Bosniak classification for complex renal cysts: history and critical analysis*

Classificação de Bosniak para cistos renais complexos: histórico e análise crítica

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Abstract

The Bosniak classification for renal cysts was developed in the late 1980s in an attempt to standardize the description and management of complex cystic renal lesions. Alterations were made to such a classification in the 1990s and, the last one, in 2005. Currently, five categories of cystic renal lesions are defined – namely, I, II, II-F, III and IV –, according to their degree of complexity and likelihood of malignancy. Despite being initially described for computed tomography, this classification has been also utilized with some advantages also for magnetic resonance imaging. The present article reviews the different phases of this classification, its diagnostic efficacy and the most controversial features of its use.

Keywords: Renal cysts; Bosniak; Computed tomography; Magnetic resonance imaging.

INTRODUCTION

With the disseminated use of imaging methods for the investigation of abdominal diseases, the identification of incidental findings whose management is not always easy or consensual has become increasingly common. Complex renal cysts are fully representative of such a situation.

In 1986 Morton Bosniak published a review article in which he suggested a classification and further management of cystic lesions of the kidneys based on findings on contrast-enhanced computed tomography (CT)⁴. The classification was gradually adopted by imaging specialists and urologists, and is currently a reference in the field (Figure 1).

However, in spite of the standardized description that was suggested by Bosniak, there remained a subjective component to the assessment of these lesions, in particular for distinguishing between minimally complex and benign lesions (Bosniak II) whose surgical approach is not mandatory, or complex and possibly malignant cysts (Bosniak III), for which surgical approach is recommended⁵–⁷. In order to address this problem, a few years later Bosniak and his...
collaborators suggested the introduction of a fifth category, called II-F (“F” as follow-up), in his classification\(^6\text{–}^8\). The classification would undergo another small change in 2005\(^9\), reaching its current format\(^10\), which is shown in Table 1. According to the current classification, lesions in category I correspond to simple cysts without septa or vegetations, with thin and smooth walls, and no contrast enhancement after the administration of intravenous contrast agents (Figure 2A). Category II includes cysts with thin septations, minimally thick walls and fine parietal calcifications, and no contrast enhancement after intravenous contrast agent injection (Figure 2A). Homogeneous hyperdense cysts ≤ 3.0 cm are included in this category. Lesions with irregular and/or thick septa, with course calcifications, and clear enhancement after intravenous contrast injection are described as category III (Figure 2B). Category IV is reserved for lesions with septa or walls with well-defined solid components that demonstrate contrast-enhancement after intravenous contrast injection (Figure 2C). Category II-F corresponds to indeterminate lesions with findings described on Table 1, which, although not sufficient to indicate surgical exploration, suggest a slight risk of malignancy (Figure 3).

### VALIDATION AND CONTROVERSIES

Several studies, most retrospective, have evaluated the effectiveness of the Bosniak classification\(^11\text{–}^13\). A recent meta-analysis that included nine studies with at least 30 cases each\(^14\) showed that the inclusion of the category II-F led to a reduction of the number of cases included in category III and, consequently, to a decrease in the number of surgical exploration of benign lesions. The negative predictive value of categories I and II remained the same\(^16\). The percentage of malignant lesions in category I was 0%, 15.6% for category II, 0% for category II-F, 65.3% for category III, and 91.7% for category IV. The high frequency of malignant lesions in category II was driven by a single study in which two lesions were classified as Bosniak II and one was malignant\(^11\). In another recent study, patients with cysts classified as II-F and III were followed either until proved stable or submitted to surgical resection\(^17\). The frequency of malignant lesions was 25% and 54% for categories II-F and III, respectively. The authors have also observed that previous history of malignant renal neoplasia, and coexistence of malignant solid lesion, Bosniak category IV, or multiple Bosniak III cysts represent risk factors and increase

| Table 1—Imaging findings and Bosniak classification (adapted from references 1, 5, 6 and 9). |
| --- |
| Type | Imaging features without contrast | Contrast enhancement features |
| I | Water density (0–20 HU), thin margins, sharp delineation with the renal parenchyma, thin and smooth walls, homogeneous | No contrast enhancement |
| II | Presence of one or few thin septations, small and fine calcifications; hyperdense cysts measuring up to 3.0 cm (60–70 HU) | No contrast enhancement, or no measurable or perceptible enhancement of septa |
| II-F | More complex lesions which cannot be included in category II or III. Multiple septa. Walls or septa with nodular or irregular calcifications | Absent, dubious or hair-like enhancement |
| | Hyperdense cysts > 3.0 cm or with only 25% of their walls visible (exophytic) | Wall or septum enhancement |
| III | Thick-walled cystic lesion, septum irregularity and heterogeneous septum and wall and/or contents. Gross and irregular calcifications with measurable enhancement | Enhancement of wall and/or solid component(s) |
| IV | Lesions with all the findings of category III, and solid component, soft parts, independent of finding of wall or septa | |

**Figure 2.** A: Categories I and II. Contrast-enhanced, axial CT section demonstrates a cyst with smooth and imperceptible walls, category I, and another with fine calcifications on its walls (arrow), category II, both without perceptible contrast-enhancement. B: Category III. Contrast-enhanced axial CT section demonstrates a cyst with smooth walls and a thin septum with perceptible and measurable enhancement after intravenous contrast injection (arrow). C: Category IV. Contrast-enhanced axial CT section demonstrates a mixed, thick-walled cystic-solid lesion with a solid component in the posterior wall (asterisk) that shows homogeneous enhancement after intravenous contrast injection.
the proportion of malignant lesions in cysts category III. Except for one study, the review of the most relevant articles (n > 30 patients) published until 2012 (Table 2) shows that one should expect a very low frequency of malignancy in category II-F.

