

Computed tomography – and magnetic resonance imaging-based Bosniak Classification of Cystic Renal Masses Version 2019: a comprehensive review and comparison to version 2005

Klasyfikacja zmian torbielowatych nerek według Bosniaka w tomografii komputerowej i rezonansie magnetycznym, wersja z 2019 roku – przegląd piśmiennictwa i porównanie z wersją z 2005 roku

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Słowa kluczowe: zmiany torbielowate w nerkach, klasyfikacja wg Bosniaka wersja 2005, klasyfikacja wg Bosniaka wersja 2019, zgodność między obserwatorami.

Abstract

Cystic renal lesions are common findings on abdominal imaging studies. Bosniak Classification version 2005 and 2019 consists of five categories of cystic masses. The 2019 modification is more detailed and extensive compared to version 2005. The novelties in version 2019 are implementation of diameter values of cystic septa and walls as well as inclusion of magnetic resonance imaging for classification of cystic renal masses. The aim of our study was to review a new proposal for the assessment of renal cysts and review the results of studies which compared diagnostic performance and interobserver agreement of both versions from 2005 and 2019.

Streszczenie

Zmiany torbielowate w nerkach występują często w badaniach obrazowych. Klasyfikacja wg Bosniaka, wersja z 2005 roku i 2019 roku, składa się z pięciu kategorii torbielowatych zmian w nerkach. Modyfikacja klasyfikacji z 2019 roku jest bardziej szczegółowa i dokładniejsza w porównaniu z wersją z 2005 roku. Nowością w wersji z 2019 roku jest ocena grubości przegród i ścian w zmianach, jak również uwzględnienie w klasyfikacji obrazów z rezonansu magnetycznego. Celem pracy jest przeanalizowanie nowej propozycji klasyfikacji mas torbielowatych w nerkach oraz przegląd piśmiennictwa, w którym porównywane są dwie klasyfikacje oraz badana jest zgodność pomiędzy obserwatorami przy użyciu dwóch wersji.

Introduction

The Bosniak Classification of cystic renal masses, introduced in 1986 stratified the probability of malignancy on the basis of imaging characteristics in computed tomography (CT) and guided clinical management [1]. The classification system was based on

several morphological changes in renal cysts: septa formation, wall thickening, including nodal components, calcification in the wall or septa, hyperdense cystic content and contrast enhancement after intravenous contrast injection. The main objective of this classification was to differentiate nonsurgical (category I/II) from surgical cystic masses (category III/IV).

Table 1. Details of the current Bosniak classification of cystic renal masses

Class	Current Bosniak Classification
I	Hairline-thin wall; water attenuation; no septa, calcifications, or solid components; non-enhancing
II	Two types: 1. Few thin septa with or without perceived (not measurable) enhancement; fine calcification or a short segment of slightly thickened calcification in the wall or septa 2. Homogeneously high-attenuating masses ≤ 3 cm that are sharply margined and do not enhance
II F	Two types: 1. Minimally thickened or more than a few thin septa with or without perceived (not measurable) enhancement that may have thick or nodular calcification 2. Intrarenal nonenhancing hyperattenuating renal masses > 3 cm
III	Thickened or irregular walls or septa with measurable enhancement
IV	Soft-tissue components (i.e., nodule(s)) with measurable enhancement

After original description, it became obvious that there were some category II cysts that were slightly more complicated than most category II lesions, but not complicated enough to place them in category III. For that reason, category IIF (F for follow-up) was introduced in 1993. Next refinements were in 2005 and 2019 [2–4]. The most important modifications in version 2019 include the incorporation of magnetic resonance imaging (MRI)-based classification and introduction of detailed measurement of cystic septa and wall thickness, which determines their categorization.

The goals of the update are to reduce interobserver variability and improve ability to predict the likelihood of malignancy in a cystic renal lesion. The most important purpose of the novelties in the classification was to objectify and unify the radiologist's estimate.

The aims of our paper were, first, to discuss and compare the principles of Bosniak classification version 2005 to version 2019 and, second, to summarize the results of published articles investigating diagnostic performance and interobserver agreement of a newly proposed version.

