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Incidental findings on electron beam tomography renal angiography in hypertensive patients

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Aim: To evaluate the prevalence, spectrum, and significance of incidental lesions identified on electron beam tomography (EBT) renal angiography performed to investigate renovascular hypertension.

Materials and methods: EBT renal angiography images of 148 cases were evaluated in terms of renal artery variations and renal artery stenosis. Extravascular renal findings, abdominal aorta, iliac artery, liver and gallbladder findings, vertebral lesions, and other intraabdominal organ findings were assessed during the examination.

Results: No incidental finding was found in 30 cases (20.2%) in total. The most frequent incidental findings were benign ones without any clinical significance. A total of 13 (8.7%) clinically significant findings were identified.

Conclusion: When evaluating renal EBT angiography, a detailed review of other systems as well as target organ assessment is of crucial importance as it may affect patient prognosis.

Key words: Incidental findings, renal CT angiography, renovascular hypertension, electron beam tomography

1. Introduction

Hypertension is a major risk factor for cardiovascular morbidity and mortality. The latest studies demonstrate that hypertension control significantly reduces the incidence of cardiovascular diseases (1).

In addition to detecting the target organ damage, establishing the underlying cause is important for hypertensive patients. A cause can be determined by advanced investigation in approximately 5% of patients with hypertension (2–4). The identifiable causes are led foremost by renal diseases. Although renal parenchymal diseases are the most prominent causes, detection of renal artery stenosis as a correctable cause is of high clinical importance.

When renal artery stenosis is clinically suspected, it can be diagnosed by noninvasive methods such as Doppler ultrasonography, computed tomographic angiography (CTA), and magnetic resonance angiography (MRA). Invasive renal angiography is considered the gold standard to show the anatomy of the renal arteries, whereas it is not recommended as a routine procedure due to its risks (5).

Electron beam computed tomographic angiography (EBT angiography) is a noninvasive method that can be used for tomographic examination of the vascular system. Motion-related artifacts are less common due to the scanning speed in this technique. Another significant advantage of EBT is that it causes lower radiation exposure levels when compared with other computerized tomographies (6,7). The anatomy of the renal vascular structures, their variants, and stenoses can easily be shown with EBT and CT angiography 3-dimensional images (8,9).

In addition to the region of interest, it is also possible to identify variations and lesions in other organ systems that are in the scope of the area examined by EBT renal angiography. Similarly, during cardiac multislice computer tomography, Durmaz et al. reported in their study that if the observer does not consider the possible presence of a coronary artery anomaly, these anomalies can be overlooked (10). Although a considerable portion of the incidental findings have no clinical significance, others can be life-threatening.

Radiologists who examine EBT renal angiography images, especially at busy clinics, may only focus on renal vascular structures and kidneys, neglecting surrounding organs and not mentioning these in their final reports. Reporting the lesions that could become potentially life-

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threatening when overlooked is of the utmost importance for patient health. The aim of the present study was to evaluate the prevalence, spectrum, and significance of incidental lesions determined on EBT renal angiography.

2. Materials and methods

2.1. Subjects

A total of 148 patients (71 females, 77 males) who had undergone EBT renal angiography between October 2005 and July 2007 were included in the study. The mean age was 54 ± 14 [SD]. All patients were hypertensive, and some of them were our clinic's patients while the others were referred from outside institutions for EBT renal angiography. Patients with clinically suspected renovascular hypertension had first been evaluated by renal Doppler ultrasonography.

EBT renal angiography was performed in patients with suspected stenosis revealed by Doppler ultrasonography and in those with strong suspicion of renal artery stenosis even if their Doppler ultrasonography results were normal. Renal functions were examined before performing angiography, and patients with creatinine levels above 1.5 mg and those allergic to contrast material as well as those with arrhythmias were excluded. The patients were asked to sign an informed consent form. Approval was obtained from the scientific committee of the center.

