Am J Nucl Med Mol Imaging 2014;4(2):193-201
www.ajnmmi.us /ISSN:2160-8407/ajnmmi1401003

Original Article

FDG-PET/CT can rule out malignancy in patients with vocal cord palsy

Anders Thomassen[1], Anne Lerberg Nielsen[1], Jeppe Kiilerich Lauridsen[1], Björn Alexander Blomberg[1], Søren Hess[1], Henrik Petersen[1], Allan Johansen[1], Jon Thor Asmussen[2], Jesper Roed Sørensen[3], Jørgen Johansen[4], Christian Godballe[3], Poul Flemming Høilund-Carlsen[1]

[1]Department of Nuclear Medicine, Odense University Hospital, Denmark; [2]Department of Radiology, Odense University Hospital, Denmark; [3]Department of ENT Head and Neck Surgery, Odense University Hospital, Denmark; [4]Department of Oncology, Odense University Hospital, Denmark

Received January 16, 2014; Accepted January 26, 2014; Epub March 20, 2014; Published March 30, 2014

Abstract: The aim was to investigate the performance of ^{18}F-fluorodeoxyglucose PET/CT to rule out malignancy in patients with confirmed vocal cord palsy (VCP). Between January 2011 and June 2013, we retrospectively included consecutive patients referred to PET/CT with paresis or paralysis of one or both vocal cords. PET/CT results were compared to clinical workup and histopathology. The study comprised 65 patients (32 females) with a mean age of 66±12 years (range 37-89). Eleven patients (17%) had antecedent cancer. Twenty-seven (42%) were diagnosed with cancer during follow-up. The palsy was right-sided in 24 patients, left-sided in 37, and bilateral in 4. Median follow-up was 7 months (interquartile range 4-11 months). Patients without cancer were followed for at least three months. PET/CT suggested a malignancy in 35 patients (27 true positives, 8 false positives) and showed none in 30 (30 true negatives, 0 false negatives). Thus, the sensitivity, specificity, positive and negative predictive values, and accuracy were (95% confidence intervals in parenthesis): 100% (88%-100%), 79% (64%-89%), 77% (61%-88%), 100% (89%-100%), and 88% (78%-94%), respectively. Sixteen patients had palliative treatment, while 11 were treated with curative intent, emphasising the severity of VCP and the need for a rapid and accurate diagnostic work-up. In this retrospective survey, biopsy proven malignancy (whether newly diagnosed or relapsed) was the cause of VCP in almost half of patients (42%). PET/CT had a high sensitivity (100%) with a relatively high false positive rate, but was excellent in ruling out malignancy (negative predictive value 100%).

Keywords: FDG-PET/CT, palsy, paresis, paralysis, vocal cord, laryngeal nerve

Introduction

Vocal cord palsy (VCP) - i.e. paresis or paralysis - of one or both vocal cords is a rather common finding, but may be a warning sign of underlying malignant disease [1]. In patients with no obvious signs of mucosal pathology of the larynx, a variety of other clinical diseases affecting the innervation to the vocal cords may be sought. This obviously includes the identification of any extra-laryngeal neoplasm as the underlying cause of the vocal cord palsy, or, equally important, the exclusion of such malignancy, allowing the ENT-specialist to focus on neuropathic or idiopathic etiologies.

In Denmark, a fast track cancer program for patients suspected of head and neck cancer was introduced in 2007 to reduce waiting times with the aim of improving prognosis [2]. The program enrolled prebooked time slots for an extensive examination program including fluorodeoxyglucose (FDG) positron emission tomography/computed tomography (PET/CT). At our institution, patients with newly diagnosed vocal cord palsy (VCP) were included in this program, because of a high incidence of cancer in this category of patients [3, 4]. Recently, the role of FDG-PET/CT was retrospectively evaluated in 59 individuals with confirmed VCP in a variety of malignant and benign conditions, including primary tumours of the larynx [5]. However, the diagnostic value of PET/CT in ruling out cancerous lesions in patients with VCP has not explicitly been reported so far.

Our aim was to investigate the diagnostic performance of PET/CT in ruling out malignancy in patients with verified VCP.

Materials and methods

Study population

Between January 2011 and June 2013 consecutive patients with newly diagnosed VCP were included retrospectively. All patients were referred for a FDG-PET/CT from the Department of ENT Head and Neck Surgery at our institution. The follow-up of patients included a search in a common Danish registry to which reports of all histopathological samples are collected.

Approval from the Institutional Review Board was waived.

