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Characterization of renal cell carcinoma, oncocytoma, and lipid-poor angiomyolipoma by unenhanced, nephrographic, and delayed phase contrast-enhanced computed tomography

Kousei Ishigami [a,*], Marius G. Pakalniskis [a], Leandro V. Leite [a], Daniel K. Lee [b], Danniele G. Holanda [c], Maheen Rajput [a]

[a] Department of Radiology, University of Iowa Hospitals and Clinics, Iowa City, IA, USA
[b] Department of Urology, University of Iowa Hospitals and Clinics, Iowa City, IA, USA
[c] Department of Pathology, University of Iowa Hospitals and Clinics, Iowa City, IA, USA

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ABSTRACT

The purpose of this study was to assess the characterization of renal cell carcinoma (RCC) and benign renal tumors by unenhanced, nephrographic, and delayed phase computed tomography (CT). The study group consisted of 129 renal tumors including 79 clear cell RCCs, 17 papillary RCCs, 6 chromophobe RCCs, 21 oncocytoma, and 6 lipid-poor angiomyolipomas (AMLs). CT studies were retrospectively reviewed. Our results suggested that it was possible to discriminate clear cell RCC from papillary RCC, chromophobe RCC, and lipid-poor AML. CT findings of oncocytoma overlapped with both clear cell and non-clear cell RCCs, although oncocytoma more commonly became homogeneous in the delayed phase.

1. Introduction

Clear cell renal cell carcinoma (RCC) is the most common subtype of RCC, accounting for approximately 70%–80% of RCCs [1,2]. It has a poorer prognosis than other relatively common subtypes of non-clear cell RCC, such as papillary RCC and chromophobe RCC [1,2]. Angiomyolipoma (AML) is the most common benign tumor. Approximately 10%–17% of surgically resected renal masses are benign, and approximately 2%–6% of such benign renal masses are AML [3]. Imaging diagnosis of AML is not difficult unless macrosocopic fat is absent [4]. Oncocytoma is the second common benign renal tumor, accounting for approximately 3%–7% of all renal tumors [5]. Clinically, it remains important to both differentiate clear cell from non-clear cell RCCs and to differentiate RCC from benign renal tumors such as oncocytoma and lipid-poor AML.

Differentiating subtypes of RCC and benign renal tumors on imaging studies has been investigated by many previous studies [6–11]. It is well known that clear cell RCC typically shows avid arterial enhancement and non-clear cell RCC shows lesser degrees of enhancement than clear cell RCC [6–11]. On contrast-enhanced (CE) computed tomography (CT), clear cell RCC is heterogenous and non-clear cell tends to be homogenous [10,11].

The detection of a renal mass on CT has been based on both unenhanced and CE-CT studies. For the detection of intraparenchymal renal masses, the nephrographic phase may outperform the arterial (corticomedullary) phase [12] owing to its uniform renal parenchymal enhancement. However, Songib et al. [13] described that omitting the nephrographic phase from the quadruple renal CT protocol (i.e., unenhanced, corticomedullary, nephrographic, and delayed phases) did not reduce the ability to detect and characterize renal lesions. Additionally, it was reported that the corticomedullary phase was important for the characterization of clear cell RCC and oncocytoma [14]. Furthermore, Kim et al. [15] found that segmental enhancement inversion based on the corticomedullary (30–40 s) and early excretory (120–180 s) phase was a characteristic enhancement pattern of oncocytoma. Segmental enhancement inversion is a term used to describe a renal lesion which has two distinct zones of enhancement which reverse between the corticomedullary and early excretory phases. One zone is hyperenhancing on the corticomedullary phase and becomes hypoenhancing on the early excretory phase, and the other zone is hypoenhancing on the corticomedullary phase and becomes hyperenhancing on the early excretory phase [15,16]. Therefore, for the characterization of renal tumors, CT protocols vary by institution.

At our institution, unenhanced, nephrographic, and delayed phases have been utilized for patients with hematuria or suspected renal

* Corresponding author. Department of Radiology, University of Iowa Hospitals and Clinics, 3885 JPP, 200 Hawkins Dr, Iowa City, IA 52242, USA. Tel.: +1 319 356 1071; fax: +1 319 356 2220.
E-mail address: Ishigamikousei@aol.com (K. Ishigami).

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Table 1
The profiles of patients and each renal tumor

	Age (years)	Size (cm)
Clear cell RCC (n=79)	25–93 (56±13)	1.3–16.1 (5.2±3.5)
Papillary RCC (n=17)	41–82 (62±11)	1.3–8.4 (3.6±1.9)
Chromophobe RCC (n=6)	37–78 (51±15)	1.1–13.8 (6.5±4.7)
Oncocytoma (n=21)	43–86 (66±10)	1.5–5.6 (3.2±1.3)
Lipid-poor AML (n=6)	50–63 (57±5)	1.3–6.0 (3.1±1.7)

Note. The data in age show the range [mean±standard deviation (S.D.)]. The data in size also show the range (mean±S.D.).

mass on ultrasonography. The corticomedullary phase is not routinely obtained at our institution because of heightened concern for increased ionizing radiation dose [17]. Although a lack of the corticomedullary phase may limit the evaluation of tumor vascularity and vascular anatomy, whether it is necessary for the characterization of renal tumors remains uncertain, especially to differentiate benign versus malignant renal tumors.

