肺转移瘤SBRT放射治疗技术中Tomo计划同BrainLab计划的剂量学研究

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摘 要：【目的】对比肺转移瘤立体定向放射治疗(Stereotactic Body radiation therapy，SBRT)使用Tomo技术和BrainLab技术的剂量学差异。【方法】分别选取单一肺转移瘤、两个肺转移瘤、三个肺转移瘤和四个肺转移瘤病例各一例，PTV体积为2.89 ± 1.15 cm^3。使用Tomo和BrainLab计划系统分别进行计划设计，每次剂量5 Gy，总剂量50 Gy并覆盖95%PTV体积的处方剂量，比较治疗计划的脊髓、双肺和其它正常器官的DVH曲线、靶区的CI和HI指标。【结果】Tomo计划设计的靶区剂量的适型指数CI=0.687 ± 0.075、均匀指数HI=1.0314 ± 0.0700，BrainLab计划设计的靶区剂量适型指数*CI*=0.571 ± 0.042、均匀指数HI=1.0764 ± 0.1241，两组HI和CI进行独立样本*t*检验，*P*值均小于0.001具有统计学意义，Tomo计划的靶区CI和HI指标均优于BranLab计划。BrainLab系统中的脊髓的低剂量要高于Tomo计划，而两组正常器官和双肺的剂量无明显的差异，肺的V20均小于10%。【结论】对于最长径小于4 cm的小体积的肺转移瘤，应该优先使用Tomo技术。

关键词：体部立体定向放疗；肺转移瘤；断层螺旋调强治疗
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Dosimetry Study for Lung Metastases in SBRT Technology Using Tomo Planning System versus BrainLab Planning System

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Abstract:【Objective】To compare and contrast the dosimetry between Tomo planning and BrainLab planning for lung metastases in stereotactic body radiation therapy(SBRT).【Methods】Four Patients with one, two, three and four metastases were selected. The PTV is 2.89 ± 1.15 cm^3. Two plannings with total dose of 50 Gy to cover 95% of PTV, 5 Gy/Fraction and 10 fractions were designed using Tomo planning system and BrainLab planning system respectively. The DVH curves of spinal cord, both lungs and normal tissue were compared. The conformity index andhomogeneityindex were analyzed as well.【Results】The homogeneity index (HI) and conformity index (CI) of the targets in Tomo planning system were 1.0314 ± 0.0700 and 0.687 ± 0.075, respectively. In BrainLab planning system the HI and CI of the targets were 1.0764 ± 0.1241 and 0.571 ± 0.042, respectively. To HI the *P* value in T test was less than 0.01 and the HI was better in Tomo than BrainLab and so was CI. The dose to spinal cord was higher in BrainLab planning system than that in Tomo. The dose to nomal tissue and both lungs were not different in the two planning systems and V20 of lung is as small as 10%.【Conclusions】For small volume lung metastases which longest diameter were less than 4 cm, the tomotherapy should be better choice.

Key words: stereotactic body radiation therapy; lung metastases; tomotherapy
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Tomotherapy is an advanced technique in the field of radiation therapy, as formetastases in lung, there are researches [1-3] showed thattomotherapy is the first choice for lung metastases with diameter over 4 cm. Tomotherapy is still a technique of priority When dealing with lung metastases with diameter less than 4 cm and the number of the metastases is more than 4. However, there is little researches and study about the performance of tomotherapy technique when dealing with lung metastases with diameter less than 4 cm and the number of metastases is less than. To research this situation, we compared tomotherpy radiation treatment planning technique with BrainLab [4-5] radiation treatment planning technique to study the difference between these two techniques usually chosen for stereotactic radiation therapy for lung metastases, and offer some advises for clinical situation.

1 Materials and Methods

1.1 Patient data

Four cases of lung metastases which had went through stereotactic body radiation therapy using BrainLab technique were chosen retrospectively, all male, middle age is 55-years old. They were separated into four group with one metastases, two metastases, three metastases, four metastases, each group, two treatment plans using tomotherapy and BrainLab technique were designed for each group.

1.2 Target contouring

Gross tumor volume (GTV) was contoured on computed tomography using BrainlabiPlan RT Image software(Brainlab, Version 4.1, German), and planning target volume (PTV) was created according to guideline of ICRU report #50 ,#60 and #83[6-8]. 4 set of CT images with target volume contours were exported to tomotherapy radiation treatment planning system from brainlab treatment planning system according to DICOM protocols.

1.3 Treatment prescription

Stereotactic body radiation therapy technique was applied to each case with 5 Gy for each fraction, and 10 fractions were given to at least 95% volume of PTV.

