Contribution of contrast-enhanced ultrasound in the assessment of abdominal cystic lesions.

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Learning objectives

- Review the different appearances of cystic abdominal lesions on contrast-enhanced ultrasound (CEUS).

- Illustrate key imaging findings that help in the differentiation between of solid and cystic lesions, malignant and non-malignant or provide a more accurate diagnosis.
Background

The cysts in the solid organs of the abdomen are more common in the liver, pancreas, spleen and kidneys. These cysts may be classified as congenital or acquired types. The congenital cyst may occur associated to congenital cystic diseases (von Hippel-Lindau, autosomal polycystic kidney disease, polycystic liver disease, cystic fibrosis) and acquired cysts are caused by infection or trauma. Collections may also be found in the abdominal and pelvis cavity after surgery. There are some cystic masses that mimic true cysts as abscesses or cystic tumors that must be differentiated and distinguished from simple cysts.

Most of abdominal cystic lesions show a characteristic appearance in ultrasound (US), that do not require complementary techniques for their characterization, but some complex cystic lesions or cystic tumors may present a diagnostic challenge because of non-specific features and need further tests or monitoring in order to determine their origin, components or aggressiveness.
Imaging findings OR Procedure details

One of the most important contributions of the use of CEUS in abdominal pathology is its ability to detect enhancement since this property allows the identification of the cystic or solid components and visualize the vascularity of the internal nodules, septa and cystic wall.

We illustrate examples of abdominal cystic lesions in different areas including liver, spleen, pancreas, renal, mesentery and abdominal cavity, gastrointestinal tract or gynecologic organs. Key findings will be discussed.

LIVER PATHOLOGY

- The most common non neoplastic benign lesions of the liver are simple cysts. They show anechoic content, with smooth borders, thin-walled (1 mm or less) with no septations or mural nodularity. Fig. 1 on page 10

Simple cyst is detected in US, no further imaging studies are required. Cyst content greater than water may be due to hemorrhage or infection. In CEUS, both show internal absence of uptake (intralesional enhancement). The infected cyst can show a peripheral enhancement corresponding to the thick wall. Fig. 2 on page 10

- Biliary cystic neoplasms are suspected with large, uni or multilocular anechoic mass. Cystadenoma are more typically multilocular lesion and cystadenocarcinoma may demonstrate nodularity of margins and mural or septal nodule with diameter > 1 cm. CEUS is useful to demonstrate vascularity of the lesions and mural or nodule enhancement.

- Hepatic pyogenic abscesses may manifest as a single lesion or cluster of small abscesses coalesce into a single large cavity. They may be hypeechoic and ill-defined, sometimes at initial stages look like solid lesions or indeterminate. The lesion will be more defined and the content will be more liquid when the liquefaction process will be occurring. Three patterns of enhancement have been described:

  • type 1, peripheral ring enhancement and absence of enhancement intralesional;
  • type 2, enhancement areas (septa) alternating with liquefied areas (honeycomb appearance);
  • type 3, most of the lesion shows enhancement at arterial phase and subsequent washing out. Fig. 3 on page 11
- **Hydatid cyst** has variable appearances in US: well-defined unilocular or multilocular, numerous peripheral daughter vesicles, cyst with undulating floating membranes, solid pattern or calcification (curved, peripheral or thick). The usefulness of CEUS is to confirm the absence of intralesional enhancement in cases with semisolid appearance or demonstrate membranes or daughters vesicles. **Fig. 4** on page 12

- Other lesions as **cystic metastases** (mucinous carcinoma, neuroendocrine, testicular carcinoma or sarcoma) may mimic a liver abscess and are differentiated in CEUS by enhancement of irregular walls or mural nodularity.

- **Lesions treated with radiofrequency** are seen on US as hypoechoic or anechoic lesions. CEUS allows assessment of any viable tumor component that is seen as hypervascular nodules with subsequent washing localized in the periphery or intralesional. **Fig. 5** on page 13 Besides being a fast and efficient technique, can serve as a guide to direct and complete the treatment.

**PANCREATIC PATHOLOGY**

One of the major benefits of the use of contrast in the pancreas is its ability to differentiate between pseudocysts and cystic tumors:

- **Pseudocysts** are nonvascular, and therefore, show no internal enhancement at all vascular phases, regardless of their internal content in B-mode US **Fig. 6** on page 14. In some cases, arterial macrovessels can be seen through the lesion or the capsule can enhance, findings typically found in the early stages. The accuracy of CEUS to differentiate between pseudocysts and cystic neoplasia is about 100%.