General principles of Bosniak classification (version 2005 vs. version 2019)

Bosniak Classification 2005 evaluates cystic renal lesions in CT and has five categories: I (benign cysts), II (minimally complicated cysts: benign), IIF (requires CT follow-up), III (more complicated cysts; requires surgery, biopsy controversial), IV (malignant lesions, requires surgery) (Table 1).

Categories I and IV lesions are generally simple for interobservers, but categories II, IIF and III are often more problematic and the studies demonstrated high disagreement between readers [5]. Accurate distinction between categories II, IIF and III is very important and crucial for further treatment as type II cyst does not need any follow-up, type IIF requires follow-up and type III cystic mass is treated surgically.

Several studies have highlighted limitations of using this classification, including considerable interobserver variability among readers and a significant proportion of benign lesions among Bosniak type III masses [6, 7].

Therefore, there was a demand among radiologists and urologists for improvement of the Bosniak Classification 2005.

The newly proposed Bosniak Classification 2019 defines a cystic mass as a lesion with less than 25% enhancing components. Similarly to the previous version it also have five categories, but, additionally includes MRI for the assessment of renal cysts. Moreover, the new classification is more precise in the evaluation of walls and septa, due to measurement of their thickness (Figures 1 A–C). Previously used subjective terms, such as “thickened” and “multiple” are now numerically defined and the lesion size have been removed [4, 5] (Table 2).

Comparison of Classification 2005 vs Classification 2019 in individual categories (Table 1) [5]

Bosniak type I masses

Category I is used to describe simple cysts. In Classification version 2005 there are imprecise terms like “hairline thin wall” which were replaced in the 2019 version by “well-defined, thin (≤ 2 mm) smooth wall”. In the latest edition of the Bosniak classification the wall may enhance, which is a difference in comparison to the previous classification. The criteria in MRI are the same as in CT, however signal intensity of fluid in the cyst is compared to CSF (should have similar signal intensity) (Figure 2).

Bosniak type II masses

The prevalence of malignancy in cysts categorized as Bosniak II is approximately 0%.

The Bosniak Classification version 2005 defines the following types of lesions in this category: cysts

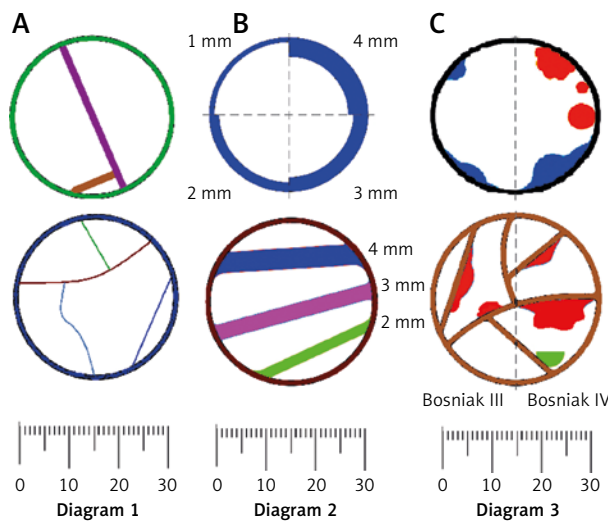


Figure 1. **A** – Bosniak II cyst (top) and IIF cystic mass (bottom) classified on the basis of the number of thin (≤ 2 mm) septa (version 2019). **B** – Bosniak I cyst: smooth and thin (≤ 2 mm) wall, Bosniak II cyst: a smooth and thin (≤ 2 mm) wall and septa, Bosniak IIF cyst: smooth and minimally thickened (3 mm) wall or septa, Bosniak III mass: thickened (≥ 4 mm) enhancing wall or septa (version 2019). **C** – Bosniak III irregular thickening (≤ 3 mm), obtuse margins with wall or septa. Bosniak IV: enhancing convex protrusions that arise from a wall or septa are either nodules; any size if they have acute margins with walls or septa or ≥ 4 mm if they have obtuse margins with the wall or septa (version 2019)

with “few thin septa with or without perceived enhancement; fine calcification or a short segment of slightly thickened calcification in the wall or septa” and “homogenous high-attenuating masses ≤ 3 cm that are sharply margined and do not enhance”. The Bosniak classification 2019 defines that every cyst in this category must have well-defined thin smooth walls with thickness ≤ 2 mm. In the new version, the number of septa is also defined (1–3) (Figure 3). In the new classification, Bosniak type II cyst may have calcifications of any type, whereas in version 2015 cysts with thick or nodular calcifications were defined as IIF (Figures 4 A, B). Both walls and cysts may show contrast enhancement. In version 2019 masses must be homogenous attenuating with precisely described densities at non-contrast CT and at portal venous phase CT. “Homogenous low-attenuating masses that are too small to characterize” are also assigned to Bosniak II category.

