

Extraperitoneal Urinary Bladder Perforation Detected by FDG PET/CT

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Radiology Case. 2011 Apr; 5(4):32-40 :: DOI: 10.3941/jrcr.v5i4.656

ABSTRACT

Accurate localization of areas of increased metabolic activity on PET only imaging can be challenging. Fusion of PET with CT imaging provides anatomic detail which aids in localization of functional information. As a result, the overall sensitivity and specificity of information provided by PET or CT alone is improved with combined PET/CT resulting in improved diagnosis and patient management. We report a case of an unexpected emergent finding of urinary bladder perforation on PET/CT to stress the importance of accurately interpreting the anatomic and functional data. To our knowledge, diagnosis of bladder perforation on PET/CT has not been previously reported in the literature. Failure to recognize such complications may lead to adverse outcomes.

CASE REPORT

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The patient is a 76 year-old female with newly diagnosed adenocarcinoma of the rectum who initially presented for contrast enhanced CT examination for staging. The CT scan of the chest, abdomen, and pelvis demonstrated a 2.8 x 1.9 cm rectal mass and an enlarged perirectal lymph node. In addition, the CT scan revealed a 1.5 x 1.0 cm mass in the urinary bladder and a 1.5 x 1.0 cm mass in the left renal pelvis, both of which were suspicious for synchronous multifocal urothelial neoplasm (Figure 1A and 1B). Biopsy of the bladder mass was consistent with a low-grade noninvasive urothelial carcinoma (Figure 2A). Biopsy of the left renal pelvis lesion showed minute fragments of papillary, hyperplastic urothelium and was not diagnostic of malignancy (Figure 2B). CT examination of the lungs revealed two right upper lobe nodules of mixed confluence measuring 2.2 x 0.9 cm and 1.4 x 0.8 cm and numerous small bilateral ground-glass nodules measuring up to 1.1 cm. These lung findings were suspicious for additional synchronous primary lung malignancy of bronchioloalveolar carcinoma - adenocarcinoma type, metastatic disease, or inflammatory lesions.

A week after the bladder mass biopsy and approximately three weeks after the CT scan, the patient presented for a

baseline FDG PET/CT prior to treatment. Whole-body contrast enhanced CT and PET scan were acquired consecutively 60 minutes following the intravenous administration of 13.2 mCi of FDG using a Siemens Biograph 6 PET/CT system. The patient's blood glucose level was 131 mg/dl at the time of the FDG injection. No urinary bladder catheterization was performed. IV and oral contrast were administered prior to the CT portion of the examination. Data obtained from the CT scan was used for attenuation correction of the PET data, anatomic localization, fusion with the PET images, and diagnostic purposes[1-4]. PET, CT, and fused PET/CT images were available for review in axial, coronal, and sagittal planes. The PET data were displayed as non-corrected and attenuation-corrected images and also in a rotating maximum intensity projection.

The two mixed confluence lung lesions in the right upper lobe showed no interval change on the CT component of the hybrid imaging. The corresponding functional images demonstrated very mild FDG uptake with maximum SUV of 0.8 for both lesions (Figure 3). The small bilateral ground-glass lung nodules did not demonstrate discrete metabolic activity, probably too small or not dense enough for functional characterization. Considering the absence of significant metabolic activity, the lung findings remained suspicious for

multifocal primary lung malignancy of bronchioloalveolar carcinoma - adenocarcinoma type, metastatic disease, or inflammatory lesions.

The PET images demonstrated FDG uptake within the primary rectal malignancy with maximum SUV 8.5 (Figure 4). A 1.2 cm left perirectal lymph node revealed discrete FDG uptake with maximum SUV 2.4 and remained suspicious for regional nodal metastatic lymphadenopathy.

The 1.1 cm solid mass in the left renal pelvis could not be assessed on the functional images due to the normal excretion of FDG in the renal collecting system (Figure 5). The urinary bladder mass which was previously identified on CT was no longer seen on the PET/CT performed after biopsy of this lesion. The CT portion of the hybrid imaging demonstrated a new focal defect in the right lateral wall of the bladder and perivesical fluid collection consistent with bladder perforation (Figure 6). Functional images demonstrated FDG uptake in the dependent right lateral portion of the fluid collection, suggestive of active extravasation of radioactive urine into the collection. The referring physician was immediately informed about the bladder perforation which was managed conservatively with placement of a Foley catheter (Figure 7).

DISCUSSION

The importance of recognizing and accurately interpreting the anatomic and functional components of the PET/CT examination is exemplified in our patient where an incidental finding of urinary bladder perforation was discovered. For bladder perforation to occur, the mucosa, submucosa, and muscularis must all be penetrated[5]. The incidence of bladder perforation following bladder biopsy is reportedly as high as 36% [6]. In our patient, bladder perforation was a complication following transurethral bladder mass biopsy. Although most patients with bladder perforation initially exhibit nonspecific symptoms such as suprapubic or abdominal pain and inability to void, our patient was asymptomatic[5]. Gross hematuria which is a very reliable sign of bladder injury was also absent in this case [5].

