Original Article

Additional Non-Contrast-Enhanced Computed Tomography (NCECT) of Abdomen to the Routine Magnetic Resonance Cholangiopancreatography (MRCP) Protocol, Increase the Accuracy of Common Bile Duct Stone Detection or Not

Busabong Noola, MD[1], Onnapat Laohataiwaykin, MD[1], Chutcharn Kongpanich, MD[1], Supakajee Saengruang-orn, PhD[1], Sutiporn Khampunnip, MD[1]

[1] Department of Radiology, Phramongkutklao Hospital, Bangkok, Thailand

Objective: To compare the diagnostic accuracy of magnetic resonance cholangiopancreatography (MRCP) in addition to the non-contrast-enhanced computed tomography (NCECT), with MRCP alone, or NCECT alone for common bile duct (CBD) stone detection using endoscopic retrograde cholangiopancreatography (ERCP) as a gold standard.

Materials and Methods: The medical records and image findings were retrospectively reviewed in all consecutive patients that underwent both MRCP and NCECT at Phramongkutklao Hospital between May 2012 and December 2015. The imaging data were reviewed using the consensus of two radiologists who were blind of the final diagnoses from ERCP. The accuracy of each modality in detecting CBD stone was reported as sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). The other associated findings were reported as the presence of gallstones aerobilia, pancreatic calcification, biliary stenting, intrahepatic duct (IHD) dilatation, and CBD dilatation using intermodality agreement and kappa statistics.

Results: Two hundred forty-one patients underwent both MRCP and NCECT. The accuracy, sensitivity, specificity, PPV, and NPV of the combined modalities were 98%, 99%, 95%, 98%, and 95%, respectively, which was higher than MRCP alone but it did not reach a statistical significance (accuracy, sensitivity, specificity, PPV, and NPV of MRCP were 97%, 98%, 95%, 99%, and 91%, p=0.77 for accuracy). The other abnormalities found such as aerobilia, presence of gallstone, presence of IHD, and CBD dilatation were similar in both combined MRCP and NCECT as compared with MRCP alone.

Conclusion: The accuracy of MRCP alone was good and acceptable for the detection of CBD stone. Adding NCECT to the routine MRCP did not result in a significantly higher accuracy. Thus, routinely adding the NCECT was no longer recommended to avoid unnecessary radiation exposure and increasing the cost of investigation.

Keywords: Common bile duct stone, MRCP, NCECT, ERCP, Accuracy

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The common bile duct (CBD) stone is one of the important causes of hospitalization, occurring in 10% to 20% of individuals with gallstones. The CBD stones can be found in up to 3% to 10% of the gallstone patients admitted for cholecystectomy(1) and increases with age.

Correspondence to:

Noola B.

Department of Radiology, Phramongkutklao Hospital, 315, Rajavithi Road, Ratchathewi, Bangkok 10400, Thailand.

Phone: +66-89-4855012, **Fax**: +66-2-3545243

Email: bbnoola@yahoo.com

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In general, the diagnosis of CBD stone can be made based on history taking, physical examination, presence of symptoms of bile duct obstruction, and laboratory tests. Standard investigation of this disease is an endoscopic retrograde cholangiopancreatography (ERCP), which is not only an accurate diagnostic modality but also a therapeutic intervention[2]. However, it is an invasive procedure causing some complications during or after the procedure, including pancreatitis, hemorrhage, perforation, infection, and bile leakage[3,4].

There are other non-invasive investigations to detect CBD stones, such as, abdominal ultrasound. However, the sensitivity was limited to only 36% with 98% specificity, and there are still some limitations in evaluating the distal part of CBD due to bowel gas obscuration. Non-contrast-enhanced computed tomography (NCECT) has a better sensitivity (72% to 88%) for the detection CBD stone, but with an increased risk from the ionizing radiation. Thus, the magnetic resonance cholangiopancreatography (MRCP) has been used with better sensitivity and specificity of 89% to 100% and 83% to 100%, respectively[5]. MRCP is useful both in evaluating biliopancreatic diseases and a good substitute to ERCP for detecting CBD stones[6].

