorithm and radiation dose fractionation were prescribed to cover PTV as much as possible with accepted percentage isodose line to gain the maximum therapeutic ratio (the ratio between percentage of tumor controlled and normal tissue complication at the same radiation dose, need to be more than 1). The radiation treatment dose would be calculated approximately to biological equivalent dose (BED) around 60 to 100 gray (Gy_{10}) if possible (limited by surrounding normal tissue radiation tolerance dose). The conformality of treatment plan was concerned from the four treatment parameters. They were 1) the percentage of the target volume covered by the prescription isodose line, 2) Conformity Index (CI), which was the ratio of the total volume of tissue treated compared to the volume of the tumor treated, 3) Homogeneity Index (HI), which was indicated the degree of uniformity of dose within the target volume, and 4) New Conformity Index (nCI), which was the CI multiplied by the ratio of the total target volume to the target volume received the prescription dose or more, and was used to describe the degree to which the prescribed isodose volume conforms to the shape and size of the target volume[3,4]. The latter three parameters were calculated to keep the value of less than 1.5 if possible. The maximum radiation point dose and/or critical volume dose of each critical structure was defined and corrected to keep the severity of any adverse event as low as possible[5].

Follow-up schedule

After complete treatment, clinical evaluation including general appearance, daily activity and toxicity criteria from CTCAE volume 3.0 grading system[6] was provided at the fourth week after treatment and during the follow-up period. Chest X-ray or CT scan chest was evaluated for roentgenographic tumor response to treatment which modified the criteria of response from World Health Organization (WHO)[7] (compete response, CR = disappearance of tumor; partial response, PR = 50% decrease in size; stable disease, SD = neither PR nor PD criteria were met; progressive disease, PD = 25% increase in size) at the third month after completed treatment, and later if the patient could still be contacted. Other investigations were considered when abnormal clinically suspected or indicated. All patients would be suggested for follow-up until the disease progressed, loss contact, or death.

Results

There were six cases with 20 lesions of lung metastases treated with CyberKnife® with the primary malignant sites being clarified into three colorectal cases, two endometrial cases, and one soft tissue of upper

Table 1. Demographic data of patients

Case No.	Sex	Primary tumor site	Pathology	Stage of primary tumor at diagnosis	Previous treatment
1	Male	Rectum	Adenocarcinoma	T2 N1 M0	Low anterior resection with adjuvant chemoradiotherapy
2	Male	Sigmoid colon	Adenocarcinoma	T2 N0 M0	Hartmann's operation
3	Male	Colon	Adenocarcinoma	T2 N1 M0	Colectomy with adjuvant chemotherapy
4	Female	Uterus	Adenocarcinoma	IBG1	Complete surgical staging, radiotherapy for vaginal stump recurrence 1 year later
5	Male	Soft tissue of forearm	Fibromyxoid sarcoma	Unknown*	Resection with no adjuvant treatment, reresection for local recurrent at 4th month after primary treatment
6	Female	Uterus	Uterine sarcoma	IB	Complete surgical staging and postoperative radiotherapy without chemotherapy

* Unknown stage from incomplete medical record

extremity case. The demographic data of the patients are demonstrated in Table 1. The treated 20 lesions were located by lung location into 11 peripheral (tumor that is not closed to the zone of proximal bronchial tree), four central (tumor that is closed to the zone of proximal bronchial tree), and five overlapping peripheral and central sites. The maximum diameter of each lesion treated varied from 1.5 to 7.3 cm (mean = 3.61 cm) and PTV varied from 2.53 to 119.70 cc (median = 13.05 cc). The characteristics of patients and lesions at the time of treatment are presented in Table 2. The prescribed radiation dose was varied from single fraction of 7.5 to 19 Gy (equivalent BED Gy_{10} 13.13 to 55.1 Gy) in eight lesions and multiple fractions of 30 Gy in three fractions to 50 Gy in five fractions (equivalent BED Gy_{10} 60 to 110 Gy) in 12 lesions with mean radiation dose being 71.4 Gy_{10} coverage 87.54% at 70% of the prescribed dose. The mean value of CI = 2.56, HI = 1.83 and nCI = 3.52. The mean numbers of nodes/beams per treatment fraction was 62/232. The example of radiation dose distribution from treatment planning is shown in Fig. 1. The maximum numbers of lesions treated per one patient were 10 lesions (not at the same treatment time). The treatment parameters and prescribed radiation dose for each lesion are shown in Table 3.

