Original Article

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CT Evaluation of Long-Term Changes in Common Bile Duct Diameter after Cholecystectomy

담낭 절제술 후 총담관 직경의 장기 변화에 대한 CT 평가

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Purpose The present study aimed to investigate the frequency and extent of compensatory common bile duct (CBD) dilatation after cholecystectomy, assess the time between cholecystectomy and CBD dilatation, and identify potentially useful CT findings suggestive of obstructive CBD dilatation.

Materials and Methods This retrospective study included 121 patients without biliary obstruction who underwent multiple CT scans before and after cholecystectomy at a single center between 2009 and 2011. The maximum short-axis diameters of the CBD and intrahepatic duct (IHD) were measured on each CT scan. In addition, the clinical and CT findings of 11 patients who were initially excluded from the study because of CBD stones or periampullary tumors were examined to identify distinguishing features between obstructive and non-obstructive CBD dilatation after cholecystectomy.

Results The mean (standard deviation) short-axis maximum CBD diameter of 121 patients was 5.6 (± 1.9) mm in the axial plane before cholecystectomy but increased to 7.9 (± 2.6) mm after cholecystectomy ($p < 0.001$). Of the 106 patients with a pre-cholecystectomy axial CBD diameter of < 8 mm, 39 (36.8%) showed CBD dilatation of ≥ 8 mm after cholecystectomy. Six of the 17 patients with long-term (> 2 years) serial follow-up CT scans (35.3%) eventually showed a significant (> 1.5-fold) increase in the axial CBD diameter, all within two years after cholecystectomy. Of the 121 patients without obstruction or related symptoms, only one patient (0.1%) showed IHD dilatation > 3 mm after cholecystectomy. In contrast, all 11 patients with CBD obstruction had abdominal pain and abnormal laboratory indices, and 81.8% (9/11) had significant dilatation of the IHD and CBD.

Conclusion Compensatory non-obstructive CBD dilatation commonly occurs after cholecystectomy to a similar extent as obstructive dilatation. However, the presence of relevant symptoms, significant IHD dilatation, or further CBD dilatation 2–3 years after cholecystec-

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tomy should raise suspicion of CBD obstruction.

Index terms Cholecystectomy; Common Bile Duct; Common Hepatic Duct; Multidetector Computed Tomography; Dilatation

INTRODUCTION

With the widespread use of abdominal CT and ultrasonography (US) for various indications such as abdominopelvic pain, trauma, non-traumatic abdominal emergencies, laboratory abnormalities, and evaluation or planning for tumors (1), common bile duct (CBD) dilatation is increasingly being identified in patients lacking symptoms and/or laboratory abnormalities. These incidentally detected CBD or common hepatic duct (CHD) dilatation may indicate the presence of an obstructive lesion or a stone, and therefore pose a diagnostic dilemma.

The most common cause of obstructive CBD dilatation is intraductal stones, referred to as choledocholithiasis. Choledocholithiasis typically presents as colicky abdominal pain along with other symptoms such as nausea, vomiting, fever, and jaundice. CT or US is generally the initial imaging test for the evaluation of such patients (2, 3). However, choledocholithiasis may be asymptomatic (4, 5), and in most cases, CBD stones are not sufficiently radiopaque to be detected on CT (6). Malignancy is a less common but equally important cause of CBD obstruction, as its initial misdiagnosis may lead to loss of opportunity for curative treatment. Despite the overall good sensitivity of CT for the detection of CBD malignancies, some small obstructive tumors can still be missed (7). Therefore, even in the absence of symptoms or recognizable obstructive lesions, the possibility of CBD obstruction by a hidden tumor or radiolucent stone should be considered in cases of CBD dilatation.

In the absence of conclusive CT or US findings, CBD dilatation is often evaluated using further tests, including MR retrograde cholangiopancreatography (MRCP), endoscopic ultrasonography, or endoscopic retrograde cholangiopancreatography (ERCP). However, unless a biliary obstruction is clinically suspected, these additional tests rarely yield positive findings (5). This is because CBD dilatation is commonly non-obstructive, with the two most common etiologies being senile changes (8-11) and compensatory dilatation after cholecystectomy (12-20).

Hypothetically, considerable CBD dilatation may occur after cholecystectomy as compensation for the disappearance of the reservoir function of the gallbladder (15). However, not all CBD dilatations after cholecystectomy indicate compensatory non-obstructive dilatation. Thus, when CBD dilatation is noted in patients who undergo cholecystectomy, it is important to determine whether it is an obstructive or non-obstructive compensatory dilatation to minimize unnecessary expensive investigations or invasive procedures. Therefore, we attempted to identify clinical and radiological findings that are useful for evaluating non-obstructive CBD dilatation.

Most previous studies investigating post-cholecystectomy changes in the CBD diameter were based on US findings with short follow-up times, mostly one year (14-20). However, with the considerable expansion of the indications for CT (1), an increasing number of cases of incidental CBD dilatation have been identified. As the CBD diameters measured using US and CT may be quite different, the results obtained using US may not be directly applicable to those obtained using CT. In addition, the full-length CBD is often not visualized using US, mainly because of overlying bowel gas or obesity (21), whereas CT enables evaluation of the entire CBD without much difficulty (12). Therefore, the maximum CBD diameters measured with US and CT can differ, even in the same patient, and CT measurements may more accurately reflect the actual CBD diameter.

Furthermore, few studies have examined the time taken for the occurrence of significant CBD dilatation following cholecystectomy. Owing to the short follow-up intervals in previous studies, it was difficult to determine whether the CBD continued to dilate. Therefore, a longer follow-up period may provide indications regarding the duration of CBD dilatation.

Thus, the purpose of this study was to investigate the frequency and extent of compensatory CBD dilatation after cholecystectomy, as measured by CT, and the average time period between its occurrence and cholecystectomy by analyzing serial pre- and postoperative CT scans. In addition, the clinical and CT findings of patients with obstructive CBD dilatation and those with non-obstructive compensatory dilatation after cholecystectomy were compared to identify distinguishing features between the two conditions.

