Incidental diagnosis of tumor thrombosis on FDG PET/CT imaging

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**Abstract**

**Objective:** Clinical data are presented on patients with tumor thrombosis (TT) incidentally detected on FDG PET/CT imaging, as well as determining its prevalence and metabolic characteristics.

**Materials and methods:** Out of 12,500 consecutive PET/CT examinations of patients with malignancy, the PET/CT images of 15 patients with TT as an incidental finding were retrospectively investigated. A visual and semiquantitative analyses was performed on the PET/CT scans. An evaluation was made of the pattern of FDG uptake in the involved vessel as linear or focal via visual analyses. For the semiquantitative analyses, the metabolic activity was measured using SUVmax by drawing the region of interest at the site of the thrombosis and tumor (if any).

**Results:** The prevalence of occult TT was 0.12%. A total of 15 patients had various malignancies including renal (1 patient), liver (4), pancreas (2), stomach (1), colon (1), non-Hodgkin lymphoma (1), leiomyosarcoma (1), endometrial (1), ovarian (1), melanoma (1) and parotid (1). Nineteen vessels with TT were identified in 15 patients; three patients had more than one vessel. Various vessels were affected; the most common was the inferior vena cava (n=7) followed by the portal (n=5), renal (n=3), splenic (n=1), jugular (n=1), common iliac (n=1) and ovarian vein (n=1). The FDG uptake pattern was linear in 12 and focal in 3 patients. The mean SUVmax values in the TT and primary tumors were 8.40 ± 4.56 and 13.77 ± 6.80, respectively.

**Conclusion:** Occult TT from various malignancies and locations was found incidentally in 0.12% of patients. Interesting cases with malign melanoma and parotid carcinoma and with TT in ovarian vein were first described by FDG PET/CT. Based on the linear FDG uptake pattern and high SUVmax value, PET/CT may accurately detect occult TT, help with the assessment of treatment response, contribute to correct tumor staging, and provide additional information on the survival rates of oncology patients.

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**Diagnóstico incidental de trombosis tumoral con FDG PET/CT**

**Resumen**

**Objetivo:** Se presentan los datos clínicos de pacientes con trombosis tumoral (TT) detectada incidentalmente en estudios FDG PET/TC, y se determinan su prevalencia y sus características metabólicas.

**Material y Métodos:** De 12,500 exploraciones consecutivas PET/TC realizadas en pacientes con tumores malignos, se analizaron de forma retrospectiva las imágenes PET/TC de 15 pacientes con TT como un hallazgo incidental. Se realizaron un análisis visual y un análisis semicuantitativo de las exploraciones PET/TC. El patrón de captación de FDG en el vaso afecto, evaluado por análisis visual, fue lineal o focal. En el análisis semicuantitativo se midió la actividad metabólica usando SUVmax, dibujando regiones de interés en el sitio de la trombosis y en el tumor (si existía).

**Resultados:** La prevalencia de TT fue 0.12%. Quince pacientes tenían diversos tumores malignos incluyendo riñón (1), hígado (4), páncreas (2), estómago (1), colon (1), linfoma no Hodgkin (1), leiomirosarcoma (1), endometrio (1), ovario (1), melanoma maligno (1) y parótida (1). Se identificaron 19 vasos con TT en 15 pacientes. Tres pacientes tenían más de un vaso afecto. El vaso más frecuentemente afectado fue la vena cava inferior (n=7), seguido de la porta (n=5), renal (n=3), esplénica (n=1), jugular (n=1), ilíaca común (n=1) y venas ováricas (n=1). El patrón de captación de FDG fue lineal en 12 y focal en 3 pacientes. El SUVmax medio en el TT y en los tumores primarios fue 8.40 ± 4.56 y 13.77 ± 6.80, respectivamente.

