

THE USE OF CONTRAST ENHANCEMENT IN THE ULTRASOUND DIAGNOSIS OF SIMPLE AND COMPLEX KIDNEY CYSTS

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Abstract

In developed countries, the main methods of research and dynamic monitoring of cystic kidney formations are CT and MRI, but their use is impossible in patients with severe concomitant diseases, as well as in the presence of metal structures, pacemakers, etc. Additionally, taking into account the high dose of radiation exposure when using CT obtained by the patient during dynamic observation, the development of alternative methods is relevant. These include, but not limited to, ultrasound using contrast enhancement, which can be used as an alternative or additional method in primary diagnosis or in the dynamic observation of cystic kidney formations. In the article, the authors provide their own experience with the use of an ultrasound contrast medium for the diagnosis and dynamic observation of complex kidney cysts, as well as the introduction of ultrasound observation using a contrast medium to classify patients according to Bosniak M.A.

The study included the results of the use of contrast enhanced ultrasound (CEUS) in 28 patients with various cystic formations of the kidneys. The patients were previously divided into two groups: the first consisted of 13 patients with simple cysts, the second – 15 with suspected complex cysts. As a result of the study, the patients were distributed as follows: 15 patients were classified as Bosniak type I, 7 patients – as type II, 3 - type III, 3 - type IV. The studied CEUS method is simple and effective. The specificity of the method was 78.57%, the accuracy of the method was 85.71%, the predictive value of the positive result was 81.25%, and the predictive value of the negative result was 91.66%. CEUS helps to quickly and accurately conduct differential diagnosis between a simple cyst and a complex one, as well as classify cysts according to M.A. Bosniak.

Keywords: contrast enhanced ultrasound, CEUS, contrast agent, Bosniak classification.

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ИСПОЛЬЗОВАНИЕ КОНТРАСТНОГО УСИЛЕНИЯ ПРИ УЛЬТРАЗВУКОВОМ ИССЛЕДОВАНИИ ПРОСТЫХ И СЛОЖНЫХ КИСТ ПОЧЕК

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Резюме

В развитых странах основными методами исследования и динамического наблюдения за кистозными образованиями почек являются КТ и МРТ, однако их применение невозможно у пациентов с тяжелыми сопутствующими заболеваниями, а также при наличии в организме металлоконструкций, кардиостимуляторов и т.д. Дополнительно принимая во внимание высокую дозу лучевой нагрузки при использовании КТ, получаемой пациентом при динамическом наблюдении, является актуальной разработка альтернативных методик. К относится ультразвуковое исследование с применением контрастного усиления (КУУЗИ), которое может использоваться как альтернативный или дополнительный метод в первичной диагностике или в динамическом наблюдении кистозных образований почек. В статье авторы приводят собственный опыт применения при ультразвуковом исследовании контрастного препарата для диагностики и динамического наблюдения сложных кист почек, а также внедрения этой технологии для распределения пациентов по классификации M.A. Bosniak.

В основу исследования вошли результаты применения КУУЗИ у 28 пациентов с различными кистозными образованиями почек. Предварительно пациенты были разделены на две группы: первую составили 13 пациентов с простыми кистами, вторую – 15 пациентов с подозрением на сложные кисты. В результате исследования было получено следующее распределение пациентов по М.А. Bosniak: 15 отнесены к I категории, 7 – ко II, 3 – к III, 3 – к IV. Исследуемый метод КУУЗИ отличается простотой и эффективностью. Специфичность метода составила 78,57%, точность метода – 85,71%, прогностичность положительного результата – 81,25%, прогностичность отрицательного результата – 91,66%. КУУЗИ помогает быстро и качественно провести дифференциальную диагностику между простой кистой и сложной, а также классифицировать кисты по М.А. Bosniak.

Ключевые слова: УЗИ с контрастным усилением, контрастный препарат, классификация М.А. Bosniak.

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Introduction

Cystic kidney disease is fairly common, with the occurrence rate in people under the age of 40 from 5% to 20%, and exceeding 30% in patients older than 60 or 70. During ultrasound examination of the kidneys, specialists often encounter complex cysts: they are distinguished by the presence of partitions, calcinates, thick contents, a solid component, as well as thickened walls.

