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Original Article

Evaluation of Preoperative Magnetic Resonance Cholangiopancreatography in Acute Cholecystitis to Predict Technical Difficulties in Laparoscopic Cholecystectomy

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Magnetic resonance cholangiopancreatography (MRCP) is a non-invasive imaging technique that provides high-quality visualization of the biliary tree, including the gallbladder. This study aimed to evaluate the usefulness of preoperative MRCP for acute cholecystitis in predicting technical difficulties during laparoscopic cholecystectomy (LC). A total of 168 patients who underwent LC with preoperative MRCP were enrolled in this study. Patients were divided into two groups according to preoperative MRCP findings: the visualized group (n = 126), in which the entire gallbladder could be visualized; and the non-visualized group (n = 42), in which the entire gallbladder could not be visualized. The perioperative characteristics and postoperative complications of the two groups were retrospectively analyzed. Operation time was longer in the non-visualized group (median 101.5 vs. 143.5 min; $p < 0.001$). The non-visualized group had significantly more intraoperative blood loss than the visualized group (median 5 vs. 10 g; $p = 0.05$). The rate of conversion to open cholecystectomy was significantly higher in the non-visualized group (1.6 vs. 9.5%; $p = 0.03$). In conclusion, patients in the non-visualized group showed higher difficulty in performance of LC. Our MRCP-based classification is a simple and effective means of predicting difficulties in performing LC for acute cholecystitis.

Key words: laparoscopic cholecystectomy, magnetic resonance cholangiopancreatography, acute cholecystitis, gallbladder disease, non-invasive imaging

The Tokyo Guidelines 2018 (TG18, updated from TG13) provide simple criteria and management strategies for acute cholecystitis [1-5]. The guidelines in TG18, based on evidence from retrospective multicenter analyses, are very helpful in the management of acute cholecystitis, providing severity assessment criteria, clinical flowcharts, and many new diagnostic and therapeutic modalities [1-5]. TG18 lists several predictors of surgical difficulties with laparoscopic cholecystectomy (LC), including gallbladder wall thickness, C-reactive protein (CRP) level, and impacted stones [4]. Magnetic resonance cholangiopancreatography (MRCP) is a non-invasive imaging technique that provides high-quality three-dimensional (3D) images for visualization of the biliary tree, including the gallbladder [6-8]. Images can, for example, preoperatively detect the presence of an impacted stone at the neck of the gallbladder. In this study, we aimed to evaluate the usefulness of preoperative MRCP for acute cholecystitis to predict technical difficulties in LC.

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Material and Methods

Patients. This retrospective analysis included patients who underwent LC for acute cholecystitis at the National Hospital Organization Nagasaki Medical Center between January 2015 and December 2019. The diagnosis of acute cholecystitis and its severity grading were based on the TG18 [2]. During this period, 186 patients were diagnosed with acute cholecystitis. Of these, 168 were enrolled in this study; 18 patients in whom the biliary tract was evaluated by endoscopic retrograde cholangiography alone were excluded. All 168 patients underwent LC with preoperative MRCP, ultrasonography (US), and computed tomography (CT) scan. MRCP scans were performed on a 1.5T Philips Achieva MRI system (Philips Healthcare, Best, Netherlands). Patients were divided into two groups according to preoperative MRCP findings: those for which the gallbladder could be visualized as a whole (visualized group), and those in which it could not be (the non-visualized group) (Fig. 1). Informed consent was obtained from all patients, and the study protocol (#29060) was approved by the Ethics Committee of the National Hospital Organization Nagasaki Medical Center.

Operative technique. LCs were performed either immediately after diagnosis or after medical treatment. All LCs were performed by a dedicated team of doctors, including expert biliary surgeons. LC was performed using the four-trocar technique under general anesthesia. Patients were placed in the supine position. The first 12-mm laparoscopic trocar was inserted at the umbilicus using an open technique and the pneumoperitoneum was set at 8 mmHg. The maximum intra-abdominal pressure was 12 mmHg. Three additional trocars were inserted: two 5-mm trocars in the right subcostal area, and one 12-mm trocar in the subxiphoid area. We first dissected the junction between the neck of the gallbladder and the cystic duct at the inferior margin of the gallbladder. After dissection of Calot's triangle, we exposed the cystic duct and artery, and confirmed the critical view of safety. Both the cystic artery and duct were clipped and then divided with laparoscopic scissors. The gallbladder was dissected from the liver bed using a regular hook electrocautery device. A disposable retrieval bag was directly inserted, and the gallbladder and gallstones were extracted. No intraperitoneal drainage tube was placed. The decision to convert to an open cholecystectomy was made when the safety and certainty of laparoscopy could not be guaranteed — for instance, due to difficulty in dissecting Calot's triangle.

