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Successful Laparoscopic Cholecystectomy in Moderate to Severe Acute Cholecystitis: Visual Explanation with Video File

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Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Conflict of interest: None declared

Case series
Patient: —
Final Diagnosis: Acute cholecystitis
Symptoms: Abdominal pain
Medication: —
Clinical Procedure: Laparoscopic cholecystectomy
Specialty: Surgery

Objective: Management of emergency care

Background: Experience alone is insufficient to ensure successful laparoscopic cholecystectomy (LC), although LC has become widespread worldwide. Iatrogenic biliary injuries occur beyond the learning curve.

Case Report: Biliary injury during laparoscopic cholecystectomy results from anatomical misidentification. The use of a critical view of safety has been established, to identify the cystic artery and the cystic duct, as the cystic duct can be hidden by inflammation (infundibular cystic duct). Seven patients who underwent emergency laparoscopic cholecystectomy due to acute cholecystitis are presented who underwent a critical view of safety protocol during surgery. Five men and two women (mean age, 63.0±13.0 years) included five cases of acute severe cholecystitis and two cases of acute moderate cholecystitis. The mean operative time to complete the critical view of safety exposure was 54.0±17.4 minutes. No cases underwent conversion to open surgery. The mean postoperative duration to ambulation and normal diet was 0.7±0.5 days and 1.0±0.6 days, respectively. The mean time to postoperative patient discharge was 3.9±0.9 days. In all seven cases, the postoperative course was uneventful. The protocol for this surgical procedure is presented, with schematic figures and videos.

Conclusions: A case series of seven patients who presented with moderate-to-severe acute cholecystitis and who underwent laparoscopic cholecystectomy, showed good postoperative outcome without surgical complications, using a using a critical view of safety protocol.

MeSH Keywords: Cholecystectomy, Laparoscopic • Cholecystitis, Acute • Gallbladder • Laparoscopes • Laparoscopy

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Background

Laparoscopic cholecystectomy is now used worldwide due to its recognized and validated advantages [1]. Laparoscopic cholecystectomy has a rapid learning curve because techniques such as lymph node dissection and anastomotic reconstruction are not required during laparoscopic surgery [1,2]. The first case of laparoscopic cholecystectomy was reported in 1989 [3], which was followed by its use worldwide [4–7]. However, clinical studies have shown that the experience of the surgeon alone is not enough to ensure a successful outcome in laparoscopic cholecystectomy for acute cholecystitis [2]. Unexpected biliary injury is a terrible nightmare for any surgeons, and this iatrogenic complication is usually caused by anatomical misidentification due to the assumption by the surgeon of the anatomical location of the cystic artery and the cystic duct, despite the visual field being altered by inflammation [1,2].

In recognition of the iatrogenic complications arising from poor visualization of key arterial and biliary structure during laparoscopic cholecystectomy for acute cholecystitis, in 1995, the concept of the 'critical view of safety' was proposed, which highlighted that the cystic artery and the cystic duct should be positively identified as they join the gallbladder [8]. Briefly, this protocol recommends that a tentative division of cystic structures should be completed at Calot's triangle, which consists of the cystic duct, the common hepatic duct, and the cystic artery [8]. Inflammatory, fibrous, and fatty tissues are dissected, the structures of Calot's triangle are dissected, the neck and body of the gallbladder are separately blunt-dissected from the liver bed, and as important structures become visible, key anatomic structures will only be cut when their identification is confirmed [8].

An 'infundibular cystic duct' may be hidden by inflammation in acute cholecystitis, leading the surgeon to wrongly identify the common bile duct or the common hepatic duct as the cystic duct [9]. Conclusive identification of the cystic structures is a key for successful laparoscopic cholecystectomy [2,8], and severity of acute cholecystitis is an important risk factor in anatomic misidentification [9]. Unless the identification of these key arterial and biliary structures are confirmed, iatrogenic surgical errors may occur due to the surgeon's incorrect assumptions [2,8]. From the technical viewpoint, laparoscopic cholecystectomy may become difficult in patients who have extrinsic compression of the main biliary tree (e.g. Mirizzi syndrome), for example in patients with obstruction of the common hepatic duct due to an impacted gallstone in the cystic duct or Hartmann's pouch (Mirizzi syndrome).

A case series is presented of seven patients who presented to our institution with moderate-to-severe acute cholecystitis and who underwent laparoscopic cholecystectomy using an established critical view of safety protocol and includes a visual description of the procedure with discussion of the technical approaches and pitfalls in these cases.

