

## Ultrasound in Emergency Medicine

### EMERGENCY BILIARY SONOGRAPHY: UTILITY OF COMMON BILE DUCT MEASUREMENT IN THE DIAGNOSIS OF CHOLECYSTITIS AND CHOLEDOCHOLITHIASIS

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**Abstract—Background:** Measurement of the common bile duct (CBD) has traditionally been considered an integral part of gallbladder sonography, but accurate identification of the CBD can be difficult for novice sonographers. **Objective:** To determine the prevalence of isolated sonographic CBD dilation in emergency department (ED) patients with cholecystitis or choledocholithiasis without laboratory abnormalities or other pathologic findings on biliary ultrasound. **Methods:** We conducted a retrospective chart review on two separate ED patient cohorts between June 2000 and June 2010. The first cohort comprised all ED patients undergoing a biliary ultrasound and subsequent cholecystectomy for presumed cholecystitis. The second cohort consisted of all ED patients receiving a biliary ultrasound who were ultimately diagnosed with choledocholithiasis. Ultrasound data and contemporaneous laboratory values were collected. Postoperative gallbladder pathology reports and endoscopic retrograde cholangiopancreatography (ERCP) reports were used as the criterion standard for final diagnosis. **Results:** Of 666 cases of cholecystitis, there were 251 (37.7%) with a dilated CBD > 6 mm and only 2 cases (0.3%; 95% confidence interval [CI] 0.0–0.7%) of

isolated CBD dilation with an otherwise negative ultrasound and normal laboratory values. Of 111 cases of choledocholithiasis, there were 80 (72.0%) with a dilated CBD and only 1 case (0.9%; 95% CI 0.0–2.7%) with an otherwise negative ultrasound and normal laboratory values. **Conclusion:** The prevalence of isolated sonographic CBD dilation in cholecystitis and choledocholithiasis is <1%. Omission of CBD measurement is unlikely to result in missed cholecystitis or choledocholithiasis in the setting of a routine ED evaluation with an otherwise normal ultrasound and normal laboratory values. © 2014 Elsevier Inc.

**Keywords—**biliary tract diseases; choledocholithiasis; cholecystitis; common bile duct; emergency department; gallbladder; ultrasonography

#### INTRODUCTION

Right upper quadrant (RUQ) abdominal pain is common in patients in the emergency department (ED). The goal of ED evaluation is to identify clinically significant biliary pathology, such as cholecystitis and choledocholithiasis, that may merit prompt surgical consultation, operative intervention, or admission. These patients typically undergo serum laboratory testing and most often receive a RUQ ultrasound as the first-line imaging

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modality. Focused point-of-care (POC) biliary ultrasound has been shown to expedite the care of patients presenting with possible biliary disease and decrease duration of stay in the ED (1). POC biliary ultrasound typically includes sagittal and transverse views of the gallbladder to assess for the presence or absence of gallstones and sonographic evidence of cholecystitis, such as gallbladder wall thickening > 3 mm (GWT), pericholecystic fluid (PCF), and sonographic Murphy's sign (SMS). Views of the portal triad are also obtained and the common bile duct (CBD) diameter is measured (2,3). From our experience teaching emergency physicians, residents, and medical students, it is the proper and timely identification of the CBD that proves most difficult for the novice sonographer.

The typical presentation of cholecystitis includes sonographic cholelithiasis with variable combinations of SMS, GWT, PCF, and abnormalities in serum blood testing (2,4). CBD diameter is not generally included in the diagnostic criteria for cholecystitis, but there is a paucity of published data looking specifically at the prevalence of CBD dilation in the setting of acute cholecystitis (2). Conversely, CBD dilation has been a traditional diagnostic marker for possible choledocholithiasis; however, the literature suggests that a significant proportion of ductal stones occur without sonographic CBD dilation and a majority of choledocholithiasis cases have concurrent serum laboratory abnormalities (5–7). We sought to determine what unique information CBD diameter adds to the evaluation for cholecystitis and choledocholithiasis in ED patients.

### *Goals of This Investigation*

The aim of this study was to determine the prevalence of isolated sonographic CBD dilation in ED patients with cholecystitis or choledocholithiasis without laboratory abnormalities or other pathologic findings on biliary ultrasound.

## **METHODS**

### *Study Design and Setting*

This was a retrospective chart review performed at a single academic, tertiary care hospital with Emergency Medicine and Radiology residency programs. The research team comprised two emergency ultrasound fellows, one emergency medicine resident, one medical student, and four undergraduate research assistants.