Once bladder rupture is recognized, management depends upon whether it is intraperitoneal or extraperitoneal[5]. In our patient, there was no visualization of contrast material outlining bowel loops, consistent with extraperitoneal bladder rupture[5]. The usual treatment of uncomplicated extraperitoneal bladder rupture is conservative with urethral catheter drainage using at least a 22 French catheter as well as initiation of antibiotics until three days after the catheter is removed[5]. Approximately 87% of uncomplicated extraperitoneal bladder ruptures will be healed in ten days, and nearly all are healed within three weeks[7]. On the other hand, complicated extraperitoneal bladder injuries such as those with penetrating injuries from trauma or those with extensive extraperitoneal extravasation warrant immediate open surgical repair to prevent complications such as fistula, abscess, and prolonged leak[5]. Intraperitoneal bladder rupture should also be managed immediately with operative repair[5].

Prompt diagnosis and appropriate management of bladder injuries provides successful results and minimizes morbidity and mortality[5]. The mortality rate in patients with bladder rupture ranges from 11% to 44% however death is usually due to injury of other organs[8].

Failure to recognize bladder injuries may lead to acidosis, azotemia, fever, sepsis, low urine output, peritonitis, ileus, urinary ascites, or respiratory difficulties[5]. Most complications from bladder perforation occur as a result of delayed diagnosis or treatment due to misdiagnosis or delayed presentation[5]. Both CT and PET demonstrated signs of bladder perforation. While the functional images demonstrated an indirect sign of perforation with radiotracer layering in the dependent pelvis lateral to the bladder, the CT directly demonstrated the wall perforation and the presence of perivesical fluid collection with fluid-contrast level.

In addition to bladder perforation, there were other important findings on the PET/CT. The patient had biopsy proven synchronous rectal and urothelial cancer in the bladder. In addition, there were mixed confluence (FDG uptake maximum SUV of 0.8) and ground-glass lung nodules. It is well known that bronchoalveolar carcinoma is notorious for not being FDG avid, thus leading to false negative scan interpretation[9, 10]. The CT appearance of these nodules correlates with the postulated path of progression from atypical adenomatous hyperplasia to multifocal bronchoalveolar carcinoma with ground-glass appearance to adenocarcinoma with mixed attenuation nodules. No follow-up imaging or lung biopsy was performed to differentiate primary malignancy from metastatic lung malignancy or inflammatory lesions.

Lastly, even though the biopsy of the left renal pelvis lesion showed no definite evidence of malignancy it remained suspicious, recognizing the possibility of sampling error. The lesion could not be assessed on the functional images due to the normal excretion of FDG in the renal collecting system. It is well known that renal cortical and urothelial tumors are extremely difficult to evaluate on FDG PET imaging because 40% of the administered activity is excreted via the kidneys in the first 2 hours[9, 10]. In addition, misregistration between CT and PET images may occur as a result of bladder filling with radionuclide during the PET scan acquisition[9-11]. Interpretation can also be complicated by the occasional normal variant of increased FDG in perirenal fat and benign renal lesions such as angiomyolipomas[9, 10]. Activity in the ureters segmented by peristalsis can also mimic pathologic retroperitoneal nodes or tumors[9, 10]. Although FDG is not a useful tracer for the detection of primary urothelial cancer, it is very useful in evaluating for metastases or recurrent disease [9, 10, 12].

In conclusion, we demonstrate the appearance of bladder perforation on PET/CT which was recognized in a timely fashion. Failure to recognize such complication could lead to significant morbidity and mortality. In addition, we would like to emphasize the importance of combined anatomic and functional imaging interpretation.

TEACHING POINT

Bladder perforation can be demonstrated on FDG-PET imaging with radiotracer layering in the dependent pelvis lateral to the bladder. The CT component of the examination can directly show the wall perforation in addition to the presence of perivesical fluid collection.

