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ORIGINAL RESEARCH

Utility of Common Bile Duct Identification on Biliary Ultrasound in Emergency Department Patients

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Background: Biliary ultrasound is often utilized in the evaluation of abdominal pain in the Emergency Department (ED). Common bile duct (CBD) identification is traditionally a standard component of the biliary ultrasound examination but can be challenging to perform for the novice sonographer. Previous work has demonstrated that CBD dilatation is rare in cases of cholecystitis with normal liver function tests (LFTs). We sought to assess the frequency of CBD dilatation in the subset of ED patients undergoing hepatobiliary ultrasound who have normal LFTs and an absence of gallstones or biliary sludge on ultrasound. We also performed an assessment of changes in CBD diameter by age and cholecystectomy status.

Methods: This was a retrospective chart review at a single academic ED. Patients were enrolled in the study if they underwent a radiology performed (RP) hepatobiliary ultrasound within the 2 year study period. Records were reviewed for the presence of gallstones or sludge, CBD diameter, age, clinical indication for the ultrasound, and LFTs. Descriptive analyses were performed, and interobserver agreement among data abstractors was assessed by *K* analysis for the presence of CBD dilatation. The Mann–Whitney test was utilized to assess statistical significance in the comparison of differences between CBD diameters amongst age groups.

Results: Of 1929 RP hepatobiliary ultrasounds performed in the study period, 312 were excluded and 1617 met inclusion criteria. Amongst these, there were 506 patients who had normal LFTs and an ultrasound with no stones or sludge. Ten patients within this group had a dilated CBD > 7 mm (1.98%, 95% CI of 1.08% to 3.6%). We also noted a statistically significant increase in CBD size in the older age cohort and in those individuals with a history of cholecystectomy.

Conclusion: CBD dilation in ED patients who present with normal LFTs and an absence of gallstones and biliary sludge is rare. Physicians should be reassured that the routine identification of the CBD on ultrasound in this setting is of low yield and need not be pursued.

Plain Language Summary: The common bile duct is often taught as part of the biliary point-of-care ultrasound examination. However, it is more challenging to identify than the gallbladder and thus may limit adoption of POCUS by ED physicians. Our study adds to the body of work demonstrating that omitting the common bile duct from an ultrasound evaluation is likely reasonable when both the gallbladder and liver function tests are normal. Our study also adds to the literature regarding the increase in common bile duct size with age and with post-cholecystectomy status.

Keywords: biliary, common bile duct, ultrasound, gallstones, cholelithiasis, point-of-care ultrasound

Introduction

Background

Acute manifestations of biliary disease are a common source of Emergency Department (ED) visits in the United States.[1,2] Ultrasound is often the initial diagnostic imaging modality employed in the evaluation of these patients,[3] as alternate imaging modalities such as computed tomography (CT) often have inadequate sensitivity for gallstone identification.[4] Point-of-care

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biliary ultrasound performed by the ED physician has been shown to have high accuracy in the detection of both cholelithiasis and cholecystitis.[5–8] In addition, it has been shown to be predictive of surgical outcomes[9] and expedite care via a reduction in ED length of stay.[10,11] However, ED physicians using point-of-care ultrasound have demonstrated more mixed results in successfully identifying the common bile duct (CBD), with sensitivities ranging from 0% to 60%.[12] CBD identification is often considered a core component of the biliary ultrasound in the setting of right upper quadrant pain.[12,13] CBD identification is also part of the American College of Emergency Physicians (ACEP) emergency ultrasound imaging compendium, wherein the strategy to identify this structure is discussed.[14]

