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Original Article

Incidental renal masses on SPECT/CT and PET/CT

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Abstract: While the presence of incidental breast and lung masses on cardiac scans is well known, renal masses are often incidentally discovered as well on cardiac examinations, some of which are malignant. We searched the electronic medical record system over the past 18 years, since the system was installed, for patients with a cardiac rubidium-82 (^{82}Rb) rubidium PET/CT or technetium-99m (^{99m}Tc) sestamibi SPECT/CT performed within 1 year of a renal-protocol CT or MR. Each PET/CT or SPECT/CT was examined for presence of a renal lesion on the attenuation-correction CT images. We found 43 SPECT/CT and 18 PET/CT studies which fit the desired criteria. Of these, 7 SPECT/CT studies and 2 PET/CT studies demonstrated the renal mass on at least one of the two sets of CT images (rest or stress); if not visible, most commonly the tumor was either out of the field of view or had already been removed. Of these, 6 SPECT/CT and 2 PET/CT studies demonstrated a malignancy. Cardiac SPECT/CT and PET/CT images demonstrate incidental renal masses with a non-negligible frequency, and CT images should be carefully examined.

Keywords: SPECT/CT, SPECT, PET/CT, PET, sestamibi, rubidium, cardiac imaging, renal mass, incidental findings

Introduction

Myocardial perfusion imaging (MPI) nuclear cardiology scans, whether using single photon emission computed tomography (SPECT) or positron emission tomography (PET), are often performed with computed tomography (CT) scans for attenuation correction and correction of anatomical artifacts. The CT portion of SPECT/CT or PET/CT is not contrast-enhanced, is often acquired using lower-dose technique, and is therefore not of "diagnostic quality" according to manufacturers, but lung parenchyma and major structures and organs can be easily identified nonetheless. As a result, lung nodules are the most frequent incidental finding on cardiac SPECT/CT or PET/CT. However, major CT findings with direct prognostic value for cardiac conditions can also be seen, most prominently the presence of coronary calcifications and aortic aneurysms. The list of other incidentally recognizable findings in this setting is long and includes hiatal hernia, thyroid nodules, renal and liver cysts, cholecystectomy, splenectomy, pleural effusions, sarcoidosis, etc. [1, 2].

Clinically significant masses have also been described, usually in the chest, many of which may be at an advanced stage at the time of diagnosis [3]. The reported rate of incidental malignancy (most commonly lung cancer, as might be expected) on SPECT/CT ranges from 0.5% [4]-2% [5], with similar values of 1.4% [6]-1.9% [7] on PET [3-5]. Overall frequency of lung nodules, which may be benign or malignant, and are often benign, may be as high as 8% [8]-27% [5]. While the presence of occasional incidental renal masses on SPECT has been described [9], no large-scale study of the frequency and malignancy of incidental renal masses has been performed, possibly due to the location of the kidneys at the extreme lower end of the field of view.

Incidental renal masses are quite frequent, with cysts in particular being seen in 12% of the population and possibly as much as 30-50% by the seventh decade [10]. Most of these are benign, and there is a whole system (the Bosniak classification [11]) for risk stratification of renal masses. However, some renal masses are malignant and potentially life-threatening.

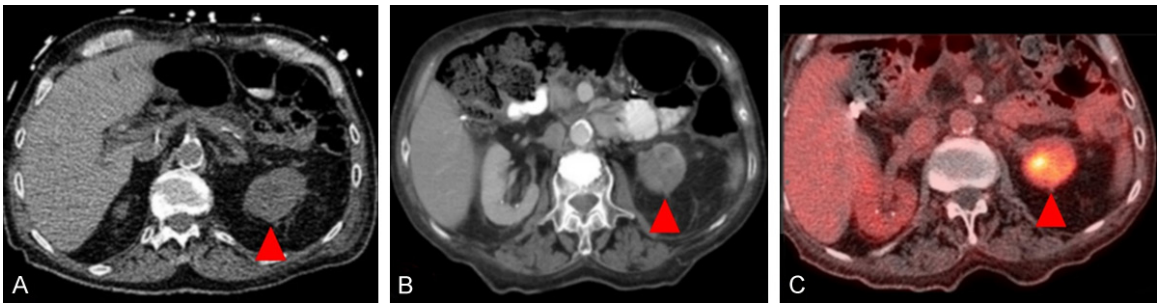

Figure 1. Incidentally discovered urothelial lesion on SPECT/CT (case 1 above). A. Attenuation correction CT of the abdomen shows poorly visualized but visibly abnormal mass lesion in the posterior aspect of the left kidney (red arrowhead). B. On later contrast-enhanced CT, lesion (red arrowhead) enhances but is still less bright than contralateral kidney. C. On a later FDG PET/CT, the lesion (red arrowhead) is slightly more avid than adjacent kidney.