The Bosniak Classification, version 2019 includes the following additional entities in MRI: “homogenous masses markedly hyperintense at T2-weighted imaging (similar to CSF) at non-contrast MRI”, “homogenous masses markedly hyperintense at T1-weighted imaging (approximately $\times 2.5$ normal parenchymal signal intensity) at non-contrast MRI”.

Bosniak type II F masses

The percentage of malignancy in this category is about 5% [8].

In 2012, Morton Bosniak suggested that Bosniak IIF cysts with minimal findings need follow-up for only 1–2 years, whereas more complex Bosniak IIF cysts should be followed for a longer period (e.g., 3–4 years or longer) [3].

The Bosniak Classification, version 2005 defines lesions in IIF category using ambiguous terms, such as, “minimally thickened”, “more than a few thin septa”, and “thick and nodular calcification”. In version 2019 these terms were changed and clarified by adding measurements of septa and walls: “smooth minimally thickened (3 mm) enhancing wall of one or more enhancing septa” (Figures 5, 6), “many (≥ 4) smooth thin (≤ 2 mm) enhancing septa” (Figures 7, 8).

In version 2005 the size criterion of homogeneously hyperattenuating and non-enhancing renal masses (with a threshold of 3 cm) was important, however this is no longer valid for the new version 2019. The subjective terms such as “perceived” or “measurable” enhancement from the previous classification were abandoned in a new version and replaced by a simple term of “enhancement”. Enhancement of the cystic renal mass or its part may be determined if the enhancement is unequivocally perceived by the reader, whereas in masses with equivocal appearance on CT images, contrast enhancement may be better perceived on subtracted MR images.

Some cystic masses in this category may be heterogeneously hyperintense at MR unenhanced fat-saturated T1-weighted imaging, usually indicating previous hemorrhage or high-protein content.

Bosniak type III masses

Lesions classified to that category have probability to be malignant of about 50% [9–11].

In 2005 version cysts with thickened irregular or smooth walls or septa with measurable enhancement are classified as type III Bosniak mass. In 2019 version more precise criteria were applied to categorize these lesions: “one or more enhancing thick (≥ 4 mm width) or enhancing irregular (displaying ≤ 3 mm obtusely margined convex protrusions) walls or septa”. They were designed to help radiologists in more accurate and objective classification of cystic lesions detected on CT and MRI.

It is very important to exclude certain lesions from this category, such as, abscesses, post-ablation, post-hemorrhagic and posttraumatic cysts. These lesions may undergo careful follow-up instead of surgical excision.

Bosniak type IV masses

These masses are malignant in approximately 90% [10]. The Bosniak classification 2005 determines

