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DIAGNOSTIC ACCURACY OF ULTRASOUND AND LIVER FUNCTION TESTS FOR THE EARLY DETECTION OF COMMON BILE DUCT STONE

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ABSTRACT

Introduction:
Common bile duct stone (CBDS) is significantly challenging to predict via basic ultrasound impressions and LFTs; hence, making decisions and taking prompt action is difficult. The main goal of this study is to find out how useful ultrasound (US) and liver function tests (LFTs) are for finding common biliary duct stones.

Materials and Methods:
This retrospective observational study was conducted at the gastroenterology ward of Shifa International Hospital Islamabad. It includes data on 768 patients who underwent ultrasound and LFTs for the diagnosis of CBDS. After receiving consent, the investigator documented relevant patient demographics, ultrasound reports, and LFTs. Receiver operating characteristic curve (ROC) and area under the curve (AUC) analyses were used to compare the diagnostic performance of US and LFTs.

Results:
Compared to LFTs that included ALP, gGT, and SGOT, the

sensitivities were 0.801, 0.913, and 0.849. The sensitivity reported for ultrasound impressions—CBD Diameter and CBD Obstruction—was 0.727 and 0.753, while the specificities were 0.587 and 0.819, respectively. ROC and AUC showed p-values < 0.05 (p = 0.0001), indicating highly significant outcomes. Each variable had a different AUC. The AUC for bile obstruction and CBD diameter (>7 mm) was 0.786 and 0.735. In contrast, gGT and ALP had AUCs of 0.953 and 0.897, respectively.

Conclusion:

Transabdominal ultrasound impressions are not as sensitive as LFTs in detecting choledocholithiasis, which involves the liver and bile ducts. The gGT test demonstrated the highest sensitivity in diagnosing CBDS

INTRODUCTION

Common bile duct stones (CBDS) represent a significant clinical challenge due to their potential to cause biliary obstruction and associated complications. Timely and accurate diagnosis of CBDS is essential for guiding appropriate management strategies. In the modern era of medical diagnostics, two commonly employed modalities for detecting CBDS are ultrasonography (US) and liver function tests (LFTs) (1).

Moving into diagnostics of CBDS, identification of the right patient is required, where a patient feels pain in the right upper quadrant or epigastric region, mostly accompanied by jaundice, commonly referred to as obstructive jaundice, with fever. This stone condition is also to be expected in patients with acute pancreatitis, as gall stone may move towards the common bile duct (2).

CBDS is one of the complications of Gall stones and may be secondary to acute pancreatitis or possibly during surgery, about 20% are surgical while 10% are mostly asymptomatic (3).

There are three divisions of gallstone formation, one is cholesterol-based, others are pigmented black and hard, or maybe sometimes brown and soft, and the latter is common in bile ducts (4). Cholesterol Stones are primarily associated with genetics and are caused by precipitation of imbalanced cholesterol levels in bile and crystallization (5). The liver can secret high levels of cholesterol, hyper-saturating the bile deposits and cholesterol stones. Impaired gallbladder motility is another cause of gall-stones, this may be because of elevated progesterone levels during pregnancy or maybe in similarity to pregnancy levels of progesterone, increased weight loss, or probably due to parenteral nutrition (6).

Black pigment Stones, causing higher levels of bilirubin in bile, as a result of increased hemolysis can be formed. This kind of stone sometimes post-surgical loss of salts in bile, with increased bilirubin levels as in post-terminal ileum resection patients. Increased enterohepatic blood circulation with increased bilirubin reabsorption promotes black-pigmented stone formation in the gall bladder, this type is common in Crohn's Disease or Liver Cirrhosis (6). Another subtype of pigmented stone is brown pigment stones which are soft compared to black pigment stones and are caused by bile flow obstruction due to any obstruction or maybe because of anaerobic bacterial infection (7).