2.2. EBT renal angiography

For EBT renal angiography, a C150 XP scanner (GE-Imatron Inc., South San Francisco, California, USA) was used. The scans were performed at 130 kV, 630 mA, 0.2 s,, and 3-mm collimation. Initially, noncontrast images of 3 mm sectional thickness were obtained in the area that extends from the upper poles of the kidneys to the symphysis pubis. Vascular calcifications and renal stones were displayed in this phase. Subsequently, following a bolus injection of 20 mL of nonionic contrast agent at a rate of 4 mL/s, images were obtained with a 10–14 s delay for time-density analysis. The optimal time for contrast agent infusion was calculated. Thereafter, following intravenous administration of 70 to 120 mL of nonionic contrast agent at a rate of 4 mL/s based on the patient's weight, the abdominal aorta and its branches from the start of the celiac trunk to the iliac bifurcation level were continuously scanned in 1.5 mm axial slices. The patients were asked to hold their breath throughout the scanning process. The obtained images were converted to 3-D using volume rendering (VR) and maximum intensity projection (MIP) via Workstation (AccuImage Inc., San Francisco, California, USA). No complications emerged during the procedures.

The EBT renal angiography images obtained were retrospectively evaluated by 2 radiologists who were blind to the ultrasonography findings. Renal artery stenosis was classified as mild, moderate, and severe in patients with stenoses of 20–30%, 50–75%, and 75%, respectively.

In addition to the renal artery findings, the patients were also assessed in terms of extravascular renal findings as well as findings of the abdominal aorta, main iliac arteries, liver, gallbladder, vertebrae, and other intraabdominal organs. Criteria for simple cyst in the liver and kidneys included 0–20 Hounsfield Units (HU) of density, absence of thick septum, nodularity, and contrast enhancement. Lymph nodes with a short axis of greater than 1 cm in the portal hilum and paraaortic region were considered pathological. In noncontrast sections, lesions smaller than 4 cm in the adrenal region with a density of < 10 HU were considered to be adrenal adenoma. An increased diameter of greater than 30 mm in the abdominal aorta was regarded as an aneurysm.

Histopathologically proven malignant lesions, findings requiring further evaluation for actual diagnosis, and lesions requiring immediate therapy were classified as *clinically significant* lesions.

3. Results

3.1. Renal arteries

When the cases were assessed with regard to renal artery variations, multiple renal arteries were detected on the right side in 15 (10.1%) and on the left side in 12 (8.1%) out of the 148 cases. Eleven cases (7.4%), on the other hand, had bilateral multiple renal artery variation. Of these, there were 3 renal arteries on the right in 3 cases (2%), and on the left in 1 case (0.6%).

Mild renal artery stenosis was detected in 11 cases (7.4%), 7 on the right and 4 on the left. Moderate stenosis was observed in 8 cases (5.4%), detailed as 3 on the right and 5 on the left. There was severe renal artery stenosis in 16 cases (10.8%), including 11 on the right and 5 on the left. A total of 8 cases (5.4%), including 1 on the right and 7 on the left, had total renal artery occlusion (Table 1).

3.2. Extravascular renal findings

The most common nonvascular benign renal finding that did not require any further investigation was simple cortical cysts. Cortical or parapelvic cysts were observed on the right side, on the left side, or bilaterally in 9, 10, and 14 cases, respectively. One case had a hemorrhagic cortical cyst.

In terms of the renal variations, left duplicated collecting system was determined in 1 case and ectopic left kidney in another.

Right renal atrophy and left renal atrophy were seen in 3 and 5 cases, respectively. Four cases had renal stones in the left kidney, and 2 cases had bilateral renal stones. A left ureter stone causing hydronephrosis was seen in 1 case (Figure 1). One other case had hydronephrosis without any stones, whereas another had ureteropelvic stenosis (Table 2).

Table 1. Renal artery stenosis detected by EBT renal angiography.

