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A Research about Registration marker and method of esophageal cancer after CBCT scan. Registration marker and method of cancer

Ricerca sui marcatori e metodi di Registrazione del cancro esofageo dopo CBCT scan

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Summary

Aim. **To explore the 6D registration marker and method for patients with esophageal cancer after CBCT scan.** ***Materials and methods.*** **30 groups of CBCT images were acquired before IGRT and the corresponding planning CT images of esophageal cancer were chosen. We defined and contoured registration markers which would be used for 6D image registration. With the reference of manual match, bone match, grey value match, manual match and bone plus manual match were compared.** ***Results.*** **1) For patients with esophageal cancer, the application of registration marker could make the 6D registration before IGRT quick and precise; 2) Compared with manual match, two statistical differences in bone match and bone match plus manual match and 4 statistical differences in grey value match were present; 3) The coincidence rate of bone match plus manual was the highest, and the results of bone match and grey value match were similar; 4) The compared result of registration time: manual match> bone plus manual match>**

Riassunto

Finalità. **L'esplorazione del marcatore di registrazione 6D e del metodo del tumore esofageo dopo CBCT scan.** ***Materiali e metodi.*** **Per la comparazione sono stati acquisiti 30 gruppi di immagini ottenute con CBCT prima dell'IGRT ed è stato selezionato il corrispondente CT di immagini e materiale relativo al tumore esofageo. Abbiamo definito e circoscritto i marcatori di registrazione che sarebbero stati utilizzati per la registrazione di immagini 6D. Con l'aiuto della comparazione manuale, abbiamo messo a confronto campioni di ossa, di materia grigia e di ossa più la comparazione manuale.** ***Risultati.*** **1) Per i pazienti con tumore esofageo, l'applicazione di marcatori di registrazione era in grado di rendere veloce e precisa la registrazione 6D prima dell'IGRT; 2) In confronto alla comparazione manuale, abbiamo riscontrato due differenze statistiche nei campioni di ossa e ossa più comparazione manuale mentre erano 4 nel caso del campione di materia grigia; 3) Il tasso di coincidenza per il campione di ossa più comparazione manuale si è**

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grey value match> bone match. *Conclusions.* The registration of patients with esophageal cancer before IGRT needs registration marker. Bone match plus manual is the best registration method for registration time and accuracy. Eur. J. Oncol., 17 (3), 135-139, 2012

dimostrato il più alto, mentre il risultato di campioni di ossa e di materia grigia era simile; 4) Il risultato di comparazione del tempo di registrazione: comparazione manuale> campione di ossa più comparazione manuale> campione di materia grigia> campione di ossa. *Conclusioni.* La registrazione di pazienti con tumore esofageo prima dell'IGRT necessita del marcatore di registrazione. Il campione di ossa più comparazione manuale è il miglior metodo di registrazione considerato il tempo di registrazione e la precisione.Eur. J. Oncol., 17 (3), 135-139, 2012

Key words: **esophageal carcinoma, IGRT, Registration**

Parole chiave: **carcinoma esofageo, IGRT, Registrazione**

Introduction

Image-guided Radiotherapy (IGRT), allows tumor tissue to receive more targeted treatment, while normal tissues are better protected (1,2). The registration of Cone Beam Computed Tomography (CBCT) images and planning CT images is one of the most important things at the step of correcting setup errors before therapy (3, 4). Only the correct registration is able to measure and rectify the setup errors (5). For specificity of the registration of esophageal cancer, our research focused on the registration marker and method for patients with esophageal cancer.

Patients and methods

General data

From July 2008 to January 2009, patients with esophageal cancer who received Three Dimensional Conformal Radiotherapy (3DCRT) and Intensity Modulated Radiotherapy (IMRT) were treated with the Elekta Synergy image-guided treatment system. All patients received kilovoltage cone beam computed tomography (kV-CBCT) with 6MV X-ray; 30 groups of the CBCT images were acquired before IGRT and the corresponding planning CT images of esophageal cancer were chosen. Due to greater mobility, we excluded the patients with disease at the inferior esophagus. Considering the difficulties in registration since the target area of esophageal cancer were different, we searched for registration marker to register more quickly and accurately in the X, Y, Z axises translation direction and U (around X axis rotation), V (around the Y axis rotation), W (around the Z axis rotation) rotation direction (namely around the X, Y, Z axis rotation), which may also be called 6 degrees of freedom (6D) registration. Therefore we choosed bone and canalis vertebralis landmarks behind the target as registration markers. In our study we estimated the displacement on left/right direction (the X axis), front/back direction (the Z axis) through the vertebral location, and up/down direction (the Y axis) through spinous process location. Moreover the rotation deviations on U, V, W axises were measured through the location of canalis vertebralis and vertebral body beside on rotating sagittal plane, transverse section and coronal plane.

