Influence of FDG/PET CT image registration and fusion on the anal canal carcinoma target volume delineation

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SUMMARY

The best option for treatment of anal cancer is chemoirradiation. FDG-PET detects the primary tumor and metastatic involved lymph nodes better and more frequently than CT only. During last decade, fusion of different imaging modalities became important factor in radiotherapy treatment planning. Patient was diagnosed for squamous cell carcinoma by colonoscopy and FDG/PET followed by histopathological confirmation. A precise determination of target volume is very important in radiotherapy. In recent years higher utilization of FDG-PET CT fusion in radiotherapy treatment planning of anal cancer is recorded. Image registration and fusion between CT for radiotherapy treatment planning and FDG PET can help better visualization and especially in the determination of boost target volume. We observed much better detection of affected lymphatics by the data obtained by image co-registration of PET and CT data. This fact allowed us to increase dose prescribed to tumor and affected lymph nodes. PET is very important imaging modality for patients with anal canal cancer. FDG-PET has proved to be important tool for the radiotherapy treatment planning of anal canal carcinoma

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INTRODUCTION

Anal cancer is a rare malignancy and 5-year survival rate is approximately 60%. During last decade, an increased incidence of patients with anal canal carcinomas was recorded. Incidence of anal canal carcinoma in developed countries is about 0.5-1 cases on 100 000 inhabitants per year (1, 2). In Serbia, incidence of anal canal carcinoma is approximately 0.5-1.3 (3, 4). The best option for treatment of anal cancer is chemoirradiation. Two most important prognostic factors are tumor size and nodal status associated with TNM classification. However, staging of the primary tumor and nodal status are essential for the treatment decision. Due to the fact that the radiotherapy plays crucial role in the treatment of anal canal carcinoma, the precise visualization and delineation of target volumes is required (5, 6). 3-D conformal radiotherapy and intensity modulated radiotherapy (IMRT) use CT imaging for isodose calculation and treatment planning. In the last decade, fusion of different imaging modalities became important factor in treatment planning. Advantage of fusion of multiple modalities in radiotherapy was also implemented in our clinic. Image registration and fusion can be done between CT and MRI, CT and US and in past several years CT and PET. Recently, the use of PET in oncology is increasing rapidly. PET imaging is primarily functional rather than structural, also useful in staging, identification of regional and distant metastases and it is very important for radiotherapy treatment planning (7-9). CT, MRI, and WE detect abnormalities based on anatomical changes, and on the other side, PET is different and it detects glucose metabolism in three dimensions (5). FDG-PET detects the primary tumor and metastatic involved lymph nodes better and more frequently than CT do. As we have mentioned, in radiotherapy treatment process CT data are used to delineate the target volumes. The first region defines a gross tumor volume (GTV), this volume indicates macroscopically noticeable tumor. Furthermore, GTV is expanded to obtain a clinical target volume (CTV), indicating possible microscopic tumor spread. The CTV is further added the variable margin to account of patient and organ movement, and setup errors to provide the planning target volume (PTV) (9).

This case report analyzes the benefits of PET-CT fusion in the delineation of boost target volume. PET is very important in determining the stage of the disease but is known to be increasingly used in radiotherapy.

CASE REPORT

Patient was diagnosed for anal canal squamous cell carcinoma by colonoscopy and FDG-PET followed by histopathological confirmation.

FDG-PET-CT hybrid scans were performed by (Biograf 64 True- D SIEMENS). Patient in supine position was immobilized with the thermoplastic mask (Civco), and with knee and ankle supporting cushions (Civco), to improve the reproducibility and keep patient still in the same position at each treatment session. All PET patients were advised to fast for at least 6 hours prior to FDG-PET examination. After injection of FDG, patient rested for a period of about 1 hour. Emission images ranging from the proximal femur to the base of scull were acquired for 3 to 4 minutes per bed position.

Treatment planning CT was obtained by Siemens Somatom Plus. The position of a patient was identical to the one at the PET procedure, using the same immobilizing equipment. The distance between slices was 5 mm, as well PET images. Both imaging modalities were imported into XIO (Elekta) treatment planning system, v 4.62. Using software tools to improve visualization of PET images, automatic rigid fusion, and registration of both modalities was performed, and manual correction was applied.

PET imaging, on performed PET-CT image registration, showed FDG focus along the anal canal and sphincter, which was 19.50 SUV maximal level. In addition, 3.63 SUV maximal level in the group of superficial right inguinal lymph nodes was observed. Oncologic multidisciplinary commission decided that patient should be treated with chemoirradiation protocol.

