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Medical Sciences

PREOPERATIVE IMAGING DIAGNOSIS OF COMMON BILE DUCT LITHIASIS. A LITERATURE REVIEW

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ABSTRACT:
COMMON BILE DUCT LITHIASIS OCCURS IN 10-15% OF THE PATIENTS HAVING GALLSTONES. POSITIVE PREOPERATIVE DIAGNOSIS OF COMMON BILE DUCT LITHIASIS CAN ONLY BE DONE BY IMAGING INVESTIGATIONS. POSITIVE FINDINGS USING ANY OF THE ESTABLISHED METHODS SHOULD LEAD TO THE REFERRAL OF THE PATIENT FOR THERAPEUTIC INTERVENTION. NEGATIVE RESULTS IN TRANSABDOMINAL ULTRASOUND OR CT SCANS SHOULD BE FURTHER INVESTIGATED BY MAGNETIC RESONANCE CHOLANGIOGRAPHY OR ENDOSCOPIC ULTRASONOGRAPHY. DUE TO ITS MORE INVASIVE NATURE AND ITS ASSOCIATED MORBIDITY AND MORTALITY RISKS, ENDOSCOPIC RETROGRADE CHOLANGYOPANCREATOGRAPHY SHOULD ONLY BE USED FOR DIAGNOSIS PURPOSES IN SELECTED CASES OR WHEN MAGNETIC RESONANCE CHOLANGIOGRAPHY OR ENDOSCOPIC ULTRASONOGRAPHY ARE NOT AVAILABLE.

KEY WORDS: DIAGNOSIS OF COMMON BILE DUCT LITHIASIS (CBDL), IMAGING METHODS, SENSITIVITY, SPECIFICITY.

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INTRODUCTION

Biliary lithiasis is a frequent occurrence in medical practice. It is estimated that around 20% of the population above 40 years of age will be affected; the incidence may rise to 30% in patients above 70 years[8]. The clinical manifestations vary form being completely asymptomatic to severe, life-threatening forms. Common bile duct lithiasis occurs in 10-15% of the patients having gallbladder stones[9] and a different and more complex diagnosis treatment algorithm.

Considering these, we may say that all patients diagnosed with gallstones have a smaller or greater risk of also having common bile duct stones.

Over the years some imaging methods became the standard in diagnosing common bile duct lithiasis – transabdominal ultrasound, CT-scan, MRI scan, endoscopic retrograde pancreato-cholangiography and endoscopic ultrasonography.

OBJECTIVES

The current paper aims to review literature data in PubMed indexed papers communicating the sensitivity and specificity of the above-mentioned imaging methods used in the diagnosis of common bile duct lithiasis.

MATERIALS AND METHODS

PubMed indexed papers assessing the sensitivity and specificity of these imaging methods were reviewed, comparing the reliability of the clinical information provided by each of these techniques.

RESULTS

Transabdominal ultrasound was chronologically the first of the imagistic methods that are still in use on a regular basis. It has the advantage of being low-cost, non-invasive and readily available in most of the medical facilities. However, the sensitivity of transabdominal ultrasound in detecting common bile duct stones is low; it varies between 18% and 80%; this wide variation may be since transabdominal ultrasound scan is operator dependent, as highlighted by studies showing lower sensitivity, specificity and accuracy rates for less-experienced examiners compared to experienced ones[10]. The low sensitivity rate of the ultrasound in diagnosing common bile duct stones is due to the fact that the distal segment of the CBD, where most of the CBD stones are lodges is frequently obscures by gas, or they do not show acoustic shadowing[11]. The specificity of the method ranges from 68 to 98%. Most of the times, a transabdominal ultrasound will not directly show a common bile duct stone, but rather indirect signs, such as common bile duct dilation or multiple small-sized gallstones; corelating these findings to other clinical features, such as jaundice and/or elevated liver function tests will require further investigations for positive diagnosis of common bile duct lithiasis.

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[11] Costi R et al. *Diagnosis and management of choledocholithiasis in the golden age of imaging, endoscopy and laparoscopy*. World J Gastroenterol. 2014; 20(37): 13382–13401.

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Table 1. Transabdominal ultrasound sensitivity and specificity by different authors.