Although MRCP can detect as small stones as 2 mm, there are some limitation of interpretation in small stones not surrounded by bile or small gas bubble because the aerobilia can mimic CBD stone. In addition, blood clots in the bile duct may be difficult to be distinguished from CBD stones[7].

Using computed tomography (CT) scan, air bubble as well as a small, impact, high-density CBD stone, which was usually missed by MRCP, can be demonstrated clearly. For this reason, NCECT was routinely added to the MRCP protocol to increase the accuracy in diagnosis of CBD stones in the authors' institution. However, NCECT may result in unnecessary radiation exposure to the patients and increase the cost of the investigation. Therefore, the present study was conducted to evaluate the value of adding the NCECT to the investigation, which may lead to adapting the protocol in the future.

Objective

The primary objective of the present study was to compare the accuracy of CBD stone detection by MRCP plus NCECT, MRCP alone, and NCECT alone. The secondary objective was to find out whether adding NCECT to MRCP protocol improve the accuracy of detecting CBD stones.

Materials and Methods

The present study was conducted as an observational-descriptive, retrospective study. The proposal was approved by the Institutional Review Board of the Royal Thai Army Medical Department (R076h/58). Target population was images of all consecutive patients that underwent MRCP with NCECT of abdomen at the Department of Radiology, Phramongkutklao Hospital between May 2012 and December 2015. The exclusion criterion was the images of patients with known CBD obstruction from cancer including cholangiocarcinoma, gallbladder carcinoma, pancreatic adenocarcinoma, or metastatic cancer of any primary sites. Sample size calculation was made based on a study of Soto et al[8], which the sensitivity of NCECT was 0.65. Using an equation: $n = Z_{\alpha}^2 S(1-S) / d^2$, while n=sample size, S=sensitivity of NCECT in detecting the CBD stone (0.65), d=error was 0.10 and Zα=standard values from table Z at α=0.05 (1.96). Then, number of patients be recruited was 87.39. Thus, the sample size would be 90.

The MRCP was performed using a 1.5-Tesla closed magnet unit (Achieva: Phillips Medical System Nederland B.V., The Netherlands) in supine position after at least six hours-fasting. Coronal and axial sequences of T2-weighted images with dual echo axial gradient T1-weighted images of the upper abdomen were initially obtained for general information. Then, thin-slice studies were performed at bile and pancreatic ducts. The imaging parameters used were coronal and axial turbospin echo T2-weighted at 380 to 460 millisecond repetition time and 110 millisecond echo time, 3 mm-slice thickness with no gap. Image matrix was 236×206 and 252×173 for coronal and axial planes, respectively. The 3D-MRCP technique was the last sequence using heavily T2 weighted images with repetition time of 1100 millisecond and echo time of 650 millisecond at a slice thickness of 1.6 mm with 0.8 mm overlapping and the matrix was 256×256.

The NCECT of the upper abdomen was performed in all patients using Phillips Brilliance 190p 64-slice MDCT in supine position after fasting time of at least six hours. The scanner was set at 120 KVp, 140 mAs, with the pitch of 1.078, 0.625 mm collimation, 0.4 second rotation time and 2 mm-slice thickness with 1 mm increment. The collected images were evaluated on axial, coronal and sagittal views.

To interpret the result of MRCP and NCECT, two experienced radiologists were asked to interpret each modality independently who were blind of the result from the other imaging modality as well as the result from another radiologist. If the results were not in concordance, the consensus was made to get the final diagnosis for each imaging. The results were recorded as presence or absence of CBD stones, gallstones, aerobilia, pancreatic calcification, biliary stenting, intrahepatic duct (IHD) dilatation, and CBD dilatation. The gold standard test to diagnose the CBD stone was ERCP. The final diagnosis from ERCP was recorded as presence or absence of the CBD stone. In the patients without ERCP done, clinical follow-up of at least one year was done to confirm the true absence of CBD stone.

