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Effect of Differences in CT and MR Imaging between Skull and Brain Tissues on Radiotherapy Dosimetry in Patients with Brain Tumors

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Abstract: Objective: To study and analyze the effect of differences in CT/MR imaging between skull and brain tissues on radiotherapy dosimetry in patients with brain tumors. Methods: 32 patients with brain tumors who received radiotherapy in the hospital from January 2021 to January 2022 were selected for this study. CT and MR scanning were performed on the above patients, and the tumor target areas were delineated on the images according to the image information. And the areas were named as Skull-CT and Skull-MIR, Brain Tissue-CT, Brain Tissue-MR1 (excluding meninges), Brain Tissue-MR (including meninges). According to the image information, the radiotherapy plan was formulated. The first plan was Intensity Modulated Radiotherapy (IMRT). And the second one was based on the CT/MR imaging to obtain the CT2 image by giving the CT value 20 HU according to the differences of skull imaging. And then the first plan was copied to the CT2 image to recalculate the radiotherapy dose. The matching of volume of Skull and Brain Tissues and the influence of different methods on skull MR/CT dosimetry were compared. Results: The volume of the Skull-MR was significantly smaller than that of the Skull-CT ($P<0.05$), but there was no significant difference between Brain Tissue-MR and Brain Tissue-CT ($P>0.05$). When local radiotherapy was used, the Skull-Dmax decreased ($P<0.05$), and the Skull-Dmean increased ($P<0.05$). And for whole brain radiotherapy, Skull-Dmax decreased ($P>0.05$), Skull-Dmean increased ($P<0.05$). Conclusion: There exist certain differences in CT/MR imaging between Skull and Brain Tissues, and the effects of different radiotherapy doses are different.

1. Introduction

Brain tumor is one of the common malignant tumors in clinical practice, which poses a great threat to the life safety of patients. And the patient's condition is controlled with the use of radiation therapy in clinic.The use of CT simulation positioning in radiotherapy can accurately locate the location and size of the patient's brain tumor, and it is one of the important basis for the selection of radiotherapy dose. However, in CT imaging, the estimation of CT value is affected to a certain extent due to the sclerosis effect. Magnetic resonance imaging (MRI) scanning can improve the resolution of patients' brain soft tissue and calculate the accuracy of radiation dose [1]. Therefore, in order to further study the effect of different methods on the radiation dose of Brain Tumor in Skull and Brain Tissue, this paper mainly studies and analyzes the effect of differences in CT/MR imaging between Skull and Brain Tissue on the radiotherapy dosimetry in brain tumor.

2. Information and Methods

2.1 General Information

32 patients with Brain Tumors who received radiotherapy in the hospital from January 2021 to January 2022 were randomly selected by computer for retrospective analysis. CT and MR scanning were performed on the above patients, and the tumor target areas of the patients were delineated on the images according to the image information. The areas were named as Skull-CT and Skull-MIR, Brain Tissue-CT, Brain Tissue-MR1 (excluding meninges), Brain Tissue-MR (including meninges). The patients were 22 males and 10 females, and their mean age was (48.67 ±5.23) years.

Inclusion criteria: (1) All patients were clinically diagnosed as Brain Tumors; (2) The patients and their families knew the contents of this study and signed the informed consent; (3) This study was discussed and approved by the Ethics Committee of the hospital.

Exclusion criteria: (1) Incomplete data; (2) Patients with other tumor diseases.

2.2 Methods

The one method is CT simulation positioning scanning. It was carried out for the above patients from the head to the lower edge of the occipital foramen, and the supine position was maintained. The head and neck were fixed with a thermoplastic mask. A large aperture CT positioning machine was selected. When CT simulation positioning scanning was used, the thickness of the layer was 3 mm and the spacing of the layer was 3 mm. The other method is MR simulated localization. Three-dimensional T1WI scanning was performed on the patients with GE 3.0T superconducting MR scanner. When MR simulated localization was carried out, TR is 5 160 ms, TE is 11.5 MS, Matrix is 256 * 256, FOV = 256 mm * 256 mm, the thickness of the layer was 3 mm and the spacing of the layer was 0. The paramagnetic contrast agents Gd-DTPA was used as the contrast agent during the scanning. According to the image information, the radiotherapy plan was formulated. The first plan was IMRT. And the second one was based on the CT/MR imaging to obtain the CT2 image by giving the CT value 20 HU according to the differences of skull imaging. And then the first plan was copied to the CT2 image to recalculate the radiotherapy dose.

2.3 Observation Indicators

The matching of volume of patients' Skull and Brain Tissues and the influence of different methods on Skull MR/CT dosimetry were compared.

2.4 Statistical Methods

The data were analyzed by SPSS 19.0, and the measurement data were compared by t-test with ($x \pm s$), if $P<0.05$, there was significant difference.

3. Results

3.1 Comparison of Volume of Patients' Skull and Brain Tissues

In this study, the volume of the Skull-MR was significantly smaller than that of the Skull-CT

(P<0.05), but there was no significant difference between Brain Tissue-MR and Brain Tissue-CT (P>0.05). The specific data are shown in Table 1.