Measurements method

The bone match, grey value match, manual match and bone plus manual match were studied by the authors. Disagreements will be solved by majority vote and, if necessary, by a third review author. Manual match was adjusted by translation and rotation to check the curvature tolerance of tumor target and bony landmarks on planning CT and CBCT images. This process has required the judgment of two physicians. Because this registration method was

operated by physicians and macroscopically fitted, it was regarded as baseline standard for comparison, and other registrations were research objects.

Statistical analysis: we used SPSS13.0, and the method of registration was the paired Student's t-test.

Results

Registration marker

For more accurate judgment of the registration, we choosed registration marker as a reference standard. 6D registration markers of esophageal cancer were vertebral on left/right direction (the X axis) and front/back direction (the Z axis), spinous process at up/down direction (the Y axis). Moreover the rotation deviation on U, V, W axises were measured through the location of canalis vertebralis and vertebral body beside on rotating sagittal plane, transverse section and coronal plane. We verified that targets were in alignment after the registration of these markers. For the purpose of convenience, we contoured registration markers on the planning CT with CBCT bone window (window width was 690 and window level was 781). Then, corrected markers revealed by CBCT images, were acquired through X-ray Volumetric Images (XVI) software. With such methods, we could register more rapidly and accurately before IGRT (Fig.1-2).

Difference of registration markers and methods compared with manual match

The differences are listed in the tables 1 and 2.

Compared with manual match, there were two statistical differences in bone match and bone match

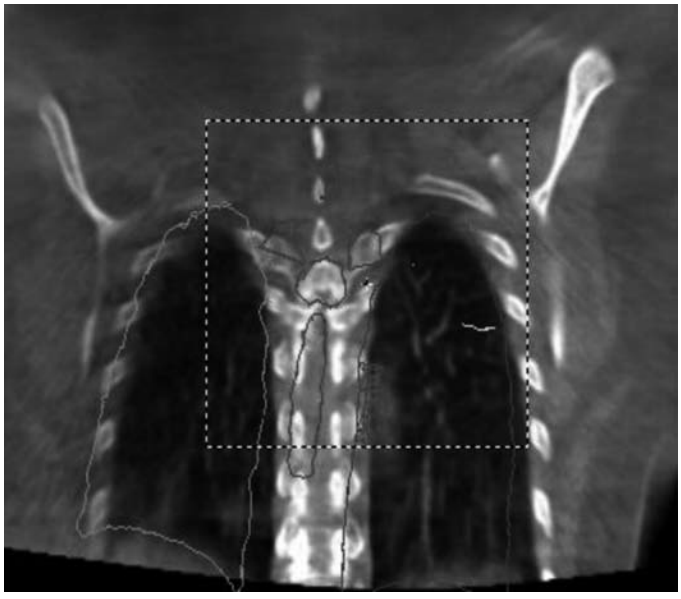

Fig. 1. Before registration of W rotation

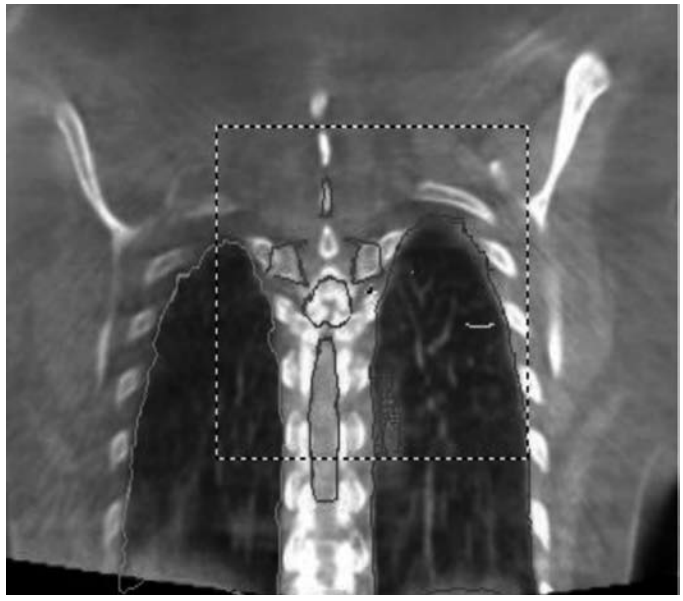

Fig. 2. After registration of W rotation

Table 1 - The data of various registration methods

Methods	Translation (mm)			Rotation (degree)		
	X axis	Y axis	Z axis	U	V	W
Ma	-2.33±0.1	0.42±0.4	-0.13±0.3	1.69±1.43	-0.88±0.7	-0.59±0.84
B+Mb	3.80±0.2	0.41±0.3	-0.17±0.3	1.75±1.37	-0.55±0.9	-0.35±0.93
Bc	0.12±0.1	0.38±0.3	-0.15±0.2	1.51±1.65	-0.35±1.5	-0.38±0.90
Gd	7.20±0.1	0.31±0.3	-0.19±0.2	1.42±1.35	-1.11±1.1	-0.10±0.90

Ma=manual match, B+Mb=bone match plus manual match, Bc=bone match, Gd=grey value match

