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Özgün Çalışma / Original Article

Effıcacy Of Navıgator-Trıggered Pace Technıque Mrcp In Choledocholıthıasıs

Navigatör Tetiklemeli Pace Tekniği İle Elde Olunan Mrkp Tetkikinin Koledokolitiazis Tanısında Etkinliği

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ÖZET

AMAÇ: Navigatör tetiklemeli "Prospective Acquisition Correction Enhancement" tekniği, manyetik rezonans kolanjiyopankreatografi tetkiklerinde solunuma bağlı oluşan hareket artefaktlarını gidermek için geliştirilmiş bir yöntemdir. Bu çalışmada "Prospective Acquisition Correction Enhancement" tekniği ile elde olunan manyetik rezonans kolanjiyopankreotografi görüntülerinin koledokolitiazis tanısındaki etkinliğinin, altın standart olarak kabul edilen endoskopik retrograt kolanjiyopankreatografi tetkiki ile karşılaştırılması amaçlanmıştır.

GEREÇ VE YÖNTEM: Koledokolitiazis varlığının tanısında "Prospective Acquisition Correction Enhancement" tekniği ile yapılan manyetik rezonans kolanjiyopankreatografi tetkikinin tanısal doğruluğu altın standart olarak kabul edilen endoskopik retrograt kolanjiyopankreatografi tetkiki sonuçlarına göre karşılaştırıldı.

BULGULAR: Çalışmaya dahil edilen 107 hastadan manyetik rezonans kolanjiyopankreatografi ile 40, endoskopik retrograt kolanjiyopankreatografiile 36 hastaya koledokolitiazis tanısı konuldu. Manyetik rezonans kolanjiyopankreatografiile koledokolitiazis tanısı konulan 40 hastanın 36'sında endoskopik retrograt kolanjiyopankreatografi taş varlığını gösterdi. "Prospective Acquisition Correction Enhancement" tekniği ile yapılan manyetik rezonans kolanjiyopankreatografi tetkikinin pozitif prediktif değeri %90, negatif prediktif değeri %98.5, sensitivitesi %97.3, spesifisitesi %94.3 ve tanısal doğruluk oranı %95.3 olarak hesaplandı.

SONUÇ: Navigatör tetiklemeli "Prospective Acquisition Correction Enhancement" tekniği ile elde olunan manyetik rezonans kolanjiyopankreatografi tetkikinin koledokolitiazis tanısında yüksek doğruluğa sahip güvenilir bir yöntem olduğunu düşünmekteyiz.

Anahtar kelimeler: Endoskopik retrograt kolanjiyopankreatografi, Manyetik rezonans kolanjiyopankreatografi, Navigatör tetikleme, "Prospective Acquisition Correction Enhancement" tekniği.

ABSTRACT

AIM: The navigator-triggered Prospective Acquisition Correction Enhancement technique is a method used to eliminate respiratory motion artifacts caused in magnetic resonance cholangiopancreatography examinations. The purpose of this study was to compare the diagnostic accuracy of navigator-triggered Prospective Acquisition Correction Enhancement tecnique magnetic resonance cholangiopancreatography examination with endoscopic retrograde cholangiopancreatography as a gold standard reference in presence of choledocholithiasis.

MATERIAL AND METHOD: The diagnostic rates of magnetic resonance cholangiopancreatography examination performed with Prospective Acquisition Correction Enhancement technique in the diagnosis of choledocholithiasis were compared according to the results of the endoscopic retrograde cholangiopancreatography examination, which was accepted as a gold standard reference.

RESULTS: Among 107 patients included in the study, 40 patients with magnetic resonance cholangiopancreatography and 36 patients with endoscopic retrograde cholangiopancreatography were diagnosed with choledocholithiasis. Endoscopic retrograde cholangiopancreatography showed the presence of choledocholithiasis in 36 patients among 40 patients diagnosed as choledocholithiasis with magnetic resonance cholangiopancreatography. The positive predictivity value of the magnetic resonance cholangiopancreatography examination performed with the Prospective Acquisition Correction Enhancement technique was 90%, the negative predictivity value was 98.5%, the sensitivity was 97.3%, the specificity was 94.3%, and the diagnostic accuracy was 95.3%.