Patient preparation

All patients fasted 6 hours prior to injection of 4 MBq/kg (min. 200 MBq and max. 400 MBq) of FDG. PET/CT imaging commenced 60 minutes after injection of the compound. Patients were instructed to cease voicing during the first half hour after FDG-injection.

Scan protocol

All scans were performed with a 16-slice or 64-slice hybrid PET/CT scanner (GE Discovery 690, GE Discovery VCT, GE Discovery RX, or GE discovery STE) and extended the posterior fossa of the skull to the upper thighs. Contrast enhanced CT (0.8 ml per kg bodyweight of Iopromide 370 mg iodine/ml, flow rate 2.5 ml/s) was used in patients with a normal s-creatinine. A dual phase injection protocol was applied: i) injection of one third of the contrast media; ii) delay of 20 seconds; iii) injection of the remaining two thirds of contrast media; iv) saline flush. Transmission images of the head and neck in the arterial phase were acquired immediately after the saline flush and reconstructed with filtered back projection and a standard GE-filter with a field of view of 25 cm (slice thickness of 0.625 mm, Smart mA 80-400 mA, 120 kV). Immediately hereafter a whole body conventional CT scan was performed with a standardized CT protocol reconstructed with filtered back projection and a standard GE-filter with a field of view of 50 cm (slice thickness of 3.8 mm Smart mA 80-400 mA, 120 kV, noise index 18.0, 0.8 sec/rotation. Emission images were acquired in 3-dimensional mode (2.5 min per bed position). Data were reconstructed with a 70 cm field of view, matrix size 128x128 or 256x256, slice thickness of 3.75 mm by an iterative ordered-subset expectation maximization algorithm. The contrast enhanced CT-scan was also used for attenuation correction applying a standard vendor provided filter for this purpose.

Interpretation of PET/CT scans

Scan reports were reviewed and compared to the clinical diagnostic workup including biopsy and histopathology. Thus the readers of the PET/CT scans were blinded to the final diagnosis, because the scans were performed as part of the diagnostic workup. A PET/CT scan was considered true positive if - in a patient with a biopsy verified cancer - an FDG-avid tumour was identified i) along the route of the vagal nerves, or ii) along the laryngeal nerves, iii) close to the brain stem, or iv) as a paraneoplastic phenomenon. PET/CT was considered false positive if such findings were not confirmed by biopsy during follow-up. A true negative result was defined as a PET/CT scan without abnormal FDG-uptake and follow-up demonstrating no malignancy, whereas a false negative scan was present if follow-up was consistent with malignancy while PET/CT failed to detect a malignant lesion.

Quantitative analysis in patients with unilateral VCP

To evaluate the uptake pattern of FDG in palsied and non-palsied vocal cords the maximum body-weight adjusted standardized uptake value (SUVmax) (g/ml) was evaluated by carefully placing a spherical volume of interest over the posterior part of the vocal cord. The volume of interest was guided by CT and also by PET images to avoid errors caused by misregistration.

Statistical analyses

Categorical variables were expressed as absolute numbers and percentages, continuous variables as mean ± the standard deviation and range, or as median, interquartile range and range. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy with regard to malignancy, accompanied with Wilson-score based 95% confidence intervals (CI), were calculated to

Table 1. Patient characteristics, *n* = 65

Mean age (years) ± SD, range	66±12, 37-89
Gender, *n* (%)	
Female	32 (49%)
Male	33 (51%)
Location of vocal cord palsy, *n* (%)	
Right-sided	24 (37%)
Left-sided	37 (57%)
Bilateral	4 (6%)
Antecedent malignant disease, *n* (%)	
Yes	11 (17%)
No	54 (83%)
Median follow-up (days), range	210, 11-902

determine the diagnostic performance of FDG PET/CT in detecting malignant lesions. The Wilcoxon signed rank sum test and the unpaired Student's *t*-test were used to evaluate differences in SUVmax of the vocal cords and age, respectively. Fisher's exact test was applied for testing differences in localization of VCP against presence/absence of cancer. The significance level was set at 5%. Statistical analyses were performed with Stata/IC 12.1 (StataCorp, Texas, USA).

Results

The study comprised 65 patients, mean age 66±12 years (range 37-89), 32 were females. Twenty seven patients (42%) were diagnosed with cancer or relapse during follow-up. Median follow-up was 210 days, interquartile range 133-339 days (range 11-902). Patients without cancer were followed for at least 3 months. During follow-up, 13 patients died. One patient with cancer died 11 days after PET/CT, which explains the follow-up range. Patient characteristics are listed in **Table 1**.