**Conclusión:** Trombosis tumoral oculta en diversos tumores malignos y en diferentes localizaciones se encontró incidentalmente en un 0.12%. Casos interesantes fueron el melanoma maligno y el carcinoma de parótida. La TT en la vena ovárica se describe por primera vez mediante FDG PET/TC. Basado en el patrón lineal captación de FDG y el elevado valor SUVmax, la PET/TC puede detectar con exactitud la TT oculta, ayudar en la evaluación de la respuesta al tratamiento, contribuir en la correcta estadificación del tumor y también proporcionar información adicional sobre la supervivencia en pacientes oncológicos.

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Introduction

Thrombosis is a common finding in patients with malignancies compared with the general population.\(^1\) It can be divided into two clinical entities: venous thromboembolism (VTE) and tumor thrombosis (TT). VTE is a well-recognized, relatively common complication in cancer patients and a significant cause of morbidity and mortality. However, TT is a rare but serious complication in oncological patients. The true incidence of TT is unknown. The presence of TT has significant impacts on staging, treatment and prognosis.\(^2\) VTE is managed with anticoagulant therapy; TT requires aggressive multimodality management. Therefore, the correct diagnosis of TT and its differentiation from VTE can change patient management and might facilitate the start of an appropriate therapy.\(^3\)

Thrombosis is most often detected by chance during staging investigations.\(^4\) Anatomical diagnostic imaging including ultrasonography, contrast-enhanced computed tomography (CEPT) and magnetic resonance imaging is used to confirm the existence of the thrombus, evaluate the extent of its spread and monitor its response to therapy.\(^4\) Positron emission tomography/computed tomography (PET/CT) using fluorodeoxyglucose (FDG) is a very powerful functional imaging modality for the diagnosis, staging, restaging, treatment planning and follow-up of patients with various malignancies. It also provides the best anatomical and functional information. The routine use of FDG PET/CT has resulted in clinicians detecting many incidental findings, which have proven to be clinically significant, such as TT (2–17). The recognition of this rare complication by FDG PET/CT is essential for the accurate management of patients, preventing unnecessary long-term anticoagulation treatment and also decreasing morbidity.\(^2\)\(^-\)\(^3\) However, limited sporadic case reports and retrospective studies with small cohorts of patients due to the rarity of this disease have reported the role of FDG PET/CT in TT (2–24). Therefore, the purpose of this retrospective study was to present clinical data of patients with TT incidentally detected on FDG PET/CT imaging and also to determine its prevalence and metabolic characteristics in our population of oncological patients.

Material and methods

Patients

Between November 2009 and October 2014, we conducted 12,500 consecutive FDG PET/CT examinations of patients with malignancy at Department of Nuclear Medicine of Basakent University, we retrospectively investigated FDG PET/CT imaging of 15 patients with TT. In these 15 patients, FDG uptake in the TT was recorded as an incidental finding on FDG PET/CT imaging. The demographic and clinical data of the patients, including type of cancer, site of thrombus, indication of scan and other imaging findings for confirmation of TT, were analyzed. The protocol of this study was approved by our local ethics committee for retrospective analyses.

FDG PET/CT imaging

PET/CT scans were obtained 60 min after injection using an integrated scanner (Discovery-STE 8; General Electric Medical System, Milwaukee, WI, USA). All patients fasted for at least 6 h before the intravenous administration of 370–555 mBq (10–15 mCi) FDG. We measured preinjection blood glucose levels to ensure that they were below 200 mg/dL. During the distribution phase, patients lay supine in a quiet room. The patients were scanned on a flat-panel carbon fiber composite table insert. First, an unenhanced CT scan with a slice thickness of 3.3 mm from the vertex or base of the skull to the inferior border of the pelvis was acquired using a standardized protocol (140 kV and 80 mA). The subsequent PET scan was acquired in the three-dimensional mode from the vertex or base of the skull to the inferior border of the pelvis (6–7 bed positions, 3 min per bed position) without repositioning the patient on the table. The patient was allowed to breathe normally during the PET and CT acquisitions. FDG PET images were reconstructed using CT data for attenuation correction.

