Clinical Imaging 51 (2018) 12–22

Contents lists available at ScienceDirect

Clinical Imaging

journal homepage: www.elsevier.com/locate/clinimag

Fat status detection and histotypes differentiation in solid renal masses using Dixon technique

Jun Sun[a,1], Zhaoyu Xing[b,1], Jie Chen[a], Tingting Zha[a], Yunjie Cao[b], Dachuan Zhang[c], Dexing Zeng[d], Wei Xing[a,*]

[a] Department of Radiology, The Third Affiliated Hospital of Soochow University, Changzhou, Jiangsu 213003, China
[b] Department of Urology, The Third Affiliated Hospital of Soochow University, Changzhou, Jiangsu 213003, China
[c] Department of Pathology, The Third Affiliated Hospital of Soochow University, Changzhou, Jiangsu 213003, China
[d] Department of Medicine & Radiology, University of Pittsburgh, Pittsburgh, PA 15219, USA

ARTICLE INFO

Keywords:
Solid renal masses
Fat status
Histotype
Dixon technique

ABSTRACT

Purpose: To detect fat status and differentiate histotypes of renal masses by using Dixon technique.
Materials and methods: This study included 134 solid renal masses. Signal intensity index (SII) and fat fraction (FF) in different histotypes were compared.
Results: Only angiomyolipoma (AML), clear cell renal cell carcinoma (RCC), and papillary RCC were confirmed to contain fat. The FF of 16.8% can effectively differentiate AML from clear cell RCC, so did the SII of 9.2% can differentiate clear cell RCC from non-clear cell RCC and rare benign histotypes.
Conclusion: Dixon technique successfully evaluated the fat status and histotypes of renal masses.

1. Introduction

Solid renal masses are rather common neoplasms occurring in adults that can be classified into benign and malignant histotypes [1–3]. Among benign histotypes, angiomyolipoma (AML) is the most common type, and oncocytoma is relatively uncommon that accounts for 3%–7% of solid renal masses, while leiomyoma is very rare [1,2]. Renal cell carcinoma (RCC) is the most common malignant histotype and accounts for > 90% of all renal malignancies, specifically composed of clear cell RCC and non-clear cell RCC [4]. Clear cell RCC is the most common adult RCC, representing 70% of all RCCs [4]. Non-clear cell RCC include papillary RCC accounting for 10%–15%, chromophobe RCC accounting for 4%–6%, and relatively rare mucinous tubular and spindle cell carcinoma (MTSCC) accounting for < 1% of all RCCs [4,5].

Originally, fat was considered as a unique feature for AML in all solid renal masses [6,7]. However, recent studies [6–8] suggested that fat could also be observed in clear cell RCC. In addition, papillary RCC, the most common non-clear cell RCC, has also been reported to contain fat [8–10]. Additionally, other rare histotypes of solid renal masses, such as oncocytoma and chromophobe RCC, were sporadically reported to probably contain little fat [6,8]. Therefore, it is necessary to systematically detect the fat status in all solid renal masses.

As it is well known, therapeutic methods of benign solid renal masses are completely different from that of the malignancies. Even for malignant solid renal masses, their surgical treatment, immunotherapy, and targeted therapies are not identical [11,12]. For example, clear cell RCC with more aggressive behavior has a less favorable prognosis and demands more aggressive therapeutic strategies (such as radical nephrectomy), whereas non-clear cell RCC such as papillary RCC and chromophobe RCC can be managed with nephron-sparing surgery [3,4]. It is highly desirable to differentiate the histotypes of solid renal masses.

Dixon technique, firstly published in 1984, is a novel method that is able to separate water and fat on MR imaging [13,14]. This technique acquires two separate images by using a three-dimension (3D) dual-echo gradient-recalled echo (GRE) sequence [13,15]. One is a conventional image with water and fat signals in-phase (IP) and the other image is acquired with the readout gradient slightly shifted so that the water and fat signals are 180° opposed-phase (OP) [14]. Through processing the simple summation and subtraction of the two separate images can respectively generated a fat-only (FO) image and a water-only (WO) image, without adding data acquisition time [14,15]. So far, Dixon technique has been applied successfully in the evaluation of fat content within liver, renal AML, and adrenal lesion [15–17]. The purpose of this study is to detect fat status and differentiate histotypes of solid renal masses by using Dixon technique.

* Corresponding author.
E-mail address: suzhxingwei@sina.cn (W. Xing).
[1] These authors contributed equally to this work.

https://doi.org/10.1016/j.clinimag.2018.01.012
Received 19 September 2017; Received in revised form 20 January 2018; Accepted 23 January 2018

Table 1
Demographic data in and clinical characteristics of 134 patients

Histotype	n	Gender (n)		Age (years)		Tumor size (cm)	
		Male	Female	Median	Range	Median	Range
Angiomyolipoma	26	8	18	42	26–75	2.8	1.4–9.5
Rare benign histotypes	7	3	4	47	42–53	3.7	2.8–6.4
Oncocytoma	5	2	3	47	42–53	3.7	3.5–6.4
Leiomyoma	2	1	1	48	45–51	3.1	2.8–3.3
Clear cell RCC	65	41	24	61	29–78	4.4	1.3–12.6
Non-clear cell RCC	36	19	17	55	27–77	4.5	1.4–9.6
Papillary RCC	17	10	7	52	27–72	4.3	1.5–9.6
Chromophobe RCC	12	6	6	54	42–75	5.3	1.4–8.1
MTSCC	7	3	4	57	49–77	4.3	3.0–7.4

Note: RCC = renal cell carcinoma, MTSCC = mucinous tubular and spindle cell carcinoma.

