Received: 20 October 2021 | Revised: 20 February 2022 | Accepted: 1 March 2022

DOI: 10.1002/ags3.12568

AGSurg Annals of Gastroenterological Surgery Open Access WILEY

HOW I DO IT

Application and utility of surgical techniques for cystic plate isolation in liver surgery

Yukio Tokumitsu[1] | Takao Tamesa[2] | Yoshitaro Shindo[1] | Kazuhiko Sakamoto[3] | Hiroaki Nagano[1]

[1]Department of Gastroenterological, Breast and Endocrine Surgery, Yamaguchi University Graduate School of Medicine, Ube, Japan

[2]Department of Surgery, Tokuyama Central Hospital, Shunan, Japan

[3]Department of Surgery, National Hospital Organization Kanmon Medical Center, Shimonoseki, Japan

Correspondence
Hiroaki Nagano, Department of Gastroenterological, Breast and Endocrine Surgery, Yamaguchi University Graduate School of Medicine., 1-1-1 Minami-kogushi, Ube, Yamaguchi 755-8505, Japan.
Email: hnagano@yamaguchi-u.ac.jp

Abstract

One of the most important areas of anatomical knowledge for liver surgery is the plate system in the hilar area. Four plates comprise the hilar area plate system: the hilar plate, cystic plate, umbilical plate, and Arantian plate. Based on the theory that the cystic plate is continuous with the hilar plate, isolation of the cystic plate can be applicable to various scenarios in liver surgery. We describe herein the procedure and usefulness of cystic plate isolation to approach the hilar plate, in both open and laparoscopic surgeries. This isolation can be applied in various manners. First, cystic plate traction can facilitate the Glissonian approach, drawing out the extrahepatic Glissonian pedicles and thus lengthening the pedicle, and facilitate isolation of these pedicles. Second, inflow control can be obtained by applying the cystic plate traction method to the Glissonian approach. This is suitable to control hepatic inflow when there is no need to divide vessels such as lymph node dissection or vascular resection and reconstruction. Third, the Glissonian approach can be used in surgery for hepatocellular carcinoma patients with portal thrombosis. The cystic plate traction method potentially avoids injury to the Glissonian pedicle that would cause unnecessary bleeding, and is thus particularly efficient for advanced cancers such as hepatocellular carcinoma patients with portal thrombosis and collateral vessels around the area of obstruction in the Glissonian sheath. In this article, we focused on our anatomical knowledge and technical tips for making use of cystic plate isolation in liver surgery.

KEYWORDS
cystic plate, Glissonian pedicle approach, hepatectomy laparoscopic surgery, surgical anatomy

1 | INTRODUCTION

Surgical techniques for liver cancers have advanced considerably with increased anatomical knowledge of the plate system in the hilar area. There are four plates in the hilar area: the hilar plate, the cystic plate, the umbilical plate, and the Arantian plate. At the hilum, all variations in bile ducts and blood vessels occur within the hilar plate, and these branches penetrate the plate system and form Glisson's capsule. Thus, proper isolation of the plate system can bring about developments in the era of widespread liver surgery, including minimally invasive surgery.

The cystic plate is a sheet of fibroareolar tissue located in the gallbladder bed. Isolation of the cystic plate appears applicable to

various scenarios in liver surgery, from awareness of the theory that the cystic plate is continuous with the hilar plate and Glisson's capsule, but methods have not been standardized.

This article focuses on our anatomical knowledge to provide technical tips on how to make use of cystic plate isolation in liver surgery.

2 | ANATOMICAL CONSIDERATIONS

Couinaud[1] established the concept of the plate system, and Hayashi et al[2] reported precise histological findings for the liver capsule and vascular sheath using cadaveric specimens. Recently, Sugioka et al[3] reported that recognition of the surgical anatomy of the liver, including the plate system, is essential for standardization of systematic extrahepatic Glissonian pedicle isolation, and emphasized the importance of comprehensive understanding of the surgical anatomy of the liver based on Laennec's capsule surrounding the Glissonian pedicles. Currently, we consider the cystic plate as the essential structure for surgical techniques in liver surgery, and propose herein novel comprehensive surgical considerations and techniques regarding isolation of the cystic plate and Glissonian pedicles (Figure 1A,B).

3 | METHODS

3.1 | Procedure for cystic plate isolation

First, we describe a procedure for cystic plate isolation that facilitates the approach to the hilar plate.