After approval by the institutional review board, master patient lists were obtained via a medical records query using codes from the *International Classification of Diseases, 9th revision* (ICD-9). The results were filtered to

return only those patients with an index visit through the ED. Two patient cohorts were evaluated.

In the first cohort, ICD-9 codes for cholecystectomy (i.e., 51.21, 51.22, 51.23, and 51.24) identified all patients between July 2000 and June 2010 who were admitted from the ED and who underwent cholecystectomy during the same hospitalization. Patients with a preoperative biliary ultrasound performed in the radiology department during their ED course and a postoperative pathology report were included. Patients lacking an ultrasound performed in the radiology department, a sonographic CBD measurement, or a pathology report were excluded.

The second cohort evaluated all ED patients between July 2000 and June 2010 who received a diagnosis of choledocholithiasis during the index ED visit or the resulting admission. ICD-9 codes for choledocholithiasis (i.e., 574.5, 574.51, 574.9, and 574.91) were queried, and returned charts were limited to those without concurrent ICD-9 codes for cholecystitis (i.e., 574.3, 574.4, 574.7, and 574.8). This distinction was made to specifically examine cases of isolated choledocholithiasis for which CBD diameter might be the only sonographic evidence of pathology. Choledocholithiasis patients were included in the second cohort if they received a biliary ultrasound performed by the radiology department during their ED course and excluded if no ultrasound performed by the radiology department was conducted, CBD was not measured by ultrasound, or patients were postcholecystectomy.

The presence or absence of POC biliary ultrasound was not specifically considered for patient selection in either cohort. Obtaining an ultrasound performed by the radiology department, regardless of POC biliary ultrasound, was standard practice at the institution for the majority of the study period.

### *Data Collection and Processing*

All members of the research team participated in medical chart review after one-on-one training on the use of the electronic medical record and proper data collection. A standardized data collection sheet was used for chart review. Demographic information, preoperative ultrasound findings, and concurrent laboratory values were collected for each patient. Postoperative pathology findings and endoscopic retrograde cholangiopancreatography (ERCP) results were included in data collection for patients in the first and second cohorts, respectively. Formal interrater reliability analysis was not performed, but a 10% cross-sectional sample of each participant's data was reviewed by a study coresearcher and cross-referenced with patient charts to ensure accuracy.

All ultrasound data were obtained from finalized radiology reports from studies universally read by the

attending radiologist. Results of POC biliary ultrasounds were not specifically evaluated. A sonographic CBD measurement  $> 6$  mm was defined as dilated, and a measurement  $\leq 6$  mm was considered normal (2,3). Although there is evidence suggesting that normal CBD diameter increases with age, we used a static cutoff of 6 mm. This conservative threshold was chosen to optimize the dilated CBD subset and maximize the likelihood of identifying cases of isolated CBD dilation.

In addition to the required CBD measurement, each ultrasound radiology report was evaluated for the presence or absence of GWT, PCF, and SMS. An ultrasound was defined as “positive” by the presence of  $\geq 1$  of these parameters. A “negative” ultrasound was defined as lacking GWT, PCF, and SMS. Classification of the ultrasound as positive or negative was determined independently of CBD diameter. The review of choledocholithiasis cases in the second cohort included the presence or absence of sonographic cholelithiasis. In both cohorts, any parameter not explicitly addressed in the ultrasound report was considered to be absent. These conservative definitions and methods were chosen to maximize the subset of negative ultrasound and ensure that all potential cases of isolated CBD dilation were identified as such.

Serum laboratory values included a white blood cell count (WBC; normal 4–10.5 K/mcL), aspartate amino-

transferase (AST; normal 8–40 IU/L), alanine aminotransferase (ALT; normal 0–60 IU/L), alkaline phosphatase (ALP; normal 26–110 IU/L), total bilirubin (tBIL; normal 0–1.4 mg/dL), direct bilirubin (dBIL; normal 0–0.2 mg/dL), and lipase (LIP; normal 22–51 U/L). Abnormal laboratory values were defined as those exceeding the upper limit of the normal range as determined by the pathology department. Each case was classified as “normal labs” if all laboratory values were within normal limits or “abnormal labs” if  $\geq 1$  laboratory value exceeded the upper normal limit. Unreported or missing laboratory data were considered to be within the normal range to maximize the subset of cases classified as isolated CBD dilation.

### Outcome Measures

The primary outcome in each cohort was CBD dilation in cholecystectomy or choledocholithiasis cases with normal laboratory values and an otherwise negative biliary ultrasound.

