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Additive value of ^{18}FDG-PET/CT to positive ^{131}I whole body scan in recurrent differentiated thyroid cancer patients with potential influence on treatment strategy: single Egyptian center experience

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Abstract

Background: Years ago the utility of of^{18}F-fluorodeoxyglucose-positron emission tomography/computerized tomography (^{18}FDG-PET/CT) in differentiated thyroid cancer was confined mainly to cases with elevated serum thyroglobulin and negative ^{131}I whole body scan. In this study, we try to assess the diagnostic performance of ^{18}FDG-PET/CT in recurrent differentiated thyroid cancer patients with positive ^{131}I whole body scan and in addition to evaluate the impact of ^{18}FDG-PET/CT on the treatment strategy.

Results: The ^{18}FDG PET/CT detected tumor recurrence in 35 (81.3%) patients most of them (91.4%) were in stage IV, while the rest 8.5% was in stage III. No recurrence was detected among patients in stage II and III by ^{18}FDG PET/CT.

Regarding lesion-based analysis, sensitivity of ^{18}FDG-PET/CT was superior to that of ^{131}I post-therapeutic whole body scan (TxWBS) (78.2% vs. 69.4%, respectively), while both modalities had the same specificity (50%). ^{18}FDG-PET/CT changed the treatment plan in 18 (41.6%) patients.

Conclusion: ^{18}FDG-PET/CT may be complementary to ^{131}ITxWBS in high-risk DTC with impact on treatment strategy.

Keywords: The ^{18}FDG PET/CT, DTC, ^{131}ITxWBS, Serum Tg, ^{131}I avid

Background

Thyroid cancer is a common head and neck malignancy and also it is the most common endocrine tumor in the body [1–3]. The incidence of thyroid cancer has rapidly increased in the USA and other developed countries over the past 30 years [4–7]. From 1975 to 2009 there was a three-fold increase in incidence rates, from 4.9 to 14.3 per 100,000 individuals [6, 8]. Papillary thyroid carcinoma (PTC) and follicular thyroid carcinoma (FTC) are collectively classified as DTC and account for at least 94% of thyroid carcinoma [9]. Both have an excellent prognosis, with a 20 years survival of 90%–95% and 75%, respectively [10]. The postoperative recurrence rate of thyroid cancer is up to 23–30% [11–16]. The most effective therapeutic strategies for differentiated thyroid carcinoma (DTC) are thyroid surgery (total or near-total thyroidectomy) followed by iodine-131 (^{131}I) ablation [17]. ^{131}I therapy is not only appropriate for primary tumors but also for lymph node (LN) and distant metastases [18, 19]. However, therapeutic strategies should be more cautiously refined [20].

The role of ^{18}F-fluorodeoxyglucose-positron emission tomography/computerized tomography (^{18}FDG-PET/

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CT) starts with the development of metastatic diseases, which are not responsive to radioiodine therapy anymore. FDG accumulates in tumor lesions that are missed by iodine scintigraphy [21–23]. Loboulleux et al. in their study concluded that in patients with elevated serum Tg level after a total thyroidectomy and a normal post-ablation whole body scan (WBS), ^{18}FDG-PET/CT rather than a post-empiric ^{131}I WBS is preferred for detection of recurrence/metastases [24]. Over the last years, several studies have shown high sensitivity (80–90%) of ^{18}FDG-PET/CT in detecting local or distant recurrences in patients with high thyroglobulin level and negative ^{131}I WBS [25–28] in addition to recent studies that discuss the role of ^{18}FDG-PET/MR in those patients [29, 30]. However, Piccardo et al. [31] in their study declared impact of ^{18}FDG-PET/CT in changing the management plan in stage IV DTC subgroup with positive ^{131}I WBS. To the best of our knowledge, there is a paucity of studies discussed this issue.

The current study aims to evaluate additive value of ^{18}FDG-PET/CT to patients who were ^{131}I post-therapy whole-body scan (TxWBS) positive for recurrent DTC and to assess how this can influence the treatment strategy.

Methods

The present study enrolled 43 patients selected from 1002 DTC patients referred to nuclear medicine and clinical oncology department from January 2011 to May 2021 by reviewing their medical records, including clinical evaluation, serum Tg and anti-Tg antibodies, neck US, diagnostic ^{131}I WBS, ^{131}I TxWBS, and ^{18}FDG-PET/CT. ^{18}FDG-PET/CT was done at the national cancer institute during the follow-up.

