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"Magnetic Resonance Cholangio-Pancreaticography of Cholecysto-Cholangio-Pancreatic Disorders with Ultrasound Correlation"

Radiodiagnosis

Dr. Deepakkumar Vinodray Mehta DNB (Radiodiagnosis), DMRD, Professor of Radiodiagnosis, Pramukhswami Medical College and Shree Krishna Hospital, KARAMSAD. 388 325 (GUJ) INDIA Corresponding Author

Dr. Anup Devendra Singh MD (Radiodiagnosis) Consultant Radiologist, In-Focus Diagnostics, Stadium-Commerce College Road, AHMEDABAD. (GUJ) INDIA

ABSTRACT

Introduction: Diseases of gall bladder and biliary tree are common. Ultrasonography (USG) is used as primary modality for diagnosing hepatobiliary and pancreatic diseases; but complete hepatobiliary evaluation requires good acoustic window and lack of gas in overlying bowel. Magnetic Resonance Cholangio-Pancreatography (MRCP) is considered excellent modality for extra-hepatic biliary tree and pancreatic duct (MPD) evaluation.

Aims: Aims were to compare MRCP and USG findings in cholangio-pancreatic diseases and to measure and compare diameters of extra-hepatic bile ducts and main pancreatic duct on MRCP and USG with same fasting status on same day.

Study Design: This was prospective cross sectional analytical study.

Material and Methods: During two and a half years of study, 33 patients referred for MRCP and USG to Radiodiagnosis Department of Shree Krishna Hospital, Karamsad and done on same day were included in this study. Clinical history and laboratory tests were collected. MRCP and USG were done with same fasting status and their observations were compared.

Results: Statistical analysis for sensitivity and specificity of Ultrasound was done. Right, left & common hepatic ducts, common bile ducts (CBD) and MPD diameters were measured by MRCP & Ultrasound; which were compared by Bland-Altman method for statistical agreement.

Conclusion: Sensitivity and specificity of USG as compared to MRCP in diagnosing cholangio-pancreatic disorders were 75.61% and 100% respectively. Excellent agreement was found in the measurements of extra-hepatic biliary tree and MPD diameters with < 1.0 mm variation.

KEYWORDS:

Biliary-pancreatic diseases, MRCP & Ultrasonography correlation, bile ducts & MPD measurements, extra-hepatic biliary duct dilatation.

Introduction:

Diseases of gall bladder (GB), extra-hepatic biliary ducts (EHBD) and pancreatic ducts (PD) are common in India. Population-based study to estimate prevalence and determine risk factors of gall bladder diseases by Unisa S, Palepu J, Dhir V, Khandelwal C, Sarangi *et. al* (2011, p.117) in rural Gangetic basin of North India had revealed prevalence of Gall Bladder Disease (GBD) of 6.20%; which was significantly more common as symptomatic disease (7.12%) as compared to asymptomatic disease (2.99%) . The risk factors of GBD found in that study were females of > 50 years age; multiparity and genetic history. In males, increased risk was noted in diabetes, chickpea consumption and drinking unsafe water. Prevalence of gall stones found was 4.15 percent; which was significantly more in females (5.59%) than in males (1.99%). [1]

Prevalence of gall stone disease in adults in western developed world is 10-15 % (with 16.6% in women and 7.9% in men), 3-15 % in Asians and 3-4% in Africans (lowest), as reported by Reshetnyak VI (2012, p.18) and Marschall HU, Einarsson C. (2007, p. 529). [2, 3] Shaffer EA (2005, p. 132) reported that > 98% of all gallbladder and biliary tract disorders have some connection to gall stones. [4] He also referred that relative difference in prevalence of gall bladder disease between men and women was much greater in younger age group rather than in old age in third National Health And Evaluation examination survey (NHANES III) of 14,000 Ultrasonography.

Hermann RE (1989, p. 171) had reported that up to 10% of patients with gall stones have common bile duct stones. He also reported that CBD stones were found days to several years after cholecystectomy in as high as 5% of patients. [5]

Kimura Y, Takada T, Kawarada Y, Nimura Y et. at. (2007, p. 15) reported in Tokyo Guidelines that acute cholecystitis was cause of abdominal pain in 3%–10% of all patients , but in patients having age > 50 years it was as high as 20.9% (average, 10%). [6] According to them, gall stones was cause for 90–95% of all acute cholecystitis cases; while remaining 5–10% occur as acalculous cholecystitis. Acute cholangitis occurs due to two factors; which are biliary obstruction and bacterial growth in bile (bile infection). Patients with incomplete obstruction of bile duct had higher positive bile culture rate than those with complete obstruction of bile duct. Tokyo guidelines mentioned aetiologies of acute cholangitis and their proportions as per various research studies; which were gall stones (28-70%), malignant stenosis (10-57 %), benign stenosis (5-28%), sclerosing cholangitis (0-24%) and idiopathic/others (0-4%).

