

# Computed Tomography-guided Core Needle Biopsy for Renal Tumors: A Review

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## Abstract

Small renal tumors are sometimes challenging to diagnose accurately through imaging alone, and image-guided biopsies are performed when histological diagnoses are needed. Although ultrasound guidance is usually chosen for renal tumor biopsies, computed tomography guidance is preferred for selected cases; e.g., obese patients or when the target is undetectable by ultrasound (as those in the upper pole). In the 14 recently published studies covering  $\geq 50$  procedures, computed tomography-guided renal tumor biopsies had a wide range diagnostic yield (67.4%-97.4%). Complications often occurred; however, most were minor and asymptomatic. No biopsy-related deaths and tumor seeding occurred. This study aimed to review the advantages and disadvantages, procedure techniques, diagnostic yields, and complications of core needle biopsies for renal tumors under computed tomography guidance.

**Key words:** Biopsy, Kidney, Computed tomography

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## Introduction

The incidental detection of renal tumors has increased as a result of the widespread use of diagnostic abdominal imaging techniques, such as ultrasound (US) imaging, computed tomography (CT), and magnetic resonance imaging (MRI) [1]. Such incidental lesions include various types of tumors, including both malignant and benign lesions. It is sometimes difficult to correctly diagnose renal tumors except for some benign lesions (e.g., simple cyst and typical angiomyolipoma) through imaging alone. Therefore, image-guided biopsies are performed first when their diagnoses are needed. Although this procedure was previously not preferred because of concerns for the risks of complications, a false-negative diagnosis, and tumor seeding of the biopsy tract, recent studies have attested to safe and effective outcomes following this procedure [2].

Image-guided renal tumor biopsy is usually performed un-

der US guidance; however, recently, they have been performed under CT guidance, including both “conventional CT” and “CT fluoroscopy”, for selected targets. Studies have reported the advantages and disadvantages, techniques, diagnostic yield, and complications of CT-guided core needle biopsy for renal tumors. This study aimed to review the advantages and disadvantages, procedure techniques, diagnostic yields, and complications of CT-guided core needle biopsy for renal tumors.

## Literature Search

Literature searches were performed using PubMed in March 2020 with the following keywords: i) “kidney or renal” and “tumor or mass” and “biopsy” and “CT”, ii) “biopsy” and “renal cell carcinoma” and “angiomyolipoma or oncocytoma”, and iii) “radiofrequency ablation or microwave ablation or cryoablation” and “kidney or renal” and “biopsy”. The search was limited to articles published in

**Table 1. Summary of studies including  $\geq 50$  CT-guided core biopsies**

Author (reference number)/ Year	Tumor number	Procedure number	Guided modality	Tumor diameter (cm)	Needle gauge	Core number
Iguchi (3)/ 2018	208	217 (208 initial and 9 repeat)	217 CTF	mean, 2.3 range, 0.9–8.5	18G (159)/ 20G (56)/ both (2)	mean, 3.1 range, 1–10
Tsang Mui Chung MS (4)/ 2018	317	317	317 CTF	mean, 2.6 range, 1.0–6.8	20G (275)/ unkonwn (42)	mean, 2.5
Sadat-Khonsari (5)/ 2018	101	101	101 CCT		18G	2
Kim (6)/ 2017	74	74	74 CCT	mean, 2.1	18G	$\geq 3$
Ingels (7)/ 2016	79	79	79 CCT	median, 2.5 range, 1.85–3.2	18G	
Lober (8)/ 2014	463	456	298 CCT/ 158 laparoscopy	*mean, 2.6 range, 0.3–5.5	18G	3
Castle (9)/ 2013	211	211 (including 3 without biopsy)	208 CCT	mean 2.49	18G	$\geq 2$
Lebret (10)/ 2007	106	119	112 CTF/7 CCT	mean, 3.3 range, 1.0-10.0	18G	1–4
Davis (11)/ 2013	276	276	276 CCT (249 core and 276 FNA)		20G	
Schmidbauer (12)/ 2008	78	78	78 CTF (78 core and 44 FNA)	mean, 4 range, 0.8–9	18G	2 or 3
Heilbrun (13)/ 2007	93	93	93 CCT (89 core and 91 FNA)	mean, 2.9	19G or 20G	
Iguchi (14)/ 2017	120	128 (120 initial and 8 repeat)	96 CTF/26 US/6 both	**mean, 2.2 range, 0.9–4.0	***18G (76)/20G (49)/both (3)	mean 3.5 range, 1–12
Seager (15)/ 2018	95	103 (95 initial, 7 repeat, and 1 re-repeat)	64 CTF/39 US	**mean, 2.6 range, 0.9–4.0	***Initial biopsy 18G (72)/20G (18)/unkonwn (5)	
Maturen (16)/ 2007	152	152	76 CCT/76 US	**mean, 4.1 range, 1–13	18G	**up to 4 (mostly 3 or 4)

