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PICTORIAL REVIEW

Genitourinary involvement of lymphomas on FDG-PET

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ABSTRACT

Primary extranodal lymphomatous involvement of the genitourinary tract is rare and secondary extranodal involvement in disseminated disease occurs more frequently. Imaging of metabolic activity with 2-(fluorine-18) fluoro-2-deoxy-d-glucose (FDG) used in PET facilitates the identification of these extranodal sites of disease, particularly in the absence of structural lesions on conventional imaging modalities. Primary extranodal lymphoma affecting the genitourinary system is often caused by high-grade Non-Hodgkin's Lymphoma (NHL) with the most common subtype being diffuse large B-cell lymphoma (DLBCL). Although rare, the incidence of extranodal lymphoproliferative disease is increasing and a delay in diagnosis holds a poor prognosis. Familiarity with benign and physiological causes of FDG uptake, particularly due to the urinary tracer excretion is crucial in identifying sites of lymphomatous involvement in the genitourinary system. Additionally, non-lymphomatous malignancies are usually treated surgically, whereas lymphoma is primarily treated with chemotherapy and/or radiotherapy. Therefore, accurate identification and staging together with histological confirmation significantly impacts management of these patients. This article serves to review and illustrate the imaging findings on FDG-PET/CT of primary extranodal lymphoma affecting the genitourinary system.

INTRODUCTION

Extranodal lymphoma (ENL) describes lymphomatous proliferation from sites other than native lymph nodes or lymphoid tissue.¹ Primary ENL is confined to one organ with or without closely adjacent lymph nodes. Secondary extranodal involvement is more common, occurring in cases of disseminated disease.¹ The incidence of ENL is increasing due to the increasing prevalence of immunosuppression (*e.g.*, HIV/AIDS, immunosuppressive therapies) and due to increased detection from advances in novel imaging and laboratory diagnostic techniques.¹

PET is a functional imaging modality using radiolabelled isotopes to identify biological processes such as glucose metabolism, serving as a surrogate biomarker for malignancy. The most widely used tracer is 2-(fluorine-18) fluoro-2-deoxy-d-glucose (FDG) for Hodgkin's lymphoma (HL) and Non-Hodgkin's lymphoma (NHL).¹ PET-CT is incorporated in the management of lymphoma and is superior than conventional imaging at staging, therapy monitoring and prognostication,¹ identifying metabolic changes prior to structural changes. Detection of extranodal involvement is critical, often leading to treatment escalation.^{1,2} Bone marrow involvement is the most common extranodal site

and recent evidence suggests PET could obviate the need for bone marrow biopsy in high-grade lymphoma.²

Lymphomas demonstrate variable FDG avidity especially in low-grade disease such as mucosa associated lymphoid tissue (MALT) lymphoma, where the absence of structural abnormalities makes detection challenging.³

Most genitourinary (GU) lymphomas are high-grade demonstrating intense FDG avidity. Aggressive lymphomas have been shown to be more FDG avid compared with indolent subtypes with a maximum standardised uptake value (SUV_{max}) > 10.⁴

Unlike glucose, FDG is not reabsorbed in the kidneys and in the absence of structural abnormalities, intense physiological accumulation or hold-up in the urinary tract can obscure disease detection in the GU system. Bladder catheterisation/lavage or delayed post-void imaging with or without administering a diuretic can decrease urinary FDG concentration.³

Figure 1. MENSTRUAL ACTIVITY. A 50-year-old female with newly diagnosed head and neck cancer who presented for staging FDG PET scan. Fused coronal PET-CT image demonstrates focal moderately increased tracer uptake in the uterine corpus (arrow) in keeping with physiological endometrial activity during active menstruation. Further intense physiological tracer accumulation is noted in the cerebral cortex, left ventricular myocardium, right renal pelvis and urinary bladder. FDG, fluoro-2-deoxy-d-glucose.