Imaging analysis

The diagnosis of TT was based on the increased FDG uptake of solid masses inside the vessels. We performed visual and semi-quantitative analyses of the PET/CT scans. We evaluated the pattern of FDG uptake in the involved vessel as linear or focal via visual analyses. For the semiquantitative analyses, we measured metabolic activity using SUVmax by drawing the region of interest at the site of thrombosis and primary tumor (if any). The FDG PET/CT results were confirmed with CECT, clinical follow-up or follow-up FDG PET/CT for assessment of the response to anticancer treatment.

Statistical analysis

All data were expressed as mean ± standard deviation. The clinical data of the patients and scan results were analyzed with using descriptive statistics including frequencies, means and medians. All statistical analyses were performed using Statistical Package for the Social Sciences software (SPSS, version 15.0; SPSS Inc, Chicago, IL, USA) for Windows.

Results

A total of 15 patients with TT were evaluated: 9 men and 6 women with a mean age 55.40 ± 15.53 years (range: 21–83 years). The prevalence of occult TT accounted for 0.12% of our population. All demographic and clinical data of the patients, including type of cancer, site of thrombus, indication of scan and scan results are presented in Table 1. These patients had various types of malignancies including renal cell carcinoma (RCC) (1 patient), liver adenocarcinoma (1), hepatocellular carcinoma (HCC) (1), cholangiocellular carcinomas (2), pancreas (2), stomach (1), colon adenocarcinoma (1), non-Hodgkin lymphoma (1), retroperitoneal leiomyosarcoma (1), endometrial carcinoma (1), ovarian carcinoma (1), malignant melanoma (1) and parotid (1), as shown in Table 1.

Indication for the scan was initial staging in 9 patients, restaging in 4 patients and the diagnosis of an unknown primary tumor in 2 patients. Eight patients were lost to follow-up with a median follow-up duration of 5 months (range: 1–16 months) after the diagnosis of TT via PET/CT imaging. At the time of this analysis, 7 patients were alive with a median follow-up duration of 15 months (range: 1–20 months) after the diagnosis of TT on PET/CT imaging.

Nineteen vessels of TT were identified in 15 patients; three patients had more than one vessel of TT. Various vessels were affected; the most common was the inferior vena cava (IVC) (n = 7, Figs. 1 and 2) followed by portal vein (n = 5, Fig. 3), renal vein (n = 3, Fig. 1), splenic vein (n = 1, Fig. 4), jugular vein (n = 1, Fig. 5), common iliac vein (n = 1) and ovarian vein (n = 1, Fig. 6). The pattern of FDG uptake was increased linearly in 12 patients (Figs. 1 and 3–6) and focal in 3 patients (Fig. 2). Direct invasion from tumors or metastases was present in all veins. The mean SUVmax value in the TT of the 19 involved vessels was 8.40 ± 4.56 (range: 3.3–18.3) and the mean SUVmax of the primary tumor of the 12 patients was 13.77 ± 6.80 (range: 6.1–30.8). Three patients underwent surgery due to a primary tumor before PET/CT imaging; only one patient had a residual tumor (case 13).
Table 1
The demographic and clinical data of the 15 patients with tumor thrombosis.