Risk factors, mnemonic "5F", shows the increased chances of gallstone in females, increased fats, age above forty, given birth to

more than 1 offspring (fertility), and light-toned skin (fair). There are evident reports of family history of patients with gall stones, hence a 6th factor added to the mnemonic (8).
In terms of gender differences, females are more prone to develop gallstones, especially during adolescence and menopause. Although this prevalence would be similar in both genders with age over 40 years. Birth control hormones or pills will increase the level of progesterone and estrogen; the prior one decreases the motility of the gallbladder and the later promotes Cholesterol level and also its precipitation increasing the chances of cholesterol stones. Hence gall stone is most common cause of pregnant women hospitalization (9).
The highest prevalence of gallstones has been seen in North and South American Natives, but it has been reported that 70% of females who are over the age of 30 had gall stones (10). Almost 5% has been recorded in black Africans, while in Caucasians and Asians, the prevalence is somewhat in the middle of both stated earlier (11).
Body mass index above 25, doubles the risks of gall Stone, while it is seven times riskier with a BMI above 45 (12). This is due to more cholesterol levels in the blood and deposition in the bile or bile duct, where it precipitates and crystalizes. HDL levels are high-risk factors for cholesterol stones compared to other variants of cholesterol (13).
This may be common that the identification of gallstones is accidental sometimes while diagnosing for other disease through multiple modalities. A greater majority of patients are asymptomatic, and 20% may develop complications secondary to the stones (14). Symptomatic ones are more probably about 2% per year. Although there is 10 to 20% chance of symptoms recurrence with in the same year (15).
The most common complication is biliary colic (abdominal pain) located under the right rib or at the epigastric region radiating to the back, symptoms are probable to be felt after meal more specifically a fatty meal (16). One-fifth of the population may experience cholecystitis which is the lodging of the stones in the bile duct or at the neck of it. This increases the pressure within the gall bladder causing reduced perfusion and increased edema formation (17). In mild to severe cases, it may cause secondary pancreatitis following bile duct obstruction reducing bile flow and pancreatic juice flow. Laboratory diagnosis for this complication will show a threefold increase in amylases and /or lipases (18).
For definitive diagnosis of suspected Common Bile duct stones, shortly CBDS, the primary diagnostic modality is ultrasound imaging. Although the quality of results may be affected depending on user experience and the nature of CBDS. Sometimes stones are only seen through ultrasonography when and once the stone moves during the examination, where it would cast a shadow, though it is possible to observe stuck stones in the common bile duct or main biliary duct tree (19).
Ultrasonography is a non-invasive imaging technique widely utilized for evaluating hepatobiliary pathology. Its advantages include accessibility, cost-effectiveness, and lack of ionizing radiation. However, the specificity and sensitivity of ultrasound in detecting CBDS remain subjects of debate, particularly regarding its ability to identify smaller stones and those located distally within the common bile duct (20).
Liver function tests, on the other hand, provide valuable biochemical information regarding hepatobiliary function. Elevated levels of serum bilirubin, alkaline phosphatase (ALP), and transaminases are indicative of biliary obstruction, which may result from CBDS. While LFTs offer supplementary diagnostic information, their comparative effectiveness with ultrasound in detecting CBDS warrants further investigation (21).
In the context of the Pakistani population, where the prevalence of CBDS may differ from other regions, there is a notable gap in the literature regarding the comparative diagnostic accuracy of ultrasound and LFTs

for CBDS detection. Addressing this gap is imperative for optimizing diagnostic strategies and improving patient outcomes (22).

Therefore, this study aims to conduct a comparative analysis of ultrasound and liver function tests for the early detection of common bile duct stones. By evaluating the diagnostic performance of these modalities and their respective strengths and limitations, this research contributes valuable insights to the field of hepatobiliary imaging and aids clinicians in making informed diagnostic decisions for patients presenting with suspected CBDS.

Materials and Methods:

This study used a retrospective observational design, analysing data collected from the hospital database spanning 2021 to 2024. It was conducted in the gastroenterology ward of Shifa International Hospital, Islamabad, Pakistan, a tertiary care facility. The study lasted four months, from July 2024 to September 2024, following approval of the research synopsis. The sample size was calculated using the WHO formula with 80% power, a 5% alpha error, and a 95% confidence level for an expected proportion of 50%, yielding a total of 768 patients. The formula used was: $= 2 \times Z^2 \times p\,(1-P) / d^2$. Consecutive sampling was used, focusing on patients meeting the inclusion criteria.

