

# Rouviere's Sulcus: Anatomy and its Clinical Significance in Laparoscopic Cholecystectomy

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## ABSTRACT

**Background:** Laparoscopic cholecystectomy (LC) is associated with an increased rate of bile duct injuries than open cholecystectomy (OC). Majority of the bile duct injuries result from structural misidentification. The surgeon needs some anatomical landmarks to guide him for a safe cholecystectomy. Rouviere sulcus (RVS) is one such landmark. M Henri Rouviere first described it in 1924, but it was forgotten and neglected. It is not mentioned in anatomy or surgery textbooks. Its importance was recognized only in the late 1990s with the acceptance of LC as gold standard surgery. As there is paucity of the literature on RVS, a study was conducted on RVS.

**Materials and methods:** A prospective study of RVS was conducted in 130 cases of LC noting the presence, morphology, and use of the RVS in safe LC.

**Results:** Rouviere sulcus was present in 81.5% of cases. Open type sulcus with a horizontal direction was the most common presenting type. Rouviere sulcus is an extrabiliary landmark in a solid organ, liver, which is not affected by the gallbladder disease or retraction. It is well visualized in laparoscopic surgery than the open cholecystectomy due to opening of the sulcus by CO<sub>2</sub> pressure and magnification of digital cameras. The cystic duct and artery lie in a safe zone ventral and anterior to the plane of RVS and the common bile duct (CBD) lies below it. Rouviere sulcus indicates a safe plane of dissection for surgeon to avoid bile duct injuries.

**Conclusion:** Rouviere sulcus is an important and first landmark that a surgeon must look to achieve the safe cholecystectomy and minimize bile duct injuries.

**Keywords:** Bile duct injury, Common bile duct, Critical view of safety, Gallbladder, Laparoscopic cholecystectomy, Open cholecystectomy, Rouviere sulcus.

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## INTRODUCTION

M Henri Rouviere, a French surgeon, first described Rouviere sulcus (RVS) in 1924. He noticed a 2–5 cm long fissure running transversely between caudate process and right lobe of the liver.<sup>1</sup> He described it as "Sillon du processus caude." Somehow RVS was forgotten and there was no mention of it in the anatomy or surgery books. Majority of the data on RVS have come from the works of Reynaud, Gans, and Couinaud on the liver anatomy.<sup>2</sup> In 1955, Gans in his doctoral thesis described RVS as an extension of porta hepatis but he did not elaborate on it.<sup>3</sup> Gans incisura, incisura hepatica dextra were other names for RVS. The present name "Rouviere's sulcus" was suggested by the French hepatobiliary surgeon Claude Couinaud. Now the name RVS is internationally accepted. With the increasing popularity of laparoscopic cholecystectomy (LC), the surgical importance of RVS is well recognized in recent times. Rouviere sulcus accurately determines the plane of the common bile duct (CBD). The cystic duct and artery lie above and ventral to it, whereas CBD lies below to it. This was confirmed by intra-operative cholangiogram. Rouviere sulcus is visible more clearly during LC than the open cholecystectomy (OC). There is a wide opening of sulcus due to CO<sub>2</sub> pressure and magnified view of RVS with digital cameras and lighting.<sup>4</sup> Hugh et al. were the first to recognize the importance of RVS in LC as it shows the correct plane of CBD.<sup>5</sup> They demonstrated the lowest rate of bile duct injury (BDI) by dissecting the Calot's triangle above the RVS. Peti and Moser described RVS as a lesser known but important landmark for successful completion of LC and to avoid BDI.<sup>6</sup> Rouviere sulcus

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is an extrabiliary landmark in the solid organ liver. It is not affected by diseases or retraction of the gallbladder. It is also an important landmark for right hepatectomy.