MATERIALS AND METHODS

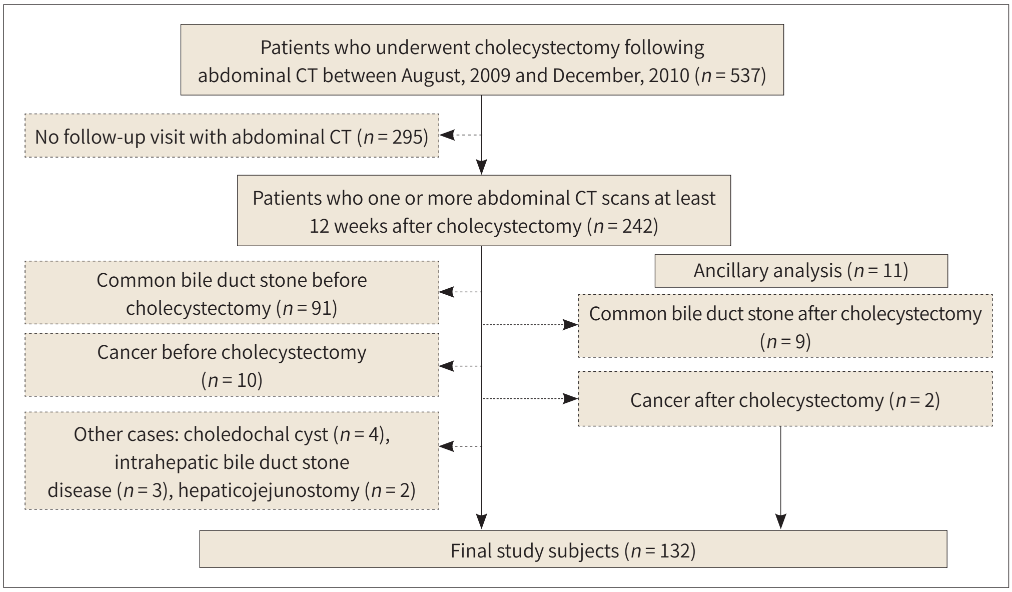
PATIENTS

Our Institutional Review Board approved this retrospective study and waived the requirement for informed consent (IRB No. 2022-10-028). A total of 537 adult patients who underwent cholecystectomy within a week of contrast-enhanced CT at a single center (National Health Insurance Service Ilsan Hospital) between August 2009 and November 2011 were identified from the medical records. Of these, 242 patients who underwent one or more follow-up CT scans at least three months after surgery were eligible for inclusion in the study. A total of 121 patients were excluded because their pre- or post-cholecystectomy normal CBD diameters could not be measured due to obstructive stones (n = 100), tumors (n = 12), choledochal cysts (n = 4), intrahepatic duct (IHD) stone disease (n = 3), or prior surgeries such as pancreaticoduodenectomy (n = 2). However, as an ancillary analysis, 11 of the 121 patients who were excluded due to obstructive stones (n = 9) or tumors (n = 2) after cholecystectomy were analyzed to identify the presence of any clinical or CT findings that could distinguish between obstructive and non-obstructive compensatory CBD dilatation (Fig. 1). Therefore, the final study population consisted of 132 patients: 121 patients whose CBD diameters could be properly measured before and after cholecystectomy CT scans and 11 patients for ancillary analysis.

CT

All CT scans were performed on a machine with 128 detectors (SOMATOM Definition Flash; Siemens, Erlangen, Germany) using the following parameters: tube voltage and current, 90 kV and 110–150 mAs; slice thickness, 3 mm; pitch factor, 0.6; and rotation time, 0.5 s. After obtaining unenhanced images, contrast-enhanced images were obtained approximately 90 s after intravenous administration of 100–150 mL of 3 mg/mL nonionic iodine contrast medium

Fig. 1. Flowchart for patient selection.



(Iohexol, Omnihexol injection 350; Korea United Pharm, Seoul, Korea) at a rate of 2–4 mL/s.

MEASUREMENT OF CBD AND IHD DIAMETERS

Anatomically, the CHD originates where the right and left hepatic ducts join outside the liver and ends once it is joined by the cystic duct to form the CBD. However, in this paper, both CBD and CHD has been referred to as CBD for convenience. Using a picture archiving and communication system workstation (Centricity; GE Healthcare, Milwaukee, WI, USA), a board-certified abdominal radiologist (C.A.) with 12 years of experience in abdominal CT measured the maximum CBD diameters in both the axial and coronal planes for each CT scan. In the axial plane, the short-axis inner diameter of the CBD lumen was measured on the slice with the maximum diameter. In the coronal plane, the inner diameter perpendicular to the CBD walls was measured at the level where the diameter was largest. To ensure reliable measurements, care was taken to avoid the part involving the insertion of the cystic duct while selecting the slice or level with the largest CBD diameter.

For each CT scan, IHD dilatation was assessed by the same radiologist (C.A.). If dilatation occurred, the maximum IHD diameter was measured in the axial plane.

DEFINITION OF SIGNIFICANT DILATATION OF CBD AND IHD

According to previous studies, the CBD is typically < 6 mm in diameter (22), and CBD diameters > 8 mm are potentially pathological, irrespective of age (10, 11, 23). Thus, in this study, CBD dilatation > 8 mm was considered significant. In addition, because it has been reported that the CBD diameter tends to be larger on CT by 1–2 mm than on US (24), a diameter of 10 mm was used as another criterion for significant CBD dilatation.

If the IHD diameter was 1–3 mm, it was considered mild dilatation; IHD dilatation of ≥ 3 mm was considered significant because the upper limit of normal IHD dilatation has been reported to be 2 mm (13).

INTRA-INDIVIDUAL CHANGE IN CBD DIAMETER OVER TIME AFTER CHOLECYSTECTOMY

The post-cholecystectomy follow-up period was divided into three groups: < 1, 1–2, and > 2 years after cholecystectomy. Of the patients included in the study, 17 patients who underwent follow-up CT during at least two of these periods were examined for temporal changes in CBD diameter after cholecystectomy. For example, patients who underwent two follow-up CT scans at six months and three years after cholecystectomy could be examined for both short- and long-term changes after cholecystectomy. In contrast, patients who underwent four follow-up CT scans within one year after cholecystectomy but were lost to follow-up afterwards were excluded, as the long-term results could not be assessed.

COMPARISON WITH CBD OBSTRUCTION CASES AFTER CHOLECYSTECTOMY

Eleven patients were excluded because of obstructive stones (n = 9) or tumors (n = 2) after cholecystectomy (Fig. 1). In these patients, the presence of CBD stones or periampullary tumors was confirmed by stone removal using ERCP or biopsy, respectively. As an ancillary analysis, the clinical and CT findings of these patients were examined to identify potentially useful findings for differentiating between obstructive and non-obstructive compensatory CBD dilatation after cholecystectomy.

STATISTICAL ANALYSIS

CBD diameters are presented as mean ± standard deviation (SD). Statistical significance was assessed using the chi-square test for between-group differences and the paired t-test for intra-individual differences in the diameter before and after cholecystectomy. Statistical analyses and plotting were performed using the R software (R, version 4.0.4; R Development Core Team, R Foundation for Statistical Computing, Vienna, Austria). Two-sided p-values < 0.05 were considered statistically significant.