	Mild n (%)	Moderate n (%)	Severe n (%)	Total occlusion n (%)
Right renal artery (n = 22)	7	3	11	1
Left renal artery (n = 21)	4	5	5	7
Total (n = 43)	11 (7.4)	8 (5.4)	16 (10.8)	8 (5.4)

n: Number of patients

Figure 1. Left ureter stone in the middle section of the ureter (solid arrow) in noncontrast **a.** axial and **b**. coronal sections (solid arrow). Dilatation of the proximal ureter and pelvicalyceal structures (outlined arrow). Aneurysmal dilatation (arrow head) of the abdominal aorta prior to the iliac bifurcation. **c.** Axial cross sectional image of the aneurysm in the arterial phase after injection of contrast material (solid arrow) **d.** 3-dimensional image of the aneurysm (solid arrow). Dilatation of the ureter (outlined arrow) proximal to the stone.

The solid mass lesion that showed heterogeneous contrast enhancement during the arterial phase in the left kidney was considered to be a renal tumor, and it was histopathologically proven to be a hypernephroma (Figure 2).

3.3. Extrarenal findings

In the abdominal aorta and common iliac arteries of 59 cases, mild to moderate atherosclerotic changes, which might be attributed to conventional risk factors, were observed. Mural thrombus was present in the abdominal aorta in 2 cases and in the bilateral common iliac arteries in 1 case. In addition, there were a total of 3 thrombosed aneurysms including 1 in the aorta, 1 in the right common iliac artery, and 1 in the bilateral common iliac arteries. In 2 cases, dissections in the right common iliac artery and the left common iliac arteries (Figure 3), and in 1 case, occlusion of the superior mesenteric artery (SMA), inferior mesenteric artery (IMA), and celiac arteries were found (Table 3).

Benign hepatobiliary findings that did not require intervention were hepatic parenchymal calcifications in 8 cases and simple cysts in 6 cases. Gallbladder stones were detected in 6 patients with no increase in gallbladder wall thickness. A lesion that required further examination for accurate diagnosis that was compatible with hemangioma was observed in 1 case. The only hepatobiliary system findings with clinical significance were hydropic gallbladder and gallbladder wall thickening compatible with acute cholecystitis (Table 4).

A total of 12 cases of benign findings requiring no further investigation (vertebral degenerative changes in 11 cases and scoliosis in 1 case) were detected during evaluation of vertebrae. Lesions requiring further examination and evaluation were a focal sclerotic lesion in the L1 vertebra in 1 case and focal lytic lesions of the L3 and L4 vertebrae in another case (Table 4). The sclerotic lesion was later assessed as metastasis from a previously diagnosed prostate carcinoma on further evaluation.

The other extrarenal findings requiring further examination were a solid mass lesion in 1 case, which showed mild contrast enhancement in the arterial phase and was considered to originate from the small intestine (Figure 4), and pathologically large lymph nodes located in the portal hilar and paraaortic region in another case.

The other findings that did not require further examination were 3 cases of lesions compatible with adenoma in the left adrenal gland, 1 case of thickening of the right adrenal gland compatible with hyperplasia, 1 case of nonspecific dilation of the common bile duct and the Wirsung duct, and 2 cases of calcification in the spleen (Table 4).

A total of 13 clinically significant findings (8.7%) were detected and there were no incidental findings in 30 cases (20.2%). The clinically significant lesions are summarized in Table 5.

Table 2. Renal findings excluding arterial lesions.

Findings	Right n	Left n	Bilateral n	Total n (%)
Cortical/parapelvic cyst	9	10	14	33 (22.2)
Hemorrhagic cyst	1	-	-	1 (0.6)
Nephrolithiasis	-	4	2	6 (4)
Ureteral stone	-	1	-	1 (0.6)
Ectopia	-	1	-	1 (0.6)
Duplicated collecting system	1	1	-	2 (1.3)
Ureteropelvic obstruction	1	-	-	1 (0.6)
Hydronephrosis	1	1	-	2 (1.3)
Atrophy	3	5	-	8 (5.4)
Mass	-	1	-	1 (0.6)