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (year)</th>
<th>Sex</th>
<th>Type of cancer</th>
<th>Site of thrombus</th>
<th>Thrombus SUVmax</th>
<th>Pattern of FDG uptake</th>
<th>Primary tumor SUVmax</th>
<th>Indication for PET/CT</th>
<th>Confirmation</th>
<th>Follow-up period after PET/CT (month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>51</td>
<td>M</td>
<td>RCC</td>
<td>IVC (residual)</td>
<td>3.3</td>
<td>Linear</td>
<td>Opere</td>
<td>Restaging</td>
<td>CECT</td>
<td>Alive (18)</td>
</tr>
<tr>
<td>2</td>
<td>53</td>
<td>M</td>
<td>Liver adenocarcinoma</td>
<td>IVC</td>
<td>3.4</td>
<td>Linear</td>
<td>11.9</td>
<td>Initial staging</td>
<td>CECT</td>
<td>Alive (15)</td>
</tr>
<tr>
<td>3</td>
<td>21</td>
<td>F</td>
<td>HCC</td>
<td>PV</td>
<td>7.6</td>
<td>Linear</td>
<td>10.5</td>
<td>Diagnosis of primary tumor</td>
<td>–</td>
<td>Died (16)</td>
</tr>
<tr>
<td>4</td>
<td>59</td>
<td>F</td>
<td>Cholangiocellular carcinomas</td>
<td>PV</td>
<td>5.3</td>
<td>Fokal</td>
<td>9.3</td>
<td>Diagnosis of primary tumor</td>
<td>CECT</td>
<td>Died (3)</td>
</tr>
<tr>
<td>5</td>
<td>58</td>
<td>M</td>
<td>Cholangiocellular carcinomas</td>
<td>PV</td>
<td>8.8</td>
<td>Linear</td>
<td>10.4</td>
<td>Initial staging</td>
<td>CECT</td>
<td>Died (1)</td>
</tr>
<tr>
<td>6</td>
<td>52</td>
<td>M</td>
<td>Pancreas</td>
<td>PV</td>
<td>3.6</td>
<td>Linear</td>
<td>11.55</td>
<td>Initial staging</td>
<td>CECT</td>
<td>Alive (3)</td>
</tr>
<tr>
<td>7</td>
<td>69</td>
<td>F</td>
<td>Pancreas</td>
<td>PV</td>
<td>4.2</td>
<td>Linear</td>
<td>6.1</td>
<td>Initial staging</td>
<td>CECT</td>
<td>Died (5)</td>
</tr>
<tr>
<td>8</td>
<td>71</td>
<td>M</td>
<td>Stomach</td>
<td>IVC</td>
<td>8.7</td>
<td>Linear</td>
<td>11.8</td>
<td>Initial staging</td>
<td>CECT</td>
<td>Died (7)</td>
</tr>
<tr>
<td>9</td>
<td>60</td>
<td>M</td>
<td>Colon adenocarcinoma</td>
<td>IVC</td>
<td>9.8</td>
<td>Fokal</td>
<td>7.7</td>
<td>Restaging</td>
<td>CECT</td>
<td>Died (10)</td>
</tr>
<tr>
<td>10</td>
<td>32</td>
<td>M</td>
<td>NHL, DLBCL</td>
<td>SPV</td>
<td>16.5</td>
<td>Linear</td>
<td>17</td>
<td>Initial staging</td>
<td>Follow-up PET/CT</td>
<td>Alive (20)</td>
</tr>
<tr>
<td>11</td>
<td>68</td>
<td>F</td>
<td>Leiomyosarcoma</td>
<td>IVC</td>
<td>5.5</td>
<td>Linear</td>
<td>Opere</td>
<td>Restaging</td>
<td>PET/CT</td>
<td>Alive (19)</td>
</tr>
<tr>
<td>12</td>
<td>54</td>
<td>F</td>
<td>Endometriat carcinoma</td>
<td>IVC</td>
<td>16.7</td>
<td>Linear</td>
<td>30.8</td>
<td>Initial staging</td>
<td>PET/CT</td>
<td>Alive (1)</td>
</tr>
<tr>
<td>13</td>
<td>59</td>
<td>F</td>
<td>Ovarian carcinoma</td>
<td>Common iliac vein</td>
<td>12.3</td>
<td>Linear</td>
<td>Opere 20.0 (residual)</td>
<td>Initial staging</td>
<td>CECT</td>
<td>Alive (1)</td>
</tr>
<tr>
<td>14</td>
<td>41</td>
<td>M</td>
<td>Malignant melanoma</td>
<td>IVC (right)</td>
<td>8.9</td>
<td>Linear</td>
<td>–</td>
<td>Restaging</td>
<td>CECT</td>
<td>Died (2)</td>
</tr>
<tr>
<td>15</td>
<td>83</td>
<td>M</td>
<td>Parotid</td>
<td>JV (right)</td>
<td>5.2</td>
<td>Linear</td>
<td>18.2</td>
<td>Initial staging</td>
<td>CECT</td>
<td>Died (5)</td>
</tr>
</tbody>
</table>