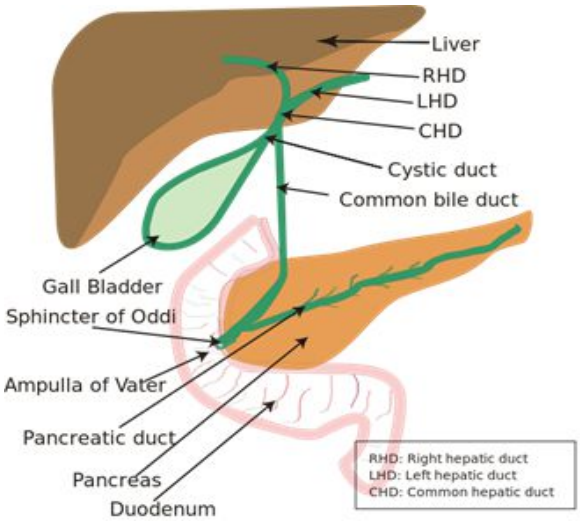
Gall bladder cancer is a rare malignancy. However, Randi G, Franceschi S & La Vecchia C. In their review wrote that highest incidence rate of gall bladder cancer in the world of 21.5/100,000 was in women in Delhi, India. [7] Pathogenesis of GB cancer is poorly understood; but many factors like genetic susceptibility, lifestyle factors and GB infections appear to play in it. Shrikhande SV, Barreto SG, Singh S at. al (2010, p.514) in their systematic review of available scientific literature from 1891 to 2009 on cholelithiasis and gall bladder cancer mentioned that some epidemiological studies support gall stones having causative role in gall bladder cancer; which had reported increased risk of cancer with increase in size, volume & weight of gall stone as well as their number; but other research studies have found relatively low incidence of gall bladder cancer in countries having high incidence of gallstones. According to them gall stone is a co-factor in aetiology of gall bladder malignancy.

Yadav D and Lowenfels AB (2013, p. 1252) had reported that annual incidence of Acute Pancreatitis (AP) ranges from 13 to 45/100000 persons, and that of Chronic Pancreatitis (CP) from 5 to 12/100,000 in US with prevalence of Chronic Pancreatitis being about 50/100,000 persons. [9] Prevalence of a type of chronic calcific pancreatitis is endemic to tropical countries with reported prevalence of 20–125/100,000 persons in parts of South India (Kerala & Chennai). They have also mentioned that gall stones are most common cause of acute pancreatitis in west. Alcohol-related pancreatitis is more common in West and in Japan among Asian countries. Risk factors for pancreatitis are 1. Alcohol (single most important risk factor for CP). 2. Smoking 3. Male gender (for CP) 4. Black race 5. Obesity (BMI >30 kg/m) and abdominal adiposity (girth > 105 cm) 6. Diabetes 7. Metabolic factors like hypertriglyceridemia, hypercalcemia, renal failure and acidosis 8. Auto-immune disease like celiac disease 9. Pancreatic ductal abnormalities (annular pancreas and ductal stricture). After first episode of alcohol-related AP, risk of progression to CP varies from 14% to 41% depending on occasional to heavy intake of alcohol.

According to study of Yadav D and Lowenfels AB (2013, p-1252), Significant risk factors for pancreatic cancer include chronic pancreatitis, smoking and non-O blood groups (about 15-20% of pancreatic cancer). Red meats, particularly when cooked at high temperatures and obesity are also risk factors.[9]

Anatomy of Extra-hepatic Biliary Apparatus:

Figure 1. Anatomy of extra-hepatic bile ducts & pancreatic duct (Source: www.wikipaedia.org)



Role of Radiological Investigations:

MRCP was first clinically applied by Wallner BK, Schumacher KA, Weidenmaier W, Fariedrich JM (1991, p. 805) using breathhold 2D T2 weighted gradient echo image by Steady State Free Precision (SSFP) sequence.Since then, MRCP has evolved in an excellent modality to see the extra-hepatic biliary tree and Pancreatic Duct (PD) and their diseases as described in textbook by Edelman RR, Hesselink JR, Zlatkin MB, Crues JV III (2006, p-2483). [11] MRCP is non-invasive investigation; which has advantage of excellent soft tissue contrast and lack of ionizing radiation. Its disadvantages are long scan time, high cost and non-availability in remote areas.