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FIGURES

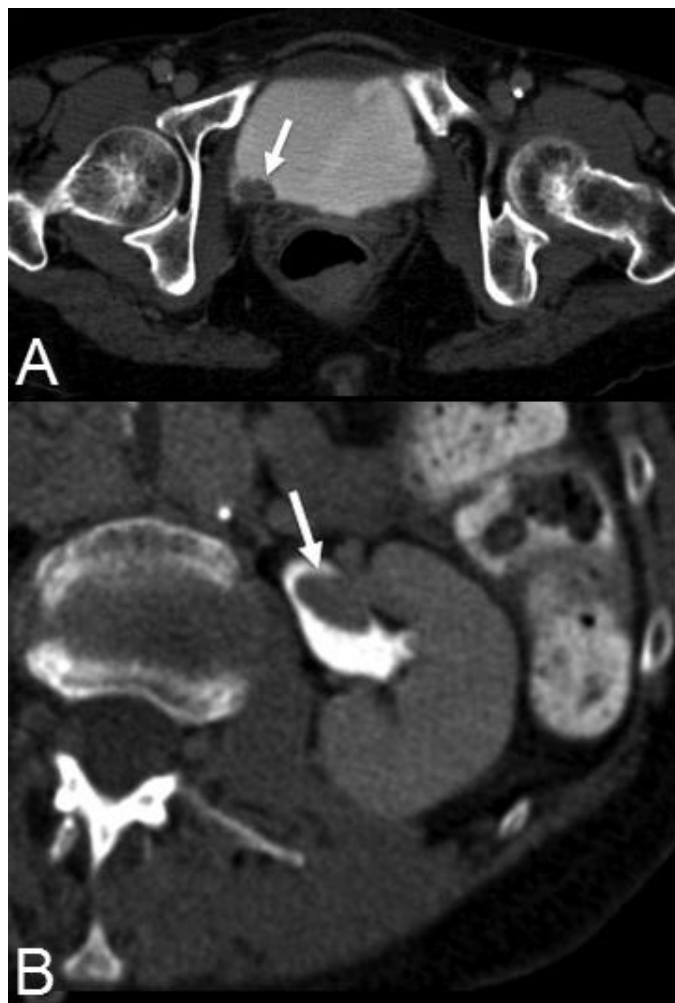


Figure 1: 76 year-old female with adenocarcinoma of the rectum and low-grade noninvasive urothelial carcinoma of the bladder. CT images of the abdomen and pelvis demonstrate: A. 1.5 x 1.0 cm soft tissue mass arising from the right posterior bladder wall near the right ureteral insertion; B. 1.5 x 1.0 cm soft tissue mass in the left renal pelvis; both suspicious for urothelial neoplasm. Biopsy of the left renal pelvis lesion showed minute fragments of papillary, hyperplastic urothelium and was not diagnostic of malignancy. Images were acquired on a Siemens SOMATOM Sensation 16 CT Scanner with settings of auto mA, 120.00 kV, and 3.00 mm slice thickness. Approximately 90 ml of Ultravist 300 intravenous contrast and 900 ml of Redi-Cat 2 oral contrast were administered. Images in the delayed excretory phase were acquired 5 minutes after injection of intravenous contrast.

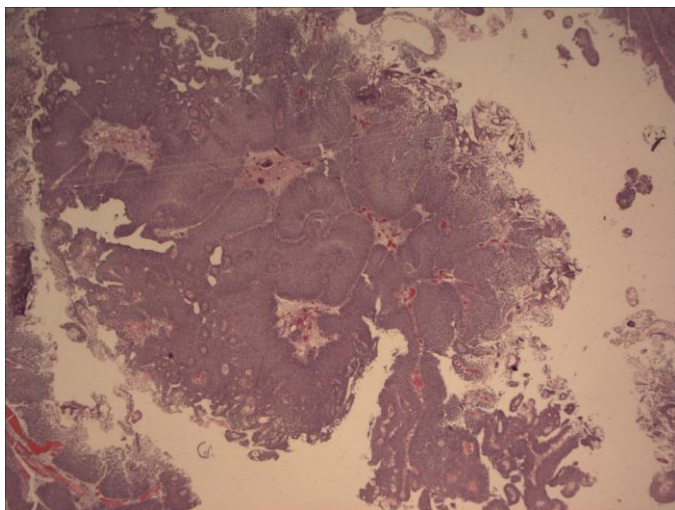


Figure 2a: 76 year-old female with adenocarcinoma of the rectum underwent biopsy of a bladder mass and a left renal pelvis mass which were found on CT scan. Biopsy of the bladder mass at 20X with H&E stain demonstrates a complex, florid papillary urothelial proliferation with mild nuclear atypia, consistent with low-grade noninvasive urothelial carcinoma.

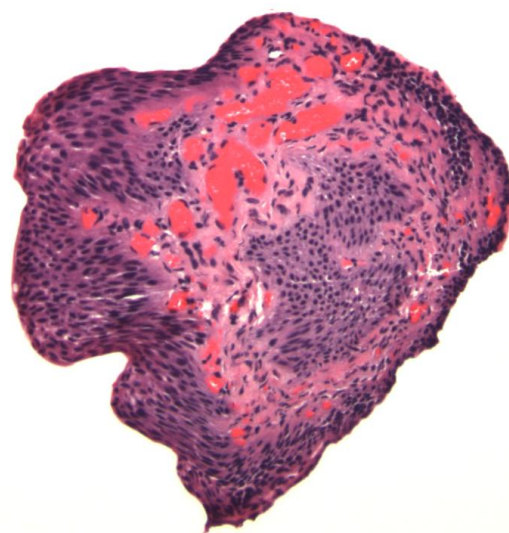


Figure 2b: 76 year-old female with adenocarcinoma of the rectum underwent biopsy of a bladder mass and a left renal pelvis mass which were found on CT scan. Biopsy of the left renal pelvis lesion at 100X with H&E stain demonstrates normal and hyperplastic urothelium with some crush artifact and congested subepithelial capillaries and is not diagnostic of malignancy.