Importance

Given the difficulty in CBD identification and the potential perceived importance of this component of biliary ultrasound, an ED physician may hesitate in employing POCUS for right upper quadrant evaluations. CBD dilatation can be important to identify, as it can be associated with malignancy, choledocholithiasis, chronic pancreatitis, periampullary diverticula, and choledochal cysts.[15,16] However, prior work has demonstrated that CBD identification is not always necessary for the ED physician utilizing biliary ultrasound in certain scenarios. Lahham et al performed a prospective study of ED patients receiving biliary POCUS, liver function tests (LFTs), and white blood cell count (WBC).[13] They found that complicated biliary pathology was rare in the setting of normal laboratory values and a POCUS exam that was without gallbladder wall thickening, pericholecystic fluid, and sonographic murphy's sign. A retrospective study by Becker at al. assessed a cohort of ED patients who had received radiology performed (RP) biliary ultrasound, had normal laboratory values, and were diagnosed with cholecystitis.[17] They found that isolated CBD dilatation was rare in this population, occurring in 0.3% of the cohort.

Goals of This Investigation

Our study seeks to add to the above literature through evaluation of how often CBD dilatation occurs in the setting of normal LFTs and a biliary ultrasound that is without gallstones or biliary sludge. This question was targeted for the bedside clinician who seeks to understand how often the CBD might be dilated when the gallbladder is without stones or sludge and the LFTs are normal. As biliary ultrasound examinations are often negative, our study seeks to reassure the ED physician encountering an otherwise negative ultrasound and reassuring LFTs regarding the omission of routine CBD identification.

Materials and Methods

Study Design

This was a retrospective medical record review performed at a single academic tertiary care center with an annual ED census of 70,000 patients. The University of Virginia Institutional Review Board approved the study protocol prior to study initiation. The study period was the two years between January 1, 2020, and December 31, 2021. This academic site includes active emergency medicine, radiology, and surgery residency programs. Point-of-care biliary ultrasound is also performed at the hospital site, but these generally do not include a CBD measurement and thus were not analyzed in the present study. The reporting of this study conforms to Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[18]

Patients who received both LFTs and a radiology performed biliary or hepatobiliary ultrasound during the course of their ED visit were included in the study. The radiology picture archiving and communication system (PACS) was queried to identify all ED patients who had received a biliary ultrasound in the specified two-year time period. This included both adult and pediatric ED patients. The electronic medical record was queried to identify those patients who had also received LFTs as part of their ED evaluation. The clinical indication for the ultrasound was recorded for each patient. The majority of enrolled patients had abdominal pain as the clinical indication for the ultrasound. It is standard practice for RP biliary ultrasounds to include a measurement of the CBD at our institution. Variables assessed included the presence of gallstones, presence of biliary sludge, clinical indication for the ultrasound, and CBD diameter. These were abstracted from the radiologist report. Figure 1 represents an allocation diagram that details the inclusion and exclusion criteria for the study.