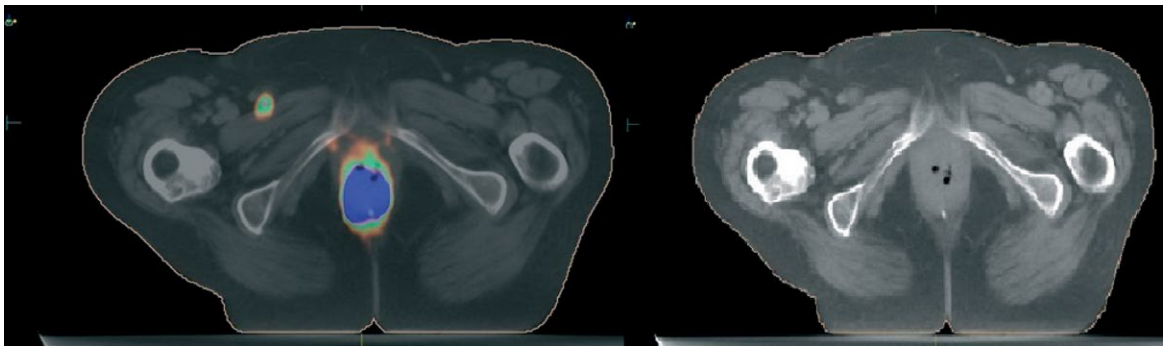


Figure 1a. PET CT fusion and image registration vs CT data only

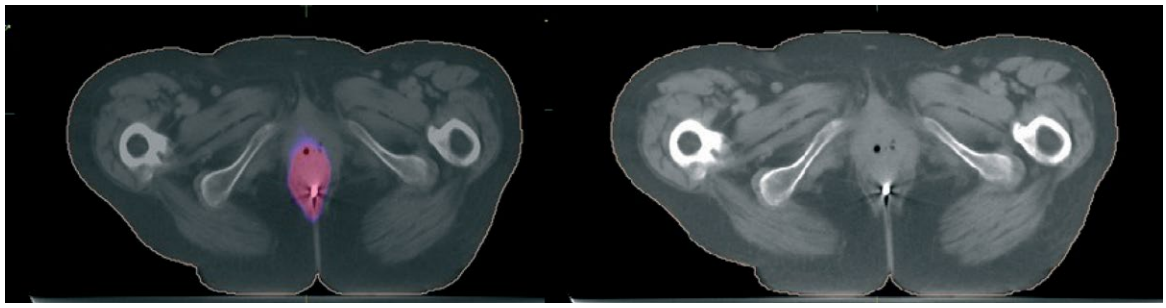


Figure 1b. In this figure, we can see the difference in the data of primary tumor only of anal canal between FDG PET and CT. On the left side of the figure is image fusion PET-CT and on the right only CT imaging

To be able to better determine the GTV, we have decided to take advantage of PET CT fusion and image registration. In figure 1a, we see the comparison of tumor and lymph node data obtained by fusion of FDG-PET (left side) and CT for radiotherapy planning and data obtained only from CT for radiotherapy planning (right side).

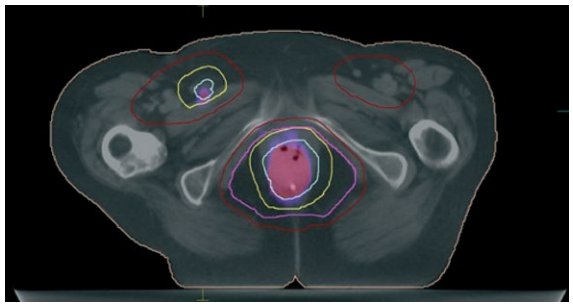


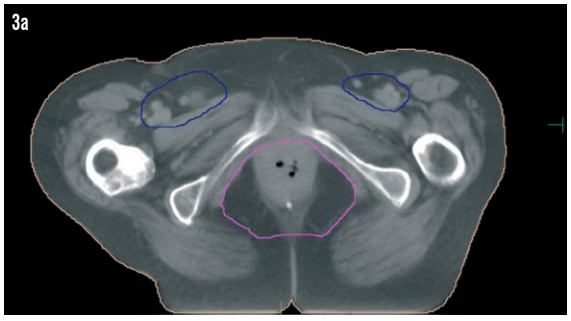
Figure 2. Dose prescribed to tumor and affected lymph nodes (boost- yellow line)