FDG accumulation can occur in infection and inflammation [e.g. following surgery or radiotherapy (RT)], granulomatous disorders, uterine fibroids, and part of the normal menstrual cycle,³ (Figure 1) and PET should be scheduled accordingly to minimise false positive results.²

While GU lymphoma is rare, early detection is vital in order to assign an accurate stage and appropriate treatment regimen. This article describes and illustrates its features on FDG-PET (Table 1).

RENAL

Primary renal lymphoma (PRL) accounts for less than 1% of ENL as renal parenchyma is normally devoid of lymphoid tissue.⁵ Occurring in middle aged or older, PRL, typically caused by B-cell NHL, are often bilateral but can be unilateral with solitary or multiple lesions, or diffuse infiltration⁵ (Figures 2–4). FDG excretion is typically evident in the pelvicalyceal system, therefore any focal or diffuse hypermetabolism within the cortices would be concerning for lymphoma.

PRL is usually asymptomatic, but can present as acute renal injury⁵ (Figures 2–4). The prognosis is poor with a median survival of less than a year. Early detection and initiation of chemotherapy has resulted in a good response⁵ and rapid improvement of renal function.

Renal cell carcinomas (RCCs) have a lower level of metabolic activity when compared to high-grade lymphomas (Figure 5) and PET-CT can be useful in its differentiation. In one series, lymphomas demonstrated an $SUV_{max} > 5.98 \text{ g ml}^{-1}$, whereas RCC had an $SUV_{max} < 5.26 \text{ g ml}^{-1}$ with no significant difference in renal size.⁶

URETERIC

Reported cases⁷ noted a male predominance with the median age of presentation as 56 years, the majority being asymptomatic. Conventional imaging often demonstrates hydronephrosis with no other specific imaging characteristics.⁷

Lymphomas affecting the proximal and distal ureter are usually caused by para-aortic and iliac adenopathy respectively (Figures 6 and 7).

Documented subtypes included diffuse large B-cell lymphoma (DLBCL), follicular lymphoma (FL), small lymphocytic lymphoma (SLL), MALT and HL.⁷ Due to its rarity, treatment guidelines have not been established with variable outcomes.

BLADDER

Primary bladder lymphomas are frequently caused by MALT.⁸ Secondary involvement commonly arises from DLBCL.⁸ Typically affecting adults above 60 years, 75% are women with associated chronic cystitis. Initial symptoms include haematuria, dysuria, abdominal or back pain.⁸

Table 1. Summary of cases presented in this article.

Case	Figure	Age	Sex	Subtype	Treatment given	Response
Diffuse renal	2a	44	F	DLBCL	Chemotherapy	Remission
Multifocal renal	2b	59	F	Follicular	Chemotherapy	Remission for 7 months, relapse and poor response to ongoing therapy
Unilateral renal	2c	59	M	DLBCL	Chemotherapy	Remission
Ureteric	4a	63	M	DLBCL	Chemotherapy, systemic methotrexate	Remission
Focal ureteric	4b	82	F	DLBCL	Chemotherapy	Remission for 14 months, para-aortic relapse, poor response to secondary chemotherapy, disease progression, passed away
Bladder	5	63	M	MALT	Chemotherapy	Remission, developed transitional cell carcinoma which was treated with radical cystectomy and ileal conduit.
Adrenal	7	64	F	DLBCL	Chemotherapy	Remission
Uterus	8		F	Mantle cell	Chemotherapy, radiotherapy	Remission
Cervix and uterus	9	82	F	DLBCL	Chemotherapy.	Remission, central nervous system relapse 5 months later, passed away
Uterus and left ovary	10	59	F	Follicular	Chemotherapy, radiotherapy	Remission
Vaginal	11	64	F	DLCBL	Chemotherapy, radiotherapy	Remission
Vulval	12	64	F	DLBCL	Chemotherapy	Unknown, Lost to follow up
Prostate	14	87	M	DLBCL	Chemotherapy	Remission, relapsed 2 years later, undergoing further treatment
Prostate	14	60	M	Marginal zone	Chemotherapy	Remission
Seminal vesicle	15	74	M	DLBCL	Chemotherapy	Remission
Bilateral testicular	18a	76	M	DLBCL	Chemotherapy, intrathecal methotrexate	Remission for 5 years, CNS and testicular relapse, passed away
Unilateral testicular	18b	74	M	DLBCL	Chemotherapy, intrathecal methotrexate, planned radiotherapy	Passed away prior to planned radiotherapy
Relapsed testicular	18c	78	M	DLBCL	Right orchidectomy, chemotherapy, radiotherapy to the left testis and CNS prophylaxis with intrathecal methotrexate	Remission for 5 months, relapse left testicle, declined further treatment, palliated
Spermatic cord	19	52	M	DLBCL	Chemotherapy, bilateral testicular radiation and intrathecal methotrexate	Remission, 12 months later relapsed in spermatic cord, salvage chemotherapy and autologous BMT
Penile	20	89	M	DLBCL	Declined chemotherapy	Passed away 5 months following diagnosis