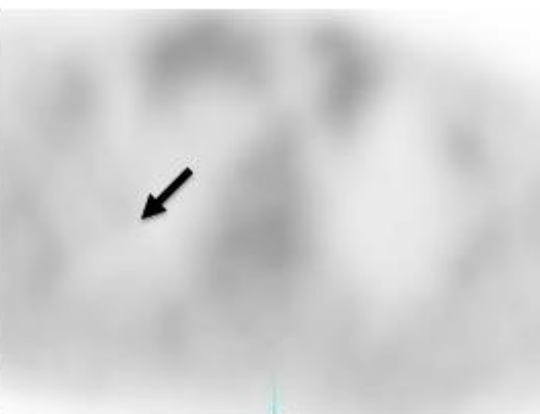
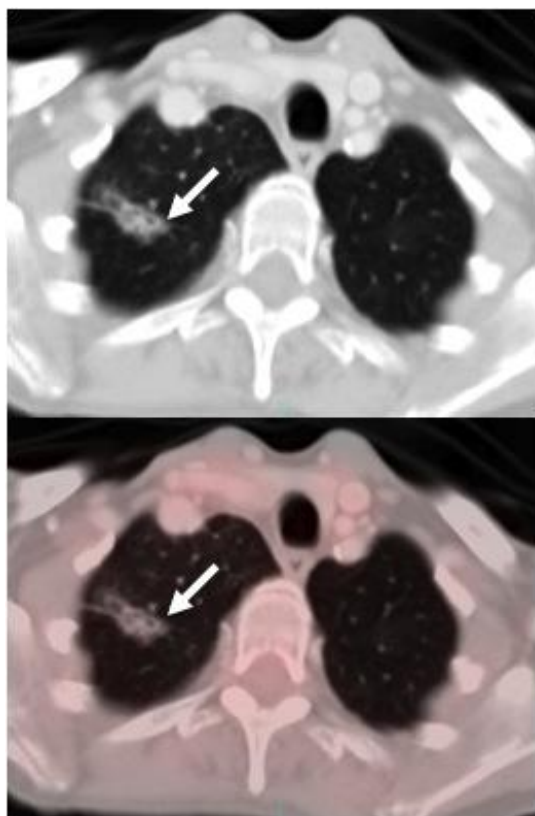


Figure 3: 76 year-old female with adenocarcinoma of the rectum and low-grade noninvasive urothelial carcinoma of the bladder. The scan was performed one week after the bladder mass biopsy and approximately three weeks after the CT scan in Figure 1. CT (upper left), PET (upper right), and PET/CT fusion images (lower left) demonstrate one of the two nodules of mixed confluence in the right upper lobe. On functional images, these lesions demonstrate very mild FDG uptake with maximum SUV of 0.8. Bilateral small ground-glass lung nodules (not shown) did not demonstrate discrete metabolic activity. Findings were suspicious for lung malignancy of bronchoalveolar carcinoma - adenocarcinoma type. Whole-body contrast enhanced CT and PET scans were acquired consecutively on a Siemens Biograph 6 PET/CT system approximately 60 minutes following the intravenous administration of 13.2 mCi of FDG using. The patient's blood glucose level was 131 mg/dl at the time of the FDG injection. CT scan settings were auto mAs, 130 kV, and 5 mm slice thickness. Contrast agents consisted of 75 ml of Ultravist 300 intravenous contrast and one 450 ml bottle of Readi-Cat 2 oral contrast. CT images acquired 70 seconds post contrast injection.