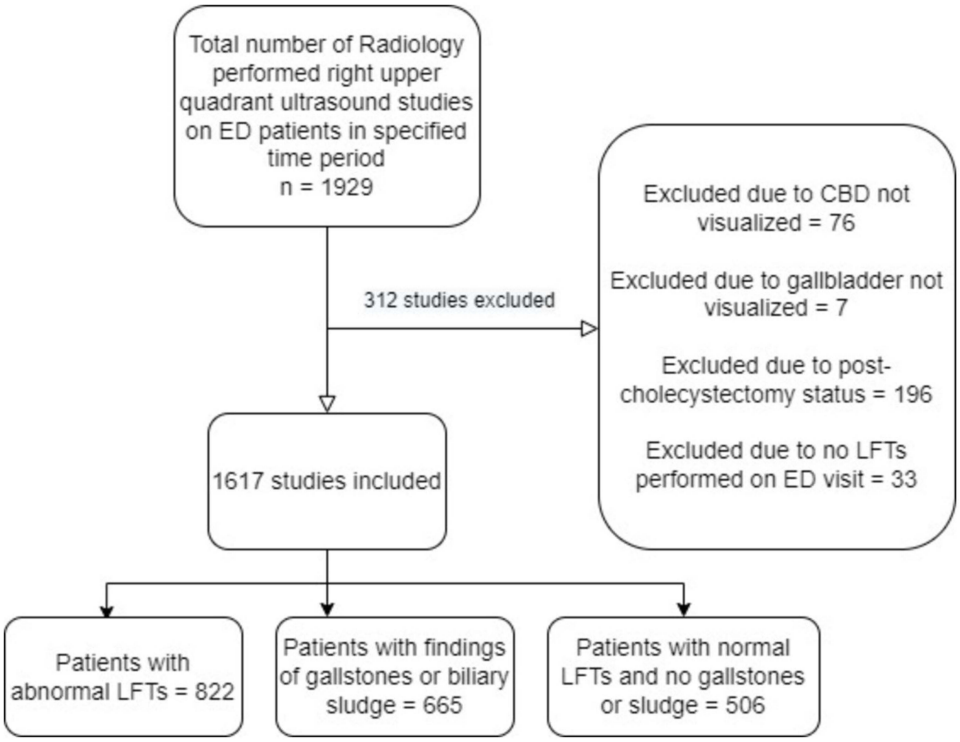

Figure 1 Allocation diagram for included studies. Note that there were patients with both abnormal liver function tests (LFTs) and gallstones, which results in a total of greater than 1617.

Data Abstraction

PACS and the electronic medical record were reviewed by two separate physician investigators and one medical student investigator utilizing a standardized data abstraction form. Each investigator independently abstracted data following a training session to standardize data collection strategies. The training session involved a stepwise, systematic procedure to abstract each data element and record it onto the standardized data abstraction form. Any discrepancies in data extraction were resolved through discussion and consensus. Interobserver agreement among data abstractors was assessed by *K* analysis for the presence of CBD dilatation.

All ultrasound data were obtained from the finalized radiology report, and each ultrasound was read by an attending radiologist. The presence of gallstones, biliary sludge, CBD diameter, and the indication for the exam were each recorded. A sonographic CBD measurement >7 mm was defined as dilated for this study, with CBD diameters ≤7 mm defined as normal. The age of each patient was also recorded.

From the electronic medical record (Epic Systems, Verona, Wisconsin), the data abstractors recorded the presence or absence of elevated LFTs. This involved assessing the level of aspartate aminotransferase (AST; normal <35 IU/L), alanine aminotransferase (ALT; normal < 55 IU/L), alkaline phosphatase (ALP; normal 40–150 IU/L), and total bilirubin (Tbili, normal 0.3–1.2 MG/DL).

Objectives

The primary objective was to assess the frequency of CBD dilatation amongst patients with normal LFTs and a biliary ultrasound with no gallstones or sludge present. Secondary Objectives included an analysis of CBD diameter in different age cohorts.

Analysis

Descriptive analyses were performed using VassarStats statistical computation software. Continuous data were presented as means with standard deviations (SD), while percentage frequency of occurrence is presented with 95% confidence

intervals (CI). Interobserver agreement among data abstractors was assessed by *K* Analysis for the presence of CBD dilatation. The Mann–Whitney test was utilized to assess statistical significance in the comparison of differences between CBD diameters amongst age groups.

Results

A total of 1929 RP biliary ultrasounds were performed on ED patients in the two-year study period. Out of these 1929 ultrasound studies, 312 were excluded secondary to the CBD being not visualized (n = 76), the gallbladder being not visualized (n = 7), the patient having had a prior cholecystectomy (n = 196), and no LFTs being performed during the ED visit (n = 33). Average patient age was 42 years old with a standard deviation of 18.6. Ninety-four patients in our cohort were pediatrics, as defined by age less than 18 years old.

Amongst the 1617 studies included, 506 met our target population of having normal LFTs and no gallstones or sludge visualized in the gallbladder. Within this cohort of 506, ten patients had a dilated CBD > 7 mm (1.98%, 95% CI of 1.08% to 3.6%). The details of these patients are shown in Table 1. Only one of the ten patients received an intervention for pathology associated with the dilated CBD. Seven hundred and ninety-five of the 1617 included studies had normal LFTs, with 40 of this

Table 1 Details of Ten Patients with Normal Liver Function Tests, No Gallstones or Sludge on Ultrasound, and a Common Bile Duct Diameter >7 Millimeters

