American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Right Upper Quadrant Pain**

Variant 1: **Fever, elevated white blood cell count (WBC), positive Murphy sign.**

Radiologic Procedure	Rating	Comments	RRL*
US abdomen	9		O
MRI abdomen without and with IV contrast	6		O
Cholescintigraphy	6	Based on US findings, this generally should follow US of the right upper quadrant.	☢ ☢
CT abdomen with IV contrast	6		☢ ☢ ☢
MRI abdomen without IV contrast	4		O
CT abdomen without IV contrast	4		☢ ☢ ☢
CT abdomen without and with IV contrast	3		☢ ☢ ☢ ☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 2: **Suspected acalculous cholecystitis.**

Radiologic Procedure	Rating	Comments	RRL*
US abdomen	8	If gallbladder dilation, wall thickening, or fluid are present, proceed with percutaneous cholecystostomy, as clinically indicated.	O
MRI abdomen without and with IV contrast	6		O
Cholescintigraphy	6	This procedure is used for hospitalized patients, following an equivocal US.	☢ ☢
CT abdomen with IV contrast	6		☢ ☢ ☢
Percutaneous cholecystostomy	6	This can be both diagnostic and therapeutic, particularly with ICU patients. Consider using this procedure for the nonoperative patient or if other causes of sepsis have been excluded. This usually requires imaging first. It is performed only in certain patients (elderly, immunocompromised, etc.).	Varies
MRI abdomen without IV contrast	4		O
CT abdomen without IV contrast	4		☢ ☢ ☢
CT abdomen without and with IV contrast	3		☢ ☢ ☢ ☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition: **Right Upper Quadrant Pain**

Variant 3: **No fever, normal WBC.**

Radiologic Procedure	Rating	Comments	RRL*
US abdomen	9	This is performed to exclude a diagnosis of stones and bile duct obstruction.	O
MRI abdomen without and with IV contrast	6		O
Cholescintigraphy	6	This is performed if US is equivocal.	☢☢
CT abdomen with IV contrast	6		☢☢☢
MRI abdomen without IV contrast	5		O
CT abdomen without IV contrast	3		☢☢☢
CT abdomen without and with IV contrast	3		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 4: **No fever, normal WBC, ultrasound shows only gallstones.**

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen with IV contrast	7		☢☢☢
MRI abdomen without IV contrast	6		O
MRI abdomen without and with IV contrast	6		O
Cholescintigraphy	6	This is performed to exclude other sources of pain from the diagnosis.	☢☢
CT abdomen without IV contrast	3		☢☢☢
CT abdomen without and with IV contrast	3		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition: **Right Upper Quadrant Pain**

Variant 5: **Hospitalized patient with fever, elevated WBC, and positive Murphy sign.**

Radiologic Procedure	Rating	Comments	RRL*
US abdomen	9		O
CT abdomen with IV contrast	7		☢☢☢
MRI abdomen without and with IV contrast	6		O
Cholescintigraphy	6	This is performed if US is inconclusive.	☢☢
Percutaneous cholecystostomy	6	This can be both diagnostic and therapeutic, particularly with ICU patients. Consider using this for the nonoperative patient or if other causes of sepsis have been excluded. This usually requires imaging first. It is performed only in certain patients (elderly, immunocompromised, etc.).	Varies
MRI abdomen without IV contrast	5		O
CT abdomen without IV contrast	4		☢☢☢
CT abdomen without and with IV contrast	3		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Variant 6: **Fever, leukocytosis, pregnant patient.**

Radiologic Procedure	Rating	Comments	RRL*
US abdomen	9		O
MRI abdomen without IV contrast	8		O
MRI abdomen without and with IV contrast	3		O
Cholescintigraphy	3		☢☢
CT abdomen without IV contrast	3		☢☢☢
CT abdomen with IV contrast	3		☢☢☢
CT abdomen without and with IV contrast	1		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

RIGHT UPPER QUADRANT PAIN

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Summary of Literature Review

Introduction/Background

Acute right upper quadrant pain is very common as a presenting symptom in hospital emergency departments and occasionally in patients hospitalized initially for unrelated conditions. This review will focus largely on the diagnostic accuracy of imaging studies performed to evaluate acute cholecystitis (AC), the primary diagnostic concern in the setting of acute right upper quadrant pain.