Of these, renal cell carcinoma (RCC) being the most common malignancy, with most renal cell carcinomas being discovered as incidental findings on a CT of the abdomen and pelvis [12]. If discovered incidentally, the mass may not yet have spread, theoretically allowing for a life-saving resection, and indeed 65% of RCCs are discovered at the localized stage [13]. It is thus important to be aware of incidental renal masses, and detecting even a small percentage of renal masses in a commonly performed study such as MPI nuclear cardiology scans may save many lives.

Materials and methods

We first obtained Institutional Review Board (ethics committee) approval and ensured Health Insurance Portability and Accountability Act (HIPAA) compatibility for this retrospective study. Patient consent was waived under exemption for minimal risk in this retrospective study.

The electronic medical record system was queried from the present (2021) back through 2007, when cardiac SPECT/CT and PET/CT were first introduced at our institution. A search was made for patients with a cardiac PET/CT or SPECT/CT performed within 1 year (either before or after) of a CT or MR obtained to evaluate a renal mass. Inclusion criteria were thus the presence of a nuclear cardiology study (obtained for any purpose, though the vast majority were for evaluation of coronary artery disease in renal transplant patients) within 1 year of a CT or MR specifically chosen to evaluate the kidneys.

This search found a total of 43 relevant SPECT/CT and 18 relevant PET/CT studies. Once the list of studies had been obtained, each PET/CT or SPECT/CT was reviewed by two nuclear medicine physicians independent from each other. The purpose of the review was to see if they could detect the renal lesion on the accompanying attenuation correction CT images. The mass was considered detectable if it could be seen on the CT scan accompanying the rest or stress portions, or both, of the cardiac SPECT/CT or PET/CT, since small discrepancies between the limits of the field of view on each scan are common.

Our standard protocol for SPECT/CT includes a CT with 130 mAs and 50 kVp, and slice thickness of 5 mm with no overlap. Our standard PET/CT protocol includes a CT with 120 mAs and 50 kVp, and slice thickness of 3 mm with overlap of 1 mm. SPECT/CT images were acquired on a Siemens Symbia T6 (6 slice CT) or Siemens Symbia T16 (16 slice CT). PET/CT images were acquired on a Siemens Biograph mCT (128-slice CT) or Siemens TruePoint (40-slice CT) (Siemens Medical Solutions USA, Inc., Malvern, PA, USA). Each scan had two CT scans performed, one for rest images and one for stress images. Each CT scan was acquired using shallow-breathing low-dose technique. For SPECT, the tracer used was ^{99m}Tc-sestamibi with a one-day protocol, with 10 mCi followed by 30 mCi. For PET, the tracer used was ^{82}Rb-rubidium chloride with a dose of 30-45 mCi on both occasions.

Results

Of the 43 cardiac ^{99m}Tc-sestamibi SPECT/CT studies, only 7 demonstrated an actual renal mass on attenuation correction CT. (An example is shown in **Figure 1**). This was for a variety

Table 1. Discovered renal tumors

Case	Later workup	Size (cm)	Histology	Other findings
1	A/P CT	4.5	Urothelial cancer	Incidentally discovered pancreatic cancer
2	Renal mass CT	1.6	Poorly differentiated	
3	Chest CT	3.4	RCC (not fully investigated)	
4	A/P CT	4.8	Papillary RCC	
5	A/P MR	13.8	Clear cell RCC	
6	A/P CT	2.1	Papillary RCC	
7	Renal mass CT	5.2	Clear cell RCC	
8	A/P CT	2.4, 1.8, 1.5, 1.1	Acquired cystic disease	Polycystic kidney disease, on dialysis
9	A/P CT	2.7, 1.1	Unknown (lost to followup)	

A/P: abdomen/pelvis, CT: computed tomography, MR: magnetic resonance, RCC: renal cell carcinoma.

of reasons. In 7 cases, the tumor had already been removed. In 3 cases, the images were not available (likely due to the antiquity of the study). In 19 cases, the SPECT images were obtained at an outside hospital which did not use CT for attenuation correction. In 5 cases, the kidney was out of the field of view; there were also 2 ambiguous cases where the mass was just barely visible at the field of view.

