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Original Research Article

The role of Rouvière's sulcus and R4U line in safe laparoscopic cholecystectomy: a prospective observational study of 130 cases

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ABSTRACT

Background: Bile duct injury (BDI) remains a serious complication of laparoscopic cholecystectomy (LC), most commonly due to misinterpretation of biliary anatomy. Rouvière's sulcus (RVS) is an extra-biliary anatomical landmark that defines the plane of the common bile duct, while the R4U line delineates a safe zone for dissection. Identification of these landmarks may reduce the risk of BDI, particularly in difficult cholecystectomies.
Methods: This prospective observational study was conducted at a tertiary care center between March 2023 and March 2025. A total of 130 patients undergoing elective LC for symptomatic gallstone disease was included. RVS was identified intraoperatively and classified according to presence, type, orientation, and dimensions. In cases where RVS was absent, dissection was guided by the R4U line. Operative difficulty was graded using the modified Nassar scale. Outcomes assessed included achievement of the critical view of safety (CVS), bile duct injury, bile leak, conversion to open surgery, and need for subtotal cholecystectomy.
Results: Was identified in 106 patients (81.5%). The open type was the most common morphology (72.6%), with a predominantly horizontal orientation. CVS was achieved in all cases. No bile duct injuries were recorded. Bile leakage occurred only in patients undergoing subtotal cholecystectomy. Conversion to open surgery was required only in early cases of the study. With increasing adherence to RVS and R4U-guided dissection, difficult cases were successfully managed laparoscopically.
Conclusions: Rouvière's sulcus is a reliable and consistent anatomical landmark for safe laparoscopic cholecystectomy. When absent, the R4U line provides an effective alternative guide. Routine identification and use of these landmarks may significantly reduce the risk of bile duct injury.

Keywords: Rouvière's sulcus, R4U line, Laparoscopic cholecystectomy, Bile duct injury, Critical view of safety, USG, Liver function test, Subtotal cholecystectomy

INTRODUCTION

Laparoscopic cholecystectomy (LC) is the standard surgical treatment for symptomatic gallstone disease. Despite its widespread acceptance, bile duct injury (BDI) remains a serious and potentially devastating complication, with an incidence ranging from 0.3% to 0.5%. Such injuries are associated with significant morbidity, mortality, impaired quality of life, and medicolegal consequences. Misinterpretation of biliary anatomy within the hepato-cystic triangle is recognized as the principal cause of BDI. Achieving the critical view of safety (CVS) is the most effective strategy to prevent misidentification of biliary structures. However, in cases of acute inflammation, dense fibrosis, or distorted

anatomy, obtaining CVS can be technically challenging. In these situations, reliance on consistent extra-biliary anatomical landmarks is essential to guide safe dissection. Rouvière's sulcus (RVS) is a fissure on the inferior surface of the liver, running between the caudate process and the right lobe. First described by Henri Rouvière in 1924, it corresponds to the plane of the right portal pedicle. The cystic duct and artery typically lie anterior and superior to this plane, while the common bile duct lies inferior to it. As RVS is part of the liver parenchyma, it remains unaffected by gallbladder inflammation or traction, making it a dependable landmark during LC.

Owing to pneumoperitoneum and magnified laparoscopic vision, RVS is often more clearly visualized during LC than during open surgery. The surgical relevance of RVS was highlighted by Hugh and colleagues, who demonstrated a reduced incidence of BDI when dissection of the hepato-cystic triangle was initiated above the level of the sulcus. Subsequent studies have reinforced its role as a guide for safe cholecystectomy.

The Tokyo Guidelines 2018 further emphasized the importance of anatomical landmarks, recommending the use of the R4U line—an imaginary line drawn from the roof of RVS across the base of segment IV to the umbilical fissure—to define a safe dissection zone, particularly in difficult or inflamed gallbladders.

When RVS is absent, the R4U line serves as an alternative reference, allowing surgeons to remain within a safe anatomical plane and minimize the risk of bile duct injury. Despite growing recognition of these landmarks, prospective clinical data on their routine application during LC remain limited. The present study was therefore undertaken to evaluate the incidence and morphological variations of Rouvière's sulcus and to assess the role of RVS and the R4U line in facilitating safe laparoscopic cholecystectomy.