During open surgery, isolation of the cystic plate should be started from whole-layer cholecystectomy. The outermost layer of the gallbladder is separated from the liver parenchyma from the gallbladder fundus to the neck to expose the cystic plate. Use of a soft coagulation system allows rapid control of bleeding from the gallbladder bed and/or liver parenchyma,even if the liver is cirrhotic. When the gallbladder is placed under adequate traction, the cystic plate with the liver capsule is easily revealed at the gallbladder neck. (Figure 1C,D). Subsequently, the surface of the hilar plate and Glissonian pedicle with liver capsule are clearly visualized (Figure 1E–H), and the liver capsule can provide protection against Glissonian pedicle injury.

In addition to the traditional open approach, we have now developed a laparoscopic approach. During laparoscopic surgery, the dissection is started at the neck of the gallbladder, in contrast to the open "fundus-first" approach. This is because the "neck-first" approach can be considered suitable for laparoscopic surgery for the following reasons. First, this approach uses a similar procedure to the standard laparoscopic cholecystectomy. Second, the area around the gallbladder neck can be visualized clearly through the laparoscopic caudally or in close-up view. Third, dividing the cystic plate from the liver is easier around the gallbladder neck than at the fundus. After dividing the cystic artery and cystic duct, the cystic plate around the neck of the gallbladder is separated from the liver parenchyma. During this procedure, the mesocyst is pinched with forceps to apply tension between the cystic plate and liver parenchyma (Figure 2A). Our unique technique helps identify the boundary of the cystic plate and liver parenchyma under a close-up laparoscopic view, then the cystic plate with liver capsule is easily separated from the liver bed (Figure 2B,C) and isolated (Figure 2D).

3.2 | Application of cystic plate isolation and the cystic plate traction method for liver surgery

3.2.1 | The cystic plate traction method for isolation of the Glissonian pedicle

Couinaud[1] described three main approaches at the hepatic hilus: the intrafascial approach; the extrafascial transfissural approach; and the extrafascial approach. Of these, the extrafascial approach, also recognized as the extrahepatic Glissonian pedicle approach, was introduced in clinical practice by Takasaki et al,[4] followed by Yamamoto[5] and Okamoto et al,[6] then popularized by Machado et al.[7]

Cystic plate traction can be useful for right-sided extrahepatic Glissonian pedicle isolation, because such traction can draw out the extrahepatic Glissonian pedicle,and thus lengthen the pedicle. In our procedure, the surface of the hilar plate and the Glissonian pedicle with liver capsule are visualized clearly by blunt dissection with traction on the gallbladder and cystic plate. This procedure results in a well-defined space on the superior side of the hilar plate (Figure 3A), and the dissector is readily passed from this space toward the inferior side of the hilar plate, and isolation of the right Glissonian pedicle can then be achieved (Figure 3B). We named this procedure that leads to exposure of the outer layer of the hilar plate and the right Glissonian pedicle "the cystic plate traction method." In addition, the anterior Glissonian branch can be easily isolated with sufficient length by connecting the space on the upper side of the hilar plate with that on the lateral side of the anterior branch (Figure 3C,D). The right posterior pedicle can be encircled by subtracting the anterior branch from the right main pedicle.

Furthermore, this approach is also useful in laparoscopic surgery. During laparoscopic surgery, whole-layer cholecystectomy without cutting the cystic plate isolated by a "neck-first approach" is performed. Afterward, a clear border between the hilar plate and the liver parenchyma is visualized by placing the cystic plate under traction (Figure 4A,B), as well as open surgery. The right anterior Glissonian branch with liver capsule is then separated from the liver bed by blunt dissection (Figure 4C–F). Furthermore, changing the direction of traction on the cystic plate can change the direction of the Glissonian branch. Thus, we consider this technique allows easy isolation of the pedicle despite restricted instrument motion during laparoscopic surgery (Figure 4G,H).

3.2.2 | Inflow control using the extrahepatic Glissonian pedicle approach

The Glissonian pedicle approach is suitable to control hepatic inflow before hemi-hepatectomy, offering simplicity and saving time when there is no need to divide vessels, such as with lymph node dissection or vascular resection and reconstruction.[8] This procedure is also useful for obtaining selective inflow control.[9] Of course, the Pringle maneuver is a useful initial technique to control the inflow system,[10,11] and selective clamping of both sides of the Glissonian pedicle of the cut surface is reasonable to avoid blood congestion in the portal vein and total liver ischemia. For example, during