Patients aged 18 and above presenting with clinical symptoms of CBDS (e.g., biliary colic, jaundice, abnormal LFTs), who underwent ultrasound and LFTs for suspected CBDS, and had complete medical records including demographics and diagnostic findings were included in the study. Patients with a history of biliary surgeries or known liver/biliary tract diseases other than CBDS, those with incomplete medical records or inadequate documentation of ultrasound or LFTs, those undergoing additional investigations without LFTs or ultrasound, and pregnant patients or those unsuitable for ultrasound were excluded.

Patient demographic and clinical data were retrieved from electronic medical records. This included ultrasound reports noting common bile duct (CBD) diameter, obstructions, and strictures, as well as Liver Function Tests (LFTs), including serum bilirubin, ALP, SGOT, ALT, and GGT. Data were retrieved from the gastroenterology ward and radiology department databases. Ultrasound and LFT reports were reviewed to assess diagnostic findings for CBDS. Relevant data were recorded, excluding any confidential patient information. Surgery records confirmed CBDS in suspected cases. Secondary data was used, retrieved from hospital and ward records, ensuring no direct patient interaction. Confidential patient information, such as names, contact details, and identification numbers, was excluded to maintain anonymity. Ethical approval was obtained from the hospital ethics committee and the head of the wards. Consent was secured from the hospital administration and data management officers for the sole purpose of research, with strict adherence to confidentiality protocols.

Laboratory investigations included LFTs such as ALP, bilirubin, SGOT, ALT, and GGT. Elevated LFT levels were considered indicative of biliary obstruction. Ultrasound impressions included common bile duct diameter, bile duct obstructions, and strictures. Surgery reports confirmed primary or secondary CBDS. Descriptive statistics included means and standard deviations for continuous variables, while frequencies and percentages were used for categorical variables. LFT biomarkers were categorized into elevated and normal levels and cross-tabulated with CBDS prevalence. Diagnostic performance comparisons used ROC curves and AUC values. All statistical analyses were conducted using SPSS version 22, with results presented in tables and graphs.

RESULTS

The data collected for this study was analyzed via SPSS version 22. A total of 768 individual patient records were obtained from the hospital wards and radiological database. The age of the patients whose data was obtained had a mean age of 38.66 and a standard deviation of 12.498 years, with a minimum age of 18 years and a maximum age limit of 60 years.

Total of 614 patients had no previous hepatic insults, accounting for at least 79.9% of the patients, n=42 (5.5%) of the cases had hepatitis, n=36 (4.7%) underwent hepatic surgeries prior to current hepato-biliary-pancreatic pathologies, other n=41 (5.3%) had undergone Cholecystectomy and n=35 (4.6%) had Obstructive jaundice.

Ultrasound imaging record of previous exposure was obtained for hepatobiliary system assessment, where normal assessments were n=182 (23.7%), Hyperechogenic Liver were seen in n=203 (26.4%) patients, Hypoechogenic was seen in n=194 (25.3%), and dilated CBD was seen in 189 (24.6%) of the cases. Biliary obstructions were seen in almost 487 of the cases, accounting for 63.4% while other 281, that is 36.6% had no biliary obstructions possibly smaller sized stones were there

In total of 608 cases, about 79.2% of the cases, had confirmed CBDS, while 160 (20.8%) cases were without CBDS in records. More negative CBDS cases were seen in females than in male with proportions of 22.6% and 19% respectively. The maximum incidence of Choledocholithiasis was seen in age group of 39 to 45 years with rate of 18.4%, accounting for 112 out of total 608 positive cases Fig.1.

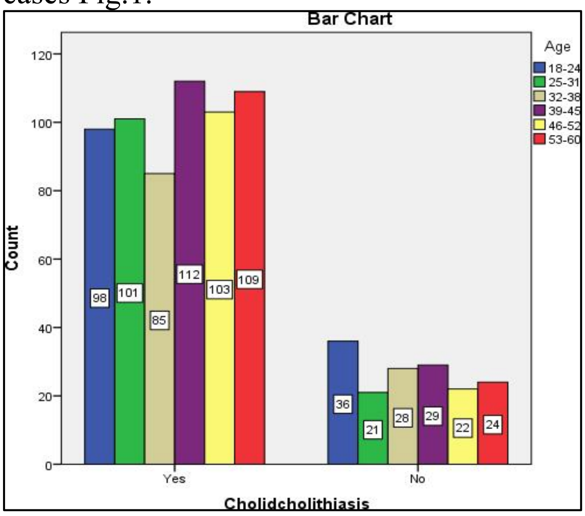

Fig.1.Choledocholithiasis x Age Groups (Clustered bar Chart)