LC is the standard surgical treatment for symptomatic gallstone disease. Despite its widespread acceptance, BDI remains a serious complication, with an incidence ranging from 0.3% to 0.5%. Misinterpretation of biliary anatomy within the hepato-cystic triangle is recognized as the principal cause of BDI.[7] Achieving the critical view of safety (CVS) is the most effective strategy to prevent misidentification of biliary structures.

However, in cases of acute inflammation, dense fibrosis, or distorted anatomy, obtaining CVS can be technically challenging. RVS was first described by Rouvière in 1924 and later elaborated by Gans, Reynaud, and Couinaud.[1-3] It represents the plane of the right portal pedicle, with the cystic duct and artery lying anterior and superior to it, and the common bile duct lying inferiorly.[4-8] Nassar et al emphasized that dissection of the hepato-cystic triangle should be initiated above the level of Rouvière's sulcus to reduce the risk of bile duct injury.[7] Subsequent studies have validated RVS as a reliable extra-biliary landmark during laparoscopic cholecystectomy.[4-6,9] The Tokyo Guidelines 2018 recommend the use of anatomical landmarks such as the base of segment IV and the roof of Rouvière's sulcus to guide safe dissection in difficult cholecystectomies.[15] The imaginary line connecting these landmarks, known as the R4U line, defines a safe zone for dissection.[7-10]

Objectives

The objectives of the study were to determine the incidence of RVS during laparoscopic cholecystectomy, to analyze its morphological characteristics including type, orientation, and dimensions, to evaluate the utility of RVS and the R4U line in preventing bile duct injury during laparoscopic cholecystectomy, and to assess intraoperative difficulty and surgical outcomes using the modified Nassar grading system.

METHODS

Operative difficulty was graded using the modified Nassar grading system.[7] In cases where RVS was absent, the R4U line was used as an alternative guide to maintain dissection within the safe zone.[7-10]

Study design and setting

This prospective observational study was conducted in the Department of General Surgery at a tertiary care teaching hospital between March 2023 and March 2025.

Study population

A total of 130 consecutive patients undergoing elective laparoscopic cholecystectomy for symptomatic gallstone disease were included.

Inclusion criteria

Patients aged 18 years and above with symptomatic cholelithiasis planned for elective laparoscopic cholecystectomy were included in the study.

Exclusion criteria

Patients with suspected or confirmed gallbladder malignancy, acute cholecystitis requiring emergency surgery, and those in whom laparoscopic cholecystectomy was converted to open surgery for reasons unrelated to biliary anatomy were excluded from the study.

Preoperative evaluation

All patients underwent detailed clinical evaluation and routine investigations, including complete blood count, liver function tests, and abdominal ultrasonography. Additional investigations were performed when clinically indicated.

Surgical technique: All procedures were performed under general anesthesia using a standard four-port laparoscopic cholecystectomy technique. After establishing pneumoperitoneum, the gallbladder fundus was retracted towards the right shoulder, and the infundibulum was retracted medially to facilitate identification of RVS

Intraoperative assessment

The following parameters were recorded intraoperatively:

The presence or absence of RVS, its morphological type (open or other variants), orientation (horizontal, oblique, or vertical), and its dimensions measured using a marked feeding tube were recorded.

In cases where RVS was identified, dissection of the hepato-cystic triangle was performed strictly above the level of the sulcus. When RVS was absent, an imaginary R4U line—drawn from the base of segment IV across the hepatoduodenal ligament towards the umbilical fissure—was used to guide safe dissection.

Operative difficulty and bailout procedures

The degree of operative difficulty was graded using the modified Nassar scale. The CVS was attempted in all cases. In difficult cholecystectomies where CVS could not be safely achieved, bailout procedures such as subtotal cholecystectomy or conversion to open surgery were undertaken after intraoperative consultation with a senior surgeon. All bailout procedures were performed above the R4U line.

Postoperative assessment

Postoperative outcomes assessed included bile duct injury, bile leak, postoperative bleeding, need for drainage, conversion to open surgery, and requirement for subtotal cholecystectomy. Drains were used selectively in difficult cases.

Statistical analysis

Data were analyzed using descriptive statistics. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages.

Study design

The study was a prospective observational study conducted at a tertiary care hospital from March 2023 to March 2025.

Inclusion

Patients with symptomatic gallstone disease undergoing laparoscopic cholecystectomy were included in the study.