Data collection and statistical analysis. Preoperative clinical status of patients were examined by age, gender, comorbidity, American Society of Anesthesiologists (ASA) classification, laboratory findings (such as leukocyte count and CRP levels), and radiological findings (such as thickness of the gallbladder wall on CT imaging). Gallbladder wall thickness was measured using the maximum thickness on a transverse image of a CT scan. Numerical data are presented as median and range, and were evaluated using the Mann-Whitney

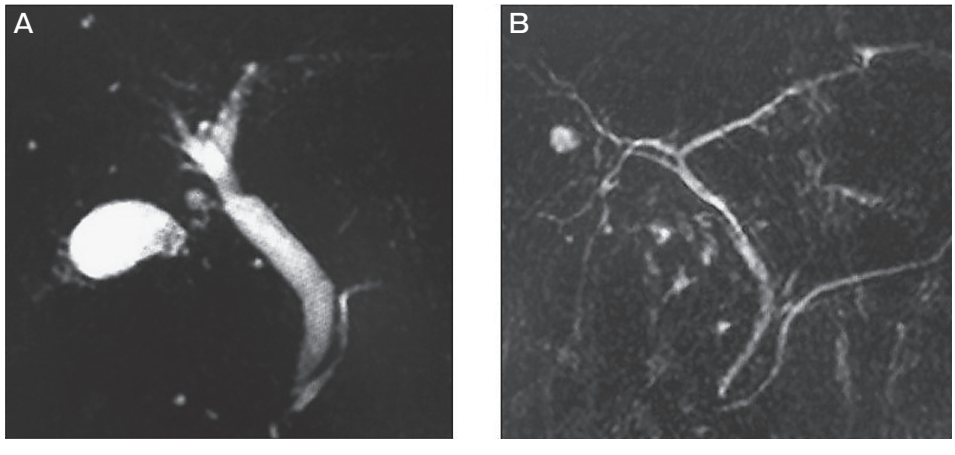

Fig. 1 The two classification categories according to the magnetic resonance cholangiopancreatography (MRCP) findings: (A) visualized type: the gallbladder could be visualized as a whole; and (B) non-visualized type: the gallbladder could not be visualized as a whole. Only the cystic duct was visualized.

U-test. Statistical analysis was performed using SPSS version 23 (SPSS, Chicago, IL, USA). A *p*-value of < 0.05 was considered statistically significant.

Results

Clinical characteristics on admission. During the study period, 168 consecutive patients underwent LC; 126 patients (75%) were included in the visualized group, and 42 (25%) in the non-visualized group. The clinical characteristics of the 2 groups are listed in Table 1. The median age of patients in the visualized and non-visualized groups was 62 and 60 years, respectively. In the visualized group, 67 patients (53%) were female, versus only 13 female patients (31%) in the non-visualized group, and this difference in gender proportion was statistically significant. Median body mass index in the visualized and non-visualized groups was 23.9 and 23.2 (kg/m^2), respectively. With one exception, all cholecystitis cases were caused by gallstones; the exception was caused by transcatheter arterial chemoembolization for hepatocellular carcinoma. Comorbidity and history of previous upper abdominal surgery did not differ significantly between groups.

The severity gradings of acute cholecystitis of patients in the visualized and non-visualized groups were grade I in 86 and 8 patients, grade II in 37 and 32 patients, and grade III in 3 and 2 patients, respectively. The severity grading of acute cholecystitis in the non-visualized group was significantly higher than that in the visualized group ($p < 0.001$). Preoperative white blood cell counts were also significantly different (7,300 vs. 12,150 count/μL; $p < 0.001$) between the visualized and non-visualized groups, respectively, while CRP levels were 0.44 and 12.82 mg/dL ($p < 0.001$). Finally, there was a significant difference in the median gallbladder wall thickness on CT imaging between the visualized group (2 mm) and non-visualized group (6.5 mm; $p < 0.001$).

Perioperative characteristics of patients. The perioperative characteristics of patients are presented in Table 2. Operation time was longer in the non-visual-

Table 1 Comparison between the clinical characteristics of the visualized and non-visualized groups

Characteristics	Visualized Group ($n = 126$)	Non-visualized Group ($n = 42$)	*P*-value
Age [years] (median, range)	62 (23–98)	60 (34–90)	0.726
Gender			0.024
Male	59	29	
Female	67	13	
BMI	23.9 (15.6–37.4)	23.3 (16.0–36.9)	0.376
Gallstone cholecystitis	125	42	0.999
Comorbidity			
Cardiovascular disease	13	5	0.999
Diabetes mellitus	10	3	0.999
Pulmonary disease	7	4	0.589
Chronic liver disease	5	3	0.675
Previous upper abdominal surgery	5	0	0.3329
Tokyo Guidelines 2018			<0.001
Grade I (mild)	86	8	
Grade II (moderate)	37	32	
Grade III (severe)	3	2	
WBC on admission [count/μL] (median, range)	7,300 (2,900–27,000)	12,150 (5,000–28,000)	<0.001
CRP on admission [mg/dL] (median, range)	0.44 (0.01–33.56)	12.82 (0.04–31.44)	<0.001
Gallbladder wall thickness using CT [mm] (median, range)	2 (1–12)	6.5 (2–12)	<0.001

BMI, body mass index; WBC, white blood cell; CT, computed tomography; CRP, C-reactive protein.