Ching-Ruei Hung, Ay-Chiao Huang, Yen-Chen Chen et. al. (2011, p.93) and Nai-Chi Chiu & Yi-You Chiou (2012, p. 423) reported good reliability of measurements of common bile duct on MRCP using single shot thick slab MRCP sequence & 3D MRCP sequence respectively. [12,13]

In the report published by Ludwig GD & Struthers FW (1949); Ludwig had first described the use of ultrasonography to diagnose gall stones. [14] Ultrasonography (USG) is a very good modality for evaluation of hepato-biliary and pancreatic diseases as written by Rumack CM. Wilson SR, Charboneau JW, Levine D. (2011 p. 202) in their textbook of Diagnostic Ultrasound. [15] It has advantages of low cost, easy availability, fast evaluation, good contrast resolution and real time assessment. Endoscopic Ultrasound is excellent test for pancreatic duct lesions and small pancreatic lesions. But disadvantages of USG are requirement of good acoustic window and lack of visualisation of areas distal to bowel gas and bones, if they are overlying region of interest. Bijan B, Eslamy H, McGahan JP. (In: Goldberg BB & McGahan JP, 2008, p. 419) have reported upper limit of normal diameter on ultrasonography for Extra-hepatic Biliary Duct (CHD or CBD) is 6-7 mm for age below 65 years and 10 mm for age above 65 years or after cholecystetomy; while that for MPD in head and body of pancreas are 3 mm and 2 mm respectively. [16] They reported normal size of Gall Bladder of 8-12 cm (Length) and up to 4 cm (width). As written in BD Chaurasia's anatomy textbook (Editor: Krishna Garg, 2016, Vol. 2, p.315), Gall bladder has volume of 30-50 ml; while normal length of CHD, Cystic Duct (CysD) and CBD are about 3 cm, 3-4 cm and 8 cm respectively. [17] Prasanna LC, D'Souza AS, Rajagopal KV & Bhat KM (2015, p. 58) found that range of MPD length varies from 11-21.2 cm with average of 17.3 cm, and hepatopancreatic ampulla length varies from 1-10 mm in their study of 40 specimen. [18]

Computed Tomography (CT) scan is an excellent modality for evaluation of pancreatic lesion and is gold standard in diagnosis of pancreatitis. But disadvantages of CT scan are ionizing radiation and low sensitivity for gall stones and biliary stone, as of plain radiographs. Endoscopic Retrograde Cholangio-Pancreatography is an invasive radiographic procedure; which is done only when simultaneous biliary intervention to be done or occasionally as problem solving in equivocal or dilemma cases. Percutaneous Transhepatic Cholangiography is not used now-a-day due to invasive nature and high complication rate for biliary peritonitis & liver injury.

Aims and Objectives:

1. To study MR Cholangio-Pancreatography appearances in various cholecysto-cholangio-pancreatic disorders.
2. To compare the findings of MR Cholangio-Pancreatography and Ultrasonography in various cholecysto-cholangio-pancreatic disorders for sensitivity and accuracy.
3. To measure diameters of various extra-hepatic biliary ducts and main pancreatic ducts by MRCP and USG and to compare them in groups of dilated ducts and normal duct diameter.

Material and Methods:

This prospective cross sectional analytical study was approved by Human Research Ethics Committee. Adult patients who were referred to Radiodiagnosis Department of Pramukhswami Medial college and Shree Krishna Hospital, Karamsad for MRCP and whose Ultrasonography was also done on same day with fasting status, were included in this study. Total 33 patients were included in 2 years and 8 months study from January 2012 to August 2014. Patients having absolute contra-indications for MRI (cardiac pacemaker, ferromagnetic aneurysmal clip, neuro-muscular stimulator etc.) were excluded as MRCP cannot be done. These patient's clinical features, haemogram & hepatic function test were noted in proforma. Serum amylase, serum lipase and other tests were done, where ever required.

Patients were advised for overnight fasting for at least 8 hours. Informed consent was taken for each patient. Then, MRCP with screening MRI scan of upper abdomen was done on 1.5 Tesla Magnetom Symphony-Vision Maestro class MRI scan. (Manufacture: Siemens AG Co., Erlangen, Germany). Four element body coil array was used with bed-sheet covering patient's abdomen to prevent direct contact with radio-frequency coil.

Table 1. Protocol for non-contrast MRI scan of abdomen.