The roentgenographic response to treatment of each case and lesion showed no complete response, whereas eight partial response and eight stable disease were demonstrated at the first three months. Six progressive disease of treated lesions was shown in case No. 6 during the follow-up period. The response to treatment is shown in Table 4 and Fig. 2, 3.

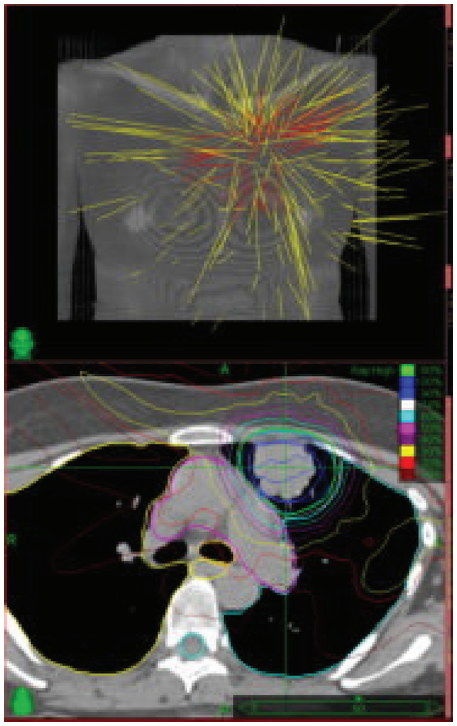


Fig. 1 The example of radiation dose distribution from treatment planning.

Table 2. The characteristics of patients and lesions at the time of CyberKnife® treatment

Case No.	Age (yr)*	Status of disease at the time of treatment	No.of lesion(s) treated/location	Maximum diameter (cm)	PTV (cc)
1 Adeno CA rectum	77	1 year after primary treatment; primary site controlled with single lung metastasis and not fit for systemic treatment	1/overlap	5.50	97.24
2 Adeno CA colon	71	5 years after primary treatment; primary site controlled but progressive lung and liver metastases and failed chemotherapy	1/peripheral	3.70	16.10
3 Adeno CA colon	63	3 years after primary treatment; primary site controlled but progressive lung metastasis after lobectomy and failed chemotherapy	1/peripheral 2/peripheral	3.60 2.30	16.50 5.36
4 Adeno CA uterus	32	3 years after primary treatment; primary site controlled but progressive lung metastasis, patient refused chemotherapy	1/central 2/peripheral 3/peripheral	4.50 2.20 2.80	38.00 5.00 12.40
5 Sarcoma (fibromyxoid) forearm	52	4 years after primary treatment; primary site controlled but progressive lung and brain metastases** and failed chemotherapy	1/peripheral 2/peripheral 3/peripheral	2.29 2.38 1.50	3.81 5.36 2.53
6 Uterine sarcoma	77	2 years after primary treatment; primary site controlled, progressive lung metastasis, patient requested for CyberKnife® before chemotherapy	1/overlap 2/central 3/central 4/peripheral 5/peripheral 6/peripheral 7/overlap 8/overlap 9/central 10/overlap	6.95 2.20 2.35 2.70 2.50 3.30 5.54 6.08 3.50 7.30	88.49 6.17 9.80 7.78 5.83 14.05 59.60 54.67 13.70 119.70
Mean	62			3.61	13.05*** (SD 35.56)

overlap = lesion involve from central to peripheral site; PTV = planning target volume
* Age at time of CyberKnife® treatment
** Received SRT
*** Median

Fibrosis of surrounding lung parenchyma was an adverse event found in roentgenographic images of all patients but it did not cause any respiratory problem. The detail of radiation dose to each critical structure and adverse event is shown in Table 5 and 6.

The follow-up period ranged from one month to three years after treatment. The patient's status at last visit was demonstrated in Table 7. Two cases were still alive at the time of report with stable lung lesion in one case and progressive bone and more lung metastases in the other. Both of them still received palliative chemotherapy. Two cases died from uncontrolled progressive metastases and failed palliative chemotherapy. Two cases lost follow-up after progressive metastases with unknown surviving status.