Exclusion

Suspected malignancy, acute cholecystitis requiring emergency surgery, or conversion for unrelated reasons. All patients underwent clinical evaluation, LFT, USG.

Standard 4-port LC was performed under GA, RVS identified, and data recorded. Dissection above RVS or R4U Line in its absence. Outcomes included CVS, BDI, bile leaks, conversion, and STC. Nassar grading applied.

Standard 4-port LC was performed under GA, RVS identified, and data recorded. Dissection above RVS or R4U Line in its absence. Outcomes included CVS, BDI, bile leaks, conversion, and STC. Nassar grading A prospective study of RVS was conducted in the Department of General Surgery of a tertiary care hospital from March 2023 to March 2025. A total of 130 patients were included in this study. All patients with symptomatic gallstone disease were thoroughly investigated with routine hematological investigations, ultrasonogram (USG), liver function test (LFT), and other needed investigations.

Laparoscopic cholecystectomy was conducted under general anesthesia. A standard 4-port LC was done. After retracting fundus of GB toward the right shoulder, the infundibulum of GB is retracted to the left of the patient to see RVS.

Following data are noted: presence or absence of RVS, type, direction and measurements were made using marked feeding tube. Intraoperative difficulty in LC is graded according to the modified Nassar scale. Laparoscopic cholecystectomy was completed with RVS as the landmark and keeping above it to achieve CVS. When RVS is absent imaginary R4U line is used as the landmark.

In cases of difficult cholecystectomy, where CVS is not achieved, after consultation with another surgeon bail out procedures were undertaken with OC or subtotal cholecystectomy (STC) above R4U line. Drains were used only in difficult cases. Postoperative complications of bleeding and bile leak were noted.

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RESULTS

A total of 130 patients underwent laparoscopic cholecystectomy during the study period. The age of patients ranged from 18 to 73 years, with a mean age of 43.72 years. Female patients constituted 64% (n=83) of the cohort, while males accounted for 36% (n=47). RVS was

identified in 106 patients (81.5%). Among these, the open type was the most frequently observed morphology (72.6%).

Table 1: Demographic data.

Parameter	Data
Number of patients	130
Age range (years)	18–73
Mean age (years)	43.72
Peak incidence	4th decade (32%), 5th decade (28%)
Gender distribution	Female 83 (64%), male 47 (36%)

Table 2: Outcomes.

Parameter	Data
Bile duct injuries	0 cases
Bile leaks	Only in STC cases
Conversion to open surgery	Early cases only
Subtotal cholecystectomy	Used in difficult cases

Table 3: RVS morphology.

Parameter	Data
Presence of RVS	81.5%
Absence of RVS	18.5%
Open type	72.6%
Other types	27.4%
Horizontal direction	Most common

The sulcus was most commonly oriented horizontally, while oblique and vertical orientations were less frequent. The critical view of safety was successfully achieved in all cases.

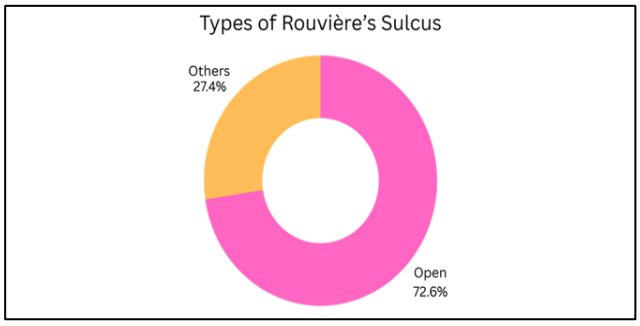

Figure 1: Pie chart showing types of Rouvière's sulcus.

No bile duct injuries were encountered in the study population. Bile leakage occurred only in patients who underwent subtotal cholecystectomy as a bailout procedure. Conversion to open surgery was required only in the early phase of the study. With increasing familiarity and adherence to dissection guided by Rouvière's sulcus and the R4U line, subsequent difficult cases were successfully managed laparoscopically.