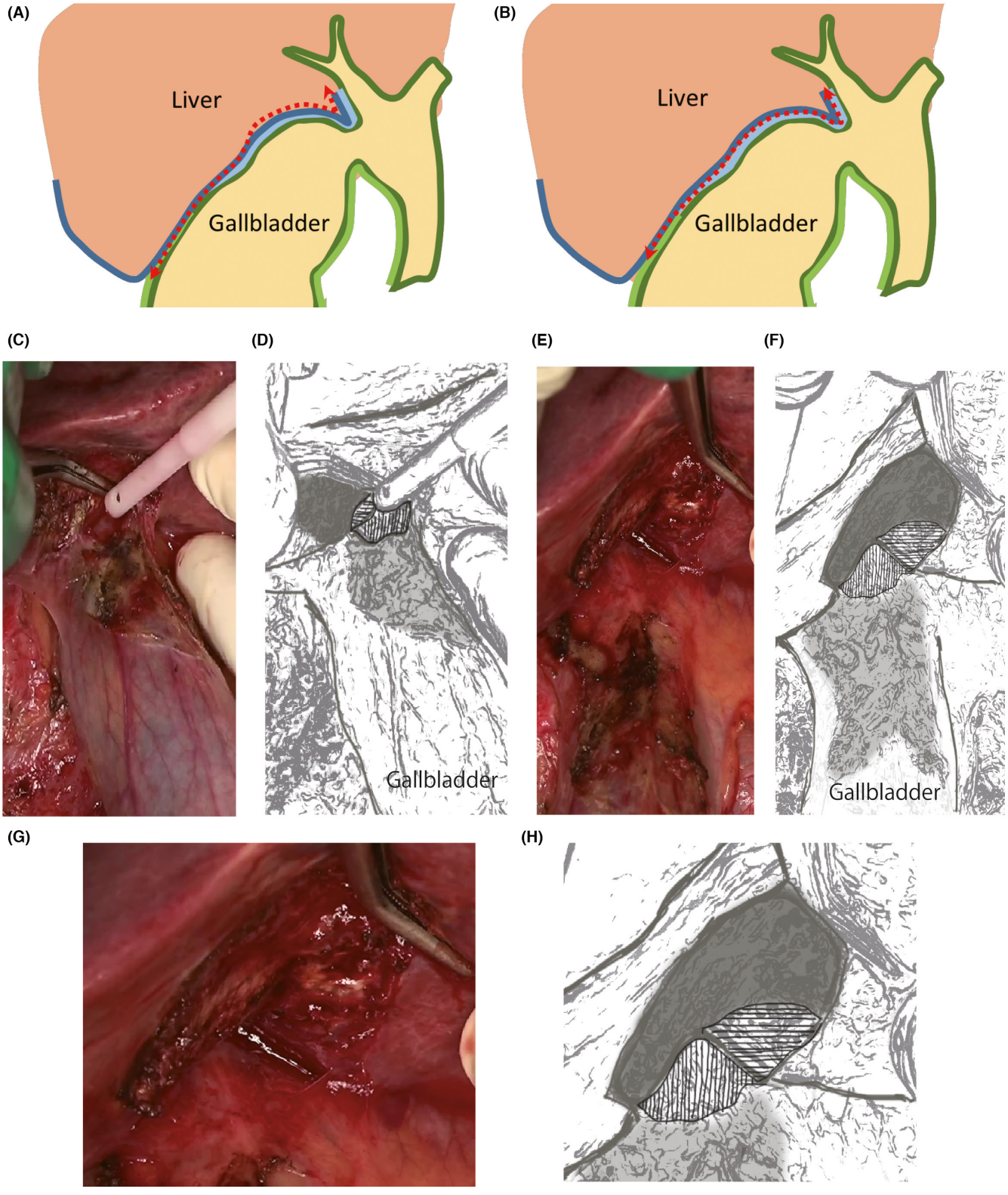


FIGURE 1 Isolation of the cystic plate during open surgery. A: The schema of surgical dissection layer of our procedure. The surfaces of the gallbladder, which are in contact with the liver, are not covered with serosa (light green line), but rather, they are covered with the cystic plate (light blue line) adjacent to subserosa (green line). In our procedure, the cystic plate is detached along with the liver capsule (blue line), including Laennec's capsule, from the liver parenchyma to provide protection against Glissonian pedicle injury. Although bleeding from the gallbladder bed and/or liver parenchyma is found, use of a soft coagulation system allows rapid control of the bleeding. B: The schema of surgical dissection layer of the procedure reported by Sugioka et al, which divide between Laennec's capsule and Glissonian pedicle. Although this technique would be ideal if successful, however, a risk of injury to the Glissonian sheath exists due to its proximity. C: Cystic plate with liver capsule can be revealed by exerting traction on the cystic plate. D: The schematic drawing of (C). Cystic plate with liver capsule (vertical stripe), the outermost layer of the gallbladder, which are dissected form the liver, ie, cystic plate (light gray), liver surface without liver capsule (horizontal stripe), and gallbladder bed (dark gray) are visualized. E: The outermost layer of the cystic plate/hilar plate with liver capsule is separated from the liver parenchyma. F: The schematic drawing of (E). Cystic/hilar plate with liver capsule (vertical stripe), the outermost layer of the gallbladder, which are dissected form the liver, ie, cystic plate (light gray), liver surface without liver capsule (horizontal stripe), and gallbladder bed (dark gray) are visualized. G: The enlarged figure of (E). H: The enlarged figure of (F)