Case Report

This case series and the surgical approach was approved by the Institutional Review Board of Tenri Hospital according to the Declaration of Helsinki. The patients involved in this study provided written informed consent authorizing the use and disclosure of their anonymized health information and surgery. In all seven cases, surgical treatment was clinically indicated [10]. All surgical procedures were undertaken according to the current 2018 Tokyo Guidelines, of the Japanese Society of Hepato-Biliary-Pancreatic Surgery [11–13].

Seven patients are presented who underwent emergency laparoscopic cholecystectomy for moderate-to-severe acute cholecystitis. Clinical and demographic data were recorded and expressed as the mean ± standard deviation (SD) for the seven patients in this case series. The mean age was 63.0±13.0 years. There were five men and two women. The clinical diagnoses included five cases of severe or gangrenous cholecystitis and two cases of acute cholecystitis with moderate inflammation.

The laparoscopic cholecystectomy procedure, using the critical view of safety protocol, are described and illustrated in Figures 1–4), and the accompanying videos. The mean operative time and mean operative blood losses were 71.6±17.2 minutes and 36.9±15.0 ml, respectively. The mean operative time to complete the critical view of safety protocol was 54.0±17.4 minutes. None of the seven cases underwent conversion to open surgery. The mean postoperative duration to adequate ambulation and normal diet were 0.7±0.5 days and 1.0±0.6 days, respectively. Patients discharged at a mean of 3.9±0.9 days following emergency laparoscopic cholecystectomy. In all seven cases, the postoperative course was uneventful, and postoperative complications categorized as ≥Grade II according to the Clavien-Dindo classification were not observed [14]. None of the seven cases who underwent laparoscopic cholecystectomy had biliary injury, because the critical view of safety protocol was followed [1].

The surgical protocol used in this case series, for improved patient outcome following laparoscopic cholecystectomy, has been previously documented in detail [1]. Based on our protocol [1]. Figures 1–4 show the schema that visually explain the surgical protocol, which were drawn for this report by the co-author Tomohide Hori.

Briefly, the key points in the surgical procedures undertaken in this case series can be summarized as follows. The U-shaped

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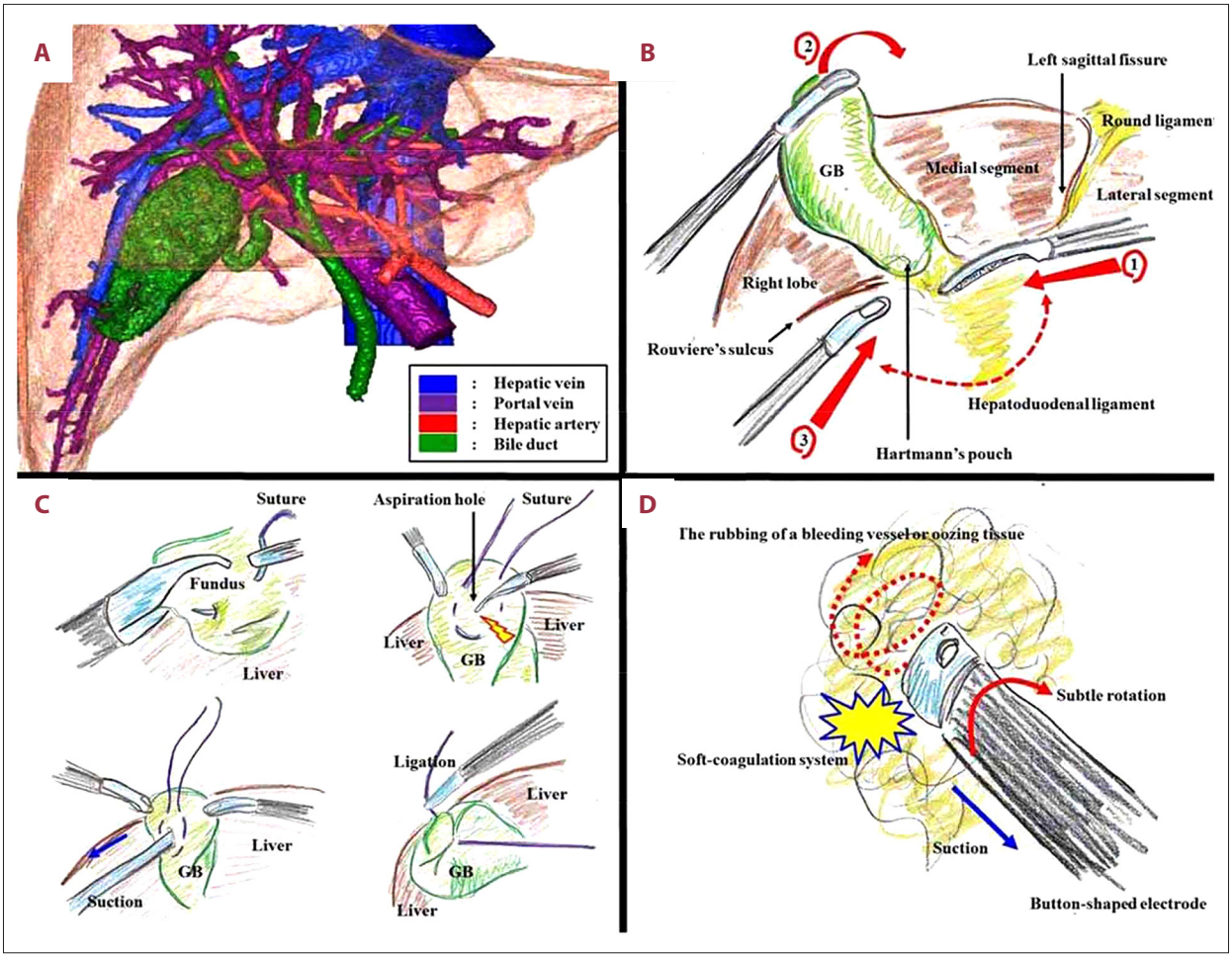