The purpose of this retrospective study is to assess the characterization of RCC and benign renal tumors by unenhanced, nephrographic, and delayed phase CE-CT.

2. Materials and methods

2.1. Patient population

This retrospective study was approved by the institutional review board, and informed consent was waived.

Between 2008 and 2012, a computerized search of the pathology and radiology database at our institution found 109 patients with RCCs that had undergone triple-phase CE CT including precontrast and the venous and delayed phases. Four cases were excluded because the tumors consisted of mixed components of RCC subtypes (mixed clear cell and papillary or chromophobe RCCs). Three cases were excluded because of rare histologic subtypes including mucinous tubular and spindle cell RCC (n=1) and unclassified RCC (n=2). For multifocal RCCs (n=9), the largest lesion was evaluated. Therefore, 102 patients with 102 RCCs were recruited. There were 79 clear cell RCCs, 17 papillary RCCs, and 6 chromophobe RCCs.

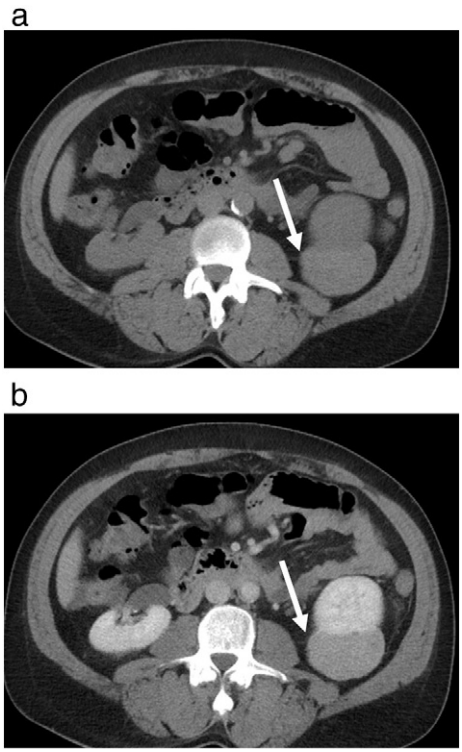

Fig. 1. A 51-year-old man with lipid-poor AML. (a) The axial unenhanced CT shows an exophytic mass in the left kidney (arrow). The mass is high attenuation relative to the normal renal parenchyma. (b) The nephrographic phase shows the mass to be homogeneous with moderate enhancement (arrow).

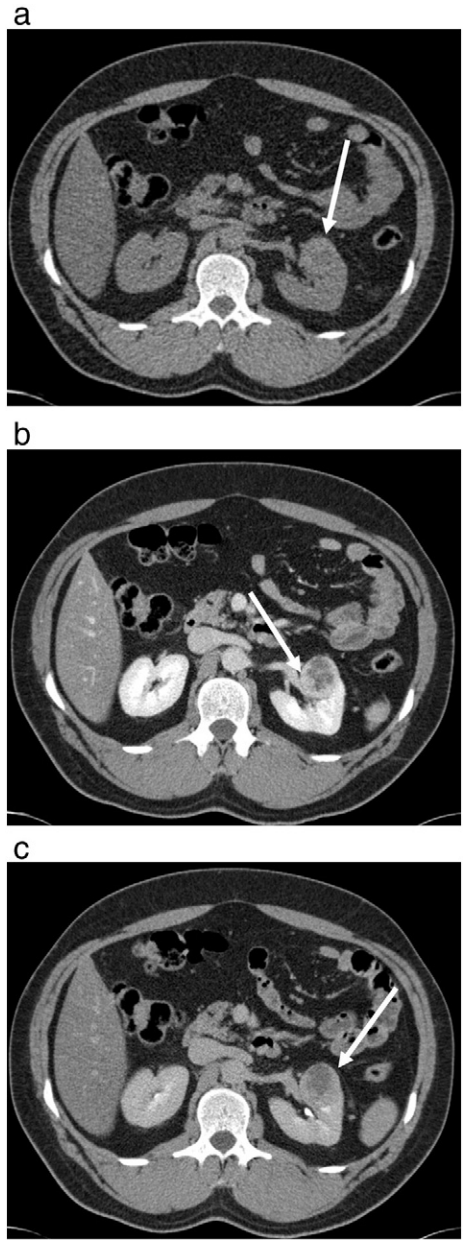

Fig. 2. A 37-year-old man with clear cell RCC. (a) Unenhanced axial CT shows a mixed high and low attenuation mass in the left kidney (arrow). (b) The nephrographic phase demonstrates a heterogeneously enhancing mass (arrow). The degree of enhancement is nearly similar to the renal cortex. (c) The delayed phase shows the mass to be heterogeneous (arrow).

Between 2003 and 2012, triple-phase CE-CT was performed for 21 histologically proven oncocytomas and 10 histologically proven angiomyoplipomas. To focus on lipid-poor AML, four cases were excluded because a small portion of macroscopic fat [<−20 Hounsfield unit (HU)] was present on precontrast CT, in retrospect. Therefore, there were six lipid-poor AMLs.

Overall, the study group consisted of 129 patients with 79 clear cell RCCs, 17 papillary RCCs, 6 chromophobe RCCs, 21 oncocytomas, and 6 lipid-poor AMLs. The profiles of the patients and renal tumors are summarized in Table 1.