AC may be life-threatening; therefore, correct, timely diagnosis is essential for proper treatment. However, information derived only from clinical history, physical examination, and routine laboratory tests has not yielded acceptable likelihood ratios sufficient to predict the presence or absence of AC. Also, this information does not yield sufficient diagnostic certainty for making management decisions. Imaging studies, therefore, play a major role in establishing a diagnosis of AC and assessing possible alternate diagnoses, if AC is not present [1].

Radiography of the abdomen is of limited value for evaluating right upper quadrant pain. Although abdominal radiographs performed for initial evaluation may identify gallstones, they are not sufficient for establishing diagnoses of AC. Ultrasound (US) and cholescintigraphy are the imaging studies most often used to diagnose AC. Computed tomography (CT), however, may confirm or refute the diagnosis and reveal complications that are less clearly identified using other imaging modalities. Several studies support the diagnostic potential for magnetic resonance imaging (MRI) in patients with suspected AC; however, its use has yet to be fully assessed.

Ultrasound and Cholescintigraphy

An initial study from 1981 defined the sonographic Murphy sign as focal tenderness corresponding to a sonographically localized gallbladder, which, along with stones, sludge, and gallbladder wall thickening, allowed for separating AC from gallstones alone and chronic cholecystitis with gallstones [2]. Unfortunately, the sonographic Murphy sign has a relatively low specificity for AC [3], and its absence is unreliable as a negative predictor of AC if the patient has received pain medication prior to imaging. Since that initial study, many subsequent studies have been conducted to assess the accuracy of US and cholescintigraphy. The meta-analysis of Shea et al [4] reviewed 22 studies evaluating cholescintigraphy and 5 studies evaluating US published between 1978 and 1990. The authors concluded that cholescintigraphy demonstrated the best sensitivity (97%; 95% confidence interval [CI]: 96%, 98%) and specificity (90%; 95% CI: 86%, 95%) in detecting AC, whereas US had a sensitivity of 88% (95% CI: 74%, 100%) and specificity of 80% (95% CI: 62%, 98%).

A 2012 meta-analysis by Kiewiet et al [5] built on the results of Shea et al [4] and included 40 studies evaluating cholescintigraphy and 26 studies evaluating US published between 1978 and 2010. This analysis confirmed the sensitivity and specificity values noted by Shea et al, with cholescintigraphy at 96% (95% CI: 94%, 97%) and 90% (95% CI: 86%, 93%), respectively. However, Kiewiet et al [5] reported a slightly lower sensitivity for US at 81% (95% CI: 75%, 87%) and slightly higher specificity at 83% (95% CI: 74%, 89%). Similarly, direct comparisons of the diagnostic accuracy of US and cholescintigraphy performed in 11 studies confirmed the superior accuracy of cholescintigraphy.

Although cholescintigraphy is recognized to have a higher sensitivity and specificity, US remains the initial test of choice for imaging patients with suspected AC for a variety of reasons, including greater availability, shorter

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study time, lack of ionizing radiation, morphologic evaluation, confirmation of the presence or absence of gallstones, evaluation of intrahepatic and extrahepatic bile ducts, and identification or exclusion of alternative diagnoses [2,6-8] .

Despite providing information limited to the hepatobiliary tract, cholescintigraphy has been advocated as a useful preoperative modality. Specifically, findings of gallbladder nonvisualization or gallbladder ejection fraction <30% are noted to be useful in predicting the severity of cholecystitis and are associated with a higher complication rate in the setting of laparoscopic cholecystectomy [9]. Ideally, the surgeon or emergency physician, in consultation with the radiologist, should determine the role of scintigraphy in each case [10-14].