Patients with normal LFTs, no gallstones or sludge on US, and CBD > 7 mm	
Presentation with abdominal pain and emesis CBD 8 mm, US otherwise unremarkable Discharged home	Returned in 2 days and was admitted for COVID, later found to have perforated duodenal ulcer four days after initial ED visit
Presentation with abdominal pain CBD 8 mm, US otherwise unremarkable Discharged home	No return ED visit or follow up identified in electronic health record
Presentation with abdominal pain CBD 9 mm, US otherwise unremarkable Discharged home	No return ED visit. Had outpatient clinic follow up appointment one week later wherein pain had resolved
Presentation with abdominal pain CBD 13 mm, US noted unchanged chronic dilatation of the CBD	Admitted to hospital for pancreatitis. Had ERCP performed which revealed a pancreatic ductal leak. Received sphincterotomy and pancreatic ductal stent. Etiology of pancreatitis felt to be most likely alcohol related at time of discharge.
Presentation with abdominal pain CBD 12 mm, US noted borderline distended gallbladder	Admitted to hospital for sepsis and received a HIDA scan two days later, which was negative for cholecystitis or CBD obstruction
Presentation with abdominal pain CBD 8 mm, US noted that there was a single area of focal CBD dilatation that was possibly a type I choledochal cyst Discharged home	No return ED visit. Had a follow up MRCP six weeks later that was normal, with no evidence of choledochal cyst or CBD dilatation.
Presentation with abdominal pain CBD 8 mm, US noted CBD diameter was unchanged from prior imaging Discharged home	No return ED visit. Had a follow up gastroenterology clinic appointment one month later, wherein she was treated for constipation.
Presentation with abdominal pain CBD 11 mm, US noted stable extrahepatic ductal dilatation, unchanged from prior imaging.	Admitted to hospital for abdominal pain. Had HIDA scan one day after admission, which showed no evidence of cholecystitis or CBD dilatation.
Presentation with abdominal pain CBD 10 mm, US noted that CBD diameter was unchanged from multiple prior examinations Discharged home	No return ED visit. Had a follow up Family Medicine clinic appointment 3 weeks later, wherein her pain had resolved
Presentation with abdominal pain CBD 11 mm, US noted that CBD diameter was unchanged from prior exams Discharged home	Returned to ED one month later, with no pathology identified and discharged home again. Also followed up with Family Medicine outpatient clinic, who initiated treatment for reflux disease.

Abbreviations: US, ultrasound; CBD, common bile duct; mm, millimeter; ED, emergency department; ERCP, endoscopic retrograde cholangiopancreatography; MRCP, magnetic resonance cholangiopancreatography; HIDA, hepatobiliary iminodiacetic acid scan.

cohort having a dilated CBD (5.0%, 95% CI of 3.7% to 6.8%). There were 289 studies that had normal LFTs but the presence of stones or sludge, with 30 of these having a dilated CBD (10.4%, 95% CI of 7.4% to 14.4%). Interobserver agreement among chart reviewers was excellent for the presence or absence of CBD dilatation (k = 1).

Within the 506 patients with normal LFTs and no gallstones or sludge on ultrasound, the average CBD diameter was 0.383 mm (SD 0.15). Figure 2 provides the average CBD diameter by age group within this cohort of 506 patients. The clinical indication for the ultrasound of these 506 patients was abdominal pain in 496 cases. Alternate clinical indications included vomiting (n = 2), chest pain (n = 3), and abdominal distension (n = 2). The absolute difference in average CBD diameter was small between each age cohort. When comparing the age 18 to 49 cohort to the age 50 and older cohort, the absolute diameter difference was small but also statistically significant. The average CBD diameter was 0.36 cm (SD 0.118) in the age 18 to 49 cohort and CBD 0.46 cm (SD 0.189) in the age 50 and older cohort, $p < 0.0001$.