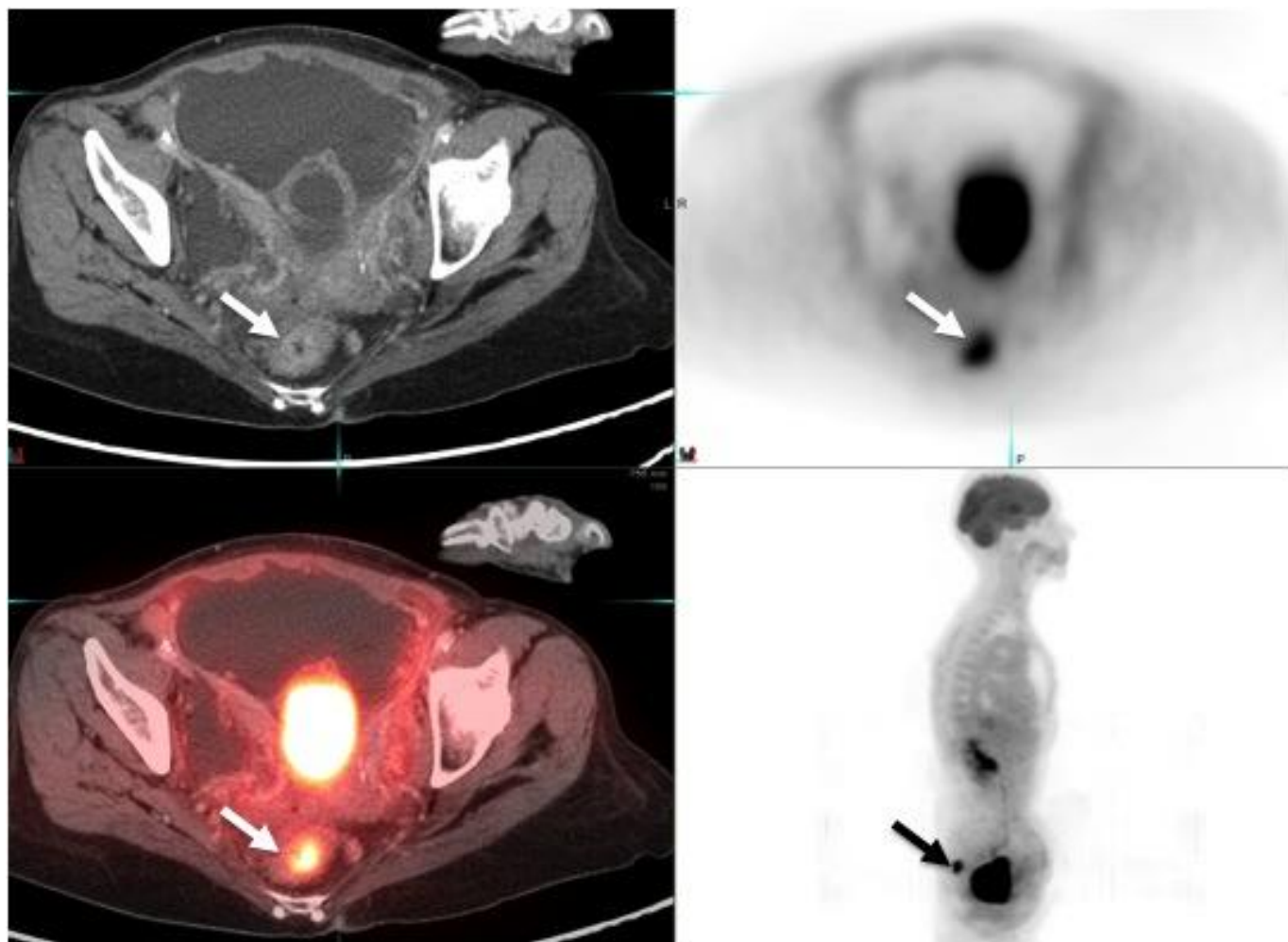


Figure 4: 76 year-old female with adenocarcinoma of the rectum and low-grade noninvasive urothelial carcinoma of the bladder. The scan was performed one week after the bladder mass biopsy and approximately three weeks after the CT scan in Figure 1. CT (upper left), PET (upper right), PET/CT fusion images (lower left), and maximum intensity projection (lower right) demonstrate a hypermetabolic rectal mass with maximum SUV 8.5 consistent with known rectal malignancy. Whole-body contrast enhanced CT and PET scans were acquired consecutively on a Siemens Biograph 6 PET/CT system approximately 60 minutes following the intravenous administration of 13.2 mCi of FDG using. The patient's blood glucose level was 131 mg/dl at the time of the FDG injection. CT scan settings were auto mAs, 130 kV, and 5 mm slice thickness. Contrast agents consisted of 75 ml of Ultravist 300 intravenous contrast and one 450 ml bottle of Read-Cat 2 oral contrast. CT images acquired 70 seconds post contrast injection.