Discussion

The objective of palliative radiotherapy for malignant disease is to alleviate locally distressing symptom and offer the potential to improve quality of life while minimizing potential treatment toxicity[8]. For lung metastasis, systemic treatment has been used as a mainstay palliative treatment if the patient's status is available. Local treatment, such as surgical metastesectomy, is concerned in some selective cases of isolated and limited number of metastatic lesions or from some primary malignant site (such as sarcoma, colorectal cancer)[9]. According to the Norton-Simon hypothesis, local treatment for metastatic disease is based on two goals, first, to reduce the patient's total burden of disease in such a way that the remaining

Table 3. Treatment parameters and prescribed radiation dose for each lesion

Case No.	Lesion No.	CI	HI	nCI	% coverage at prescribed isodose line	No.of nodes/beams per treatment fraction	Tumor dose (Gy x fraction)	Equivalent BED Gy_{10}
1	1	1.10	1.27	1.16	94.70% at 79%	59/318	10x5	100.0
2	1	1.22	1.28	1.23	98.58% at 78%	83/362	15x3	112.5
3*	1	1.63	1.30	1.71	95.25% at 77%	57/288	15x3	112.5
	2	4.85	1.30	4.53	98.35% at 77%	57/288	15x3	112.5
4*	1	1.42	1.47	1.25	96.44% at 80%	75/299	13x3	89.7
	2	16.11	1.25	24.94	64.58% at 80%	75/299	12x3	79.2
	3	6.01	8.51	1.25	70.68% at 80%	75/299	12x3	79.2
5*	1	1.26	1.23	1.31	96.58% at 81%	54/211	13.5x3	95.2
	2	1.18	1.23	1.22	96.77% at 81%	50/303	13.5x3	95.2
	3	1.31	1.27	1.36	96.36% at 79%	50/293	27x1	99.9
6**	1	1.33	1.33	1.39	95.41% at 75%	80/228	11.5x3	74.2
	2	2.01	1.33	2.01	95.65% at 75%	77/230	11x3	69.3
	3	1.62	1.52	1.62	95.08% at 66%	77/230	10x3	60.0
	4	1.19	1.67	1.85	95.47% at 60%	63/181	18x1	50.4
	5	1.12	1.75	1.17	95.41% at 57%	66/160	18x1	50.4
	6	1.18	1.69	1.24	94.72% at 59%	55/186	19x1	55.1
	7	1.40	1.67	2.10	66.84% at 60%	49/111	12x1	26.4
	8	2.19	1.67	15.73	17.10% at 50%	36/112	12x1	26.4
	9	1.99	1.67	2.16	92.13% at 60%	36/112	12x1	26.4
	10	1.21	2.22	1.27	94.98% at 45%	65/120	7.5x1	13.1
Mean		2.56	1.83	3.52	87.54% at 70%	62/232		71.4
SD		3.43	1.59	5.98	19.61% coverage			31.7

CI = conformity index, try to keep <1.5; HI = Homogeneity Index, try to keep <1.5; nCI = New Conformity Index, try to keep <1.5; node = the position of the linear accelerator focal spot; BED = biological equivalent dose

* Case No. 3-5 treatment all lesions at the same time.

** Case No. 6 try treatment for relief pressure symptoms from progressive enlarge lesions: lesion 1 was the first treatment, lesions 2, 3 were treated at the same time, 1 year 9 month interval from lesion 1, lesions 4-6 were treated at the same time, 6 month interval from lesions 2, 3, lesions 7-9 were treated at the same time, 5 month interval from lesions 4-6, lesions 10 was treated at 3 month interval from lesions 7-9 (All treatment were 5 radiotherapy courses).