CONCLUSION: We think that navigator-triggered magnetic resonance cholangiopancreatography examination obtained with Prospective Acquisition Correction Enhancement technique is a reliable method with high accuracy in the diagnosis of choledocholithiasis.

Keywords: Endoscopic retrograde cholangiopancreatography, Magnetic resonance cholangiopancreatography, Navigator–triggering, Prospective Acquisition Correction Enhancement technique.

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INTRODUCTION

Magnetic resonance cholangiopancreatography (MRCP) is a noninvasive imaging technique that provides detailed information on the anatomy and pathology of the pancreaticobiliary tree. T2-weighted MRCP has been essential for both the detection and characterization of pancreaticobiliary diseases.[1] Respiratory motion artifact is a major problem that leads to impaired MRCP image quality.

The navigator-triggered prospective acquisition correction (PACE) technique is a virtual respiratory monitoring technique. This technique can reduce respiratory motion artifacts by directly monitoring the superior-inferior movement of the right diaphragm with navigator echoes. The PACE technique is a real-time gradient recalled echo fast low angle shot navigator sequence for monitoring diaphragmatic movement.[2,3] The hallmark of this technique is that it does not require patients to hold their breath during imaging. Among the techniques used to reduce respiratory artifacts, the PACE technique has always an indispensable place, especially in the patient group who can not establish respiratory cooperation, and we think there is not enough information in the literature about the efficacy of this technique.

The purpose of this study was to compare the diagnostic accuracy of navigator-triggered PACE technique isotropic 3D-MRCP using a parallel imaging technique for choledocholithiasis with that of endoscopic retrograde cholangiopancreatography (ERCP) as a gold standard reference.

MATERIAL AND METHOD

This study was approved by the Ethics Committee and Health Sciences Research Board of Başkent University (decision no: 0.05.05.01/586, date: 07/09/2010).

Study population

The participants were the patients who presented with clinical signs and symptoms that has suspected pancreaticobiliary disease and performed both MRCP and ERCP at Başkent University Faculty of Medicine Ankara Hospitalbetween February 2009 and December 2012. The time interval between ERCP and MRCP ranged from 0-to 30 days (mean 7,2 days). Inclusion criteria were defined as performing MRCP first, then performing ERCP for patients with the above-mentioned complaints and findings within the specified time, and being successful in both examinations. Patients who had ERCP before MRCP and whose examinations were not successful were excluded from the study. Written inform consent was obtained from each patient separately before the examinations, and there was a confirmation clause in the consent forms stating that the hospital where these examinations were performed was a university institution and that the images could be used in possible future studies.

MRCP protochol and ERCP prosedure

Before MRCP imaging, the patients were asked to fast for a minimum of 6 hours to maximize gallbladder filling and gastric emptying. MRCP imaging was performed with a 1,5 T (Magnetom Symphony, Siemens Medical Solutions) using a 6-channel body phased-array surface coil as a radiofrequency receiver. 3D heavy T2 weighted Turbo Spin Echo (TSE) sequence, slice thickness 5 mm, flip angle 90 degrees, field of view (FOV) 400 mm, matrix size 384x384, and gap: 0 were selected as sequence parameters. The MRCP examination was performed using the navigator-triggered PACE technique, without holding a breath. Repeat Time (TR) time was determined individually for each patient according to the cycle of diaphragm movements detected by navigator echoes. Echo Time (TE) time was determined as 100 msn and turbo factor was determined as 21.

The source images were obtained in two planes, providing better anatomic orientation. We processed MRCP data sets with maximum intensity projection (MIP) and shaded surface display (SSD) algorithms. The MIP algorithm was used to obtain 3-dimensional (3D) images of the intrahepatic and extrahepatic biliary systems from the source images.