### Primary Data Analysis

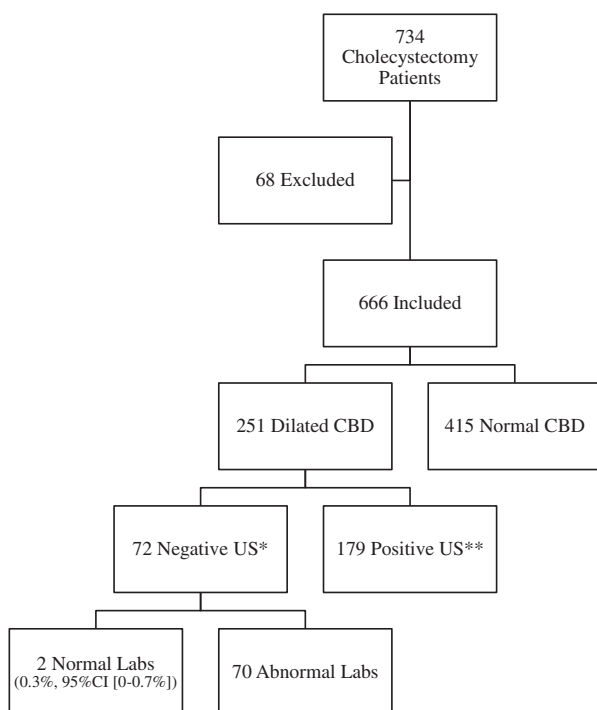
Data compilation and analysis was performed using Stata software (version 10.1; StataCorp, LP, College Station, TX).

## RESULTS

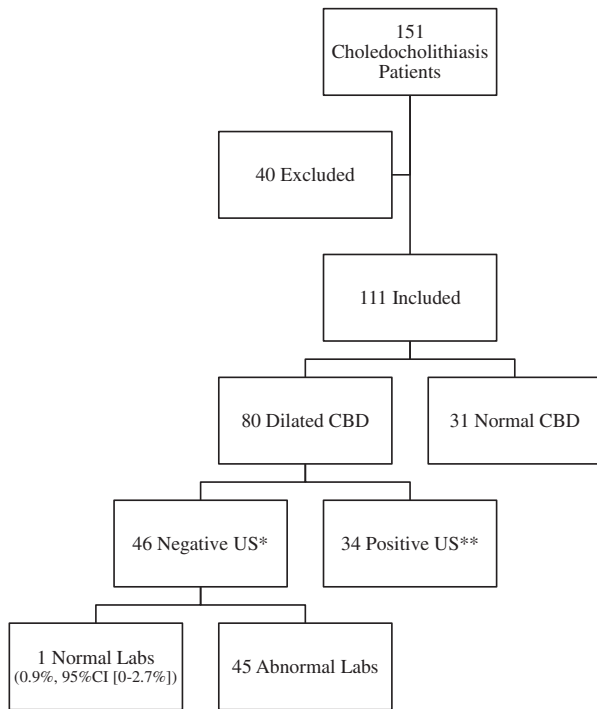
The first cohort included 734 patients undergoing cholecystectomy between June 2000 and July 2010. Patients were 9–90 years of age, and the cohort was 70.8% female. A total of 666 charts were included after 40 (5.4%) exclusions for missing ultrasound or CBD measurements and 28 (3.8%) for missing pathology reports. Of the 666 inclusions, 633 (95.1%) had confirmed cholecystitis according to the final pathology report.

There were 301 (45.2%) unique patient charts that revealed  $\geq 1$  equivocal or nonreported sonographic criterion, specifically 32 (4.8%) GWT, 111 (16.7%) PCF, and 243 (36.5%) SMS. There was a single case missing AST, ALT, ALP, and tBIL measurements (0.2%). WBC, LIP, and dBIL values were missing in 4 (0.6%), 6 (0.9%), and 525 (78.8%) cases, respectively.

There were 251 (37.7%) cases that had a dilated CBD  $> 6$  mm. Of these patients with a dilated CBD, positive ultrasounds were seen in 179 (71.3%) cases and otherwise negative ultrasounds were seen in 72 (28.7%) cases. Seventy (97.2%) of the 72 patients with a dilated CBD and a negative ultrasound had  $\geq 1$  laboratory abnormality. Of the 666 patients included in this cohort, only 2 (0.3%; 95% confidence interval 0.0–0.7%) cases had isolated CBD dilation with both a negative ultrasound and normal laboratory values (Figure 1).