Figure 1. Basic points for successful laparoscopic cholecystectomy (supported by Video 1). (**A**) Three-dimensional imaging studies, including drip-infusion cholangiography, may be performed if needed. (**B**) A flexible laparoscope provides excellent multiple-angled views. The operator's upper port is placed first. Then, the second port is placed at the left lateral portion, and the gallbladder fundus is superiorly and cranially lifted by the assistant. The operator's lateral port (the third port) is placed with use of the forceps tip at an adequate degree around Calot's triangle (the cystic duct, the common hepatic duct, and the cystic artery) (approximately 90–120°) (as shown by the dotted arrow). (**C**) Decompression of a swollen gallbladder by aspiration (blue arrow) is advantageous for laparoscopic procedures in acute cholecystitis. The aspiration site is then promptly closed by an intraperitoneal suture or by extracorporeal ligation. (**D**) Inflammation can cause bleeding and by chronic oozing. A button-shaped cauterization electrode with suction used in conjunction with a soft-coagulation system is an effective tool to control hemostasis. A bleeding vessel or oozing tissue is massaged (dotted red arrow) using gentle rotation (solid red arrow) of the button-shaped electrode, and coagulation (yellow) is adequately performed with suction (blue arrow).
AC – acute cholecystitis; GB – gallbladder. Schema drawn by Tomohide Hori.

line at the hepatic hilum was identified, and the common hepatic duct was identified in the base of this line, thereby avoiding unexpected injury of the common hepatic duct and right anterior biliary duct. The line of surgical dissection was undertaken close to the common hepatic duct, the common bile duct, and the gallbladder. Using an adequate overhead view, the angle between the cystic duct and the common hepatic duct was widely dilated, to prevent unexpected biliary injuries due to the hidden or parallel cystic ducts. Therefore, in this protocol, alignment of the components of the biliary tree should be maximized to avoid any tenting of the common bile duct and the common hepatic duct. Using an adequate lower view, the S-shaped curve from Hartmann's pouch and the gallbladder infundibulum to the infundibulum-cystic duct junction were confirmed, so that the infundibulum-cystic duct junction and the cystic duct were dissected according to an inverted V-shaped line. Using an adequate rightward and upward view, Rouviere's sulcus should be intentionally recognized to avoid biliary injury, especially to avoid unexpected injury to the common bile duct and right posterior biliary duct. The gallbladder