Table 4. Response to treatment of each treated lesion

Case No.	Lesion No.	Response of each lesion to CyberKnife®
1	1	PR at 3rd and 12th month
2	1	SD at 3rd month, PR at 6th, 9th month
3	1, 2	SD at 3rd month
4	1, 2, 3	PR at 3rd, 6th, 12th month
6	1, 3	PR at 3rd month, PD around 1 year
	2	PR at 3rd month, PD at 6th month
	4, 6	SD at 3rd month, PD at 8th month
	5	PR at 3rd month, PD at 8th month
	7, 8, 9	SD at 3rd month

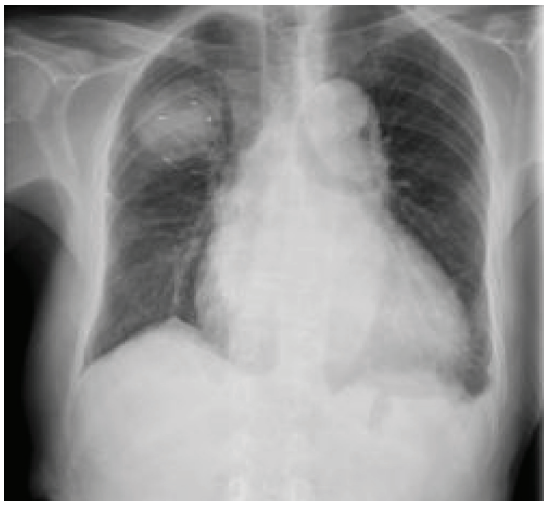
PR = 50% decrease size of tumor; SD = decrease size less than 50%; PD = 25% increase in size

* Case No. 5 loss contact from hospital.

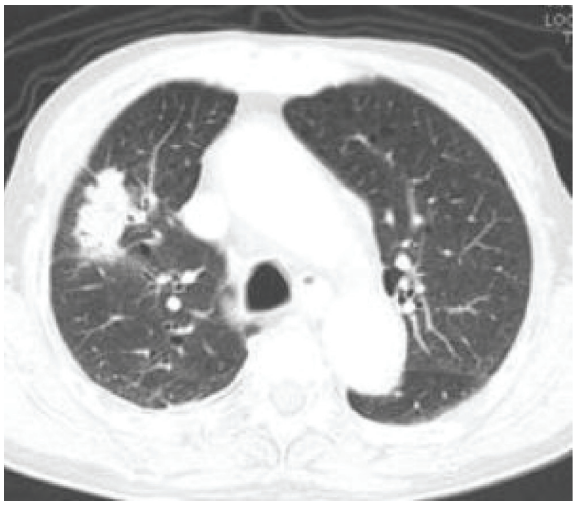
** Case No.6, lesion 10, patient died before evaluated.

cancer within the patient's body enters a state of relatively higher growth fraction and is thus more susceptible to cytotoxic systemic agents, and the second is to prevent or delay as long as possible the condition of lethal tumor burden that is fatal to the patient[10].

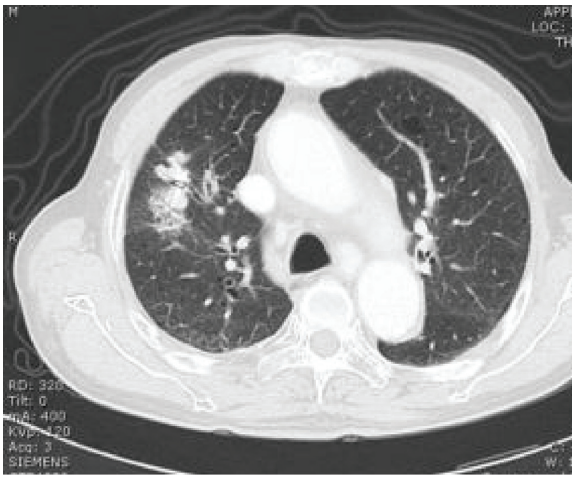
High dose radiotherapy has a limited or no role in local palliative treatment in lung metastasis, because severe complications in normal tissue can cause suffering symptoms to the patient. Until the SBRT era, the idea of applying high radiation dose in short-course treatment to each lung lesion to eradicate tumor cells has been considered for local treatment. The theoretical advantages of SBRT short-course high radiation dose for lung metastasis can be clarified in the view of tumor and normal lung parenchyma radiobiology. In the view of tumor, SBRT overcomes