**Figure 1. Cholecystectomy patient results.** \*Negative US lacks gallbladder wall thickening, pericholecystitic fluid and sonographic Murphy’s sign. \*\*Positive US has gallbladder wall thickening, pericholecystitic fluid, or sonographic Murphy’s sign. US = ultrasound; CBD = common bile duct.



**Figure 2. Choledocholithiasis patient results. \*Negative US lacks gallbladder wall thickening, pericholecystic fluid and sonographic Murphy's sign. \*\*Positive US has gallbladder wall thickening, pericholecystic fluid, or sonographic Murphy's sign. US = ultrasound; CBD = common bile duct.**

In the second cohort, a total of 151 patients were diagnosed with choledocholithiasis without concurrent cholecystitis between June 2000 and July 2010. Patients ranged from 13–94 years of age, and the cohort was 73.5% female. A total of 111 charts were included after excluding 27 (17.9%) for lacking an ultrasound or CBD measurements and 13 (8.6%) for previous cholecystectomy. Of the 111 cases included, 87 (78.4%) patients underwent ERCP, with a stone identified in 65 (58.6%) cases. Cholelithiasis was seen by ultrasound in 93 (83.8%) of 111 included choledocholithiasis patients.

There were 25 (22.5%) unique patient charts that had  $\geq 1$  equivocal or nonreported sonographic criterion, specifically 2 (1.8%) cases missing GWT, 6 (5.4%) cases missing PCF, and 18 (16.2%) cases missing SMS. LIP and dBIL values were missing in 2 (1.8%) and 75 (67.6%) charts, respectively. All other laboratory values were present for each chart included in the cohort.

Dilated CBD  $> 6$  mm was seen in 80 (72.0%) of the included patients with choledocholithiasis. Of the patients with CBD dilation, a positive ultrasound was seen in 34 (42.5%) cases, and 46 (57.5%) had an otherwise negative ultrasound. Forty-five (97.8%) of the 46 patients with a dilated CBD and a negative ultrasound had  $\geq 1$  laboratory abnormality. Of the 111 patients

with choledocholithiasis included in the cohort, only 1 (0.9%; 95% CI, 0.0–2.7%) had isolated CBD dilation with both a negative ultrasound and normal laboratory findings (Figure 2).

Notably, all of the 31 (28.0%) choledocholithiasis patients with normal CBD  $\leq 6$  mm had abnormal laboratory values. There were only 3 (2.7%) cases of normal laboratory values in the entire second cohort. All 3 of these cases had CBD dilation, and 2 had an otherwise positive ultrasound.

In a pooled analysis of both cohorts including 777 patients with cholecystitis or choledocholithiasis, isolated CBD dilation without other ultrasound or laboratory abnormalities occurred in 3 (0.4%; 95% CI 0.0–0.8%) cases.

## DISCUSSION

Few ( $<1\%$ ) ED patients with cholecystitis requiring cholecystectomy or choledocholithiasis present with isolated sonographic CBD dilation. In the setting of an ultrasound without GWT, PCF, or SMS and normal laboratory testing, our results suggest sonographic CBD measurement has limited use in diagnosing cholecystitis and choledocholithiasis.

Clinical medicine has traditionally eschewed sonographic CBD measurement as a diagnostic marker for acute cholecystitis, and the results of the first cohort support this practice. A minority (37.7%) of cholecystitis patients had CBD dilation, and only two (0.3%) exhibited CBD dilation in isolation.

Evaluation for choledocholithiasis typically places a greater emphasis on CBD diameter, but a review of the choledocholithiasis literature suggests that the performance characteristics of diagnostic ultrasound are variable and that sonographic CBD measurement alone is not sufficient to rule out choledocholithiasis (8–12). This is reinforced by the significant proportion of choledocholithiasis cases (28.0%) with a normal CBD measurement seen in the second cohort.

Moreover, there were only three choledocholithiasis patients with normal laboratory values in more than a decade at our institution. All but one had an abnormal ultrasound finding aside from cholelithiasis and CBD dilation. Previous research has also suggested that a majority of CBD stones occur in the setting of elevated liver function tests. Pereira-Lima et al. found that liver function test elevations were 94.3% sensitive for choledocholithiasis in those undergoing endoscopic papillotomy, and Yang et al. concluded that an elevation in any liver function test was 87.5% sensitive for choledocholithiasis in patients undergoing laparoscopic cholecystectomy (5,6). Weinstein et al. found that even anicteric patients with biliary ductal dilation seen on ultrasound had

a concurrent elevation in ALP 77% of the time (7). The authors considered ALP a more sensitive indicator of incomplete biliary obstruction than sonographic ductal dilation (7).