FIGURE 2 Our unique technique to isolate the cystic plate during laparoscopic surgery. A: After cutting the cystic artery and cystic duct, the mesocyst is pinched with forceps (double arrow) to apply tension between the cystic plate and liver parenchyma. B: The cystic plate around the neck of the gallbladder with liver capsule is separated from the liver parenchyma (left side). C: The cystic plate around the neck of the gallbladder with liver capsule is separated from the liver parenchyma (right side). D: The cystic plate is isolated

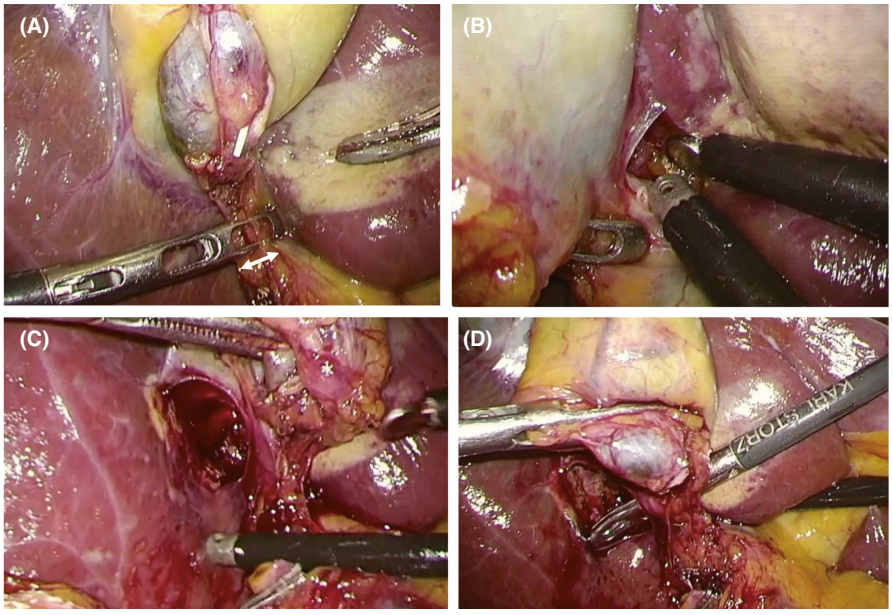
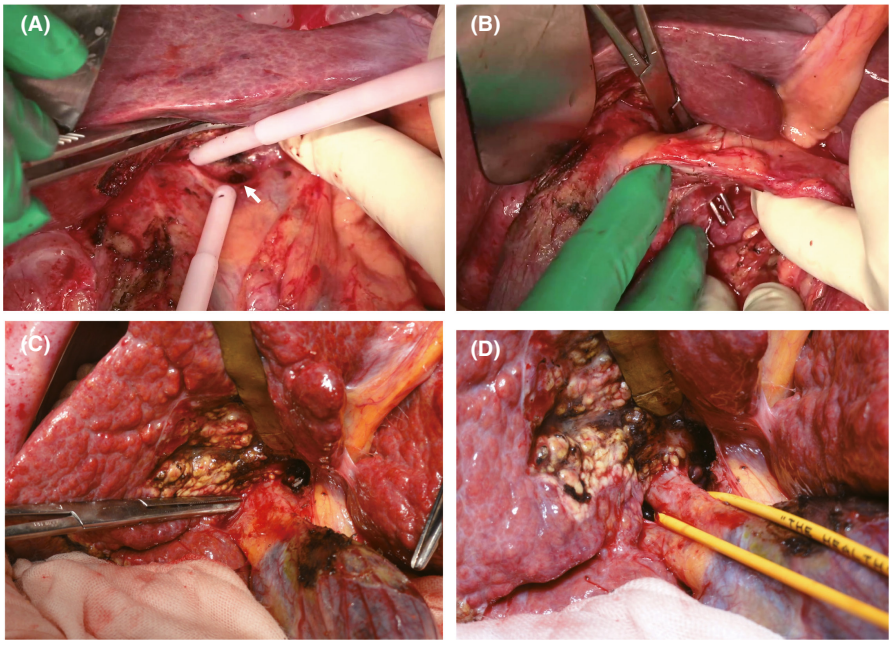