RESULTS

PATIENTS

The final study population consisted of 121 patients (71 male and 50 female) with an average age of 56 years (range, 19–81 years) at the time of the cholecystectomy. The median follow-up time after cholecystectomy was 6.5 years (range, 99 days to 12.9 years). During the observation period, 56.2% (68/121) of the patients underwent one follow-up CT scan after cholecystectomy, 17.3% (21/121) underwent two scans, and 26.4% (32/121) underwent more than two scans. The most common reasons for follow-up CT scans were abdominal pain and cancer evaluation or follow-up. The patient who received the most follow-up CT scans underwent 11 scans over a period of 12.9 years, mostly as a follow-up after lymphoma remission.

CHANGE IN CBD DIAMETER BEFORE AND AFTER CHOLECYSTECTOMY

Prior to cholecystectomy, the mean (SD) maximum short-axis CBD diameter in the axial plane was 5.6 (± 1.9) mm. After cholecystectomy, it increased by 2.3 (± 1.8) mm, to 7.9 (± 2.6) mm. A similar post-cholecystectomy increase of 2.3 (± 1.9) mm in the mean CBD diameter was observed in the coronal plane. However, the diameters measured in the coronal plane tended to be larger than those in the axial plane, with the mean pre-cholecystectomy and post-cholecystectomy diameters being 6.4 (± 2.0) mm and 8.7 (± 2.7) mm, respectively (Table 1, Figs. 2, 3). The differences in the mean diameter between pre- and post-cholecystectomy were statistically significant in both the axial and coronal planes ($p < 0.001$).

When a diameter criterion of 8 mm was used in the axial plane, 12.4% (15/121) of the patients had significant CBD dilatation (≥ 8 mm) before cholecystectomy; however, the frequency significantly increased to 44.6% (54/121) after cholecystectomy ($p < 0.001$). In the intra-individual comparison, among the 106 patients whose pre-cholecystectomy CBD diameter was < 8 mm, 39 (36.8%) showed significant CBD dilatation (≥ 8 mm) after cholecystectomy.

Using the criterion of 10 mm in the axial plane, the frequency of significant CBD dilatation increased from 2.5% (3/121) to 23.1% (28/121) after cholecystectomy. On intra-individual comparison, of the 118 patients whose pre-cholecystectomy CBD diameter was < 10 mm, 26 (22.0%) showed significant CBD dilatation (≥ 10 mm) after cholecystectomy. Similar trends were observed in coronal plane measurements (Table 1, Fig. 2).

POST-CHOLECYSTECTOMY CBD DILATATION ACCORDING TO THE AGE GROUP

The CBD diameter tended to increase with age (Table 2, Fig. 4). Prior to cholecystectomy, 4.2% (3/71) of the patients aged < 60 years had a CBD dilatation of ≥ 8 mm in the axial plane compared to 24% (12/50) of those aged > 60 years ($p = 0.002$). After cholecystectomy, the frequencies increased; 33.3% (18/54) of patients aged < 60 years (18/54) and 53.7% (36/67) of those > 60 years at the time of their last follow-up CT had a CBD dilatation of ≥ 8 mm ($p = 0.029$).

Prior to cholecystectomy, none of the 13 patients aged < 40 years (0%) had CBD dilatation of ≥ 8 mm in the axial plane. However, after cholecystectomy, three of the six patients aged < 40 years (50%) had a CBD dilatation of ≥ 8 mm in the axial plane (Table 2).

Table 1. Short-Axis CBD Diameter before and after Cholecystectomy in the Axial and Coronal Planes

	Axial Plane			Coronal Plane		
	Before	After	*p*-Value	Before	After	*p*-Value
Comparison of mean diameter before vs. after cholecystectomy						
Mean (range, mm)	5.6 (1.9–11.6)	7.9 (2.6–15.1)	< 0.001*	6.4 (2.1–11.5)	8.7 (2.5–16.0)	< 0.001*
No. of patients for each category according to CBD diameter and cholecystectomy state						
< 8 mm (%)	106 (87.6)	67 (55.4)	< 0.001†	97 (80.2)	52 (43.0)	< 0.001†
8–10 mm (%)	12 (9.9)	26 (21.5)		17 (14.0)	33 (27.3)	
≥ 10 mm (%)	3 (2.5)	28 (23.1)		7 (5.8)	36 (29.3)	
Total (%)	121 (100)	121 (100)		121 (100)	121 (100)	

**t*-test.
†Chi-square test.
CBD = common bile duct

Fig. 2. Histogram of axial and coronal CBD diameter measured on CT before and after cholecystectomy.
CBD = common bile duct

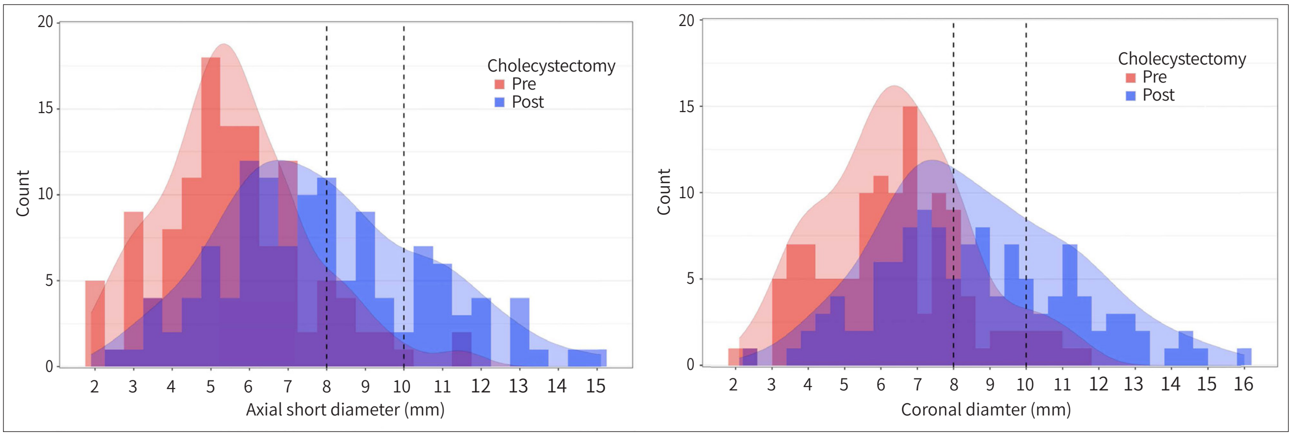


Fig. 3. Pre-cholecystectomy CT scan of a 48-year-old male who developed non-obstructive compensatory CBD dilatation after cholecystectomy shows numerous small gallstones with the largest CBD diameter (red lines) measured as 8.3 mm in the coronal plane (A) and 6.8 mm in the axial plane (B), and follow-up CT scan approximately 10 years after cholecystectomy shows significant dilation of the CBD without obstruction, with the largest CBD diameter measured as 14.8 mm in the coronal plane (C) and 12.1 mm in the axial plane (D), at the same level as pre-cholecystectomy measurements.
CBD = common bile duct