Patients, with histologically verified malignancy, were not significantly older than patients without (mean age 68 years±10 versus 64 years±14, respectively, $p = 0.4$). The palsy was right-sided in 24 patients, left-sided in 37 and bilateral in 4. Cancer was found in 9/24 (38%) of the right-sided palsies, in 16/37 (43%) of the left-sided palsies, and in 2/4 (50%) of the bilateral palsies. No statistically significant difference was found between localization of VCP and the presence of cancer, $p = 0.9$.

Median SUVmax in 58 non-palsied vocal cords was 2.9 g/ml (range 1.3-12.8) and in palsied vocal cords 2.2 g/ml (range 0.8-8.9), $p<0.0001$, (**Figure 1**). Seven patients were omitted from this analysis because of 'spill over' activity from the tumour, bilateral VCP, or severe inflammation in the palsied vocal cord. **Table 2** summarizes the distribution of PET/CT findings according to patient category. Eleven patients (17%) had a history of cancer, relapse caused the VCP in nine of them. Six patients had lesions suspicious for a malignant process at the time of referral for PET/CT. All of them proved to have cancer.

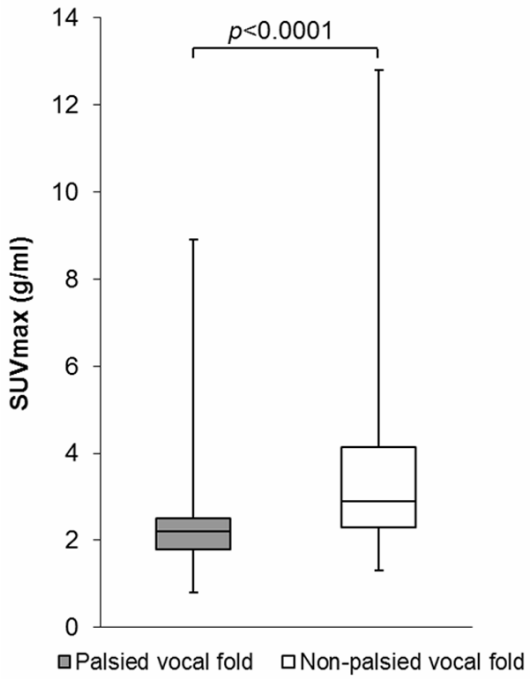

Figure 1. Differences in maximal standardized uptake value (SUVmax) between palsied and non-palsied vocal cords. Median, 1st and 3rd quartile, and range of palsied vs. non-palsied vocal cord in patients with unilateral vocal cord palsy (*n* = 58).

PET/CT was suggestive of malignancy in 35 patients (27 true positive, 8 false positive) and showed no malignant FDG uptake in 30 (30 true negative, 0 false negative). Thus, the sensitivity, specificity, positive predictive value, negative predictive value and accuracy were (95% CIs in parenthesis): 100% (88%-100%), 79% (64%-89%), 77% (61%-88%), 100% (89%-100%), and 88% (78%-94%), respectively.

Neoplastic causes of VCP

Nine patients had lung cancer, which was the most frequent cause of VCP. Five had breast

Table 2. Distribution of PET/CT findings in patients with i) Previous cancer, ii) No previous cancer, but findings suspicious of malignancy by clinical examination including ultrasound of the neck, and iii) No previous cancer nor suspicious findings clinically

	PET/CT			
	True negative	False negative	True positive	False positive
i) Previous cancer	2	0	9	0
ii) No previous cancer, but suspicious findings by clinical examination	0	0	6	0
iii) No previous cancer nor suspicious findings	28	0	12	8

