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Diagnostic Accuracy of Magnetic Resonance Cholangiopancreatography against Percutaneous Transhepatic Cholangiography among Patients with Obstructive Jaundice Treated at Muhimbili National Hospital

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Abstract

Background: Biliary obstruction carries high morbidity and mortality, often complicated by diagnostic challenges. While Magnetic Resonance Cholangiopancreatography (MRCP) offers a noninvasive method for detecting biliary strictures, its accuracy compared to the established Percutaneous Transhepatic Cholangiopancreatography (PTC) remains underexplored in Tanzania. This study evaluates the diagnostic performance of MRCP against PTC among patients with obstructive jaundice at Muhimbili National Hospital (MNH), aiming to support evidence-based clinical decision-making.

Objective: To determine the diagnostic accuracy of MRCP compared to PTC for detecting biliary strictures in patients with obstructive jaundice treated at MNH from July 2019 to December 2022.

Methodology: This cross-sectional study was conducted at MNH from July 2019 to December 2022. Patients with obstructive jaundice who underwent both MRCP and PTC were selected using non-probability consecutive sampling. The study assessed the sensitivity, specificity, negative predictive value (NPV), positive predictive value (PPV), and overall accuracy of MRCP compared to PTC results.

Results: In a study of 57 obstructive jaundice patients, MRCP demonstrated high performance in identifying ductal strictures, with sensitivities ranging from 70.0% to 98.1% and specificities between 89.4% and 100%, depending on the stricture site. PPV varied from 58.3% to 100%, while NPV ranged from 75.0% to 95.6%. The overall diagnostic accuracy for MRCP across all stricture types was notably high at 98.2%.

Conclusion: In the current study, MRCP has demonstrated a high overall diagnostic accuracy in the detection of biliary strictures. Therefore, affirming the reliability and consistency of MRCP as a valuable non-invasive diagnostic tool for biliary strictures.

Recommendation: Physicians should utilize a non-invasive MRCP technology to ensure accurate and timely diagnosis of biliary strictures.

Keywords: *Biliary strictures, Diagnostic accuracy,* Magnetic Resonance Cholangiopancreatography (MRCP), Percutaneous Transhepatic Cholangiopancreatography (PTC).

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Introduction

Biliary obstruction is a global health concern resulting from the blockage of biliary flow to the duodenum (1). It is associated with diminished quality of life, heightened morbidity, and mortality, further complicated by diagnostic challenges (2–4). Biliary obstruction occurs among 20 people per 1,000 population in the United States (5) and in 10 to 50 people per 1,000 population in Africa (1). It can be caused by several factors, ranging from benign to malignant, with common benign factors including choledocholithiasis, chronic pancreatitis, and hepatic abscesses (3,4). The malignant etiologies in that order are pancreatic head cancer, cholangiocarcinoma, and gallbladder carcinoma (3,4). Biliary obstruction presents clinically with symptoms such as jaundice, generalized itching, and darker urine, along with common manifestations including weight loss, fever, and vomiting (3,4). It may cause complications such as ascending cholangitis, septicemia, and hepatic abscesses in severe cases (6). Various laboratory tests, including serum bilirubin levels, alkaline phosphatase (ALP), gamma-glutamyl transferase (GGT), and tumour biomarkers such as carbohydrate antigen 19-9 (CA19-9), can be utilized to detect biliary obstruction (1,7).

Multimodality imaging plays a critical role when it comes to the proper diagnosis and treatment of biliary strictures (8). MRCP is noninvasive and has great sensitivity, specificity, and accuracy in diagnosing obstructive causes of jaundice (9). Conventional cholangiography such as Endoscopic Retrograde Cholangiopancreatography (ERCP) and interventional radiology-based PTC are considered gold standard tests due to their diagnostic reliability, but these two procedures are invasive and come with a high risk of adverse effects (10). MRCP, as an index test, provides a valuable non-invasive alternative, particularly in settings where minimizing patient risk is crucial (10). The performance of MRCP is assessed through various measures, including sensitivity, specificity, PPV, NPV, and overall accuracy. However, clinical variability, specific clinical setting, and prevalence of disease could influence these metrics (11,12).

