The Journal of Global Radiology
Ensuring Medical Imaging Access for All

RESEARCH ARTICLE

Magnetic Resonance Cholangiopancreatography in 3 Tesla: 2D MRCP vs 3D MRCP in Diagnostic Evaluation with Special Reference to Different Acquisition and Reconstruction Planes

Vikram Patil[1*], Nayana Shabadi[1], Sudha Das[1], SMC Shetty[1], Kamal Sen[1]

[1] JSS Medical College, JSS University, Mysore, India

***Corresponding author. Current address:** 101 Gayathri Apartments, New Kantharj Urs Road, Mysore 570004, India; drvikrampatil@yahoo.com

DOI: 10.7191/jgr.2015.1003

Received: 12/26/2014

Accepted: 2/25/2015

Published: 3/10/2015

Citation: Patil V, Shabadi N, Das S, Shetty SMC, Sen K. Magnetic resonance cholangiopancreatography in 3 Tesla: 2D MRCP vs 3D MRCP in diagnostic evaluation with special reference to different acquisition and reconstruction planes. J Glob Radiol. 2015:1(1):Article 3.

Keywords: MRCP, 2D, 3D, Magnetic resonance cholangiopancreatography, bile ducts, common hepatic duct

Word count: 2,229

Abstract

Purpose: Magnetic resonance cholangiopancreatography (MRCP) is an established technique for the evaluation of intra- and extrahepatic bile ducts in patients with known or suspected hepatobiliary disease. However, the ideal acquisition and reconstruction plane for optimal bile duct evaluation with 3D technique has not been evaluated.The purpose of our study was to compare different acquisition and reconstruction planes of 3D MRCP for bile duct assessment.
Methods: 51 consecutive adult patients suspected to have pancreatico-biliary disease were examined with 3 Tesla (Philips 3 T Ingenia) system both a multi thin slice (3D) and a breath-hold (Single Shot) MRCP technique were performed. In the multi thin slice technique both source images and maximum intensity projections were examined. Two radiologists blinded to clinical information viewed both MRCP techniques independantly. Measure of correlation between each of the techniques and the inter observer agreement were computed. Coronal and axial MIP were reconstructed based on each dataset (resulting in two coronal and two axial MIP, respectively) and assessed the MIP, regarding visualization of bile ducts and image quality.Results were compared (Wilcoxon test). Intra- and interobserver variability were calculated (kappa-statistic).
Results: In case of coronal data acquisition, visualization of bile duct segments was significantly better on coronal reconstructed MIP images as compared to axial reconstructed MIP ($p < 0.05$). Regarding visualization, coronal MIP of the coronal acquisition were equal to coronal MIP of the axial acquisition ($p > 0.05$). Image quality of coronal and axial datasets did not differ significantly. Obstruction due to tumor was shown in 30% of patients, and calculi in the common bile duct were shown also in 30% of patients employing the 3D MRCP technique. Obstruction due to tumor and calculi were shown in 30% and 21% of patients, respectively, using the SS 2D MRCP technique. Sensitivity and specificity in distinguishing calculi in the common bile duct by 3D MRCP and SS MRCP were 100%, 100%, 70% and 100% respectively.
Conclusions: Although the 3D MRCP multislice technique is more time consuming than the SS MRCP breath-hold technique at a 3 Tesla (Philips 3 T Ingenia) system it is advisable to use thin slice 3D MRCP in order not to misdiagnose calculi in the common bile duct.The results of our study suggest that for visualization and evaluation of intra- and extrahepatic bile duct segments reconstructed images in coronal orientation are preferable.

Introduction

MAGNETIC resonance cholangiopancreatography (MRCP) is an established technique for the evaluation of intra- and extra-hepatic bile ducts in patients with known or suspected hepatobiliary disease [1]. It is considered a reliable, non-invasive alternative to diagnostic endoscopic retrograde cholangiopancreatography (ERCP) [2,3]. Since the first description by Wallner and colleagues in 1991 [4], different acquisition techniques have evolved. Most current MRCP techniques are based on heavily T2-weighted fast spin echo (FSE) pulse sequences, which yield a luminal image of the bile ducts that is based on the inherent signal of slow-flowing or stationary bile.

Both single-shot projections and multislice techniques are available [5], with the latter being distinguished into 2D- [6] and 3D-techniques [7]. Single-shot projections are preferred in individuals who are unable to hold their breath, such as severely sick patients or small children [7]. 3D-imaging techniques provide better image quality compared to 2D-sequences [1,8,9], even though the combination of different MRCP sequences has proven to be valuable in the assessment of bile duct anatomy and pathology [10]. 3D FSE sequences are usually acquired with the slab in coronal orientation.