In practice, our findings assist clinicians in scenarios in which the CBD is unable to be reliably identified sonographically. Even in the presence of cholelithiasis, a set of normal laboratory values and an otherwise unremarkable gallbladder appearance on ultrasound should provide reassurance that acute cholecystitis and choledocholithiasis are unlikely to be present. Conversely, given the non-negligible prevalence of normal CBD diameter in choledocholithiasis, it seems prudent to consider more definitive diagnostic tests, such as ERCP, in excluding choledocholithiasis in patients with RUQ pain and abnormal liver function tests, regardless of CBD size.

### Limitations

The study was a retrospective chart review performed at a single center and confers all inherent limitations as such. Patients with cholecystitis or choledocholithiasis diagnosed by radiologic modalities other than ultrasound, such as computed tomography (CT), were not included in the study analysis. The biliary ultrasound studies included in our analysis were conducted by the radiology department and not performed directly by emergency physicians at the bedside. This may limit the applicability of the study to ED POC biliary ultrasound, although it has been found that accuracy of the modality is similar for radiology- and emergency-trained sonographers (13).

Most significantly, we considered only the specific biliary diagnoses of cholecystitis and choledocholithiasis. The study does not directly address the role of CBD measurement in diagnosing other emergent pathologies that may cause RUQ pain. Acute pancreatitis and cholangitis are particularly relevant to the ED setting and warrant specific comment.

Laboratory testing typically plays a significant role in the clinical diagnosis of pancreatitis. The Revised Atlanta Classification of Acute Pancreatitis requires two of three following features for the diagnosis of acute pancreatitis: 1) abdominal pain; 2) lipase/amylase levels > 3 times the normal upper limit; and 3) characteristic findings on CT or ultrasound imaging. CBD diameter and ductal dilation are not included in the guidelines for diagnosis (14).

Acute cholangitis is associated with CBD dilation, but laboratory abnormalities or other clinical signs are present in a majority of cases. The Tokyo Guidelines for the diagnosis and severity assessment of acute cholangitis notes that WBC, ALP, AST/ALT, and tBIL elevation occurs in 63–82%, 74–93%, 57–97%, and 78–91% of cases, respectively. The incidence of fever ranges from

38.7–100%, and jaundice typically occurs in 60–93% of cases. Evidence of biliary obstruction by imaging is incorporated into the diagnosis of acute cholangitis but is not a sole diagnostic criterion (15).

Whereas previous research and expert consensus appear to de-emphasize a central role of ultrasound in the diagnosis of acute pancreatitis and cholangitis, our study does not specifically address the role of CBD diameter in diagnoses other than cholecystitis and choledocholithiasis. Additional research is needed to evaluate the practical utility of sonographic CBD measurement in identifying other disease processes in ED patients.

## CONCLUSIONS

The prevalence of isolated sonographic CBD dilation in cholecystitis and choledocholithiasis is <1%. Omission of CBD measurement is unlikely to result in missed cholecystitis or choledocholithiasis in the setting of a routine ED evaluation with an otherwise normal ultrasound and normal laboratory values.

*Acknowledgments*—We thank Stacy Hata, Catherine Kelly, Erik Kochert, Michael Menchine, Natalie Nguyen, Andrew Richardson, Amy Stacey, and Maryjane Vennat.

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## ARTICLE SUMMARY

### **1. Why is this topic important?**

Emergency physicians are using more point-of-care biliary ultrasound, but less experienced sonographers often identify the common bile duct (CBD) incorrectly. This raises concern for biliary pathology that might be missed by inaccurate CBD measurement.

### **2. What does this study attempt to show?**

This study attempts to show that CBD dilation rarely occurs in the absence of other abnormal ultrasound or laboratory findings in the setting of cholecystitis and choledocholithiasis. We hope to show scenarios for which CBD measurement could safely be omitted in cases when adequate CBD identification is technically difficult or otherwise uncertain.

### **3. What are the key findings?**

Isolated CBD dilation without other ultrasound or laboratory abnormalities is a rare finding in cholecystitis and choledocholithiasis. Sonographic CBD measurement does not provide unique information in the ED workup for cholecystitis or choledocholithiasis.

### **4. How is patient care impacted?**

A decreased emphasis on the sonographic CBD measurement should bolster emergency physician confidence in performing biliary ultrasound. Improving emergency physician comfort with point-of-care biliary ultrasound and increasing its use in the ED could expedite patient care and disposition.