COMPARE ^{18}FDG-PET/CT SIMULATION AND CT SIMULATION IN THE 3D CONFORMAL RADIATION THERAPY ON THE PATIENTS WITH ESOPHAGEAL CANCER

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SUMMARY

Objectives: To compare the technical parameters of the radiotherapy plan using ^{18}FDG PET/CT simulations to the plan of using CT simulation in 3D conformal radiation therapy in patients with esophageal cancer. Subjects and methods: A prospective clinical interventional study was performed on 22 patients who were diagnosed with esophageal cancer and were indicated radiotherapy at Cancer Center, 103 Military Hospital from January 2017 to July 20118. Results: The length of primary tumors on ^{18}FDG PET/CT was 7.94 ± 3.74 cm, it was 8.80 ± 3.36 on CT with p = 0.029. Compared to CT simulation, ^{18}FDG PET/CT reduced primary tumor length in 59.09% of patients and increased primary tumor length in 40.91% of patients. ^{18}FDG PET/CT increased the number of lymph nodes in 50% of patients and decreased in 27.27% of patients; 22.73% of the patients had the same number of lymph nodes. The overall average of cumulative radiation in the nodes on ^{18}FDG PET/CT was 35.00 ± 39.25 cm^3, it was 16.48 ± 18.16 cm^3 on CT with p = 0.009. V40 of both lungs on the plan of using^{18}FDG PET/CT simulations was 4.82 ± 3.32%; the plan of using CT was 3.59 ± 1.90 with p = 0.041. Conclusion: The application of ^{18}FDG PET/CT simulations in 3D conformal radiation therapy help to determine the volume of tumor and lymph nodes more accurately than CT and should be routinely applied in esophageal cancer radiotherapy.

** Keywords: Esophageal cancer;^{18}FDG PET/CT simulation; 3D conformal radiotherapy.*

INTRODUCTION

In the treatment of esophageal cancer, radiation therapy is an important and effective method. 3D conformal radiotherapy is a modern technique that allows to concentrate high doses of radiation in the tumor and minimizes the dose of radiation to the surrounding healthy organs. To achieve this target, it is required to determinate accurately the volume of radiation therapy. Many domestic and foreign studies show that ^{18}FDG PET/CT is more sensitive than CT to detect tumors and lymph nodes in patients with esophageal cancer, thus helping to identify major radiotherapy volumes more accurately.

In Vietnam, there have been several studies on the application of ^{18}FDG PET/CT simulation in the plan of radiotherapy for esophageal cancer by Nguyen Van Chau and Bui Quang Bieu [1]. However, the application of ^{18}FDG PET/CT simulations in radiation therapy for esophageal cancer is limited. To evaluate the value of ^{18}FDG PET/CT in the plan of radiotherapy for esophageal cancer, we conducted this study aiming:

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SUBJECTS AND METHODS

1. Subjects.

22 patients were diagnosed with esophageal cancer and had radiotherapy indication at Cancer Center, 103 Military Hospital from January 2017 to July 20118.

** Inclusion criteria:*

- Patients diagnosed with esophageal cancer who had radical radiotherapy indication.

- Patients were treated for the first time.

- Patients agreed to participate in the study.

** Exclusion criteria:*

- Weak general condition: PS score 3 - 4.

- Patients with esophageal cancer had combined severe diseases.

- Esophageal cancer with complications: Esophageal fistula, gastrointestinal bleeding...

- Metastatic cancer to the esophagus: Lower throat cancer, lung metastatic cancer to the esophagus.

- Patients whose research parameters were not collected sufficiently.

- Patients with a history of allergy to contrast medium.

2. Methods.

A prospective, clinical, intervention study was performed on patients with esophageal cancer who had radiotherapy indication were simulated CT and ^{18}FDG PET/CT simulations. Two radiologists determined the radiotherapy volumes on two imaging systems CT simulation and ^{18}FDG PET/CT simulation. Conducting two independent radiotherapy plans and comparing two plans about radiotherapy parameters into tumors, radiotherapy parameters into lymph nodes and absorbed dose in healthy organs. The data was processed by SPSS software 20.0

RESULTS AND DISCUSSION

Table 1: Compare the number of tumor lesions.

The length of primary tumor was determined on ^{18}FDG PET/CT simulations and CT simulations.

Method	Number of tumor lesions	Number of patient (n = 22)	Percentage (%)
^{18}FDG PET/CT	1 lesion	19	86.38
	2 lesions	3	13.62
	Total	22	100
CT	1 lesion	21	95.46
	2 lesions	1	4.54
	Total	22	100

One primary lesion was detected by CT in 21 patients accounting for 95.46% and only 1 patient had 2 primary lesions, accounting for 4.54%. ^{18}FDG PET/CT detected 2 patients with 2 primary lesions. The second minor tumor lesions (10 mm and 15 mm), without significant morphologic changes were missed on CT. ^{18}FDG PET/CT provides both anatomical and metabolic imaging that allows to detect malignant lesions even without significant morphological changes. Nkhali L et al (2011) showed that ^{18}FDG PET/CT can detect the malignant lesions of the esophagus at T1 stage [2].