Maximum intensity projections (MIP) can then be obtained in any plane [7]. Previous studies have addressed the matter of optimal slice thickness for data acquisition [11] and different techniques regarding respiratory triggering [12]. However, to the best of our knowledge, the ideal acquisition and reconstruction plane, in practical terms meaning best suitable for optimal bile duct visualization with 3D techniques, has not been evaluated. The purpose of this study was to compare different acquisition and reconstruction planes of T2-weighted 3D MRCP acquisitions for assessment of the intra- and extra-hepatic bile ducts.

Methods and materials

51 patients (30 female, 21 male, mean age 47.5 years, range 18-79 years) who were referred for liver MRI and dedicated MRCP were included in this prospective study, with approval of the institutional review board.

Inclusion criteria

Patient age equal to or greater than 18 years with suspected CBD pathologies

MR imaging technique

MR examinations were performed on a 3 Tesla system (Philips Ingenia) using dedicated multi-channel surface coils covering the abdomen. Prior to image acquisition, patients received 200 mL of a negative oral contrast agent for suppression of gastroenteric fluid signal. All patients underwent a clinical routine imaging protocol of the liver, including a respiratory-triggered 3D-MR cholangiography in the coronal (dataset A) as well as in the axial plane (dataset B) apart from 14 slices of 2D MRCP, single-shot breath-hold acquisition. Results from ERCP were considered as truth for sensitivity and specificity analysis. The specific MRCP sequences had sequential k-space filling with partial Fourier filling allowed, resulting in acquisition of central k-space lines approximately three minutes after the start of the sequence. MRCP sequence parameters are provided in detail in Table 1.

Image evaluation

Two readers independently performed image evaluation in terms of visibility of different bile duct segments up to the third order and assessment of technical quality. Readers were blinded to each patient's history and other imaging findings. A single coronal and axial maximum intensity projection (MIP) covering the central, left, right, and peripheral bile ducts was generated from each acquired MRCP dataset, resulting in two coronal and two axial MIP datasets, respectively.

Each reader evaluated the reconstructed MIP in the following way:

1, Coronal reconstructed MIP of the coronal acquisition vs. coronal reconstructed MIP of the axial acquisition;

2, Axial reconstructed MIP of the coronal acquisition vs. axial reconstructed MIP of the axial acquisition.

Depiction of bile duct segments was assessed using the following four-point scale proposed by Papanikolaou and colleagues [13]: 1, segment not seen; 2, segment faintly seen; 3, segment well seen but portion of the duct or the confluence not seen; and 4, excellent depiction including the proximal and distal portions. This scale was applied to the following sections (segments) of the biliary tract: the common bile duct (CBD), the right anterior bile duct, the right posterior bile duct, the left hepatic duct, and third-order biliary branches.

Overall technical image quality was assessed using a four-point scale proposed by Lim and colleagues [14]: 1, poor quality with severe artifacts; 2, satisfactory quality with few artifacts; 3, good quality with minimal artifacts; and 4, excellent quality without artifacts.

The two radiologists graded studies obtained with each sequence in a blinded fashion, and the paired student test was used to assess differences in technical quality and visibility of individual ductal segments of the biliary tree.

Table 1.
Imaging parameters of the respiratory-triggered fat-saturated 3D T2-weighted MR cholangiographic sequence

	Geometry	3D (Triggered navigator)	2D Single Shot (Breath-Hold)
1	Total scan duration	05.00.0 min	00.06.0 sec / slice
2	TE	926 ms	5670 ms
3	TR	80 ms	740 ms
4	Acquisition Matrix MXP	336 x 254	320 x 256
5	Acquisition Voxel MPS (axial/sagittal/coronal)	1.10 / 1.11 / 5.00	0.94 / 1.17 / 40.0
6	Reconstruction Voxel MPS	0.77 / 0.77 / 5.00	0.59 / 0.59 / 40.0
7	Scan percentage	99.20%	80.00%
8	WFS (PIX) / BW (Hx)	0.759 / 572.3	1.067 / 406.9
9	TSE Factor	80	256
10	PNS / Level	79% / Normal	50% / Normal
11	Sound Pressure Level	21.5 Hz	19.1 Hz
12	Slice Thickness	-	40 mm

Statistical analysis

Results regarding bile duct visualization and overall technical image quality were compared with a two-sided Wilcoxon signed-rank test after Bonferroni correction (with a p-value <0.05 deemed significant) in the following way:

1, Coronal reconstructed MIP of the coronal acquisition vs. coronal reconstructed

MIP of the axial acquisition;

2, Axial reconstructed MIP of the coronal acquisition vs. axial reconstructed MIP of the axial acquisition;

3, Coronal vs. axial reconstructed MIP of the coronal acquired dataset;

4. Coronal vs. axial reconstructed MIP of the axial acquired dataset.

Interobserver agreement was assessed by means of a kappa-statistic and classified as follows: a K value of less than 0.20 indicated poor agreement; K values of 0.21-0.40, fair agreement; K values of 0.41-0.60, moderate agreement; K values of 0.61-0.80, good agreement; and K values of 0.80-1.00, excellent agreement [14].