1.4 Treatment plan designation

For BrainLab technique, the treatment planning was designed using BrainlabiPlan Dose software (Brainlab, Version4.1.4, German), with 2 arcs, separated angle of 120 degree, treatment couch was set to 0 degree, small multiple leaf collimator of 25 mm to 30 mm was used.

For tomotherapytechnique, the treatment planning was designed using TOMO treatment planning software(Accurate, version 5.01.7, the United States), with field width 1 cm, pitch off 0.143, modulation factor set as 3.5.

1.5 Planning optimization

BrainLab technique planning needs no optimization. In tomotherapy technique planning, the dose to normal tissues were kept as low as possible without at the cost of PTV homogeneity and conformity.

1.6 Dose distribution and statistical analysis

The dose distribution of PTV, lungs, spinal cord and the rest normal tissue of were analyzed, their dose volume histogram (DVH) curves, homogeneity index (HI) and conformity index CI generated from BrainLab technique planning and tomotherapy were compared[9-10]. The definition of HI and CI are: which Dx% represents the dose level that x% volume of PTV received, Vx represents the volume receives dose level higher than X.

Independent samples t test was applied to analyze all data using IBM SPSS 21 software, and considering the limits of samples, $P < 0.001$ was considered to be significant.

2 Results

2.1 Dose volume histogram (DVH) Curves

Fig.1 to Fig.4 show the comparison of DVH of Brainlab technique planning and tomotherapy technique planning. As can be seen, the D5 of PTV in tomotherapy is smaller than that in BrainLab technique planning, this means that tomotherapy produced a much more uniform dose distribution than BrainLab technique planning. For lung, V20 of both technique plans increased with the number of metastases, and

V20 < 10. The volume received 5 Gy (V5) of tomotherapy plans were somewhat more than that of BrainLab technique plans. For spinal cord, the maximum dose received changed littlewith the number of metastases, and were lower than 11.23 Gy, with BrainLab technique, the maximum dose received by spinal cord increased gradually with the number of metastases, and the maximum value was 15.01 Gy, moreover, in the lower dose level, V10 of spinal cord was much larger than that of tomotherapy technique plans. As for the rest normal tissue, tomotherapy technique contributed more to the lower dose level.

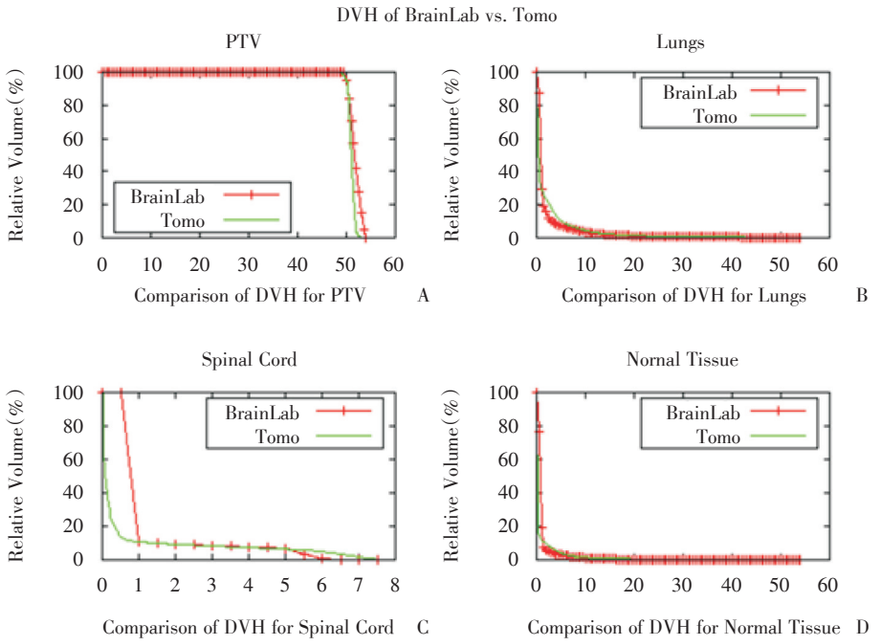

Fig.1　Comparison of DVH for PTV, both lungs, spinal cord and normal tissue in single metastases