2. Materials and methods

2.1. Patients

The local ethics committee approved this retrospective study and waived the informed consent requirement. All research procedures were conducted in accordance with the Declaration of Helsinki.

A total of 149 consecutive patients who underwent MR examination for the evaluations of renal masses between April 2011 and August 2016 were reviewed. Fifteen cases were excluded due to complicated cyst (n = 7), cystic RCC (n = 4), and unavailability of images (n = 4). Finally, 134 patients [71 male and 63 female; age median (range), 57 (26–78) years; tumor size median (range), 4.2 (1.4–12.6) cm] were included in our study. The histotypes and clinical characteristics of 134 patients are shown in Table 1.

2.2. MRI

All patients successively underwent conventional MRI, Dixon technique, and dynamic contrast-enhanced MRI (DCE-MRI). The scan range covered the area from the upper pole to the lower pole of the affected kidneys, particularly covering the renal masses. All the MRI images were acquired on a 3T MRI scanner (Magnetom Verio, Siemens Healthcare, Erlangen, Germany) with a standard 12-channel body matrix-coil.

The protocols of conventional MRI, Dixon technique, and DCE-MRI were provided in Table 2. The Dixon technique utilized a region-growing phase-correction step to achieve decomposition of water and fat signal and generate four separate image sets: IP, OP, WO, and FO images [15,16]. DCE-MRI was performed before and after intravenous administration of 0.1 mmol of gadopentetate dimeglumine (Magnevist; Bayer Healthcare, Germany) per kilogram of body weight. Gadopentetate dimeglumine was injected at a rate of 2.0 mL/s followed by a 15 mL saline flush at the same flow rate using a power injector (Optistar LF; Liebel-Flarsheim Company, USA). The first and second post-contrast scan started at 35–45 and 70–80 s after the beginning of contrast injection, respectively.

2.3. Imaging analysis

Two genitourinary radiologists with > 10 years' diagnostic experience analyzed all the MRI images on a commercially available workstation (Syngo Workplace, Siemens Healthcare) and they were blinded to all tumorous histotypes. In ambiguous cases, both reviewers reached a consensus in their decision.

For masses analysis, the corresponding IP, OP, FO, and WO images were displayed simultaneously on the screens of the workstation. The signal intensity measurements for each mass were obtained by placing an appropriate region of interest (ROI) on IP, OP, FO, and WO images at the same level with the kidney and the same location within the mass.

On IP image, a ROI was placed as large as possible at the level of the mass's greatest axial diameter, avoiding the mass margin. Meanwhile, contrasting with transverse T2-weighted, T1-weighted, and DCE-MRI images, regions of apparent necrosis, hemorrhage, and calcification were excluded from the ROI measurement. Necrosis was defined as areas of hypointense on T1-weighted, hyperintense on T2-weighted, and no enhancement on DCE-MRI images. Hemorrhage was defined as areas of hyperintense on T1-weighted and hypointense or hyperintense on T2-weighted, or hypointense on both T1-weighted and T2-weighted. Calcification was defined as areas of decreased signal intensity on IP images relative to the corresponding OP image or significant hyperintense on IP images [15].

By applying the copy and paste function of the workstation, the ROI on IP image was copied to the OP, FO, and WO images. The location, size and area of ROIs were kept constant among the four separate image sets: IP, OP, FO, and WO images. The signal intensity value of each ROI was recorded.

To minimize the error, all measurements were repeated once every other week. The measurements were conducted three times in total. The mean signal intensity values of triple measurements for each ROI were used to calculate two quantitative metrics: signal intensity index (SII) and fat fraction (FF) [15,16]. SII was calculated as follows: $[(SI_{IP} - SI_{OP}) / SI_{IP}] \times 100\%$, where SI_{IP} is mass signal intensity on IP images and SI_{OP} is mass signal intensity on OP images [15,16]. FF was

Table 2
Sequences and parameters for sample renal MRI protocols

Parameters	Conventional MRI			Dixon Technique	DCE-MRI
	T2-weighted HASTE	T2-weighted HASTE	T1-weighted GRE	T1-weighted dual-echo spoiled GRE	T1-weighted GRE
Orientation of plane	Coronal	Transverse	Transverse	Transverse	Transverse
Acquisition type	2D	2D	2D	3D	3D
Repetition time (ms)	1400	1800	161	5.470	3.92
Echo time (ms)	91	96	2.5	3.675 (IP), 2.450 (OP)	1.39
Field of view (mm)	380 × 380	285 × 380	285 × 380	296 × 380	308 × 380
Matrix	117 × 256	168 × 320	180 × 320	167 × 320	182 × 320
Slice thickness (mm)	4	5	5	2	3
Inter-slice gap (mm)	1.95	1.0	1.0	0.4	0.375
Flip angle (degrees)	160	150	70	9	9
Bandwidth (Hz/pixel)	781	500	270	500 (IP), 780 (OP)	400
Fat suppression	None	None	None	None	Saturation
Acquisition time (s)	34	39	16	22	51
Physiology control	Breath-hold	Breath-hold	Breath-hold	Breath-hold	Breath-hold

Note: HASTE = half acquisition single-shot turbo spin echo, GRE = gradient-recalled echo, D = dimension, IP = in-phase, OP = opposed-phase.