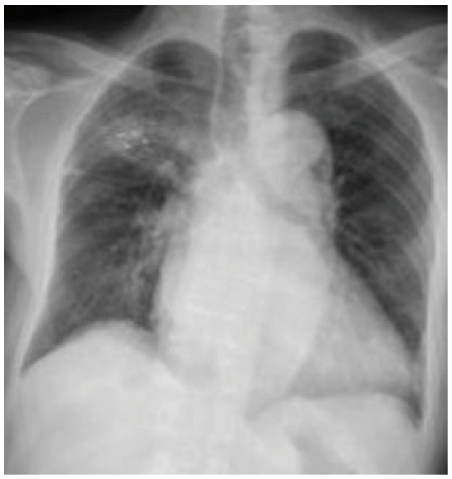
A) Case No. 1, CXR before treatment



B) Case No. 1, CT scan of overlapping lesion 5.5 cm before treatment



C) Case No. 1, PR of CT scan, 3 months after treatment



D) Case No. 1, PR of CXR, 1 year after treatment

Fig. 2 The example of diseases response to CyberKnife® treatment.

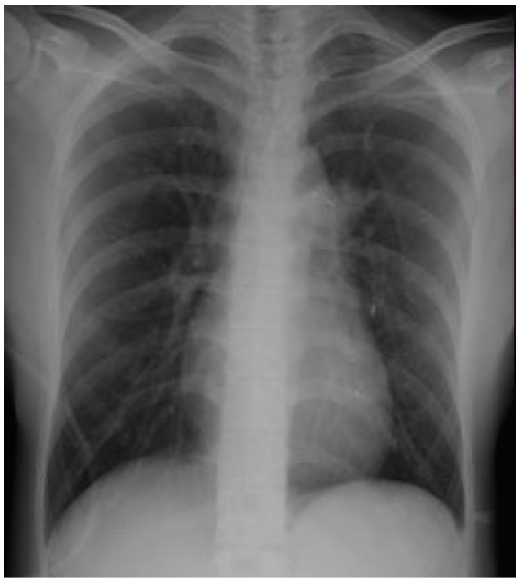
the capability of repopulation and repairable damage of tumor cells from the benefit of very short overall treatment time and very high radiation dose, respectively[11]. Moreover, SBRT can destroy a vast majority of tumor cells from induced loss of autocrine-paracrine loop stimulation along with bystander effects and generating ceramide to stimulate apoptosis of endothelial cells. However, transforming growth factor beta released from those microvascular injuries can produce excessive fibrosis in surrounding lung parenchyma at the same time[12,13]. In the view of normal tissue, lung parenchyma is classified as the parallel functioning subunits (FSUs) characterized by redundancy of function and large inherent reserves, which meant that no matter how large the radiotherapy dose was applied to lung parenchyma, severe toxicity could be avoided by limiting treatment volume, because the undamaged FSUs could maintain the organ function[14]. However, toxicity from treatment must be kept in mind when deciding to treat multiple lung lesions or very large tumor size.

Most reports of radiotherapy planning and regimen of SBRT in lung metastasis modified from the data of primary lung cancer treatment. The retrospective studies demonstrated that the benefit of local control rates ranges from 63% to 98% (mostly exceeding 85%) with variation of radiation treatment dose and fractionation but the survival benefit is still questionable[15]. To provide the real clinical benefit of SBRT in lung metastasis, some authors suggested

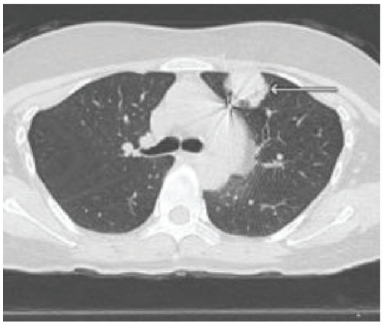
this treatment modality for oligometastasis condition (locally confined metastasis[16]). However, there is still no consensus for using this treatment modality as a standard approach in this condition of disease[17]. For CyberKnife® treatment, a few literatures of clinical outcome report the benefit of local lesion control rate, whereas the effect on survival outcome is still inconclusive[18-21] (Table 8).