Currently, computer tomography (CT) and magnetic resonance imaging (MRI) are the standard for differential diagnosis of benign and malignant kidney formations. The introduction and use of a contrast agent allows for the visualization of the solid component, the septum, calcinates, and other inclusions that accumulate contrast in cystic formations, which makes it possible to determine which patients require surgery. According to the degree of severity of partitions and their location, cysts are assigned to one of the four main groups in accordance with the classification developed by M. A. Bosniak and adopted in 1986 Kidney cysts classification by M. A. Bosniak [1-3], in its simple version, can be presented as a table (Table 1).

The authors distinguish between 4 categories of kidney cysts based on the presence of multiple partitions, filling with the contrast agent, as well as the presence or absence of calcinates and a solid component [5]. Cysts assigned to group III and IV require surgical treatment since the probability of the presence of a malignant lesion is high, 92% and 100%, respectively [6-9]. When CEUS is performed, these cysts accumulate the contrast agent in the walls, partitions, have a solid contrasting component, or feature all of the above at the same time.

Not so long ago, contrast agents (CA) were introduced to the ultrasound imaging procedure. Contrast-enhanced ultrasound technique (CEUS) is developing. The technology has found intensive application in the diagnosis of heart and liver diseases, and by 2008 recommendations for extrahepatic use of CA were issued [10-12].

The purpose of this research is to determine the diagnostic significance of the use of contrast agent for ultrasound, as well as to evaluate the possibility of using CEUS for the follow-up of simple and complex kidney cysts.

Materials and methods

In the period from 2017 to 2018, we used contrast enhancement ultrasound to examine 28 patients with various cystic kidney formations. In most patients with simple cysts, CEUS was performed in connection with another cancer as the principal disease or in order to confirm the presence of liver metastases. The study included cysts ranging in size from 15 mm to 35 mm. Larger cysts were screened out. Not all patients with the studied cysts were further examined with other diagnostic methods, including CT with contrast enhancement and MRI with contrast enhancement. Contrasting for ultrasound was performed with a SonoVue CA (Bracco Swiss S. A., Switzerland) based on sulfur hexafluoride on a Philips Epiq 7 unit (Philips, Netherlands), with a 1-5 MHz convex transducer. Initially, all patients underwent ultrasound of the kidneys without contrast enhancement, then 2.4 ml of SonoVue was injected into the vein via an ulnar catheter. During the study, a video recording was performed for 3 minutes. After the study, the organ and formations were evaluated both visually and with QLAB software (Philips, Netherlands).

The accumulation of contrast in unchanged kidney tissue and in the walls of cysts was evaluated, special attention being paid to the partitions in the lumen of anechoic formations, as well as to complex cysts, in which blood flow appeared in the modified partitions and walls in the arterial phase.

Results and discussion

During the study, we identified the following conventional groups of patients with the use of contrast enhanced ultrasound diagnostics (Fig. 1).

Таблица 1
 Классификация кистозных образований почки по М.А. Bosniak [4]
Table 1
 Classification of kidney cystic formations according to M.A. Bosniak [4]