FIGURE 3 Glissonian approach using the cystic plate traction methods during open surgery. A: A well-defined space on the superior side of the hilar plate (single arrow) is revealed by blunt dissection. B: The right Glissonian pedicle is isolated. C: The cystic plate traction method can draw out the extrahepatic right anterior Glissonian pedicle and thus maximize the pedicle length. The pedicle is then easily isolated by connecting the space on the upper side of the hilar plate and the lateral side of the anterior branch. D: The right anterior Glissonian pedicle is encircled



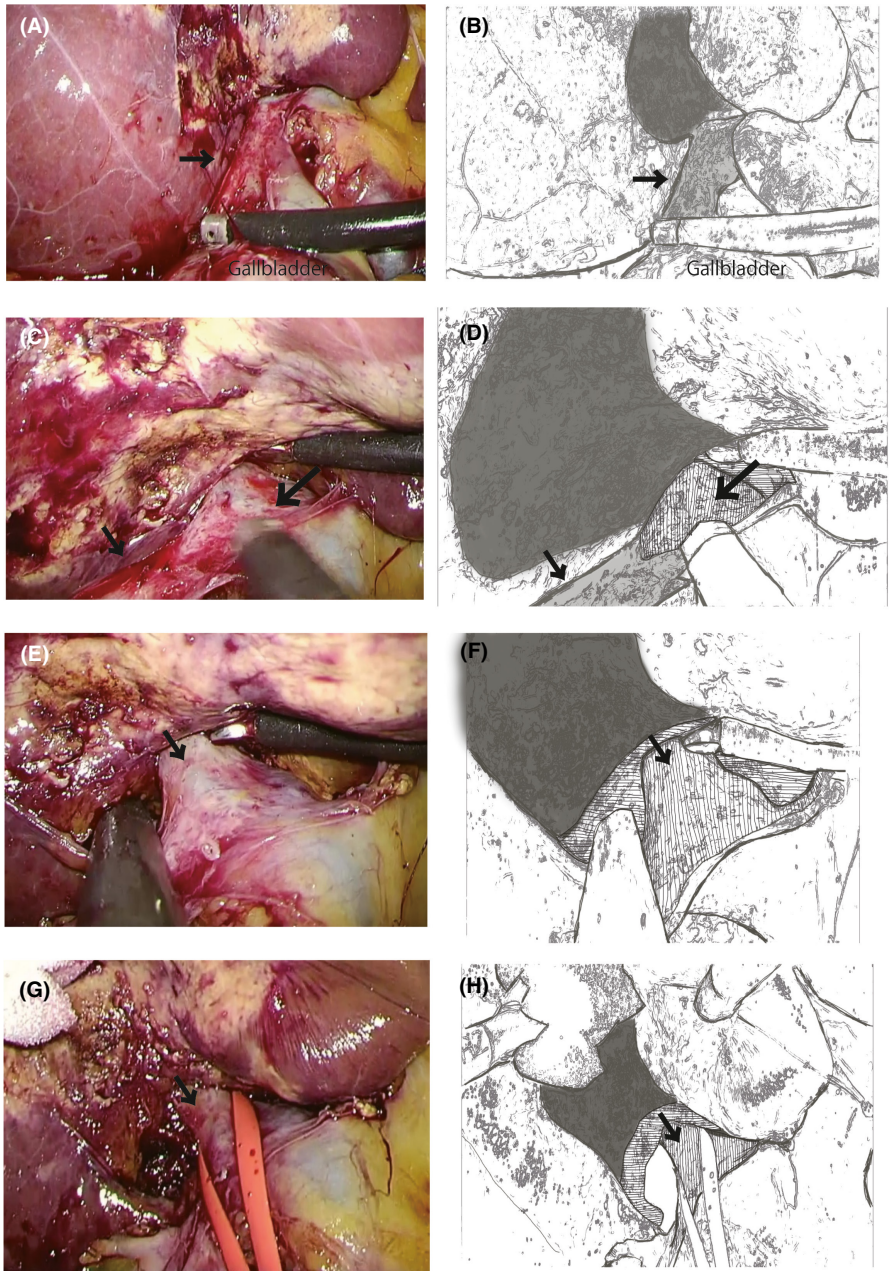


FIGURE 4 Isolation of the right anterior Glissonian pedicle during laparoscopic surgery. A: After whole-layer cholecystectomy without cutting the cystic plate (arrow), a clear border between the hilar plate and liver parenchyma is visualized by placing the cystic plate under traction. B: The schematic drawing of (A). The outermost layer of the gallbladder (light gray), ie, cystic plate (arrow) and gallbladder bed (dark gray), are visualized. C: The cystic plate (small arrow) and the upper side of the hilar plate (large arrow) with liver capsule is exposed by blunt dissection. D: The schematic drawing of (C). Hilar plate (large arrow) with liver capsule (vertical stripe), the outermost layer of the gallbladder (light gray), ie, cystic plate (small arrow), liver surface without liver capsule (horizontal stripe), and gallbladder bed (dark gray) are visualized. E: The lateral side of the anterior branch (arrow) is exposed by blunt dissection. F: The schematic drawing of (E). The anterior branch (arrow) with liver capsule (vertical stripe), liver surface without liver capsule (horizontal stripe), and gallbladder bed (dark gray) are visualized. G: The right anterior Glissonian pedicle (arrow) is isolated. H: The schematic drawing of (G). The right anterior Glissonian pedicle (arrow) with liver capsule (vertical stripe), liver surface without liver capsule (horizontal stripe), and gallbladder bed (dark gray) are visualized