The clinical outcome of the patients in the present report could be defined into three subgroups. Group 1was failure of treatment with poor clinical outcome for those who had progressive multiple metastases within short interval after treatment and lost to follow-up with unknown surviving status (case No. 3 and 5). Group 2 was response to treatment and gain some survival for those who could receive further systemic treatment though eventually progress to multiple metastases and death (case No. 2 and 6). Group 3 was response to treatment and still alive for those who still received palliative chemotherapy and survived at the time of report (case No. 1 and 4).

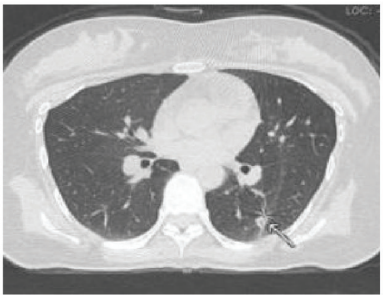
Although the outcome was limited by the number of patients, the results could be evaluated to answer the two objectives of the present study. For the first objective, the effectiveness of CyberKnife® treatment planning, when concerning the four parameters was not as good as expected (Table 3). This could be explained by the large variable in number



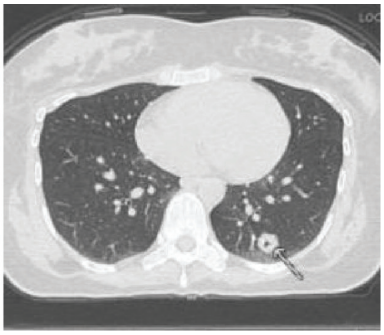
A) Case No. 4, CXR before treatment



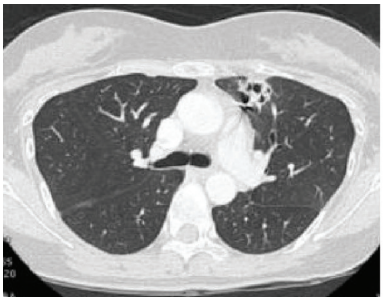
B) Case No. 4, CT scan centrally lesion 1, diameter 4.5 cm before treatment



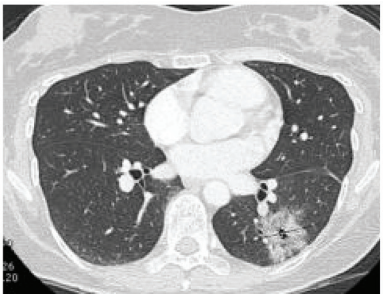
C) Case No. 4, CT scan peripheral lesion 2, diameter 2.8 cm before treatment



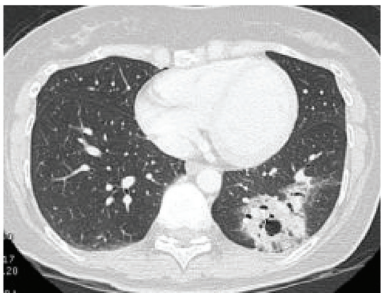
D) Case No. 4, CT scan peripheral lesion 3, diameter 2.2 cm before treatment



E) Case No. 4, PR of CT scan lesion 1, 3 months after treatment



F) Case No. 4, PR of CT scan lesion 2, 3 months after treatment with lung fibrosis



G) Case No. 4, PR of CT scan lesion 3, 3 months after treatment with lung fibrosis

Fig. 3 The example of diseases response to CyberKnife® treatment.

Table 5. Maximum radiation dose (Gy) of cririca structures (point dose and/or critical volume dose)

Case No.	Right and left lung (1,000 cc volume)	Pericardium (max point/15 cc volume)	Spinal cord (max point)	Esophagus (max point)
1	5.06	47.67*/25.95	9.96	12.36
2	3.46	11.67/6.92	5.34	13.71
3	5.26	12.39/7.60	5.10	7.55
4	6.34	38.59/14.13	9.06	12.83
5	6.98	15.55/10.21	9.86	10.61
6				
1st course	1.90	28.40/NA	9.59	16.13
2nd course	4.63	12.09/NA	10.15	7.14
3rd course	3.02	1.85/NA	3.74	NA
4st course	1.51	5.95/NA	5.52	5.61
5st course	0.50	4.63/NA	3.04	7.40
Limited dose (for 1, 3 and 5 fraction(s))	7.40, 11.40, 13.5	22/16, 30/24, 38/32	14, 22, 30	19, 27, 35

NA = not analysis (radiation dose is too low to analyzed)
Radiation dose limitation of each critical structure is varied to radiation fractionation and functioning subunits of each structure[5].
* Radiation dose over maximum point dose but limited maximum volume dose and cause no clinical adverse event.