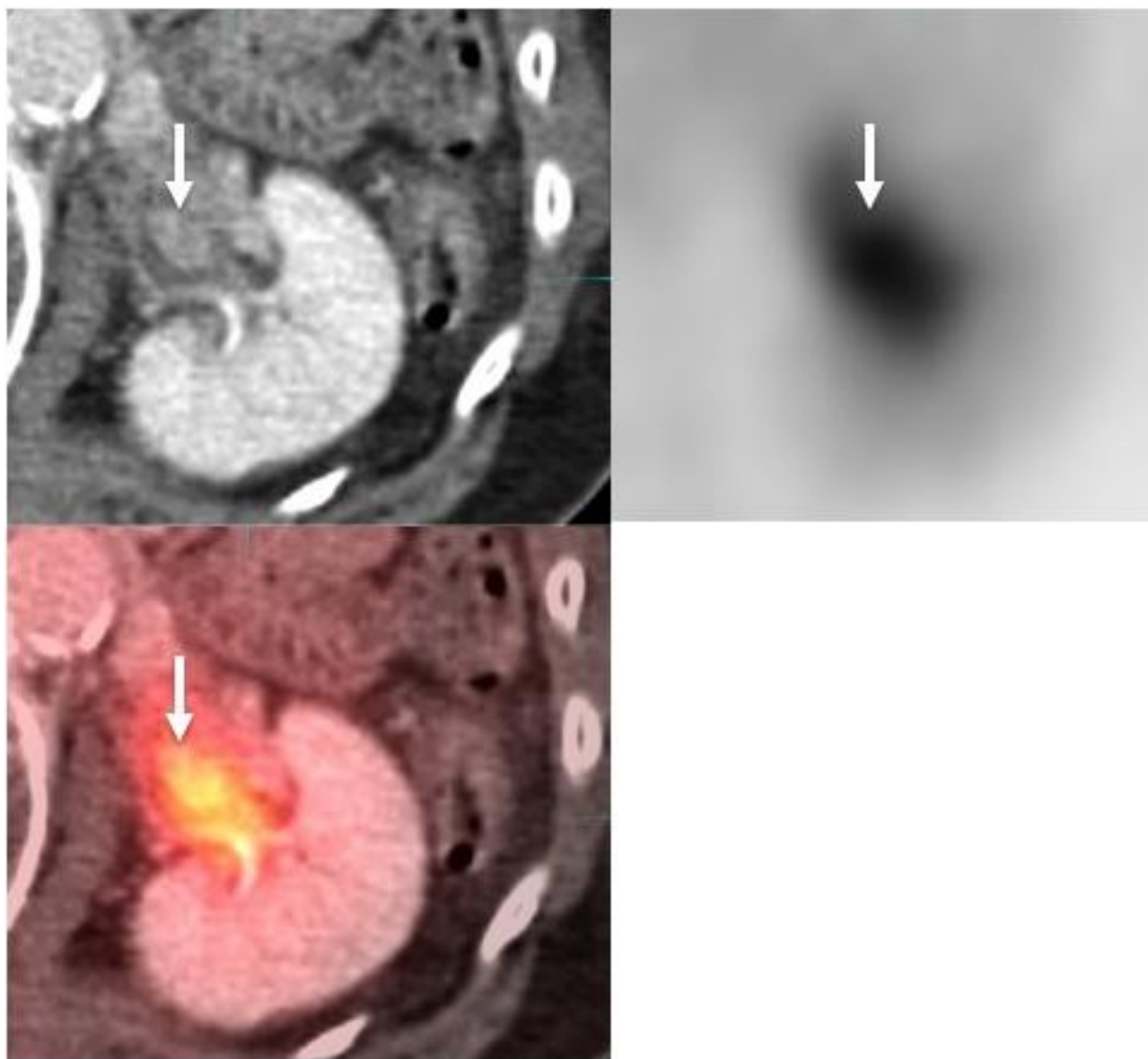


Figure 5: 76 year-old female with adenocarcinoma of the rectum and low-grade noninvasive urothelial carcinoma of the bladder. The scan was performed one week after the bladder mass biopsy and approximately three weeks after the CT scan in Figure 1. CT (upper left), PET (upper right), and PET/CT fusion images (lower left) demonstrate the 1.1 cm solid lesion in the left renal pelvis. The metabolic activity of this lesion could not be assessed due to normal excretion of FDG in the renal collecting system. Biopsy of the left renal pelvis lesion showed minute fragments of papillary, hyperplastic urothelium and was not diagnostic of malignancy. Whole-body contrast enhanced CT and PET scans were acquired consecutively on a Siemens Biograph 6 PET/CT system approximately 60 minutes following the intravenous administration of 13.2 mCi of FDG using. The patient's blood glucose level was 131 mg/dl at the time of the FDG injection. CT scan settings were auto mAs, 130 kV, and 5 mm slice thickness. Contrast agents consisted of 75 ml of Ultravist 300 intravenous contrast and one 450 ml bottle of Readi-Cat 2 oral contrast. CT images acquired 70 seconds post contrast injection.