dissection of the intersegmental plane between the anterior and posterior segments, selective clamping of anterior and posterior branches allows the left lobe branch to remain free from clamping. Our Glissonian pedicle approach applying cystic plate traction can facilitate selective clamping of Glissonian branches due to its ease of use for isolating Glissonian branches.

3.2.3 | Application for hepatocellular carcinoma patients with portal thrombosis

One of the advantages of the Glissonian pedicle approach is that dividing vessels can be avoided, thus also avoiding unnecessary bleeding in the hepatoduodenal ligament. An intrafascial approach is recognized as the conventional dissection for separating elements in the hepatoduodenal ligament, and is usually used during surgery for hepatocellular carcinoma patients with portal vein thrombosis,[12] for the purpose of the secure removal of the thrombosis. Inoue et al[12] reported the peeling-off technique as a thrombectomy after separation of the elements in the hepatoduodenal ligament using an intrafascial approach. However, an applied extrafascial approach can also be efficient to avoid unnecessary bleeding, which can be caused by collateral vessels around the area of obstruction in the hepatoduodenal ligament.[13-15] In such cases, we usually isolate the right Glissonian pedicle using the cystic plate traction method, and subsequently encircle the main and first branches of the portal veins from the right side of the hepatoduodenal ligament with minimal dissection (Figure 5A). The right Glissonian pedicle, except for the portal vein (thus including collateral vessels, hepatic artery, and bile duct), is then isolated by the subtraction method and can

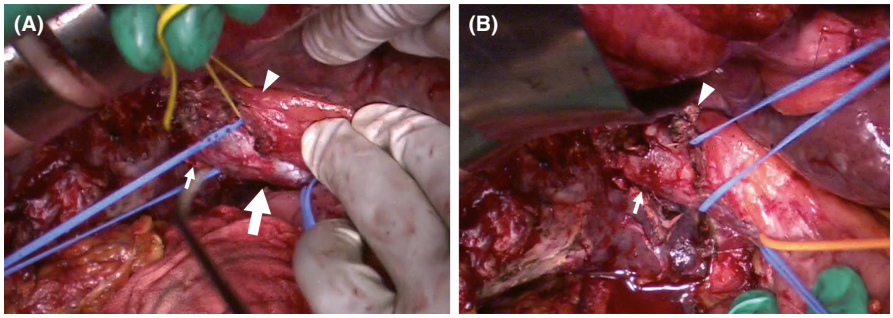


FIGURE 5 Application for hepatocellular carcinoma patients with main portal thrombosis. A: After a Glissonian approach using the cystic plate traction method, isolation of the main (large arrow) and first branch (small arrow) of the portal vein including thrombosis is performed with minimal dissection. The right Glissonian pedicle except for the portal vein, which includes collateral vessels, hepatic artery, and bile duct, is isolated by the subtraction method (triangle). B: After ligating the right Glissonian pedicle without a portal vein (triangle), the first branch (single arrow) of the portal vein including thrombosis is visualized more clearly

be ligated together and divided without contact from collateral vessels (Figure 5B). In this procedure, the right pedicle should be ligated as peripherally as possible with sufficient length, after making the pedicle thinner by dissecting the connective tissue or branch of the hepatic artery, to avoid the left bile duct stricture. Even during making the pedicle thinner, the bleeding from the collateral vessels and injury of the right biliary branches can be minimized because we can pull it up as a bundle surrounded by the connective of the Glissonian pedicle. Of course, the use of intraoperative cholangiography can also help to avoid bile duct stricture. Afterward, the thrombectomy can be utilized when portal thrombosis extends beyond the root of the portal branch. In this kind of situation, the cystic plate traction method followed by dividing the right Glissonian pedicle can provide good preparation for thrombectomy.