CT: computed tomography; CTF: CT fluoroscopy; CCT: conventional CT; US: ultrasound; FNA: fine needle aspiration

Including CT and laparoscopy guidance\*, all tumors\*\*, and CT and US guidance\*\*\*

English in the last 15 years (that is, between 2005 and 2019). Consequently, a total of 4973 articles (i.e., i) 2895 articles, ii) 933 articles, and iii) 965 articles) were identified. The list of all the electronically identified literature was then manually examined to identify potentially relevant studies. We included articles with  $\geq 50$  CT-guided core biopsy procedures. The following articles were excluded: i) those including mixed CT guidance and US guidance, and unknown numbers and results of CT guidance only or ii) those including mixed CT-guided core biopsy and CT-guided aspiration, and unknown numbers and results of CT-guided core biopsy only. Additionally, cited references from the selected articles and review articles retrieved in the search were assessed to identify significant manuscripts that were not previously included. Of these, articles that met the inclusion criteria were added to our review. As a result, we identified 14 studies,

which comprised a total of 2065 cases of renal tumors [3-16] (**Table 1**) and evaluated the advantages and disadvantages, procedure techniques, diagnostic yields, and complications of CT-guided core needle biopsy for renal tumors.

## US-guided Biopsy

There are no prospective and randomized controlled trial studies that have compared the diagnostic performance and safety of CT- and US-guided biopsy [15-20]. However, an international consensus panel recommended that US guidance is usually preferable to conventional CT [21]. In one study of 208 CT fluoroscopy-guided biopsies, the authors reported that US guidance was initially attempted; however, CT fluoroscopy guidance was finally used in the following cases: i) when the target was undetectable by US imaging,

ii) when the use of CT fluoroscopy seemed to be safer and/or more reliable, or iii) when the biopsy was performed in the same session as CT fluoroscopy-guided ablation therapy of the target [3].

In a meta-analysis including 56 studies that recruited 5228 patients [22], the diagnostic rate and complications of US-guided renal tumor biopsies were in the range of 87%-100% and 4%-15.3% (hematoma, 4%-15.3%; pain, 4%-5.1%), respectively. US guidance has some advantages, including mobility, ability to provide multiplanar and real-time imaging, no radiation exposure, and lower cost, when compared with conventional CT guidance [17, 23]. Conversely, some renal tumors of the upper pole may be obscured by an aerated lung and/or the rib configuration through US imaging, and obesity can limit US penetration for anterior lesions [21]. In such cases, CT guidance should be selected. Seager et al. reported that upper pole masses were more frequently biopsied under CT guidance (22/27 upper pole under CT guidance vs. 40/68 inter/lower pole under CT guidance; odds ratio, 3.08;  $P = 0.04$ ) [15]. Additionally, under US guidance, some tumors tend to slip from the tip of the needle when punctured, and this is avoided under CT fluoroscopy guidance [12].

### **Advantages and Disadvantages of CT Guidance**

The potential advantages of CT guidance include the following: better resolution and tissue contrast [24], better ability to localize the lesion [24], and excellent visualization of extrarenal structures adjacent to the renal tumor, such as the vascular elements, the bowels, and the ureter [6, 25]. CT can visualize almost all renal masses, although intravenous contrast material may be needed on rare occasions (e.g., entirely endophytic small renal masses) [4, 17]. In US-guided biopsy, hematomas, which may occur during needle insertion, can obscure the contours of small renal masses when obtaining the biopsy specimen, making it difficult to target these masses accurately [23].

The main disadvantage of CT guidance is radiation exposure. Another disadvantage is that it is sometimes difficult to identify targets on unenhanced CT images. In such a situation, it is possible to detect the target only after intravenous administration of contrast medium [3]. However, the radiation dose and the amount of contrast medium should be as low as possible [6].

Lack of real-time confirmation of the position of the needle tip is another disadvantage of conventional CT-guided biopsies. However, CT fluoroscopy guidance overcomes this disadvantage while keeping the advantages of conventional CT guidance [3]. Since CT fluoroscopy can confirm the target and position of the needle tip in real-time, it allows operators to puncture even small lesions [3].

If there are no CT machines available for the exclusive use of interventional radiology procedures in the institution, it may be challenging to perform CT-guided biopsies when

they are needed owing to clinical scheduling issues in the CT room.

### **Biopsy Procedure**

Biopsies are usually performed with a coaxial system under local anesthesia. According to some reports, biopsies were performed under general anesthesia in the same session as the ablation therapy [8, 9]. The gauge of the needle used varied (18-20 gauge); 18-gauge was the most commonly used [3-16]. A minimum of two cores were usually sampled [3-16].