The study design was approved by institutional review board of clinical oncology and nuclear medicine department. Patient consent was not possible because of the retrospective design of the study.

Inclusion criteria: Patients age above 18 years old, with histopathologically proven DTC treated by thyroidectomy and ^{131}I treatment. We selected the patients who done^{18}FDG-PET/CT within 3 months prior to ^{131}I therapy in whom ^{131}I WBS was positive for suspicious locoregional or distant recurrence either clinically or biochemically by elevated Tg serum level in hypothyroid status. The locoregional and distant recurrences were proven pathologically (fine needle aspiration [FNA] cytology or excisional biopsy), or by conventional imaging (neck ultrasound [US], Tc99m MDP bone scan, chest CT and triple phase CT) or by follow-up for at least one year post ^{18}FDG-PET/CT scan to evaluate lesion behavior overtime; stationary or regressive course of the lesion after ^{131}I therapy or progression with time confirms its malignant nature.

Exclusion criteria: Patients with elevated thyroglobulin (Tg) serum level and negative ^{131}ITxWBS or with history of second primary malignancy.

Serum Tg and Tg antibodies measurement: Blood samples were obtained to measure both Tg and Tg antibodies serum levels in all patients in hypothyroid state (thyroid stimulating hormone (TSH) level $\geq$ 30 mIU/L). Serum Tg level was considered abnormal when its value was higher than 1 ng/ml.

Neck ultrasound (U/S): Neck U/S was performed for all the patients to evaluate the thyroid bed as well as central and lateral cervical nodal compartments. Sonographically suspicious lymph nodes were biopsied for cytology or excised for histopathology. Suspicious criteria for metastases include round shape, hyperechogenicity, microcalcification, hypervascularity, cystic aspect and loss of hilar fat.

CT chest and triple phase CT were done for suspected lung and liver metastases, respectively. CT imaging was acquired by 64 multi-detectors CT scanner. All CT images were interpreted by expert radiologists.

Technetium methylene diphosphonate (Tc99m MDP) scan: 3 h post-injection of 740 Mbq (20 mCi) of Tc99m MDP anterior and posterior whole body planner images were acquired. Abnormal focal tracer uptakes are suspicious of osseous deposits.

^{131}I scans: Both diagnostic and Tx WBS were done in all the patients after hormonal withdrawal for 4 weeks with the TSH serum level $\geq$ 30 mIU/L. Patients were also instructed to follow a low iodine diet 2 weeks prior to iodine intake. Diagnostic ^{131}I WBS was performed after oral intake of 185 MBq (5 mCi), while ^{131}I TxWBS was done after large dose (100-200 mCi) 5–7 days later. Imaging was done with a dual-headed gamma camera using high-energy collimators. The energy window was set at 15% centered on 364 keV with a 256×1024 size with a scan speed of 15 cm/min. The images were evaluated for iodine avid locoregional or distant recurrences. Images were interpreted by two experienced nuclear medicine physicians. Any abnormal focal iodine activity in operative thyroid bed, anatomical sites of lymph nodes or the rest of the body was interpreted as positive result.

^{18}FDG-PET/CT: The scan was done using (PET/CT 710, Discovery; general electric (GE)). All patients were instructed to fast for 4–6 h before injection of 5.2 MBq (0.19 mCi)/kg body weight ^{18}FDG. Blood glucose level was not exceeding 150 mg/dL, 40–60 min post-tracer injection CT was acquired first followed by PET scanning (5–7 bed positions; acquisition time, 2–3 min/bed position). CT without contrast agent was performed with the following parameters: 40 mAs, 130 kv, slice

thickness: 2.5 mm, and pitch: 1.5. The CT scans were acquired during breath holding. Patients are scanned in the supine position from skull base to mid-thigh. The CT-data were used for attenuation correction and anatomical localization. Images were reconstructed applying a standard iterative algorithm (ordered-subset expectation maximization). Images were interpreted at a workstation equipped with fusion software that provides multi-planar reformatted images and enables display of the PET, CT and fused PET/CT images. Image interpretation was accomplished by two experienced nuclear medicine physicians. Abnormal FDG uptake was defined as a focal increased uptake higher than that of liver activity at anatomic localizations.

Data analysis was based on patients, organs and lesions. Organs are classified into: thyroid bed, LN (cervical), lung, liver, and bone. Lesions in one lung regardless of their numbers were counted as one lesion.