Table 2: Changes in tumor length determined on ^{18}FDG PET/CT simulation compared to CT simulation.

<table>
<tr><th colspan="2">Method</th><th colspan="3">The length of primary tumor (cm) (n = 22)</th><th>p</th></tr>
<tr><td colspan="2">^{18}FDG PET/CT</td><td colspan="3">7.94 ± 3.74</td><td rowspan="2">0.029</td></tr>
<tr><td colspan="2">CT</td><td colspan="3">8.80 ± 3.36</td></tr>
<tr><td colspan="6">Changes in tumor length determined on ^{18}FDG PET/CT simulation compared to CT simulation</td></tr>
<tr><td colspan="2">Increase</td><td colspan="2">Decrease</td><td colspan="2">Unchange</td></tr>
<tr><td>n</td><td>%</td><td>n</td><td>%</td><td>n</td><td>%</td></tr>
<tr><td>9</td><td>40.91</td><td>13</td><td>59.09</td><td>0</td><td>0</td></tr>
<tr><td colspan="6">Reduction in tumor length on^{18}FDG PET/CT simulation compared to CT simulation</td></tr>
<tr><td colspan="2">Method</td><td colspan="3">The length of primary tumor (cm) (n = 13)</td><td>p</td></tr>
<tr><td colspan="2">^{18}FDG PET/CT</td><td colspan="3">6.38 ± 2.39</td><td rowspan="2">0.000</td></tr>
<tr><td colspan="2">CT</td><td colspan="3">10.35 ± 3.50</td></tr>
</table>

The tumor length determined on ^{18}FDG PET/CT was 7.94 ± 3.74 cm, smaller than that on CT simulation at 8.80 ± 3.36 cm, the difference was statistically significant with p = 0.029. Compared to CT simulation, ^{18}FDG PET/CT reduced the length of tumor in 13 patients, accounting for 59.09%, increasing the length of tumor in 9 patients accounted for 40.91%. Among 13 patients who had a decrease in tumor length compared to CT, the length of tumor on ^{18}FDG PET/CT was 6.38 ± 2.39 cm, it was 10.35 ± 3.50 cm on CT, the difference was statistically significant with $p < 0.05$. This difference is very significant in the practice of radiation therapy to reduce the length of the radiation field, minimize the damage to surrounding institutions. According to Konski et al (2005), the average length of primary esophagus tumor determined on CT was 6.77 cm, while it was 5.4 cm on ^{18}FDG PET/CT [3]. Nguyen Dinh Chau (2018) conducted a study on 22 patients with 1/3 upper esophageal cancer showed that the average tumor length on ^{18}FDG PET/CT was 5.6 ± 1.8 cm, less than on CT at 6.3 ± 1.7 cm with p = 0.03 [1].

Table 3: Changes in tumor volume determined on ^{18}FDG PET/CT simulation compared to CT.

Primary tumor volume change on ^{18}FDG PET/CT simulation compared to CT					
Increase		Decrease		Unchange	
n	%	n	%	n	%
9	40.90	13	59.1	0	0
Reduction in tumor volume on ^{18}FDG PET/CT simulation compared to CT					
Method	Gross tumor volume (GTV) (cm^3) (n = 13)				p
^{18}FDG PET/CT	53.88 ± 44.50				0.008
CT	81.62 ± 56.62				

Compared to CT simulation, ^{18}FDG PET/CT simulation decreased gross tumor volume in 13 patients (59.1%), but increased in 9 patients (40.9%). Of the 13 patients with tumor size on ^{18}FDG PET/CT smaller than CT, the mean GTV determined on ^{18}FDG PET/CT was 53.88 ± 44.50 cm^3, it was 81.62 ± 56.62 cm^3 on CT, the difference was statistically significant with p = 0.008. With this difference, the plan to use ^{18}FDG PET/CT helped to reduce the volume of irradiation in the esophagus compared to conventional CT.

This finding was consistent with the results of some authors in the world according to Moureau in 2005, ^{18}FDG PET/CT reduced volume in 35% of patients compared to CT. According to Leong T (2006), ^{18}FDG PET/CT changed the radiation volume in 38% of patients [5].

Table 4: Change in the number of lymph nodes identified on ^{18}FDG PET/CT simulation compared to CT.