Table 6. Adverse events grading from CyberKnife® treatment

Cases	Skin and subcutaneous tissues	Respiratory disorders	Cardiac disorders	Vascular disorders	Esophagitis	Myelitis
All cases	1*	1**	1*	1*	1*	1*

1* = asymptomatic
1** = radiologic pulmonary fibrosis <25% of lung volume (all cases) with symptomatic cough in case No. 6 (cardiac arrhythmia in Case No. 6 was caused from process of septicemia and shock)

Table 7. Last follow-up status of patient

Case No.	Status of patient
1	1 year after CyberKnife®, alive with stable disease of lung metastasis, continue palliative chemotherapy
2	10 months after CyberKnife®, failed palliative targeted and chemotherapy, dead from progressive liver and other lung metastases
3	6th month after CyberKnife®, progressive other lung metastases, loss to follow-up
4	1 year 8 months after CyberKnife®, alive with progressive other lung and bone metastases, continue palliative chemotherapy
5	1 month after CyberKnife®, progressive both other lung and brain metastases (personal contact), loss to follow-up
6	3 years after first CyberKnife®, failed palliative chemotherapy, dead from progressive lung metastases, cardiac arrhythmia and septicemia

and size of the treated lesions, which were difficult to perform a good treatment planning, especially to minimize normal tissue toxicity at the same time. For the second objective, the clinical outcome seemed to demonstrate non-impressive results for metastatic controlled and clinical outcome (no CR achieved while the process of metastasis was hard to control and poor survival). It was the fact that the process of distant metastases was presumed to be caused from many variable factors such as natural history of primary tumor site, genetic alteration, tumorigenesis process, cytokines, and growth factors substances released, all of which may alter tumor growth and immunogenicity or even multiple microscopic lesions that may be

Table 8. Clinical outcome of CyberKnife® treatment

Authors	No. of lesions treated	Primary malignant sites	Mean lesion size	Radiation dose	Outcome
Collins et al 2007[18]	9 solitary metastasis 15 primary lung cancer	NSCLC, GI cancer, renal cell cancer, skin cancer	Mean 8 cc	15 or 20 Gy x3 fractions	1-year local control 78%
Brown et al 2008[19]	69 metastases (maximum = 8 lesions/case)	Head and neck cancer, GI cancer, renal cell cancer, NSCLC, mesothelioma, breast cancer, sarcoma, uterine cancer, testis cancer	Mean 12.1 cc	5-60 Gy in 1-4 fraction(s)	1.5-year local control 71%
Unger et al 2010[20]	17 solitary metastasis 3 primary lung cancer	Head and neck cancer, GI cancer, renal cell cancer, NSCLC, mesothelioma, breast cancer, sarcoma	Mean 73 cc	6-8 Gy x5 fractions	1-year local control and overall survival = 63% and 54%
Snider et al 2012[21]	24 solitary metastasis	GI cancer, renal cell cancer, bladder cancer, NSCLC, uterine cancer, ovarian cancer	Mean maximum diameter 2.5 cm	45-60 Gy in 3 fractions	2-year local control and overall survival = 87% and 50%

NCLC = non-small cell lung cancer; GI cancer = esophageal, colorectal cancer

presented at the beginning process. All of these could explain the reason why aggressive local treatment might not reflect the overview of clinical outcome[22].

Conclusion

This is the first report in Thailand that has demonstrated the clinical results of radiotherapy plan and tumor response of CyberKnife® treatment for lung metastasis in Ramathibodi Hospital. It can provide some benefit in some patients with partial response detected and can be continued with systemic treatment. This report provides the idea of appropriated patient selection to receive CyberKnife® for lung metastasis that must strictly clarify the real clinical outcome benefit of each selected case such as oligometastasis and further systemic treatment plan to achieve the best outcome from this treatment procedure.