The collected data were computerized and statistically analyzed using Statistical Package for Social Science (SPSS) program version 25.0. Quantitative data were expressed as median and range. Qualitative data were represented as frequencies and relative percentages. Chi square test was used to calculate difference between qualitative variables. Cohen's kappa test was used to estimate the agreement between different methods of diagnosis. Validity data were calculated using Sensitivity, Specificity, Positive predictive value, negative predictive value and accuracy. *P* value of < 0.05 indicates significant results and *P* value of < 0.001 indicates highly significant results.

Results

This retrospective cohort study enrolled 43 patients with female predominance 34 (79%) and 9 males (21%) with median age 55 years and range 34–59 years. Regarding the histopathological analysis, papillary type represented 33(76.7%) out of 43 patients, while follicular type was less than 10 (23.3%). According to the American Joint Cancer Committee (AJCC) TNM staging system 8th edition, the majority of the patients (76.7%) were at stage IV, while the remainder of the patients were represented almost equally at stages I, II, III (Table 1).

Two patients out of 43, in whom diagnostic ^{131}I WBS and US revealed only small recurrence in thyroid bed with significantly high serum Tg.^{18}FDG PET/CT was done which revealed 3 cervical LN metastases, the dimensions of the smallest LN were 1.1 × 0.8 cm. Those patients were referred to surgery before receiving ^{131}I therapy so they were excluded from the comparison between ^{18}FDG PET/CT and ^{131}I Tx WBS.

Table 1 Clinico-pathological data of the studied group

Variable	*N*	%
Sex		
Male	9	21
Female	34	79
Age		
< 55	6	13.9
≥ 55	37	86.1
Tumor histology		
Papillary	33	76.7
Follicular	10	23.3
Staging at diagnosis		
I	3	6.9
II	3	6.9
III	4	9.3
IV	33	76.7

Performance of ^{18}FDG-PET/CT

The ^{18}FDG-PET/CT detected tumor recurrent lesions in 35 (81.3%) patients with statistically significant relation between positivity of ^{18}FDG-PET/CT and old age, female sex, high tumor stage and progressive course as 94.5% of patients equal or older than 55 years, 91.1% of females,75 and 97% of patients in stage III and IV and 97%showed progressive course. compared to 0% of patients with positive ^{18}FDG-PET/CT < 55 years old, 44.4% of males, 0% of patients in stage I and II and 30% with regressive course (*P* value = 0.000, 0.001, < 0.001 and 0.000, respectively) (Table 2).

Comparison between ^{18}FDG-PET/CT and ^{131}I TxWBS

In one patient ^{131}ITxWBS falsely revealed skull osseous deposit that was attributed to surgical intervention and also ^{18}FDG-PET/CT falsely reported cervical LN metastasis (1 lesion) in one patient, which was confirmed to be sarcoidosis by FNA biopsy.

Based on lesion analysis (Table 3) ^{18}FDG-PET/CT could detect more lesions compared to ^{131}ITxWBS [98 (79%), 87 (70.2%) out of 124] lesions, respectively. Regarding the different organs, PET/CT detected 52 out of 61 (85.2%) versus 48(78.6%) detected by TxWBS. Kappa value of agreement was poor between each technique and the confirmatory different tools; however, statistically significant good agreement between ^{18}FDG-PET/CT and ^{131}I TxWBS was noted (Kappa 0.78 and $p < 0.001$) (Table 3).

^{18}FDG-PET/CT could detect additive lesions compared to ^{131}I TxWBS in 18 patients, while ^{131}I TxWBS could detect additive lesions in only 6 patients.

Table 2 Relation between positivity of ^{18}FDG-PET/CT and age, sex, DTC staging and outcome

Variable	Total	^{18}FDG-PET/CT				χ^2	*P*
		+ve		−ve			
		N	%	*N*	%		
Age							
< 55	6	0	0	6	100	30.5	0.000
≥ 55	37	35	94.5	2	5.5		
Sex							
F	34	31	91.1	3	8.9	**10.2**	**0.001**
M	9	4	44.4	5	55.6		
Staging at diagnosis							
I	3	0	0	3	100	**31.64**	**< 0.001****
II	3	0	0	3	100		
III	4	3	75	1	25		
IV	33	32	97	1	3		
Outcome							
Regressive course	10	3	30	7	70	22.7	**0.000**
Progressive course	33	32	96.9	1	3.1		

χ^2: Chi square test

**Highly significant ($P < 0.01$)

Table 3 Organ- and lesion-based analysis by ^{18}FDG-PET/CT and ^{131}I TxWBS in the context of histopathology, conventional radiological tools and lesion behavior over time