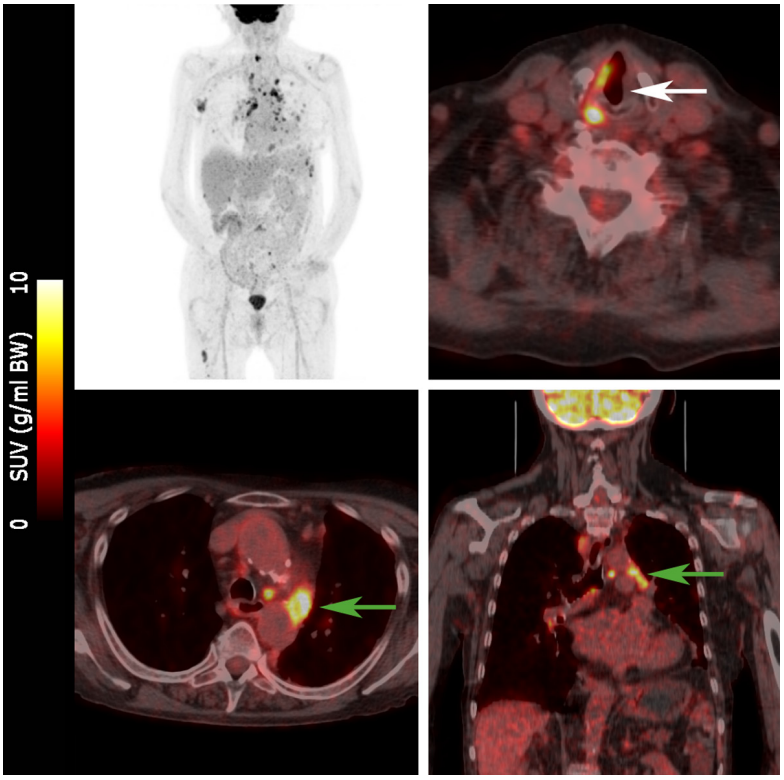

Figure 2. Vocal cord palsy caused by metastatic tumor invasion of the left recurrent laryngeal nerve - A true positive examination. A 77-year old female with a history of invasive ductal carcinoma of the breast with the second relapse (patient number 3). She developed a left-sided vocal cord palsy, which was evident because of absent fluorodeoxyglucose in the left vocal cord (white arrow). This was caused by lymph node metastasis beneath the aortic arch (green arrows).

cancer (**Figure 2**), five had oesophageal cancer, whereas another eight had miscellaneous cancers (**Table 3**). Patient number 25 had a bilateral VCP and a pulmonary tumour by PET/CT without signs of mediastinal spread. Biopsy proved a pulmonary adenocarcinoma. The location of the tumour by itself could not explain the bilateral VCP, except as a paraneoplastic phenomenon, which has been casuistically reported previously [6]. The same patient was diagnosed with a hepatocellular carcinoma two months later on a stand alone CT. This patient was categorized true positive.

Non-neoplastic causes of VCP

In the majority of cases the cause of the VCP stayed idiopathic (**Figure 3**). In some instances it was speculated to represent sequelae secondary to upper respiratory tract infections, to intubation after general anaesthesia, or cricoarytenoid arthritis secondary to ankylosing spondylitis, as VCP has been reported in systemic inflammatory diseases [7]. One person had a central paresis secondary to an infection of the mastoid with intracranial involvement. **Table 4** shows the benign findings by histopathology or imaging which include thyroid follicular neoplasia, inflammation, and cardiovascular causes.

Misclassified findings by PET/CT

Biopsy was performed in only four out of eight false positive PET/CT scans, in most cases because the PET/CT findings were equivocal and reported as such. At biopsy, two cases of inflammatory lymph nodes and one case of benign thyroid follicular neoplasia was demonstrated, whereas in one single case histopathology did not explain the PET/CT findings. **Table 5** lists the misclassified findings by PET/CT.

Table 3. Malignant findings in patients with VCP. All were categorized as true positive by PET/CT, *n* = 27