Accurate and early detection of biliary strictures through noninvasive radiological procedures such as MRCP is vital for better treatment outcomes (10). Despite the advantages of MRCP, the extent to which its diagnostic accuracy in detecting biliary strictures compares to that of PTC, a well-established intervention-based procedure, remains insufficiently explored in Tanzania. Therefore, this study aimed to determine the diagnostic accuracy of MRCP in detecting biliary obstruction using PTC as a gold standard, along with sociodemographic characteristics and clinical features, among patients with obstructive jaundice treated at MNH. This study is pioneering in its thorough evaluation of MRCP and PTC within a resource-limited setting, using a blinded assessment for objective comparison. Its findings could significantly enhance the insights of physicians on evidence-based selections of MRCP, thereby influencing clinical practices.

Methodology

Study Design

A cross-sectional study was undertaken at the Department of Radiology and Medical Imaging at MNH, drawing upon a comprehensive review of medical records from the institutional database and diagnostic imaging data retrieved from the Picture Archiving and Communication System (PACS).

Study population and study area

This study involved a retrospective review of medical records for patients initially diagnosed with obstructive jaundice at MNH in Dar es Salaam, Tanzania, based on clinical evaluation and preliminary imaging, including ultrasonography and, in some cases, conventional abdominal Computed Tomography scans. These patients subsequently underwent both MRCP and PTC between July 2019 and December 2022. MNH, a tertiary referral centre, has a 3 Tesla MRI and state-of-the-art fluoroscopy facilities. On average, the Radiology and Imaging Department performs 40 MRCPs and 8 PTCs per month.

Sampling strategy

Patients with obstructive jaundice were selected consecutively, provided they met the inclusion criteria of having undergone both MRCP and PTC. Exclusions were made for those without retrievable MRCP or PTC records and patients under the age of 18 years. To minimize selection bias, the study included all eligible patients who underwent both MRCP and PTC within the specified timeframe, ensuring that the sample was representative of the typical clinical workflow at MNH.

Sample size estimation

The sample size of 57 was based on a known population, with post hoc power analysis conducted using a 0.05 significance level, medium effect size (Cohen's d = 0.5), and a two-tailed Chi-square test. The resulting power was approximately 75.4%, indicating a reasonable ability to detect a medium effect with the given parameters.

Inclusion criteria

Patients with obstructive jaundice who had undergone both MRCP and PTC procedures at MNH between July 2019 and December 2022.

Exclusion criteria

Patients without retrievable MRCP or PTC records and patients under the age of 18 years.

Variables

The study assessed the sensitivity, specificity, NPV, PPV, and overall accuracy of MRCP in detecting biliary strictures compared to PTC findings. In addition to diagnostic accuracy, sociodemographic factors (sex, age) and clinical features (symptoms, signs and laboratory findings) were analyzed to ensure a comprehensive assessment.

Data collection methods

MRCP assessments were performed by blinded radiologists with over five years of hepatobiliary imaging experience. The decision to proceed with PTC was made collaboratively by a multidisciplinary team, including interventional radiologists, surgeons, and primary clinicians. This was based on the complexity of the case, the need for detailed anatomical delineation, and therapeutic planning. MRCP was performed using a 3T MRI scanner with a standard protocol optimized for biliary imaging, enhancing the detection of dilatations, strictures, stones, and tumours. The primary outcome measures included the identification of biliary strictures, such as strictures or occlusions. PTC was performed using a standardized technique, which involved percutaneous access to the biliary system, typically via the right or left hepatic duct, under fluoroscopic and ultrasound guidance. This procedure was often followed by percutaneous transhepatic biliary drainage (PTBD) if necessary, to relieve the biliary obstruction. PTC criteria included visible strictures, occlusions, or filling defects within the biliary tree. The procedures were carried out by interventional radiologists with a minimum of two years' experience, most of whom were blinded to the MRCP findings, reflecting real-world practice at MNH. The average interval between MRCP and PTC was 2 weeks. The principal investigator, who has over 3 years of experience in clinical research reviewed and collected the clinical data and images from the database and the Picture Archiving and Communication System (PACS). Data collection was done using a structured form within the KoboCollect platform, capturing sociodemographic, clinical, and imaging data.