Table 1: Comparison of volume of patients' Skull and Brain Tissues

Group	Case	Volume	t	p
Skull-CT	32	583.23±72.32	10.432	0.001
Skull-MR	32	317.93±43.72		
Brain Tissue-CT	32	1326.34±132.93	-	-
Brain Tissue-MR1	32	1325.33±138.29	2.834	0.832
Brain Tissue-MR2	32	1401.23±129.53	3.219	0.723

3.2 Comparison of Effects of Different Methods on Skull MR/CT Dosimetry

In this study, compared with plan one and plan two, Skull-Dmax decreased by 1.71% on average and Skull-Dmean increased by 4.00% on average (P<0.05). For patients with whole brain radiotherapy, Skull-Dmax decreased by 0.06% on average (P>0.05), and Skull-Dmean increased by 3.61% on average (P<0.05). Specific data are shown in Table 2.

Table 2: Comparison of the effects of different methods on Skull MR/CT dosimetry (n = 32)

Group	Local radiotherapy		Whole brain radiotherapy	
	Skull-Dmax	Skull-Dmean	Skull-Dmax	Skull-Dmean
Plan one	65.23±5.23	21.78±16.01	35.21±0.82	30.43±1.12
Plan two	64.11±5.31	22.65±16.08	35.19±1.02	31.53±1.38
t	10.102	10.023	2.734	10.431
p	0.001	0.001	0.839	0.001

4. Discussion

Brain tumor is a kind of common malignant tumor in clinic, which is also called intracranial tumor. However, as far as the current clinical technology is concerned, the therapeutic effect of brain tumor is not good. And surgical treatment cannot achieve good surgical effect, and it has the possibility of recurrent trouble, which has a great impact on the quality of the patient's life, and also poses a certain threat to life safety. At present, radiotherapy can be used to treat patients with brain tumors, which has a certain clinical therapeutic effect. However, different radiotherapy dose has different effects on the therapeutic effect of patients during the treatment process, and certain control is needed for the radiation dose.

Clinically, radiotherapy for patients with brain tumors can effectively prolong their life, and improve the quality of life. MR scanning has a high resolution. By using MR scanning, the tumor target area close to the skull and various soft tissues can be better delineated, which is convenient for doctors to observe the pathological changes around the skull and brain tissues of patients. But due to the lack of electronic density information, MR scanning technology cannot effectively calculate the radiation dose. By using CT images to scan the patient's skull and brain tissue, the dose of radiation therapy can be effectively determined. However, the continuous energy spectrum X-ray scanning will lead to radiation hardening of the skull during the scanning process, resulting in a certain cup-shaped artifact. Consequently, it makes the CT value inaccurate and reduces the accuracy of the electron density information, which is not conducive to determining the dose of radiation therapy [2].

Radiotherapy is to give sufficient dose distribution to the target tumor of skull and the soft tissues of various tissues, so as to minimize the radiation to the normal tissues around the target tumor of skull and the soft tissues, so as to obtain the best therapeutic effect. In the clinical treatment process, there will be some differences in the coverage change rate of the target area. It is because that certain dose tolerance is allowed during the radiotherapy treatment, so that the whole skull tumor target area and the soft tissues of various lesions can be completely covered. Generally speaking, the dose change rate should be controlled within 2%, so as to ensure that the normal tissues and organs around the skull tumor target area and the soft tissues of various lesions are not affected by the radiation dose, reduce the radiation damage to normal organs and tissues caused by radiation [3]. MR scanning is a relatively accurate scanning method at present. By scanning the patient's skull and brain tissue, it can effectively improve the resolution of soft tissue, facilitate doctors to delineate the target areas of skull tumor and various tissues, and improve the detection rate of skull and brain tissue lesions. However, the method lacks electron density information and cannot effectively calculate radiation doses. Therefore, the use of combined scanning with CT/MR can play a complementary role in clinical practice, which not only ensures the accuracy of scanning, but also effectively calculates the radiation dose [4]. During the research on the influence of skull and brain tissue CT/MR display difference on brain tumor radiotherapy dosimetry, it is impossible to accurately measure the radiotherapy dose. Therefore, CT scanning is needed for auxiliary measurement in the measurement process. In actual detection, CT scanning and MR scanning have complementary advantages, which can not only effectively ensure the accuracy of target areas, but also ensure the accuracy of radiotherapy after clearly observing the pathological changes of patients' tissues and organs [5]. In this study, the results of relevant data research are basically consistent with those of Li Yongheng's research on the influence of skull and brain tissue CT and MR display differences on brain tumor radiotherapy dosimetry [6]. It proves that the data results of this study have certain reference value.

In conclusion, CT/MR scanning of skull and brain tissues can effectively determine the radiation dose in patients with brain tumors, but there are certain differences in CT/MR imaging of skull and brain tissues, and different radiation doses have different effects. Therefore, it is clinically necessary to select the appropriate radiotherapy dose according to the patient's condition.

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