SUVmax, maximal standardized uptake value; M, male; F, female; RCC, renal cell carcinoma; HCC, hepatocellular carcinoma; NHL, non-Hodgkin lymphoma; DLBCL, diffuse large B cell lymphoma; IVC, inferior vena cava; RV, renal vein; PV, portal vein; SMV, superior mesenteric vein; SPV, splenic vein; JV, jugular vein; PET/CT, positron emission tomography/computed tomography; CECT, contrast-enhanced computerized tomography.

Fig. 1. Case of a 41-year-old male with malign melanoma who underwent FDG PET/CT for restaging due to brain and bilateral adrenal metastases. The maximum intensity projection (MIP) (A), coronal fusion PET/CT (B) and transaxial fusion PET/CT (C) images show increased linear FDG uptake in the IVC, right and left renal veins (SUVmax: 8.9, 7.1 and 6.7, respectively), suggestive of TT. The diagnosis was confirmed with CECT.
PET/CT findings were verified by clinical follow-up and CECT in 12 cases. Follow-up PET/CT imaging after anticancer treatment was performed in two cases (cases 10 and 11), and these results proved the resolution of the thrombotic lesions. Only one case (case 3, Fig. 3) was referred to our center for PET/CT imaging from another institution and TT was considered based on typical PET/CT findings.

Discussion

Tumor thrombosis is a relatively rare complication in patients with malignancies. Tumor thrombosis is usually seen in solid cancers such as HCC and RCC. However, there are sporadic reports of TT in solid cancers such as ovarian/testicular tumors, tumors of the colon, pancreas, lung, breast, and thyroid, lymphomas, sarcomas, neuroendocrine tumors and many others. In this study we have reported patients with TT from various common and rare malignancies. Carcinomas of the liver, in particular cholangiocellular carcinomas, were the most common cause of TT in this small group. The other causes of TT included RCC, stomach, colon, non-Hodgkin lymphoma, retroperitoneal leiomyosarcoma, endometrial, ovarian, malignant melanoma and parotid. The last two cases are interesting because TT from such an etiology has not been diagnosed previously by FDG PET/CT.

In our oncological population, the prevalence rate of occult TT was found to be 0.12%. Occult IVC TT has also been reported with an incidence rate of 0.11%. The most common site of TT is reportedly the IVC, with other common sites including the portal and renal veins. Our study also showed that most of the TT occurred in the IVC in seven cases, followed by the portal vein in five cases, and the renal vein in three cases, in consistent with previous reports. Some case reports have also described rare sites of TT, such as the mesenteric, aygos, paraumbilical and gonadal veins, the superior vena cava and even the cardiac chambers. Other rare sites of TT in our study were the splenic vein in one case, the jugular vein in one case, the common iliac vein in one case and the ovarian vein in one case. To the best of our knowledge, TT in the ovarian veins has not been reported perviously by FDG PET/CT.
The pathophysiology of TT is poorly understood due to probably its rarity and poor prognosis. Tumor thrombosis may be a direct extension of the primary tumor or metastases into the blood vessel or may occur at a distant site due to embolism. It is most commonly seen in solid tumors adjacent to large veins as an extension of the malignancy infiltrating the lumen of adjacent veins, such as HCC or RCC. However, it may also embolize to distant sites in most cancers.\textsuperscript{16,17–19} In our cases, TT was considered to be direct extension of the primary tumor and/or metastases into the veins.