A biopsy with the coaxial system is performed as follows. After a patient is placed on the CT table, a conventional CT examination is performed to identify the location of the renal tumor and to determine the needle insertion pathway. When a renal tumor is not detected visibly on unenhanced CT images, a contrast medium is administered intravenously to visualize the tumor. The introducer needle is advanced until its tip is in front of the tumor under CT guidance. The biopsy needle then replaces the internal stylet of the introducer needle, followed by obtaining sequential specimens. Immediately after obtaining the specimens, complications are evaluated using conventional CT.

There was no mention of tumors that could not be identified after the use of a contrast medium. In entirely endophytic small renal masses, intravenous administration of a contrast medium was almost always needed to detect the target (in 66/74 lesions, 89.2%) [6]. When a contrast medium cannot be administered to patients because of an allergy and/or renal dysfunction, it may be challenging to perform CT-guided biopsy for renal tumors that are undetectable through unenhanced CT images [3].

As a countermeasure to reduce radiation exposure to the patients, Kim performed renal tumor biopsies using a reduced-dose CT protocol [6]. Diagnostic yield of the biopsy performed with guidance using a reduced-dose CT protocol (mean reference tube current-exposure time setting,  $42.0 \pm 7.5$  mAs; mean dose-length product [DLP],  $152 \pm 63$  mGy  $\times$  cm) was comparable with that of the biopsy performed with a standard-dose CT protocol (mean reference tube current-exposure time setting,  $205.0 \pm 19.0$  mAs; mean DLP,  $574 \pm 232$  mGy  $\times$  cm), without any increase in the complication rate or the procedure duration [6].

An increase in radiation exposure is a major disadvantage of CT fluoroscopy-guided procedures [26]. To ensure that the radiation exposure to the operators is kept as low as possible during CT fluoroscopy-guided renal biopsy, methods such as positioning of the operator from the CT gantry, intermittent use of CT fluoroscopy, use of plastic forceps, and placing a lead apron on the patient are used [3].

### **Diagnostic yield of Biopsy**

Diagnostic yields of biopsies under CT guidance were similar to those under US guidance. No studies have com-

**Table 2. Summary of results including  $\geq 50$  CT-guided core biopsies**

Author (reference number)/ Year	Results of CT-guided core biopsy	Diagnosis of histologic subtype and Fuhrman grading	Complication of CT-guided biopsy	Tumor seeding
Iguchi (3)/ 2018	initial biopsy 189/208 diagnostic (90.9%) 176/189 malignant 13/189 benign	97.1% histologic subtype 82.7% Fuhrman grading	53.9% procedures (117/217) 117 Grade I bleeding 1 Grade I pneumothorax 1 Grade IIIa pneumothorax (with chest tube placement)	none median 13.7 months follow-up
Tsang Mui Chung MS (4)/ 2018	299/317 diagnostic (94.3%) 262/317 malignant or suspicious 30/317 likely benign 7/317 definitely benign			none
Sadat-Khonsari (5)/ 2018	78/101 diagnostic (77.2%)			
Kim (6)/ 2017	71/74 diagnostic (96%)		no grade 2 or higher complications	
Ingels (7)/ 2016	70/79 diagnostic (88.6%) 47/70 malignant 23/70 benign	93% histologic subtype 64% Fuhrman grading	no major complications 2.5% procedures (2/79) 1 Grade II lumbar pain associated with fever 1 Grade II acute bladder retention	none
Lober (8)/ 2014	241/298 diagnostic (80.9%) 184/241 malignant 57/241 benign			
Castle (9)/ 2013	195/211 diagnostic (92.4%) 140/195/malignant 55/195 benign			
Lebret (10)/ 2007	94/119 diagnostic (79.0%) 70/94 malignant 24/94 benign	86% histologic subtype 46% Fuhrman grading	no significant post-biopsy morbidity	none
Davis (11)/ 2013	*212/276 diagnostic (76.8%) 207/212 malignant or potentially malignant			
Schmidbauer (12)/ 2008	76/78 diagnostic (97.4%) 60/76 malignant 16/76 benign	91.2% histologic subtype 75.9% Fuhrman grading	1 marginal pneumothorax, 4 small perirenal hematomas	
Heilbrun (13)/ 2007	60/89 diagnostic (67.4%)		no complication	
Iguchi (14)/ 2017	84/96 diagnostic (87.5%)			
Seager (15)/ 2018	initial biopsy 51/62 diagnostic (82.3%)			
Maturen (16)/ 2007	74/76 diagnostic (97.4%)			none mean 9.7 months follow-up

CT: computed tomography

\* Result with CT-guided 249 core and 276 aspiration

pared the results (e.g., diagnostic yield, safety, the dose of radiation exposure, and procedure time) of renal tumor biopsies under conventional CT guidance to those under CT fluoroscopy guidance. The summary of the results is shown in **Table 2**. Recent studies with  $\geq 50$  CT-guided biopsies show that diagnostic yield varies (ranging from 67.4%-97.4%) [3-16]. When the initial biopsy was a failure, a repeat biopsy was sometimes performed for the renal tumors that were suspected of malignancy [3, 14, 15].