The introduction of category II-F has allowed for a more systematic approach to distinguish between categories II and III; however, there remains room for improvements, as findings that define a cyst as II-F are not always clearly noticeable. For example, in addition to being tenuous, the identification of enhancement in hair-like septa is subjective (Figure 3). It is widely known that experience and, mainly, the correlation with surgical exploration and histopathological findings improve the individual performance in the utilization of the Bosniak classification.

The Bosniak classification suggests the necessity of follow-up of lesions classified as II-F, but it does neither establish an interval for imaging repetition nor the total follow-up duration period. This has led to distinctive approaches reported in recent publications[14,15,17]. Bosniak himself recognized that the method is appropriate for his classification[23].

| Study            | I  | II | II-F | III | IV  |
|------------------|----|----|------|-----|-----|
| Siegel et al.[16] | 0/22 | 1/8 | —    | 5/11 | 26/29 |
| Koga et al.[12]  | 0/11 | 1/2 | —    | 10/10 | 12/12 |
| Israel et al.[19] | —   | —  | 0/39 | 2/3  | —   |
| O’Malley et al.[20] | —  | —  | 0/81 | 27/33 | —   |
| Song et al.[15]  | 0/3 | 3/26 | 0/3 | 21/38 | 32/37 |
| Smith et al.[17]  | —  | —  | 4/16 | 58/107 | —   |

Table 2 — Frequency of malignancy in cystic lesions, stratified by Bosniak classification; studies with more than 30 patients.

Figure 3. Bosniak II-F cyst. Contrast-enhanced CT image shows a partially exophytic cyst with a fine septation inside. Subtle nodularity is observed in the septum, which has perceptible but not measurable contrast-enhancement (arrow).

The enhancement of thin septa, described as capillary or hair-like enhancement, is much more conspicuous at MRI than at CT, providing greater confidence in their detection and for denying the absence of contrast-enhancement. This fact, however, is unlikely to change management the vast majority of lesions will be classified within category II, rather than I. Other advantage of MRI is the identification of contrast-enhancement of internal septa within hemorrhagic cysts[25]. The high density of blood hinders the perception of contrast enhancement on CT, but subtraction techniques on MR imaging can bypass this situation (Figure 5).

The use of ultrasound (US) in the Bosniak classification has never been unquestionably accepted, as the detection of neovascularization in malignant lesions, indicated by contrast enhancement of solid components, septa or walls, is a fundamental part of the classification[26,27]. However, it is known that US may demonstrate internal septa better than CT and even MRI. Accordingly, it has been suggested that simple (Bosniak I) and minimally complex (Bosniak II) cysts may be followed with US only[28].

Another potential advantage of US is its capacity of defining the cystic or solid nature of the lesion. In some situ-
ations, the characterization of remarkably hypovascular lesions may be difficult on CT (Figure 6). The papillary renal cell carcinoma is an example of such tumors and its diagnosis may be difficult if the change in density between pre- and post-contrast phases approaches pseudoenhancement values (around 20 HU at 64-channel MDCT, and 10 HU at 16-channel MDCT). In addition to their hypovascular nature, papillary tumors present cystic degeneration with a frequency similar to the clear cell variant.

Although not used to classify renal cystic lesions according to the Bosniak criteria, US can accurately indicate their degree of complexity and is an excellent method for the initial evaluation of patients with renal cystic lesions (Figure 7).

NEW PROSPECTS

Recent studies have demonstrated that the use of intravenous sonographic contrast agent may allow for the detection of enhancement in complex cystic lesions, even in cases of very thin septa (hair-like enhancement), with an accuracy superior to CT. Limitations of such a technique include low reproducibility of the method, US operator dependence, and the cost of the contrast agent four times higher than the value of the iodinated contrast agent, a difference that might increase in cases of multiple cysts requiring repeated contrast injections.

Other techniques have been employed in an attempt to improve the characterization of complex renal cystic lesions. Among them, diffusion-weighted MRI has attracted more attention. The method allows for indirect evaluation of the cellularity of neoplasms, and in complex cystic lesions, restricted diffusion in solid components was shown to have a high positive predictive value for cancer (32,33) (Figure 8).

In summary, the Bosniak classification has allowed for the standardization of the description and management of renal cystic lesions. Initially described for CT, the classification is now used with some advantages with MRI. The introduction of the intermediate category II-F has created conditions to reduce the number benign lesions treated with surgery. Although not utilized to determine the Bosniak classification, ultrasound remains as an excellent method for detecting and defining the complexity of cystic lesions.
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