- By contrast, the detection of microvessels or enhancement of septa or nodules is typical of **cystic tumors** **Fig. 7** on page 15 Using surgical pathological findings as the reference standard, there are not significant differences between CEUS and MRI, regarding in the detection of intralesional septa or nodules. However, the use of contrast does not differentiate between benign and malignant tumors.

- **Serous cystoadenoma** typically have a microcystic appearance, which multiple septa. CEUS can improve tumor characterization showing enhancement of septa and typical pattern in honeycomb **Fig. 8** on page 16. When cysts are small, CEUS may suggest a solid lesion because of the enhancement is homogeneous.
- **Mucinous cystadenomas and cystadenocarcinomas** show thick walls and internal nodules that enhance on CEUS, similar to intraductal papillary mucinous tumor of secondary ducts. However, CEUS cannot detect the communication with the pancreatic duct, which is the key for the diagnostic process.

- **Neuroendocrine tumors** are often associated with multiple endocrine neoplasia (MEN). They typically present as hyperenhanced masses on CEUS, but in larger masses they may have cystic degeneration. In these cases, CEUS demonstrates intense and early enhancement of the solid component Fig. 9 on page 17

**SPLENIC PATHOLOGY**

Splenic cystic lesions are usually solitary and include primary or true cysts, acquired or pseudocysts and cystic neoplasms.

- **Congenital cysts** as the epidermoid cyst present incidentally; most of them are unilocular and solitary. They usually have a thin wall and may contain debris, hemorrhage or cholesterol crystals inside. No rim or intracystic enhancement following contrast agent injection.

- **Inflammatory cysts** include hydatid cysts and abscesses. A typical abscess shows absence of enhancement during all vascular phases. However, it can be impossible to differentiate an abscess with an enhancing capsule from a tumour with central necrosis and peripheral enhanced ring.

- In the context of acute trauma, a [pseudoaneurysm](#) is easily demonstrated after contrast administration, because of the intense and persistent enhancement seen from the arterial phase into a cystic lesion Fig. 10 on page 18

- **Cystic lymphangioma** appear as a multilocular lesion with thin septa. CEUS shows a characteristic moderate enhancement of the septa without enhancement of cystic spaces interposed Fig. 11 on page 19 .

- "**Cystic" splenic metastases** can be seen in melanoma, ADK of breast, ovary and endometrium. CEUS can show an irregular enhancement both inside as peripheral, difficult to distinguish from bacterial abscess. Consider the clinical setting.

**RENAral PATHOLOGY**
Kidney cysts are very common (> 50% of patients over age 50 develop cysts). Benign renal cysts can be simple or complex secondary to infection, inflammation or bleeding. They are defined as complex cysts if show internal echogenicity, calcifications, septa, thick-walled or solid nodules.

B-mode US is not reliable to differentiate between benign complex cysts and cystic renal carcinomas (10%).

- The main clinically recognized indication of CEUS in the urinary system is the characterization of renal complex cysts. CEUS has proven to be a useful technique to characterize complex renal cysts according to the Bosniak classification, with similar results to CT or MRI. CEUS detects the presence of enhancement in the thickened irregular wall, septa or mural nodules, which are the most specific signs suggesting malignancy. Furthermore, due to the absence of radiation, CEUS is a useful technique for monitoring lesions managed conservatively.

The classification of cysts by Bosniak is defined with CEUS in this manner:

- **Bosniak I**: thin-walled cyst, anechoic content, without septa, calcifications, or solid components and there are not enhancement after contrast administration.

- **Bosniak II**: cyst with thin septa, thin calcifications in a segment of the wall and may have a minimum enhancement of the septa without nodular enhancement. Fig. 12 on page 20

- **Bosniak III**: containing multiple thin septa, minimum wall thickening, thin or nodular calcifications and can present minimal enhancement of the septa without nodular enhancement. These are lesions that require monitoring.