Amongst the 196 patients with post-cholecystectomy, 53 had normal LFTs. The average CBD diameter in this group of 53 patients was 0.57 cm (SD 0.23). This is also shown in Figure 2. Comparing adults without cholecystectomy (average CBD 0.39 cm, SD 0.15) to adults with cholecystectomy (average CBD 0.57 cm, SD 0.23), there was a statistically significant difference in CBD diameters, $p < 0.0001$.

Discussion

It is uncommon for ED patients with normal LFTs and no biliary sludge or gallstones on ultrasound to have a dilated CBD (<2% of cases in our cohort). In addition, the approximately 2% of patients who do have a dilated CBD in this setting rarely have identifiable pathology pertaining to biliary obstruction or biliary ductal pathology. Our study suggests that in the setting of normal LFTs and no gallstones or sludge visible on ultrasound, the utility of routinely identifying the CBD is low. While not the direct subject of our investigation, this may have implications for the ED physician performing bedside ultrasound, as they will frequently encounter the scenario of ED patients, with abdominal pain

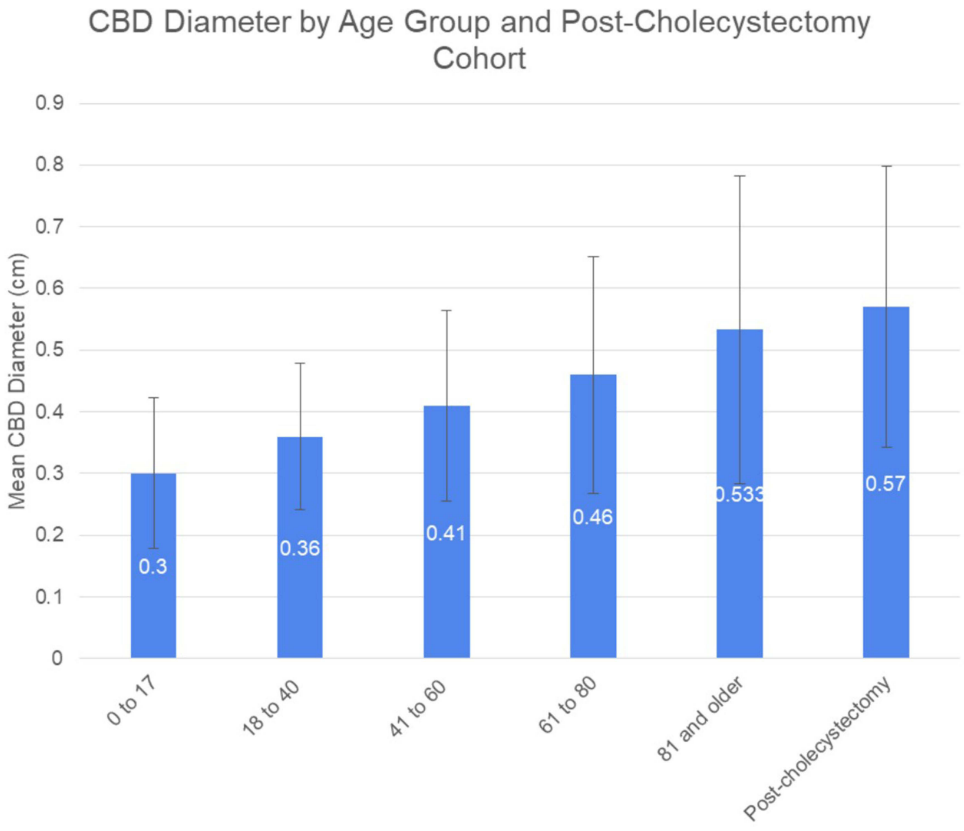

Figure 2 The average common bile duct (CBD) diameter is shown for each age group amongst patients with normal liver function tests (LFTs). Additionally, the average CBD diameter for the post-cholecystectomy cohort is shown.