DISCUSSION

A precise determination of target volume is very important in radiotherapy (8,10,11,12). With the help of image registration and fusion of different imaging modalities, we can more accurately determine the target volume than with CT only. It is shown that using CT-MRI fusion leads to easier and better determination of target volume of head and neck tumors and endocranial tumors as well as tumors of the pelvis (13-15). In Figure 1a, we see an increased metabolic activity, which indicates the existence of a primary carcinoma of the anal canal, and primary cancer and the presence of lymphatic metastases in the right inguinal region can be seen. Many authors indicate the benefits of using PET in the diagnosis and staging of anal carcinoma. Also very important is good visibility of the FDG-PET imaging so that it can be of great help in radiotherapy treatment planning (9). Figure 1b visualizes the another cross-section in axial view: with and without PET-CT fusion. We see undefined and blurred boundaries of the primary tumor, and on the other hand, clear and precise data obtained with FDG-PET CT image registration. In addition, we observe much better detection of affected lymphatics with the data obtained by image co-registration of PET and CT data (Figure 1a). This fact allows us to increase dose prescribed to tumor and affected lymph nodes (yellow line on the Figure 2). Figure 3a and 3b shows clearly the difference between the CT based delineated contours without the PET data used for treatment planning (left), and CT based contours with the PET data fused (right). In this case- without PET data, the patient reported would have different contours (Figure 3a) and doses prescribed, but using image fusion, clinically used contours were as presented on Figure 3b. This is recommended by many authors because the presence of inguinal node metastasis leads to dose increase to the boost volume (10).

In recent years higher utilization of FDG-PET CT fusion in radiotherapy treatment planning of anal cancer is recorded (5, 10). Image registration and fusion between CT for radiotherapy treatment planning and FDG PET can help better visualization and especially in the determination of boost target volume. According to the recommendations for the delineation of target volumes for anal canal cancer, we performed delineation of bilateral inguinal, external and internal iliac, perirectal, and presacral lymph nodes. The lymph nodes listed received 45 Gy in 25 daily fractions (5, 6). Boost volume marked with a yellow line in Figure 2 (primary tumor and affected LGL) received 9 Gy-14. 4 Gy in 5-8 fractions. Because of the presence of tumor cells in involved lymph nodes, they require higher radiation dose than in case of elective lymph node irradiation (6, 11). For treatment purposes, PTV was obtained by 10 mm symmetric expansion of CTV taking into

account setup uncertainties and organ motion. The GTV with symmetric expansion of 10 mm was used as a volume for boosting macroscopic disease. However, precise visualization and detection of affected lymphatics by FDG PET-CT image co-registration assisted us in delineation of boost volumes of the primary tumor and affected inguinal lymph nodes from the right side. In addition, the data obtained with PET lead to a change and correction of radiotherapy plan. Consequently, dose to the affected lymph nodes increased. Many authors agree that the registration of PET-CT is very useful in determination of the target volume in radiotherapy treatment planning (5, 6, 10, 12). Without FDG-PET imaging data, in this case, the precise determination of boost target volumes would be complicated and difficult. Precise determination of the target volume is the key issue in radiotherapy. In this case, the affected inguinal lymph nodes probably would not be determined without PET-CT. Two affected lymphatics from the right *inguinum*, without the possibility of fusion diagnostic FDG-PET and CT for radiotherapy treatment planning could not be detected; consequently, delivered dose would be inadequate. Furthermore metastatically involved lymph nodes in right *inguinum* would receive 45 Gy in 25 fractions which would be enough for elective irradiation of lymph nodes but not for involved lymph nodes, which had to be covered with higher dose (54 Gy) (6, 11).



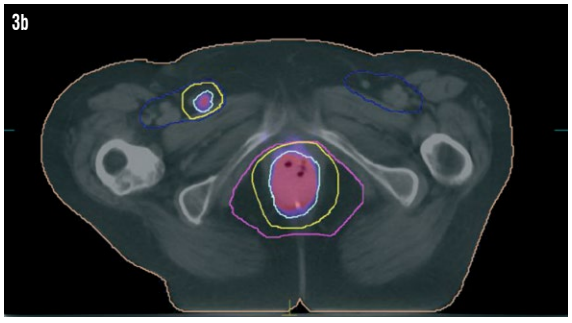


Figure 3. Difference between the CT based delineated contours without the PET data used for treatment planning (Figure 3a), and CT based contours with the PET data fused (Figure 3b)

CONCLUSION

FDG-PET is useful for detection of locally advanced disease. PET imaging can successfully detect lymph node metastases superiorly to CT, as shown in this case report (Figures 1a, 1b, 3a, 3b). However, advantages of the successful fusion and image registration between FDG PET and CT for conformal radiotherapy can be used in radiotherapy. PET is very important imaging modality for patients with anal canal cancer. FDG-PET has proved to be important tool for the radiotherapy treatment planning of anal canal carcinoma in cases like the one described.

Conflict of interest

We declare no conflicts of interest.

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