Statistical analysis

General data were analyzed using descriptive statistics as percentage, mean, and standard deviation. The diagnostic performance of each modality will be reported as sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV). For the data without gold standard comparison, such as, the presence of gallstones aerobilia, pancreatic calcification, biliary stenting, IHD dilatation, and CBD dilatation, intermodality agreement was used to evaluate. Regarding this intermodality agreement, kappa statistics were used and categorized by kappa values as slight (less than or equal to 0.20), fair (0.21 to 0.40), moderate (0.41 to 0.60), substantial (0.61 to 0.80), or almost perfect (greater than 0.80). The IBM SPSS Statistics for Windows, version 22.0 (IBM Corp., Armonk, NY, USA) was used to analyze the data and a p-value of less than or equal to 0.05 was considered significant.

Ethical consideration

The present study was designed as a retrospective study using the review of medical records and imaging data. No intervention was performed in any patients and data were recorded without identification of the patients.

Table 1. Characteristics of the patients underwent both MRCP and NCECT

Characteristics	Number of patients n (%)
Sex	
Male	147 (61.0)
Female	94 (39.0)
Age (years); range (mean±SD)	26 to 87 (63.96±14.35)
<50	36 (14.9)
50 to 59	51 (21.1)
60 to 69	63 (26.0)
70 to 79	60 (24.8)
>80	32 (13.2)

SD=standard deviation

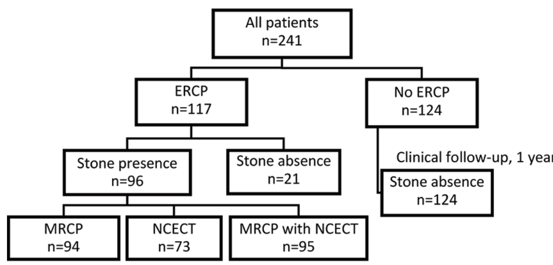

Figure 1. The patients underwent MRCP with NCECT and mode of stone detection.

Results

During the present study period, 241 studies were included in the analyses. The mean age of the patients was 63.96 years with a range of 26 to 87. Most of the patients (26%) were in 60 to 69 age-group with a male-to-female ratio of 1.5:1. The characteristics of the patients are shown in Table 1.

Among the 241 patients that underwent both MRCP and NCECT, 117 patients also had ERCP, and in 96 out of 117, the CBD stones were found. In these patients with CBD stones, stones were detected from MRCP with NCECT in 95 patients, from MRCP alone in 94 patients, and from NCECT alone in 73 patients. All patients and their modes of stone detection are summarized in Figure 1. The patients without ERCP were followed clinically for at least one year to confirm the true absence of CBD stone.

Among the 21 patients that underwent ERCP and no stone was found, most of them (16/21, 76.1%) were patients with pancreatitis that requested for ERCP to find out the causes. Only few abnormalities were found in this group of patients, i.e., dilatation of CBD without identifiable causes (n=2), intraductal papillary mucinous neoplasm (IPMN) (n=2), and biliary stenosis (n=1).

To analyze the accuracy of CBD detection, 95 out of 96 of the stone-positive patients can be diagnosed using combined MRCP and NCECT. The only patient missed had a tiny size stone (of less than 2 mm in diameter) as shown in Figure 2. The sensitivity, specificity, PPV, and NPV was 99%, 95%, 98%, and 95%, respectively.

Regarding the accuracy of MRCP alone, 94 out of 96 stones could be detected. Among the two patients that the stones were missed, the size of stone was smaller than 2 mm in the first patient and the stone location was the most distal part of CBD in another one. The sensitivity, specificity, PPV and NPV was 98%, 95%, 99% and 91%, respectively.

For NCECT alone, only 73 out of 96 CBD stones could be found, which was equal to sensitivity, specificity, PPV, and NPV of 76%, 100%, 100%, and 48%, respectively. The missed stones were due to their non-opacification.