Imaging platform

MRCP imaging was conducted using a Siemens MAGNETOM Spectra 3.0 Tesla MRI scanner (Siemens Healthineers, Erlangen, Germany), equipped with the Tim and Dot system for advanced imaging capabilities. The standardized protocol was optimized for biliary imaging, employing a combination of heavily T2-weighted half-fourier acquisition single-short turbo spin echo (HASTE) and respiratory-triggered 3D T2-weighted sequences in the coronal plane, supplemented by axial T2-weighted fast spin-echo and fat-suppressed T2-weighted imaging for enhanced bile duct visibility. Views included coronal MRCP MIP, axial T2-weighted, and optional 3D volume rendering to provide a comprehensive assessment of ductal dilatations, strictures, stones, and tumours. Conversely, PTC imaging was performed using Siemens Arcadis Avantic fluoroscopy machines (Siemens Healthineers, Erlangen, Germany), which offer high-resolution imaging and advanced C-arm technology for optimal visualization. The procedure was carried out under local anaesthesia with fluoroscopic and ultrasound guidance to achieve precise needle placement into the biliary ducts. A contrast medium was injected to delineate the biliary anatomy, allowing for the identification of strictures, stones, and other obstructions. Standard imaging views were obtained, including anterior-posterior, oblique, and lateral projections, to ensure comprehensive assessment and accurate diagnosis of biliary pathologies. Both imaging modalities were operated by skilled radiographers, ensuring optimal performance and accuracy of the equipment.

Data analysis

Statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS) version 27. Continuous variables, including patient age, were summarized using measures of central tendency and corresponding measures of dispersion. Categorical variables, such as clinical signs and symptoms, were described using frequencies and percentages. The sensitivity, specificity, PPV, NPV, and overall accuracy of MRCP were calculated in comparison to PTC results. These metrics were derived from two-by-two contingency tables, representing true positives, false positives, false negatives, and true negatives for the relevant variables. A p-value of less than 0.05 was considered statistically significant.

Ethical Issues

The research proposal underwent a comprehensive review and obtained ethical approval from the MUHAS Institutional Review Board (MUHAS-REC-02-2023-1529). Due to the retrospective design of the study, a waiver for informed consent was granted. Permission to collect data was also obtained from the executive director of MNH. The confidentiality of all information and data was strictly upheld throughout the study. No patient-identifying information was included in the data analysis. Furthermore, access to the data was restricted to the investigators alone.

Results

Sociodemographic characteristics of patients with obstructive jaundice treated at MNH

The study encompassed 57 patients diagnosed with obstructive jaundice, with a mean age of 55.89 years (±13.48 SD) and an age range from 19 to 77 years. The most common age group was 56 to 65 years, representing 35.1%. The gender distribution revealed a slight female predominance at 52.6%, compared to 47.4% for males (Table 1).

Clinical features among patients with obstructive jaundice treated at MNH

Pruritus was the predominant symptom, reported by 47 patients (82.5%) with obstructive jaundice, followed by upper quadrant abdominal pain, noted in 42 patients (73.7%) (Table 2).

