Rouviere's Sulcus in the Era of Laparoscopic Cholecystectomy; New Anatomical Types, Surgical Impact, And Possible Circumstances That Can Turn It from a Good Servant into a Deceptive Guide.

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ABSTRACT

Study design: *case series.* ***Background:*** *The gallstones are as old as eternity. Laparoscopic cholecystectomy (LC) is now considered the gold standard therapeutic option for symptomatic cholelithiasis. Rouviere's Sulcus (RS), as a surgical landmark, is not widely used. However, the surgical interest in the RS has increased in the recent years with the development of LC. It is a fissure running to the right of the porta hepatis between the right lobe and caudate process. It is the best anatomical landmark that could accurately determine the safe area of dissection during LC. The aim of this study is to focus the light on the RS, anatomical description, types, relation to the right portal pedicle, the surgical impact of all these data on the technique of LC, and the possible circumstances in which RS could be a deceptive guide.* ***Material and Methods:*** *150 consecutive patients suffered from gallstone disease were included in this study database within a period from May 2015 to May 2016, scheduled for LC. RS was looked for during the posterior dissection, its frequency and type were documented.* ***Results:*** *RS was recognizable in 126 patients (84%), being either fully open in 52.6%, partially open in 6.66%, superficial in 19.3% and scar type 2.66%. I discovered 2 new types unmentioned in any previous research before (the triangular type and the pit type).* ***Conclusion:*** *RS is the only known extra-hepatic landmark, identifiable in 84% of the patients. If an imaginary line drawn along its axis to the porta hepatis, it determines the level ventral to which dissection is mostly safe. However, the major bile ducts may be brought ventral to the RS by either excessive upward traction of the gall bladder or by adhesions turning it into a deceptive guide. It represents the line of effacement between Segment V and Segment VI, which may have variable degrees of fusion resulting in variant types. The two new types will help in better understanding of the relation between it and the right portal pedicle.*

Keywords: *Rouviere's Sulcus, triangular type, pit type laparoscopic cholecystectomy, Anatomical landmarks*

INTRODUCTION

The gallstones are as old as eternity. It had been demonstrated in the autopsies of ancient Egyptian and Chinese mummies dating back over 3500 years.[(1)] It affects 10- 20 % of the adult population.[(2)]

Although LC is now considered the gold standard therapeutic option for symptomatic cholelithiasis, it is still associated with higher incidence of bile duct injury (BDI) when compared with open cholecystectomy (OC).[(3-6)]

So to decrease the incidence of BDI, we should focus on the defects of the current techniques in the identification of the cystic duct.

The BDI has been a subject for study throughout ages. The main cause of BDI is misinterpretation of anatomy mistaking common bile duct (CBD) for cystic duct (CD). [(5-7)]

The BDI is mainly due to anatomical structural misidentification. Thus, the key solution to such problem should has an anatomical background. In other words, practicing LC safely is based largely on careful determination of the anatomy.

Upon analysis of the development of the technical strategy of the LC, three major overlapping changes could be observed:

The first was the change of area of dissection by the introduction of the critical view of safety (CVS) that rapidly replaced the old unreliable infundibular technique. This change based upon the concept hepatocystic triangle instead of Calot's triangle [(8,9)].

Although it is thought that up to 80% of BDIs occur while the surgeon is attempting to safely establish the critical view**,** [(10)] hence CVS alone is not enough to prevent BDI.

The second change was the trial to delineate biliary ducts from inside by many techniques as intraoperative cholangiography, methylene blue cholangiography, Olsen cholangiocatheter[(11)] and endoscopically placed optical fiber in the CBD, but its disadvantages are to be invasive and increase operative time.[(12-14)]

The third major change was the use of anatomical landmark that can facilitate the identification of the structures. Some advised to proceed the dissection on basis of six anatomical landmarks that includes Hartmann's pouch, Mascagni lymph node, Cystic artery and right hepatic artery, Calot's triangle, cystic duct junction with bile duct, and RS.[(9)]

At the beginning, surgeons used Hartman's pouch as a landmark. However, sometimes it is distorted in atrophic cholecystitis, or impacted stone, and in sever adhesions.[(5)] Congenital anatomical variants of the cystic duct occurring in 18%–23% of cases,[(15)] and its junction with the gall bladder and the bile duct may show significant variations.[(16)] This makes its use as an anatomical landmark holds something of danger.