The diagnosis of TT is important because it affects tumor staging, treatment decisions and prognosis in many malignancies. Tumor thrombosis is usually inaccessible for biopsies, making diagnosis difficult. Imaging modalities play an important role in the diagnosis of TT. Detecting a thrombus, determining its extent and resectability, and differentiating it from a VTE are several common difficulties. The current diagnostic techniques poorly differentiate between TT and VTE. Recently, due to developments and increases in the use of FDG PET/CT in oncology, unsuspected/occult TT detections have been reported in various malignancies and in various locations in the venous vasculature. Since FDG PET/CT imaging can identify and characterize malignant lesions on a functional level, this technique has opened up new horizons for solving the diagnostic difficulties of TT. However, limited retrospective studies have reported about the diagnosis of TT and differentiating it from VTE by FDG PET/CT imaging based on the pattern of FDG uptake and/or SUV\textsubscript{max}.\textsuperscript{17–23} The combined use of visual and semiquantitative analyses may increase the performance of FDG PET/CT for the detection and characterization of TT compared with other imaging modalities, help the assessment of treatment response and also facilitate differentiation between VTE and TT. Moreover, the added information obtained from PET/CT imaging may be helpful to determine prognosis. Another advantage of PET/CT imaging is the ability to perform whole-body imaging, which can easily determine the cranial extension of TT.

The first and smallest study by Lai et al., which focused on six patients, reported the benefit of FDG PET/CT imaging in the diagnosis of TT using visual analysis.\textsuperscript{2} Another study using visual analysis by Davidson et al. reported an accuracy of 100% at differentiating between VTE and TT in 11 patients.\textsuperscript{3} The pattern of uptake based on visual analysis has been reported to be either focal or linear. Most studies published to date have reported increased FDG uptake in a linear pattern along the course of the vessel.\textsuperscript{15} However, focal FDG uptake has also been reported in TT.\textsuperscript{24} In our study, FDG uptake was found to be linear in the majority of patients. However, a focal pattern of FDG uptake was also seen in three cases, consistent with previous reports.\textsuperscript{2,3,17}

The uptake of FDG by TT has been shown to be considerably higher than that by VTE in previous studies.\textsuperscript{17–23} Although there is no reliable SUV\textsubscript{max} cutoff for differentiating VTE from TT, some studies have reported an optimum SUV\textsubscript{max} cutoff for their study groups. In our study, the mean SUV\textsubscript{max} was found to be 8.40 ± 4.56 (range: 3.3–18.3). However, our study did not compare SUV\textsubscript{max} values of patients with VTE and TT, as compared with corresponding values for VTE in the literature, we also found high SUV\textsubscript{max} values. Our study demonstrated that linear FDG uptake and high SUV\textsubscript{max} values compared with that of VTE in the literature may support TT and facilitate its differentiation from VTE. FDG uptake in the primary tumors varies due to the heterogeneous types of the tumor. The mean SUV\textsubscript{max} of the primary tumors of our patients was 13.77 ± 6.80 (range: 6.1–30.8). A previous study demonstrated

Fig. 3. Case of a 21-year-old female with an unknown primary tumor who underwent FDG PET/CT for diagnosis of her unknown primary tumor. Maximum intensity projection (MIP) (A), coronal fusion PET/CT (B) and transaxial fusion PET/CT (C, D, E) images show increased linear FDG uptake in the intrahepatic and extrahepatic portal vein (SUV\textsubscript{max}: 7.8), suggestive of TT based on typical PET/CT findings.
a positive correlation between the level of uptake in the primary tumor and TT.\textsuperscript{12}

The early detection of TT is important because a thrombectomy can prevent sudden death from tumor embolism or heart valve obstruction.\textsuperscript{10} Unresectable TT is usually treated palliatively. Metabolic imaging of these patients during or after therapy has been shown to be useful for assessing treatment response.\textsuperscript{4,10,25} In two of our cases, follow-up PET/CT results demonstrated an excellent metabolic response to anticancer treatment of thrombotic lesions, and we concluded that the appropriate treatments were administered.