Table 1: Sociodemographic characteristics of patients with obstructive jaundice treated at MNH between July 2019 and December 2022, (n = 57)

Variables		Frequency	Percentage
Age (years)	<45	9	15.8
	46-55	15	26.3
	56-65	20	35.1
	66-75	10	17.5
	76+	3	5.3
Age (years): Mean = 55.89, SD = 13.48, Minimum 19, Maximum = 77			
Sex	Female	30	52.6
	Male	27	47.4

Table 2: Signs and symptoms among patients with obstructive jaundice treated at MNH between July 2019 and December 2022, (n = 57)

Sign/Symptom	Frequency (n)	Percentage (%)
Palpable gallbladder	2	3.5
Ascites	5	8.8
Palpable upper quadrant abdominal mass	8	14
Upper quadrant tenderness	16	28.1
Fever	22	38.6
Abdominal distension	23	40.4
Dark urine	29	50.9
Clay-coloured stool	31	54.4
Nausea/belching/vomiting	33	57.9
Low body weight	37	64.9
Upper quadrant abdominal pain	42	73.7
Body itching (pruritus)	47	82.5

The study population presented with elevated mean levels of total bilirubin (287.3 µmol/L), direct bilirubin (181.3 µmol/L), aspartate aminotransferase (AST) (107.3 IU/L), alanine aminotransferase (ALT) (89.0 IU/L), ALP (594.7 IU/L), GGT (529.5 IU/L), and International Normalized Ratio (INR) (1.72). Conversely, the mean white blood count (WBC) count remained within the normal range (9200 cells/µL) (Table 3).

Table 3: Laboratory findings among patients with obstructive jaundice treated at MNH between July 2019 and December 2022, (n = 57)

Variable	Mean	Standard Deviation	Minimum	Maximum	Normal reference value
Total bilirubin (µmol/L)	287.3	151.3	6.8	641.3	5.1 to 17.1
Direct bilirubin (µmol/L)	181.3	90.1	2.6	292.4	0.0 to 5.1
AST (IU/L)	107.3	60.8	29	327	10 to 40
ALT (IU/L)	89.0	57.8	19	3333	7 to 56
ALP (IU/L)	594.7	414.2	115	2336	40 to 129
GGT (IU/L)	529.5	519.8	4.0	2644	9 to 48
INR	1.72	1.1	0.76	2.7	0.8 to 1.2
WBC (x1000 cells/µL)	9.2	3.0	3	16	4.5 to 11

Diagnostic accuracy of MRCP in detecting biliary strictures using PTC as a gold standard among patients with obstructive jaundice treated at MNH

MRCP demonstrated high performance in identifying ductal strictures, with sensitivities ranging from 70.0% to 98.1% and specificities between 89.4% and 100%, depending on the stricture site. PPV varied from 58.3% to 100%, while NPV ranged from 75.0% to 95.6%. The overall diagnostic accuracy for MRCP across all stricture types was notably high at 98.2% (Table 4).

Table 4: Diagnostic accuracy of MRCP in detecting biliary strictures using PTC as a gold standard among patients with obstructive jaundice treated at MNH between July 2019 and December 2022

MRCP		PTC			Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	DA %
		Yes	No	Total					
Any ductal stricture	Yes	53	0	53	98.1	100	100	75.0	98.2
	No	1	3	4					
	Total	54	3	57					
Common Bile Duct stricture	Yes	23	1	24	92.0	96.9	95.8	93.9	94.7
	No	2	31	33					
	Total	25	32	57					
Common Hepatic Duct stricture	Yes	19	2	21	79.2	93.9	90.5	86.1	87.7
	No	5	31	36					
	Total	24	33	57					
Right Hepatic Duct stricture	Yes	10	3	13	76.9	93.2	76.9	93.2	89.5
	No	3	41	44					
	Total	13	44	57					
Left Hepatic Duct stricture	Yes	7	5	12	70.0	89.4	58.3	93.3	86.0
	No	3	42	45					
	Total	10	47	57					