Patient number	Sex F/M	Age (years)	Side of VCP	Histopathology/follow-up	TNM-staging	Curative intent of treatment	History of cancer (except from skin)
1	F	64	Left	Carcinoma. Believed to represent relapse of invasive ductal carcinoma of the breast, though HER2-receptor profile had changed.	n/a, disseminated	No	Breast cancer
3	F	77	Left	Histopathology n/a. Second relapse of invasive ductal carcinoma of the breast. The patient died 1½ years afterwards	n/a, disseminated	No	Breast cancer
4	F	62	Left	Invasive ductal carcinoma of the breast	n/a, disseminated	No	Breast cancer
6	F	81	Left	Anaplastic carcinoma of the thyroid	T4NxM1	No	-
7	F	73	Left	Mantle cell lymphoma	Ann Arbour stage II	No	Cervical cancer of the uterus
9	M	64	Right	Squamous cell carcinoma of the esophagus	TxN3M1b	No	-
10	M	69	Right	Squamous cell carcinoma of the lung	TxN3M0	Yes	-
11	M	58	Left	Pulmonary adenocarcinoma	T4N2M0	Yes	-
14	M	67	Left	Pulmonary adenocarcinoma	T2N2M1a	No	-
21	M	88	Bilateral	Pulmonary adenocarcinoma	T1bN3M1b	No	Prostate cancer
22	F	52	Left	Pulmonary adenocarcinoma	T4N2M0	Yes	-
25	F	60	Bilateral	Pulmonary adenocarcinoma	T2aN0M0	Yes	-
26	F	70	Right	Adenocarcinoma of the breast	TxNxM1	No	Breast cancer
34	F	67	Left	Invasive ductal carcinoma of the breast	TxNxM1	No	Breast cancer
35	F	70	Right	Squamous hypopharyngeal carcinoma	n/a, disseminated	No	Cancer of the esophagus, hypopharyngeal cancer
37	F	51	Left	Pulmonary adenocarcinoma	T3N2M1b	No	-
38	M	71	Left	Squamous cell carcinoma of the esophagus	T1N1M1	Yes	-
39	M	76	Right	Squamous hypopharyngeal carcinoma	T1N1M0	Yes	-
41	F	66	Left	Pulmonary adenocarcinoma	T4N3M1b	No	-
46	F	41	Left	Rectal adenocarcinoma	TxNxM1	Yes	Rectal cancer
48	F	69	Left	Squamous cell carcinoma of the esophagus	T3N1M1a	No	-
50	M	68	Right	Squamous subglottical carcinoma of the larynx	T4AN0M0	Yes	-
51	M	68	Right	Squamous cell carcinoma of the tongue	TxN2AM0	Yes	Tongue cancer
54	F	79	Right	Papillary thyroid adenocarcinoma	T4AN0M0	Yes	-
55	M	67	Right	Squamous cell carcinoma of the esophagus	T3N2M0	Yes	-
59	M	74	Left	Pulmonary adenocarcinoma	T1aN3M1a	No	-
62	M	63	Left	Squamous cell carcinoma of the esophagus	T3N1M1	No	-

Abbreviations: VCP, vocal cord palsy; F, female; M, male; *HER2,* human epidermal growth factor receptor 2; *n/a,* not available.

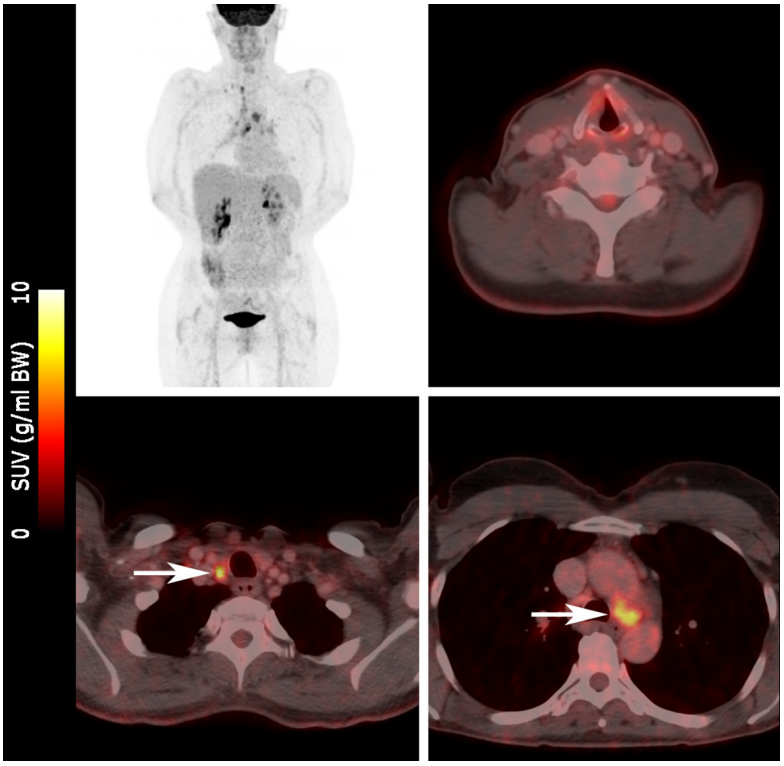

Figure 3. Vocal cord palsy presumably caused by inflammatory lymph nodes with compression of the left recurrent laryngeal nerve - A false positive examination. A 56-year-old female with hoarseness during 6-12 month, previous smoker, had a subtotal immobilization of the left vocal cord by laryngoscopy (patient number 5). Enlarged, fluorodeoxyglucose-avid lymph nodes were identified in the mediastinum and neck suggestive of inflammation or malignancy (arrows). Biopsy from mediastinal lymph nodes revealed no malignant cells. A follow-up scan at 3½ months demonstrated complete regression.