Variable	^{18}FDG-PET/CT	^{131}I TxWBS	Confirmatory investigations	^{18}FDG-PET/CT	^{131}I TxWBS	Confirmatory investigations
	O	O	O	L	L	L
Lung	8	8	8	12	12	12
Bone	15	13	18	45	44	64
Liver	3	3	5	3	3	5
Thyroid bed	13	13	15	16	16	19
LN	13	11	15	22	12	24
Sum	52	48	61	98	87	124
Kappa	0.16[1] 0.03[2] 0.69[3]			0.04[1] 0.02[2] 0.78[3]		
P	0.02* 0.59 NS < 0.001**			0.34 NS 0.56 NS < 0.001**		

O, organ; L, lesion; NS, non-significant ($p > 0.05$)

* Significant ($p < 0.05$)

** Highly significant ($p < 0.01$)

[1] Confirmatory versus ^{18}FDG-PET/CT; [2]Confirmatory versus ^{131}I TxWBS; [3] ^{18}FDG-PET/CT versus ^{131}I TxWBS

^{18}FDG-PET/CT has higher sensitivity than that of ^{131}ITxWBS either based on lesion or organ analysis (78.2% vs. 69.4 and 85.2% vs. 77%, respectively) (Tables 4, 5).

Impact of ^{18}FDG-PET/CT on the treatment plan

Twenty-five patients (58.2%) out of the 43 patients revealed no change in management (8 patients with negative ^{18}FDG-PET/CT and 17 with positive

Table 4 Diagnostic performance of ^{18}FDG-PET/CT and ^{131}I WBS based on lesion analysis in relation to histopathological results, conventional radiological tools and lesion behavior overtime

Findings	True +ve	False +ve	True −ve	False −ve	Validity	
^{18}FDG PET/CT						
Bone	45	–	1	19	Sensitivity	78.2%
Lung	12	–	–	–	Specificity	50%
Liver	3	–	–	2	PPV	99%
LN	21	1	–	3	NPV	3.6%
Thyroid bed	16	–	–	3	Accuracy	77.8%
Sum	97	1	1	27		
I^{131}WBS						
Bone	43	1	–	21	Sensitivity	69.4%
Lung	12	–	–	–	Specificity	50%
Liver	3	–	–	2	PPV	98.9%
LN	12	–	1	12	NPV	2.6%
Thyroid bed	16	–	–	3	Accuracy	69%
Sum	86	1	1	38		

PPV, positive predictive value; NPV, negative predictive value

Table 5 Diagnostic performance of ^{18}FDG-PET/CT and ^{131}IWBS based on organ analysis in relation to histopathological results, conventional radiological tools and lesion behavior overtime

Findings	True +ve	False +ve	True −ve	False −ve	Validity	
^{18}FDG-PET/CT						
Bone	15	–	1	3	Sensitivity	85.2%
Lung	8	–	–	–	Specificity	100%
Liver	3	–	–	2	PPV	100%
LN	13		–	2	NPV	10%
Thyroid bed	13	–	–	2	Accuracy	85.5%
Sum	52	0	1	9		
^{131}IWBS						
Bone	12	1	–	6	Sensitivity	77%
Lung	8	–	–	–	Specificity	0%
Liver	3	–	–	2	PPV	97.9%
LN	11	–	–	4	NPV	0%
Thyroid bed	13	–	–	2	Accuracy	75.8%
Sum	47	1	0	14		

^{18}FDG-PET/CT), while ^{18}FDG-PET/CT could change the treatment plan in 18 (41.8%) patients out of 43; in two patients, WBS and US revealed only small recurrence in thyroid bed with significantly high serum Tg, so ^{18}FDG PET/CT was done which revealed cervical lymph nodes (LN) metastases; therefore, the treatment plan was changed from only RAI therapy to pre-RAI therapy neck dissection (Fig. 1). Besides, ^{18}FDG-PET/CT detected symptomatic osseous deposits that were missed by diagnostic and post-therapeutic WBS in seven patients that necessitated external radiation after receiving ^{131}I therapeutic dose instead of only radioactive iodine (RAI) (Fig. 2). Also large hepatic metastasis was detected by^{18}FDG-PET/CT in one patient with maximum standard uptake value (SUV-max) 30 in addition to recurrence in thyroid bed, while the diagnostic ^{131}I WBS and post-therapeutic scans revealed only recurrence in thyroid bed, the decision was taken to undergo surgical excision of the hepatic metastasis then patient will receive RAI dose. Unfortunately, the surgery was postponed as the patient was surgically unfit, so he received his ^{131}I therapeutic dose only. Moreover, adjustment of the RAI dose from 5.55 GBq (150 mCi) to 7.4 GBq (200 mCi) in six