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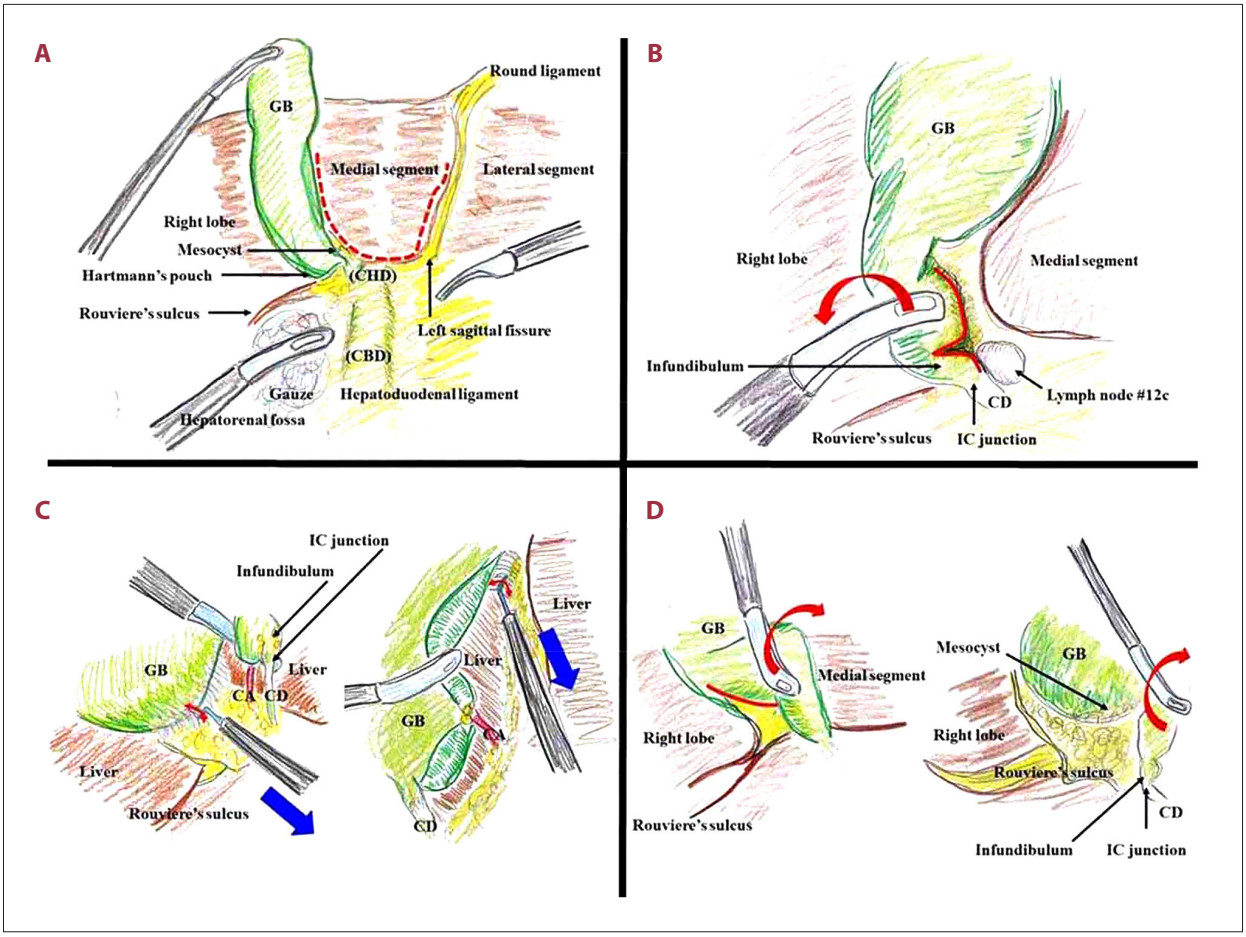