In total 608 positive Choledocholithiasis cases, elevated bilirubin has been seen in 376 patients' records, which is about 61.8% in positive cases while, the elevated levels have also been seen in 67 (41.9%) of negative CBDS patients. Total of elevated gGT levels were seen in 558 cases that is about 72.7% cases, The total reports with below normal levels of gGT were n=210 (27.3%).

This study recorded 698 cases with dilated CBD, making up for 90.9% cases. Out of these 698, total of 608 had positive confirmation of CBD stones that is about 87.1%, while 90 (12.9%) cases did not have any confirmation of CBD stones. Total of 70 (43.8%) of non- dilated CBD were negative for CBDS.

In Summary there were n=608 positive cases of bile Obstruction with Choledocholithiasis. For which ROC curve was implemented with Area under Curve (AUC) was 0.786 and p value of 0.000 ($p<0.05$). The Sensitivity for biliary obstruction (True Positive) as per ultrasound impression for Choledocholithiasis was 0.753 and 1-specificity was 0.181 suggesting specificity of 0.819 Fig.2.

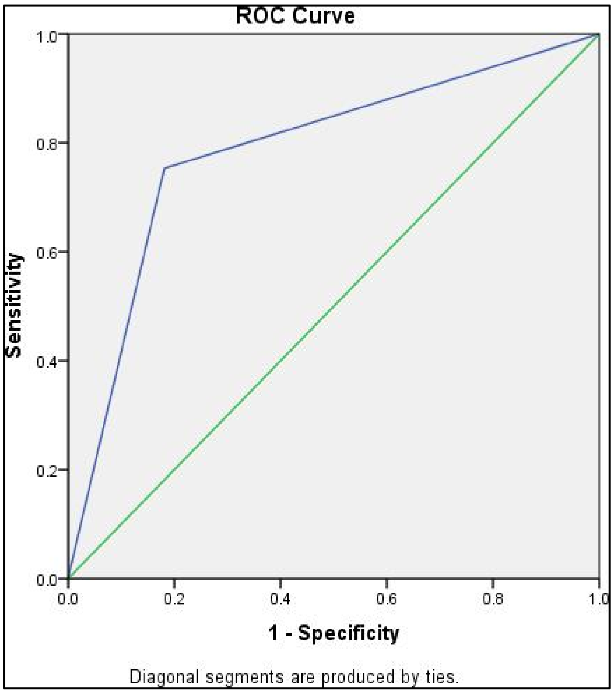

Fig.2.ROC Curve for Bile Obstruction against Choledocholithiasis

According to ROC analysis for LFTS including ALP, ALT, gGT and SGOT levels against Choledocholithiasis, the area under the curve for the said markers were 0.897, 0.747, 0.953, and 0.883, respectively. The maximum AUC in these markers is for g-GT, about 0.953 or 95.3%, as an indicator for more chances of its elevation in cases with prominent CBDS with the cutoff value of above 450 mU/L. On other hand ALP and SGOT are also having 89.7% and 88.3% of significantly accurate positive prediction for CBDS. For all these variables the p value was less than 0.05 at margin where significance is very high for their variable diagnostic accuracy as per AUC Fig.3.
Bilirubin levels were tested out under ROC and AUC for its sensitivity and specificity. The sensitivity above normal levels of Bilirubin for CBDS are very low which 61.8% with specificity of 58.1%. This is suggesting that bilirubin levels are not much statistically relevant to diagnosing CBDS. Also, the AUC for bilirubin is also at 0.621 which is 62.1% indicating poor association.