Results

Bile duct visualization

In case of coronal data acquisition, visualization of bile duct segments was significantly better on coronal reconstructed MIP as compared to axial reconstructed MIP ($p < 0.05$). This was true for visualization of the CBD, right anterior hepatic duct, left hepatic duct, and third-order biliary branches. In case of axial data acquisition, one reader observed a significantly better visualization of the CBD and left hepatic duct on coronal reconstructed MIP as compared to axial reconstructed MIP.

Regarding bile duct visualization, coronal MIP of the coronal acquisition (Dataset A) was equal to coronal MIP of the axial acquisition (Dataset B) (p > 0.05) (Figure 1).

Axial MIP of the axial acquisition (Dataset B) was significantly better than axial MIP of the coronal acquisition (Dataset A) for visualization of third-order biliary branches, whereas lower-order branches did not show a difference (Figures 2 and 3).

Interobserver agreement was moderate to good regarding bile duct visualization in both datasets (coronary acquisition: weighted K range 0.51-0.75; axial acquisition: weighted K range 0.42-0.67).

Bile duct visualization up to the third-order is equal on both datasets, even though the image impression is more blurred on the MIP derived from the axial acquired dataset (B). P values were calculated with the two-sided Wilcoxon Test after Bonferroni correction to compare depiction scores of coronal axial acquired datasets.

Technical image quality

Regarding overall technical image quality (including axial and coronal reconstructed MIP of a given dataset), there was no significant difference between the coronal and axial acquired datasets (p > 0.05). However, in the case of coronal data acquisition, detailed dataset analysis showed that technical image quality of the coronal MIP was significantly better as compared to the axial reconstructed MIP (p < 0.05). In the case of axial data acquisition, there was no significant difference regarding technical image quality of the reconstructed MIP (p > 0.05).

Intraobserver agreement regarding technical image quality was moderate to excellent (weighted K range 0.55-0.96); interobserver agreement was moderate (weighted K range 0.42-0.59).

Choice of preferred image dataset

When reading coronal reconstructed MIP, readers preferred coronal acquisitions over axial acquisitions in 66% of the readings. Regarding axial MIP reconstruction, axial acquisitions were preferred over coronal acquisitions in 80% of the readings. Intraobserver agreement regarding choice of the preferred image dataset was excellent (weighted K range 0.94-1.00); interobserver agreement was moderate to excellent (weighted K range 0.57-0.85).

ERCP showed 30% malignant obstructions, 30% calculi in the common bile duct, 8% miscellaneous disorders and in 32% no abnormalities (Table 2). A significantly higher diagnostic accuracy of the 3D MRCP technique over the SS MRCP technique (p <0.05) using the McNemar's test was observed. Obstruction due to tumor was shown in 30% of patients, and calculi in the common bile duct were also shown in 30% of patients employing the 3D MRCP technique. Obstruction due to tumor and calculi were shown in 30% and 21% of patients, respectively, using the SS 2D MRCP technique.

Table 2.
Comparison of 3D versus 2D MRCP in detection of various disease pathologies with ERCP (Gold standard)

	ERCP	3D MRCP	2D MRCP
Malignant Obstruction	30%	30%	30%
Calculi	30%	30%	21%

Sensitivity and specificity in distinguishing calculi in the common bile duct by 3D MRCP coronal acquisition and SS MRCP were 100%, 100%, 70% and 100%, respectively. Interobserver agreement for 3D acquisition coronal MRCP was good for all diagnosis at a Kappa value ranging from 0.76 to 0.90, but bad to moderate for the SS MRCP at a Kappa value ranging from 0.20 to 0.63.