Rouviere sulcus shows wide anatomical variations. It is present in majority of cases ranging from 68 (Zubiar et al., 2009) to 82%.<sup>2</sup> Absent RVS is noted in 10–30% cases in the literature. Length of RVS varies from 1 to 5 cm with an average of 3 cm. Width vary from 0.5 to 2 cm averaging 1.1 cm. Depth varies from 0.5 to 2 cm with an average of 1.1 cm.<sup>2</sup> The position of RVS is either horizontal, oblique, or vertical. The horizontal lie is most common and vertical type is least common.<sup>2</sup> Dahmane et al.<sup>7</sup> demonstrated 97% oblique in their

dissection of cadaveric livers. Rouviere sulcus is classified as (1) open, (2) closed, (3) slit, and (4) scar. *Open sulcus* is continuous with the porta hepatis at its medial end and has measurable dimensions of length, breadth, and depth. Branches of right hepatic pedicle are visible in it. *Closed sulcus* has a closed medial end and partly visible right hepatic pedicle. Length, breadth, and depth can be measured. *Slit sulcus* is a shallow sulcus with no visible right hepatic pedicle. Only length can be measured. The breadth and depth are barely measurable. *Scar sulcus* appears as a white scar that is completely fused. Some authors combine both open and closed sulci together as deep sulcus.<sup>2</sup> Rouviere sulcus contains right portal pedicle or its branches. It contains right posterior sectoral pedicle in 70% cases. The vein to segment VI, anterior sectoral pedicle, or cystic vein is seen in 25%, 5%, and 18% of cases, respectively.<sup>8</sup> Majority of knowledge on RVS comes from the works of Dahmane et al.<sup>7</sup> on cadaveric livers. The surgical importance of RVS—the cystic duct and the artery lie above the plane of RVS and the CBD lies below it, making RVS an established anatomical landmark for a safe cholecystectomy. In LC it is easy to see the sulcus when gallbladder is pulled medially toward umbilical fissure. Hugh et al.<sup>5</sup> stressed that during LC, the RVS is the first landmark from where the dissection of the Calot's triangle should start. Peti and Moser<sup>6</sup> also stressed the same for conduct of safe cholecystectomy and to avoid BDI. The importance of RVS is also stressed in the Tokyo guidelines (2018) for management acute cholecystitis.<sup>7</sup> They suggest that in acute cholecystitis, the base of segment IV and the roof of RVS should be used as anatomical landmarks, and any surgical procedures during cholecystectomy should be performed above the line connecting these two landmarks.<sup>7</sup> This line is known as R4U line, which is drawn from the roof of RVS and the base of segment IV to the umbilical fissure. The zone above this line is a safe zone for LC and below the R4U line is unsafe. When RVS is absent, an imaginary line is drawn from umbilical fissure across base of segment IV and extended to the right across the hepatoduodenal ligament to mark a safe zone. The dissection of the hepatocystic triangle must be performed in the safe zone to achieve the critical view of safety and avoid BDI.

The *objective* of this work is to study incidence and morphology of RVS and its importance in LC.

## MATERIALS AND METHODS

A prospective study of RVS was conducted in the Department of General Surgery of a tertiary care hospital from March 2021 to June 2022. 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.<sup>9</sup> 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 bailout procedures were undertaken with OC or subtotal cholecystectomy (STC) above R4U line. Drains were used only

**Table 1:** Type of sulcus

Type of sulcus	No. of patients	Percentage
Open	77	72.6
Closed	14	13.2
Slit	11	10.4
Scar	04	03.8
Total	106	100

**Table 2:** Direction of sulcus

Direction	No. of cases	Percentage
Horizontal	74	69.80
Oblique	31	29.25
Vertical	01	00.95
Total	106	100

**Table 3:** Measurements of sulcus

Type of RVS	Length in mm (average)	Breadth in mm (average)	Depth in mm (average)
Open	24–42 (31)	8–15 (11)	6–12 (10)
Closed	18–28 (22)	6–11 (8)	4–9 (7)
Slit	10–16 (13)	2–4 (3)	0
Scar	42–87 (58)	0	0

in difficult cases. Postoperative complications of bleeding and bile leak were noted

## RESULTS

- Age distribution: Age in this study varied from 18 to 73 years. Mean age was 43.72 years. Maximum incidence is in 4th decade with 32% and 5th decade with 28%. The youngest was 18 years old girl and the oldest patient was a 73 years old man.
- Sex: Females (83) dominate males (47) with F:M ratio of 64:36.
- Incidence of RVS: Rouviere sulcus is seen in 106 (81.5%) cases and absent in 24 (18.5%) cases. In majority of cases (84 of 106), it is seen on retraction of infundibulum to the left. In 22 cases, RVS was visible after the separation of adhesions.
- Type of sulcus: Open type is most common with 72.6% and scar is least with 3.8% (Table 1).
- Direction of sulcus: Horizontally directed RVS is most common. Vertical directed sulcus is rarely seen (Table 2).
- Measurements of RVS: See Table 3.
- Pre-operative diagnosis: Cholelithiasis was found in 93 (71.5%) cases, cholecystitis in 23 (17.7%), choledocholithiasis in 11 (8.5%) (taken up after ERCP stone removal and stenting), and biliary pancreatitis in 3 (2.3%) cases.
- Difficulty in LC: NASSER Classification.<sup>9</sup> 103 (79%) cases are simple in grades 1 and 2, 27 (21%) cases are difficult Calot's in grades 3 and 4.
- Critical view of safety achieved using RVS as landmark.