n: Number of patients

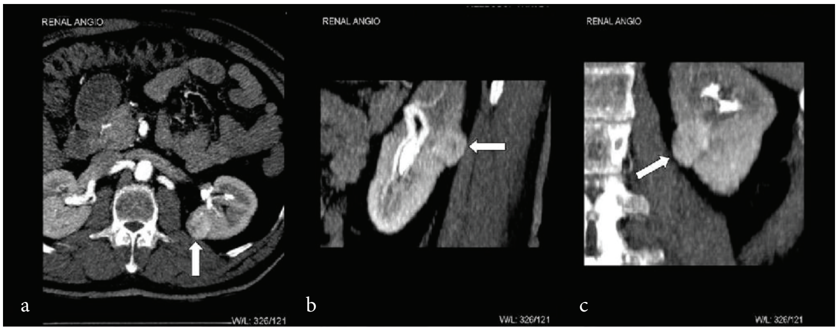

Figure 2. Solid mass lesion showing heterogeneous contrast enhancement in arterial phase in the central part of the left kidney by **a**. axial **b.** sagittal and **c.** coronal sections (solid arrows). Histopathological examination has yielded the diagnosis of hypernephroma.

4. Discussion

Diagnosis of renal artery stenosis as an underlying cause of hypertension is important since it can be treated interventionally. Renal artery anatomy can be clearly and noninvasively delineated by renal CTA (11). In a meta-analysis, Vasbinder et al. have reported a sensitivity of 94%–100% and a specificity of 92%–99% for CT angiography in the diagnosis of renal artery stenosis (12). Apart from renal artery stenosis, renal artery variations can be easily detected on CTA. Kidney and renal artery mobility, which are likely factors in renal artery stent failure and restenosis, can also be evaluated by CT by measuring changes in kidney location and renal artery angle (13). Eren et al. and Toprak et al. have stated in their studies that preoperative evaluation of the renal vasculature is essential in correct surgical planning and in avoiding serious vascular injury by minimizing unexpected hemorrhagic complications associated with vascular variations (14,15). Kara et al. drew attention to the lack of data about the histopathological properties of accessory renal arteries, which is a frequent variation, as histological and anatomic properties of these arteries might be important in terms of pathologies like stenosis of the renal artery, renovascular hypertension, and transplantation (16,17). In our study, accessory renal arteries were encountered in 15 and 12 patients on the right and left side, respectively, and in 20 patients bilaterally.

There are several studies that investigate the frequency and significance of incidental findings in systems apart from the target organ, during cardiac CT examination, abdominal aorta and lower extremity CT angiography, CT colonography, and maxillofacial region cone beam CT (18–22). To our knowledge, the prevalance and importance of incidental findings on renal CTA have not been reported before.

Thirteen (8.7%) out of the 148 patients in this study had incidental lesions that were either malignant or required further evaluation or treatment, and therefore were classified as 'clinically significant'. In a 500-patient study, Belgrano et al. identified 43 (5%) cases with clinically significant incidental findings during abdominal aorta

Table 3. Extrarenal vascular findings.

Extrarenal vascular findings	n (%)
Atherosclerotic changes in aorta	59 (39.8)
Aortic mural thrombus	2 (1.3)
Thrombosed aortic aneurysm	1 (0.6)
Thrombosed iliac artery aneurysm	2 (1.3)
Iliac artery dissection	2 (1.3)
Bilateral iliac artery mural thrombus	1 (0.6)
SMA, celiac artery, IMA occlusion	1 (0.6)

n: Number of patients, SMA: Superior mesenteric artery, IMA: inferior mesenteric artery

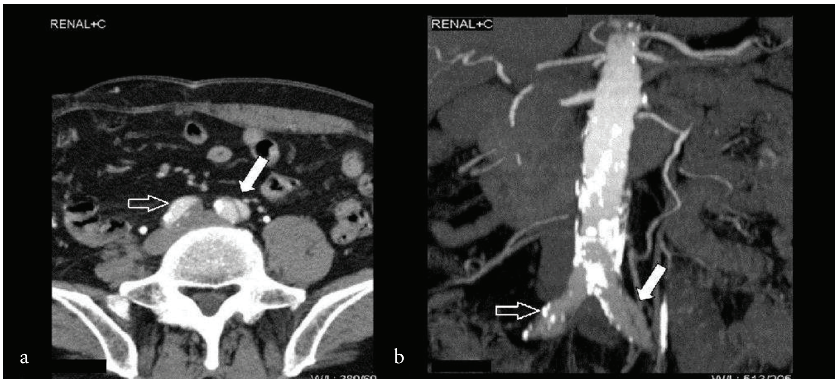

Figure 3. a. Dilatation and dissection of the left common iliac artery in contrast-enhanced axial section (solid arrow), thrombotic dilatation of the right common iliac artery (outlined arrow), **b.** fusiform aneurysm and dissection of the left main iliac artery in contrast-enhanced coronal section (solid arrow), right common iliac artery dilatation (outlined arrow).