Категория по Bosniak Category by Bosniak	Особенности Features	Результат исследования Study results
I	<p>Простая, доброкачественная с тонкой стенкой, не содержит септ, очагов обызвествлений и солидных компонентов. По плотности соответствует воде и не контрастируется.</p> <p>Simple benign with a thin wall, does not contain septa, foci of calcifications or solid components. The density corresponds to water and does not contrast</p>	<p>Доброкачественная киста.</p> <p>Benign cyst</p>
II	<p>Доброкачественная киста, в которой могут быть немногочисленные тонкие септы. В стенке или септах возможны мелкие очаги обызвествления. Гомогенное гипоинтенсивное по сравнению с паренхимой образование диаметром <3 см, с четкими границами, не накапливающее контраст.</p> <p>A benign cyst in which there may be a few thin septa. Small foci of calcification are possible in the wall or septa. Homogeneous hypointense (compared to parenchyma) formation with a diameter of <3 cm, with clear boundaries, without contrast</p>	<p>Доброкачественная киста.</p> <p>Benign cyst</p>
IIIF	<p>В кистах, относящихся к этой категории, может быть больше тонких септ. Возможно незначительное усиление септ и стенки кисты, а также минимальное утолщение их. В кисте могут быть относительно крупные очаги обызвествления, имеющие нодулярную структуру, но не накапливающие контрастное вещество. Мягкотканые элементы, усиливающие сигналы, отсутствуют. К этой категории относятся также расположенные полностью интратенально кистозные образования диаметром ≥3 см, не накапливающие контрастное вещество, имеющие четко очерченные границы и повышенную плотность.</p> <p>The cysts belonging to this category may contain more thin septa. A slight strengthening of the septa and cyst walls, as well as their minimal thickening. The cyst may contain relatively large foci of calcification with a nodular structure, but not accumulating contrast medium. Soft tissue features amplifying the signals are absent. This category also includes fully intrarenal cystic formations with a diameter of ≥3 cm that do not accumulate contrast medium and have clearly defined borders and increased density</p>	<p>Необходимо наблюдение большого.</p> <p>Иногда возможно злокачественное перерождение.</p> <p>Observation is necessary. Malignant degeneration is sometimes possible</p>
III	<p>Кистозные образования с неровными утолщенными стенками или септами, в которых может накапливаться контрастное вещество (контрастное усиление).</p> <p>Cystic formations with uneven thickened walls or septa, in which contrast medium can accumulate (contrast enhancement)</p>	<p>Показано хирургическое лечение или наблюдение в динамике. Более чем в 50% случаев кисты III категории бывают злокачественными.</p> <p>Surgical treatment or observation in dynamics. In more than 50% of cases, category III cysts are malignant</p>
IV	<p>Явно злокачественные кисты, содержащие мягкотканый компонент, для которого характерно контрастное усиление.</p> <p>Obviously malignant cysts containing a soft tissue component, which is characterized by contrast enhancement</p>	<p>Рекомендуется хирургическое удаление. В основном это злокачественные новообразования.</p> <p>Surgical removal is recommended. These are mainly malignant neoplasms</p>