Table 2 Comparison between the perioperative characteristics of the visualized and non-visualized groups

Characteristics	Visualized Group ($n=126$)	Non-visualized Group ($n=42$)	*P*-value
Operation time [min] (median, range)	101.5 (47–221)	143.5 (60–197)	<0.001
Intraoperative blood loss [g] (median, range)	5 (0–1010)	10 (0–485)	0.05
Conversion (%)	2 (1.6)	4 (9.5)	0.03
Hospital stay [days] (median, range)	4 (2–27)	4.5 (3–25)	0.01

ized group (median 101.5 vs. 143.5 min; $p<0.001$). The non-visualized group had significantly more intraoperative blood loss (median 5 vs. 10 g; $p=0.05$), and a significantly higher rate of conversion to open cholecystectomy (1.6 vs. 9.5%; $p=0.03$). However, there was no significant difference in postoperative complications between the groups. In the visualized group, 2 patients displayed minor bile leakage and one acquired a surgical site infection. In the non-visualized group, two patients had minor postoperative bleeding. There were no fatalities in either group. Postoperative hospital stay of the non-visualized group was significantly longer than that of the visualized group (median 4 vs. 4.5 days; $p=0.01$).

Discussion

This study validated a new classification of acute cholecystitis, based on preoperative MRCP findings, to predict technical difficulties in LC. We divided patients requiring LC into visualized and non-visualized groups. Patients in the non-visualized group had a higher severity of inflammation in acute cholecystitis than those in the visualized group. In addition, patients in the non-visualized group showed higher difficulty of LC as evidenced by increased operation time, intraoperative blood loss, and conversion rate to open laparotomy.

Normal bile fluid shows a prominent hyperintensity on T2-weighted MRI and MRCP images. However, the gallbladder cannot be identified on MRCP images in cases of concentrated bile fluid because the T2 level is decreased, eliminating the hyperintensity. Impacted stones, torsion, or neoplasms can all result in obstruction of the gallbladder cystic duct, which in turn causes non-visualization of the gallbladder via MRCP. An obstructive cystic duct can also cause edema, thickening, or hardening of the gallbladder wall. In addition, these changes can result in chronic severe inflammation and dense adhesion in Calot's triangle. A gangrenous gallbladder may also disturb identification of the critical view of safety for LC.

MRCP is a well-known and non-invasive technique for the preoperative assessment of hepatobiliary-pancreatic disorders, and preoperative MRCP allows surgeons to understand biliary anatomy for safe LC procedures [9,10]. Preoperative MRCP might be especially useful to prevent intraoperative bile duct injury [11]. In our study, MRCP classification was a straightforward, accessible, and feasible predictive method for evaluating potential surgical difficulties in LC. This classification could be clearly categorized in 2 groups based on MRCP, even in weakly visualized cases. It was, however, difficult to predict the difficulty of LC based on the strength of the gallbladder imaging by MRCP because the strength could not be quantified.

LC is one of the most common surgical procedures in the field of general surgery and is often performed by resident surgeons to gain operative experience [12]. Although LC is a safe surgical procedure with a relatively simple technique, bile duct injury persists as the most feared and serious complication. The incidence of bile duct injury after LC is from 0.5-1.5% [13-15]. A major factor in bile duct injury is the surgeon's misidentification due to severe inflammation in Calot's triangle [13-15]. Therefore, performing preoperative MRCP classification can facilitate accurate case selection to allow residents to gain operative experience. Cases of visualized type defined by preoperative MRCP might be appropriate candidates for trainees. Although this classification does not affect the choice of treatment like the severity grading of acute cholecystitis, it should be considered when making decisions about the surgical procedure itself, such as allowing expert biliary surgeons to perform the surgery in non-visualized cases.

Recently, laparoscopic subtotal cholecystectomy has been reported as a safe and feasible alternative surgical procedure in cases of difficult LCs with potential risks of common bile duct injury [16-18]. Laparoscopic subto-

tal cholecystectomy is a safe surgical procedure for cases of technically difficult laparoscopic total cholecystectomy because dissection is not performed near the common bile duct [16-18]. If surgeons recognize a case classified as a non-visualized type via preoperative MRCP, they might consider preoperative subtotal cholecystectomy as a potential surgical procedure.

Our study was limited by sample size; therefore, further large-scale multicenter prospective controlled studies should be conducted to confirm our findings. In conclusion, our MRCP classification into visualized and non-visualized gallbladder types is a straightforward and useful means of predicting difficulties in LC for acute cholecystitis.

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