requiring biliary ultrasound evaluation. We chose to investigate the variables of gallstones and biliary sludge, as these are two commonly encountered findings in ED practice[13] and readily identified on ultrasound. It is often reassuring when these entities are not present on a biliary ultrasound, but the question of how intensely one then needs to pursue CBD identification had not been previously addressed in the literature. Prior studies have focused on the utility of CBD identification in cases of cholecystitis or choledocholithiasis,[13,17] while our study centered on the setting where the gallbladder is without stones or sludge. Given our results, the ED physician should be reassured that the expertise and time surrounding CBD identification will generally not be needed in these scenarios. This knowledge may help incentivize point-of-care biliary ultrasound usage, as CBD identification takes additional time and expertise[12] and thus could discourage point-of-care ultrasound. We would note that the skill of CBD identification should still be encouraged and our results would suggest that CBD identification becomes more important in the setting of gallstones or biliary sludge, even with normal LFTs. A protocol of omitting CBD identification in the setting of no stones or sludge and normal LFTs would likely be reasonable based on our results and those of related studies. However, if a provider is trained in CBD identification and there are elevated LFTs or gallstones, then a pursuit of the CBD would be prudent. Alternatively, the presence of gallstones or elevated LFTs might necessitate an RP ultrasound if the CBD is not able to be identified on POCUS.

Figure 3 provides an example of a normal gallbladder on biliary ultrasound, while Figure 4 provides an example of CBD identification and measurement with a normal CBD diameter. It should be noted that as CBD diameter increases, it is likely easier to identify on ultrasound. Figure 5 provides an example of a dilated CBD.

We chose a cuttoff of 7 mm for the top normal CBD diameter, as this has been supported as the upper limit of normal in previous literature and systematic reviews.[15,19,20] This is also perhaps somewhat conservative in the older age group, where the upper limit of normal has been suggested to be up to 8.5 mm.[21] However, there exists some debate on the upper limit of normal and whether this should be dependent on age, post-cholecystectomy status, height, weight, or BMI.[20] It is also important to note that the imaging modality itself can affect CBD measurements. In one study comparing endoscopic retrograde cholangiopancreatography (ERCP) to ultrasound, there was a 2 mm difference in measurement between the modalities.[22]

Whether the CBD diameter increases with higher age groups has also been subject to debate. Existent literature generally supports the notion that the CBD diameter increases by age,[19,23,24] but there is also literature that refutes this association.[25] The landmark study by Wu et al that established the "changes by decade" paradigm so that 5 mm is normal in the 50s, 6 mm in the 60s, and so forth was felt to exaggerate the age change secondary to the significant inclusion of pediatric patients.[25] This was felt

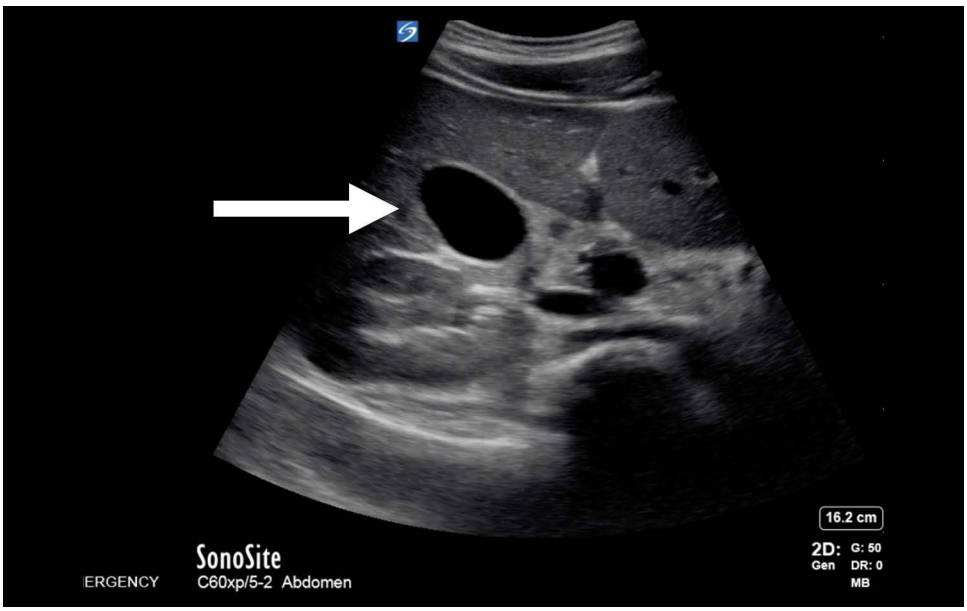

Figure 3 Normal sonographic appearance of the gallbladder on ultrasound. Arrow denotes gallbladder.