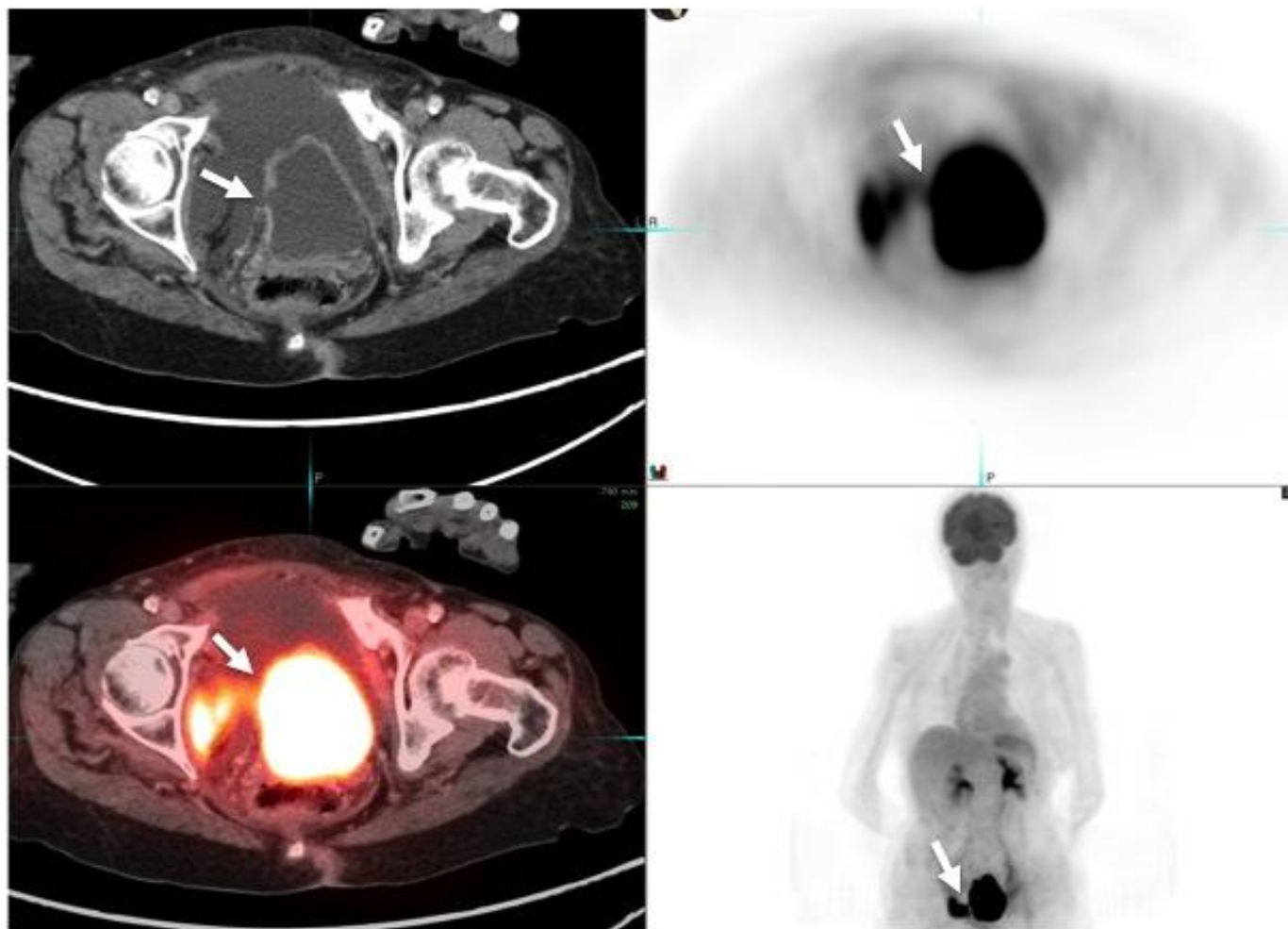


Figure 6: 76 year-old female with extraperitoneal urinary bladder perforation after biopsy of a low-grade noninvasive urothelial carcinoma. The scan was performed one week after the bladder mass biopsy and approximately three weeks after the CT scan in Figure 1. CT (upper left), PET (upper right), PET/CT fusion images (lower left), and maximum intensity projection (lower right) demonstrate bladder perforation with extravasation of radioactive urine. Whole-body contrast enhanced CT and PET scans were acquired consecutively on a Siemens Biograph 6 PET/CT system approximately 60 minutes following the intravenous administration of 13.2 mCi of FDG using. The patient's blood glucose level was 131 mg/dl at the time of the FDG injection. CT scan settings were auto mAs, 130 kV, and 5 mm slice thickness. Contrast agents consisted of 75 ml of Ultravist 300 intravenous contrast and one 450 ml bottle of Read-Cat 2 oral contrast. CT images acquired 70 seconds post contrast injection.