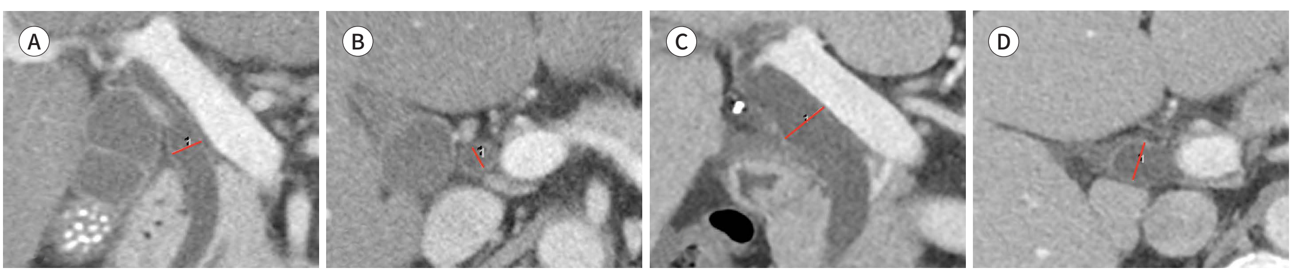


Table 2. Short-Axis CBD Diameter Measured in the Axial Plane before and after Cholecystectomy according to the Three Age Groups

	Before Cholecystectomy				After Cholecystectomy			
	< 40 Years	40–60 Years	≥ 60 Years	*p*-Value	< 40 Years	40–60 Years	≥ 60 Years	*p*-Value
< 8 mm	13 (100)	55 (94.8)	38 (76.0)	0.021	3 (50.0)	33 (68.8)	31 (46.3)	0.108
8–10 mm	0 (0)	3 (5.2)	9 (18.0)		2 (33.3)	9 (18.8)	15 (22.4)	
≥ 10 mm	0 (0)	0 (0)	3 (6.0)		1 (16.7)	6 (12.5)	21 (31.3)	
Total*	13 (100)	58 (100)	50 (100)		6 (100)	48 (100)	67 (100)	

Data are number (%) values.
*Total number of patients in each age-based subgroup are different before and after surgery because of aging of the patients.
CBD = common bile duct

INTRA-INDIVIDUAL CHANGE IN CBD DIAMETER OVER TIME AFTER CHOLECYSTECTOMY

Examination of intra-individual CBD diameter changes over time based on serial CT scans revealed that in most patients, significant CBD dilatation tended to occur within a couple of years after cholecystectomy (Figs. 5, 6). For example, when at least a 1.5-fold increase in diameter was considered significant, 6 of the 17 patients (35.3%) eventually showed significant CBD dilatation in the axial plane, all within 1.5 years after cholecystectomy. When measured

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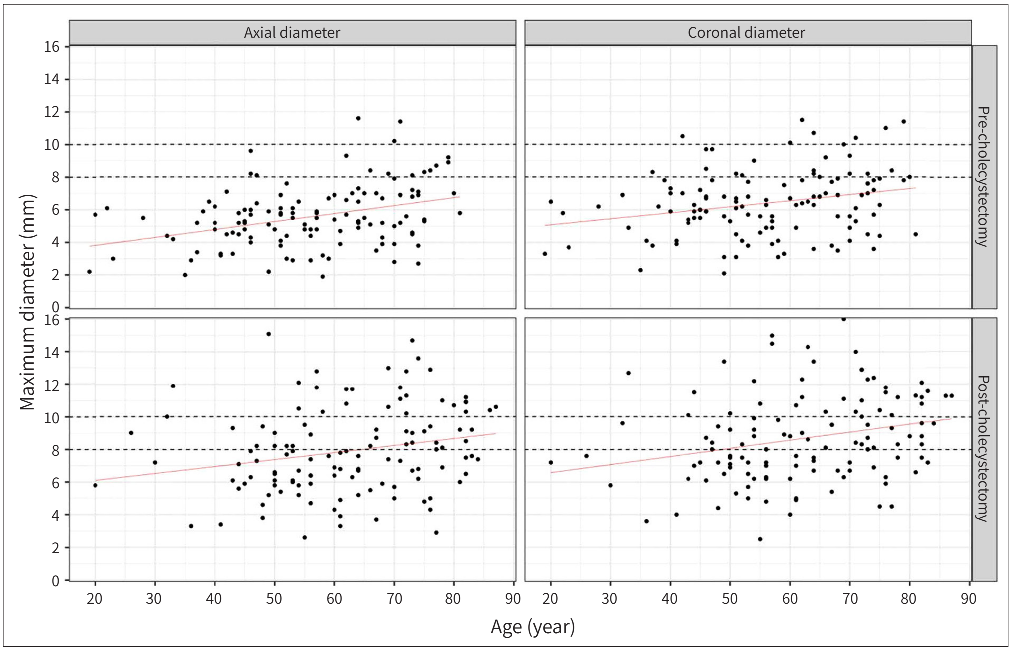
Fig. 4. Axial and coronal common bile duct diameters according to age before and after cholecystectomy.



in the coronal plane, seven patients (41.2%) eventually showed highly significant increases in diameter, and the increase occurred within 2.5 years in all but two cases (Fig. 5). The largest extent of CBD dilatation after cholecystectomy was a 2.3-fold increase in axial CBD diameter.