CTA (18). Naidu et al. have reported this rate to be 15% in a similar study (19). In 2 CT colonography studies, the rate of clinically significant incidental extracolonic findings was reported to be 11% and 9%, respectively (20,21). One of the main reasons for the differences in rate may be the different criteria of *clinical significance* defined by the authors. Other reasons that could be mentioned include differences across the studies in terms of the mean ages of the patients and existing risk factors, as well as the scope of the anatomical regions examined.

When the results of this study are compared with the incidental findings detected by Glockner et al. in renal MRA, the consistency of the results of both studies in terms of the rate of clinically significant lesions is remarkable. In the mentioned study, 5% out of the 380 cases had significant incidental findings (23). In addition to its advantages, MR angiography has some limitations as compared with EBT angiography in detecting incidental lesions. One noteworthy advantage could be the high soft-tissue contrast of MRI. The ability to establish diagnosis in indeterminate lesions without the need for further investigations and the absence of ionizing radiation are among the other advantages of MRI. The important advantages of CTA over MRI could be the short test duration and fewer motion artifacts. In addition, CT is superior to MRI in the evaluation of calcifications.

One of the clinically significant findings found in this study was a renal mass lesion. In the study by Glockner et al., on the other hand, malignant lesions were found in 10 cases in total, 8 of which were not diagnosed before. Three of these were renal cell carcinoma (23). Hara et al., in a CT colonography study including 264 patients, and Yee et al., in a CT colonography study in 500 patients, found 2 renal cell carcinomas each incidentally (20,21). The rates in these studies are consistent with that of our study. As no intravenous contrast material was used in CT colonography, the detected renal masses were classified as indeterminate, and additional examination was required for lesion characterization. The EBT 3D imaging technique enables the determination of the size, extension, and relationship with the collecting system of renal masses easily and with a high accuracy rate so that kidney-sparing surgery can be performed (24,25).

Glockner et al. have identified pathologic lymphadenopathy (histopathologically diagnosed as sarcoidosis) in one case (23). In this study as well, lymph

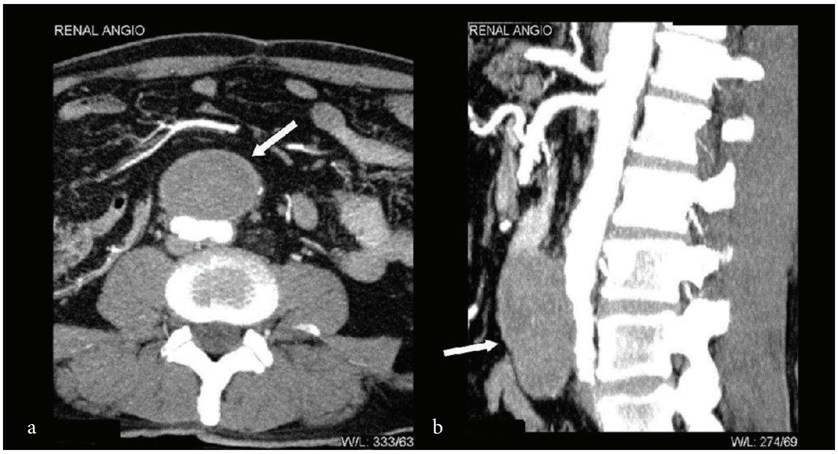

Figure 4. A 4 × 5 × 7.5 cm solid mass lesion (solid arrows) showing slight contrast enhancement in the arterial phase and compression of abdominal aorta anteriorly, **a.** axial and **b.** sagittal sections.