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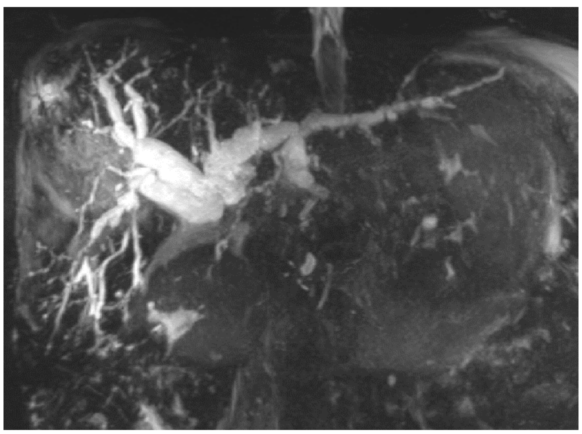
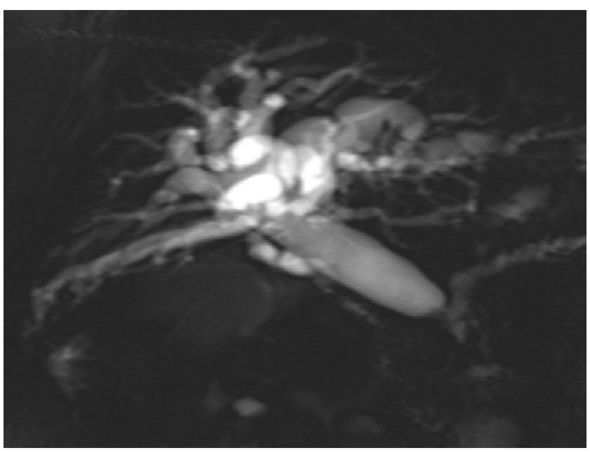
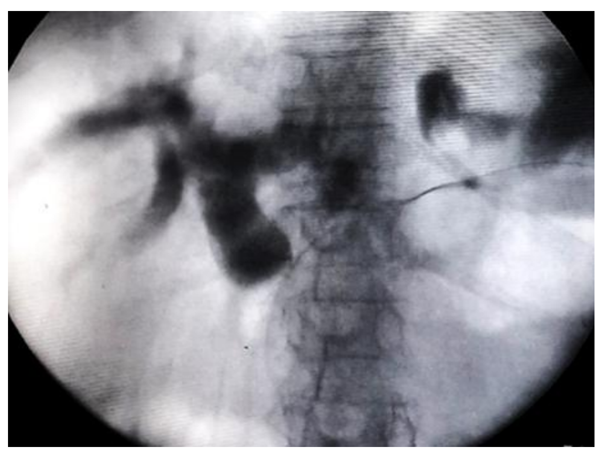
Representative Magnetic resonance and percutaneous transhepatic cholangiograms from the patients with biliary strictures

Figure 1: Representative Magnetic resonance and percutaneous transhepatic cholangiograms from the patients with biliary strictures. Source: MNH's PACS, 2022. Images (a) and (c) depict magnetic resonance cholangiograms in three dimensions, while images (b) and (d) represent percutaneous transhepatic cholangiograms, posteroanterior views. Cholangiograms (a) and (b) reveal significant dilation of the intrahepatic bile ducts, with an abrupt interruption at the confluence of left and right hepatic ducts due to a Klatskin tumour. Cholangiograms (c) and (d) reveal significant dilation of the intrahepatic and extrahepatic bile ducts, with an abrupt interruption at the distal common bile duct due to a pancreatic head neoplasm.



(a) (b)





(c) (d)

Figure 2. Representative Magnetic resonance and percutaneous transhepatic cholangiograms from the patients with biliary strictures

Discussion

This hospital-based retrospective cross-sectional study evaluated 57 patients with obstructive jaundice with a mean age of 55.89 years. The highest prevalence of obstructive jaundice was observed in the 56 to 65 years age group. This finding is consistent with previous studies conducted in Tanzania and Nigeria, where the majority of patients were aged between 55 and 64 years (4,13). The similarity in age distribution patterns may be attributed to the non-probability consecutive sampling methods and the matching inclusion criteria for obstructive jaundice. It is vital to note this high-risk age group for biliary obstruction, urging vigilant screening and diagnosis, especially when patients present with jaundice.