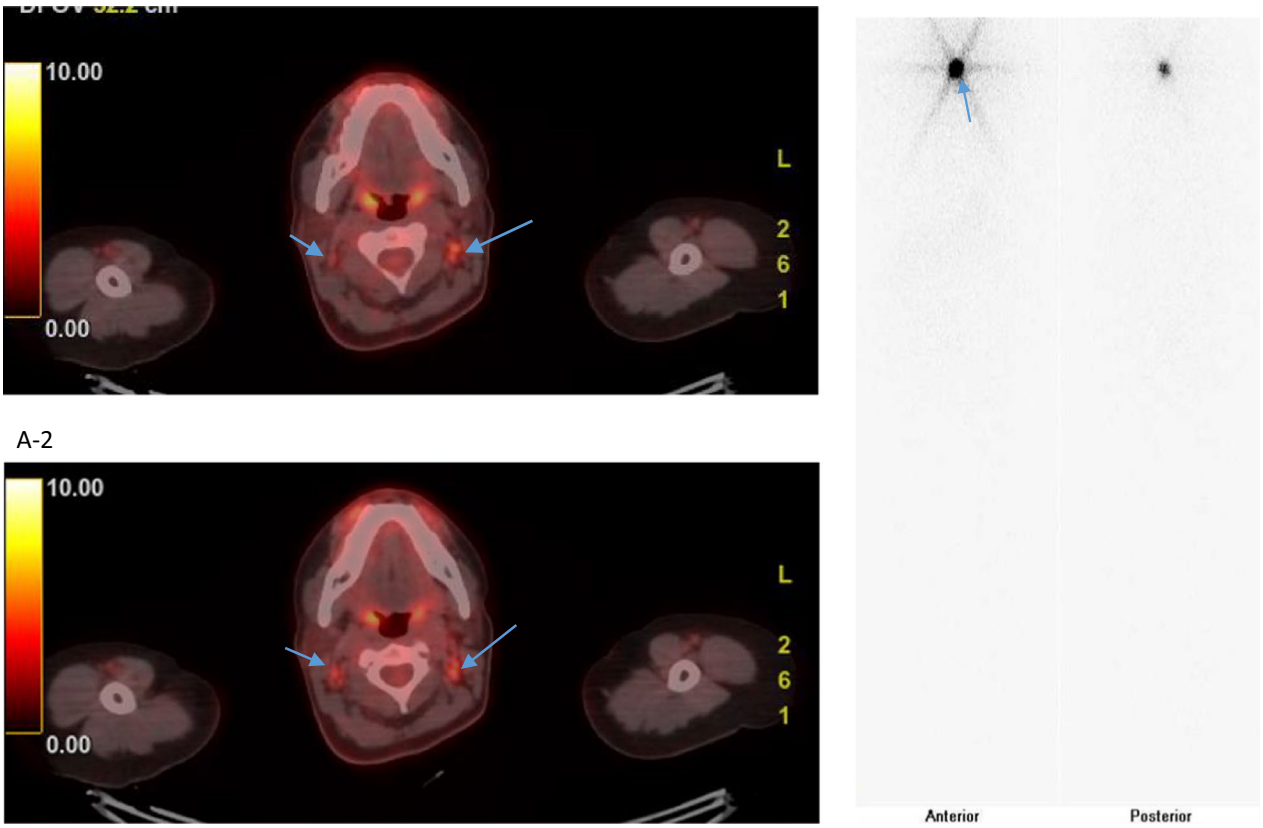

Fig. 1 60 year old male patient with stage III papillary thyroid cancer who underwent total thyroidectomy then he received radioactive iodine ablative dose. During follow up he was represented by elevated level of I diagnostic WBS revealed only small sized recurrent thyroid ^{131} and ng/ml While both neck US 60, serum Tg-FDG^{18} was done for proper evaluation of the condition. (**A1**, **A2**); Axial FDG-PET/CT^{18}, cancer. Therefore (arrows) sections reveal bilateral metastatic cervical LNs level II PET/CT (**B**) ^{131}I diagnostic WBS shows only iodine avid residual thyroid tissue in the operative thyroid bed (arrow)

patients in consideration with their lung and bone recurrences determined by ^{18}FDG-PET/CT, which were not detected by the conventional radiological tools. In two patients ^{18}FDG-PET/CT demonstrated thyroid recurrence in operative thyroid bed encroaching on larynx and tracheal lumen which warranted surgical referral before RAI; however, one patient refused the surgical approach and the other was unfit for surgery so both patients received their therapeutic ^{131}I doses only. It was noticed that TxWBS detected the lesions but unfortunately failed to characterize the lesion as accurately as ^{18}FDG-PET/CT did (Table 6).