4 | SURGICAL OUTCOME

From May 2006 to September 2019, a total of 101 patients (hepatocellular carcinoma, 75 cases; metastatic carcinoma, 21 cases; other, five cases) underwent right-sided anatomical open liver resection without biliary reconstruction in our department. Among these, the cystic plate traction method was not applicable in 17 cases with previous cholecystectomy and seven cases with tumors in contact with the hilar plate, given the risk of injury to the tumor. A total of 77 cases (right hemihepatectomy, 42 cases; right anterior sectionectomy, 24 cases; right posterior sectionectomy, 11 cases) were intended to undergo extrahepatic right-sided Glissonian pedicle isolation using the technique, and this aim was achieved in 74 (96.1%) cases. Twenty-five (32.5%) of the 77 cases experienced postoperative complications (≥Clavien–Dindo grade 3), and six (7.8%) cases showed bile leakage. Of these, central type leakage occurred in two (2.6%) cases. One of them had leakage continued from the intraoperative bile duct injury of the posterior branch by liver parenchymal transection at hilum during anterior sectionectomy, and the other had postoperative leakage from the stump of the right hepatic duct caused by inadequate closure after right hemihepatectomy. Thus, we consider that there was no postoperative leakage associated with the cystic plate traction method. No mortality occurred within 90 d after surgery. In addition, from 2017 to 2019 we performed laparoscopic right or right anterior Glissonian pedicle isolation on three consecutive patients.

5 | DISCUSSION

Machado et al[7] reported that an intrahepatic Glissonian approach to the right pedicle was facilitated by small parenchymal incisions around the perihilar Glissonian pedicle. Mouly et al[15] and Figueroa et al[16] also reported similar techniques, and described the feasibility rate of the Glissonian approach as 75% and 88%, respectively. In the current report, we could isolate the extrahepatic Glissonian pedicle in 96.1% of patients using cystic plate traction methods during open surgery. To isolate the Glissonian pedicle more reliably, surgeons should be aware of the layer of the Glissonian pedicle based on the surgical anatomy of the plate system.

Sugioka et al[3] reported that the extrahepatic Glissonian pedicle in the right liver could be reached by detaching the cystic plate from Laennec's capsule. Our procedure is also similar in style to this approach, but shows two key differences. First, we emphasize the effectiveness of gallbladder and cystic plate traction, which can draw the Glissonian pedicle extrahepatically to facilitate isolation of the Glissonian pedicle. Second, we detach the cystic plate along with liver capsule, including Laennec's capsule, from the liver parenchyma to provide protection against Glissonian pedicle injury. Although the procedure of Sugioka et al[3] would be ideal if successful, a risk of injury to the Glissonian sheath exists due to its proximity. In our procedure, the layer of Glissonian pedicle isolation can be outside the liver capsule, so we believe that our procedure will be widely accepted in terms of avoiding injury to the Glissonian sheet with what is called the "anchor" considered as several pieces of fibrous tissue and vessels connecting the hilar plate and the liver parenchyma. In addition, they described that the anterior pedicle could be isolated by connecting Gates IV and V, and the posterior pedicle could be isolated by connecting Gates V and VI. These procedures are ideal, however, especially during isolation of the

posterior pedicle, Rouviere's sulcus may be deceiving as many variations. Therefore, the posterior pedicle would be isolated following the right main pedicle after the anterior pedicle, pulling the tape passed around the right pedicle to the lateral side of the anterior pedicle. In these series of our procedures, the layer of Glissonian pedicle isolation can also be outside the liver capsule.

Laparoscopic anatomical resection has recently become feasible,[17] but isolation of the Glissonian pedicle is still challenging. Although we have only treated a limited number of patients, the laparoscopic procedure was successfully performed to encircle the target Glissonian pedicle. This approach is different from open surgery in terms of initial dissection of Calot's triangle; however, it makes the cystic plate thinner and can facilitate isolating the cystic plate despite restricted instrument motion. Furthermore, this procedure is also applied to laparoscopic surgery for suspected gallbladder cancer, because the cystic plate provides a landmark for the inferior edge in total removal of the gallbladder.[18] We believe this technique is applicable to not only liver surgery, but also biliary surgery.

6 | CONCLUSION

Isolation of the cystic plate is applicable to various scenes in liver surgery, providing a basis for further developments, including minimally invasive surgeries.

ACKNOWLEDGMENTS

The authors thank Minekatsu Nishida MD, PhD, and Yoshitaka Maeda MD, PhD, for providing technical help.

DISCLOSURE

Funding: The authors received no specific funding for this study.

Conflict of Interest: Hiroaki Nagano is an editorial board member of the Annals of Gastroenterological Surgery.

Author contributions: Yukio Tokumitsu and Takao Tamesa drafted the paper. Yoshitaro Shindo obtained and analyzed data. Kazuhiko Sakamoto contributed to the concept and helped to write the manuscript. Hiroaki Nagano is a supervisor and edited the manuscript. All authors critically revised the report, commented on drafts of the manuscript, and approved the final report.