- **Bosniak III**: irregular thickening of the walls or septa of the cyst with enhancement after contrast administration. Solids poles are not observed. Fig. 13 on page 21 Hemorrhagic or inflammatory complex cysts are included in this category. Fig. 14 on page 22

- **Bosniak IV**: nodule or soft tissue mass with contrast enhancement, regardless of the enhancement of the wall or septa. Fig. 15 on page 23

- In renal inflammatory pathology, the use of sonographic contrast allows identify foci of pyelonephritis and confirm the presence of collections or abscesses, showing the necrotic avascular component and the enhancement of the wall Fig. 16 on page 24

**GYNECOLOGICAL PATHOLOGY**
- **Cystic adnexal lesions** may be classified according to their sonographic appearance as uni or multilocular cystic masses. US features suspicious for malignancy include a large adnexal mass, the presence of solid component, a wall thickness or papillary projection greater than 3 mm and the presence of ascitis and/or peritoneal disease. CEUS is useful in demonstrate presence of vascularity of nodules or internal septations, although there are overlap especially between benign and borderline tumors. Fig. 17 on page 25 Fig. 18 on page 26

- The **uterine cystic lesions** are grouped into endometrial lesions (hematometra, pyometra or submucosal lesions) or myometrial conditions (bicornuate uterus with rudimentary horn, myoma with cystic degeneration or cystic adenomyosis). CEUS may help to define its location and dependence as well as confirm cystic nature. Fig. 19 on page 27 Fig. 20 on page 28

**PATHOLOGY OF THE PERITONEAL CAVITY OR RETROPERITONEAL**

Cystic lesions of the intra or retroperitoneum can be classified as either neoplastic or nonneoplastic. Neoplastic lesions include mesenteric cyst (cystic lymphangioma, cystic teratomas, enteric duplication cyst, cystic mesothelioma), epidermoid cyst, tailgut cyst, pseudomyxoma peritoneal and cystic change in solid neoplasms.

Nonneoplastic lesions include post-surgical collections (lymphocele, urinoma, and hematoma) and abscesses.

- **Post-surgical collections**, both intra or retroperitoneal, include lymphocele, seroma, hematoma, peritoneal inclusion cyst, biloma or urinoma. The antecedent of surgery or trauma is the key for the diagnosis, but some of them may persist over time or can assess with difficulty due to the conditions under which the study is conducted. In the case of trauma is useful for detecting active bleeding. Fig. 21 on page 29

- **Abdominal abscesses** are most commonly secondary to post-operative complication although can be in relation to acute appendicitis, cholecystitis, diverticulitis or Crohn’s disease. CEUS may add information about etiology Fig. 22 on page 30, confirm the nature of collections, define more accurately the size and complexity of echostructure Fig. 23 on page 31, so that assess the need for drainage.

- CEUS is very helpful in differentiating between **phlegmon and abscess**, especially in cases where Doppler color signal is not very accurate within the inflammatory mass. Phlegmons have internal enhancement while abscesses have peripheral enhanced wall,
Fig. 24 on page 32 This is important in patient management, because abscesses may require percutaneous or surgical drainage.

- **Pseudomyxoma peritonei** is seen as ecographic multiseptated peritoneal fluid. Its appearance resembles semisolid component, however on CEUS it is well differentiate because the masses or collections not show contrast enhancement. The origin is the rupture of mucinous tumor of appendix. Appendiceal mucocele is located in the right lower quadrant and manifests in US as well-demarcated cystic lesion, round or ovoid, sometimes with curvilinear calcification in the wall. The CEUS can determine the malignant nature if is identified nodular, thick or irregular wall or the presence of thick septa. Fig. 25 on page 33

-In the evaluation of **cystic tumors** there are many overlapping characteristics among the various types. Overall, the intra-abdominal cystic tumors will require other techniques for characterization. CEUS is useful to determine the solid component of the lesion. Fig. 26 on page 34
**Fig. 1:** Simple hepatic cyst. A) Basal US. A large cyst with thin wall and septa (blue arrow) is showed in the right hepatic lobe. B) After contrast ultrasound there is not enhancement of wall, septa or mural nodules.

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Fig. 2: Infected hepatic cyst. Polycystic liver disease and right upper quadrant pain. A) Axial US, a complex cystic lesion is filled by echogenic material. B) CEUS confirms the absence of enhancement inside the cyst with thick wall enhancement representing inflammatory changes (blue arrows).

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**Fig. 3:** Liver abscess type II. A) Basal US depicts a poorly defined hypoechoic focal lesion in VI segment of the liver. B) CEUS shows liquefied areas with absence of enhancement and hypoechoic septa.