BMT, bone marrow transplant; CNS, central nervous system; DLBCL, diffuse large B-cell lymphoma; MALT, mucosa-associated lymphoid tissue.

Figure 2. A DIFFUSE RENAL LYMPHOMA. A 44-year-old female initially presented with haematuria and acute renal injury (creatinine = 212 mmol l^{-1} , eGFR = $23 \text{ mL/min/1.73 m}^2$). A subsequent biopsy of the kidneys confirmed DLBCL. MIP shows (a) diffuse intense increased FDG uptake throughout both kidneys. There was also mild diffuse increased FDG uptake in bone marrow consistent with bone marrow activation secondary to anaemia. Axial fused FDG-PET image showed (b) intense increased FDG uptake localising to the renal cortices (long green arrow) in markedly enlarged kidneys with a maximum standardised uptake value of 14.1 g ml^{-1} . A small intense focus is also indicated in the left para-aortic region (short green arrow), corresponding to a metabolically active lymph node also representing DLBCL. Following completion of R-CHOP (rituximab-cyclophosphamide, doxorubicin, vincristine, prednisolone) chemotherapy kidney function normalised (creatinine = 58 mmol l^{-1} and eGFR $>90 \text{ mL/min/1.73 m}^2$). A post-treatment PET scan demonstrates (c) normal appearing kidneys (blue arrow) with physiological urinary tracer excretion within the pelvicalyceal systems bilaterally with complete resolution of abnormal tracer uptake in the cortices. DLBCL, diffuse large B-cell lymphoma; eGFR, estimated glomerular filtration rate; FDG, fluoro-2-deoxy-d-glucose; MIP, Maximal intensity projection.

Radiologically, 70% are solitary bladder masses, 20% multiple masses and 10% have diffuse wall thickening.⁸ Due to physiological FDG accumulation, lesions are obscured, and the main role of PET was to identify other disease sites (Figure 8).

Prognosis varies and depends on histological subtype with MALT having an excellent prognosis. Recurrent bladder lymphoma is associated with disseminated disease and poor prognosis.⁸

Figure 3. MULTIFOCAL RENAL LYMPHOMA. A 59-year-old female with grade III follicular lymphoma presented with acute kidney injury where a PET-CT scan (a) demonstrated multifocal areas of intensely metabolically active tracer uptake within the renal cortices (green arrows) with a maximum standardised uptake value of 10.3 g ml^{-1} , in keeping with high-grade transformation to DLBCL. This is separate from the pelvicalyceal urinary tracer activity (blue arrow). The concurrent low-dose non-contrast enhanced CT (b) showed otherwise normal appearing kidneys (green arrow). Following chemotherapy, this patient's renal function recovered. Creatinine normalised from 176 mmol l^{-1} (high) to 62 mmol l^{-1} . DLBCL, diffuse large B-cell lymphoma.