The histological diagnosis of the tumor being malignant was more frequent than that of it being benign, and a majority of the malignant tumors were renal cell carcinomas (RCC). The histological subtype can be easily diagnosed (ranging from 86%-97.1%) [3, 7, 10, 12], and Fuhrman grading was determined in 46%-82.7% cases [3, 7, 10, 12].

Two risk factors of diagnostic failure have been reported, including smaller tumor size ( $\leq 1.5$  cm; odds ratio, 3.750;

95% confidence interval, 1.362-10.326;  $P = 0.011$ ) [3] and low RENAL score (odds ratio, 1.78;  $P = 0.036$ ) [7]. In US guidance, some risk factors for diagnostic failure have been reported, including small tumor size [27], a cystic tumor [27], an upper pole tumor [27], and a tumor in the left kidney [28]. CT guidance may be more appropriate in upper pole tumors and those in the left kidney than US guidance to avoid diagnostic failure.

In the report with the worst result (diagnostic yield, 67.4%) among those we reviewed, Heilbrun et al. suspected three reasons: i) the 20-gauge size of the core biopsy samples, ii) the lesion size, and iii) the order of the procedures [13]. In this study, of the 93 conventional CT biopsies, including 89 core biopsies and 91 aspirations, the operators performed the aspiration first, hence the tissue obtained during the core biopsy might already have been damaged, and therefore might have been more difficult to interpret [13].

## Complications of Biopsies

Complications often occurred; however, most were minor and asymptomatic (**Table 2**). The CT-guided biopsy is considered to be a safe procedure [3, 18] and has associated low morbidity rates; no biopsy-related deaths have occurred. Some authors report that renal biopsies may be or were safely performed as an outpatient procedure [7, 18], and no CT guidance-specific complications were reported. Renal tumors are frequently hypervascular [29], and in both CT- and US-guided renal tumor biopsies, the most common complication was bleeding (e.g., perirenal/subcapsular hematoma and hematuria), which was usually managed through basic observation [18]. In this review, the maximum frequency of bleeding was 53.9% in one study [3]. More perirenal hematomas were noted after CT-guided biopsy; however, this might be because CT was more sensitive to picking up small, post-biopsy hematomas [15]. Other complications, such as pneumothorax, infections, and arteriovenous fistulas, were uncommon. No study clearly assessed the correlation between the needle sizes, the number of cores obtained, tumor location, operator expertise, the rates of post-biopsy bleeding, and other complications.

One reason for the past reluctance to perform percutaneous renal tumor biopsies is the risk of tumor seeding [3]. However, the current consensus is that the risk of tumor seeding is exceedingly rare [21]. In a review published in 1995, Herts and Baker estimated the risk of tumor seeding at 0.01% [30]. In this review, no tumor seeding was reported in any of the studies. However, the follow-up periods (median, 13.7 months [3]; mean, 9.7 months [16]) were not sufficiently long for the course of RCC. Compared with a non-coaxial technique, the use of a coaxial biopsy may be viewed as an aid in preventing tumor seeding [21]. Volpe et al. recommended the use of a coaxial sheath to minimize exposure of tumor cells to surrounding tissues [23].

## Discussion

Renal tumor biopsies will become increasingly crucial because of an increase in the incidental renal masses, percutaneous ablation therapies (such as radiofrequency ablation, microwave ablation, and cryoablation), and treatment with precision medicine based on immunohistochemical and/or molecular information. The use of some other modalities, including US-CT fusion [31], positron emission tomography/CT [32], MRI [33], cone-beam CT [34], and fluoroscopy [35] have been reported for renal tumor biopsies. However, compared to these methods, US- and CT-guided biopsies are more established.

Many studies of renal tumor biopsies have already been published. However, most of them included case reports, results of <50 biopsies, results of US-guided biopsy alone, results of mixed CT- and US-guided biopsies, and results of mixed core biopsies and aspiration. There were not many re-

ports with results of  $\geq 50$  CT-guided core biopsies alone, as shown in **Table 1**.

In conclusion, CT-guided renal tumor biopsy is a safe procedure, and the reported diagnostic yields are wide-ranged. A renal tumor biopsy should be tried under US guidance first; however, CT guidance should be used for selected targets whenever needed.

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