Incidental findings by PET/CT

Three patients had intense, focal FDG-uptake in the colon suggestive of polyps. All three had a colonoscopy. Two turned out to be tubular adenomas with low-grade dysplasia and in one patient no larger polyps were identified. This patient was not satisfactory emptied prior to colonoscopy and no further attempt was made due the severity of the head and neck cancer. One patient had FDG-uptake in the maxillary sinus due to chronic rhino sinusitis and a sinus cyst. By CT, one patient was diagnosed with heart failure and concomitant liver stasis. Another had a renal calculus, which was treated with extracorporeal shock wave lithotripsy. Two patients had non-FDG-avid solitary lung nodules. Follow-up imaging showed no progression of the lesions. Findings of hyperattenuating renal masses, suspected diverticulitis of the colon, and an oesophageal diverticulum were never properly investigated.

Discussion

To our knowledge, no data has been published on the diagnostic performance of PET/CT to rule out malignancy in patients with VCP. We found that PET/CT can be used to rule out malignancy with excellent reliability (NPV 100%) in patients with inexplicable VCP. Nonetheless, in eight cases (12%) PET/CT was false positive, thereby initiating a series of seemingly redundant investigations. Inflammation was the most frequent verified cause of false positive findings, which is a quite common cause of FDG-avid lesions detected by PET/CT [8, 9]. Alternatively, false positive findings can result from very low grade and slow growing cancers, which only a longer follow-up would be able to disclose. Moreover, it is important to recognize that false positive scans may demonstrate the exact *cause* of the VCP, though considered false positive in this study as they were non-malignant in nature. Regardless of the number of false positives, the potential benefit of FDG-PET/CT in exclusion of underlying malignancy outweights the disadvantages in the majority of patients.

We found a rather high prevalence of malignancy of 42% compared to 29.9% in an earlier retrospective report by Hsin-Chien et al., the reason probably being, that our data were biased by referral, because patients with an obvious benign cause of VCP, were not referred [3]. Thus, in a previous report from our institution, comprising 229 cases of VCP not examined by PET/CT, only 22% of VCPs were caused by neoplastic changes, but yet traumatic causes were found in 39% [10], which would represent a population, that would normally not undergo PET/CT in the fast track cancer program.

Based upon the TNM-staging of our cohort most cancers, in patients presenting with VCP,

Table 4. Benign causes of VCP, verified by histopathology or other imaging modalities

Patient number	Sex F/M	Age (years)	Side of VCP	PET/CT	Follow-up	Histo-pathology available
15	M	66	Right	True negative	Sequelae to radiotherapy	Yes
19	F	64	Left	False positive	Benign thyroid follicular neoplasia of the left lobe	Yes
29	M	41	Left	True negative	Hyperkeratosis, acute and chronic inflammation in the larynx	Yes
36	M	54	Left	False positive	Biopsy from paretic vocal cord (with intense FDG-avidity) demonstrated chronic inflammation and oedema	Yes
47	M	72	Left	False positive	Biopsy from lymph nodes in the mediastinum showed inflammatory cells	Yes
56	F	43	Right	True negative	By magnetic resonance imaging: Several white matter lesions (cardiovascular cause)	No
60	F	73	Right	True negative	Nodular colloid goitre	Yes

Abbreviations: VCP, vocal cord palsy; F, female; M, male.

Table 5. Misclassified findings (all were false positive) by FDG-PET/CT in patients with VCP, $n = 8$

Patient number	Sex F/M	Age (years)	Side of VCP	Follow-up	Histo-pathology available
5	F	56	Left	Endobroncial ultrasound with fine needle aspiration of mediastinal lymph nodes: No malignant cells (**Figure 3**). Follow-up PET/CT after three months: Complete regression	Yes
18	F	76	Bilateral	PET/CT: Asymmetrically increased FDG-avidity in the base of the tongue. Magnetic resonance imaging, laryngoscopy and clinical follow-up showed no signs of cancer	No
19	F	64	Left	Benign thyroid follicular neoplasia in the left lobe	Yes
31	M	54	Right	PET/CT: FDG-avid lymph node on the neck, not enlarged. Ultrasound: benign. Biopsy was never performed. Clinical follow-up without signs of cancer	No
36	M	54	Left	Biopsy from palsied vocal cord (with intense FDG-avidity): Chronic inflammation and oedema	Yes
47	M	72	Left	Biopsy from FDG-avid lymph nodes in the mediastinum: Inflammatory cells	Yes
49	M	49	Left	Small lymph nodes, slightly FDG-avid. Clinical follow-up without progression after six months. Final diagnosis: Cricoarytenoid arthritis secondary to ankylosing spondylitis	No
57	F	57	Right	Solitary pulmonary nodule, followed with PET/CT – not malignant	No