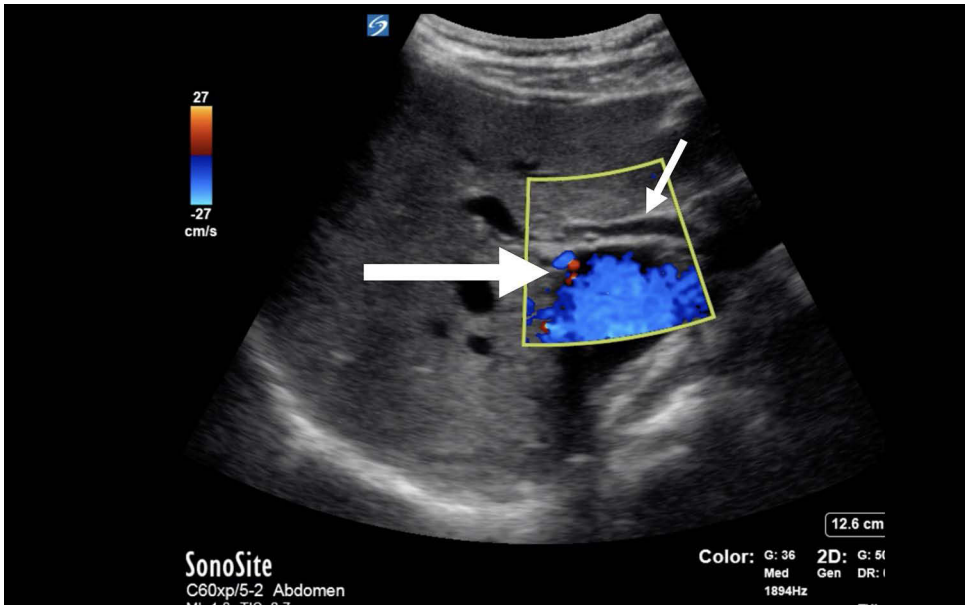

Figure 4 Normal sonographic appearance of the common bile duct. Large arrow represents portal vein with color Doppler applied. Small arrow represents common bile duct.

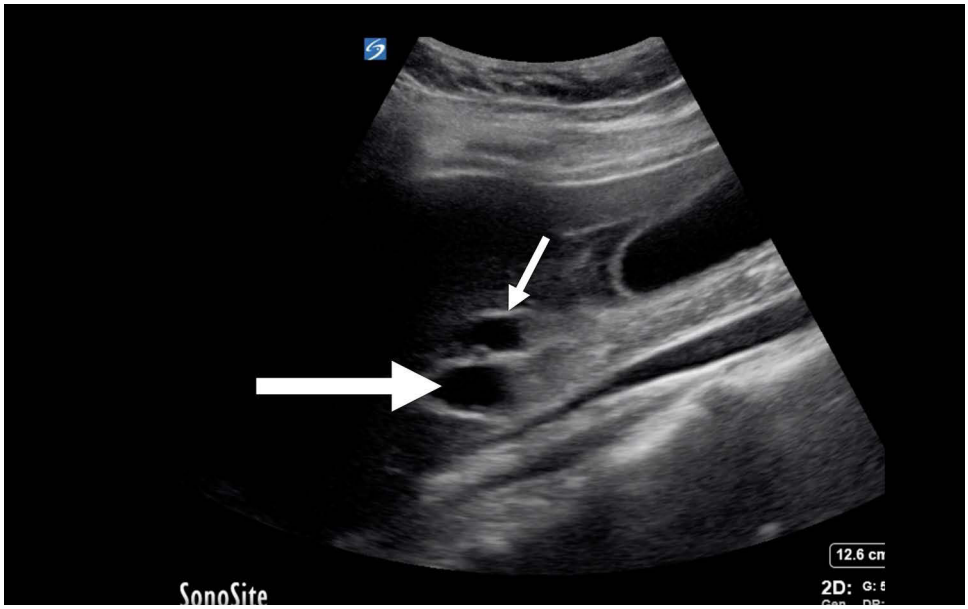

Figure 5 Sonographic appearance of a dilated common bile duct. Large arrow represents portal vein. Small arrow represents common bile duct.