Figure 4. UNILATERAL RENAL LYMPHOMA. A 59-year-old male presenting with acute kidney injury underwent a PET-CT scan which demonstrated an irregular enlarged (a) left kidney (green arrow) on CT scan with (b) heterogeneous intensely increased FDG uptake (green arrow), subsequently confirmed as DLBCL. The blue arrow indicates a normal appearing and functioning right kidney with physiological urinary excretion. DLBCL, diffuse large B-cell lymphoma; FDG, fluoro-2-deoxy-d-glucose.

Figure 5. RENAL CELL CARCINOMA. Coronal FDG PET-CT (a) and concurrent CT (b) showing a large irregular exophytic solid mass at the superior pole of the right kidney (green arrows) with minimal metabolic activity in keeping with renal cell carcinoma. Maximum standardised uptake value was 3.3 g ml^{-1} . Normal physiological urinary tracer excretion noted in the renal calyces.

URETHRA

Primary urethral NHL was first reported in 1972 and first described in 1987.⁹ All documented cases have been in older patients with a female predominance⁹ commonly presenting with a mass at the urethral meatus.⁹

Urethral lymphoma has not been reported in the PET literature to date. Due to physiological excretion, it would be difficult to differentiate between focal lesions and urinary activity. Moreover, in men who have undergone transurethral procedures, tracer pooling is often seen in a dilated prostatic urethra (Figure 9) and clinical history could prevent this pitfall.

ADRENAL

Accounting for less than 1% of all NHL and 3% of primary ENL, primary adrenal lymphoma (PAL) affects elderly men with a mean age of 62 and a male:female ratio of 1, 8:1.⁸ Often presenting with B symptoms or adrenal insufficiency, PAL can be bilateral (75%) or unilateral.⁸ Common subtypes include DLBCL and T-cell Lymphoma and cases of MALT, mantle cell, anaplastic large cell lymphoma and HL have also been documented.¹⁰ Prognosis is poor with a 12-month survival of 20% and those with DLBCL are likely to develop central nervous system (CNS) involvement.¹⁰ Adrenal lymphoma is intensely FDG avid (Figure 10) similar to

that seen in adrenal cortical carcinomas and metastases which may be indistinguishable.

Female genitourinary organs

Cervix/uterus

The median age of diagnosis of cervical/uterine lymphoma in pre-menopausal women is fourth to fifth decade who can present with dysfunctional uterine bleeding, a pelvic/cervical mass and associated pain, however, symptoms may be absent in the initial stages. DLBCL is most common and a recent study demonstrated uterine and not ovarian lymphoma to be associated with secondary CNS involvement and poor prognosis.¹¹

Cases of FL and endometrial primary marginal zone lymphoma have also been recorded.¹²

Both the cervix and uterine body are usually involved with diffuse uterine enlargement and FDG avidity (Figure 11), a large lobulated (Figure 12)/exophytic mass or nodules.¹² While submucosal leiomyomas are similar in appearance on conventional imaging¹² the hypermetabolism in lymphoma on PET is a distinguishing feature.

Figure 6. A. URETERIC LYMPHOMA. A 63-year-old male initially presenting with an *Escherichia Coli* urinary tract infection was found to have ureteric obstruction secondary to DLBCL which required stenting. A staging FDG PET-CT scan (a-c) demonstrated intensely increased tracer uptake in a markedly thickened, irregular right ureter with an associated exophytic component extending into the pelvic cavity (green arrows). An interim FDG-PET scan following three cycles of systemic chemotherapy showed (d-f) a significant improvement in the degree and extent of abnormal FDG accumulation with residual FDG uptake in (d) a mildly thickened right ureter in keeping with a partial metabolic response. The blue arrow (f) demonstrates physiological urinary tracer activity along a normal left proximal ureter. Following completion of chemotherapy with a PET scan showing complete metabolic response, he also received CNS prophylaxis with systemic methotrexate.