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Fig. 4: Hepatic hydatid cyst. A) Sagittal US, a well-circumscribed lesion with complex echogenic content is showed in the liver parenchyma. B) Arterial phase in CEUS shows enhancement in the peripheral part corresponding to the capsule and absent enhancement within the lesion.

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Fig. 5: Hepatocellular carcinoma treated with radiofrequency. A) The lesion is shown in US as hypoechoic lesion with echogenic nodule eccentric. B) After the injection of ultrasound contrast necrosis of the most part of the tumor with intense peripheral nodular enhancement (blue arrow) is observed, indicating viable tumor.

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Fig. 6: Pancreatic pseudocyst. A) B-mode US in patient with medical history of pancreatitis, show an encapsulated lesion (thick arrows) with echogenic content and anechoic central area (thin arrow) located in pancreatic head. B) CEUS demonstrates absence of enhancement of the content corresponding with pancreatic pseudocyst.

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Fig. 7: Cystic pancreatic tumor. A) Axial US shows a cystic lesion with well defined wall and echogenic content in pancreatic head. B) The presence of enhanced septa and thick wall after contrast administration indicates its tumoral origin. The pathological specimen proved to be a neuroendocrine tumor.

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Fig. 8: Pancreatic serous cystadenoma. A) B-mode US reveals in the body pancreas a lesion formed by multiple peripheral cysts and a central area of solid aspect. CEUS, arterial phase B) and portal phase C) show contrast enhancement of the multiple septa and typical pattern in honeycomb.

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Fig. 9: MEN I. A) Axial US in pancreatic head shows a complex cyst (thick blue arrows). Other cystic lesion with thin wall (thin blue arrows) is seen in the body of pancreas. B) In the early phase after contrast a nodular enhancement of the lesion is defined in pancreatic head (thick yellow arrows) with avascular inner area. The cyst wall shows uptake (thin yellow arrows). The surgical specimen showed cystic lesion in the pancreatic head with solid papillary projections (red arrows) that corresponding to neuroendocrine tumor with cystic degeneration, which is also confirmed in the other pancreas lesion.

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Fig. 10: splenic pseudoaneurysm. A) Sagital US, a rounded and well-defined lesion with hypoechoic content (thick arrow) is recognized in the spleen. A poorly defined area (thin arrow) is seen near that structure. B) Early arterial phase in CEUS reveals a marked contrast enhancement with vascular input corresponding to posttraumatic pseudoaneurysm. Hypovascular areas represent splenic laceration.

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**Fig. 11:** lymphangioma. A) In the lower pole of spleen a poorly demarcated lesion is showed on B-mode US with a heterogeneous solid-cystic appearance. B) Color Doppler US shows the presence of internal vessels. C) In the early phase of CEUS the lesion show a intense contrast enhancement of the wall and internal septa resembling a multiseptated cystic tumor, characteristic of lymphangioma.

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Fig. 12: Bosniak II cyst. A) B-mode US shows a kidney cyst with thick septum (blue arrow) and thin wall. B) CEUS depicts thin septum with enhancement without nodular uptakes.

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Fig. 13: Bosniak cyst type III. A) B-mode ultrasound. Complex cyst with several septa. B) CEUS demonstrates enhancement of the thick and irregular septa and in the wall (blue arrow), without nodular enhancement that corresponds to Bosniak cysts type III. The surgery confirmed a renal cell carcinoma (CCR).

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**Fig. 14**: Bosniak III cyst (Inflammatory cyst). Patient on dialysis for chronic renal failure with left flank pain and urinary sepsis. A) B-mode ultrasound shows a cyst with thickened wall and a nodule inside. B) Post-contrast image demonstrates a homogeneous uptake of the thickened wall of the cyst without septa or solid nodules. C) CT scan confirms contrast enhancement of the wall and the associated inflammatory process (red arrows). D) CT scan two months later shows marked reduction of the cyst. These findings are compatible with inflammatory cyst.

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**Fig. 15**: Bosniak IV cyst. A) B-mode US shows mural nodule in cortical cyst (blue arrow). B) On CEUS is demonstrated nodule enhancement that allows confirming its tumoral nature. Renal cell carcinoma was proven after surgery and histology.

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Fig. 16: Renal abscess. Clinic of left acute pyelonephritis. A) A hypoechoic lesion poorly defined is seen in the interpolar region of the left kidney (blue arrows). B) Axial section of the kidney defines a lesion well delimited by the wall, which therefore is suspected to be an abscess. C) CEUS shows an avascular lesion with wall compatible with renal abscess.