Author (Year)	Sensitivity	Specificity
Mitchel SE (1984)	18%	89%
Einstein DM (1984)	22%	n/a
Pancione L (1994)	85%	85%
Tse F (2006)	25-58%	68-91%
Molvar C (2016)	73%	91%
Almadi MA (2012)	22-65%	70-98%
Chen CC (2012)	26%	n/a
Al-Jiffry B (2013)	22-55%	n/a
Costi R (2014)	<50%	n/a
Prachayakul V (2014)	25-58%	68-91%
Surlin V (2015)	50-80%	95%
Zahur Z (2019)	76%	81%
De Silva SL (2019)	80%	87%

Abdominal computed tomography is second to transabdominal ultrasound the most frequently used imaging study when investigating a patient reporting for abdominal pain. Compared to transabdominal ultrasound, the process of image acquisition is not operator dependent; the scanning procedure is standardized, and the images will be readily available for a later review or a second opinion without the need to repeat the scan. For unenhanced CT the sensitivity is approximately 85% and the specificity approximately 85%. Stones smaller than 5mm in diameter, as well as iso-dense (usually cholesterol) stones may frequently be missed[12,13]. Better results are yielded when using iodinated contrast agent excreted into the bile in the CT-cholangiography[14, 15]. The presence of intraduodenal contrast seems to lower the rate of the stone detection[16]. The presence of some findings on the CT scan – a diameter of the CBD greater than 8mm, infiltration of the pericholecystic fat, papillitis – are indirect signs suggesting the presence of a possible CBD stone[17]. Using virtual non-contrast images acquired through dual-energy computed tomography had similar results as true non contrast images but required a lower radiation dose[18].

[12] Saito H et al. *Usefulness and limitations of dual-layer spectral detector computed tomography for diagnosing biliary stones not detected by conventional computed tomography: a report of three cases.* Clinical Journal of Gastroenterol. 2018; 11(2):172-177.
[13] Jeon TJ et al. *Diagnostic Value of Endoscopic Ultrasonography in Symptomatic Patients with High and Intermediate Probabilities of Common Bile Duct Stones and a Negative Computed Tomography Scan.* Gut and Liver. 2017; 11(2): 290–297.
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[17]Min JH et al. *Combination of CT findings can reliably predict radiolucent common bile duct stones: a novel approach using a CT-based nomogram.* European Radiology. 2019; 29(12):6447-6457
[18] Bae JS et al. *Utilization of virtual non-contrast images derived from dual-energy CT in evaluation of biliary stone disease: Virtual non-contrast image can replace true non-contrast image regarding biliary stone detection.* European Journal of Radiology. 2019; 116:34-40

Table 2. Comparison between sensitivities and specificities for unenhanced CT scan and CT cholangiography.

Author (Year)	Sensitivity		Specificity	
	Unenhanced CT scan	CT cholangiography	Unenhanced CT scan	CT cholangiography
Mitchel SE (1984)	87%	n/a	80%	n/a
Soto JA (2000)	65%	92%	84%	92%
Kondo S (2005)	n/a	88%	n/a	n/a
Chen CC (2012)	50-88%	n/a	84-98%	n/a
Kim CW (2013)	87%	n/a	85%	n/a
Prachayakul V (2014)	87%	n/a	97%	n/a
Costi R (2014)	88-92%	88-96%	75-92%	75-100%
Surlin V (2014)	60-87%	85-96%	97-100%	88-98%
Ajlan AM (2015)	77-88%	n/a	57-71%	n/a
Wang M (2016)	85-88%	n/a	88-97%	n/a
Jeon TJ (2017)	65-88%	n/a	73-97%	n/a
Bae JS (2019)	87.5%	n/a	98.5%	n/a

Magnetic resonance cholangiography (MRC) is currently considered the most accurate non-invasive imaging method to diagnose common bile duct lithiasis. MRC does not require contrast-enhancement to diagnose common bile duct lithiasis, so there is no risk of complications secondary to contrast administration. It does not involve radiation exposure and does not require anesthesia. The high sensitivity and specificity rates – approximately 95%, respectively 97%[19] alongside the previously mentioned advantages make MRC the gold standard non-invasive method to diagnose CBD stones. Using MRC in the diagnosis process avoids the possible complications of invasive procedures such as endoscopic ultrasound or endoscopic retrograde cholangiography. However, due to the fact that it is not readily available in all medical facilities and has a higher operating cost, it is not used as first-choice investigation, but rather for selected patients at intermediate risk of having CBD stones in which ultrasound and CT prove equivocal. False positive and false negative results may occur in the presence of small stones (less than 4mm in diameter), complete CBD obstruction by stones, pneumobilia[20]. The MRC cannot be used in morbidly obese or claustrophobic patients, as well as in the presence of certain metal foreign bodies/ implants[21].