Discussion

Long years ago, ^{18}FDG-PET/CT has been widely used as a tumor-seeking agent for various cancers. Nevertheless, researches on its role in thyroid cancer staging appeared only in the mid-1990s [31].

In recent years, it is obvious that ^{18}FDG-PET/CT has a major role in thyroid cancer management but its utility in

(See figure on next page.)

Fig. 2 Fifty-seven-year-old female patient with stage III differentiated follicular thyroid cancer underwent total thyroidectomy and ^{131}I ablation. During follow-up, patient was represented by elevated serum Tg level; 200 ng/ml. Diagnostic WBS revealed only small recurrent thyroid tissue in thyroid operative bed (not available), so ^{18}FDG-PET/CT was done to detect the possibility of hidden metastases. **A** ^{18}FDG-PET/CT axial, sagittal and coronal sections reveal thyroid distant metastases; supraclavicular region LN, dorsal and lumbar vertebrae, paraspinal mass, pelvic bones and left femur (arrows) suggesting dedifferentiating nature of these lesions. **B** ^{131}I-post-therapeutic WBS shows only bifocal iodine avid recurrent thyroid tissue at operative bed (arrow)

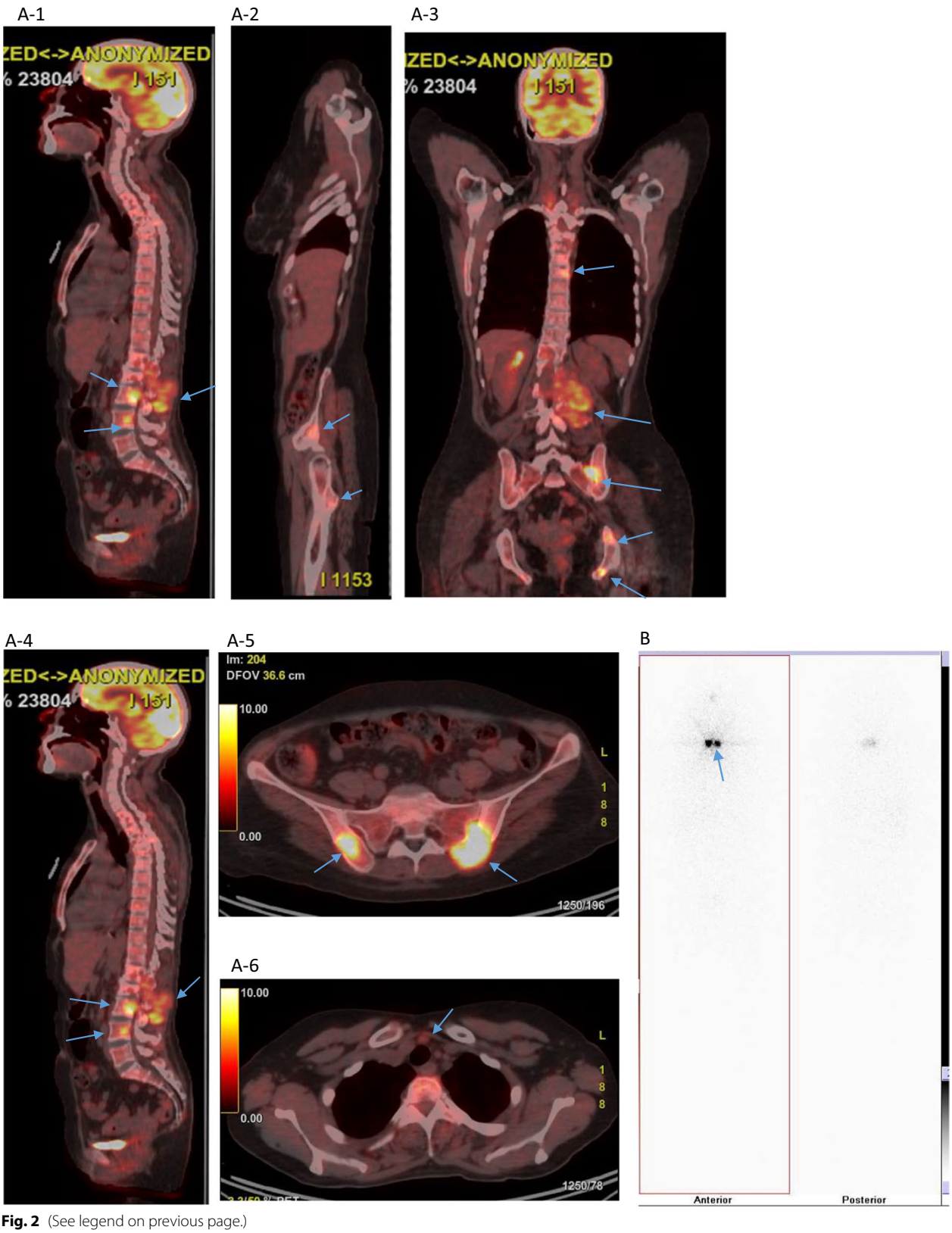

Fig. 2 (See legend on previous page.)

Table 6 Impact of ^{18}FDG-PET/CT on treatment management

n	%	Decision without ^{18}FDG-PET/CT	Decision with ^{18}FDG-PET/CT
2	4.6	Therapeutic dose of ^{131}I only	Another neck dissection prior to ^{131}I therapy
7	16.2	Therapeutic dose of ^{131}I only	External radiation to symptomatic bone recurrences after ^{131}I therapy
6	13.9	Therapeutic dose of ^{131}I 5.5 GBq	Enhancement of the dose to 7.5 GBq
1	2.3	Therapeutic dose of ^{131}I only	*Surgical excision of the large hepatic recurrence pre I ^{131}therapeutic dose
2	4.6	Therapeutic dose of ^{131}I only	*Surgical excision of thyroid recurrence before ^{131}I therapy
Sum			
18	41.6		
20	46.5	Only therapeutic dose of ^{131}I	Only therapeutic dose of ^{131}I
5	11.6	Therapeutic dose of ^{131}I followed by external radiation	Therapeutic dose of ^{131}I followed by external radiation
Sum			
43	100		

*Patients did not undergo surgical excision

patients with recurrent DTC should be tailored according to circumstance of each patient [32].

In general, the role of ^{18}FDG-PET/CT in initial staging and follow-up of low-risk patients with DTC is limited [33]. Conversely, in patients with more aggressive thyroid cancers, ^{18}FDG-PET/CT is a very useful tool for determining the extent of metastatic disease [34, 35]. Also, for prognostic purposes and treatment response assessment [33, 36]. Moreover, Abraham et al. in their study stated that performing ^{18}FDG-PET/CT in patients with recurrent/persistent DTC should take into account not only Tg levels or ^{131}I WBS findings, but also, should be on the basis of clinical and histopathological features and their individual risk [33].