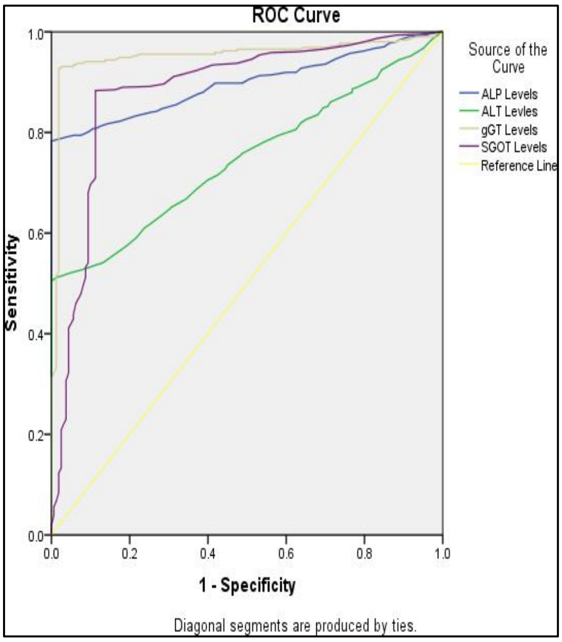

Fig.3.ROC Curve: LFTs against Choledocholithiasis

The Summary of Sensitivity and Specificity of LFTs test included in the study for CBDS diagnosis are displayed in the table below Table.1.

Variable	Cut Off	Sensitivity	1-Specificity	Specificity
ALP	Above 120 IU/L	0.801	0.094	**0.906**
ALT	Above 80 U/L	0.512	0.012	**0.988**
gGt	Above 450 mU/L	0.913	0.019	**0.981**
SGOT	**Above 40 U/L**	**0.849**	**0.113**	**0.887**

Table.1.

Comparison of ROC curve, Sensitivity and Specificity of Ultrasound and LFTs suggested that given parameter for CBDS ultrasound impression, including CBD Dilation and Bile obstruction are less sensitive as compared to levels of ALP, gGT and SGOT levels in patients with clear signs of CBDS. LFTs are more specific as well compared to observed impressions of CBD and Hepatobiliary systems under ultrasound.

DISCUSSION

Diagnosis of CBDS via ultrasound is based on the size of the stone, which is confirmative when the stone is observed in ultrasound imaging. However, this can be challenging, especially in terms of CBD diameter and the presence or absence of primary or secondary dilation. Some stones may not cause obstruction, making detection through imaging alone insufficient. Although ductal dilation or obstruction may suggest the presence of a stone, smaller stones often evade detection. For differential diagnosis, clinicians also assess liver enzymes as supportive markers. This study, being retrospective, used database records to analyse CBD diameter, CBD obstruction (via TAUS), and LFTs (ALT, ALP, gGT, Bilirubin, and SGOT) in patients with hepatobiliary conditions.
The specificity and sensitivity of both modalities—imaging and biochemical—were assessed for diagnosing CBDS. Out of

768 cases, 608 were CBDS-positive. ALT had the lowest sensitivity among LFTs. gGT was the most sensitive (91.3%) and specific (98.1%) biochemical marker, followed by SGOT (sensitivity 84.9%) and ALP (sensitivity 80.1%). The ultrasound findings showed that CBD diameter had 72.7% sensitivity and 58.7% specificity, while CBD obstruction had 75.3% sensitivity and 81.9% specificity. These findings suggest that gGT and other LFT markers are more sensitive and specific than ultrasound impressions in detecting CBDS.

Our findings are consistent with a study by Rahal et al. (2017), which also reported high sensitivity for gGT (83%) and bilirubin (79%) in CBDS cases. Likewise, a study conducted by Samara et al (23). (2022) found ultrasound sensitivity for detecting dilated CBD to be 76.1%, which is close to the 72.7% sensitivity observed in our study. This supports the moderate reliability of TAUS in identifying duct dilation. Additionally, a study by Qamar et al. (2023), conducted at Services Hospital, Lahore, showed 82.69% sensitivity and 92.39% specificity for TAUS, findings that closely align with our data (24).

On the contrary, Chen (2012) reported ultrasound sensitivity as low as 26%, significantly lower than our findings (25). Differences in operator skill, equipment quality, and patient selection criteria may explain these discrepancies. In a retrospective cohort study involving 202 patients, M. Wang et al. (2016) used endoscopic ultrasound (EUS) as a gold standard and confirmed CBDS in 126 cases (62%). EUS showed 100% sensitivity, which far exceeds the performance of TAUS. Similarly, Suzuki et al. (2022) reported that EUS had 100% sensitivity and 88.2% specificity, supporting its role as a superior but less accessible diagnostic modality(26).