Plane	Breath Hold Sequence	Weighted Image	Thickness (mm)	Inter-slice Gap (mm)	Field of View (FOV)	Matrix	NEX
AXIAL	Gradient Echo Sequence (Flip angle 70)	T1W	5-8 mm	2-3 mm	300-350 mm	134x 256	1
	Turbo Spin Echo (Turbo factor 134)	T2W	5-8 mm	2-3 mm	300-350 mm	134x 256	1
	Optional HASTE-STIR (Half-fourier Acquisition Single Shot Turbo Spin Echo-Short TI Inversion Recovery) (Turbo factor 224, TI 150 ms)	T2W	5-8 mm	2-3 mm	300-350 mm	224 x 256	1
	True-FISP (Fast Imaging with Steady State Precession) (Flip angle 60)	T2W	5-8 mm	2-3 mm	300-350 mm	146x 256	1

CORONAL	True-FISP (Fast Imagine with Steady State Precession) (Flip angle 60)		T1W	5-7 mm	2-3 mm	300-350 mm	180 x 256	2
	HASTE-STIR (Half Fourier Acquisition Single Shot Turbo Spin Echo-Short Tl Inversion Recovery) (Turbo factor 179, TI 150 ms)		T2W	5-7 mm	2-3 mm	300-350 mm	179 x 256	1
	Optional	Gradient Echo-IR (Flip angle 15, TI 850)	T1W	5-7 mm	2-3 mm	300-350 mm	166 x 256	1
SAGITTAL	Optional	Turbo Spin Echo (Turbo factor 19)	T2W	6-8 mm	2-3 mm	300-320 mm	205 x 256	1

After doing MRI screening of abdomen, whenever significant fluid was present in stomach or duodenum; water with small amount of Gadolinium (negative contrast medium) was given orally to patient to suppress fluid signals before M.R.C.P. study.

Table 2. Protocol for MRCP.

MRCP	Sequence	Weighted Image	Thickness (mm)	Inter-slice Gap (mm)	Field of View (FOV)	Matrix	NEX
	HASTE THICK SLAB (Turbo factor 307, GRAPPA- iPAT factor 2)	Heavily T2W	40-80 mm	-	2S0-350 mm	307 x 2S4	1
	HASTE THIN SLAB (Turbo factor 269, GRAPPA- iPAT factor 2)	Heavily T2W	3-5 mm	0	320-350 mm	269 x 384	1
	3D RESTORE (Respiratory Triggered Navigation based) (Turbo factor 121)	Heavily T2W	1.2 mm	0	300-350 mm	241 x 256	1

Ultrasonography of hepato-biliary system was done on GE medical systems, VOLUSON 730 PRO, LOGIQ-E or LOGIC 400 pro (G.E. Medical System, Chicago, USA) by 3.5-5.0 MHz linear convex transducer on same day with fasting status. Colour Doppler mode (if needed) was used to differentiate bile ducts from vessels.

Gall bladder volume was calculated by Ellipsoid formula mentioned by Bijan B, Eslamy H, McGahan JP. (In: Goldber BB & McGahan JP, 2008, p. 429-30). [14] By ellipsoid formula, Volume is equal to (Length x width x height) x π/6. [Value of π is taken as 3.142]

Observations and Results:

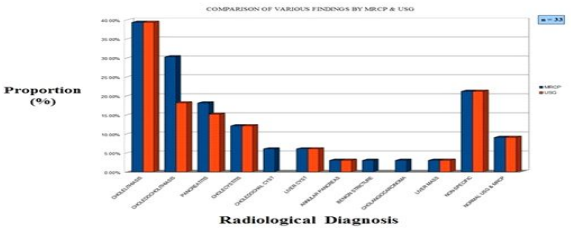
Thirty three adult persons were included in this study; having mean age of 50 years (+ 17.1) with range from 20 years to 74 years, among them 19 were male and 14 were female with M:F ratio of 1.36:1. Twelve patients had habit of alcohol intake (36.2%) and 11 were smokers (33.3%).

Diabetes and hypertension were found in 8 patients each (24.2%). In our study, commonest clinical symptom was abdominal pain in 27 patients (81.8%). Other common symptoms were nausea/vomiting in 12 patients (36.4%), yellowish discoloration of sclera/urine in 11 patients (33.3%). anorexia (24.2%) and weight loss in 4 patients (12.12%).

Table 3. Abnormal findings by MRCP & USG in Patients of biliary-pancreatic symptoms.

ABNORMAL FINDINGS [Multiple findings in patient included in all groups]	MRCP	USG
Cholelithiasis	13	13
Choledocholithiasis	10	6
Acute calculus Cholecystitis	4	4
Chronic Pancreatitis	4	4
Acute Pancreatitis	2	1
Choledochal cyst	2	0
Simple liver cyst	2	2
Annular Pancreas	1	0
Benign C.B.D. Stricture	1	0
Hilar Cholangiocarcinoma (Klatskin Tumour)	1	0
Liver Mass (Hepatocellular Carcinoma)	1	1
Total no. biliary-pancreatic abnormalities	41	31
Non-specific Findings	7	7
NORMAL	3	3

Chart 1. Bar diagram of various abnormal findings by MRCP & USG.