Figure 7. FOCAL URETERIC LYMPHOMA. A low-dose CT (a) shows an area of focal thickening of the proximal left ureter (green arrow). PET (b) and fused PET-CT (c) demonstrate focal, intensely increased tracer accumulation corresponding to the area of thickening consistent with newly diagnosed DLBCL (green arrows). The blue arrow in (b) shows physiological urinary tracer activity in the proximal ureter. The blue arrows in (c) indicate physiological urinary tracer activity in the pelvicalyceal system. CNS, central nervous system; DLBCL, diffuse large B-cell lymphoma; FDG, fluoro-2-deoxy-d-glucose.

Figure 8. BLADDER LYMPHOMA. A cystoscopy for investigation of haematuria in a 63-year-old male demonstrated mild bladder wall irregularities and a biopsy confirmed MALT lymphoma. Further staging FDG-PET scan did not show any evidence of dissemination. On the initial images, without any significant underlying structural abnormalities on (a) CT scan, the pathological tracer uptake was masked by (b) the physiological FDG urinary excretion and accumulation within the bladder (blue arrow) on PET-CT. Following in dwelling catheter insertion and bladder lavage, (c) an abnormal focus of moderate increased FDG uptake is revealed at the left bladder wall (green arrow) corresponding to the site of biopsy proven MALT lymphoma. FDG, fluoro-2-deoxy-d-glucose; MALT, mucosa-associated lymphoid tissue.

Fallopian tube

Patients can be asymptomatic or experience pelvic pain.¹² Secondary involvement is described in cases of ovarian lymphoma.¹³ Primary fallopian tube lymphoma can be

Figure 9. TURP. Focal tracer accumulation in the midline of the prostate gland (blue arrow) localising to a fluid density on the concurrent low dose CT best explained by urinary tracer pooling within the prostatic urethra following previous transurethral resection procedure.

unilateral or bilateral, with variable presentations—associated with chronic inflammation (tubo-ovarian abscess/endometriosis), a pelvic mass or an incidental finding during surgery.¹⁴ Documented subtypes include FL, MALT and T-cell.¹³ As far as we know, the appearance on PET has not been reported.

Ovarian

Burkitt's lymphoma and DLBCL are most common of both primary and secondary ovarian lymphoma.¹² FL (Figure 13) and small lymphocytic lymphoma also occur, more so in older women.¹⁴ Primary ovarian lymphoma accounts for 1.5% of all ovarian neoplasms and has a wide age range with peak incidence in the 30s to 40ss, commonly presenting with abdominal or pelvic pain, often with an elevated CA-125.^{8,14}

Involvement can be unilateral or bilateral and ascites is infrequent despite the larger size of the lesion when compared with other ovarian malignancies.¹² Less than 50% of cases demonstrate peritoneal involvement and extension often occurs through the pelvic and para-aortic lymph nodes.¹²

In premenopausal women, benign physiological FDG uptake of the ovaries and endometrium varies cyclically and occurs at

Figure 10. ADRENAL LYMPHOMA. An FDG-PET scan demonstrated focal intense homogenous tracer uptake corresponding to (a) enlarged adrenal glands more marked on the left side. This 64-year-old female who initially presented with symptoms of adrenal insufficiency was found to have hypodense enlarged adrenal glands on (b) CT imaging. Following completion of chemotherapy, a follow-up PET-CT scan (c, d) demonstrated resolution of abnormal tracer uptake and CT showed morphologically normal adrenals consistent with complete metabolic response. FDG, fluoro-2-deoxy-d-glucose.

Figure 11. (a, b) UTERUS. A post-menopausal female presenting with vaginal bleeding was found to have a markedly enlarged uterus on ultrasound where a biopsy confirmed Mantle cell lymphoma. In (a), CT scan (sagittal view) demonstrated a markedly enlarged uterus (green arrow) and a subsequent PET scan (b) showed corresponding intensely increased FDG uptake (green arrow). This was treated successfully with chemotherapy and radiotherapy. The blue arrow indicates urinary tracer activity within the bladder.