The most frequent accompanying clinical presentations among patients with obstructive jaundice were pruritus, right upper quadrant abdominal pain, and low body weight. This is in agreement with previous studies done in Tanzania and Sudan, in which jaundice was persistently prevalent, accounting for up to 100%, followed by either pruritus or abdominal pain (3,14). The sustained consistency in clinical manifestations across diverse studies underscores the potential of these symptoms to function as dependable indicators when assessing patients with suspected biliary obstruction. The study population presented with elevated mean levels of total bilirubin, direct bilirubin, AST, ALT, ALP, GGT, and INR, indicating hepatocellular injury, impaired hepatic synthetic function, and cholestasis. However, the mean WBC was within normal limits, suggesting the absence of an infection such as cholangitis. Similar patterns of laboratory findings were demonstrated in previous studies done in Tanzania and the United Kingdom (3,4,7). This observation can also be elucidated by the resemblances in the criteria for inclusion and exclusion. Consequently, these biochemical and haematological tests can serve as valuable tools for clinicians in deciphering the underlying pathophysiological mechanisms, while also aiding in the exclusion of conditions such as cholangitis.

MRCP in this study demonstrated high sensitivity, specificity, PPV, NPV, and diagnostic accuracy for detecting biliary strictures. The sensitivity, specificity, and diagnostic accuracy observed are consistent with those reported in a study conducted in Korea, which highlighted a sensitivity of 93.0%, specificity of 97.0%, and diagnostic accuracy of 97.0% (11). The alignment in findings could be attributed to similarities in sample size and inclusion criteria. Additionally, our results surpassed those reported in an Indian study, where MRCP achieved a diagnostic accuracy of 89.3% (15), this could be explained by the smaller sample size of that study. Furthermore, the diagnostic performance in our study slightly exceeded that of a German study, which reported sensitivity and specificity of 94.0% and 75.0%, respectively (12), this could also be attributed to the use of a 1.5T MRI scanner in that previous study. The comparative analysis with studies from Korea, India, and Germany not only confirms the robustness of MRCP in diverse clinical environments but also emphasizes the impact of technological advancements, such as the use of a 3T MRI scanner, on diagnostic outcomes. Collectively, these insights advocate for the continued use of MRCP as a reliable imaging tool in the assessment of biliary strictures, with the potential to guide timely and accurate therapeutic interventions.

Limitations

The study may be limited by sampling bias from non-probability consecutive sampling, which could affect representativeness across broader populations. Additionally, the findings may have limited external validity, as the research was conducted at a single centre (MNH) with specific equipment and protocols, potentially limiting generalizability to other settings.

Conclusion

This study, involving 57 patients with obstructive jaundice (mean age 55.89 ± 13.48 years), demonstrated that MRCP has high diagnostic accuracy in detecting biliary strictures. Sensitivity ranged from 70.0% to 98.1%, specificity from 89.4% to 100%, with PPV and NPV ranging from 58.3%–100% and 75.0%–95.6%, respectively. The overall accuracy was 98.2%, affirming MRCP as a reliable, non-invasive diagnostic tool.

Recommendations

Physicians should utilize a non-invasive MRCP technology to ensure accurate and timely diagnosis of biliary strictures.

Acknowledgement

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Author Contributions

TM contributed to the conception and design of the study, acquired, analyzed and interpreted the data, and drafted and revised the manuscript. BMB, ZN and EM contributed to the design of the study, data interpretation and critically revised the manuscript. All authors read and approved the final manuscript.

Conflict of Interest

The authors declare no conflict of interest.