In 118 cases, CVS was achieved using RVS and R4U line as a landmark. These 16 cases were with absent RVS. In 12 (9%) cases, CVS could not be achieved due to edema, dense adhesions, and fibrosis in the Calot's triangle. Eight of these cases are acute cholecystitis, four cases were with fibrosed Calot's triangle. Bailout procedures were taken up after a consultation with a second surgeon. Of the 12 cases, 4 cases were converted to OC. Eight cases were managed

with STC using RVS or R4U as landmark and completing the procedure in the safe zone. Out of eight STC, two were fenestrating type and six were reconstituting type.

## COMPLICATIONS

### Bleeding

Bleeding was seen in eight cases, resolved with medication, and blood transfusion was needed in two cases. Mostly seen in difficult GB with conversion to OC.

### Bile Leak

No major BDIs were seen. Bile leak was observed in five cases. Evaluation of these five cases with ERCP revealed slipped clips from the cystic duct in one case of LC. Other four cases were a difficult GB where a bailout procedure was done: two cases of STC (fenestrating) and two cases of OC. No BDI was noted here. All cases were relieved with bile duct stenting.

### Wound Infection

Wound infection seen in 12 cases, treated with drainage and dressings.

## DISCUSSION

Bile duct injury is a serious complication of LC associated with morbidity, mortality, and loss of quality of life for the patient. This one of the major causes of medicolegal litigations. The prevention of BDI is an integral aspect of LC. Misinterpretation of biliary anatomy is the major cause of BDI. Other causes are abnormal anatomy, adhesions, instrumentation, and surgeon's ability. The classical BDI occurs when the CBD is mistaken as the cystic duct and cut. The identification of anatomical structures in laparoscopic surgery is complicated by the fact that these structures exist in a 3D axis, yet the surgeon's view is fundamentally 2D.<sup>10</sup> Basically LC is a virtual surgery performed on an image without tactile sensation for surgeon. The best way to avoid misinterpretation of biliary anatomy is to achieve the CVS. Critical view of safety helps to minimize or eliminate the incidence of BDI. However, achieving CVS can be difficult in cases with severely inflamed and edematous GB or chronic fibrosed Calot's/hepatocystic triangle. Thus, to achieve CVS there is a need for anatomical landmarks to guide the surgeon to start a safe dissection. Even a beginner of LC needs some landmarks to orient himself to a safe dissection. Internal landmarks like cystic lymph node and elephant trunk sign, where infundibulum narrows to form the cystic duct are advocated. But these landmarks are not useful in cases of acute cholecystitis with edema and inflammation or chronic cholecystitis with dense fibrosis. Rouviere sulcus is a safe but less known extrabiliary landmark for LC. Though RVS was mentioned by Henri Rouviere in 1924, its significance was not recognized till the popularization of LC in late 1990s. Reasons being it is better seen in LC than OC due to distention and illumination of digital cameras. Rouviere sulcus is an extrabiliary landmark in solid organ, liver, which is not affected by the inflammatory scarring of gallbladder. Rouviere sulcus is the first landmark the surgeon should look for safe LC.<sup>8</sup> Rouviere sulcus is present in majority of the cases. Dahmane et al.<sup>7</sup> reported an incidence of 82%, while Peti et al.<sup>6</sup> described an incidence of 80%. Singh and Prasad<sup>2</sup> and Kumar et al.<sup>11</sup> reported the highest incidence of RVS >90%. Zubiari et al. reported a lower incidence of 68%.<sup>12</sup> These variations are usually