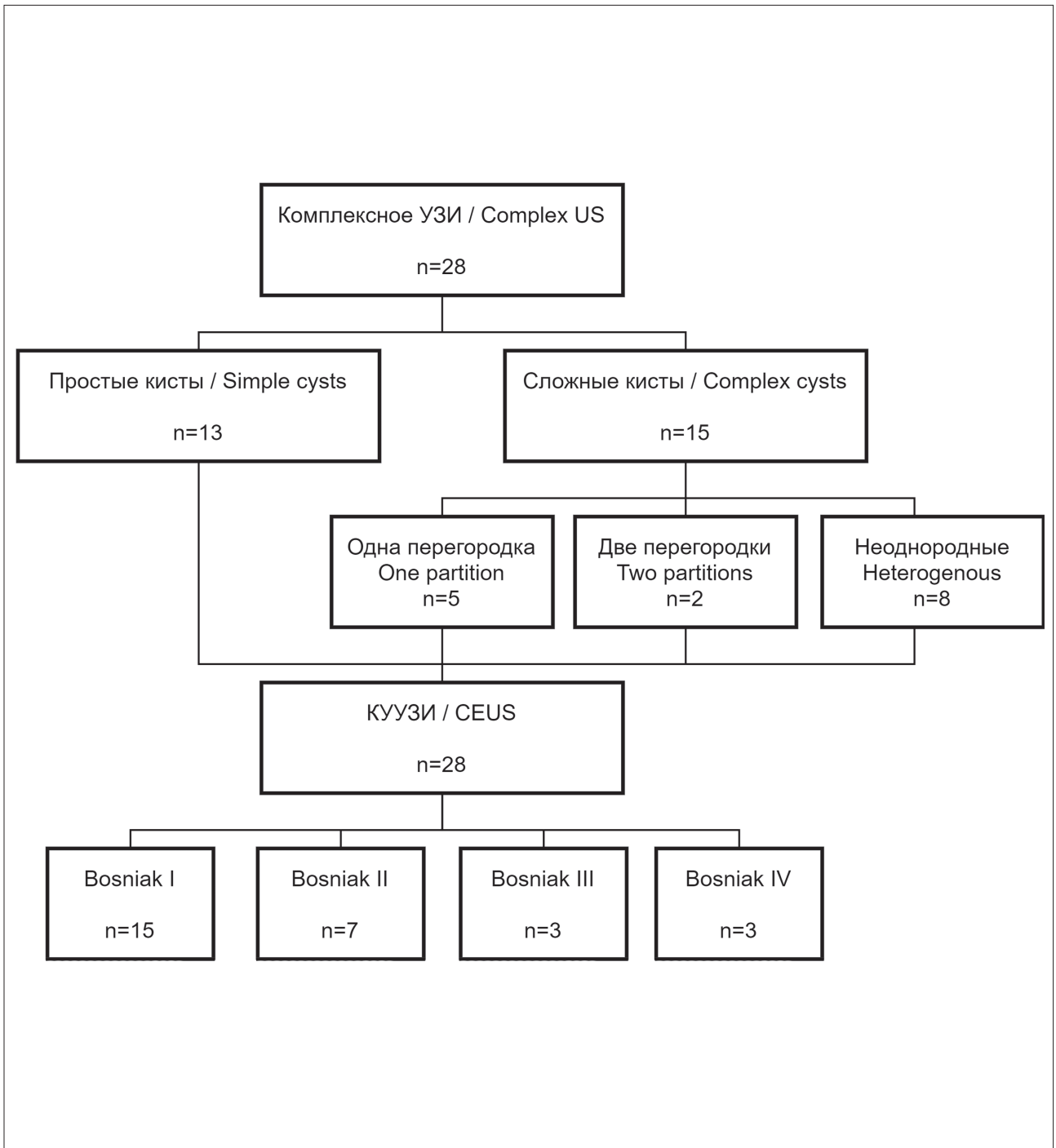


Рис. 1. Группы пациентов с кистами почек до и после КУУЗИ
Fig. 1. Groups of patients with renal cysts before and after CEUS

In the first group, consisting of 13 (46.42%) patients, contrast enhancement was administered primarily for the diagnosis of secondary liver damage. The study unexpectedly revealed some simple cysts in the kidneys. Cysts were visualized as simple thin-walled anechoic formations of a benign nature. They had no partitions. Their contents were determined to be liquid. During CUSI, no

additional inclusions were found in the lumen of the cysts. All 13 patients were classified by us as category I according to the M. A. Bosniak classification.

The second group consisted of 15 (53.58%) patients who, as a result of ultrasound examination in the gray scale and other methods of kidneys examination, were found to have clearly visualized additional

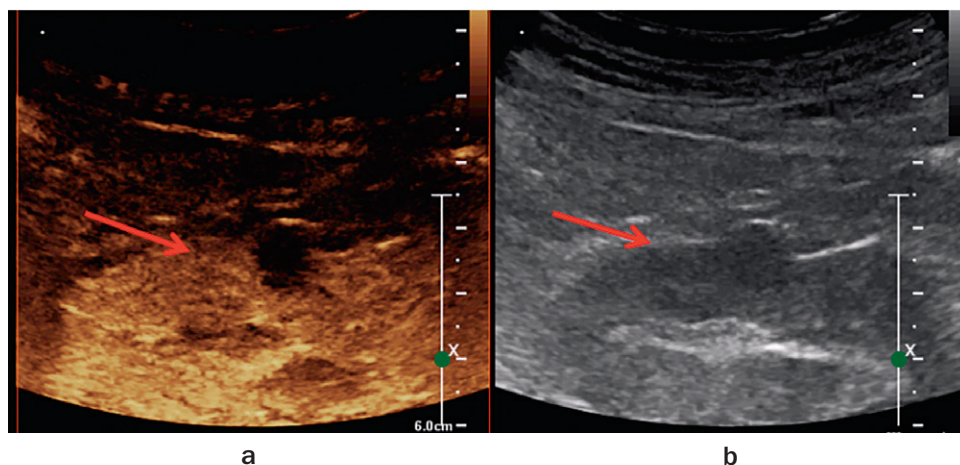


Рис. 2. Контрастирование в артериальную фазу простой кисты

При исследовании в стандартном режиме у пациента заподозрено солидное образование. При использовании контрастного препарата в артериальную фазу визуализировано неконтрастное образование, которое нами было описано как простая киста по классификации Bosniak I

Fig. 2. Left outer surface of the upper limb

When examined in standard mode, a solid formation was suspected. When using a contrast agent, a non-contrast formation is visualized in the arterial phase, which we ascribe as a simple cyst according to the Bosniak I classification

structures in the cyst, or the presence of partitions was suspected.