Abbreviations: FDG, fluorodeoxyglucose; VCP, vocal cord palsy; F, female; M, male.

were of an advanced stage (**Table 3**). However, we included patients with already suspicious findings at referral, patients with antecedent cancer, and even prior relapses, which represents a group of patients with very high pre-test likelihood of cancer. Therefore it may seem unnecessary to perform a PET/CT. In contrast, one may argue to perform a PET/CT instantly also in these patients, to stage the patients correctly and to find an adequate biopsy site. Similarly, PET/CT may be useful in therapy planning and response evaluation.

Sixteen patients already had distant metastases at the time of PET/CT scan. In 11 cases the treatment was intended curative, whereas it was palliative in 16. This underscores the importance of a dedicated cancer program, which includes PET/CT, in order to minimize the time span between symptom appearance and initiation of treatment, thereby improving prognosis.

The prognostic value of PET/CT in patients with VCP remains unresolved by our study and depends upon several factors among which the diagnostic delay may play an important role. It may be possible to detect more cancers at an earlier stage with PET/CT than with traditional workup. This has not been elucidated, and warrants prospective evaluation.

A recent retrospective work, which included 59 subjects, reported on the differentiation of FDG-accumulation in the vocal cords causing the VCP, whether originating from the *laryngeal region*, the *recurrent laryngeal nerve* or the *vagal center/proximal vagus nerve*, respectively [5]. It was concluded that FDG-accumulation in the vocal cords depended on the lesion site causing the VCP. However, we postulate that this prediction is uncertain, because i) VCP, regardless of cause, theoretically should result in decreased metabolic state of the affected muscles, and ii) we did not find *increased* FDG

accumulation in the *palsied vocal fold* in patients with causes of VCP in the laryngeal region, except in one case in which biopsy demonstrated severe inflammation. In the present study some of the vocal cords could not be evaluated by SUV measurements because of activity "spill over" from the tumour onto the vocal cords, which might explain the controversial findings by Minamimoto et al. Notably, FDG only accumulates in the vocal cords as metabolic demands increase, for instance during phonation, which is why one may not see a difference in FDG-avidity of the vocal cords, if the patient does not speak during or after injection of FDG [11]. In earlier case reports, asymmetric FDG-uptake in the vocal cord or cricoarytenoid muscle - as a sign of VCP - was demonstrated as an incidental finding in lung, oesophageal and thyroid cancer [12-15]. Lee et al. reported 15 cases with asymmetric FDG-uptake (PET without CT-scan) as a sign of VCP in patients referred for lung cancer staging [1]. Minamimoto et al. also reported on the sensitivity of PET/CT to identify the lesion causing the VCP in the three groups ranging between 60-93%, but it is important to acknowledge, that this includes *both* benign or malignant causes [5]. In fact, the causes of VCP missed by PET/CT were mainly benign. In these patients it seems more important to rule out malignancy rather than to prove the exact cause of the VCP.

Limitations

Our study was retrospective with the limitations this brings; part of the data relies on patient reports as reproduced by the referring clinician and the diagnostic work-up and decision-making was left at the discretion of the referring physician. For example, biopsy was performed only in subjects suspected of a malignancy, whereas it was not performed in lesions considered benign. However, this limitation was largely eliminated by the follow-up of patients in a national registry. Furthermore, we did not perform delayed time-point FDG-PET/CT imaging, which may increase the diagnostic accuracy, since FDG-avidity of inflammatory lesions seems to decrease or stabilize over time, whereas it tends to increase in neoplastic lesions [16, 17].

Conclusion

Patients - presenting with inexplicable VCP - constitutes a clinically important group of patients in which it is highly relevant to rule out malignancy. Biopsy proven malignancy (whether newly diagnosed or relapsed) was the cause of VCP in almost half of patients. PET/CT had a high sensitivity (100%) with a relatively high false positive rate, but was excellent in ruling out malignancy (negative predictive value 100%). Thus PET/CT appears to be an important ancillary tool in identifying patients with VCP in need of biopsy.

Disclosure of conflicts of interest

None.