due to inclusion or exclusion of scar type in their studies.<sup>13</sup> In a meta-analysis of 23 anatomical or laparoscopic studies, Cheruiyot et al.<sup>14</sup> reported an overall incidence of 83%. Our study with 81.5% is at par with majority of reports. It is well preserved in cases of acute cholecystitis. Sometimes it is visualized after adhesiolysis. Dahmane et al.<sup>7</sup> studied the contents of the RVS in their autopsy liver specimens. They noted the right portal pedicle in majority of cases. Rouviere sulcus has wide morphological variations. It is described as open, closed, slit, and scar types.<sup>2</sup> Some authors described open and close type together as deep sulcus.<sup>2</sup> Our series show 72% and 13% of open and closed sulcus, respectively. Direction is horizontal in majority of cases (74%). Vertical sulcus was seen in one case. The type, measurement, and the direction of the sulcus vary widely. When the fundus of GB is pulled upwards and to right shoulder the RVS points to the neck of GB where it tapers to form the cystic duct.<sup>15</sup> An imaginary line drawn from RVS along the base of segment IV of the liver to the umbilical fissure is known R4U line. The area cephalad to the R4U line is considered as a safe zone and caudal to it is a danger zone.<sup>16</sup> Dissection of the Calot's/hepatocystic triangle is confined to safe zone only, to avoid BDI. When RVS is absent, the R4U line is drawn at the base of segment IV and extended across the hepato-duodenal ligament. Hugh et al.<sup>5</sup> were the first to recognize the importance of RVS in LC as it shows the correct plane of CBD. They demonstrated lowest rate of BDIs by dissecting Calot's triangle above the RVS. Peti and Moser described RVS as an important landmark for successful completion of LC and to avoid BDI.<sup>6</sup> The importance of RVS is emphasized in the Tokyo guidelines 2018 for safe cholecystectomy.<sup>9</sup> They advised to use R4U line as a guideline for dissection in acute cholecystitis. In the Delphi consensus<sup>17</sup> on BDIs more than 80% of the Japanese surgeons agreed that RVS as an important landmark to avoid BDI. The Delphi consensus on bile duct injuries during LC also advise the use of safe zone dissection to avoid BDIs.<sup>17</sup> The SAGES promoted safe cholecystectomy program proposed some strategies for minimizing BDIs. SAGES advises to recognize when the dissection is approaching a zone of significant risk and halt the dissection before entering the zone. This is a part of adopting a universal culture of safety in cholecystectomy (COSIC). The zone of significant risk is below R4U line. Brittany Greene et al. proposed an anatomical landmark, inferior boundary of dissection to prevent dangerous dissection in the porta hepatis when a CVS may not be immediately achievable. The boundary extends from RVS to the peritoneum and fat overlying cystic and hilar plates, near the base of segment IV.<sup>18</sup> Another approach advised is B-SAFE landmarks. B-SAFE stands for the bile duct, the sulcus of Rouviere, the left hepatic artery pulsations, the umbilical fissure, and the duodenum (enteric).<sup>19</sup> In our series, we did not have any major BDI. Bile leaks were seen mainly in difficult bailout cases. Conversion to OC was done early in the study. Only two of four open conversions could be completed and other two were operated with open STC. Open cholecystectomy does not guarantee the completion of cholecystectomy without BDI. There is additional morbidity and complications of open surgery. The advantage of laparoscopic surgery is lost. So, we started doing laparoscopic STC above R4U line. Fenestrating type showed bile leak (2 of 3) for which ERCP was done. Later reconstitution STC was taken up with no bile leaks post-operatively. In 16 of 24 cases without RVS we could complete LC using imaginary R4U line as a guide. In difficult cases RVS guide us to do a bailout procedure of STC above R4U line. It is suggested to remember mnemonic "RANGERS" sign during LC.<sup>15</sup> Rouviere's at neck of gallbladder eases recognition of structures. This allows the

operating surgeon to recall the presence of the sulcus, and then to start safe dissection of Calot's triangle medial to and above the sulcus, and always keeping the view laterally all the times, thereby ensuring the CBD is well below the plane of dissection.

## CONCLUSION

Rouviere sulcus is an important extrabiliary landmark for safe cholecystectomy. It is present in majority of cases and provide an easy referral point to achieve the CVS and minimize bile duct injuries. It is the first landmark to seek in an LC and start dissection of Calot's triangle above and medial to it. We strongly suggest to use RVS as guide to minimize BDIs.

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