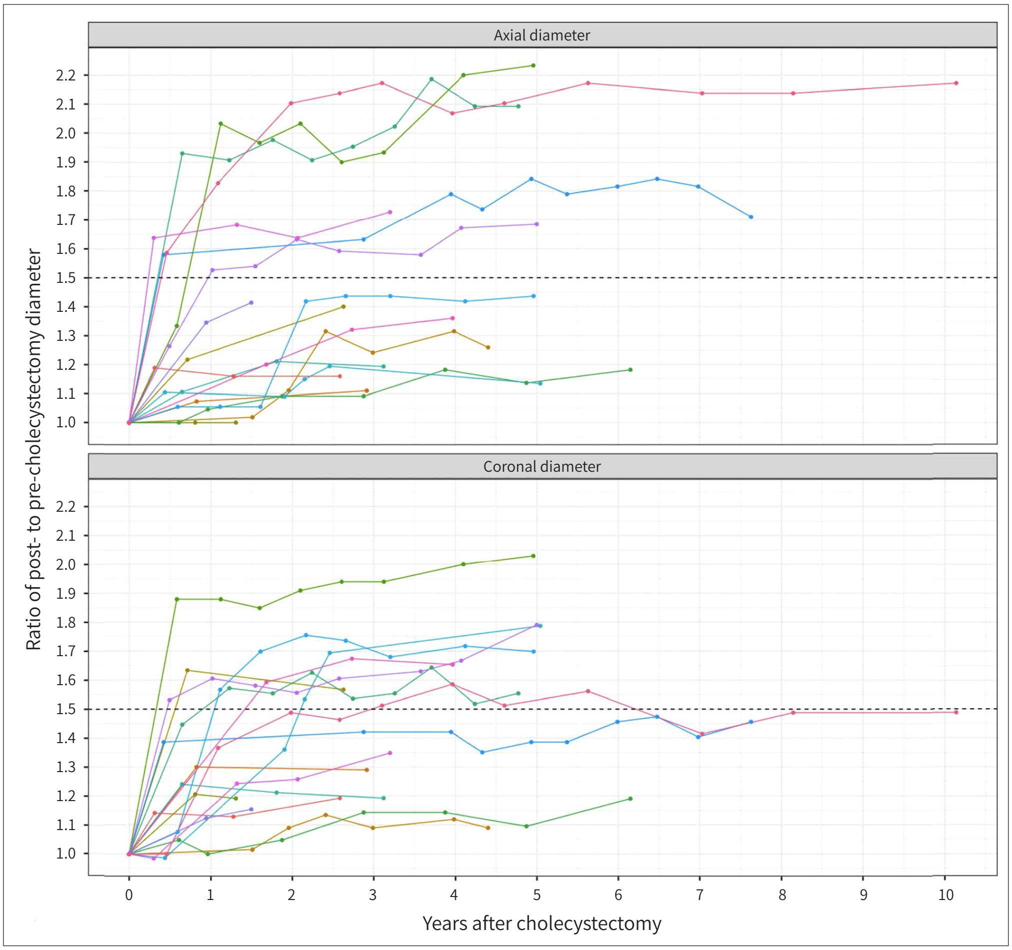
INTRAHEPATIC BILE DUCT DILATATION AFTER CHOLECYSTECTOMY

Of the 121 patients, only one patient (0.008%), who had mild IHD dilatation before cholecystectomy, developed significant IHD dilatation without biliary obstruction after cholecystectomy. Two patients had disproportional mild IHD dilatation, presumably due to prior parasitic infestation, which did not change after cholecystectomy. One patient showed significant IHD dilatation caused by compression of the perihilar bile duct by a large cystic duct stone (Mirizzi syndrome), which resolved after cholecystectomy. The remaining 117 patients (96.7%) showed no significant IHD dilatation before or after the cholecystectomy.

COMPARISON WITH CBD OBSTRUCTION CASES AFTER CHOLECYSTECTOMY

Table 3 summarizes the clinical and CT findings of 11 patients with CBD obstruction due to choledocholithiasis or periampullary cancer after cholecystectomy. All 11 patients (100%) had results suggestive of acute cholangiohepatitis or obstructive jaundice (abnormally high white blood cell counts and serum levels of C-reactive protein, bilirubin, γ-glutamyl transferase, alanine and aspartate aminotransferase, and alkaline phosphatase). In two of the nine patients with choledocholithiasis (22.2%), CBD stones were not definitively recognized on CT but were later confirmed by MRCP or ERCP. In all the patients, CBD was dilated > 8 mm, with the mean diameter (range) of 12.1 mm (8.6–17.1) and 12.9 mm (8.1–20.1) in the axial and coronal planes, respectively. Of the 11 patients, nine (81.8%) had significant IHD dilatation (> 3 mm),

Fig. 5. Increase in common bile duct diameter over time after cholecystectomy in a subgroup of 17 patients, who underwent follow-up CT during at least two of three follow-up period groups.



four (36.4%) showed enhanced CBD wall thickening suggestive of cholangitis, and one patient (9.0%) showed CT findings of acute pancreatitis (Fig. 7).

DISCUSSION

Our study demonstrates that compensatory CBD dilatation is a common finding after cholecystectomy. Hence, post-cholecystectomy CBD dilatation incidentally identified on CT is highly likely to be non-obstructive in the absence of any clinical or radiological suspicion of an obstructive stone or tumor.

Specifically, over a quarter of the patients in our cohort showed significant post-cholecystectomy CBD dilatation (e.g., > 8 or 10 mm in short-axis diameter). The increase in mean CBD diameter was 2.3 mm between pre- and post-cholecystectomy (from 5.6 mm to 7.9 mm), which did not differ greatly from the results of two previous studies that examined CT-measured CBD diameter more than one year after cholecystectomy: 1.6 mm (from 5.4 mm to 7.0 mm) and 2.5 mm (from 4.8 mm to 7.3 mm) (12, 16).

Although compensatory CBD dilatation has been well documented, most of these studies

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Fig. 6. CT findings of a 56-year-old female with progressive CBD dilatation, who underwent cholecystectomy during lymphoma remission due to acute calculous cholecystitis, show the largest CBD diameter as 7.2 mm (red line) at pre-cholecystectomy (A), progressive dilatation of axial CBD diameters to 9.3 mm and 12.3 mm approximately 6 months (B) and 1 year (C) after cholecystectomy, respectively. No further CBD dilatation at subsequent follow-ups, with largest CBD diameter measured as 12.3 mm, 12.8 mm, and 12.7 mm approximately 2 years (D), 4 years (E), and 5 years (F) after cholecystectomy.
CBD = common bile duct