On the liver surface, there are few landmarks that can reveal (or can be correlated with) the liver's internal anatomy. Among these landmarks is the RS, discovered in 1924 by Henri Rouviere,[(17)] a professor of anatomy and embryology at the University of Paris.[(18)] He was the first to name it as "the groove of the caudate process". It has been described as Incisura Dextra of Gans,[(19)] by Reynaud et al.[(20)] and also by Stringer,[(14,21)]

It was identified by Gans in 80% of the population,[(19)] and then by Couinade[(22)] and Reynaud et al.[(20)] in 2 separate studies in 73% of population. Hugh et al**.** observed it in 78% of population [23]. Peti and Moser observed it in 80% of their cases.[(24)]

This sulcus (open type) can be seen in variable lengths ranging from less than 2cm to ◦cm and its depth is 4–8 mm.[(14)] It is a fissure running to the right of the porta hepatis anterior to segment 1 between the right lobe and caudate process [9]**,** separating the renal and duodenal impressions[(14,25)] It demarcates the division between Segment VI and Segment V.[(26)] It may be either oblique **(Fig. 1)** or transverse **(Fig. 2)**.

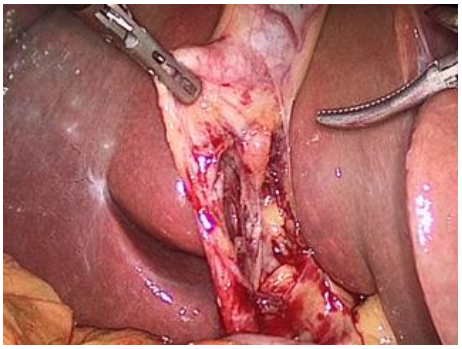

Fig 1. The oblique RS

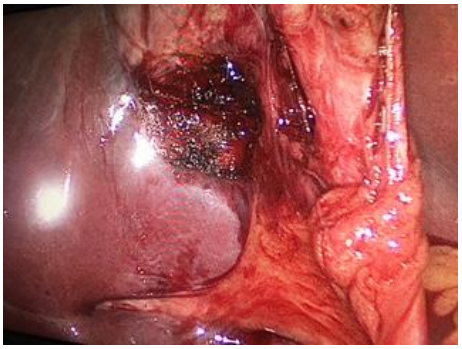

Fig 2. Transverse RS

In a study done by Dahmane et al on liver autopsies, they demonstrated that RS contains branches of the right posterior sectional pedicle in 70% of livers, vein of segment VI in 25% of livers. They dissected a branch of the anterior sectional pedicle in only 5%. In addition, they found the inconstant cystic vein in 18 % of the livers.[(14)] The right posterior duct generally runs posterior to the right portal vein.[(27)]

It was classified according to its shape and presence of the pedicle in its floor into:

1. **The deep type (Figs. 3,4)** is a cleft that has a measurable length, width and breadth, with branches of the right hepatic pedicle run in its floor, It is subdivided into 2 subtypes; fully open (open) which is open throughout its whole length and partially open (closed) which is open only in its lateral end.**(14,23)**
2. **The slit (Fig. 5)**: If the depth and breadth cannot be measured or less than 5mm.
3. **Scar type:** with or without the white line.[(28)]

It corresponds to the level of porta hepatis where the right pedicle enters the liver. So if an imaginary line is drawn along this sulcus to the base of segment IV till the porta hepatis, it will show the level ventral to which dissection is safe and dorsal to which it is not.[5,28] In other words, the cystic duct and artery lay ventral to the sulcus and the CBD lays dorsal to it.[14]

RS was initially described as landmark for right hepatic resections but nowadays it is considered to be the best landmark that should guide the start of the discussion during LC.[20,28]

Galketiya et al.[29] considered RS as an additional anatomic guard against BDI, however they emphasized that proper anatomical exposure is required to maximize its importance. Being an extra biliary reference landmark, it does not get affected by distortion due to biliary pathology.[9]

MATERIALS AND METHODS

Upon approval of the ethical committee, this prospective study was conducted within a period from May 2015 to May 2016 on 150 consecutive patients confirmed to have gall stone disease. Patients with dilated CBD with or without stone, deranged liver function tests, age <14 years, Bleeding disorders, Pregnancy (first or third trimester), and those unfit for general anesthesia were excluded.