In our study of 33 patients; commonest diagnosis was Cholelithiasis, seen in 13 patients (39.4%), Choledocholithiasis was seen in 10 patients (30.3%). So Biliary Stone was commonest group. Pancreatitis was noted in 6 patients (18.2%) and Acute Calculus Cholecystitis was diagnosed in 4 patients (12.1%). In our study, 12 patients presented with history and laboratory investigations suggesting possibility of obstructive jaundice. Out of these 12 patients; 8 had dilated biliary ducts; which were seen on both MRCP and USG; but MRI with MRCP was useful in diagnosing possible aetiology in 9 patients; while on USG, aetiology can be diagnosed only in 4 patients.

In 30 patients having disease/diseases on MRCP, the diagnosis was confirmed by clinical & laboratory findings, clinical follow up and response to medical treatment in 23 patients, by ERCP (done after MRCP) in 4 patients, by surgical findings of open cholecystectomy in 2 patients and by histopathological report of USG guided biopsy, which was done in 1 patient.

(A) Sensitivity, Specificity & Accuracy of MRCP and USG in this

Study:
In our study, MRCP had shown 41 relevant abnormal findings attributed to patient's condition in 30 out of 33 patients presented with hepato-biliary-pancreatic symptomatology. The diagnoses made on MRCP were very well correlated with final diagnosis and outcome. MRCP had sensitivity, specificity and accuracy of 100 percent in comparison to final diagnosis. MRCP had Positive Predictive Value as well as Negative Predictive Value of 100 percent.

On USG, only 31 abnormal findings are correctly diagnosed and 10 relevant abnormal findings were not diagnosed on ultrasonography. These were choledocholithiasis (4 patients), choledochal cysts (2), acute pancreatitis (1), annular pancreas (1), benign CBD stricture (1) and cholangiocarcinoma (1). These findings were diagnosed only on MRCP. So sensitivity of USG as compared to MRCP and final diagnosis in identifying cholecysto-cholangio-pancreatic disorders was 75.61% and specificity of USG was 100% with accuracy was 87.80 percent.

As compared to MRCP and final diagnosis; the Positive Predictive Value of USG was 100% with its Negative Predictive Value was 23.07 percent.

Table 4. Measurements of Gall Bladder Volume and diameters of Extra-Hepatic Biliary Ducts in patients having dilated Extra-Hepatic Biliary Ducts and having normal sized Extra-Hepatic Biliary Ducts.

MEASUREMENTS	Dilated extra-hepatic biliary tree in mm [N = 13]		Normal extra-hepatic biliary tree in mm [N = 20]	
	USG (Mean ± SD)	MRCP (Mean ± SD)	USG (Mean ± SD)	MRCP (Mean ± SD)
Right Hepatic Duct	7.29 ± 4.5	7.53 ± 4.5	2.07 ± 0.5	2.06 ± 0.5
Left Hepatic Duct	7.55 ± 3.7	7.85 ± 4.1	2.09 ± 0.4	2.05 ± 0.4
Common Hepatic Duct	12 ± 5.5	12.52 ± 5.9	4.4 ± 1.2	4.42 ± 1.3
Supra-pancreatic C.B.D.	13.9 ± 5.8	13.98 ± 5.7	5.3 ± 1.4	5.36 ± 1.3
Infra-pancreatic C.B.D.	11.17 ± 7.5	10.33 ± 6.0	4.57 ± 1.4	4.49 ± 1.4
Gall Bladder Volume (ml)	52.04 ±42.9	50.09 ±41.7	25.03 ±16.6	25.25 ±18.0

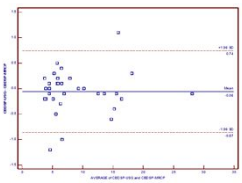
Table 5. Measurement of Main Pancreatic Ducts in patients with Dilatation and those having normal sized Extra-Hepatic Biliary Ducts.

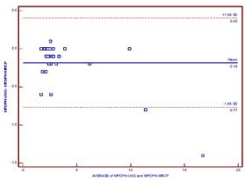
MEASUREMENTS	Main Pancreatic Duct in Pancreatitis in mm [N = 6]		Main Pancreatic Duct without pancreatitis in mm [N = 27]	
	USG (Mean ± SD)	MRCP (Mean ± SD)	USG (Mean ± SD)	MRCP (Mean ± SD)
M.P.D. in Panc. Body	7.52 ± 4.06	7.85 ± 4.39	2.29 ± 0.48	2.31 ± 0.45
M.P.D. in Panc. Head	8.18 ± 5.1	8.6 ± 5.6	2.27 ± 0.36	2.40 ± 0.48

Table 6. Comparative Agreement Analysis of Measurements of Extra-Hepatic Biliary Ducts and Main Pancreatic Duct by USG & MRCP using Bland-Altman Method.