Table 2. Proposed update to the Bosniak classification of cystic renal masses

Class	CT, version 2019	MRI, version 2019
I	Well-defined, thin (≤ 2 mm) smooth wall; homogenous simple fluid (-9 to 20 HU); no septa or calcifications; the wall may enhance	Well-defined, thin (≤ 2 mm) smooth wall; homogenous simple fluid (signal intensity similar to CSF); no septa or calcifications; the wall may enhance
II	Six types, all well-defined with thin (≤ 2 mm) smooth walls: 1. Cystic masses with thin (≤ 2 mm) and few (1-3) septa; septa and wall may enhance; may have calcification of any type 2. Homogeneous hyperattenuating (≥ 70 HU) masses at noncontrast CT 3. Homogeneous nonenhancing masses > 20 HU at renal mass protocol CT, may have calcification of any type 4. Homogeneous masses -9 to 20 HU at noncontrast CT 5. Homogeneous masses 21 to 30 HU at portal venous phase CT 6. Homogeneous low-attenuation masses that are too small to characterize	Three types, all well-defined with thin (≤ 2 mm) smooth walls: 1. Cystic masses with thin (≤ 2 mm) and few (1-3) septa; septa and wall may enhance; may have calcification of any type 2. Homogenous masses markedly hyperintense at T2-weighted imaging (similar to CSF) at noncontrast MRI 3. Homogenous masses markedly hyperintense at T1-weighted imaging (approximately $\times 2.5$ normal parenchymal signal intensity) at noncontrast MRI
II F	Cystic masses with smooth minimally thickened (3 mm) enhancing wall, or smooth minimal thickening (3 mm) of one or more enhancing septa or many (≥ 4) smooth thin (≤ 2 mm) enhancing septa	Two types: 1. Cystic masses with smooth minimally thickened (3 mm) enhancing wall, or smooth minimal thickening (3 mm) of one or more enhancing septa or many (≥ 4) smooth thin (≤ 2) enhancing septa 2. Cystic masses that are heterogeneously hyperintense at unenhanced fat-saturated T1-weighted imaging
III	One or more enhancing thick (≥ 4 mm width) or enhancing irregular (displaying ≤ 3 mm obtusely margined convex protrusion(s)) walls or septa	One or more enhancing thick (≥ 4 mm width) or enhancing irregular (displaying ≤ 3 mm) obtusely margined convex protrusion(s) walls or septa
IV	One or more enhancing nodule(s) (≥ 4 mm convex protrusion with obtuse margins, or a convex protrusion of any size that has acute margins)	One or more enhancing nodule(s) (≥ 4 mm convex protrusion with obtuse margins, or a convex protrusion of any size that has acute margins)

these lesions as having “soft-tissue components, nodules with measurable enhancement”. In version 2019 these lesions are defined more specifically in both CT and MRI as cystic masses with “one or more enhancing nodule(s) (≥ 4 mm convex protrusion with obtuse margins, or a convex protrusion of any size that has acute margins)” [11] (Figure 9).

The differences between both versions are summarized in Table 3.

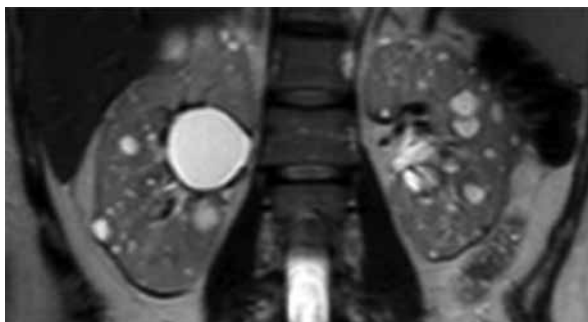


Figure 2. T2-weighted MRI, cystic masses with a thin wall, without septa; Bosniak category I with both original and version 2019 systems

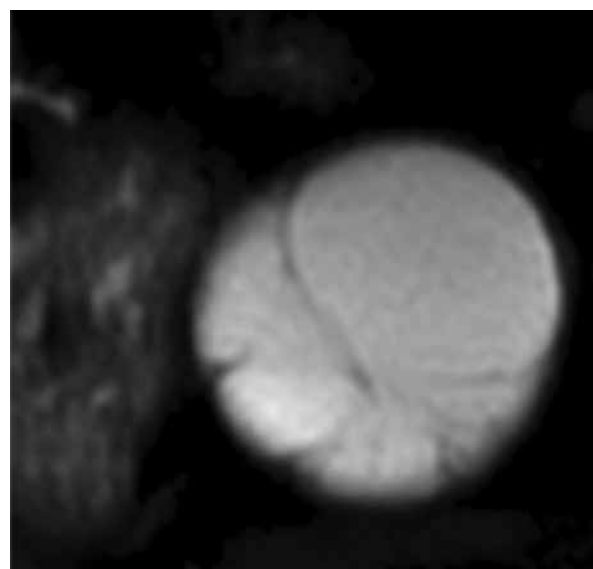


Figure 3. Fat-saturated T2-weighted MR; cystic mass with thin (≤ 2 mm) septa. Bosniak 2015 category II because of few and thin septa. Version 2019 defines many septa to be four or more, the lesion was upgraded to Bosniak category IIF