Computed Tomography

Although it has not been advocated as a primary imaging examination for acute right upper quadrant pain, CT can confirm or refute the diagnosis of AC in equivocal cases based on US and/or scintigraphy and reveal such complications as gangrene, gas formation, intraluminal hemorrhage, and perforation [6-8,15-19]. Furthermore, CT has been advocated as a useful modality in preoperative planning, with the absence of gallbladder wall enhancement and/or presence of a stone within the infundibulum associated with conversion from laparoscopic to open cholecystectomy. Prior knowledge of these imaging findings may therefore help guide appropriate surgical approach [20].

Clinical conditions that can mimic AC, in terms of presentation with acute right upper quadrant pain, include chronic cholecystitis, peptic ulcer, pancreatitis, gastroenteritis, and bowel obstruction, among others. If US and/or scintigraphy are negative for AC and there is no alternative diagnosis, CT, preferably with intravenous contrast, is the next preferred imaging examination for identifying those disorders. When a diagnosis of AC is not prospectively suspected, CT may also be used to demonstrate AC in patients who have nonspecific abdominal pain.

Magnetic Resonance Imaging

AC can be confirmed or excluded by an abdominal MRI using various protocols, which often include the use of an intravenous gadolinium-based contrast agent. As with CT, MRI is not advocated as a primary imaging examination to evaluate acute right upper quadrant pain; however, several studies have suggested that abdominal MRI is a reliable alternative and can be particularly helpful in the patient who is difficult to examine with US [21-23]. Although factors such as longer acquisition times limit its use in the emergency setting, less interpreter variability and more consistent visualization of the extrahepatic biliary tree are important advantages of its use [24,25]. MRI can be the next best imaging modality when AC is excluded, and it is considered the best modality for evaluating hepatic and biliary abnormalities that are not characterized by US.

Few studies have examined the role of MRI in evaluating AC. Based on the available literature encompassing several small studies, MRI sensitivity estimates range from 50% to 91%, with specificities ranging from 79% to 89%. According to the meta-analysis by Kiewiet et al, the summary sensitivity is 85% (95% CI: 66%, 95%) and specificity is 81% (95% CI: 69%, 90%) [5,23-25], similar to those of US. Additional studies with larger sample sizes are needed to better clarify the role of abdominal MRI in evaluating AC.

Pregnant Patients

As in the general population, US is the imaging test of choice for evaluating AC in pregnant patients. MRI is the preferred test to follow an inconclusive US, as it can be used to evaluate the entire biliary system and diagnose other causes of acute abdominal pain without exposing the patient to ionizing radiation. Magnetic resonance cholangiopancreatography is helpful in identifying patients who require immediate intervention for pancreatic or biliary pathology. It also helps guard against unnecessary endoscopic retrograde cholangiopancreatography by excluding a biliary abnormality, when US findings are equivocal. Note that during pregnancy, intravenous gadolinium is generally not administered, as it is a class III agent in pregnancy [26,27].

Acalculous Cholecystitis

The diagnosis of acute acalculous cholecystitis (AAC) is more problematic than calculous AC. AAC is a serious and potentially lethal condition that mainly affects critically ill patients who frequently have significant comorbidity. It often presents with clinical, radiologic, and laboratory features that are complex and nonspecific. Diagnosis of acalculous cholecystitis, in both hospitalized patients and emergency room patients, is often one of exclusion.

The use of US and/or scintigraphy has been advocated for AAC. The usefulness of US is limited, however, as gallbladder abnormalities are common with US in critically ill patients, with no apparent correlation to clinical or biochemical parameters related to AAC [28,29]. Cholescintigraphy may be a more sensitive diagnostic test, because most cases of AAC are associated with cystic duct obstruction, similar to the calculous form of the disease. Some cases of AAC, however, are related to direct inflammation of the gallbladder, leading to false-negative studies when using cholescintigraphy [30]. It should also be noted that diagnostic specificity is limited with cholescintigraphy, as nonvisualization of the gallbladder is a common imaging finding when no inflammation is present, despite preimaging cholecystokinin administration. CT also has a role in evaluating these critically ill patients [15], although, as with US, the frequent prevalence of nonspecific abnormal imaging findings in the gallbladders of critically ill patients limits its diagnostic value. Nevertheless, when the gallbladder appears completely normal on CT, there is a low probability of any surgical finding in the gallbladder [31]. MRI has not been evaluated sufficiently in AAC and is often impractical, given patient comorbidity.