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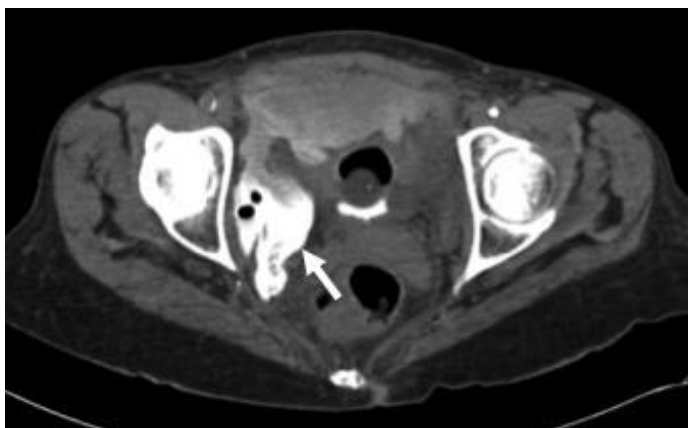


Figure 7: 76 year-old female with adenocarcinoma of the rectum and extraperitoneal urinary bladder perforation after biopsy of a low-grade noninvasive urothelial carcinoma presented for a follow-up noncontrast CT examination six hours after bladder perforation was discovered on PET/CT examination performed earlier the same day. Foley catheter had been placed immediately after bladder perforation was recognized on PET/CT. CT images were acquired on a Siemens SOMATOM Sensation 64 CT scanner with settings of auto mAs, 120 kV, and 3.0 mm slice thickness. Follow-up noncontrast CT scan of the abdomen and pelvis demonstrates extravasated contrast around the bladder filling the space of Retzius superiorly and the pelvic sidewalls laterally.

Etiology	External trauma (blunt or penetrating) Iatrogenic (Complications from gynecologic, urologic, orthopedic, and obstetric procedures) Intoxication Spontaneous / Idiopathic
Incidence	Incidence of bladder perforation is reportedly as high as 36% following bladder biopsy[6].
Gender Ratio	Unknown
Age Predilection	Unknown
Risk Factors	Previous bladder or gynecologic surgery[5].
Treatment	Intraperitoneal bladder rupture: Immediate operative repair.[5] Extraperitoneal bladder rupture (uncomplicated): conservative treatment with urethral catheter drainage and initiation of antibiotics[5]. Extraperitoneal bladder rupture (complicated): immediate open surgical repair to prevent complications such as fistula, abscess, and prolonged leak[5].
Prognosis	Traumatic bladder ruptures, once uniformly fatal, are currently managed quite successfully. Timely evaluation and proper management are critical for optimal outcomes[5]. Approximately 87% of uncomplicated extraperitoneal bladder ruptures will be healed in ten days, and nearly all are healed within three weeks[7]. The prognosis of intraperitoneal bladder rupture depends on how soon the rupture is discovered and how severe the injury is to other organs[5, 8].
Findings on Imaging	Extravasation of contrast agents or radionuclides into the intraperitoneal or extraperitoneal regions can be seen on cystography, CT, PET/CT, MRI, and renal scan. A focal perforation may also be visualized on CT or MRI [5, 13].

Table 1. Summary table for bladder perforation on imaging

	Cystography	CT	PET/CT	US	Renal Scan	MRI
Extraperitoneal bladder perforation	Extravasation of contrast into extraperitoneal regions (no outlining of bowel loops by contrast)[5].	Defect in the wall of the bladder. Extravasation of fluid/contrast into extraperitoneal regions (no outlining of bowel loops by contrast)[5].	Extravasation of fluid/contrast and activity into extraperitoneal regions (no outlining of bowel loops by fluid/contrast or FDG) [5].	Fluid collection surrounding the urinary bladder without fluid collection surrounding bowel loops[5].	Extravasation of radionuclide outside of the bladder is indicative of urinary leak[10, 14].	Subtle perforations are often visualized. Extravasation of contrast into the extraperitoneal regions (no outlining of bowel loops by contrast) [5, 13].
Intraperitoneal bladder perforation	Extravasation of contrast into intraperitoneal regions (outlining of bowel loops by contrast)[5].	Defect in the wall of the bladder. Extravasation of fluid/contrast into the intraperitoneal regions (outlining of bowel loops by contrast)[5].	Extravasation of fluid/contrast and activity into intraperitoneal regions (outlining of bowel loops by fluid/contrast or FDG) [5].	Fluid collection surrounding the urinary bladder and bowel loops[5].	Extravasation of radionuclide outside of the bladder is indicative of urinary leak[10, 14]	Subtle perforations are often visualized. Extravasation of contrast into the intraperitoneal regions (outlining of bowel loops by contrast)[5, 13].

Table 2. Differential diagnosis table for bladder perforation on imaging

ABBREVIATIONS

mCi = milliCurie
 PET = positron emission tomography
 CT = computed tomography
 FDG = fluorodeoxyglucose
 US = ultrasound
 MRI = magnetic resonance imaging

KEYWORDS

FDG; fluorodeoxyglucose; PET; positron emission tomography; PET/CT; computed tomography; bladder perforation; bladder rupture; bladder leak; extraperitoneal; intraperitoneal

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