Diuretic ^{18}F-Fluorodeoxyglucose PET/Computed Tomography in Evaluation of Genitourinary Malignancies

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KEYWORDS

• ^{18}F-FDG PET/CT • Diuretics • Urinary bladder cancer • Cervical cancer • Ovarian cancer

KEY POINTS

- The interpretation of fluorodeoxyglucose (FDG) PET/computed tomography (CT) is often challenging for pelvic pathologies because of the physiologic bowel and urinary tract activity.
- Intense radiotracer activity in the urinary tract interferes in image interpretation and leads to false-negative result in diagnosis and detection of local recurrence and regional lymph node metastases.
- It is imperative to minimize unnecessary urinary bladder activity to improve the diagnostic yield of PET/CT.
- Acquiring a postvoid image is simple and time saving, but even small residual urine usually has very high concentration of radioactivity.
- Undistended postvoid bladder leads to poor anatomic delineation thereby limiting urinary bladder wall assessment.

INTRODUCTION

FDG PET scanning is widely used in the evaluation of patients with malignancies.[1] FDG is an analog of glucose in which the hydroxyl group of the second position is replaced by radioactive fluorine (F-18) atom. FDG is taken up by the cells and phosphorylated to FDG-6-phosphate, which does not undergo further metabolism because it is not substrate for glycolysis and remains trapped in the cells.[2] FDG, unlike glucose, cannot be reabsorbed in the proximal tubules of the kidney, and so it is excreted unchanged and gets accumulated in urine.

Accumulation of radiotracer activity in the urinary bladder system may mask the hypermetabolic disease focus and affect the diagnostic accuracy of FDG PET computed tomography (CT). Also, normal physiologic activity in the bowel, endometrium, ovary, and blood vessels may interfere with image interpretation.[3] FDG uptake may vary during different phases of the menstrual cycle.[4] Various benign pathologies also show increased FDG uptake, such as serous and mucinous cystic adenoma, corpus luteal cyst, dermoid cyst, endometriosis, inflammation, pelvic kidney, bladder diverticula, and urinary

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diversions.[5] These physiologic activities are of concern especially in abdominopelvic malignancies, such as cervical, ovarian, endometrial, and bladder cancers.[6–8] It is imperative to be aware of the physiologic uptake of FDG and minimize the unnecessary radioactivity accumulated in the urinary bladder.

VARIOUS TECHNIQUES TO MINIMIZE BLADDER ACTIVITY

There are different methods to minimize bladder activity. The first one is to ask the patient to void just before imaging and acquire imaging caudocranially. This allows imaging of the pelvis before the bladder fills.[9] This is the most commonly applied technique because it simple, easy to follow, and physiologic. However, the problem with this is that even a small volume of residual urine with high FDG concentration can cause masking and therefore difficulty in interpretation of lesions close to the urinary bladder. A second method is use of single-lumen urinary catheter to drain continuously. However, in both scenarios bladder can contain a small amount but highly concentrated radioactive residual urine, which interferes in image interpretation. To avoid this problem a double-lumen Foley catheter can be used. When using a double-lumen catheter normal saline can be injected retrograde into urinary bladder to dilute the radioactive urine. However, bladder irrigation has a few disadvantages, such as increased pain during balloon catheter insertion, pain during urinary bladder irrigation, and increased radiation exposure to the technician performing the irrigation.[10] Even after proper precautions, there is a small chance of introducing infection when inserting a catheter.

Haney and colleagues[11] in their mice study used a double-lumen catheter to empty the undesired activity from urinary bladder. They found that flushing of the bladder provides a substantial attenuation in artifacts, such as streak artifacts. Forty-two percent of the images were spoiled by image artifacts directly attributed to bladder signal before application of the double-lumen catheter. After implementing the double-lumen bladder catheter with flushing, 74% of these images had no bladder signal and 19% of the images had a small bladder signal but no artifacts.

Another reported preparation is use of intravenous diuretic (furosemide), which is a safe and well-tolerated method that enhances urinary flux and allows rapid excretion of the urinary radioactivity. Diuretics used in this purpose enhance renal elimination of the excreted ^{18}F-FDG without interfering with the vesical tumor FDG uptake. Furosemide is a loop diuretic best suited for this purpose because it causes maximal diuresis, which allows a sufficient time window for reduction of bladder activity, before any significant biologic decay of ^{18}F-FDG has taken place. Urine with a low concentration of ^{18}F-FDG replaced urine with a high concentration of the tracer in the bladder as a result of the diuresis promoted by oral hydration and furosemide.[12]

In our institution, pelvic PET/CT images are obtained using the special technique of forced diuresis using intravenous furosemide (40 mg) in adult patients. Oral fluid intake (around 1.5–2 L) is advised and the patient is asked to void three to four times and then hold urine to allow maximum bladder distention. Pelvic spot view (single bed) PET/CT is then acquired after 1 hour of intravenous furosemide administration. This provides a negative contrast in bladder with nonradioactive urine, which leads to high lesion-to-background ratio. The only problem with this technique is that it is difficult to do in patients who are very sick, have urinary incontinence, or are unconscious and not able to hold urine for more than 15 minutes. In such patients, urinary catheterization is done before FDG tracer injection to minimize radiotracer activity at the pelvic region. It also avoids urinary contamination in such patients.

URINARY BLADDER CANCER

^{18}F FDG PET CT has been used in the detection of metastatic spread to regional lymph nodes and distant organs in patients diagnosed with bladder cancer; however, its role in staging is limited. Detection of the primary tumor and local visceral tumor recurrence is limited because of the presence of excreted FDG in the urinary tract, which often masks the urinary bladder lesion and probably the adjacent lymph nodes.[7] An intervention to minimize urinary radioactivity without altering the tumor uptake seems needed because most recurrences of superficial bladder cancer remain confined to the bladder wall (**Figs. 1** and **2**).

Kosuda and colleagues[8] assessed feasibility of bladder cancer imaging with FDG PET. They found that a major pitfall in patients with bladder cancer was intense FDG accumulation in the urine. They minimized the urinary FDG activity by urinary irrigation, but were unable to reduce it to the background level and they found a 40% false-negative rate for detection of recurrent or residual tumor in the bladder.[8]

Koyama and colleagues[10] evaluated the role of ^{18}F FDG PET with continuous bladder irrigation in patients with uterine and ovarian tumors. Continuous urinary bladder irrigation was done manually

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