All patients have submitted Preoperative written informed consent, then were scheduled for LC searching for RS, its shape and types.

After the 4 port insertion, diagnostic laparoscopy was done, grasping the gall bladder fundus and retracting it to the right shoulder, then grasping the Hartmann's pouch. RS is best assessed with the Hartmann's pouch retracted up and to the left and it will be noted if it is present or absent. If present, it will be observed meticulously to determine its type.

The dissection started ventral to RS in the hepatocystic triangle. Careful dissection to avoid possible injury of the Posterior branches of the cystic artery that may be present here. Continuing dissection anteriorly and posteriorly till establishing the critical view of safety till completed with sure identification of the cystic duct and artery, Clipping and division of both of them.

In 2 cases, I found Moynihan's hump deformity of the right hepatic artery, I safely dissect and clip the short cystic artery. Data were collected. Results are described using medians followed by the lowest and highest values in brackets.

RESULTS

This study was conducted on 150 patients including 37 males and 113 females. The median age is 51.5 (range 14–78) years (Table: 1).

Table 1. Clinical characteristics of the patients

Patients	*Number*	*%*
Males	37	24.66
Females	113	75.34

The sulcus was recognizable in 126 patients (84%) being either fully open in 79 patients (52.6%), partially open in 10 patients (6.66%), superficial in 29 patients (19.3%) and scar type in 4 patients (2.66%) (Table: 2).

I discovered 2 new types unmentioned in any previous research before:

1. The triangular type **(Figs 6-9)**: It is open sulcus, triangular in shape with the pedicle apparent in its floor, this pedicle noted to have oblique course inside the sulcus. I noted it in 2 cases in my series. The first is equilateral triangle with the pedicle pass obliquely at its upper angle, the second case is also triangular -shaped but contains prominent inner liver tissue component, with the pedicle pass obliquely also.
2. The pit type: this type differs completely from the other previously mentioned types, It has 2 variants:
   A) Single pit type **(Fig. 8)**.
   B) Multiple pits **(Fig. 9)**: that present on the same horizontal level.

   All over the series and by using this technique, I have 2 cases of gallbladder mass converted to open technique, however no cases of BDI and no mortality.

Table 2. Types of RS

RS	*Number*	*%*
1) Present	126	84%
A) Deep:	89	59.33%
▪ Fully open (open)	79	52.66%
▪ Partially open (closed)	10	6.66%
B) Superficial (slit)	29	19.33%
C) Scar.	4	2.66%
D) Other newly discovered types:	4	2.66%
▪ Triangular.	2	1.33%
▪ Pit.	2	1.33%
2) Absent	24	16%

DISCUSSION

The BDI is a challenging serious problem that is attributed mainly to anatomical misidentification. Many approaches have been introduced as critical view of safety, cholangiography and identification of anatomical landmarks.

RS is the only known extra-hepatic landmark that can indicate the plane of CBD accurately, so the cystic duct and artery lay ventral to the level of the sulcus and the CBD lays dorsal to it.

In my study, I observed that RS is present in 84% of patients in various types as described. Dahmane et al.**(14)** noticed in their study conducted on 40 liver autopsies, that RS is present in 82% of the autopsies.

Reynaud et al**(20)** and Hugh et al**(23)** observed it in 73% and 78% of their cases respectively. Zubair et al**(13)** found RS to be present in 68.1% of their patients.

The RS represents the line of effacement between Segment VI and Segment V, which may have variable degrees of fusion resulting in variant shapes and types. For example if it is not fused, the deep type (fully open) will be present. If RS is fused in its lateral end, the partially open type will be the result. In addition, if the fusion occurs in the deep part, the superficial type will be present. So the degree of fusion and effacement between Segment V and Segment VI is the main determinant of RS type.

Types:

1) Deep type: This type present in 59.3% of the patients in this series, and is subdivided into 2 subtypes; fully open (open) **(Fig. 3)** which is present in 52.6% and closed (partially open) **(Fig. 4)** which is present in 6.6% of the cases.

   Arora and Ranga **(28)** found it in 59% but they did not measure the differential percentage of its subtypes. Dahmane et al **(14)** found the open subtype in 70% and the closed subtype in 12% of their autopsies. Yu et al **(30)** found the open type in 78.6% and the partially closed type in 5.3% (type IIb).