A standard defined protocol was used for 3D reformatted images. For the image analysis, a series of 19 projections rotated by 10 intervals from -90° to 90° was created for each rendering algorithm. The reconstructions were obtained in the coronal plane.

For the PACE technique, the 2D-PACE with a standard protocol was used. The echoes of a gradient echo fast low angle shot (FLASH) sequence continuously acquired a coronal 2D image to monitor the movement of the right diaphragm using the following parameters, slice thickness of 10 mm, field of view of 256x512 mm using a bandwidth of 260 Hz/pixel, and a flip angle of 3 (matrix size= 256x512. TR=7.1 msec, TE=3.4 msec). Data of the end-expiratory phase were gathered via navigator-triggering. The acquisition time which depended on the patient's respiration cycle was noted in order to calculate the mean acquisition time.

ERCP was performed by one of the attending gastroenterologists using standard techniques and fiber-optic endoscopes. The ERCP reports of specified dates were scanned and patients with and without stone disease detected in ERCP were noted. All MRCP images were reviewed retrospectively by two radiologists, one with 5 years and the other with 15 years of experience at an independent workstation (Leonardo, Siemens Medical Systems, Erlangen, Germany).

Statistical analysis

Sensitivity, specificity, positive predictive values (PPV), negative predictive values (NPV), and diagnostic accuracy of the MRCP technique were calculated using SPSS software (SPPS inc. version 11, 2002, Chicago, IL, USA). The accuracy of MRCP for determining the presence of choledocholithiasis was compared with that of ERCP as the gold standard by using the McNemar test.

RESULTS

Between January 2009 and December 2012, we identified a total of 119 patients who underwent MRCP and then ERCP with the suspicion of pancreaticobiliary disease. A total of 12 patients had to be excluded from the study, 5 due to inadequate image quality on MRCP with patient-related reasons and 7 due to unsuccessful cannulation during ERCP. In the remaining 107 patients, both MRCP and ERCP were performed successfully. The patients were 51 (47,7%) men and 56 (52,3%) women with a mean age of 61,7 years. MRCP revealed choledocholithiasis in 40 of the 107 patients, whereas ERCP revealed choledocholithiasis in 36 of these 40 patients. ERCP revealed choledocholithiasis in 37 of the 107 patients. Using ERCP as the gold standard, the statistical results for MRCP in detection of choledocholithiasis were as follows: positive predictive value (PPV): 90%, negative predictive value (NPV): 98,5%, sensitivity: 97,3%, specificity: 94,3 %, and diagnostic accuracy: 95,3 %. Examples of the MRCP and ERCP images are given in

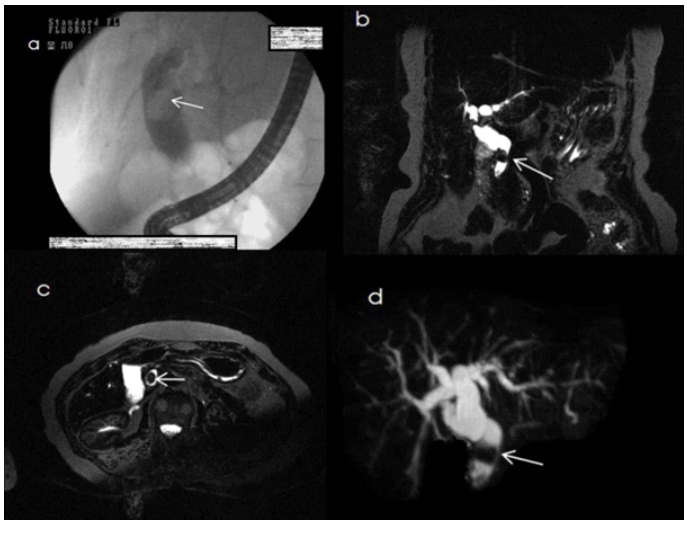

Figure 1

a) An ERCP image shows 16 mm sized stone in the common bile duct b) coronal c) axial T2-weighted TSE sequence MRCP with navigator-triggered PACE technique d) and 3D maximum intensity projection MRCP images show the filling defects as choledocholithiasis.