Table 4. Extrarenal and extravascular findings.

Organ system/finding	n (%)
Liver	
Calcification	8 (5.4)
Simple cyst	6 (4)
Hemangioma	1 (0.6)
Gall bladder symptoms	
Cholelithiasis	6 (4)
Hydropic sac, wall thickening	1 (0.6)
Vertebrae	
Degenerative changes	11 (7.4)
Sclerotic focus (L2 corpus)	1 (0.6)
Lytic focus (L3–4 corpus)	1 (0.6)
Scoliosis	1 (0.6)
Other systems	
Left adrenal adenoma	3 (2)
Thickening of the right adrenal gland	1 (0.6)
Intraabdominal solid mass	1 (0.6)
Dilatation of common bile duct and Wirsung duct	1 (0.6)
Portal hilar and paraaortic lymph nodes	1 (0.6)
Calcification in the spleen	2 (1.3)

nodes with pathological dimensions in the portal hilum and paraaortic region were detected in one case.

It is noteworthy that although lytic lesions of the vertebral corpus in one case and sclerotic foci of the vertebral corpus in other case were detected in this study, Glockner et al. do not mention any incidental findings of bone structures. This may attributed to the fact that while MRI is superior in terms of demonstrating and phasing bone marrow involvement and invasion of the surrounding tissue, CT is superior in demonstrating matrix calcification and lesions of the bone cortex (26).

In our study, a total of 3 aorta–iliac aneurysms and 2 dissections were detected, whereas in the Glockner et al. study, the numbers of identified aorta–iliac aneurysms and dissections were 25 and 9, respectively. The incidence of aorta–iliac aneurysms and dissections is known to increase with age (27). The high rate of these cases in the mentioned study could be attributed to the inclusion of patients with advanced age in their study.

In the study by Glockner et al., images compatible with mesenteric artery occlusion or stenosis in 127 cases (33%) were identified, which is quite a high rate. In our study, only one patient had occlusion in the mesenteric arteries.

Table 5. Clinically significant incidental findings requiring immeadiate treatment or further evaluation.

Lesion	n
Ureteral stone	1
Renal mass (hypernephroma)	1
Thrombosed aortic aneurysm	1
Thrombosed iliac artery aneurysm	2
Iliac artery dissection	2
SMA, celiac artery, IMA occlusion	1
Hydropic gall bladder with wall thickening	1
Vertebra sclerotic focus (L2 corpus)	1
Vertebral lytic focus (L3–4 corpus)	1
Intraabdominal solid mass	1
Portal hilar and paraaortic lymph nodes	1
Total	13 (8.7%)

n: Number of patients, SMA: Superior mesenteric artery, IMA: inferior mesenteric artery

The high rate of these cases in the mentioned study may have been caused by the false-positive results yielded by MRI to demonstrate occlusion or stenosis in these arteries.

The incidental findings without any clinical significance in this study were the most common ones, in agreement with those in the literature (20,23). These findings are led by vertebral degeneration and atherosclerotic changes due to increasing age as well as kidney cysts.

The relatively small study group, which consisted of patients with suspected renal artery stenosis, may be regarded as a limitation of the study. Another limitation is the referral of some of the patients with clinically significant lesions to our clinic from other institutions. For this reason, it has not been possible in all cases to follow up the patients and obtain their further examination results.

In conclusion, an assessment to be conducted by focusing on the renal artery only is associated with a risk of exclusion of the extraarterial incidental findings by the radiologist. With already submitted contrast material during CTA, more information about the character of the incidental lesion could be obtained. While the vast majority of these findings do not have any clinical significance, vitally significant findings that may affect the prognosis may also be detected at a lower rate. The results of this study indicate the existence of a substantial rate of clinically significant pathologies that should not be overlooked or underestimated. The detection of such pathological findings is ultimately important for the future lives of patients. In addition, unspecified pathologies may pose a problem with regard to malpractice. Therefore, as is the case with other radiological diagnostic procedures, evaluation and reporting that encompass not only the targeted organ but also other systems will prove useful in many respects.

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