Measurements	No. of Findings seen in MRCP & USG Both [N]	Mean Difference between USG & MRCP	95 % Confidence Limit	
			Upper Limit	Lower Limit
Gall Bladder Volume	29	-0.8	-26	+24.3
Right Hepatic Duct	32	-0.08	-0.57	+0.4
Left Hepatic Duct	33	-0.09	-0.82	+0.63
Common hepatic duct	33	-0.21	-1.33	+0.9
Supra-pancreatic CBD	33	-0.06	-0.87	+0.74
Infra-pancreatic CBD	16	-0.09	-0.80	+0.62
MPD in Pancreatic Body	32	-0.1	-0.68	+0.47
MPD in Pancreatic Head	32	-0.18	-0.77	+0.40

Chart 2 and 3. Bland-Altman Plotting of comparison of diameter measurements of Supra-pancreatic CBD [CBD-SP] MPD in Pancreatic Head [MPD-PH] by USG & MRCP.

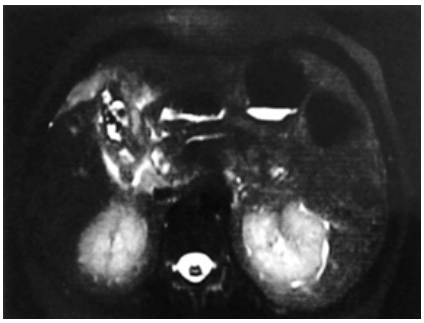




(B) Agreement between the measurements taken on MRCP and USG:
The BLAND-ALTMAN plots and their analysis of agreement had shown excellent agreement in the measurements of RHD, LHD, supra-pancreatic CBD, infra-pancreatic CBD (whenever visualised by both modalities), MPD in pancreatic head and MPD in body of pancreas with variation in the mean difference falling less than 1.0 mm at 95% of confidence limits (+ 1.96 SD). The variation in the mean difference as well as 95% confidence limit for CHD was somewhat higher and had fair degree of agreement at best.

There was good agreement in mean volume of gall bladder (calculated by ellipsoid formula for measurements in USG and MRCP) with variation in mean of < 1%, when extra-hepatic biliary ducts were normal and variation in mean of < 4%, when extra-hepatic biliary ducts were dilated. But there was high SD value with quiet high variation in upper limit (-26) & lower limit (+24.3) at 95% confidence limit; which suggested poor to fair agreement between the measurements by these modalities. Ellipsoid formula is validated for calculating gall bladder volume by ultrasonography; but this formula cannot be directly extrapolated for use in MRCP as per this study. These may be attributed to two factors: 1) Distended gall bladders have variable shapes most of the times and do not have perfect ellipsoid shape. 2) Difference in the planes used for measurement by ultrasound and planes used for measurement on MRI & MRCP.

Image Gallery of Few Cases of Study:
Case 1. 58 years old lady having gall stones with acute calculus cholecystitis & CBD stone.
(1A) MRI STIR axial image showing gall stones, thickened GB wall and pericholecystic fluid collection **(1B)** Thick slab MRCP image showing gallstone and CBD stone **(1C)** USG image showing gall stones with acute cholecystitis **(1D)** USG image showing CBD stone.



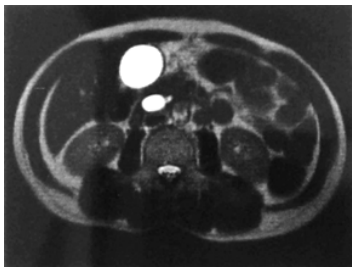
(1A)

(1B)

(1C)

(1D)

Case 2. 63 years old gentleman having choledochal cyst (type 1).
(2A) MRI T2W axial image showing dilated CBD. **(2B)** MRI STIR coronal image showing CBD & CHD dilatation, suggesting type 1 choledochal cyst. **(2C)** Thick slab MRCP image showing type 1 choledochal cyst. **(2D)** USG image showing dilated Common Duct [CD = CHD or CBD].