In the case of the 18 cardiac ^{82}Rb-rubidium chloride PET/CT studies, 2 demonstrated an actual renal mass on attenuation correction CT. 7 of the tumors had already been removed by the time the PET had been obtained. In the 8 remaining cases, the tumor was out of the field of view, often being in the inferior pole of the kidney (which was not part of the field of view of the scan) if the kidneys were visible at all; there was one case where the kidneys were large and polycystic and the tumor could not be resolved from all the surrounding cysts.

Of the 9 total discovered tumors (**Table 1**), the mean size (counting multiple tumors in one patient as separate tumors) was 3.5 cm, with a range of 1.6-13.8 cm. (One patient had 2 suspicious lesions, and another patient with polycystic renal disease had 4 suspicious tumors). One tumor could not be evaluated further, as the patient was lost to followup. Otherwise, there was 1 urothelial carcinoma (**Figure 1**) and 7 renal cell carcinomas (RCCs). One of the RCCs was not worked up further at this institution; of the remaining 6 RCCs, 1 was poorly differentiated, 2 were papillary subtype, 2 were clear cell subtype (**Figure 2**), and 1 was acquired from renal dialysis. No tumors had nodal or distant metastatic spread outside the kidney at the time of discovery (although one had metastatic disease from another tumor, an incidentally discovered pancreatic carcinoma).

In general, renal tumors were not within the field of view of the actual ^{99m}Tc-sestamibi SPECT or ^{82}Rb-rubidium chloride PET scan, which often has a smaller field of view compared to the CT scan, and could not be assessed for sestamibi or rubidium uptake characteristics.

Discussion

Of the estimated approximately 2,750 nuclear stress studies per year and 55,000 over the past 20 years, only 9 showed a renal mass; this is about 1 in 6000 studies or a 0.016% incidence rate. Renal masses are thus much less common than lung or breast masses and represent a small fraction of incidentally discovered malignancies on cardiac nuclear scans.

However, every incidentally discovered renal mass turned out to be malignant-in most cases an RCC, though this is likely due to the relative frequency of these tumors vis-à-vis other renal masses. Therefore, while these tumors are rarely discovered, they represent a potentially dangerous incidental finding that needs to be addressed.

Incidentally discovered renal masses are usually further evaluated through the use of intravenous contrast-a mass which enhances with intravenous contrast is much more likely to be malignant [12]. While the attenuation correction CTs obtained with SPECT/CT and PET/CT are usually performed without intravenous contrast, at least some malignant masses can be identified as such on noncontrast CT, and others can be clearly identified as benign [12].