Among the patients who were suspected of having complex cysts during standard ultrasound, CEUS revealed a thin septum in the cyst in 7 cases. All the formations had clear contours, the partitions did not contrast, 5 patients had one thin partition in their cysts, and 2 patients had two partitions. In the process of CEUS, the partitions did not accumulate contrast, but became clearly visible. We have assessed this phenomenon as “apparent false contrasting”. All these patients with single septa in cysts were classified as Bosniak category II.

Upon the administration of contrast, 3 patients were found to have a complex cyst with multiple partitions, uniformly thickened, partially accumulating the contrast agent. The same result was obtained by CT with contrast enhancement. In one case, the septum featured a calcinate up to 2 mm in size. All 3 patients were assigned to category III according to the M. A. Bosniak classification and assigned rigorous follow-up.

In 5 patients, cysts with thick curved septa and suspected solid components were visualized during a standard ultrasound examination. Among them, in one observation, the cyst was found to have an unevenly thickened capsule up to 3.5 mm in size. We initially considered the capsule to be a tumor change, but it did not display contrast in either the arterial or the venous phase. The patient was observed to have a low-grade fever and moderate pain in the lumbar region on the left. Due to the suspicion of inflammatory changes, surgical treatment was performed. Histological examination of the re-

moved tissue did not reveal a tumor. Based on the results of ultrasound, we initially considered this case as belonging to Bosniak category III. After a negative histological report for the presence of a tumor process was received, the patient was reassigned to category I.

In another observation, a solid formation with a partially thickened capsule was suspected during a standard ultrasound. CEAS visualized a simple cyst that remained contrast-negative throughout the study. This case was considered by us as a simple cyst and classified as I by Bosniak. The patient was assigned for a follow-up (Fig. 2).

In the other three observations, both with a gray scale image and with the introduction of contrast, the formations looked like cystic solid tumors with pronounced contrast in irregular-shaped partitions and the solid inclusions. This group of patients underwent surgery. Histological examination of the surgical material led to the diagnosis of cystic kidney cancer. The patients were classified to category IV by Bosniak (Fig. 3, 4).

As a result of the study, we obtained the following results of the patient distribution in accordance with M. A. Bosniak’s classification: 15 are classified as category I, 7 as category II, 3 as category III, and 3 as category IV (Fig. 1).

As a result of the analysis of the standard mode ultrasound findings, 2 out of the 28 patients examined were suspected of having a cyst with the signs of a complex one. Thus, the sensitivity of the method was 92.85%. During CEUS, contrasting, including false contrasting, was registered in 6 patients. Thus, the specificity of the method was 78,57%, its accuracy 85,71%, positive predictive value: 81.25%, negative predictive value: 91,66%.

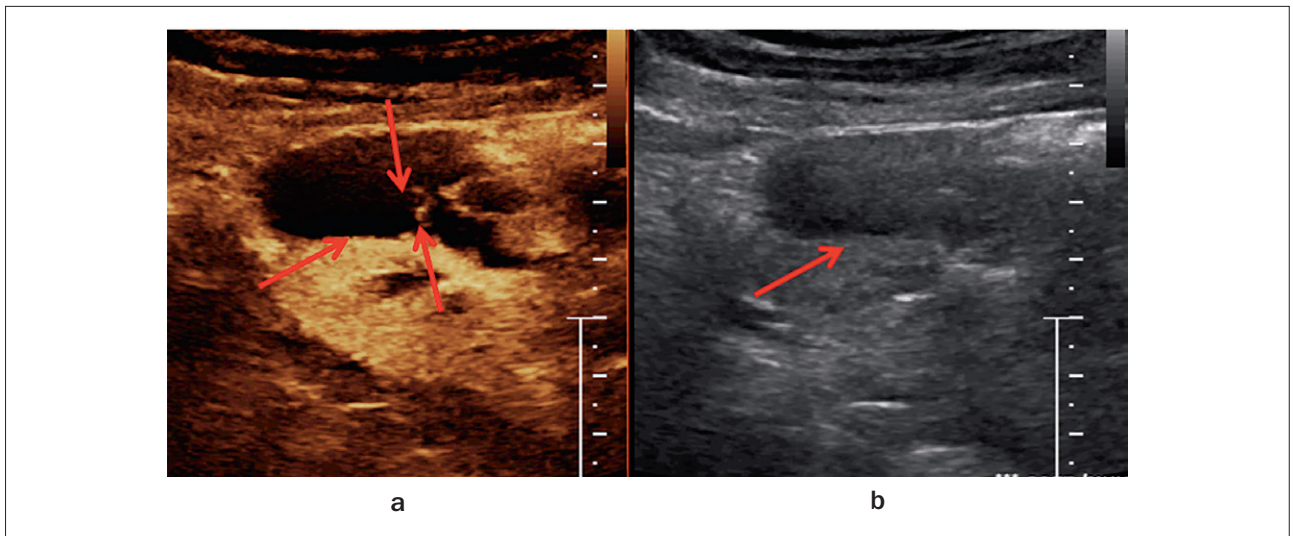


Рис. 3. Контрастирование сложной кисты. Артериальная фаза.