Figure 2. Intentional recognition of the hepatic hilum and Rouviere's sulcus (supported by Video 2). (**A**) The gallbladder fundus is lifted superiorly and cranially by the assistant's forceps, and the liver is then retracted. Stretching of the common bile duct is important to ensure a clear surgical field, and gauze is placed in the hepatorenal fossa (Morison's pouch) if needed. Fatty tissue is traced in a U-shape (dotted line) from the round ligament of the liver to the left side of the gallbladder because the bottom of this U-shaped line involves the common hepatic duct. Recognition of the tissue involving the common hepatic duct is important for subsequent isolation of the cystic duct. (**B**) Hartmann's pouch is pulled laterally and inferiorly to open the anterior left side of Calot's triangle (the cystic duct, the common hepatic duct, and the cystic artery) (red arrow). A dissectible layer should be traced as close to the gallbladder and cystic duct as possible (red line). The lymph node of the cystic duct (LN #12c) should be preserved. The overhead view is useful during this procedure. (**C**) Cautery may cause thermal necrosis of adjacent structures, such as ductal and/or perivascular tissues, but can be carefully used to dissect Calot's triangle (the cystic duct, the common hepatic duct, and the cystic artery). The use of the L-hook electrocautery technique has advantages, including the use of simultaneous cutting and pulling of the tissue from only one port, with a safe area in front of the cut tissue. For the effective performance of the L-hook electrocautery technique, it is important to locate the hook through limited amounts of tissue (red arrow), lift that tissue off the underlying structures under clear vision (blue arrow), and use a suitable electrocautery current. Tissue dissection and membrane cutting should be extended from the apparent site of the correct layer and not from the side that cannot be viewed. (**D**) The hepatorenal fossa is widely dilated, and Rouviere's sulcus and Hartmann's pouch are confirmed. Initial recognition of Rouviere's sulcus is important. A right-sided and upward view under superior and medial traction of the gallbladder neck or Hartmann's pouch (red arrow) is made. The fatty fissure of Rouviere's sulcus always involves the biliary duct, and the dissectible tissue around the gallbladder should not be followed into Rouviere's sulcus, because biliary injury may occur. The line of the dissection is made to the body of the gallbladder at a point at an adequate distance from Rouviere's sulcus (red line), and dissection of the gallbladder wall and fatty fissure of Rouviere's sulcus (red line) is important to avoid biliary injury.

A summary of this figure and video file: The bottom edge of the U-shaped line of the medial segment necessarily involves the common hepatic duct and hepatic hilum. The dissectible layer should be traced as close to the gallbladder and cystic duct as possible. A combination of blunt dissection and an L-hook electrocautery technique can be used. In the rightward and upward view, Rouviere's sulcus should be recognized. The gallbladder wall and fatty fissure of Rouviere's sulcus are separated.

CA – cystic artery; CBD – common bile duct; CD – cystic duct; CHD – common hepatic duct; GB – gallbladder; IC – infundibular cystic duct. Schema drawn by Tomohide Hori.

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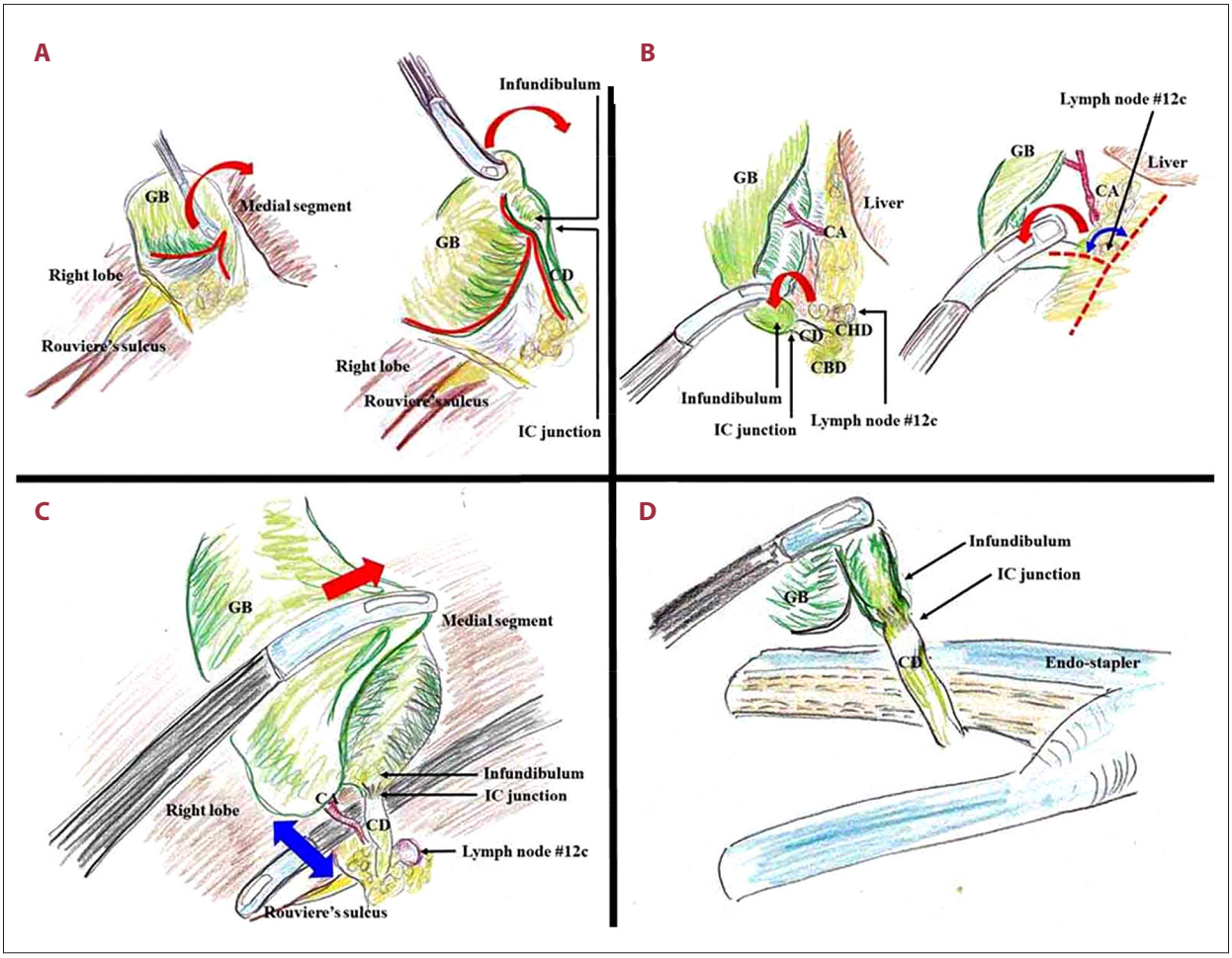