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**Fig. 17:** Ovarian serous cystadenoma  
A) Complex cystic tumor of indeterminate appearance located in right adnexal region.  
B) In early phase is identified a septum with contrast enhancement (thin arrow) and a solid pole that present contrast enhancement in the anterior wall of the lesion (thick arrow).  
C) On CT these components were not demonstrated.

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**Fig. 18:** Endometriotic cyst. Woman with 40 year old with pelvic discomfort. A) Cystic lesion beside to right ovary, component of solid aspect and echogenic content. B) After contrast administration is not identified contrast enhancement of the pseudonodular component or inside the lesion. C) Corresponding CT with iv. contrast showing absence of contrast enhancement. In the pathological piece is shows a cystic lesion of right adnexa showing hemorrhagic content. Were not identified tumors.

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Fig. 19: Uterine myoma with hyaline degeneration. A) Pelvic ultrasound showing cystic lesion of undetermined origin. B) At different times echocontrast illustrates the lesion enhancing heterogeneously with late washout and enhancement of the capsule, located in myometrium. C) The uterine location is confirmed by MRI showing heterogeneous enhancement and hypointensity in T2 related to myoma with hyaline degeneration. The right ovary (not shown) was normal.

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Fig. 20: Cystic adenomyosis of uterus in a 24-year-old woman with dysmenorrhea. A) Basal US shows a hypoechoic lesion (arrows) located in the posterior uterine wall, behind the endometrium (E). B) CEUS at arterial phase and C) at portal phase, demonstrate the cystic nature, with absence of inner enhancement. The lesion initially shows a hypovascular ring (red arrows) and a wall enhancement later (yellow arrows) These findings are probably in relation to the presence of hemosiderin.

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**Fig. 21:** Hematoma with active bleeding. A) Abdominal US in a posttraumatic patient. An echogenic collection is seen in the abdominal wall. B) CEUS shows a snake-shaped jet of contrast within the collection (blue arrow). C) Corresponding CT scan demonstrated an active bleeding.

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**Fig. 22:** Biloma in a gangrenous cholecystitis. A) Axial US, a fluid collection is identified around the gallbladder. Note the internal echogenic content. B) CEUS shows partial absence of the enhancement of the anterior gallbladder wall (blue arrow). In the surgery focal areas of necrosis wall were demonstrated in the gallbladder.

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**Fig. 23:** Acute appendicitis with abscess. A and B) Axial US demonstrate a thick appendix (a) with inflammatory fat (*) and a hypoechoic area in right flank that may correspond with an abscess or phlegmon. C and D) CEUS at different levels, where it is observed the inflammatory changes of appendix (white short arrows) and a avascular well delimited posterior collection (long arrows blue) corresponding to abscess.

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**Fig. 24:** Crohn’s Disease. A) US in right lower quadrant. A thickened ileal segment with several sinus tracts towards the mesentery (short white arrows), where is observed a poorly defined hypoechoic collection. B) CEUS demonstrated enhancement of the most part of the collection corresponding to a phlegmon (blue arrows) and non enhancement in a small area of 10 mm corresponding to small abscess that no required drainage.

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Fig. 25: Appendiceal mucinous cystadenocarcinoma. A) US in the right lower quadrant show a cystic rounded and well defined lesion that presents a heterogeneous content. The tubular end (white arrow) and its location suggest an appendiceal mucocele. B) CEUS shows a thick wall (blue arrow) and C) enhancement of multiple internal septa. Its malignant nature was demonstrated in the surgical specimen.

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**Fig. 26:** Mesenteric sarcoma infiltrating descending colon. A) US in the left quadrant, a hypoechoic lesion with peripheral gas is identified, showing intimate contact with the medial wall of the descending colon (white short arrows) B) CEUS show enhancement only of the peripheral portion of the lesion corresponding to the tumor mass (blue arrows). The surgical specimen demonstrated a mesenteric sarcoma with infiltration of the descending colon.

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Conclusion

CEUS allows a fast and noninvasive differentiation between the benign and malignant nature of cystic lesions into a wide range of situations, based on patterns of enhancement of the wall, the homogeneity, the presence of septa, mural nodules or internal solid components, similar to the assessment made with CT or MRI studies, but with the advantage of its availability and absence of radiation. Thus, CEUS helps to plan patient management and the different therapeutic strategies and may likewise serve as baseline study for injuries that require monitoring.
References