Another significant point is that bilirubin, although elevated in many hepatobiliary disorders, lacked consistent diagnostic accuracy for CBDS in our analysis. This aligns with findings from Yuen et al. (2023), who reviewed several studies showing mixed results for bilirubin as a reliable predictor. Some studies reported statistical significance for bilirubin cut-off levels (e.g., 1.8–4 mg/dL), while others found no association. Our study found that bilirubin levels, even when elevated, were not statistically significant predictors of CBDS. This is likely due to the transient nature of bilirubin elevation, variability among patients, and non-obstructive stones.

Studies have also emphasized the significance of ALP and gGT at certain thresholds. Literature supports that gGT levels above 350–450 IU/L are reliable indicators of CBDS, which is consistent with our findings where levels above 450 IU/L were associated with >90% sensitivity. ALP levels between 116 and 400 IU/L showed high diagnostic accuracy across multiple studies (Jovanović et al., 2011; Tozatti et al., 2015; Kang et al., 2016(27)). In our data, ALP was highly specific (90.6%) at levels above 120 IU/L. These biomarkers, when combined with imaging, provide more reliable diagnostic outcomes than using either alone.

On the other hand, ALT and AST were found to have low diagnostic value in our study. While literature (e.g., Bangaru et al., 2017; Björnsson, 2019) supports their temporary elevation in acute obstruction or inflammation, these enzymes rapidly normalize post-obstruction or surgery(28). Our findings indicate that ALT/AST levels around or above 80 IU/L offered minimal sensitivity and specificity, possibly due to non-occlusive stones or resolved episodes. However, CBD diameter as a predictor aligns with existing literature, with multiple studies suggesting that a diameter greater than 7–8.5 mm correlates with CBDS presence. In our study, a cut-off of 7 mm yielded 72.7% sensitivity.

Furthermore, a study by Al-Jiffry et al. (2013) showed abnormal LFTs in 47.2% of ERCP-confirmed CBDS cases, with CBD diameters averaging 8.8–9 mm. This supports our findings that LFTs are helpful but not independently definitive, and that CBD diameter, while useful, may yield false positives . A more robust diagnosis may require multimodal strategies, particularly for smaller or non-obstructive stones.

Interestingly, the current study did not explore WBC count as a potential predictor, but Nárvaez Rivera et al. (2016) suggested this might be useful when combined with LFTs and imaging. Likewise, gender-based differences in CBDS prevalence were not significant in our sample (50.5% male vs. 49.5% female), contrasting with Zgheib et al. (2021), who found higher prevalence in females. This indicates that gender may not be a consistent risk factor and that disease prevalence may vary across populations.

Lastly, some studies have emphasized the limitations of ultrasound as a standalone modality. Zahur et al. (2019) and Silva et al. (2019) suggest that US should ideally be used in combination with advanced imaging (e.g., MRCP, ERCP) for accurate stone localization. Moreover, studies such as Richard et al. (2013) and Aslam et al. (2022) emphasize the role of MRI and CT in providing more definitive diagnoses, especially in patients with inconclusive ultrasound findings. Despite this, the accessibility, cost-effectiveness, and non-invasiveness of TAUS still make it the first-line imaging modality in most clinical settings.

CONCLUSION

In conclusion, our study supports gGT and ALP as the most reliable biochemical markers for CBDS. TAUS parameters such as duct dilation and obstruction are moderately sensitive but less specific. Bilirubin and transaminases (ALT/AST) are less useful for diagnosis. These results are consistent with several other published studies. gGT, with a sensitivity of 91.3% and specificity of 98.1%, emerged as the top biomarker in our analysis.

ALP also showed high diagnostic value, with an optimal sensitivity (80.1%) and specificity (90.6%) at cutoff levels above 120 IU/L. SGPT followed closely, with high diagnostic accuracy. On the other hand, bilirubin and ALT/AST performed poorly due to their transient nature and limited specificity for CBDS.