Figure 3. Maximized alignment of the cystic duct and common hepatic duct (supported by Video 3). (**A**) The upper view is established under superior and medial traction of the gallbladder neck or Hartmann's pouch (red arrow). A dissectible and resectable layer (red line) should be made as close to the gallbladder body as possible, and the gallbladder should be followed to the presumed point of the infundibular cystic duct junction. Intentional confirmation of the S-shaped curve (red line) of Hartmann's pouch, the infundibulum, the infundibular cystic duct junction, and the cystic duct is important. The infundibular cystic duct junction can be confirmed as an inverted V-shape (red line) because of the superior and medial traction of the gallbladder (red arrow). The infundibular cystic duct junction is recognized by the paler color of the cystic duct. (**B**) The gallbladder neck or Hartmann's pouch should be pulled laterally and inferiorly (red arrow) to open the anterior and left side of Calot's triangle (the cystic duct, the common hepatic duct, and the cystic artery). A wider angle between the cystic duct and common hepatic duct (red dotted line and blue arrow) should be created. This wider angle (red dotted line and blue arrow) avoids biliary injury due to the parallel junction of the cystic duct with the common hepatic duct. The overhead view is useful during this procedure. A dissectible layer should be traced as close to the gallbladder and cystic duct as possible, and the gallbladder should be followed to the presumed point of the infundibular cystic duct junction. (**C**) A partial window is made behind cystic structures. Forceps behind cystic structures is applied from the ventral side while applying superior and medial traction to the gallbladder neck or Hartmann's pouch (red arrow). Only two structures should be confirmed to enter the gallbladder (blue arrow). (**D**) The infundibular cystic duct junction may be recognized by the pale color of the cystic duct. The structures entering the gallbladder are cut. The cystic duct is then cut with scissors after dual clipping or ligation. A laparoscopic Endo Stapler can be used to cut the dilated cystic duct. The residual infundibulum should be avoided, and the surgical resection stump should be made on the cystic duct based on the recognition of the infundibular cystic duct junction. **A summary of this figure and video file:** In the overhead view, a wider angle between the cystic duct and common hepatic duct is created to avoid a biliary injury due to the parallel junction of the cystic duct and common hepatic duct. Maximized alignment of the cystic duct and common hepatic duct is important to prevent a common hepatic duct or common bile duct tenting injury. The S-shaped curve on Hartmann's pouch, the gallbladder infundibulum, the infundibulum-cystic duct junction, and the cystic duct is confirmed. The infundibular cystic duct junction may be confirmed as an inverted V-shape. CA – cystic artery; CBD – common bile duct; CD – cystic duct; CHD – common hepatic duct; GB, gallbladder; IC – infundibular cystic duct. Schema drawn by Tomohide Hori.