Table 3. MRC sensitivity and specificity rates and positive and negative predictive value by different authors.

Author (Year)	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Pavone P (1997)	88.9%	100%	100%	90%
Hochwald SN (1998)	95%	89%	n/a	n/a
Ahn T (1998)	92%	73%	n/a	n/a
Stiris MG (2000)	87.5%	94.4%	96.6%	81.1%
Boraschi P (2002)	90%	96%	95%	93%
Ke ZW (2003)	100%	96.3%	91.8%	100%
Kats J (2003)	100%	96%	n/a	n/a
Hallal AH (2005)	100%	91%	50%	100%

[19] Romagnuolo J et al. *Magnetic resonance cholangiopancreatography: a meta-analysis of test performance in suspected biliary disease.* Annals of Internal Medicine. 2003;139(7):547-57.
[20] Pavone P et al, *MR cholangiopancreatography: technique, indications and clinical results* La Radiologia Medica. 1997; 94(6):632-41.
[21] Costi R et al. *Diagnosis and management of choledocholithiasis in the golden age of imaging, endoscopy and laparoscopy*. World J Gastroenterol. 2014; 20(37): 13382–13401.

Makary MA (2005)	94%	98%	n/a	n/a
Freitas ML (2006)	81-100%	92-100%	n/a	n/a
Schmidt S (2007)	94.9%	94.4%	97.4%	89.5%
De Waele E (2007)	82.6%	97.5%	90.5%	95.2%
Eshghi F (2008)	81.8%	87.5%	94.7%	63.3%
Scaffidi MG (2009)	88%	72%	87%	72%
Jamry A (2014)	73-97%	87.5-96%	n/a	n/a
Surlin V (2014)	82.6%	97.5%	90.5%	95.2%
Morris S (2015)	93%	96%	n/a	n/a
Jeon TJ (2017)	85%	93%	87%	92%

Endoscopic ultrasonography (EUS) became over the past two decades a reliable imaging method for diagnosing common bile duct lithiasis. It has specificity and sensitivity rates of approximately 95%[22], similar to ERCP and MRC and superior to transabdominal ultrasound and CT. EUS is less invasive than ERCP and does not require exposure to ionizing radiation. The risk of post-procedural complications is lower than for ERCP. The risk for acute pancreatitis following EUS is virtually absent[23]. In many situations, if EUS is positive for CBD stones, the procedure can be converted to ERCP to achieve CBD clearing. In a prospective randomized trial of EUS-assisted ERCP without fluoroscopy versus ERCP, standard ERCP proved superior in terms of stone clearing[24]. Compared to MRC, EUS yields similar results. It is more sensitive than MRC in detecting smaller stones (less than 5mm in diameter) and can be performed in claustrophobic patients. The disadvantages of EUS compared to MRC are the requirement for sedation and the risks of an invasive endoscopic procedure (perforation, bleeding); previous gastric surgery may render EUS impossible. MRC is more cost-effective than EUS in selecting patients that will undergo therapeutic ERCP[25].

Table 4. EUS sensitivity and specificity rates and positive and negative predictive value by different authors.

Author (Year)	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Schmidt S (2007)	97.4%	94.4%	97.4%	94.4%
Aljebreen A (2008)	89%	97%	96%	92%
Karakan T (2009)	91%	100%	n/a	n/a
Desai R (2009)	95%	98%	n/a	n/a
Lee JH (2010)	100%	95%	92%	100%
Épshteĭn AM (2014)	100%	96.2%	90%	100%
Prachayakul V (2014)	100%	80%	96.55%	100%
Surlin V (2014)	89-94%	94-96%	n/a	n/a
Morris S (2015)	95%	97%	n/a	n/a
Netinatsunton N (2016)	96%	95.8%	92.3%	97.9%
Jeon TJ (2017)	93%	96%	93%	96%

[22]Jeon TJ et al. *Diagnostic Value of Endoscopic Ultrasonography in Symptomatic Patients with High and Intermediate Probabilities of Common Bile Duct Stones and a Negative Computed Tomography Scan.* Gut and Liver. 2017; 11(2): 290–297.