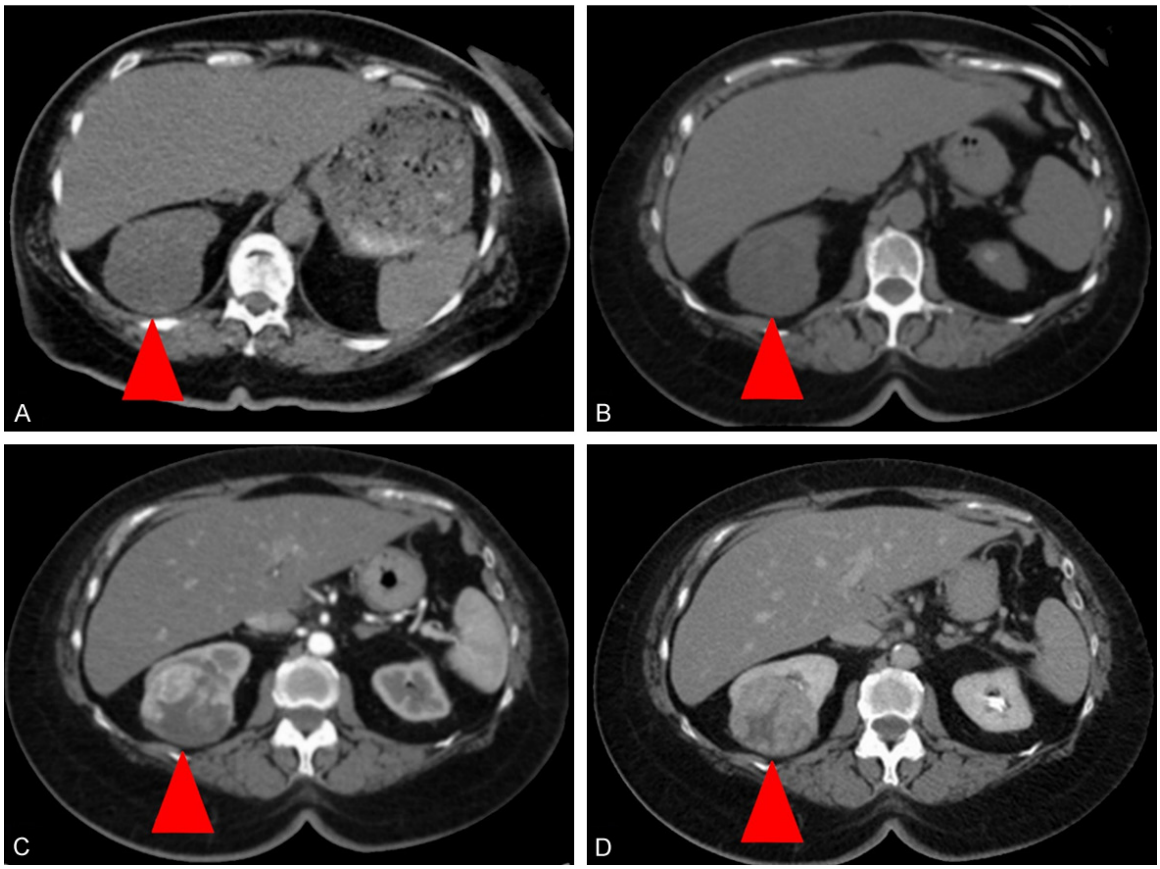

Figure 2. Incidentally-detected renal lesion on SPECT/CT (case 7 above). A. Figure shows a CT of the abdomen through the upper kidneys with a homogeneous-appearing, slightly hypoattenuating mass (red arrowhead) replacing the posterior aspect of the right kidney. This later proved to be a clear cell subtype RCC. B. Noncontrast phase on subsequent renal-protocol CT (note lower noise levels relative to A). As on the original SPECT/CT, the mass (red arrowhead) replaces the posterior aspect of the kidney and is slightly hypoattenuating. C. Arterial phase on subsequent renal-protocol CT. The mass (red arrowhead) is now clearly seen and heterogeneous in appearance. D. Nephrographic phase on subsequent renal-protocol CT. The mass (red arrowhead) is again clearly seen and heterogeneous.

In addition, none of the diagnosed tumors had nodal or distant metastatic disease. This is not necessarily different from chance as today about 65% of tumors are diagnosed at the localized stage [13]. (There is about a 2% chance such an event would occur randomly in 9 tumors, unlikely but certainly not impossible). However, it is still worth noting that reviewing the CT for incidentally discovered tumors was in fact able to diagnose RCC before spread had occurred. This highlights the importance of carefully reviewing the scan for occult incidental renal masses.

The study was retrospective in nature and limited by the relatively small number of patients who turned out to have renal masses (though this may simply be representative of the usual clinical picture). The CT modality has the obvious limitations of low resolution, respiratory motion artifacts, and incomplete coverage of the relevant area. This is a single-center trial and our experience may not be representative of centers with a higher or lower incidence of RCC. Also, the inability to access older images limited our sample size.

Conclusion

Renal masses incidentally discovered on attenuation correction CT images, while rare, are frequently malignant, and CT attenuation correction images should be examined carefully.

Disclosure of conflict of interest

None.

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