Figure 12. VULVA, VAGINA, CERVIX, UTERUS. An 82-year-old female with labial swelling, vaginal discharge and bleeding underwent a labial biopsy to confirm DLBCL. She was initially investigated as an outpatient where a pelvic ultrasound was unremarkable. Intensely increased homogenous tracer uptake on sagittal PET image (a) and PET-CT (b) was noted in a bulky mass involving the vulva, vagina, cervix and uterus. (c) The uterus appeared morphologically normal on CT scan (green arrows). Urine accumulation within the bladder in (a) is indicated by the blue arrow. This patient underwent an interim and post-treatment FDG-PET scan demonstrating complete metabolic response, however, 5 months later, she developed a CNS relapse with no evidence of lymphoma detected elsewhere and passed away. CNS, central nervous system; DLBCL, diffuse large B-cell lymphoma; FDG, fluoro-2-deoxy-d-glucose.

Figure 13. OVARY AND UTERUS. A 59-year-old post-menopausal female with abdominal bloating was found to have an enlarged left ovary and uterus. Following confirmation of grade II follicular lymphoma, an FDG-PET scan demonstrated (a) intensely increased heterogeneous tracer accumulation throughout a bulky left ovary and uterus (long green arrows) which was noted on CT (b). There was a small focus of increased tracer uptake corresponding to a closely adjacent lymph node in the left pelvic side-wall (short green arrow) (a). The blue arrow in (c) shows mild diffuse physiological tracer uptake within bowel loops. This patient was treated successfully with systemic chemotherapy and radiotherapy.

Figure 14. VAGINA (a-c) homogenous, intense, focal tracer uptake is seen in a markedly thickened vaginal wall (green arrows) with a maximum standardised uptake value of 32.8 g ml^{-1} consistent with DLBCL that was treated with chemotherapy and radiotherapy.

Figure 15. VULVA LYMPHOMA. A CT scan (a) shows a normal appearing vulva which demonstrates focal intense tracer accumulation on PET-CT (b, c) with a maximum standardised uptake value of 15.6 g ml^{-1} at the site of biopsy proven DLBCL (green arrows). The coronal PET-CT scan does not demonstrate any sites of disease elsewhere. Intense physiological cerebral cortical and urinary activity in the renal pelvicalyceal system as indicated by the blue arrows. DLBCL, diffuse large B-cell lymphoma.

Figure 16. VULVAL SQUAMOUS CELL CARCINOMA CT (a) and FDG PET-CT (b) demonstrating a small focus of intense tracer uptake (green arrow) in the vulva without significant structural abnormality on CT imaging, similar in appearance to the degree and pattern of tracer uptake seen in vulval lymphoma.

Figure 17. PROSTATE LYMPHOMA. An 87-year-old male who presented with urinary retention requiring indwelling catheter insertion underwent an ultrasound demonstrating a normal appearing prostate gland (a). A subsequent FDG PET scan (b) showed (a) focal increased tracer uptake in the right lobe of the prostate gland. His PSA was elevated at 11.21 ug l^{-1} . A biopsy confirmed DLBCL. Following treatment with systemic chemotherapy, his PSA decreased to 3.45 ug l^{-1} . A 60-year-old male extensively investigated for iron deficiency anaemia underwent a bone marrow biopsy which confirmed a lymphoproliferative disorder. A subsequent FDG PET scan showed (c) a morphologically normal appearing prostate gland with (d) abnormal intense focal increased FDG uptake in the left lobe posterosuperiorly (green arrow). PSA was elevated at 8.01 ug l^{-1} . A biopsy confirmed marginal zone lymphoma and a progress FDG PET scan following completion of RCVF chemotherapy (rituximab, cyclophosphamide, vincristine, prednisolone) showed a complete metabolic response (e). PSA fell to 3.45 ug l^{-1} . DLBCL, diffuse large B-cell lymphoma; FDG, fluoro-2-deoxy-d-glucose; PSA, prostate specific antigen.