Table 2 - Statistical results of the paired Student's t-test of various registration methods

Methods	Translation			Rotation		
	X axis	Y axis	Z axis	U	V	W
B+Mb vs Ma	P=0.047	P=0.771	P=0.418	P=0.730	P=0.029	P=0.129
Bc vs Ma	P=0.000	P=0.360	P=0.701	P=0.465	P=0.048	P=0.181
Gd vs Ma	P=0.001	P=0.004	P=0.216	P=0.048	P=0.189	P=0.004

Ma=manual match, B+Mb=bone match plus manual match, Bc=bone match, Gd=grey value match

Table 3 - Comparison of the coincidence rate of registration methods

Methods	Translation			Rotation			Men
	X axis	Y axis	Z axis	U	V	W	83.3%
B+Mb	93.3%	83.3%	86.7%	80%	90%	80%	85.55%
Bc	76.7%	80%	76.7%	50%	83.3%	80%	74.45%
Gd	83.3%	46.7%	80%	86.7%	83.3%	66.7%	74.45%

Ma=manual match, B+Mb=bone match plus manual match, Bc=bone match, Gd=grey value match

plus manual match and there were 4 statistical differences in grey value match.

The range of the differences of various registration methods

As shown in Table 3, based on manual match, we compared the differences between other registration methods and manual match respectively, and supposed a very good agreement if the value for the difference was <2 mmin in translation direction, or <1° in rotation direction. The coincidence rate was specified as the number of matched cases and the proportion of the total number of cases.

The coincidence rate of bone match plus manual was the highest, and the results of bone match and grey value match were similar. However, in bone match the cases of the difference >1° in U rotation direction were a big part of it; on the contrary in grey value match were shown the cases of the difference >2 mm in translation direction.

Comparison of registration time

Manual match: 6-10 minutes, bone match plus manual match: 1-5 minutes, grey value match: 45 seconds-1.5 minutes, bone match: 30-50 seconds. We compared the result of registration time: manual match> bone match plus manual match> grey value match> bone match.

Discussion

The first step of radiotherapy was setup, then we had to move patients to accurately accommodate the target center to the planning isocenter, besides the centre of tumor on patient, machine and plan target reached in agreement (6). In this step, the geometric deviation of targets on patients and plan manifested itself in X, Y, Z translation direction and U (around X axis rotation), V (around the Y axis rotation), W (around the Z axis rotation) rotation direction (7, 8). The previous machine could adjust in the means of translation on the X, Y, Z axises, and only adjusted artificially in two axises but not three axises in rotating aspects. This problem was really solved after the advent of 6D treatment couch with image-guided treatment system.

Along the spine, esophagus is as long and curving as spine, which leads to that up-and-down planes display forward or backward in spite of the registration of a cross-section. So we have to check the 3D deviation of the cross-section as well as the corresponding sections. As the boundary of tumor on volume CT is obscure, it is hard to be confirmed

(9,10), so a clear marker for registration of esophageal cancer must be present. Considering esophageal cancer on the whole walk along and alongside vertebral bodies which has higher definition on CBCT, we regarded vertebral body as registration marker of cross-sectional. However the length of vertebral bodies is limited which means that we have to make use of canalis vertebralis as marker on head/foot direction as well, which was also clearly displayed on CBCT. Moreover we outlined spinous process for checking the up-and-down sections. So we estimated the displacement on left/right direction (the X axis) and front/back (the Z axis) through the vertebral location, up/down direction (the Y axis) through spinous process location. Moreover the rotation deviation on U, V, W axises were measured through the location of canalis vertebralis and vertebral body beside on rotating sagittal plane, transverse section and coronal plane. This method was tested and clinically verified for practical use. With the marker, we could more rapidly and accurately register.

Registration form includes manual and automatic match which is divided into bone match and grey value match. Although the two methods were feasible, they are still suboptimal. Since manual match is operated by physicians for consistence of CBCT images and planning images, it is supposed to be the best registration. However, due to its character of time-consuming, it has not been widespreadly used in clinic. With reference to manual match, we compared with bone match, grey value match, manual match and bone plus manual match. Comparison of the differences of such four methods indicated that, two statistical differences were present in bone match and bone match plus manual match at aspects of translation on X axis and V rotation direction, and that 4 statistical differences in grey value match and manual match were also present. The results showed that there were larger deviations in grey value match, while bone match and bone with manual match were similar. Due to the range of deviation as an important influence factor in the accuracy of treatment, we compared deviation of methods with reference to manual match. The coincidence rate of bone match plus manual was the highest, and the results of bone match and grey value match were similar. Based on time-consuming, we could range these methods chronologically: manual match> bone match plus manual match> grey value match> bone match. Together with contouring registration markers, bone match plus manual is the best registration method for registration time and accuracy. Due to greater mobility, 3DCRT and IMRT have not been widely used in people with disease at inferior esophagus, so we excluded such patients. Method for registration of disease in inferior esophagus needs further study.

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