Change the number of lymph nodes identified on ^{18}FDG PET/CT simulation compared to CT					
Increase		Decrease		Unchange	
n	%	n	%	n	%
11	50	6	27.27	5	22.73
^{18}FDG PET/CT simulation detect more lymph nodes compared to CT					
Method	Number of lymphnode lesions (n = 11)				**p**
^{18}FDG PET/CT	3.63 ± 1.12				0.000
CT	1.72 ± 1.00				

In this study, we found that compared to CT, ^{18}FDG PET/CT increased lymph node numbers in 11 patients (50%), reduced in 6 patients (27.27%). There were 5 patients with the unchanged number of lymph nodes (22.73%). Among the 11 patients with an increase in lymph node numbers, the average number of lymph nodes detected on ^{18}FDG PET/CT was 3.63 ± 1.12 nodes, it was 1.72 ± 1.00 nodes on CT with $p < 0.05$.

This was a statistically significant difference indicating that ^{18}FDG PET/CT is more likely to detect lymph nodes than CT. According to Theodore S.H et al (2008), ^{18}FDG PET/CT can detect lesions with the size < 10 mm [6].

Table 5: Changes in lymph node volume of ^{18}FDG PET/CT simulation compared to CT.

Method		**Total volume of lymph node (cm^3) (n = 22)**			**p**
^{18}FDG PET/CT		35.00 ± 39.25			0.009
CT		16.48 ± 18.16			
Changes in lymph node volume of ^{18}FDG PET/CT simulation compared to CT					
Increase		Decrease		Unchange	
n	%	n	%	n	%
16	72.73	6	27.27	0	0
Increasing in lymph node volume of ^{18}FDG PET/CT simulation compared to CT					
Method	Total volume of lymph node (cm^3) (n = 16)				p
^{18}FDG PET/CT	44.19 ± 41.96				0.002
CT	17.05 ± 20.87				

The average total volume of lymph nodes determined on ^{18}FDG PET/CT was 35.00 ± 39.25 cm^3, it was 16.48 ± 18.16 cm^3 on CT. The difference was statistically significant with p = 0.009. This result is consistent with the fact that ^{18}FDG PET/CT detect more lymph nodes than CT. The ^{18}FDG PET/CT simulations increased the volume of radiotherapy into lymph nodes in 16 patients (72.73%), reduced in 6 patients (27.27%). Of the 16 patients, with a total lymph node volume on ^{18}FDG PET/CT bigger than CT. The average total volume determined on ^{18}FDG PET/CT was 44.19 ± 41.96, it was 17.05 ± 20.87 on the CT, this difference was statistically significant with p = 0.002.

Table 6: Comparison of ^{18}FDG PET/CT and CT on absorbed dose in healthy organ.

Method	**Average dose at two lungs (Gy) (n = 22)**	**p**
^{18}FDG PET/CT	13.69 ± 3.47	0.349
CT	13.15 ± 3.28	
	V40: The volume of two lungs received 40 Gy (%) (n = 22)	
^{18}FDG PET/CT	4.82 ± 3.32	0.041
CT	3.59 ± 1.90	
	Average dose at heart (Gy) (n = 22)	p
^{18}FDG PET/CT	15.06 ± 7.60	0.609
CT	14.28 ± 5.24	
	Average dose at spinal cord (Gy) (n = 22)	p
^{18}FDG PET/CT	21.87 ± 9.93	0.448
CT	22.58 ± 9.75	

On the radiotherapy plan of using ^{18}FDG PET/CT simulation, the average dose in the both lungs was 13.69 ± 3.47 Gy, at the heart and spinal cord, it was 15.06 ± 7.60 Gy and 21.87 ± 9, 93 Gy; on the plan of using CT simulation, this figure was 13.15 ± 3.28 Gy, 14.28 ± 5.24 Gy and 22.58 ± 9.75, respectively with $p > 0.05$. This difference was not statistically significant, the absorbed dose in healthy organs in both plans was in accordance with the guidelines of the NCCN and ICRU. However, V40 of both lungs on the plan of using ^{18}FDG PET/CT simulation was higher than the plan of using CT. The difference was statistically significant with $p = 0.041$. This recommends radiotherapy in clinical practice, when using ^{18}FDG PET/CT simulations to prevent and monitor adverse effects in the lung.

CONCLUSION

The ^{18}FDG PET/CT simulations helps to determine the correct volume of therapy compared to CT simulations, particularly the length of the tumor and the radiotherapy volume of lymph node. The length of primary tumor determined on ^{18}FDG PET/CT was 7.94 ± 3.74 cm, shorter than that on CT with $p = 0.029$. Compared to CT simulation, ^{18}FDG PET/CT simulation reduced tumor volume in 59.09% of patients. ^{18}FDG PET/CT increases the number of lymph nodes in 50% of patients compared to CT. The total lymph node volume determined on ^{18}FDG PET/CT was 35.00 ± 39.25 cm^3, it was 16.48 ± 18.16 cm^3 on CT with $p = 0.009$. ^{18}FDG PET/CT simulations increased the volume of radiotherapy into lymph nodes in 72.73% of patients. On the plan of using ^{18}FDG PET/CT simulation, the volume of two lungs received 40 Gy was 4.82 ± 3.32%, higher than the plan of using CT at 3.59 ± 1.90 with $p = 0.041$.

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