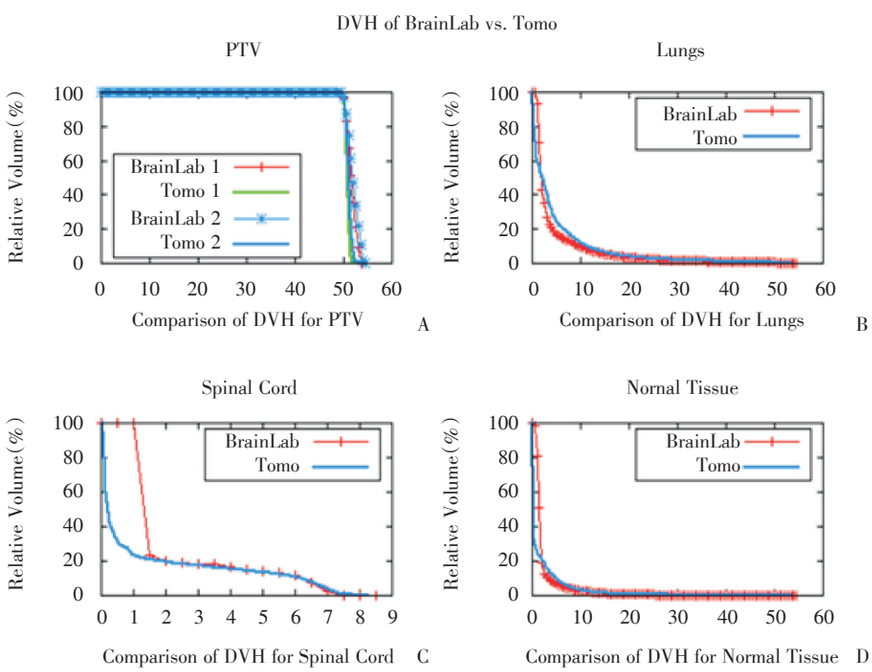

Fig.2　Comparison of DVH for PTV, both lungs, spinal cord and normal tissue in two metastases

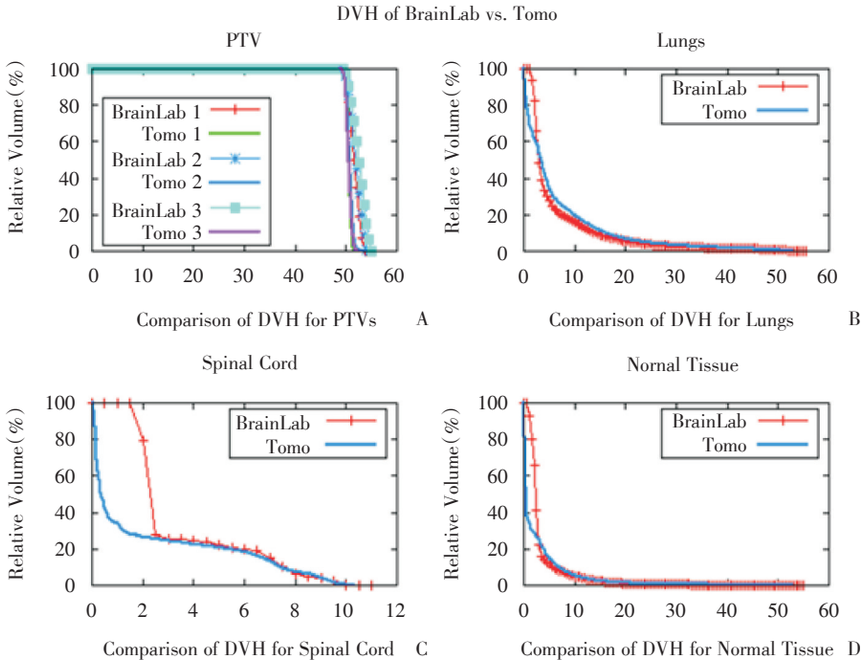

Fig.3 Comparison of DVH for PTV, both lungs, spinal cord and normal tissue in three metastases