Schönberger et al. stated that, iodine-avid lesions of DTC usually have low or absent FDG uptake with a positive correlation between expression of glucose transporter 1 (GLUT1) and dedifferentiation of thyroid cancer cells [37]. Moreover, Piccardo et al. suggested the occurrence of iodine-concentrating metastases with high glucose uptake [31].

Some researchers declared that ^{18}FDG-PET/CT has been shown to be a valuable diagnostic tool for the detection not only of ^{131}I non-avid lesions, but also of ^{131}I avid lesions of metastatic DTC [38].

Treglia et al. in a review article done in 2013 stated that; ^{18}FDG-PET/CT and ^{131}I WBS may provide complementary information useful in the restaging of DTC patients [38]. Moreover, Piccardo et al. believe that ^{18}FDG-PET/CT may change the therapeutic approach in a stage-IV DTC subgroup of patients [31].

In the current study; ^{18}FDG-PET/CT detected lesions in 35 (81.3%) out of 43 patients which goes with that declared by Loboulleux et al. in their study that enrolled 47 patients with DTC after thyroidectomy and ^{131}I treatment, ^{18}FDG-PET/CT was done for only 34 patients. The percentage of positive ^{18}FDG-PET/CT among those with positive Tx ^{131}I WBS was 5 out of 6 patients (83.3%) and also concordant with Piccardo et al. in their study which enrolled 20 stage-IV DTC patients with elevated Tg levels associated with positive ^{131}I WBS. The ^{18}FDG PET/CT was positive in 16 out of 20 patients (80%). On the other hand, the rate of ^{18}FDG-PET/CT lesion detection in the current study is lower than that of Liu et al. and higher than that of Sandra et al. and Oh et al. studies. Liu et al. study enrolled 212 DTC patients, among 59 patients with positive TxWBS the ^{18}FDG-PET/CT positivity was 51(86.4%). On the other hand, Sandra et al. in their study which enrolled 90 patients with DTC after first ^{131} I ablation ^{18}FDG-PET/CT was positive in 13(40%) out of 32 patients with positive I^{131} Tx WBS. Regarding Oh et al. study which enrolled 140 only 30 patients of the total number were positive in WBS and only 16 (53.3%) of them were positive in ^{18}FDG-PET/CT [2, 24, 39–41]. this variation may be attributed to difference in population in each study.