Address correspondence to: Dr. Anders Thomassen, Department of Nuclear Medicine, Odense University Hospital, Sdr. Boulevard 29, 5000 Odense C, Denmark. Tel: (+45)65412981; Fax: (+45)6590-6192; E-mail: anders.thomassen@rsyd.dk

References

[1] Lee M, Ramaswamy MR, Lilien DL and Nathan CO. Unilateral vocal cord paralysis causes contralateral false-positive positron emission tomography scans of the larynx. Ann Otol Rhinol Laryngol 2005; 114: 202-206.

[2] Sorensen JR, Johansen J, Gano L, Sorensen JA, Larsen SR, Andersen PB, Thomassen A and Godballe C. A "package solution" fast track program can reduce the diagnostic waiting time in head and neck cancer. Eur Arch Otorhinolaryngol 2013; [Epub ahead of print].

[3] Chen HC, Jen YM, Wang CH, Lee JC and Lin YS. Etiology of vocal cord paralysis. ORL J Otorhinolaryngol Relat Spec 2007; 69: 167-171.

[4] Yumoto E, Minoda R, Hyodo M and Yamagata T. Causes of recurrent laryngeal nerve paralysis. Auris Nasus Larynx 2002; 29: 41-45.

[5] Minamimoto R, Kubota K, Morooka M, Ito K, Mitsumoto T, Okasaki M, Shimbo T and Tayama N. Reevaluation of FDG-PET/CT in patients with hoarseness caused by vocal cord palsy. Ann Nucl Med 2012; [Epub ahead of print].

[6] Chang CY, Martinu T and Witsell DL. Bilateral vocal cord paresis as a presenting sign of paraneoplastic syndrome: case report. Otolaryngol Head Neck Surg 2004; 130: 788-790.

[7] Desuter G, Duprez T, Huart C, Gardiner Q and Verbruggen G. The use of adalimumab for cricoarytenoid arthritis in ankylosing spondylitis--an effective therapy. Laryngoscope 2011; 121: 335-338.

[8] Balink H, Verberne HJ, Bennink RJ and van Eck-Smit BL. A Rationale for the Use of F18-FDG PET/CT in Fever and Inflammation of Unknown Origin. Int J Mol Imaging 2012; 2012: 165080.

[9] Thomassen A, Lerberg Nielsen A, Gerke O, Johansen A and Petersen H. Duration of 18F-FDG avidity in lymph nodes after pandemic H1N1v and seasonal influenza vaccination. Eur J Nucl Med Mol Imaging 2011; 38: 894-898.
[10] Mehlum CS, Faber CE and Grontved AM. [Vocal fold palsy--etiology and outcome]. Ugeskr Laeger 2009; 171: 109-112.
[11] Kostakoglu L, Wong JC, Barrington SF, Cronin BF, Dynes AM and Maisey MN. Speech-related visualization of laryngeal muscles with fluorine-18-FDG. J Nucl Med 1996; 37: 1771-1773.
[12] Choong NW and Hellman RS. Recurrent laryngeal nerve palsy on integrated positron emission tomography-computed tomography. J Thorac Oncol 2008; 3: 1172.
[13] Kamel EM, Goerres GW, Burger C, von Schulthess GK and Steinert HC. Recurrent laryngeal nerve palsy in patients with lung cancer: detection with PET-CT image fusion -- report of six cases. Radiology 2002; 224: 153-156.
[14] Komissarova M, Wong KK, Piert M, Mukherji SK and Fig LM. Spectrum of 18F-FDG PET/CT findings in oncology-related recurrent laryngeal nerve palsy. AJR Am J Roentgenol 2009; 192: 288-294.
[15] Lu D, Jadvar H, Go J, Henderson R, Boyko O, Grant E and Law M. FDG-PET/MRI fusion demonstrating cricoarytenoid muscle hypermetabolism due to contralateral true vocal cord paralysis. Rev Esp Med Nucl Imagen Mol 2012; 31: 362-363.
[16] Schillaci O. Use of dual-point fluorodeoxyglucose imaging to enhance sensitivity and specificity. Semin Nucl Med 2012; 42: 267-280.
[17] Basu S, Kung J, Houseni M, Zhuang H, Tidmarsh GF and Alavi A. Temporal profile of fluorodeoxyglucose uptake in malignant lesions and normal organs over extended time periods in patients with lung carcinoma: implications for its utilization in assessing malignant lesions. Q J Nucl Med Mol Imaging 2009; 53: 9-19.