Ethical Approval: This study was approved by the Institutional Review Board of Yamaguchi University Hospital (H2020-015).

Informed consent: Informed formed consent was obtained from the patients.

ORCID

Yukio Tokumitsu https://orcid.org/0000-0003-4916-4674
Yoshitaro Shindo https://orcid.org/0000-0001-7419-5638
Hiroaki Nagano https://orcid.org/0000-0002-7074-3315

REFERENCES

1. Couinaud C. Surgical anatomy of the liver revisited. Paris: pers Ed; 1989.
2. Hayashi S, Murakami G, Ohtsuka A, Itoh M, Nakano T, Fukuzawa Y. Connective tissue configuration in the human liver hilar region with special reference to the liver capsule and vascular sheath. J Hepatobiliary Pancreat Sci. 2008;15(6):640–7.
3. Sugioka A, Kato Y, Tanahashi Y. Systematic extrahepatic Glissonean pedicle isolation for anatomical liver resection based on Laennec's capsule: proposal of a novel comprehensive surgical anatomy of the liver. J Hepatobiliary Pancreat Sci. 2017;24(1):17–23.
4. Takasaki K, Kobayashi S, Tanaka S, Saito A, Yamamoto M, Hanyu F. Highly anatomically systematized hepatic resection with Glissonean sheath code transection at the hepatic hilus. Int Surg. 1990;75(2):73–7.
5. Yamamoto M, Takasaki K, Ohtsubo T, Katsuragawa H, Fukuda C, Katagiri S. Effectiveness of systematized hepatectomy with Glisson's pedicle transection at the hepatic hilus for small nodular hepatocellular carcinoma: retrospective analysis. Surgery. 2001;130(3):443–8.
6. Okamoto E, Yamanaka N. Anatomical resection of the right hepatic subsegments preceded by suprahilar ligation of the portal pedicles. Tokyo: Springer-Verlag; 1992.
7. Machado MA, Herman P, Machado MC. A standardized technique for right segmental liver resections. Arch Surg. 2003;138(8):918–20.
8. Yamamoto M, Ariizumi SI. Glissonean pedicle approach in liver surgery. Ann Gastroenterol Surg. 2018;2(2):124–8.
9. Otsubo T. Control of the inflow and outflow system during liver resection. J Hepatobiliary Pancreat Sci. 2012;19(1):15–8.
10. Man K, Fan ST, Ng IO, Lo CM, Liu CL, Wong J. Prospective evaluation of Pringle maneuver in hepatectomy for liver tumors by a randomized study. Ann Surg. 1997;226(6):704–11; discussion 11–3.
11. Nagano H, Kishimoto S, Kobayashi S, Marubashi S, Eguchi H, Takeda Y, et al. A safe protocol of intermittent hilar vascular clamping for hepatic resection in cirrhosis. Hepatogastroenterology. 2009;56(94–95):1439–44.
12. Inoue Y, Hasegawa K, Ishizawa T, Aoki T, Sano K, Beck Y, et al. Is there any difference in survival according to the portal tumor thrombectomy method in patients with hepatocellular carcinoma? Surgery. 2009;145(1):9–19.
13. Ban D, Ogura T, Akahoshi K, Tanabe M. Current topics in the surgical treatments for hepatocellular carcinoma. Ann Gastroenterol Surg. 2018;2(2):137–46.
14. Sakamoto K, Nagano H. Surgical treatment for advanced hepatocellular carcinoma with portal vein tumor thrombus. Hepatol Res. 2017;47(10):957–62.
15. Mouly C, Fuks D, Browet F, Mauvais F, Potier A, Yzet T, et al. Feasibility of the Glissonian approach during right hepatectomy. HPB (Oxford). 2013;15(8):638–45.
16. Figueroa R, Laurenzi A, Laurent A, Cherqui D. Perihilar Glissonian approach for anatomical parenchymal sparing liver resections: technical aspects: the taping game. Ann Surg. 2018;267(3):537–43.
17. Chen HW, Wang FJ, Li JY, Deng FW, Lai ECH, Lau WY. Extra-Glissonian approach for laparoscopic liver right anterior sectionectomy. JSLS. 2019;23(2):e2019.00009.
18. Tokumitsu Y, Shindo Y, Matsui H, Matsukuma S, Nakajima M, Yoshida S, et al. Laparoscopic total biopsy for suspected gallbladder cancer: a case series. Health Sci Rep. 2020;3(2):e156.

How to cite this article: Tokumitsu Y, Tamesa T, Shindo Y, Sakamoto K, Nagano H. Application and utility of surgical techniques for cystic plate isolation in liver surgery. Ann Gastroenterol Surg. 2022;6:726–732. doi:10.1002/ags3.12568