   This difference can be explained because both studies did not consider the superficial type as a separate entity, and they include it within the open type (although it differs from the deep type in the fact that it does not have a measurable depth).
2) Superficial type **(Fig. 5)**: This is found to be present in 19.3%of the cases. Rouviere**(17)** described it as a fine groove but he did not identify its incidence. Arora and Ranga**(28)** found it in 24% of their patients. Zubair et al**(13)** did not mention any data about it.
3) Scar type: It is present in 2.6% of the cases. Yu et al**(30)** found it in 3.6% and classified it as type III. Arora and Ranga**(28)** found it in 7%. Zubair et al**(13)** considered the presence of white line alone in the usual site of the sulcus as an absent one as this white line, from their point of view, needs more experience to be identified.
4) The newly discovered types (Triangular and the pit type): The triangular type **(Figs. 6-9)** present in two cases (1.33%). each of them with a special shape. The pit type also noted in two cases (1.33%), the first is single pit **(Fig. 10)** and the other is multiple pits **(Fig. 11)**.

The difference in results is due to absence of single definition of the various types.

Fig 3. The deep type (Fully open subtype)

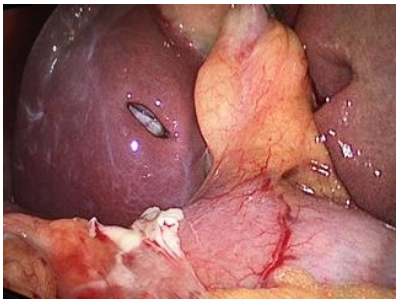

Fig 4. The deep type (Partially open subtype)

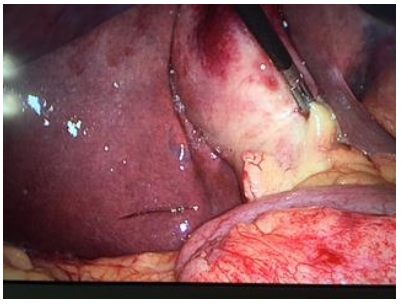

Fig 5. The superficial type

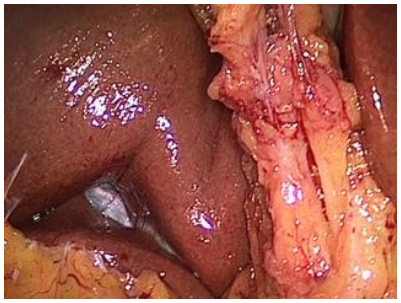

Fig 6. The triangular type

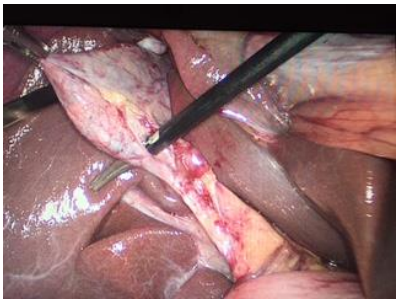

Fig 7. The triangular type (note the relation between point of dissection and the RS)

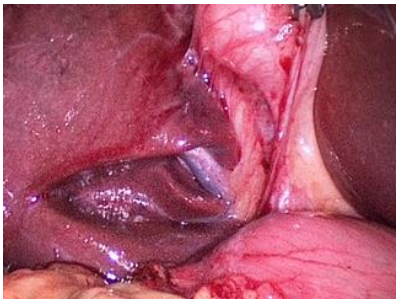

Fig 8. The triangular type (not the prominent inner liver tissue inside the RS)