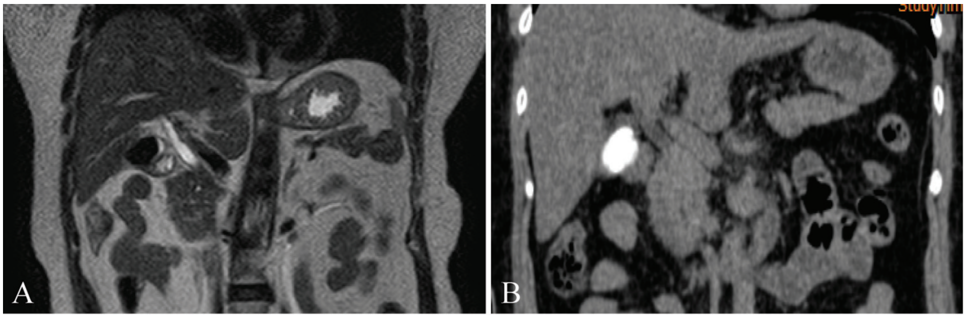

Figure 2. Demonstration of a false-negative CBD stone found on MRCP (A) and NCECT (B). This patient, ERCP confirmed a tiny (<2 mm) stone found in the CBD.

Table 2. Diagnostic accuracies of each modality comparing with the gold standard test

Modality	Sensitivity (%) (95% CI)	Specificity (%) (95% CI)	PPV (%) (95% CI)	NPV (%) (95% CI)	Accuracy (%) (95% CI)
MRCP+NCECT	99 (94.4 to 100.0)	95 (75.1 to 99.9)	98 (93.4 to 99.9)	95 (73.0 to 99.3)	98 (94.0 to 99.8)
MRCP alone	98 (92.7 to 99.8)	95 (76.2 to 99.9)	99 (93.3 to 99.8)	91 (71.7 to 97.5)	97* (92.7 to 99.5)
NCECT alone	76 (66.3 to 84.2)	100 (83.9 to 100)	100 (95.0 to 100)	48 (39.0 to 56.6)	80** (72.0 to 87.1)

MRCP=magnetic resonance cholangiopancreatography; NCECT=non-contrast-enhanced computed tomography
* p=0.77, ** p<0.001, p≤0.05 was considered statistically significant

Table 3. Intermodality agreement of the other observed variables apart from the CBD stone

Variables	MRCP+NCECT vs. MRCP alone (%)	MRCP+NCECT vs. NCECT alone (%)	MRCP vs. NCECT (%)
Gallstone	100	88	85
Aerobilia	89	100	88
Pancreatic calcification	77	100	76
Biliary Stenting	79	100	40
IHD dilatation	97	91	94
CBD dilatation	98	94	96

MRCP=magnetic resonance cholangiopancreatography; NCECT=non-contrast-enhanced computed tomography; IHD=intrahepatic duct; CBD=common bile duct

The accuracy of each modality is summarized and shown in Table 2.

Comparing the combined modalities (MRCP plus NCECT) and any single modality, an accuracy of combined MRCP and NCECT was highest but not significantly different from using MRCP alone (98% versus 97%, p=0.77). However, it was significantly higher than using NCECT alone (98% versus 80%, p<0.001). For the other findings without gold standard available for comparison, kappa statistics were used and the result about the intermodality agreement is shown in Table 3.

As shown above, with the addition of NCECT to MRCP, the presence of gallstone, the presence of aerobilia, IHD dilatation, and CBD dilatation can be detected with an almost-perfect agreement between the two modalities. The pancreatic calcification and biliary stenting had substantial intermodality agreement. The presence of aerobilia found on NCECT alone is shown in Figure 3. This false negative finding on MRCP image was due to an iron deposit found in the hemochromatosis patient resulting in a decrease in T2 signal intensity.

Discussion

In the present study, the sensitivity and specificity of MRCP in diagnosis of CBD stones was 95% and 98% respectively, which was comparable to the previously reported[3,9-11] at 81% to 100% and 85% to 100%, respectively.