The sensitivity of ^{18}FDG-PET/CT based on lesion analysis in our study more or less goes with that has been detected by Piccardo et al. (78.2% vs. 80%) meanwhile, obviously lower than that stated by Riemann et al. (91%) among positive^{131} I WBS subgroup. These differences may be attributed to the differences in study population regarding the risk stratification [31, 39, 42].

Obviously, the specificity of ^{18}FDG-PET/CT in our study was significantly lower than that was calculated by Riemann et al. in their study (50% vs. 89%). We believe that small sample size did not enable precise assessment of the specificity [42].

In the current study, the sensitivity of ^{131}I TxWBS based on lesions analysis goes with that measured by Piccardo et al. in their study (69.4% vs. 67%). Reduction in sensitivity may be attributed to an increased number of patients in III and IV stages on expense of I and II stages.

In our study ^{18}FDG-PET/CT findings led to modifications in the management of 41.6% which was less than that declared by Piccardo et al. in their study 55%, this may be explained by decrease percentage of patients in stage IV compared with that in Piccardo et al. 76.7% versus 100%, respectively [31].

Our result was higher that detected by Maamoun et al. in their study which enrolled 126 patients who underwent ^{18}F FDG PET/CT initially before ^{131}I ablation 30.6% [43].

Limitation

One of the limitations of the study was non-availability of histopathological examination in a number of patients to confirm recurrences for both practical and ethical reasons. We admit that small sample size influenced proper assessment of specificity and also fair comparison between low and high risk groups, which may be taken in consideration in future studies. Also another limitation is comparing ^{18}FDG-PET/CT with planer ^{131} I WBS and not with single photon emission tomography/computerized tomography (SPECT/CT).

Conclusion

^{18}FDG-PET/CT may be complementary to ^{131}ITxWBS in high-risk DTC with impact on treatment strategy (Additional files 1, 2, 3: Fig. 1).

Abbreviations

^{18}FDG PET/CT: 18F-fluorodeoxyglucose-positron emission tomography/computerized tomography; DTC: Differentiated thyroid cancer patients; TxWBS: Post-therapeutic whole body scan; PTC: Papillary thyroid carcinoma; FTC: Follicular thyroid carcinoma; LN: Lymph node; FNA: Fine needle aspiration; US: Ultrasound; Tc99mMDP: Technetium methylene diphosphonate; Tg: Thyroglobulin; TSH: Thyroid stimulating hormone; GE: General electric; SPSS: Statistical Package for Social Science; AJCC: American Joint Cancer Committee; SUVmax: Maximum standard uptake value; GLUT1: Glucose transporter 1; RAI: Radioactive iodine; SPECT/CT: Single photon emission computed tomography/computed tomography.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s43055-021-00692-x.

Additional file 1. Axial ^{18}FDG-PET/CT section reveals metastatic cervical LNs level II bilaterally more prominent on the left side (arrows).

Additional file 2. Axial ^{18}FDG-PET/CT section reveals bilateral metastatic cervical LNs level II (arrows).

Additional file 3. ^{131}I diagnostic WBS shows only iodine avid residual thyroid tissue in the operative thyroid bed (arrow).

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Authors' contributions

All authors have read and approved the manuscript. Study concept and design were proposed by HMA and HAA. HMA, AEM and MSF were responsible for patients' recruitment, follow-up and acquisition of data. Procedures were done by HMA, AEM and MSF. Analysis and interpretation of data and drafting of the manuscript were done by HMA and HAA. Revision of the manuscript was done by HMA and HAA. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study design was approved by institutional review board of clinical oncology and nuclear medicine department in Zagazig University in accordance with the 1964 Helsinki declaration. Number of approval: 6382. Informed written consent was waived because the study was retrospective.

Consent for publication

The patients' consent to publish the data contained within this study was waived because of the retrospective design of the study.

Competing interests

All authors declared that they had no competing interests.

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