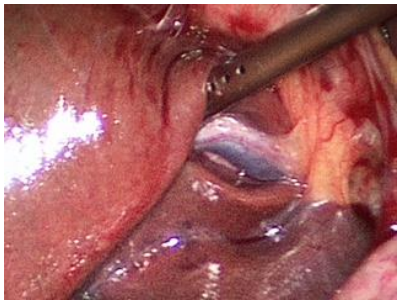

Fig 9. The triangular type

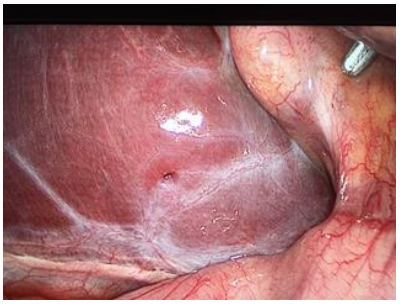

Fig 10. The single pit type

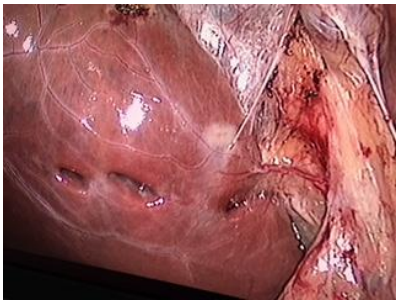

Fig 11. The multiple pit type

Surgical impact:

1. The surgical impact of these data lies in the fact that the right portal pedicle runs in the floor of the sulcus and its course takes the same axis of the RS. Hence if surgeons pass an imaginary line in this sulcus till the porta hepatis, it will pass through the plane of the major bile ducts, and so the cystic duct and artery must lie above this line. Imagining the presence of this line in the deep, superficial and the scar type is easy. However, it may be some sort difficult and different in the new types.
2. In the pit type, surgeons will only find a point from which they can start. Following the same concept, the imaginary line will pass from this pit to the porta hepatis. In the multiple pit type it is much easier as the multiple pits lie in the same level, whereas in the triangular type, the line should be drawn along the axis of the apparent pedicle to the porta hepatis. This line is usually a curvilinear line or a straight line only according to the axis of the RS.
3. This RS is a hepatic surface landmark that can be correlated with internal anatomical

structures. Hence, it will help to proceed towards safe segmentectomy in the right lobe. Not only it will lead to the identification of the pedicle during segmentectomy, but its type also can be correlated with the difficulty of dissection. The more apparent the vessels (as in the deep type), the easier the dissection will be.

4. Taking into consideration the possible presence of the portal pedicle in the RS, surgeons must deal with this area – which RS may present within- cautiously especially in adhesiolysis **(Figs. 12,13)** and cautery use to avoid pedicle injury which may lead to catastrophic outcomes.

Fig 12. Adhesions in the possible site of RS

Fig 13. RS appeared after starting adhesiolysis with superficial pedicle (that may be liable to injury)

We must not deal with the RS line rule as a solid rule, and to consider any dissection above it is completely safe due to the following proposed reasons:

1. The major bile ducts and vessels may be brought ventral to the RS by either excessive upward traction of the gall bladder (as also mentioned by Connor et al **(10)** or by adhesions that can bring not only the bile ducts but also duodenum and colon ventral to this line.
2. Some congenital anomaly may occur like the Moynihan's hump deformity of the right hepatic artery that will be above the line in the hepatocystic triangle as well as the direct drainage of the cystic duct into the duodenum (here part of the cystic duct will be below the line).

Thus to optimize the use of the RS, surgeons should confirm three things:

1. Complete adhesiolysis of all well-formed adhesions in the area between porta hepatis medially, lateral edge of RS laterally, Hartmann's pouch upward and duodenum down.
2. The gall bladder traction is optimum in force and direction.
3. Exclude the presence of the fore mentioned congenital anomalies.

Accordingly, the wise use of the RS can help in accurate duct identification, however we should realize that anatomical misidentification is not the only cause of BDI. The hazardous use of monopolar cautery and blind clipping of bleeders are some of the technical causes of BDI that is non preventable by RS identification.

CONCLUSION

BDI is the most feared complication of LC. It is mainly attributed to anatomical structural misidentification. Many approaches had been supposed to prevent BDI, the use of anatomical landmarks is one of those approaches. RS is the only extra-hepatic landmark hence is not liable to any pathological change as the intra-hepatic landmarks. It is present in 84% of the cases with different shapes and types. I described two new types, the triangular and the pit type with two variants of each type.

If an imaginary line drawn along this sulcus to the base of segment IV then to the porta hepatis, it shows the level ventral to which dissection is safe and dorsal to which it is not. However, the major bile ducts may be brought ventral to the RS by either excessive upward traction of the gall

bladder or by adhesions. Also, some congenital anomaly like the Moynihan's hump deformity of the right hepatic artery as well as the direct drainage of the cystic duct into the duodenum are possible exceptions to this rule.