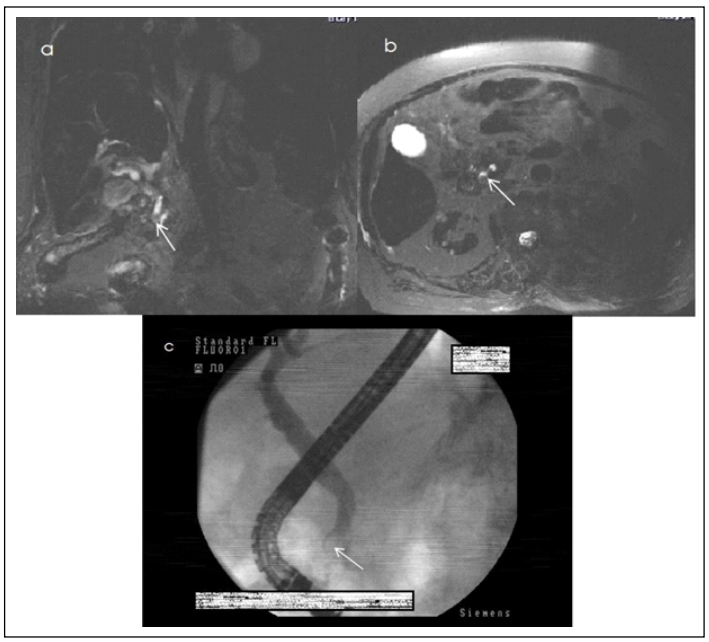

Figure 2.
a) Coronal b) and axial T2-weighted TSE sequence MRCP with navigator-triggered PACE technique images show small stone in the common bile duct c) ERCP image shows choledocholithiasis in the distal common bile duct.

figures 1, 2. The mean acquisition time was calculated 5,32 minutes (range 4,21-7,52 min)

DISCUSSION

With recent advances in the development of high-performance gradient coils and phased array torso coils and evaluation of software, numerous pulse sequences have become available for T2 weighted MRCP imaging. Artifacts caused by respiratory motion are one of the major problems with these pulse sequences because these artifacts may lead to image blurring, ghosting, loss of signal intensity, and misregistration, thereby obscuring important anatomic structures and lesions.[4]

Various techniques have been used to reduce respiratory artifacts.[5-11] A straightforward strategy is to use fast imaging techniques performed by holding a breath to the patient. Techniques such as gradient echo, 2 or 3D fast spin echo, single-shot rapid acquisition with relaxation enhancement (RARE), and half-Fourier single-shot turbo spin-echo (HASTE) sequences which can fill the k-space during the respiratory motionless period have been widely used. However, images obtained with these sequences are usually poor, and artifacts inherent to fast imaging often become troublesome.

Another strategy used for overcoming challenges about respiratory artifacts is a respiratory triggering method. In many studies surveyed in this field, it has been shown that the image contrast, signal-noise rate, and spatial resolution increase due to the extension of signal acquisition time with respiratory-triggering T2 weighted sequences. Respiratory Ordered Phase Encoding (ROPE), Phase Encoded Artifact Reduction (PEAR), and Phase Encoding Reordering Motion (PERM) techniques use respiratory gating or respiratory compensation methods known as respiratory-triggering methods. Recent studies propose that a three-dimensional (3D) thin multislice respiratory-triggered (RESP) technique using TSE sequence is superior to breath-hold sequences. The RESP technique is used in an attempt to avoidmotion artifacts for non-breath-holding sequences.[3] Movement of the abdominal wall is commonly monitored by a special belt rolled around the upper abdomento monitor respiratory motion.[6] This method can monitor the respiratory cycle easily. However, there is a possibility that the quality of the images obtained will not be satisfactory because the motion of the abdominal wall does not always synchronize with that of the abdominal parenchymatous organ. As well, patients need to be specially prepared and interruptions of an examination because of the dislocation of the respective monitoring device can occur. Therefore, the probability of experiencing problems with these techniques is relatively common.