У пациента со сложной кистой и перегородками при многократном КТ исследовании возникло сомнение в постановке стадии по Bosniak. При использовании контрастного препарата SonoVue визуализируется сложная киста с тремя контрастируемыми перегородками. Нами эта сложная киста была расценена как Bosniak IV

Fig. 3. Complex cyst contrast. Arterial phase.

In a patient with a complex cyst and septa, multiple CT scans gave doubts to assigning a Bosniak stage. When using the SonoVue contrast agent, a complex cyst with three contrasting partitions can be seen. We classified this complex cyst as Bosniak IV

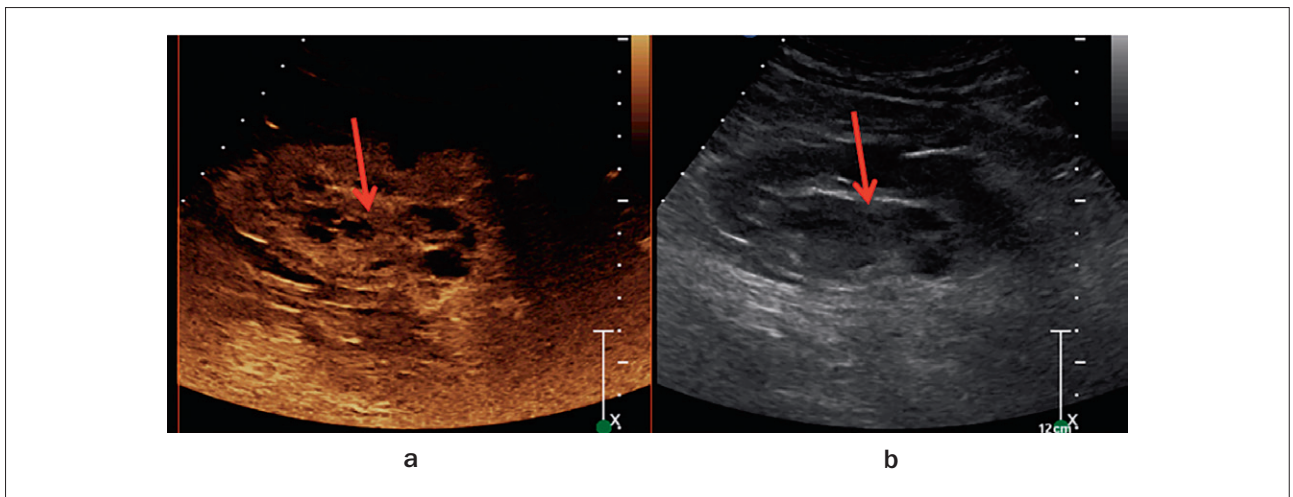


Рис. 4. Контрастирование опухоли почки с кистозным компонентом. Артериальная фаза.

У пациента с опухолью почки дополнительно при УЗИ с применением контрастного препарата визуализирован кистозный компонент с контрастируемыми перегородками.

Fig. 4. Kidney tumor with a cystic component contrast. Arterial phase.

In a patient with a kidney tumor, an additional cystic component with contrasting septa can be seen by using ultrasound with contrasting agent

Conclusion

The results of the study indicate that ultrasound with contrast enhancement can be performed as an additional method of investigation when obtaining questionable results or as a diagnostic tool for follow-up of complex kidney cysts. CEUS allows to identify the kidney cysts walls, which cannot be visualized with ultrasound in stan-

dard mode. The technique helps to conduct a quick and effective differential diagnosis between a solid formation and a usual cyst. According to the accumulation of contrast agent in cysts, patients can be put into categories according to M. A. Bosniak's classification, and the decision is then taken whether to perform surgical treatment or place the patient under dynamic observation.

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