References

1. Ethan Coucke AM, Akbar H, Kahloon A, Lopez Affiliations PP. Biliary Obstruction Continuing Education Activity. In: StatPearls Publishing, Treasure Island (FL) [Internet]. 2021. p. 4–5. Available from: https://europepmc.org/article/NBK/nbk539698
2. Pavlidis ET, Pavlidis TE. Pathophysiological consequences of obstructive jaundice and perioperative management. Hepatobiliary and Pancreatic Diseases International [Internet]. 2018;17(1):17–21. Available from: https://doi.org/10.1016/j.hbpd.2018.01.008
3. Chalya PL, Kanumba ES, McHembe M. Etiological spectrum and treatment outcome of Obstructive jaundice at a university teaching hospital in northwestern Tanzania: A diagnostic and therapeutic challenges. BMC Res Notes [Internet]. 2011; 4:1–7. Available from: https://link.springer.com/content/pdf/10.1186/1756-0500-4-147.pdf
4. Mabula JB, Gilyoma JM, Mchembe MD, Jaka H, Kamugisha E, Kidenya B, et al. Predictors of outcome among patients with obstructive jaundice at Bugando Medical Centre in north-western Tanzania. Tanzan J Health Res [Internet]. 2014;15(4):1–8. Available from: https://www.ajol.info/index.php/thrb/article/view/77036/88441
5. Wilkins T, Agabin E, Varghese J, Talukder A. Gallbladder Dysfunction: Cholecystitis,

Choledocholithiasis, Cholangitis, and Biliary Dyskinesia. Primary Care - Clinics in Office Practice [Internet]. 2017;44(4):575–97. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0095454317300969?via%3Dihub
6. Kapoor BS, Mauri G, Lorenz JM. Management of biliary strictures: State-of-the-Art review. Radiology [Internet]. 2018;289(3):590–603. Available from: https://doi.org/10.1148/radiol.2018172424
7. Garcea G, Ngu W, Neal CP, Dennison AR, Berry DP. Bilirubin levels predict malignancy in patients with obstructive jaundice. Hpb [Internet]. 2011;13(6):426–30. Available from: https://www.hpbonline.org/article/S1365-182X(15)30446-9/fulltext
8. Hennedige TP, Neo WT, Venkatesh SK. Imaging of malignancies of the biliary tract- an update. Cancer Imaging [Internet]. 2014;14(1):1–21. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4331820/
9. Rațiu I, Lupușoru R, Lungeanu D, Popescu A, Sporea I, Goldiș A, et al. Diagnosis of malignant biliary obstruction: pondering over the ERCP, MRCP and histology. Journal of International Medical Research [Internet]. 2022 [cited 2024 Aug 19];50(2). Available from: https://journals.sagepub.com/doi/10.1177/03000605221076924
10. Joo I, Lee JM, Yoon JH. Imaging diagnosis of intrahepatic and perihilar cholangiocarcinoma: Recent advances and challenges. Radiology [Internet]. 2018;288(1):7–23. Available from: https://doi.org/10.1148/radiol.2018171187
11. Park DH, Kim MH, Lee SS, Lee SK, Kim KP, Han JM, et al. Accuracy of magnetic resonance cholangiopancreatography for locating hepatolithiasis and detecting accompanying biliary strictures. Endoscopy. 2004 Nov;36(11):987–92.
12. Rösch T, Meining A, Frühmorgen S, Zillinger C, Schusdziarra V, Hellerhoff K, et al. A prospective comparison of the diagnostic accuracy of ERCP, MRCP, CT, and EUS in biliary strictures. Gastrointestinal Endosc. 2002;55(7):870–6.
13. Olatoke SA, Agodirin SO, Adenuga AT, Adeyeye AA, Rahman GA. obstructive_jaundice_in_a_North_Central. The Tropical Journal of Health Science. 2018;25(3).
14. Gameraddin M, Omer S, Salih S, Elsayed SA, Alshaikh A. Sonographic Evaluation of Obstructive Jaundice. Open Journal of Medical Imaging [Internet]. 2015;05(01):24–9. Available from: http://repo.uofg.edu.sd/bitstream/handle/123456789/362/Ar26.pdf?sequence=1&isAllowed=y
15. Kurdia KC, Irrinki S, Siddharth B, Gupta V, Lal A, Yadav TD. Percutaneous transhepatic cholangiography in the era of magnetic resonance cholangiopancreatography: A prospective comparative analysis in preoperative evaluation of benign biliary stricture. JGH Open. 2021;5(7):820–4.