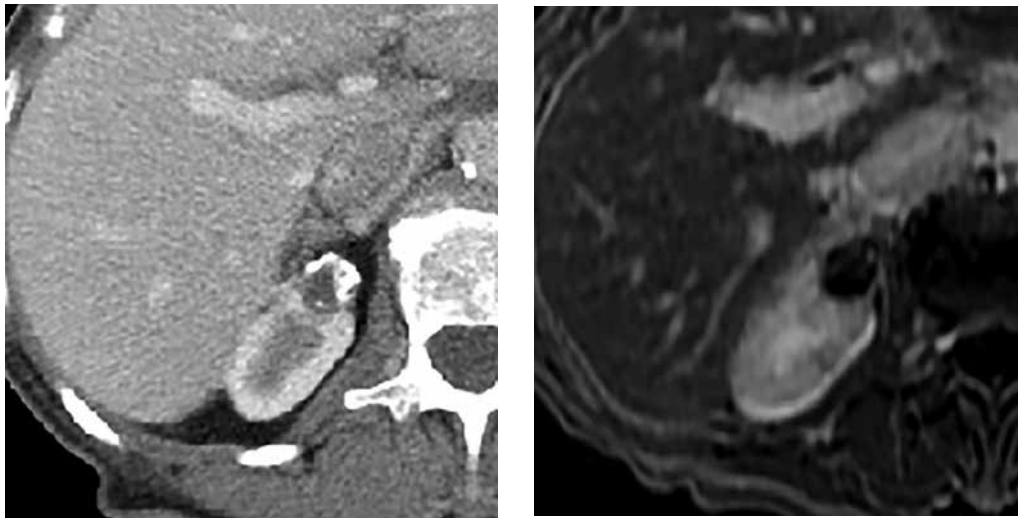


Figure 4. A – Nephrogenic phase CT; nonenhancing mass in thick calcification (B) subtraction T1-image MRI shows few ≤ 3 , thin ≤ 2 mm enhancing septa; Bosniak IIF in 2005 classification (because of calcification), Bosniak II in the update classification 2019

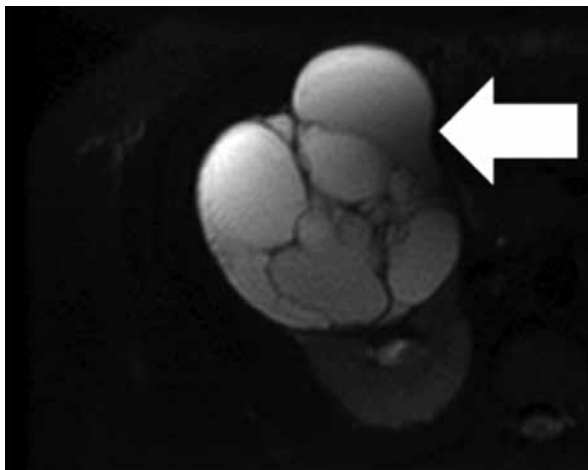


Figure 5. Fat-saturated T2-weighted MR; cystic mass (arrow) was originally classified Bosniak category III on the basis of thickened septa with measurable enhancement. Version 2019 defines thickening of 3 mm, the lesion was downgraded to Bosniak category IIF

Discussion

Accurate categorization of renal cysts using the Bosniak classification can be challenging due to its subjective criteria and variations in observer's experience and perception. To date several studies evaluating the interobserver agreement and diagnostic performance using versions 2005 and 2019, have been published.

Bai *et al.* [12] published a study comparing MRI-based Bosniak classification of cyst renal masses from 2019 to its previous version 2005. In the study, eight readers participated and evaluated 207 cystic renal masses. The interobserver agreement among the read-



Figure 6. Contrast-enhanced fat-saturated T1-weighted MR image; cystic mass (arrow) was originally classified Bosniak category III on the basis of many and thickened septa. Version 2019 defines thickening as at least 3 mm, the lesion was downgraded to Bosniak category IIF

ers was substantial with version 2019 and only moderate with version 2005. The interobserver agreement with version 2019 was significantly higher than that of version 2005.

In the study published by Chan *et al.* [13], three radiologists independently evaluated 65 cystic masses in CT, followed by MRI and assigned Bosniak version 2005 and 2019 in two sessions separated by ≥ 1 month. The result indicated similar to slightly higher agreement between radiologists when they used Bosniak version 2019.