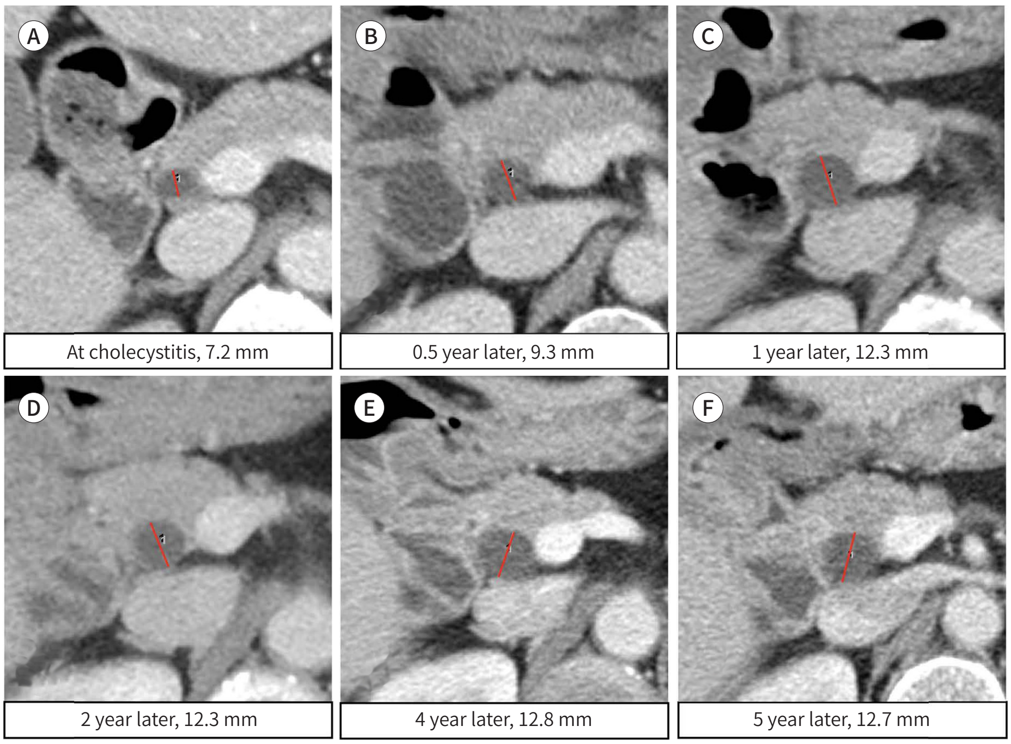
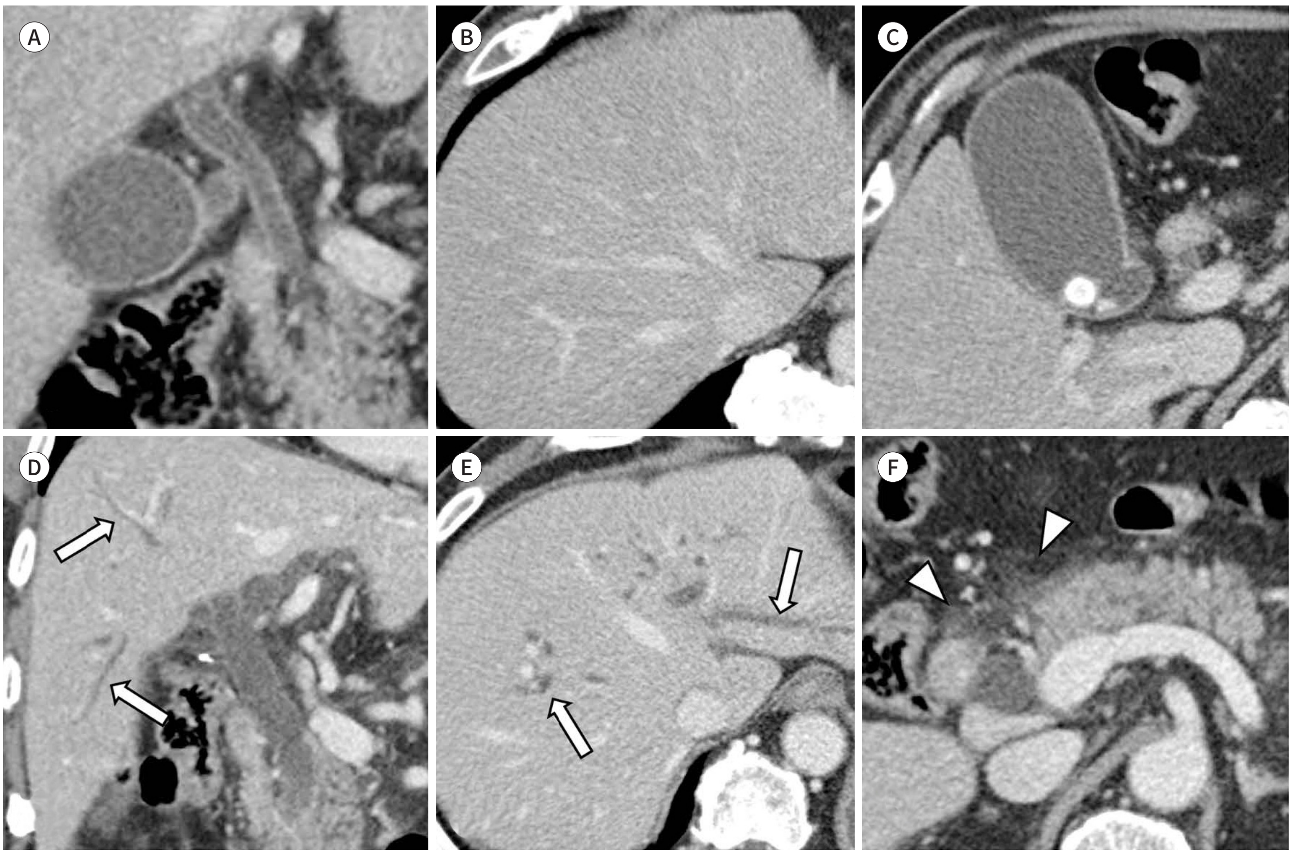


Table 3. Characteristics of 11 Patients with CBD Pathology at Follow-Up Scan after Cholecystectomy

No	Sex/Age	Cause	Axial CBD Diameter (mm)	Coronal CBD Diameter (mm)	IHD Dilatation	Acute Inflammation*	Abnormal Laboratory Test
1	M/52	CBD stone	8.6	8.1	Absent	None	AST, ALT, GGT, bilirubin
2	M/56	CBD stone	10.9	12.9	Present	Cholangitis	AST, ALT, bilirubin, CRP
3	M/58	CBD stone	17.1	20.1	Present	None	AST, ALT, GGT, bilirubin, CRP
4	F/71	CBD stone	14.1	15.2	Present	None	AST, ALT, GGT, bilirubin
5	M/74	Radiolucent CBD stone	13.8	12.0	Present	Pancreatitis	AST, ALT, bilirubin, lipase, amylase, CRP
6	M/74	CBD stone	8.8	10.1	Present	Cholangitis	AST, ALT, bilirubin
7	M/74	CBD stone	10.6	10.1	Present	Cholangitis	CRP
8	F/85	CBD stone	8.6	10.2	Absent	Cholangitis	AST, ALT, bilirubin, CRP
9	F/69	Radiolucent CBD stone	16.7	17.0	Present	None	AST, ALT
10	M/64	Ampullary cancer	16.1	16.7	Present	None	Bilirubin, AST, ALT
11	F/75	Pancreatic head cancer	20.8	22.7	Present	None	AST, ALT, lipase, amylase

All patients had abdominal pain with or without fever.
*Based on CT findings: enhancing CBD wall thickening for cholangitis, parenchymal swelling with peripancreatic fat stranding and/or fluid for pancreatitis.
ALT = alanine aminotransferase, AST = aspartate aminotransferase, CBD = common bile duct, CRP = C-reactive protein, GGT = γ-glutamyl transferase, IHD = intrahepatic bile duct