Although TAUS remains the most accessible and commonly used imaging modality, our findings emphasize the superior sensitivity of selected LFTs—particularly gGT and ALP—in diagnosing CBDS. Reliance on a single marker or modality may result in underdiagnosis. Thus, a combined diagnostic approach, using TAUS along with key liver enzymes, offers the most effective and practical solution for early and accurate CBDS detection.

REFERENCES

1. Gurusamy, K. S., Giljaca, V., Takwoingi, Y., Higgie, D., Poropat, G., Štimac, D., & Davidson, B. R. (2015). Ultrasound versus liver function tests for diagnosis of common bile duct stones. The Cochrane Database of Systematic Reviews, 2015(2), CD011548. ht.
2. Williams, E., Beckingham, I., El Sayed, G., Gurusamy, K., Sturgess, R., Webster, G., & Young, T. (2017). Updated guideline on the management of common bile duct stones (CBDS). Gut, 66(5), 765–782. https://doi.org/10.1136/gutjnl- 2016-312317.
3. Hjaltadottir, K., Haraldsdottir, K. H., & Moller, P. H. (2020). [Gallstones - review].
4. Vítek, L., & Carey, M. C. (2012a). New pathophysiological concepts underlying pathogenesis of pigment gallstones. Clinics and Research in Hepatology and Gastroenterology, 36(2), 122–129. https://doi.org/10.1016/j.clinre.2011.08.010.
5. Di Ciaula, A., Wang, D. Q.-H., & Portincasa, P. (2018). An update on the pathogenesis of cholesterol gallstone disease. Current Opinion in Gastroenterology, 34(2), 71–80. https://doi.org/10.1097/MOG.0000000000000423.
6. Rebholz, C., Krawczyk, M., & Lammert, F. (2018). Genetics of gallstone disease. European Journal of Clinical Investigation, 48(7), e12935.

https://doi.org/10.1111/ECI.12935.
7. Vítek, L., & Carey, M. C. (2012b). New pathophysiological concepts underlying pathogenesis of pigment gallstones. Clinics and Research in Hepatology and Gastroenterology, 36(2), 122–129. https://doi.org/10.1016/J.CLINRE.2011.08.010.
8. Bass, G., Gilani, S. N. S., & Walsh, T. N. (2013). Validating the 5Fs mnemonic for cholelithiasis: time to include family history. Postgraduate Medical Journal, 89(1057), 638–641. https://doi.org/10.1136/POSTGRADMEDJ-2012-131341.
9. Ansari-Moghaddam, A., Khorram, A., Miri-Bonjar, M., Mohammadi, M., & Ansari, H. (2015). The Prevalence and Risk Factors of Gallstone Among Adults in South-East of Iran: A Population-Based Study. Global Journal of Health Science, 8(4), 60–67. https://doi.o.
10. Grimaldi, C. H., Nelson, R. G., Pettitt, D. J., Sampliner, R. E., Bennett, P. H., & Knowler, W. C. (1993). Increased mortality with gallstone disease: Results of a 20-year population-based survey in Pima Indians. Annals of Internal Medicine, 118(3), 185–1.
11. Stinton, L. M., & Shaffer, E. A. (2012). Epidemiology of gallbladder disease: Cholelithiasis and cancer. Gut and Liver, 6(2), 172–187. https://doi.org/10.5009/GNL.2012.6.2.172.
12. Pak, M., & Lindseth, G. (2016). Risk factors for cholelithiasis. Gastroenterology Nursing, 39(4), 297–309. https://doi.org/10.1097/SGA.0000000000000235.
13. Cruz-Monserrate, Z., Conwell, D. L., & Krishna, S. G. (2016). The Impact of Obesity on Gallstone Disease, Acute Pancreatitis, and Pancreatic Cancer. Gastroenterology Clinics of North America, 45(4), 625–637. https://doi.org/10.1016/J.GTC.2016.07.010.
14. Shabanzadeh, D. M. (2018). Incidence of gallstone disease and complications. Current Opinion in Gastroenterology, 34(2), 81–89. https://doi.org/10.1097/MOG.0000000000000418.
15. Lammert, F., Gurusamy, K., Ko, C. W., Miquel, J.-F., Méndez-Sánchez, N., Portincasa, P., van Erpecum, K. J., van Laarhoven, C. J., & Wang, D. Q.-H. (2016). Gallstones. Nature Reviews. Disease Primers, 2, 16024. https://doi.org/10.1038/nrdp.2016.24.
16. Fraquelli, M., Casazza, G., Conte, D., & Colli, A. (2016). Non-steroid anti-inflammatory drugs for biliary colic. Cochrane Database of Systematic Reviews, 2016(9). https://doi.org/10.1002/14651858.CD006390.PUB2.
17. Kimura, Y., Takada, T., Kawarada, Y., Nimura, Y., Hirata, K., Sekimoto, M., Yoshida, M., Mayumi, T., Wada, K., Miura, F., Yasuda, H., Yamashita, Y., Nagino, M., Hirota, M., Tanaka, A., Tsuyuguchi, T., Strasberg, S. M., & Gadacz, T. R. (2007). Definitions,.
18. Greenberg, J. A., Hsu, J., Bawazeer, M., Marshall, J., Friedrich, J. O., Nathens, A., Coburn, N., May, G. R., Pearsall, E., & McLeod, R. S. (2016). Clinical practice guideline: Management of acute pancreatitis. Canadian Journal of Surgery, 59(2), 128–140.
19. Wertz, J. R., Lopez, J. M., Olson, D., & Thompson, W. M. (2018). Comparing the diagnostic accuracy of ultrasound and CT in evaluating acute cholecystitis. American Journal of Roentgenology, 211(2), W92–W97. https://doi.org/10.2214/AJR.17.18884/ASSET/IMAGE.
20. Costi, R., A, G., F, D. M., & Sarli, L. (2014). Diagnosis and management of choledocholithiasis in the golden age of imaging, endoscopy and laparoscopy. World J Gastroenterol, 20(37), 13382–13401. https://doi.org/10.3748/wjg.v20.i37.13382].
21. Everhart, J. E., & Ruhl, C. E. (2009). Burden of digestive diseases in the United States Part III: Liver, biliary tract, and pancreas. Gastroenterology, 136(4), 1134–1144.