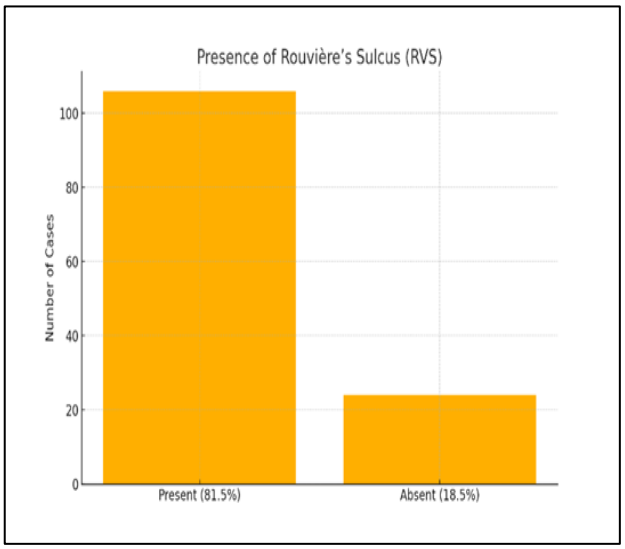

Figure 2: Bar chart showing presence of Rouvière's sulcus.

The modified Nassar grading system demonstrated higher grades of difficulty in cases requiring bailout procedures; however, adherence to the safe dissection zone above the RVS or R4U line allowed safe completion of surgery without major biliary complications.

DISCUSSION

RVS serves as a consistent extra-biliary anatomical landmark that reliably indicates the plane of the common bile duct.[4,8,9] In the present study, RVS was identified in 81.5% of cases, comparable to previously reported incidence rates ranging from 70% to 85%.[4,6,11] The R4U line provides an additional safety strategy, particularly when RVS is absent or poorly defined, and has been endorsed in international guidelines and consensus statements.[7,10,12,15] The absence of bile duct injury in this study supports existing evidence that adherence to safe zone dissection reduces biliary complications.[7,11,13,14]

Bile duct injury remains one of the most serious complications of laparoscopic cholecystectomy and is associated with significant morbidity, long-term disability, and medicolegal consequences. Misinterpretation of biliary anatomy within the hepato-cystic triangle is widely recognized as the primary mechanism underlying these injuries. Although achievement of the critical view of safety is the cornerstone of safe cholecystectomy, this may be challenging in the presence of acute inflammation, dense fibrosis, or distorted anatomy.

RVS serves as a consistent extra-biliary anatomical landmark that reliably indicates the plane of the common bile duct. As it is part of the liver parenchyma, its position remains unaffected by gallbladder pathology or traction,

making it particularly valuable in difficult cholecystectomies.

The enhanced visualization provided by laparoscopic magnification and pneumoperitoneum further facilitates its identification during LC. In the present study, RVS was identified in 81.5% of cases, a finding consistent with previously published literature reporting incidence rates between 70% and 85%.

The predominance of the open type and horizontal orientation observed in our series aligns with anatomical and clinical studies reported in the literature. These findings reaffirm the reliability of RVS as a landmark across diverse patient populations. The R4U line provides an additional safety strategy, particularly in cases where RVS is absent or poorly defined.

By delineating a safe dissection zone above the base of segment IV and the roof of RVS, the R4U line enables surgeons to avoid inadvertent injury to the common bile duct. The importance of this concept has been emphasized in international guidelines and consensus statements on safe cholecystectomy, especially in the setting of acute or difficult gallbladder disease. Notably, no bile duct injuries were recorded in this study. Bile leakage occurred only in patients undergoing subtotal cholecystectomy as a bailout procedure, highlighting the role of controlled subtotal cholecystectomy as a safe alternative when the critical view of safety cannot be achieved. Early conversions to open surgery occurred during the initial phase of the study; however, increasing experience with RVS- and R4U-guided dissection allowed successful laparoscopic management of subsequent difficult cases.

Overall, the findings of this study support the routine identification of RVS at the beginning of laparoscopic cholecystectomy and the consistent use of the R4U line as an adjunctive safety measure. Incorporation of these landmarks into surgical practice may significantly reduce the risk of bile duct injury, particularly in complex cases.

Limitations

Despite demonstrating the clinical usefulness of RVS and the R4U line, this study has certain limitations:

RVS is not universally present and may be absent. RVS may be poorly defined in a subset of patients, limiting its applicability as a landmark in all cases. Its morphological variability may also pose identification challenges, particularly in obese patients or those with altered hepatobiliary anatomy, while dense adhesions, fibrosis, or severe inflammation may further obscure the sulcus during difficult cholecystectomies. In addition, the effective use of these landmarks requires a sound understanding of hepatobiliary anatomy and appropriate surgical training, and their benefits may vary with the surgeon's experience. The study was conducted at a single centre with a relatively limited sample size and lacked long-term follow-up, and the absence of a control group limits direct comparison with conventional dissection techniques. Therefore, larger multicenter studies and randomized controlled trials are required to further validate the role of RVS and the R4U line in preventing bile duct injury.