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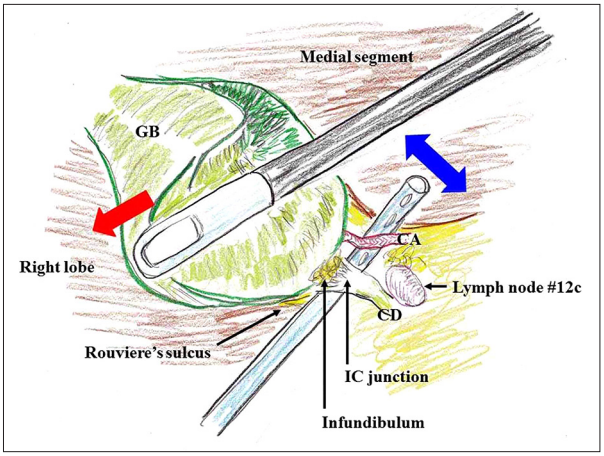

Figure 4. Complete exposure of the critical view of safety (supported by Video 4). Between half to two-thirds of the body of the gallbladder is removed from the liver bed at the time of the critical view of safety exposure. It is not necessary to confirm the common hepatic duct and common bile duct. A combination of blunt dissection and an L-hook electrocautery technique has broad utility to enable the critical view of safety. Until exposure of the critical view of safety is ensured, laparoscopic coagulating shears or stronger sealing devices should not be used because they can cut misidentified structures. Forceps are applied behind the cystic structures from the assistant's lateral port. The body of the gallbladder is removed from the liver bed. Only two cystic structures entering the gallbladder should be observed.
CA – cystic artery; CBD – common bile duct; CD – cystic duct; CHD – common hepatic duct; CVS – critical view of safety; GB – gallbladder; IC – infundibular cystic duct; LCS – laparoscopic coagulating shears. Schema drawn by Tomohide Hori.

was blunt-dissected as close to the gallbladder wall as possible, and fatty tissue of Rouviere's sulcus was dissected away. The gallbladder was completely blunt-dissected from the liver bed. Finally, all cystic structures entering into the gallbladder were 'definitively' and 'positively' dissected, and the critical view of safety protocol for laparoscopic cholecystectomy was completed (Figures 1–4). A relevant video for each figure is included as supporting information because the actual procedures should be shown.

Discussion

In cases of moderate-to-severe acute cholecystitis, inflammation can result in changes that may obscure the usual anatomical location or appearance of the vascular and biliary structures, including the cystic artery and the cystic duct. The 'infundibular cystic duct,' or 'the hidden cystic duct syndrome' can occur in acute cholecystitis as the cystic duct that may be hidden by inflammation, leading the surgeon to wrongly identify the common bile duct as the cystic duct [9].

Also, Hartman's pouch and the gallbladder neck can be unexpectedly located beneath the common hepatic duct. These pitfalls can mislead the surgeon into assuming that the common bile duct or the common hepatic duct is the cystic duct [9]. Reports of ambiguity during laparoscopic cholecystectomy, such as a 'second cystic duct,' 'accessory duct,' and 'dual common hepatic duct,' demonstrate the way in which misidentification of the cystic duct can occur [8]. We should never forget that subtotal cholecystectomy for difficult case is a terrible idea [15], though a remnant of the cystic duct is considered as permissive [1]. The 'L-hook technique' has been shown to have practical use [1,8]. It is important to make the surgical procedure of laparoscopic cholecystectomy as safe and free from complications as possible, as subtotal cholecystectomy, which that may be required following these complications, can be a difficult procedure that also has potential complication [15].

During laparoscopic cholecystectomy, technical experience, surgical skill, and anatomical knowledge do not necessarily prevent iatrogenic biliary injury. The anatomical assumptions that may be made during laparoscopic cholecystectomy are the main causes of unexpected biliary injuries [1,2,8].

Conclusions

A case series of seven patients who presented with moderate-to-severe acute cholecystitis and who underwent laparoscopic cholecystectomy, showed good postoperative outcome without surgical complications, using a using a critical view of safety protocol. Safe laparoscopic cholecystectomy should be the priority, even in acute cholecystitis. The authors hope that this presentation of a cases series that includes a detailed description of our surgical protocol for successful laparoscopic cholecystectomy will provide benefit for patients who present with moderate-to-severe acute cholecystitis.

Acknowledgments

Tomohide Hori originally drew all schema for this manuscript. Because actual procedures should be shown, a relevant video is attached as supporting information. A supplementary video is linked with the figures.

Conflict of interest

None.

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