Laparoscopic cholecystectomy is the definitive treatment for patients with AC [32-34], as its operative mortality is as low as 0.8% in patients who have major risk factors [35]. However, significant morbidity and mortality have been reported among patients who have a high surgical risk [36-40]. Percutaneous cholecystostomy, which can be both diagnostic and therapeutic, is often a safe approach in hospitalized patients suspected of having AAC [41]. Following aspiration of the bile, gallbladder drainage catheter placement may be accomplished immediately, if indicated. This can frequently bridge patients to cholecystectomy at a subsequent time [33,42,43].

Summary

- When AC is suspected in patients who have right upper quadrant pain, the diagnosis should be confirmed or excluded using US and/or cholescintigraphy.
- US is preferred as the initial imaging test, with supplemental cholescintigraphy used in problematic cases, if the latter could potentially alter patient management.
- CT or MRI may be helpful in equivocal cases and used to identify complications of AC.
- If AC is excluded by US and/or scintigraphy, CT or MRI may be appropriate, depending on the clinical scenario.
- MRI is the preferred test for pregnant patients with right upper quadrant pain when US is inconclusive.
- Percutaneous cholecystostomy may be both diagnostic and therapeutic in patients with acalculous cholecystitis.
- These guidelines should allow the radiologist, emergency physician, and surgeon to be confident when choosing an expedient modality or combination of modalities to establish or exclude this important diagnosis.

Safety Considerations in Pregnant Patients

Imaging of the pregnant patient can be challenging, particularly with respect to minimizing radiation exposure and risk. For further information and guidance, see the following ACR documents:

- ACR Practice Guideline for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation
- ACR-ACOG-AIUM Practice Guideline for the Performance of Obstetrical Ultrasound
- ACR Manual on Contrast Media
- ACR Guidance Document for Safe MR Practices

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations		
Relative Radiation Level*	**Adult Effective Dose Estimate Range**	**Pediatric Effective Dose Estimate Range**
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢ ☢	0.1-1 mSv	0.03-0.3 mSv
☢ ☢ ☢	1-10 mSv	0.3-3 mSv
☢ ☢ ☢ ☢	10-30 mSv	3-10 mSv
☢ ☢ ☢ ☢ ☢	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies".		