Another respiratory artifact prevention strategy is the navigator-triggered method. Navigators are additional RF pulses used to dynamically track anatomic motion, especially the superior-inferior position of the diaphragm. Navigator pulses may be either spin-echo (SE) or gradient echo (GRE). In the PACE technique, the movements of the right diaphragm during the respiratory cycle are monitored by echoes of a navigator. Its superiority to the conventional RESP technique for 2D sequences of the upper abdominal area has been reported.[6,7] However, judging from many past reports about 3D whole-heart coronary magnetic resonance angiography,[9-12] such an improved motion correction technique will be even more valuable for 3D sequences. The superiority of 3D MRCP using the 2D-PACE technique to conventional RESP and breath-holding 2D MRCP has been reported.[5] Morita et al.'s prospective comparative study on healthy volunteers demonstrated the superiority of the navigator-triggered PACE technique over the RESP technique in image quality.[13] However, there has been no prospective comparative report proving this superiority by comparing the 2D-PACE and RESP techniques with suspected pancreaticobiliary disease patients. Furthermore, because only a limited number of companies provide 2D-PACE, there has been some skepticism. Thus, whether PACE is superior to conventional RESP for 3D MRCP needs more consideration. This study contributes to the limited information available in the literature about the clinical efficacy of this technique, which does not require breath-holding due to the navigator-triggering method and has a critical place in the MRCP imaging, especially in the patients with breath-holding problems.

In our study, we investigated patients with 3D heavily T2-weighted MRCP using the navigator-triggered PACE technique. This TSE technique provides thin slices that display ductal filling defects as areas of signal void surrounded by bright bile signals.[12] There was an optimal contrast between the hyperintense signal of the bile and the hypointense signal of the stone (Figure 1, 2). Our results revealed a total accuracy rate 95,3 % for MRCP in the detection of choledocholithiasis in suspected pancreaticobiliary disease cases which suggests a high accuracy rate. Respiratory triggered TSE acquisition combines high SNR and contrast of images and minimal motion artifacts comparable to breath-hold techniques. Our study results show comparable diagnostic performance of 3D-MRCP with ERCP for evaluating common bile duct stones probably due to the navigator-triggered isotropic 3D-TSE sequence for MRCP.

The stone disease can be diagnosed using several different MR techniques, including 3D heavily T2-weighted TSE MR sequences, HASTE, and single-shot RARE sequences. These are currently considered optimal because they provide thin sections with higher spatial resolution, higher signal-to-noise ratios, and comparable image contrast in a single-breath time frame.[14,15] However, there is no clear consensus about which sequence is most appropriate for MRCP imaging and for detecting stones in the bile duct.[15,16] The literature indicates that MRCP is a highly sensitive (50-100%) and specific (83-100%) tool for diagnosing biliary stone disease.[16-18] In a systematic review study of Kaltenthaler et al., which included 15 studies comparing MRCP and ERCP in the diagnosis of choledocholithiasis, the overall sensitivity and specificity values calculated with the average diagnostic threshold value were found to be 91% and 95%, respectively.[19] The corresponding values in our study were very high too (97,3%, and 94,3% respectively).

Table 1. Similar studies on the efficacy of MRCP with different techniques in the diagnosis of pancreaticobiliary disease in the literature.