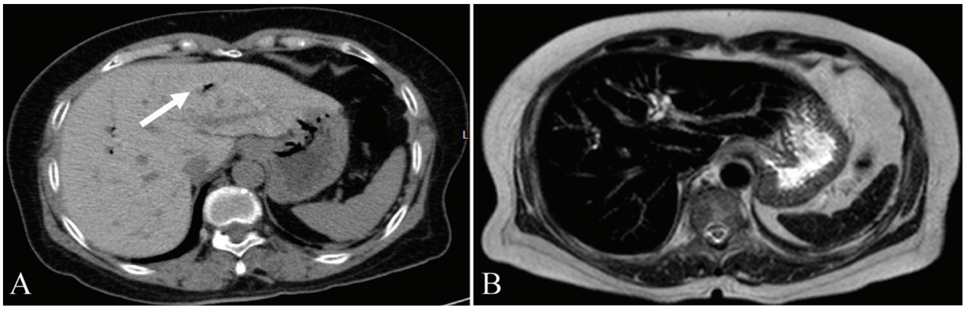

Figure 3. Demonstration of aerobilia found on NCECT alone (A, white arrow) while it was not detected in MRI (B) because of hemochromatosis of liver and iron deposition resulted in a decrease in T2signal intensity.

When the NCECT was added to detect air bubble as well as a small, impacted, high-density stone, which are usually missed by MRCP, the sensitivity and specificity were not statistically different than by using MRCP alone. This can be explained by the type and size of the missed stones. As described above, the only stone that was not seen on the combined MRCP and NCECT was a tiny stone with a size of less than 2 mm. This finding of the present study was consistent to finding from the other studies. For example, in a similar study by Laokpessi et al[9], the benefit or pre-operative MRCP in the 147 patients suspicious of CBD stones was evaluated comparing to ERCP and surgery. It was found that MRCP had a high sensitivity and specificity of 93% and 100%, respectively. False-negative results were also found in small stones of less than 3 mm in size.

In another study by Kim et al[11], the sensitivity of NCECT in detecting the CBD stone was evaluated comparing with ERCP in 191 patients, and it was found to be 85.4%. The accuracy in diagnosis of CBD stone depended on type and size of the stones. Ninety-six percent of stone with a size of at least 5 mm were detectable using NCECT, while only 67% of smaller stones were detectable. Pure cholesterol stones could not be detected regardless of their sizes. Their findings were consistent with the present study that adding NCECT, the small stones were still missed, resulted in an insignificantly higher accuracy as compared with MRCP alone.

Furthermore, with the addition of NCECT to MRCP to see other abnormalities apart from the CBD stones, it was found that the presence of gallstone, aerobilia, IHD dilatation, and CBD dilatation can be detected with an almost-perfect agreement between the two modalities. Additionally, the pancreatic calcification and biliary stenting had a substantial intermodality agreement. These findings confirmed that adding NCECT to MRCP alone did not add more benefit in detecting CBD stone or other associated findings.

However, there was some limitation in the present study. The study was a retrospective review. Some data could not be obtained, especially the size and composition of the stones, which may affect the accuracy of imaging modality.

Conclusion

The combined MRCP and NCECT had a higher accuracy as compared with MRCP alone but it was not statistically significant (p=0.77). Adding NCECT in the routine MRCP did not result in a significant benefit in detecting CBD stone or other associated abnormalities. Therefore, routine addition of NCECT to MRCP in every patient is no longer recommended as it increase the radiation exposure and costs.

What is already known on this topic?

MRCP alone had a high sensitivity and specificity in detecting CBD stone. The false-negative results are usually due to a small-sized stone.

What this study adds?

Adding NCECT to MRCP did not result in a significantly higher sensitivity or specificity. The tiny stone was still missed. The routine addition of the NCECT to MRCP is no longer recommended due to a higher radiation exposure and higher cost.

Conflicts of interest

The authors declare no conflict of interest.

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