Fig. 7. CT findings of a 74-year-old male with post-cholecystectomy choledocholithiasis and acute pancreatitis show no significant dilatation of CBD (A) and IHD (B), and presence of gallbladder stones at the time of acute cholecystitis (C), and show significant dilatation of CBD and IHD (arrows) in the coronal (D) and axial (E) planes with associated acute pancreatitis (arrowheads) at the head portion (F) six months after cholecystectomy. CBD stones were not evident on CT but later confirmed and removed by endoscopic retrograde cholangiopancreatography.
CBD = common bile duct, IHD = intrahepatic bile duct



conducted measurements using ultrasonography. Therefore, one of the strengths of this study is that the degree and frequency of post-cholecystectomy CBD dilatation were quantified using CT. An advantage of CT over US in terms of CBD diameter measurement is that, unlike US, which can only evaluate portions that are visualized through a good echogenic window, CT can evaluate the entire length of the CBD well, enabling more consistent and accurate measurements. However, our results showed that measurements in the coronal plane were generally higher than those in the axial plane; hence, it is important to specify whether the diameter is measured in the axial or coronal plane. The CBD is usually oval-shaped unless it shows tensile distension due to obstruction. Because the CBD typically runs obliquely in the craniocaudal direction, the measured long-axis diameter is likely to be longer than the actual diameter. Thus, the short-axis diameter better represents the actual CBD diameter. However, unlike the axial plane, where both short- and long-axis diameters can be identified and measured in the coronal plane, the CBD diameter can be measured along only one axis, which is likely to be closer to the long-axis diameter. Because the CBD diameter can vary even in the same patient depending on the measurement method, it is essential to mention how it was measured.

Our results show that the CBD can commonly dilate > 10 mm after cholecystectomy in the

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absence of any obstruction, whereas even with obstructive CBD stones, the dilated CBD can measure < 10 mm. In addition, although non-obstructive senile CBD dilatation is typically not observed in young people, it is not helpful in determining whether CBD dilatation is obstructive or compensatory in the post-cholecystectomy state. This is because significant post-cholecystectomy CBD dilatation commonly occurs even in patients aged < 40 years. Therefore, in patients who have undergone cholecystectomy, differentiation between obstructive and non-obstructive CBD dilatation should not be based solely on the extent of luminal distension but should also consider other clinical or radiological findings.

The presence or absence of significant IHD dilatation (> 3 mm) may help differentiate between obstructive and compensatory CBD dilatation after cholecystectomy. In our study, almost all patients without CBD obstruction showed no significant IHD dilatation after cholecystectomy, whereas most patients with CBD obstruction showed significant dilatation of the IHDs as well as the CBD. In a previous MRCP study that examined bile duct dilatation six months after cholecystectomy, post-cholecystectomy IHD dilatation was not, if present, > 2 mm in diameter (13). For significant IHD dilatation, substantial intrabiliary pressure is required to push the liver parenchyma outward and encase the ducts. In contrast, a large part of the extrahepatic bile duct is not surrounded by any hard organ and hence can be dilated much easier. This may explain why compensatory ductal dilatation after cholecystectomy occurs selectively in CHD/CBD but not in IHD. Therefore, detection of newly appearing significant IHD dilatation at post-cholecystectomy follow-up should prompt the suspicion of biliary obstruction.

In addition, post-cholecystectomy CBD dilatation should not be assumed to be non-obstructive or compensatory before assessing the possibility of an obstructive lesion or stone by evaluating the clinical manifestations and laboratory markers. Without meticulous clinical evaluation, a tiny ampullary stone or radiolucent CBD stone may be missed. Our results showed that all patients with biliary obstruction had clinical symptoms and laboratory abnormalities. In the majority of cases in which choledocholithiasis or biliary obstruction is not clinically suspected, non-obstructive compensatory dilatation can be suspected. Consequently, it is possible to distinguish between compensatory and obstructive dilatation through the incorporation of clinical and radiological findings suggesting obstruction, rather than the degree of CBD dilatation.

Another potentially useful finding of the present study was that compensatory CBD dilatation is usually completed within a couple of years after cholecystectomy. To the best of our knowledge, no previous study has analyzed serial follow-up examinations to investigate long-term changes in the CBD diameter. Most previous studies had a short follow-up period of approximately one year (14-19) and therefore, could not determine whether CBD continued to increase even after that. Although only 17 patients had a long-term follow-up period of 2–10 years, most patients showed a tendency for CBD to increase during the first 1–2 years after cholecystectomy and did not change significantly thereafter. Accordingly, our results suggest that mechanical CBD obstruction should be suspected if further CBD dilatation occurs beyond 2–3 years after cholecystectomy.

Our study has several limitations. First, the retrospective nature of our study may have introduced considerable selection bias. Because only those patients who made follow-up visits after cholecystectomy were included, it was not possible to include asymptomatic patients with CBD obstruction who may have shown different characteristics from those included in the study. Second, our study included a small number of patients for both major and ancillary analyses because many patients who underwent cholecystectomy did not undergo follow-up CT scans. Third, more than half of the patients underwent only one follow-up CT scan. Fourth, since only one radiologist performed the CT measurements, interobserver agreement for CBD diameter measurements could not be confirmed. Therefore, reliability evaluation was difficult. Fifth, because there was no comparison with other modalities such as US, MRI, or ERCP, the diameters measured on axial and coronal CT images could not be compared to the gold standard.

In conclusion, because compensatory CBD dilatation commonly occurs after cholecystectomy to a similar extent as obstructive CBD dilatation, incidentally identified CBD dilatation is most likely non-obstructive in the absence of definite radiological evidence or clinical suspicion. However, if significant proportional IHD dilatation accompanies CBD dilatation or there is an increase in CBD dilatation beyond 2–3 years after cholecystectomy, the possibility of CBD obstruction should be assessed, even in the post-cholecystectomy state.

Author Contributions

Conceptualization, A.C., K.S., P.S.; data curation, A.S.H., A.C.; formal analysis, A.S.H., A.C.; investigation, A.S.H., A.C.; methodology, A.C.; project administration, A.C., K.S., P.S.; resources, P.S.; supervision, A.C., K.S., P.S.; validation, P.S.; visualization, A.C.; writing—original draft, A.S.H., A.C.; and writing—review & editing, all authors.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

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REFERENCES

1. Caraiani C, Yi D, Petresc B, Dietrich C. Indications for abdominal imaging: when and what to choose? *J Ultrason* 2020;20:e43-e54
2. Holm AN, Gerke H. What should be done with a dilated bile duct? *Curr Gastroenterol Rep* 2010;12:150-156
3. Freitas ML, Bell RL, Duffy AJ. Choledocholithiasis: evolving standards for diagnosis and management. *World J Gastroenterol* 2006;12:3162-3167
4. Kuwatani M, Sakamoto N. Asymptomatic choledocholithiasis that causes a dilemma between treatment and observation. *JMA J* 2021;4:176-177
5. Kim JE, Lee JK, Lee KT, Park DI, Hyun JG, Paik SW, et al. The clinical significance of common bile-duct dilatation in patients without biliary symptoms or causative lesions on ultrasonography. *Endoscopy* 2001;33:495-500
6. Kim CW, Chang JH, Lim YS, Kim TH, Lee IS, Han SW. Common bile duct stones on multidetector computed tomography: attenuation patterns and detectability. *World J Gastroenterol* 2013;19:1788-1796
7. Heinzow HS, Kammerer S, Rammes C, Wessling J, Domagk D, Meister T. Comparative analysis of ERCP,