Figure 18. SEMINAL VESICLE LYMPHOMA. An FDG PET-CT scan performed on a 74-year-old male with DLBCL of the left seminal vesicle demonstrated homogenous intense increased tracer accumulation on PET-CT (a) and on PET (b) (green arrow). Following three cycles of systemic therapy (R-CHOP), an interim PET scan demonstrated a complete metabolic response (d, e) with resolution of abnormal uptake in the left seminal vesicle (green arrow). The CT images prior to treatment (c) and post-treatment (f) did not demonstrate any underlying structural abnormality. DLBCL, diffuse large B-cell lymphoma;

both ovulation and during the menses (Figure 1). Corpus luteal cysts can also have increased tracer uptake.³ In post-menopausal women, FDG accumulation is abnormal, however, benign aetiologies can mimic malignancy on PET such as fibroids and endometrial polyps.¹

Treatment often involves oophorectomy to aid diagnosis and chemotherapy. Prognosis is poor with a 5-year survival of 57%.⁸

Vaginal

Primary vaginal lymphoma (Figure 14) is exceedingly rare with a mean age of diagnosis in the fifth decade, typically presenting with perineal discomfort or vaginal discharge/bleeding.¹² Approximately, 50% are diagnosed at autopsy due to the lack of solid lesions that could otherwise be identified by conventional imaging. FDG-PET can potentially prevent a delay in diagnosis and treatment as the mean 5-year survival is 80% for early stages and 30% in advanced stages.¹⁵

Vulval

Accounting for 4% of pelvic NHL,¹⁶ the mean age is 60, often presenting with a nodule, induration, a mass in the region of Bartholin's gland or a clitoral mass.¹⁴ The most common histological subtype is DLBCL and others include T-Cell and Burkitt's.¹⁶ PET-CT demonstrates high sensitivity as an intensely FDG avid

mass (Figure 15). Squamous cell carcinoma (SCC) can appear similar on PET making it indistinguishable (Figure 16). Where surgery is a treatment option for vulval SCC, chemotherapy and RT are used in NHL.

Male genitourinary organs

Prostate

Primary prostate lymphoma (PPL) has been documented in 0.1% of NHL (DLBCL being the most common) and 0.09% of prostate malignancies, with a 5-year survival rate of 33%.^{8,17} It can mimic benign prostatic hypertrophy or carcinoma as it occurs in elderly men who present with urinary obstruction or retention, however, the PSA level is usually normal¹⁷ (Figure 17).

In contrast to prostate adenocarcinoma, which generally has low FDG avidity, PPL is intensely avid. Prostatitis also demonstrates intense FDG avidity. PET plays a role in initial staging, treatment response and prognostication, however, due to its rarity, experience is limited.

Seminal vesicle

Due to the lack of symptoms and rarity of primary seminal vesicle malignancies,¹⁸ identification and early diagnosis is challenging. Transrectal ultrasound and CT have previously reported large masses at the seminal vesicles in primary seminal vesicle DLBCL.¹⁸

We illustrate a case of relapsed DLBCL affecting the left seminal vesicle without any structural abnormality on conventional imaging (Figure 18), highlighting the superiority of PET.

Figure 19. GRANULOMATOUS ORCHITIS. Diffuse intensely increased tracer uptake (green arrows) in bilateral testicles on PET-CT similar in appearance to that of high-grade lymphomatous involvement. Biopsy confirmed granulomatous orchitis.

Figure 20. GERM CELL TUMOUR. Low level diffusely increased metabolic activity demonstrated in a germ cell tumour of the testes (green arrows). The blue arrow demonstrates physiologic myocardial uptake.

Figure 21. A BILATERAL TESTICULAR LYMPHOMA. Transformed indolent lymphoma to DLBCL with (a) right common iliac lymphadenopathy (top green arrow) and abnormal intensely increased FDG uptake in morphologically normal testicles (bottom green arrow). The blue arrows indicate (a) physiological bladder activity. After completion of treatment with systemic chemotherapy and intrathecal methotrexate for CNS prophylaxis, this patient remained in remission for 2 years. Unfortunately, (b) demonstrates relapsed lymphoma in the testicles and in the CNS (green arrow) and following significant toxicities secondary to palliative chemotherapy, this patient passed away.