https://doi.org/10.1053/j.gastro.2009.02.038.
22. Anwer, M., Asghar, M. S., Rahman, S., Kadir, S., Yasmin, F., Mohsin, D., Jawed, R., Memon, G. M., Rasheed, U., & Hassan, M. (2020). Diagnostic Accuracy of Endoscopic Ultrasonography Versus the Gold Standard Endoscopic Retrograde Cholangiopancreatography i.
23. Samara, O., Azzam, M. I., Alshrouf, M. A., Khanfar, A. N., Mohialdeen, R. R., Barham, O. F., Barham, M. F., & AlRyalat, S. A. (2022). Diagnostic accuracy of ultrasonography compared with magnetic resonance cholangiopancreatography in the detection of chol.
24. Qamar, R., Baig, M. F., & Ashraf, R. (2023). Diagnostic Accuracy of Transabdominal Ultrasound (TAUS) in Detection of the Common Bile Duct Stone in Suspected Patients Taking Intra-Operative Findings as Gold Standard. Pakistan Journal of Medical and Health .
25. Chen, C.-C. (2012). The efficacy of endoscopic ultrasound for the diagnosis of common bile duct stones as compared to CT, MRCP, and ERCP. Journal of The Chinese Medical Association, 75(7), 301–302. https://doi.org/10.1016/J.JCMA.2012.05.002.
26. Suzuki, M., Sekino, Y., Hosono, K., Yamamoto, K., Kawana, K., Nagase, H., Kubota, K., & Nakajima, A. (2022). Endoscopic ultrasound versus magnetic resonance cholangiopancreatography for the diagnosis of computed tomography-negative common bile duct stone:
27. Tozatti, J., Mello, A. L. P., & Frazon, O. (2015). Predictor factors for choledocholithiasis. Arquivos Brasileiros de Cirurgia Digestiva : ABCD = Brazilian Archives of Digestive Surgery, 28(2), 109–112. https://doi.org/10.1590/S0102-67202015000200006.
28. Björnsson, H. K., & Björnsson, E. S. (2019a). A significant proportion of patients with choledocholithiasis have markedly elevated alanine aminotransferase. Scandinavian Journal of Gastroenterology, 54(9), 1155–1159. https://doi.org/10.1080/00365521.2019.