Nuclear medicine physicians should be aware of potential pitfalls of TT diagnosis. False positive PET findings are known to be due to inflammatory lesions, including infected catheters in the venous vasculature that have been shown to be correlated with increased uptake of FDC.\textsuperscript{26,27} There has been a report of a positive PET finding in an aseptic thrombus seen in a patient with squamous cell carcinoma of the tongue.\textsuperscript{22} Sharma et al. reported that all benign aseptic thrombi in their study also exhibited increased FDG uptake.\textsuperscript{17} Activated cells in a VTE might show increased FDG uptake and, therefore, even VTE can exhibit normal or increased FDG uptake relative to background activity.\textsuperscript{17} However, the uptake of FDG by VTE is considerably lower than that by TT.

Differentiation between TT and VTE may be difficult via FDG PET/CT imaging only.\textsuperscript{26,28} Therefore, positive PET/CT findings must be correlated with clinical follow-up and other modalities such as CECT or follow-up PET/CT. However, linear FDG uptake patterns and high SUVmax values compared with that of VTE should be considered to be indicative of TT. In our study, positive PET/CT findings was correlated with clinical follow-up, CECT or follow-up PET/CT and confirmed the diagnoses in all cases except for one, this case was diagnosed with TT based on typical PET/CT finding.

The prognostic value of the presence of TT varies according to different tumor types. For example, portal vein TT in HCC is a poor prognostic factor\textsuperscript{29}; no impact on survival has been demonstrated in RCC with renal vein and IVC TT.\textsuperscript{30} In the studies discussed above about PET/CT, the median survival time was not specified. Although our study includes heterogeneous types of tumor, PET/CT imaging in patients with TT may provide important information about the aggressiveness of whole tumors that could be of prognostic
significance. In addition, optimal staging plays an important role in predicting the prognosis and directing the treatment strategy. In this study, the median survival time of 8 cases was 5 months (range: 1–16 months) after the diagnosis of TT with PET/CT imaging. More aggressive therapy could be considered in these patients with shorter survival time so the survival time may improve.

Limitations of this study include the small sample size and the lack of a true gold standard as a histological confirmation. Therefore, our results need to be confirmed in a larger cohort of patients, ideally with histological validations. However, this limitation exists in other reports due to the rarity and associated poor prognosis of TT. Therefore, any reported similar study on PET/CT will be of great interest as a guide to better assess the outcomes of these patients.

Fig. 5. Case of an 83-year-old male with carcinoma of the parotid gland who underwent FDG PET/CT for initial staging. Maximum intensity projection (MIP) (A), sagittal fusion PET/CT and transaxial fusion PET/CT (C) images show increased linear FDG uptake in the right jugular vein (SUV max: 5.2), suggestive of TT.

Fig. 6. Case of a 59-year-old female with right ovarian carcinoma who underwent FDG PET/CT for initial staging one month after surgery. Maximum intensity projection (MIP) (A), coronal fusion PET/CT (B) and transaxial fusion PET/CT (C) images show increased linear FDG uptake (SUVmax: 12.3) in the right ovarian vein, suggestive of TT. The diagnosis was confirmed with CECT.

Conclusion

Occult TT was found incidentally on PET/CT in 0.12% of our oncological patients. The patients had various common and rare malignancies that occurred in various locations of the venous vasculature, consistent with previous studies. Carcinomas of the liver, in particular cholangiocellular carcinoma, were the most common cause and the IVC was the most affected by TT. However, interesting cases of malign melanoma and parotid carcinoma and TT in the ovarian vein were first described by FDG PET/CT. Based on the linear FDG uptake pattern and high SUVmax value, PET/CT may accurately detect occult TT, help with the assessment of the treatment response, contribute to correct tumor staging and
provide additional information on the survival rates of oncological patients.

Conflict of interest

There are no conflicts of interest.

References