Discussion

To the best of our knowledge the ideal acquisition and reconstruction plane for optimal bile duct evaluation with 3D techniques has not yet been evaluated. For single-shot FSE techniques, it has been suggested that straight coronal and initial left posterior oblique images clearly depict the common hepatic duct and the left hepatic duct, whereas the CBD and right hepatic ducts are better seen in left posterior images obtained at a steeper angle [15]. In a first approach towards projection cholangiography by means of MRI in 1991, Wallner and colleagues [4] used a heavily T2-weighted gradient echo sequence for assessment of bile duct dilatation. They concluded that imaging in the coronal plane provided a good view of the biliary system, whereas no additional information was found by imaging in the sagittal plane. In this study we compared different acquisition and reconstruction planes of T2-weighted 3D MRCP acquisitions for assessment of the intra- and extra-hepatic bile ducts. In contrast to single-shot techniques, 3D MRCP has the advantage of facilitating secondary reconstructions. Coronal reconstructions were preferred, regardless of the initial acquisition plane. These findings were supported by good intra- and interobserver agreements. One of the reasons for coronal image preference may be the fact that these images are similar to image impressions of ERCP and conventional cholangiograms.

Other studies have evaluated secondary reconstruction techniques for MRCP. Schaible and colleagues [17] evaluated selective MIP reconstructions of respiratory-triggered 3D MRCP versus standard MIP reconstructions and single-shot MRCP. Single-shot and standard MIP reconstructions of 3D MRCP were comparable in terms of anatomical bile duct visualization, whereas selective MIP post-processing proved useful for detection of pathological alterations. In a retrospective study, Morita and colleagues [18] compared volume rendering (VR) and MIP of 3D-TSE MRCP sequences to define biliary anatomy mostly in patients without major biliary tract anomaly. Definition of biliary anatomy was found to be more accurate using VR reformation than MIP. However, the assessment of VR images was not the purpose of the present study. One disadvantage of VR reconstructions is that the detection degree of each structure depends on the setting of display parameters, particularly on the lower threshold of the opacity curve. Therefore, VR images need to be evaluated interactively [18].

In 1999, Boraschi and colleagues [19] compared axial and coronal 2D FSE sequences with 3D-MIP projection images in patients with suspected hepatobiliary disease. A higher global accuracy for axial and coronal FSE T2-weighted sequences was found regarding the diagnosis of the level and probable cause of biliary obstruction in depiction of small intraductal pathology, such as calculi or neoplastic lesions.

We have limited our analysis to reconstructed rather thin-slice source images, as the purpose of this specific study was to directly compare acquisition and reconstruction planes for MIP assessment. A well-known limitation of MIP is that small filling defects may be obscured due to partial volume effects [20]. Further, overestimation of ductal narrowing and pseudostricture may result from the nature of MIP reconstruction [21]. Therefore, it is important that MIP reconstructions not be appraised separately, but always in combination with the original acquired dataset, and in combination with other morphological sequences.

Conclusions

We compared different acquisition and reconstruction planes of T2-weighted 3D MRCP acquisitions for assessment of the intra- and extrahepatic bile ducts in patients with different hepatobiliary pathologies.

The biggest disadvantage of 3D imaging is its acquisition time of five minutes, compared to the short time duration of 2D acquisition.

The results of our study suggest that coronal reconstructions are preferred for visualization and evaluation of the bile ducts,. In this context, the orientation of the primary dataset (coronal or axial) is negligible.

Although the 3D MRCP multislice technique is more time-consuming than the SS MRCP breath-hold technique at a 3 Tesla (Philips 3 T Ingenia) system, it is advisable to use thin-slice 3D MRCP in order not to misdiagnose calculi in the common bile duct. Better interobserver agreement is reached employing the 3D MRCP technique. □

Acknowledgments

The authors would like to convey thanks to our MRI technicians, Santosh and Mahadevaswamy, and to all patients involved in this study.

Conflict of interest

The authors declare that there are no conflicts of interest.

References

1. Sodickson A, Mortele KJ, Barish MA, Zou KH, Thibodeau S, Tempany CM. Three-dimensional fast-recovery fast spin-echo MRCP: comparison with two-dimensional single-shot fast spin-echo techniques. Radiology. 2006;238(2):549–559.

2. Holzknecht N, Gauger J, Sackmann M, Thoeni RF, Schurig J, Holl J, et al. Breath-hold MR cholangiography with snapshot techniques: prospective comparison with endoscopic retrograde cholangiography. Radiology. 1998;206(3):657–664.

3. Hekimoglu K, Ustundag Y, Dusak A, Erdem Z, Karademir B, Aydemir S, et al. MRCP vs. ERCP in the evaluation of biliary pathologies: review of current literature. J Dig Dis. 2008;9(3):162–169.

4. Wallner BK, Schumacher KA, Weidenmaier W, Friedrich JM. Dilated biliary tract: evaluation with MR cholangiography with a T2-weighted contrast-enhanced fast sequence. Radiology. 1991;181(3):805–808.