CONCLUSION

RVS and the R4U line are critical guides for safe laparoscopic cholecystectomy, and we advocate their routine use to reduce the risk of bile duct injury. RVS is a consistent and reliable extra-biliary anatomical landmark that facilitates safe laparoscopic cholecystectomy, and when the sulcus is absent or poorly defined, the R4U line provides an effective alternative guide for maintaining dissection within a safe anatomical plane.

Routine identification and utilization of these landmarks, particularly in difficult cholecystectomies, may significantly reduce the risk of bile duct injury and improve surgical safety. In our series, no major bile duct injury was observed; bile leaks were seen mainly in difficult bailout cases, while conversion to open cholecystectomy was performed early in the study, and later, reconstituted subtotal cholecystectomy was undertaken with no postoperative bile leaks.

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REFERENCES

1. Gans HO. The anatomy of the liver. Thesis. Amsterdam: University of Amsterdam. 1955.
2. Couinaud C. Le foie: études anatomiques et chirurgicales. Paris: Masson. 1957.
3. Reynaud Y, Couinaud C. Le sillon du processus caudé (sillon de Rouvière). Bull Assoc Anat (Nancy). 1953;38:243-6.
4. Lim KH, Rajan S, Choi SH, Park HJ. Rouvière's sulcus: A useful landmark in laparoscopic cholecystectomy to prevent bile duct injury. World J Gastroenterol. 2020;26(48):7610-22.
5. Sivaraman A, Sadhasivam M, Shankar M, Chandramohan SM. Rouviere's Sulcus: An additional guide for safe laparoscopic cholecystectomy. Int Surg J. 2017;4(6):1993-7.
6. Gandhi A, Majumder A, Bindal V, Gandhi S. Importance of Rouviere's sulcus in laparoscopic cholecystectomy: A cross-sectional study. Int Surg J. 2019;6(5):1493-7.

7. Nassar AH, Ng HJ, Hamade AM. Safe cholecystectomy: the R4U line and Rouvière's sulcus. Ann R Coll Surg Engl. 2020;102(2):139-42.
8. Sharma D, Khullar R, Soni V, Baijal M, Chowbey PK. Role of Rouviere's Sulcus in safe laparoscopic cholecystectomy. J Laparoendosc Adv Surg Tech A. 2007;17(4):436-8.
9. Sasaki A, Nakajima J, Nitta H, Obuchi T, Baba S, Wakabayashi G. Identification of Rouvière's sulcus as an anatomical landmark in laparoscopic cholecystectomy. Surg Endosc. 2007;21(9):1591-4.
10. Palanivelu C, Rangarajan M, Senthilkumar R, Parthasarathi R, Rajapandian S, Babu NR. Safe laparoscopic cholecystectomy: The importance of the R4U line. World J Surg. 2008;32(3):391-5.
11. Garg P, Thakur JD, Singla SL, Chandel N, Shekhawat NS. Rouviere's sulcus: A valuable landmark in laparoscopic cholecystectomy. World J Gastrointest Surg. 2016;8(6):436-40.
12. Sundararajan LS, Muthukumar M, Sundaramurthi S, Rajamurugan A, Thirugnanam S, Kumaran V. The R4U line in safe laparoscopic cholecystectomy: a retrospective analysis. Int J Surg. 2021;93:106049.
13. Nasseri Y, Berber E. Rouviere's sulcus: An important landmark for safe laparoscopic cholecystectomy. Surg Laparosc Endosc Percutan Tech. 2012;22(3):e122-4.
14. Singh P, Yadav R, Chauhan N. Role of Rouviere's sulcus in safe laparoscopic cholecystectomy: a clinical study. Int J Contemp Med Res. 2018;5(2):B1-3.
15. Yokoe M, Hata J, Takada T. Tokyo Guidelines 2018: diagnostic criteria and severity grading of acute cholecystitis. J Hepatobiliary Pancreat Sci. 2018;25(1):41-54.

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