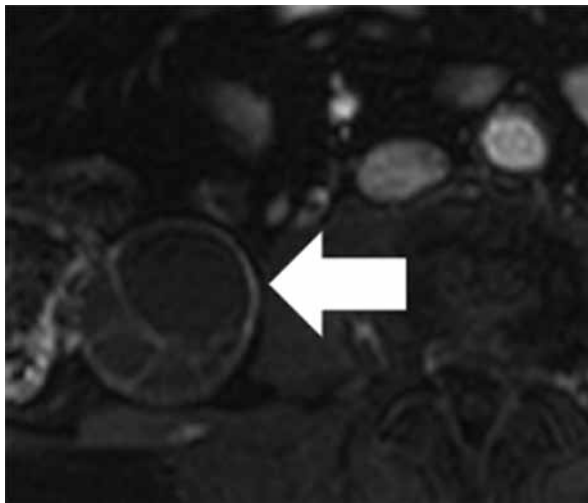


Figure 7. Fat-saturated T1 weighted MRI; cystic mass was originally classified Bosniak category II on the basis of few and thin septa. Version 2019 defines many septa to be four or more, the lesion was upgraded to Bosniak category IIF

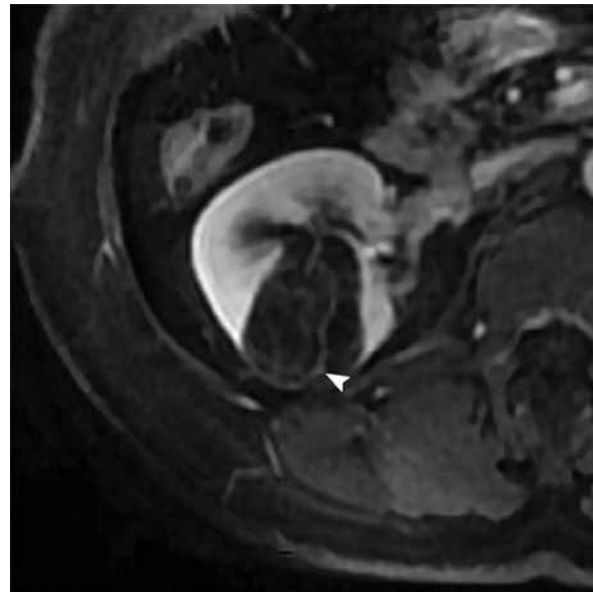


Figure 8. T1-weighted MRI scan; class IIF according to Bosniak 2005 because of more than a few septa and class IIF according to Bosniak 2019 because of the irregular enhancing septa also as class IIF

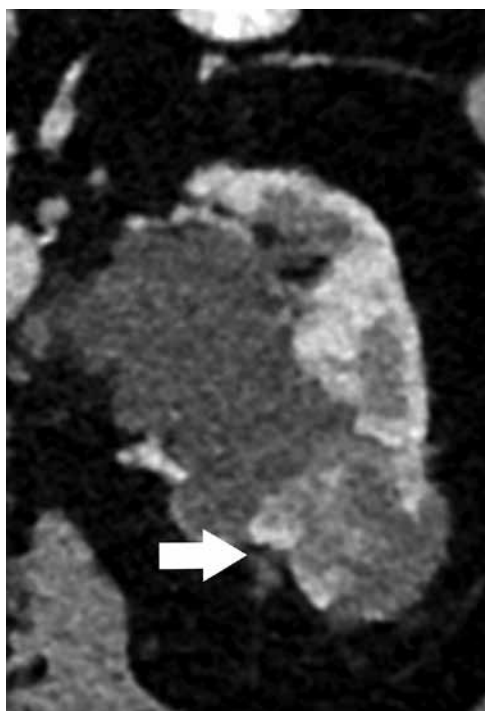


Figure 9. Nephrogenic phase CT; cystic mass with enhancing nodules; Bosniak category IV with both original and version 2019 systems

Tse *et al.* [14] conducted studies with three abdominal radiologists. The observers retrospectively reviewed 68 consecutive cystic renal masses. Overall interobserver agreement was substantial for both CT and MRI using version 2019 and was slightly higher than that of the original system for CT.