to have skewed the results and exaggerated the size difference by age. The largest study to date on this question included 1018 patients and showed a small, but statistically significant, increase in CBD diameter with a mean diameter of 3.6 mm in age 60 and younger and mean diameter of 4 mm in age over 85.[26] In our current study, we did note a similar slight increase in CBD diameter by age cohort in our group of patients with normal LFTs and no stones or sludge on ultrasound. Our difference was statistically significant, but also with small absolute changes in CBD diameter consistent with the aforementioned study of 1018 patients.

Limitations

Our study has several limitations inherent in the retrospective design and single academic location, which may limit its applicability to other practice settings. The study population chosen was ED patients who had radiology performed

hepatobiliary ultrasound studies. This population was chosen because the CBD identification and measurement are a standard component of that exam, as evidenced by only 76/1929 studies (3.9%) not having the CBD identified and measured. However, our department also has an active point-of-care ultrasound (POCUS) program, wherein approximately 250 biliary ultrasounds are performed on ED patients each year. The practice of CBD identification and measurement is much more variable in the POCUS cohort, and the total number of ultrasounds performed is significantly smaller. Given this, the RP ultrasound cohort was more appropriate for our study design and objective. However, this does highlight the potential for selection bias, wherein the group of patients receiving RP ultrasound may have been different in some fashion to the greater population of ED patients receiving biliary ultrasound as a whole. For example, more complex patients with comorbid medical conditions and a broader differential diagnosis could be more likely to receive RP ultrasound than POCUS. In addition, patients with more challenging sonographic windows, such as those with larger body habitus, could also be more likely to receive RP ultrasound. This may limit the generalizability of our findings, as the rate of CBD dilatation could differ between these patient cohorts. However, in our experience, which patient receives a POCUS biliary ultrasound or RP biliary ultrasound is more a function of whether the attending ED physician has POCUS experience and regularly performs this exam.

Importantly, we elected to consider only those patients with no gallstones, no biliary sludge, and normal LFTs for evaluation of the primary study outcome. We did not specifically assess the test characteristics of other sonographic features of biliary disease such as pericholecystic fluid (PCF), wall thickening (WT), and the sonographic Murphy's sign (SMS). While this limits the applicability of our results, it has been previously noted that only a small minority of cases (5 to 10%) of cholecystitis occurs without gallstones or biliary sludge,[27] making the identification of these entities perhaps most relevant for the ED physician. An ED physician is also more likely to encounter a gallbladder with gallstones or biliary sludge than one with PCF or WT, making this study question particularly relevant to daily ED practice. However, this does limit our findings to the select population with no gallstones and no biliary sludge, as our results do not provide data on patients with other sonographic features that could be relevant in certain cases. Our objective in choosing to analyze patients with no biliary sludge or gallstones was to provide data on this previously unstudied patient cohort.

Conclusion

In summary, CBD dilatation is rare in patients presenting to the ED with abdominal pain who have normal LFTs and ultrasound imaging without stones or sludge. Given this, the routine identification and measurement of CBD size is of low utility within this cohort. There is an association between increased CBD diameter and age, though the absolute difference between groups is small.

Ethics and Consent Statements

The University of Virginia Institutional Review Board did not require patient consent for this study. This waiver was provided secondary to the retrospective nature of the study and the maintenance of all data on secure University of Virginia Health System servers. All patient data was kept confidential and in compliance with the Declaration of Helsinki.

Acknowledgments

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Disclosure

The authors report no conflicts of interest in this work.

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