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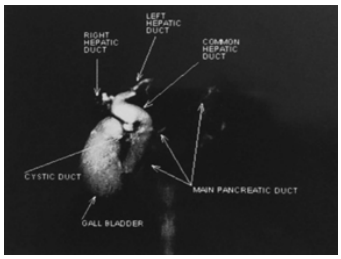

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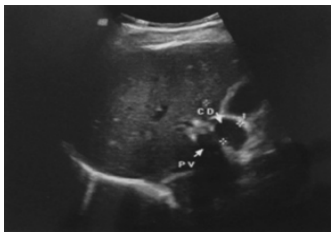
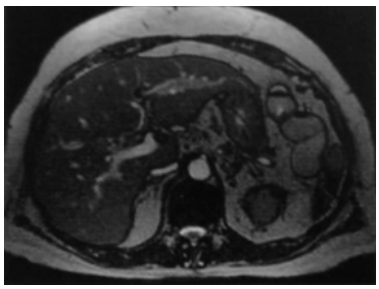


(2D)

Case 3. 67 years old lady having hilar cholangiocarcinoma (Klatskin Tumour).
(3A) MRI T2W axial image showing dilated RHD, branch of LHD and hypoechoic mass at the confluence of RHD & LHD **(3B)** MRI STIR coronal image showing RHD & LHD dilatation with mass at their confluence **(3C)** 3D RESTORE reformation showing RHD & LHD dilatation with abrupt cut off at their confluence **(3D)** USG image showing dilated RHD & LBD with hypoechoic lesion at their confluence.



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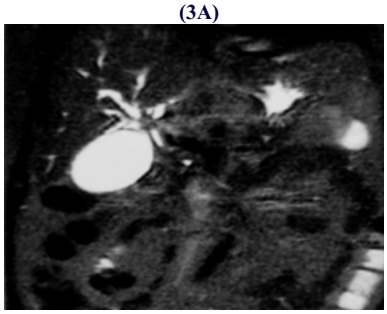

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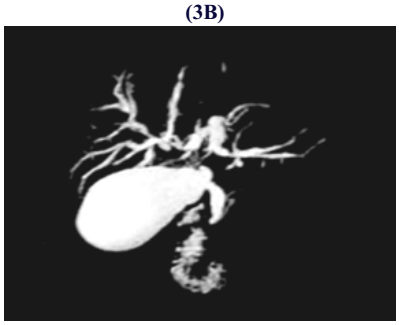
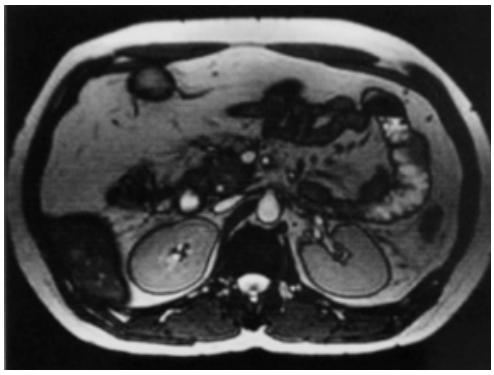


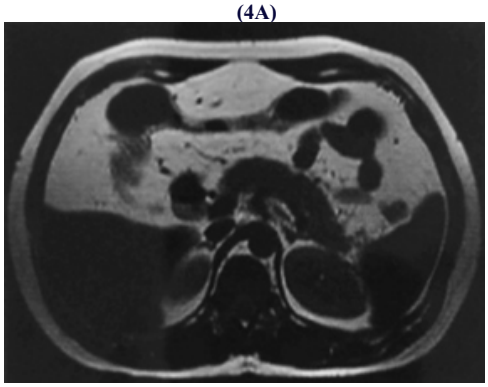
(3C)

(3D)

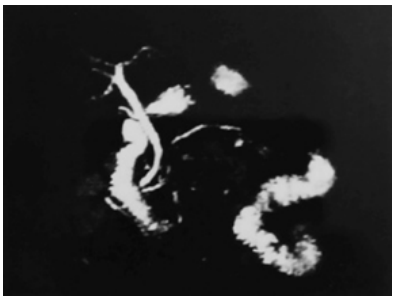
Case 4. 39 years old gentleman having annular pancreas with acute pancreatitis.
(4A) MRI True FISP T2W axial image showing small area isointense to pancreas lying on right side of descending part of duodenum with small duct within it and linear streaks around pancreatic head **(4B)** MRI T1W axial showing mildly enlarged hypointense pancreas with peripancreatic streakiness **(4C)** 3D RESTORE reformation showing small accessory duct lying on the right side of descending part of duodenum and opening separately into it. **(4D)** USG image showing bulky body of pancreas.



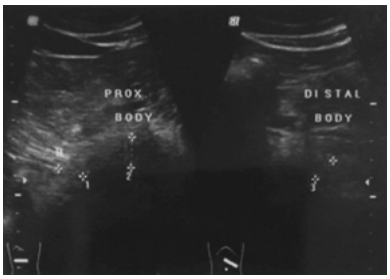
(4A)



(4B)



(4C)



(4D)

Discussion:

We have compared our results with previous research study of Ferrari SF et al (2005, p.8) [19] in Siena, Italy, as well as some of the previous research studies Bhatt C et al (2005, p-177) [20], Gabhiye et al (2013, p.83) [21] and Singh et al (2014, p-103) [22] done at Ahmedabad, Pune and Amritsir respectively in India. These comparison is tabulated below:

Table 7. Comparison of other similar research studies with our study.