5. Laubenberger J, Buchert M, Schneider B, Blum U, Hennig J, Langer M. Breath-hold projection magnetic resonance-cholangio-pancreaticography (MRCP): a new method for the examination of the bile and pancreatic ducts. Magn Reson Med. 1995;33(1):18–23.

6. Bilgin M, Shaikh F, Semelka RC, Bilgin SS, Balci NC, Erdogan A. Magnetic resonance imaging of gallbladder and biliary system. Top Magn Reson Imaging. 2009;20(1):31–42.

7. Chavhan GB, Babyn PS, Manson D, Vidarsson L. Pediatric MR cholangiopancreatography: principles, technique, and clinical applications. Radiographics. 2008;28(7):1951–1962.

8. Yoon LS, Catalano OA, Fritz S, Ferrone CR, Hahn PF, Sahani DV. Another dimension in magnetic resonance cholangiopancreatography: comparison of 2- and 3-dimensional magnetic resonance cholangiopancreatography for the evaluation of intraductal papillary mucinous neoplasm of the pancreas. J Comput Assist Tomogr. 2009;33(3):363–368.

9. Yun EJ, Choi CS, Yoon DY, Seo YL, Chang SK, Kim JS, et al. Combination of magnetic resonance cholangiopancreatography and computed tomography for preoperative diagnosis of the Mirizzi syndrome. J Comput Assist Tomogr. 2009;33(4):636–640.

10. Kinner S, Dechêne A, Ladd SC, Zöpf T, De Dechêne EM, Gerken G, et al. Comparison of different MRCP techniques for the depiction of biliary complications after liver transplantation. Eur Radiol. 2010;20(7):1749–1756.

11. Ikenoue H, Ito S, Yamada M, Takikawa Y, Yamamuro O. Comparison MR cholangiopancreatography with 3D-fast recovery fast spin echo in several different slice thicknesses. Nihon Hoshasen Gijutsu Gakkai Zasshi. 2010;66(7):749–757.

12. Matsunaga K, Ogasawara G, Tsukano M, Iwadate Y, Inoue Y. Usefulness of the navigator-echo triggering technique for free-breathing three-dimensional magnetic resonance cholangiopancreatography. Magn Reson Imaging. 2013;31(3):396–400.

13. Papanikolaou N, Karantanas AH, Heracleous E, Costa JC, Gourtsoyiannis N. Magnetic resonance cholangiopancreatography: comparison between respiratory-triggered turbo spin echo and breath-hold single-shot turbo spin echo sequences. Magn Reson Imaging. 1999;17(9):1255–1260.

14. Lim JS, Kim MJ, Myoung S, Park MS, Choi JY, Choi JS, et al. MR cholangiography for evaluation of hilar branching anatomy in transplantation of the right hepatic lobe from a living donor. AJR Am J Roentgenol. 2008;191(2):537–545.

15. Vitellas KM, Keogan MT, Spritzer CE, Nelson RC. MR cholangiopancreatography of bile and pancreatic duct abnormalities with emphasis on the single-shot fast spin-echo technique. Radiographics. 2000;20(4):939–957.

16. Arcement CM, Meza MP, Arumanla S, Towbin RB. MRCP in the evaluation of pancreaticobiliary disease in children. Pediatr Radiol. 2001;31(2):92–97.

17. Schaible R, Textor J, Kreft B, Neubrand M, Schild H. Value of selective MIP reconstructions of respiratory triggered 3D- TSE- MR cholangiography on a workstation versus standard MIP reconstructions and single-shot MRCP. Röfo. 2001;173(5):416–423.

18. Morita S, Saito N, Suzuki K, Mitsuhashi N. Biliary anatomy on 3D MRCP: comparison of volume-rendering and maximum-intensity-projection algorithms. J Magn Reson Imaging. 2009;29(3):601–606.

19. Boraschi P, Braccini G, Gigoni R, Geloni M, Perri G. MR cholangiopancreatography: value of axial and coronal fast Spin-Echo fat-suppressed T2-weighted sequences. Eur J Radiol. 1999;32(3):171–181.

20. Anderson CM, Saloner D, Tsuruda JS, Shapeero LG, Lee RE. Artifacts in maximum-intensity-projection display of MR angiograms. AJR Am J Roentgenol. 1990;154(3):623–629.

21. David V, Reinhold C, Hochman M, Chuttani R, McKee J, Waxman I, et al. Pitfalls in the interpretation of MR cholangiopancreatography. AJR Am J Roentgenol. 1998;170(4):1055–1059.