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[25] Morris S et al. *Cost-Effectiveness Analysis of Endoscopic Ultrasound versus Magnetic Resonance Cholangiopancreatography in Patients with Suspected Common Bile Duct Stones.* PLoS One. 2015; 10(3): e0121699.

Endoscopic retrograde cholangiopancreatography has established over the years as the golden standard in the diagnosis of common bile duct lithiasis. It can detect an estimated 94% of CBD stones[26]. Sensitivity rate is around 90%, with a specificity rate approaching 100%. Nevertheless, ERCP is still not a perfect method in detecting CBD stones. Some studies showed ERCP to have a smaller sensitivity rate than EUS in detecting stones under 4mm in diameter[27]. There is also a risk of false positive results secondary to the presence of air bubbles in the CBD following contrast-injection. And one should note that obtaining a cholangiogram via ERCP will only be possible in around 90% of the cases[28]. Out the imaging methods in use for diagnosing CBD lithiasis, ERCP is the most invasive; it requires at least sedation, but usually it is performed under general anesthesia, generating a mortality risk associated to the diagnostic procedure of 0.07% to 0.1% [29]. It also involves exposure to ionizing radiation. ERCP can lead to complications related to biliary instrumentation (post-procedural pancreatitis, cholangitis, bleeding) or related to the endoscopic procedure (such as perforation of the duodenum). Overall complication rate after diagnosis purposed ERCP reaches 5-8%[30]. This ads to the fact that performing non-selective ERCP in patients with suspected CBD lithiasis will detect stones in only 50% of the cases[31]; this would lead to half of the patients unnecessarily undergoing the ERCP with all the procedure-related risks.

Table 5. Sensitivity and specificity of ERCP in detecting CBD stones by author.

Author (Year)	Sensitivity	Specificity
Prat F (1996)	89%	100%
Pisani JC (2001)	94%	100%
Karakan T (2009)	75%	100%
Desai R (2009)	90%	98%
Surlin V (2014)	89%	n/a
Prachayakul V (2014)	90%	98%
Costi R (2014)	75-93%	100%
Gurusamy KS (2015)	83%	99%

DISCUSSION

The imaging methods for the diagnosis of common bile duct lithiasis evolved over the past 30 years.

Some investigations, such as intravenous or oral cholangiography were practically rendered obsolete.

Transabdominal ultrasound and unenhanced or enhanced CT scan can be useful in the positive diagnosis only if a stone is detected on the investigation. Otherwise, they can only

[26] Desai R, Shokouhi BN. *Common bile duct stones – their presentation, diagnosis and management.* Indian Journal of Surgery. 2009; 71:229–237

[27] Karakan T et al. *EUS versus endoscopic retrograde cholangiography for patients with intermediate probability of bile duct stones: a prospective randomized trial.* Gastrointestinal Endoscopy. 2009; 69(2):244-52.

[28] Freitas ML et al. *Choledocholithiasis: Evolving standards for diagnosis and management.* World J Gastroenterol. 2006; 12(20): 3162–3167.

[29] Jeon TJ et al. *Diagnostic Value of Endoscopic Ultrasonography in Symptomatic Patients with High and Intermediate Probabilities of Common Bile Duct Stones and a Negative Computed Tomography Scan.* Gut and Liver. 2017; 11(2): 290–297.

[30] Freitas ML et al. *Choledocholithiasis: Evolving standards for diagnosis and management.* World J Gastroenterol. 2006; 12(20): 3162–3167.

[31] Jeon TJ et al. *Diagnostic Value of Endoscopic Ultrasonography in Symptomatic Patients with High and Intermediate Probabilities of Common Bile Duct Stones and a Negative Computed Tomography Scan.* Gut and Liver. 2017; 11(2): 290–297.