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Potential conflicts of interest

None.

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รายงานเบื้องต้นของการใช้ Cyber Knife® ในการรักษามะเร็งชนิดแพร่กระจายมาที่ปอด: คำถามถึงประโยชน์ทางคลินิก

ธิติ สว่างศิลป์, พรพรรณ ยงวิทิตสถิต, กุมุทินี ไพรัตน์, พัชรีพร เดชสุภา, มัณฑนา ธนะไชย, สมใจ แดงประเสริฐ, ลดาวัลย์ นาควงษ์, ชมพร สีตะธนี, พุฒิพรรณ พัวทวีพงศ์, ภรมน พุทธิการันต์, ชุลีพร เจียรพินิจนันท์, ปฐมิณฑิตา วิฑูรพณิชย์, ประเสริฐ อัศวประเทืองกุล, จุฑามาศ ขาวผ่อง, รวี เรืองกาญจนเศรษฐ์

วัตถุประสงค์: *เพื่อนำเสนอประสิทธิภาพของแผนการรักษาทางรังสีรักษา, ตัวแปรทางฟิสิกส์ รวมถึงการควบคุมโรคเฉพาะที่ และผลเบื้องต้นทางคลินิกในการรักษามะเร็งชนิดแพร่กระจายมาที่ปอดด้วยเครื่อง Cyber knife® ที่โรงพยาบาลรามาธิบดี*

วัสดุและวิธีการ: *ผู้ป่วยมะเร็งชนิดแพร่กระจายมาที่ปอด 6 ราย จำนวน 20 รอยโรค ได้รับการประเมินตอบสนองหลังได้รับการรักษาด้วย Cyber Knife® ปริมาณรังสีที่ใช้ได้รับการคำนวณให้เทียบเท่า biological equivalent dose (BED) ระหว่าง 60 ถึง 100 เกรย์ $_{10}$ การตอบสนองการรักษาของแต่ละรอยโรค ประเมินจากภาพรังสีร่วมกับผลทางคลินิกของสภาวะของผู้ป่วยและโรค รวมถึงผลข้างเคียง*

ผลการศึกษา: *จากภาพรังสีติดตามผลที่ 3 เดือนแรกภายหลังการรักษา พบผลการตอบสนองบางส่วน (ขนาดรอยโรคลดลง 50%) จำนวน 8 รอยโรค รอยโรคคงที่ (ขนาดรอยโรคไม่เปลี่ยนแปลง) จำนวน 8 รอยโรค โดยไม่พบการตอบสนองสมบูรณ์ (ขนาดรอยโรคหายไป) ระหว่างติดตามภายหลังการรักษา พบขนาดของรอยโรคเพิ่มขึ้นมากกว่าเดิม (ขนาดของรอยโรคเพิ่มขึ้น 25%) จำนวน 6 รอยโรค ในช่วงที่รายงานผล ผู้ป่วย 2 ราย ยังมีชีวิตอยู่และยังได้รับการรักษาด้วยเคมีบำบัด ผู้ป่วย 2 ราย เสียชีวิตจากมะเร็งแพร่กระจายที่ไม่สามารถควบคุมได้และไม่สนองตอบเคมีบำบัด ผู้ป่วย 2 ราย ขาดการติดต่อหลังจากมะเร็งแพร่กระจายเพิ่มขึ้น และไม่ทราบการมีชีวิตอยู่ ไม่พบผลข้างเคียงที่รุนแรงจากการรักษา แผนการรักษาแสดงถึงประสิทธิภาพในการฉายรังสีที่มีปริมาณรังสีสม่ำเสมอและครอบคลุมเป้าหมายได้พอสมควร*

สรุป: *รายงานเบื้องต้นนี้แสดงให้เห็นแนวคิดในการพิจารณาเลือกผู้ป่วยมะเร็งชนิดแพร่กระจายมาที่ปอดเพื่อรับการรักษาด้วยเครื่อง Cyber Knife® ซึ่งควรระบุไว้เพื่อให้ผู้ป่วยได้รับประโยชน์สูงสุดจากการรักษา*