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

References

1. Trowbridge RL, Rutkowski NK, Shojania KG. Does this patient have acute cholecystitis? *JAMA.* 2003;289(1):80-86.
2. Laing FC, Federle MP, Jeffrey RB, Brown TW. Ultrasonic evaluation of patients with acute right upper quadrant pain. *Radiology.* 1981;140(2):449-455.
3. Bree RL. Further observations on the usefulness of the sonographic Murphy sign in the evaluation of suspected acute cholecystitis. *J Clin Ultrasound.* 1995;23(3):169-172.
4. Shea JA, Berlin JA, Escarce JJ, et al. Revised estimates of diagnostic test sensitivity and specificity in suspected biliary tract disease. *Arch Intern Med.* 1994;154(22):2573-2581.
5. Kiewiet JJ, Leeuwenburgh MM, Bipat S, Bossuyt PM, Stoker J, Boermeester MA. A systematic review and meta-analysis of diagnostic performance of imaging in acute cholecystitis. *Radiology.* 2012;264(3):708-720.
6. Bennett GL, Balthazar EJ. Ultrasound and CT evaluation of emergent gallbladder pathology. *Radiol Clin North Am.* 2003;41(6):1203-1216.
7. Hanbidge AE, Buckler PM, O'Malley ME, Wilson SR. From the RSNA refresher courses: imaging evaluation for acute pain in the right upper quadrant. *Radiographics.* 2004;24(4):1117-1135.
8. Smith EA, Dillman JR, Elsayes KM, Menias CO, Bude RO. Cross-sectional imaging of acute and chronic gallbladder inflammatory disease. *AJR Am J Roentgenol.* 2009;192(1):188-196.
9. Cho JY, Han HS, Yoon YS, Ahn KS, Lee SH, Hwang JH. Hepatobiliary scan for assessing disease severity in patients with cholelithiasis. *Arch Surg.* 2011;146(2):169-174.
10. Alobaidi M, Gupta R, Jafri SZ, Fink-Bennet DM. Current trends in imaging evaluation of acute cholecystitis. *Emerg Radiol.* 2004;10(5):256-258.
11. Kalimi R, Gecelter GR, Caplin D, et al. Diagnosis of acute cholecystitis: sensitivity of sonography, cholescintigraphy, and combined sonography-cholescintigraphy. *J Am Coll Surg.* 2001;193(6):609-613.
12. Ralls PW, Colletti PM, Halls JM, Siemsen JK. Prospective evaluation of 99mTc-IDA cholescintigraphy and gray-scale ultrasound in the diagnosis of acute cholecystitis. *Radiology.* 1982;144(2):369-371.
13. Ralls PW, Colletti PM, Lapin SA, et al. Real-time sonography in suspected acute cholecystitis. Prospective evaluation of primary and secondary signs. *Radiology.* 1985;155(3):767-771.
14. Samuels BI, Freitas JE, Bree RL, Schwab RE, Heller ST. A comparison of radionuclide hepatobiliary imaging and real-time ultrasound for the detection of acute cholecystitis. *Radiology.* 1983;147(1):207-210.
15. Bennett GL, Rusinek H, Lisi V, et al. CT findings in acute gangrenous cholecystitis. *AJR Am J Roentgenol.* 2002;178(2):275-281.
16. De Vargas Macciucca M, Lanciotti S, De Cicco ML, Coniglio M, Gualdi GF. Ultrasonographic and spiral CT evaluation of simple and complicated acute cholecystitis: diagnostic protocol assessment based on personal experience and review of the literature. *Radiol Med.* 2006;111(2):167-180.