IDUS, EUS and CT in predicting malignant bile duct strictures. *World J Gastroenterol* 2014;20:10495-10503
8. Bachar GN, Cohen M, Belenky A, Atar E, Gideon S. Effect of aging on the adult extrahepatic bile duct: a sonographic study. *J Ultrasound Med* 2003;22:879-882
9. Benjaminov F, Leichtman G, Naftali T, Half EE, Konikoff FM. Effects of age and cholecystectomy on common bile duct diameter as measured by endoscopic ultrasonography. *Surg Endosc* 2013;27:303-307
10. Perret RS, Sloop GD, Borne JA. Common bile duct measurements in an elderly population. *J Ultrasound Med* 2000;19:727-730
11. Park JS, Lee DH, Jeong S, Cho SG. Determination of diameter and angulation of the normal common bile duct using multidetector computed tomography. *Gut Liver* 2009;3:306-310
12. Senturk S, Miroglu TC, Bilici A, Gumus H, Tekin RC, Ekici F, et al. Diameters of the common bile duct in adults and postcholecystectomy patients: a study with 64-slice CT. *Eur J Radiol* 2012;81:39-42
13. PavlovićT, Trtica S, Troskot Perić R. Bile duct diameter changes after laparoscopic cholecystectomy: a magnetic resonance cholangiopancreatography prospective study. *Croat Med J* 2020;61:239-245
14. Kratzer W, Wahl S, Vonend C, Schmidt SA, Öztürk S, Hänle MM, et al. Caliber of the common bile duct: effect of cholecystectomy and other factors in a ultrasonographic study of 8534 patients. *Z Gastroenterol* 2015;53:1161-1166
15. Park SM, Kim WS, Bae IH, Kim JH, Ryu DH, Jang LC, et al. Common bile duct dilatation after cholecystectomy: a one-year prospective study. *J Korean Surg Soc* 2012;83:97-101
16. Chawla S, Trick WE, Gilkey S, Attar BM. Does cholecystectomy status influence the common bile duct diameter? A matched-pair analysis. *Dig Dis Sci* 2010;55:1155-1160
17. Valkovic P, Miletic D, Zelic M, Brkljacic B. Dynamic changes in the common bile duct after laparoscopic cholecystectomy: a prospective longitudinal sonographic study. *Ultraschall Med* 2011;32:479-484
18. Bhalerao SBS, Batra P, Utaal MS, Sasan C. Evaluation of effect of cholecystectomy on common bile duct diameter using ultrasonography and liver function test: a prospective study. *Int Surg J* 2018;5:1323-1329
19. Puri SK, Gupta P, Panigrahi P, Kumar N, Gupta S, Chaudhary A. Ultrasonographic evaluation of common duct diameter in pre and post cholecystectomy patients. *Trop Gastroenterol* 2001;22:23-24
20. Hunt DR, Scott AJ. Changes in bile duct diameter after cholecystectomy: a 5-year prospective study. *Gastroenterology* 1989;97:1485-1488
21. Rosenthal SJ, Cox GG, Wetzel LH, Batnitzky S. Pitfalls and differential diagnosis in biliary sonography. *Radiographics* 1990;10:285-311
22. Worku MG, Enyew EF, Desita ZT, Moges AM. Sonographic measurement of normal common bile duct diameter and associated factors at the University of Gondar comprehensive specialized hospital and selected private imaging center in Gondar town, North West Ethiopia. *PLoS One* 2020;15:e0227135
23. Piyawong W, Lekhavat V. Normal measurement of diameters of the common bile ducts in different aged groups. *J Med Assoc Thai* 2016;99 Suppl 4:S153-S158
24. Maqsood H, Goussous N, Parthasarathy M, Horne C, Kaur G, Setiawan L, et al. Does computed tomography (CT) overestimate common-bile-duct diameter in the evaluation of gallstone pancreatitis? *J Pancreas* 2016;17:196-200

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담낭 절제술 후 총담관 직경의 장기 변화에 대한 CT 평가

안성희[1] · 안찬식[2*] · 김승섭[1] · 박수미[3]

목적 본 연구는 담낭절제술 후 보상적 총담관 확장의 빈도와 정도를 조사하고, 담낭절제술과 common bile duct (이하 CBD) 확장 사이의 시간을 평가하고, 폐쇄성 CBD 확장을 암시하는 잠재적으로 유용한 CT 소견을 식별하는 것을 목표로 한다.

대상과 방법 2009년에서 2011년 사이에 단일 센터에서 담낭절제술 전후에 여러 차례 CT 스캔을 받은 담도 폐쇄가 없는 121명의 환자를 대상으로 한 후향적 연구를 진행하였다. 또한 담낭절제술 후 CBD 결석 또는 팽대부 종양으로 인해 초기에 연구에서 제외되었던 11명의 환자의 임상 및 CT 소견을 조사하여 폐쇄성 및 비폐쇄성 CBD 확장의 특징을 확인하였다.

결과 121명의 환자의 평균(표준편차) 단축 최대 CBD 직경은 담낭절제술 전 축면에서 5.6 (± 1.9) mm였지만 담낭절제술 후 7.9 (± 2.6) mm로 증가했다($p < 0.001$). 담낭절제술 전 축성 CBD 직경이 8 mm 미만인 106명의 환자 중 39명(36.8%)이 담낭절제술 후 ≥ 8 mm의 CBD 확장을 보였다. 장기(> 2년) 연속 추적 CT 스캔을 받은 17명의 환자 중 6명(35.3%)은 결국 모두 담낭 절제술 후 2년 이내에 축성 CBD 직경이 유의미하게(> 1.5배) 증가한 것으로 나타났다. 폐색 또는 관련 증상이 없는 121명의 환자 중 단 1명(0.1%)만이 담낭 절제술 후 intrahepatic duct (이하 IHD) 확장 > 3 mm를 보였던 반면, CBD 폐쇄가 있는 11명의 환자 모두 복통과 비정상 검사실 지수가 있었고 81.8% (9/11)가 IHD 및 CBD의 상당한 확장을 보였다.

결론 보상적 비폐쇄성 CBD 확장은 일반적으로 폐쇄성 확장과 비슷한 정도로 담낭절제술 후에 발생한다. 그러나 담낭절제술 후 담관 폐색과 관련 증상이 있거나, 의미 있는 IHD 확장 또는 2–3년 후 추가적인 CBD 확장이 발생하는 경우 CBD 폐쇄를 의심해야 한다.

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