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show indirect signs of suspected CBD lithiasis, such as CBD dilation and/or multiple small sized gallstones, but the diagnosis should be confirmed by MRC or EUS before referring the patient for a therapeutic procedure. A transabdominal ultrasound or a CT scan negative for CBD stones cannot rule out CBD lithiasis, so patients with clinical and laboratory signs suggestive for lithiasis and a negative transabdominal ultrasound and/ or CT scan should be referred for further investigation by MRC or EUS.

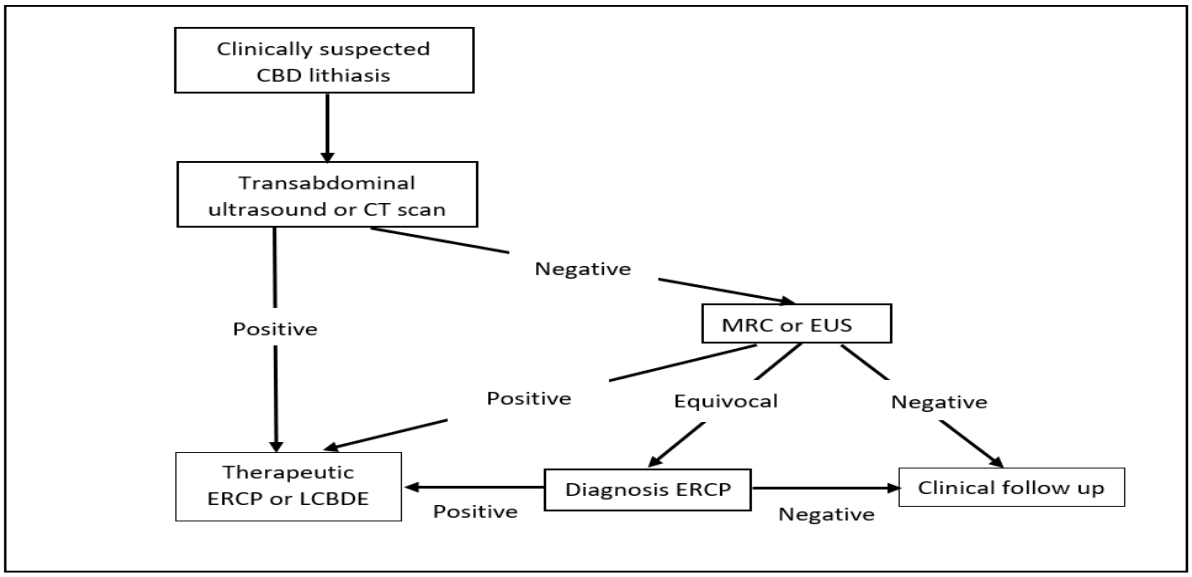
MRC and EUS are currently the most frequently used methods for confirming or ruling out the presence of CBD stones. Both techniques have high sensitivity and specificity rates and they do not require exposure to ionizing radiation. There are some limitations of these imaging techniques. MRC cannot be used in claustrophobic patients or in patients having metal implants or foreign bodies. EUS require sedation and is an invasive procedure. Both methods are not immediately available in all medical facilities, so some patients requiring them will have to be referred between different hospitals for proper diagnosis. Nevertheless, using one of these methods is still more cost-effective and has a lower morbidity/mortality risk than referring the patient directly for ERCP.

ERCP, considered for a long time the golden standard in diagnosing CBD lithiasis, is currently less used for diagnosing purpose only. Given to the fact that it is the most invasive method and has the highest procedure related risks, it currently tends to be used as a diagnosis method only in selected cases (where MRC or EUS are equivocal) or in hospitals where MRC or EUS are not available.

CONCLUSION

The use of imaging methods for diagnosing CBD lithiasis should be considered on a case by case basis. In patients with clinically suspected CBD stones, the investigating process should start by using first less complex and widely available methods (transabdominal ultrasound and CT scan) before more costly and less widely available techniques (MRC, EUS). ERCP should be used for diagnosing purpose only in selected situations. If at any point of the investigating process there is a positive result for CBD stones, the patient should be referred directly for a therapeutic procedure – ERCP or laparoscopic common bile duct exploration, as in the proposed pathway below.

Figure 1. Proposed pathway for the use of imaging methods in the diagnosis of CBD lithiasis.



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