Yan *et al.* [15] selected 73 cystic masses and three radiologists evaluated them. Interobserver agreement was slightly improved comparing version 2019 to the original Bosniak classification. Authors concluded that the Bosniak classification version 2019 may categorize a higher proportion of malignant masses in class IIF.

In another study, which was also performed by Tse *et al.* [16], two abdominal radiologists analyzed 50 cystic renal mass in MR images. The results demonstrated moderate agreement for both the original system and version 2019.

The study conducted by Park *et al.* [17] analyzed agreement using CT and MRI. The assessment was done by two radiologists who categorized 104 cystic renal masses according to both versions of Bosniak classification from 2005 and 2019. The result indicated that interobserver agreement is similar between versions.

The results of a study published by Pacheco *et al.* [18] were based on the evaluation done by eighteen non-subspecialized readers who categorized 50 renal cystic masses in CT and MRI. The assessment with Bosniak classification version 2019, compared to version 2005, did not improve interobserver agreement.

Conclusions

Observation and treatment of patients with cystic renal masses depend on the correct categorization of renal cysts according to the most commonly used Bosniak classification. Modifications of the classification in 1993 and 2005 led to improvement in the quality of radiologist's assessment and agreement between

Table 3. The differences between both versions

Class	Version 2005 (CT)	Version 2019 (CT, MRI)
I	<ul style="list-style-type: none"> Hairline-thin wall Water attenuation Nonenhancing wall 	<ul style="list-style-type: none"> Well-defined, thin (≤ 2 mm) smooth wall CT: <ul style="list-style-type: none"> Homogenous simple fluid (-9 to 20 HU) MR: <ul style="list-style-type: none"> Homogenous simple fluid (signal intensity similar to CSF) The wall may enhance
II	<ul style="list-style-type: none"> Few thin septa Septa without perceived (not measurable) enhancement Fine calcification or a short segment of slightly thickened calcification in the wall or septa High-attenuating masses ≤ 3 cm and do not enhance 	<ul style="list-style-type: none"> Thin (≤ 2 mm) and few (1-3) septa Septa and wall may enhance Septa and wall may have calcification of any type Homogeneous, any size masses: <ul style="list-style-type: none"> CT: <ul style="list-style-type: none"> Hyperattenuating (≥ 70 HU) at noncontrast CT Nonenhancing > 20 HU at renal mass protocol CT -9 to 20 HU at noncontrast CT 21 to 30 HU at portal venous phase CT Too small to characterize MRI: <ul style="list-style-type: none"> Markedly hyperintense at T2-weighted imaging (similar to CSF) at noncontrast Markedly hyperintense at T1-weighted imaging (approximately $\times 2.5$ normal parenchymal signal intensity) at noncontrast
IIF	<ul style="list-style-type: none"> Minimally thickened or more than a few thin septa Size criterion > 3 cm 	<ul style="list-style-type: none"> CT: <ul style="list-style-type: none"> Smooth minimal thickening (3 mm) of one or more enhancing septa or many (4) smooth thin (≤ 2 mm) enhancing septa MRI: <ul style="list-style-type: none"> Cystic masses that are heterogeneously hyperintense at unenhanced fat-saturated T1-weighted imaging Without size criterion
III	<ul style="list-style-type: none"> Thickened or irregular walls or septa with measurable enhancement 	<ul style="list-style-type: none"> One or more enhancing thick (≥ 4 mm width) or enhancing irregular (displaying ≤ 3 mm obtusely margined convex protrusion(s)) walls or septa
IV	<ul style="list-style-type: none"> Soft-tissue components (i.e., nodule(s)) with measurable enhancement 	<ul style="list-style-type: none"> One or more enhancing nodule(s) (≥ 4 mm convex protrusion with obtuse margins, or a convex protrusion of any size that has acute margins)

readers. However, the conclusion from several already published studies is not straightforward, the results of the majority of them indicate that the Bosniak Classification 2019 compared to the classification from 2005 is more accurate and objective due to incorporation of detailed measurement values of septa and walls of renal cysts. Moreover, it enables similar evaluation of cystic renal masses in MRI. One of important limitations of the new version may be categorization of a higher number of malignant masses in class IIF. Prior to widespread implementation of version 2019 in clinical practice, more studies evaluating its diagnostic performance and reader agreement are needed.

Conflict of interest

The authors declare no conflict of interest.

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