17. Kim YK, Kwak HS, Kim CS, et al. CT findings of mild forms or early manifestations of acute cholecystitis. *Clin Imaging.* 2009;33(4):274-280.
18. Shakespear JS, Shaaban AM, Rezvani M. CT findings of acute cholecystitis and its complications. *AJR Am J Roentgenol.* 2010;194(6):1523-1529.
19. Tsai MJ, Chen JD, Tiu CM, Chou YH, Hu SC, Chang CY. Can acute cholecystitis with gallbladder perforation be detected preoperatively by computed tomography in ED? Correlation with clinical data and computed tomography features. *Am J Emerg Med.* 2009;27(5):574-581.
20. Fuks D, Mouly C, Robert B, Hajji H, Yzet T, Regimbeau JM. Acute cholecystitis: preoperative CT can help the surgeon consider conversion from laparoscopic to open cholecystectomy. *Radiology.* 2012;263(1):128-138.
21. Akpinar E, Turkbey B, Karcaaltincaba M, et al. Initial experience on utility of gadobenate dimeglumine (Gd-BOPTA) enhanced T1-weighted MR cholangiography in diagnosis of acute cholecystitis. *J Magn Reson Imaging.* 2009;30(3):578-585.
22. Altun E, Semelka RC, Elias J, Jr., et al. Acute cholecystitis: MR findings and differentiation from chronic cholecystitis. *Radiology.* 2007;244(1):174-183.
23. Oh KY, Gilfeather M, Kennedy A, et al. Limited abdominal MRI in the evaluation of acute right upper quadrant pain. *Abdom Imaging.* 2003;28(5):643-651.
24. Hakansson K, Leander P, Ekberg O, Hakansson HO. MR imaging in clinically suspected acute cholecystitis. A comparison with ultrasonography. *Acta Radiol.* 2000;41(4):322-328.
25. Regan F, Schaefer DC, Smith DP, Petronis JD, Bohlman ME, Magnuson TH. The diagnostic utility of HASTE MRI in the evaluation of acute cholecystitis. Half-Fourier acquisition single-shot turbo SE. *J Comput Assist Tomogr.* 1998;22(4):638-642.
26. Oto A, Ernst R, Ghulmiyyah L, Hughes D, Saade G, Chaljub G. The role of MR cholangiopancreatography in the evaluation of pregnant patients with acute pancreaticobiliary disease. *Br J Radiol.* 2009;82(976):279-285.
27. Oto A, Ernst RD, Ghulmiyyah LM, et al. MR imaging in the triage of pregnant patients with acute abdominal and pelvic pain. *Abdom Imaging.* 2009;34(2):243-250.
28. Boland GW, Slater G, Lu DS, Eisenberg P, Lee MJ, Mueller PR. Prevalence and significance of gallbladder abnormalities seen on sonography in intensive care unit patients. *AJR Am J Roentgenol.* 2000;174(4):973-977.
29. Puc MM, Tran HS, Wry PW, Ross SE. Ultrasound is not a useful screening tool for acute acalculous cholecystitis in critically ill trauma patients. *Am Surg.* 2002;68(1):65-69.
30. Ziessman HA. Nuclear medicine hepatobiliary imaging. *Clin Gastroenterol Hepatol.* 2010;8(2):111-116.
31. Ahvenjarvi L, Koivukangas V, Jartti A, et al. Diagnostic accuracy of computed tomography imaging of surgically treated acute acalculous cholecystitis in critically ill patients. *J Trauma.* 2011;70(1):183-188.
32. Khan MN, Nordon I, Ghauri AS, Ranaboldo C, Carty N. Urgent cholecystectomy for acute cholecystitis in a district general hospital - is it feasible? *Ann R Coll Surg Engl.* 2009;91(1):30-34.
33. Melloul E, Denys A, Demartines N, Calmes JM, Schafer M. Percutaneous drainage versus emergency cholecystectomy for the treatment of acute cholecystitis in critically ill patients: does it matter? *World J Surg.* 2011;35(4):826-833.
34. Popkharitov AI. Laparoscopic cholecystectomy for acute cholecystitis. *Langenbecks Arch Surg.* 2008;393(6):935-941.
35. Steiner CA, Bass EB, Talamini MA, Pitt HA, Steinberg EP. Surgical rates and operative mortality for open and laparoscopic cholecystectomy in Maryland. *N Engl J Med.* 1994;330(6):403-408.
36. Bingener J, Richards ML, Schwesinger WH, Strodel WE, Sirinek KR. Laparoscopic cholecystectomy for elderly patients: gold standard for golden years? *Arch Surg.* 2003;138(5):531-535; discussion 535-536.
37. Brunt LM, Quasebarth MA, Dunnegan DL, Soper NJ. Outcomes analysis of laparoscopic cholecystectomy in the extremely elderly. *Surg Endosc.* 2001;15(7):700-705.
38. Kirshtein B, Bayme M, Bolotin A, Mizrahi S, Lantsberg L. Laparoscopic cholecystectomy for acute cholecystitis in the elderly: is it safe? *Surg Laparosc Endosc Percutan Tech.* 2008;18(4):334-339.
39. Pessaux P, Regenet N, Tuech JJ, Rouge C, Bergamaschi R, Arnaud JP. Laparoscopic versus open cholecystectomy: a prospective comparative study in the elderly with acute cholecystitis. *Surg Laparosc Endosc Percutan Tech.* 2001;11(4):252-255.
40. Winbladh A, Gullstrand P, Svanvik J, Sandstrom P. Systematic review of cholecystostomy as a treatment option in acute cholecystitis. *HPB (Oxford).* 2009;11(3):183-193.
41. Chung YH, Choi ER, Kim KM, et al. Can percutaneous cholecystostomy be a definitive management for acute acalculous cholecystitis? *J Clin Gastroenterol.* 2012;46(3):216-219.

42. Cherng N, Witkowski ET, Sneider EB, et al. Use of cholecystostomy tubes in the management of patients with primary diagnosis of acute cholecystitis. *J Am Coll Surg.* 2012;214(2):196-201.
43. Joseph T, Unver K, Hwang GL, et al. Percutaneous cholecystostomy for acute cholecystitis: ten-year experience. *J Vasc Interv Radiol.* 2012;23(1):83-88 e81.