Parameter	Our Study	Ferrari SF et al (2005)	Bhatt C et al (2005)	Gajbhiye et al (2013)	Singh et al (March 2014)
Study Type	Comparative Cross-sectional Study	Comparative reliability of US & MR	Comparative accuracy of USG & MRI	Observational Study	Comparative accuracy of USG & MRI
Total Patients	33	131	50	75	50
Age Group	20-74 Yrs 50 Yrs (± 17.1)	37-79 Yrs	All ages	All Ages	14-82 Yrs
Male : Female No. (M : F Ratio)	19 : 14 (1.36:1)	60 : 71 (1:1.18)	22 : 28 (1:1.27)	43 : 32 (1.34:1)	22 : 28 (1:1.27)
Sub-groups					
• Stones	23	83	16	49	--
• Benign	1	30	9	22	26
• Malignant	2	18	13	--	24
MRCP Sensitivity					
• Overall	100%	--	--	--	--
• Stones	–	93.97%	--	≥ USG	--
• Benign	--	90.00%	--	> USG	100%
• Malignant	–	72.23%	--	> USG	95.83%
MRCP Specificity					
• Overall	100%	--	--	--	--
• Stones	--	93.75%	--	≥ USG	--
• Benign	--	94.05%	--	> USG	95.83%
• Malignant	–	97.34%	--	> USG	100%
MRCP Accuracy					
• Overall	100%	--	98%	--	--
• Stones	--	893.89%	100%	--	--
• Benign	--	93.18%	100%	--	98%
• Malignant	--	93.89%	100%	---	98%
USG Sensitivity					
• Overall	75.61%	--	--	--	--
• Stones	--	71.08%	--	≤ MRCP	--
• Benign	--	16.67%	--	< MRCP	80.77%
• Malignant	--	61.12%	--	< MRCP	91.67%
USG Specificity					
• Overall	100%	--	--	--	--
• Stones	--	95.83%	--	≤ MRCP	--
• Benign	--	97.29%	--	< MRCP	95.83%
• Malignant	--	98.235	--	< MRCP	96.15%
USG Accuracy					
• Overall	87.80%	--	62%	--	--
• Stones	--	80.15%	25-100%	--	--
• Benign	--	78.62%	0-100%	--	88%
• Malignant	--	93.13%	50-100%	--	88%

Overall results of our study were more or less comparable to these other research studies.

Our results had also suggested that the MRCP is better modality in the diagnosis of level and obstruction and aetiology in cases presented with obstructive jaundice. Jiwani MS, Banode PJ, Kharche AD et al (2016, p.70) have published recently their research study of 100 patients of obstructive jaundice conducted from July 2014 to August 2016 [age range : 12-80 years, 42 Male & 58 Female, M:F ratio 1:1.38]; in which they had concluded that Ultrasonography is a good screening modality; while MRCP is a better non-invasive, radiation free, radiological modality in the evaluation of obstructive jaundice. [23] Hence, their results were similar to our results in cases presented with obstructive jaundice.

The limitations of our study were small sample size and inability to establish surgical correlation in all cases. Limitation of accuracy of measurements in our study is 0.1 mm.

Mean volume of gall bladder (calculated by ellipsoid formula from measurements done on both modalities) had good agreement, but there is wide range of variation, which cannot be accepted. We believe that ellipsoid method for calculation of gall bladder for use in MRCP needed to be further explored for validation by study having bigger sample size. Alternatively, other mathematical formula with less variation should be hypothesised and can be validated.

Conclusion:

In our study of 33 patients, MRI with MRCP was found more sensitive and more accurate than ultrasound in diagnosing cholecysto-cholangio-pancreatic disorders. However, both modalities have comparable high specificity.

Excellent agreement was observed in the extra-hepatic biliary ducts measurement (except fair agreement in measurements of common hepatic duct), as well as main pancreatic duct measurements done on MRCP & MR and done on Ultrasonography. Hence, measurements done on one modality can be compared with that done on other modality.

Though mean of gall bladder volume measured by both modalities are very similar, whether extra-hepatic biliary ducts are dilated or normal. There is wide variation in the range of measurement of Gall bladder volume; which implies that ellipsoid formula used for measuring GB volume cannot be directly applied for GB volume calculation on MRCP and further validation is needed or different formula should be formed and applied.

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