Author	Year	MRCP technique	Patients (n)	Sensivity (%)/ Specifity (%)	Condition
Yeniçeri [20]	2019	Respiratory triggered HASTE with T2 SPACE technique	37	93 / 69	Choledocholithiasis
Su-Lim Lee [21]	2018	Navigator-triggered MRCP images using SPACE technique	78	93 / 81	Common bile duct stones in acute biliary pancreatitis
Badger [22]	2017	Breath-hold T2-weighted noncontrast multiplanar images with 3D reconstruction	47	90 / 86	Choledocholithasis
Stella K. Kang [23]	2017	Axial-coronal HASTE with 3D PACE MRCP	123	85 / 97	Any suspected pancreaticobilary disease
Polistina [24]	2015	Multislice breath hold HASTE and respiratory gated multipl sectional sequences (3D HR)	111	77 / 100	Choledocholithiasis
Aydelotte [25]	2015	Single-shot FSE with respiratory-triggered 3D fast recovery FSE	36	90 / 88	Choledocholithiasis, malign strictures and duct injuries
Meeralam [26]	2017	NA	272	87 / 92	Metaanalysis of 5 choledocholithiasis study with MRCP
Our Study	2012	3D heavy T2-weighted TSE sequence with the navigator-triggered PACE technique	107	97 / 94	Choledocholithasis

MRCP: magnetic resonance cholangiopancreatography; HASTE: half foruier single -shot turbo spin echo; SPACE: sampling perfection with application optimized contrast using different flip angle evolution; 3D: three-dimensional; PACE: prospective acquisition correction enhanc ement; HR: high-resolution; FSE: fast spin -echo; NA: non-applicable; TSE: turbo spin -echo

shows some similar studies on the efficacy of MRCP with different techniques in the diagnosis of pancreaticobiliary disease in the literature.[20-26]

With the development of rapid imaging techniques in MRI examinations over the years, advances have also been made in MRCP imaging. With technical improvements in MRI, including faster gradients, more receiver coils, and the application of parallel imaging, 3D MRCP protocols capable of revealing images in a single breath-hold time became feasible. A faster 3D isotropic technique with a reduced and varying flip angle has recently become widely accepted for MRCP because it can produce thin isotropic images but with a shorter acquisition time and decreased specific absorption rate. Vendor-specific names that the reader would be familiar with are SPACE (sampling perfection with application-optimized contrasts using different flip-angle evolutions; Siemens Healthcare), Cube (GE Healthcare), and VISTA (Philips Healthcare).[27] In a recent prospective comparative study, it was shown that all visual scores, contrast and contrast noise ratio (CNR) of common bile duct were higher for the 3D MRCP SPACE than the conventional TSE sequence and there was a significant difference in motion artifacts.[28] Such new techniques, which shorten the acquisition time and decrease specific absorption rates, can also be used in navigator-triggered MRCP examinations. In another prospective comparative study conducted by Chen et al. in 2019, it was shown that the rapid navigator-triggered MRCP examination using the SPACE technique is superior in image quality scores compared to the conventional navigator-triggered MRCP examination whereas the mean signal-noise ratio (SNR), the contrast ratio, and the contrast noise ratio of the common bile duct were higher on navigator-triggered MRCP.[29] Nevertheless, there is a lack of studies on the accuracy of SPACE MRCP conducted on clinical pancreaticobiliary pathologies.

One limitation of our MRCP technique concerning detecting gall stones is that the slice thickness requires partial volume averaging. This can lead to false-negative results when a stone is smaller than the slice thickness in diameter. More studies to be made by thinning the section thickness can give more insight into this issue. The other limitation of our stduy is relatively low number of cases.

Another limitation is that it is not always easy to distinguish between stones and pneumobilia, tortuous common bile duct, compression of the hepatic duct by the right hepatic artery, and origin of the cystic duct mimicking common bile duct stones can be all confusing. These situations can lead to false-positive results. Our study cannot make any comments about the superiority of the techniques to each other in these confusing situations.

CONCLUSION

T2 weighted isotropic 3D MRCP using the navigator-triggered PACE technique can accurately show the presence of choledocholithiasis and since no breath-holding is necessary it can be used effectively in elderly patients who can not do breath-holding. Prospective studies that investigate pancreaticobiliary disease patients by comparing the navigator-triggered PACE technique with other methods are needed.

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Author Contributions:
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Design: AB, NÇT
Data collection: AB
Analysis and interpretation: AB, NÇT
Literature review: AB
Writer: AB
Critical review: AB, NÇT

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