Figure 22. UNILATERAL TESTICULAR LYMPHOMA. Unilateral irregular intense testicular uptake in keeping with DLBCL in an enlarged right testis (green arrow).

Figure 23. RELAPSED TESTICULAR DLBCL. This 78-year-old male initially presenting with painless right testicular enlargement and was found to have DLBCL and was treated with a right orchidectomy, chemotherapy, radiotherapy to the left testis and CNS prophylaxis with intrathecal methotrexate. He developed recurrent DLBCL of the left testis demonstrating intensely increased tracer uptake with a standardised uptake value of 39.8 (green arrow). CNS, central nervous system; DLBCL, diffuse large B-cell lymphoma; FDG, fluoro-2-deoxy-d-glucose.

Figure 24. SPERMATIC CORD LYMPHOMA. A 52-year-old male initially diagnosed with Stage IV DLBCL (green arrows) involving various lymph node groups (a–c) above and below the diaphragm and along the left spermatic cord (bottom green arrow) that demonstrated intensely increased tracer uptake. The spermatic cord was markedly thickened on the concurrent CT scan. Complete metabolic response was achieved following treatment with chemotherapy, bilateral testicular irradiation and intrathecal methotrexate. However, 12 months later developed relapsed disease on FDG-PET scan, which showed (d, f) intense heterogeneous tracer uptake in a markedly thickened (e) left spermatic cord similar in appearance to the initial study. This was rebiopsied and confirmed to be DLBCL. DLBCL, diffuse large B-cell lymphoma; FDG, fluoro-2-deoxy-d-glucose.

Testicular

Testicular lymphoma, affecting 0.26 in 100,000 people annually, is the most common primary testicular malignancy in males over 60 years,¹⁹ significantly different to that of germ cell tumours (GCT) who present at 15–35 years of age.⁸ DLBCL is the most common subtype with reported cases including immunoblastic, plasmablastic and Burkitt-like lymphoma.⁸

Primary testicular lymphoma (PTL) is intensely avid on FDG-PET. Orchitis demonstrates intense FDG uptake and can be indistinguishable (Figure 19) whereas GCT are less metabolically active (Figure 20). We describe four patterns of FDG avid PTL [(focal or multifocal, diffuse asymmetrical or symmetrical uptake¹⁹ (Figures 21–23)].

Figure 25. PENILE LYMPHOMA. An FDG PET/CT scan of an 89-year-old male with penile pain, where a biopsy confirmed DLBCL demonstrated heterogeneous intensely increased tracer accumulation throughout the inflamed penis (green arrows). The blue arrow in (d) indicates physiological bladder activity. Due to the patient's age and multiple comorbidities, he declined chemotherapy and passed away 5 months following his initial diagnosis.

The testis is an occult sanctuary site with a high rate of relapse in the contralateral testis and CNS, with a median survival between 12 and 24 months.¹⁹

Inguinal orchidectomy and RT along with prophylactic intrathecal chemotherapy, CNS irradiation, and adjuvant RT to the contralateral testis can improve survival.¹⁹

Spermatic cord

Primary spermatic cord lymphoma accounts for 1.6% of all primary spermatic cord tumours affecting patients with a mean age of 60 years, who typically present with a mass in the inguinoscrotal region.²⁰ DLBCL (Figure 24) is most common, however, cases of FL, MALT and Burkitt's lymphoma have been documented.²⁰ Overall prognosis is poor with a median survival of 12.2 months.²⁰

Penile

Penile lymphoma, whilst rare is a diagnosis to consider for patients presenting with painless nodules, non-healing ulcers, or diffuse penile swelling,²¹ most commonly affecting the shaft followed by the glans penis.²¹ DLBCL is most common (Figure 25) with reported cases of T-cell and lymphoblastic lymphoma,²² and a wide age range (3–77 years).²² Malignant differential diagnoses also avid on FDG-PET include SCC or sarcoma.²¹

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