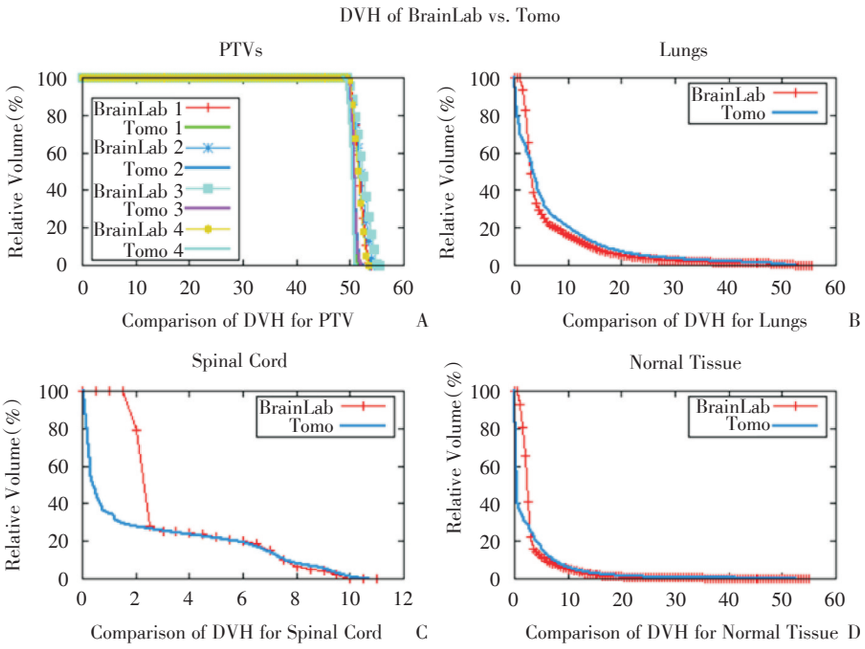

Fig.4 Comparison of DVH for PTV, both lungs, spinal cord and normal tissue in four metastases

2.2 Analysis of homogeneity and conformity

Table 1 shows the homogeneity index of PTV of plans created using tomotherapy BrainLab technique. As can be seen, HI of tomotherapy and brainLab were 1.0314 ± 0.08 and 0.0764 ± 0.1242, respectively, homogeneity of tomotherapy was better than that of BrainLab technique, and the $P < 0.001$, this is statistical significant. Table 2 shows the conformity index of tomotherapy is better that of BrainLab technique. As the CI can only be calculated when all the metastases are taken as a integrated one target, CI for each metastases can not be calculated, and the P was 0.036, considering the very small sample, it is not statistical significant.

Table 1　Homogeneity index of dose to targets comparison between Tomo treatment Planning System and BrainLab treatment planning system

	Tomo	BrainLab
1 Target	1.0404	1.0746
2Targets	1.0302	1.0702
	1.0426	1.0810
3Targets	1.0257	1.0680
	1.0342	1.0788
	1.0305	1.0962
4Targets	1.0262	1.0724
	1.0337	1.0810
	1.0320	1.0906
	1.0188	1.0516
Average	1.0314 ± 0.0700	1.0764 ± 0.1241
P	0.000	
F	1.889	
t	−9.994	

Table 2　Comparison of dose distribution Conformity Index（CI）to targets between Tomo planning system and BrainLab planning system

	Tomo	BrainLab
1 Target	0.696	0.616
2 Targets	0.623	0.593
3 Targets	0.789	0.552
4 Targets	0.639	0.523
Average	0.687 ± 0.075	0.571 ± 0.042
P	0.036	
F	1.156	
t	2.700	

3　Discussion

Stereotactic body radiation therapy(SBRT) is now becoming a new technique to treat lung cancer[11-13]. Hideomi Yamashita et al applied Volumatic modulated arc therapy technique using Pinnacle Treatment planning system to treat one metastases in lung, with prescription 50Gy to 55Gy, 95% volume of PTV coverage and V20 of lung smaller than 10. Ye et al[14] studied the difference of dose distribution of lung metastases treated using SBRT planning created from tomotherapy and Pinnacle treatment planning systems, and they pointed out that a better dose distribution, both HI and CI, can be achieved when using tomotherapy technique treatment planning, as well as better protection of organs at risk, and a higher low dose distribution in normal tissues[15].

When come to SBRT, since the existence of the breath, the precise and accuracy of poisoning needs taking much more attention to assure the treatment outcome. When Brainlab treatment system was applied to offer SBRT, in most clinical situation, the Brainlab Exact Trac system will be applied to guide positioning. Videtic[16], after retrospectivelyanalyzing 80 cases of lung cancer treated using online positioning system, showed that an acceptable outcome can be achieved when using Brainlab Exact Trac system to guide positioning . For single small Volumatic metastases in lung, Brainlab system can create treatment plans that satisfy the clinical requirement. However, when compared with plans created using tomotherapy technique, the HI and CI of plans from Brainlad system still have potential to be improved. For multiple small Volumatic metastases which longest diameter were less than 4cm in lung, tomotherapy created better dose distribution for PTV and organ at risk contoured, however companied a somewhat worst lower dose distribution for those normal tissue that did not be contoured, especially the V2 of lung was higher than that of Brainlab system, this may lead to distant toxic effect.

On conclusion, for small Volumatic lung metastases which longest diameter were less than 4 cm, tomotherapy technique should be considered as a more advanced technique to apply stereotactic body radiation therapy except for its lower distribution in normal tissues.

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