Advances in anatomical research in this aspect will help in better understanding of the relation between it and the right portal pedicle, which will aid in preventing BDI and facilitating right segmental resection.

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REFERENCES

1. Lambou-Gianoukos S, Heller SJ. Lithogenesis and bile metabolism. Surg Clin North Am. 2008;88:1175-1194.
2. Stinton LM, Shaffer EA. Epidemiology of gallbladder disease: cholelithiasis and cancer. Gut Liver. 2012;6:172–187.
3. Ramos AC, Ramos MG, Galvão-Neto MDP, Marins J, De Souza Bastos EL and Zundel N. Total clipless cholecystectomy by means of harmonic sealing. ABCD Arq Bras Cir Dig. 2015;28:53-56.
4. Eikermann M, Siegel R, Broeders I, Dziri C, Fingerhut A, Gutt C. *et al.*, Prevention and treatment of bile duct injuries during laparoscopic cholecystectomy: the clinical practice guidelines of the European Association for Endoscopic Surgery (EAES). Surg Endoscopy. 2012; 26:3003–3039.
5. Machado NO. Biliary Complications Post Laparoscopic Cholecystectomy: Mechanism, Preventive Measures, and Approach to Management: A Review. Diagnostic Therapeutic Endoscopy. 2011:1-9.
6. Viste A, Ovrebo K, Christensen J, Angelsen H, Hoem D. Bile duct injuries following laparoscopic Cholecystectomy. SJC. 2015;103:1-5.
7. Felekouras E, Petrou A, Neofytou K. et al. Early or Delayed Intervention for Bile Duct Injuries following Laparoscopic Cholecystectomy? A Dilemma Looking for an Answer. Gastroenterology Research and Practice. 2015:1-10.
8. Strasberg SM, Eagon CJ, Drebin JA. The 'hidden cystic duct' syndrome and the infundibular technique of laparoscopic cholecystectomy – the danger of the false infundibulum. J Am Coll Surg. 2000; 191:661–667.
9. Arora R and Arora B. Six anatomical landmarks for safe Laparoscopic Cholecystectomy. International Journal of Enhanced Research in Medicines and Dental Care. 2014;1:30-34.
10. Connor SJ, Perry W, Nathanson L, Hugh TB and Hugh TJ. Using a standardized method for laparoscopic cholecystectomy to create a concept operation-specific checklist. HPB. 2014;16:422–429.
11. Olsen D. Bile duct injuries during laparoscopic cholecystectomy. Surgical Endoscopy. 1997;11:133–138.
12. Wang ZY, Xu F, Liu YD, Xu CG and Wu JL. Prevention of Biliary Duct Injury in Laparoscopic Cholecystectomy Using Optical Fiber Illumination in Common Bile Duct. Gastroenterology Research. 2010; 3:207-212.
13. Zubair M, Habib L, Memon F, Mirza MR, Khan MA, and Quraishy MS. Rouviere's sulcus: a guide to safe dissection and laparoscopic cholecystectomy. Pakistan Journal of Surgery. 2009;22:119–121.
14. Dahmane R, Morjane A and Starc A. Anatomy and Surgical Relevance of Rouviere's Sulcus. The Scientific World Journal. 2013; 254287:1-4.
15. Turner MA & Fulcher AS. The Cystic Duct: Normal Anatomy and Disease Processes. 2001;21:3-22.
16. Mariolis-Sapsakos T, Kalles V, Papatheodorou K, Goutas N, Papapanagiotou I, Flessas I. et al., Anatomic Variations of the Right Hepatic Duct: Results and Surgical Implications from a Cadaveric Study. Anatomy Research International. 2012:1-5.
17. Rouviere H. Sur la configuration ET la signification du sillon du processus caud´e. Bulletin ET Memoires de la Societ´e Anatomique de Paris. 1924;94:355–358.
18. Sandström P, Gullstrand P, Sundqvist T, Winbladh A and Friman S. Liver anatomy and nomenclature In: Methods to Reduce Liver Ischemia/Reperfusion Injury.

Sandström P. Linköping University Medical Dissertations. 2014;1418:25-29.
19. Gans H, Study of anatomy of the intrahepatic structures and its repercussions of hepatic surgery [Ph.D. thesis], University of Nijmegen, Elsevier, Amsterdam, The Netherlands. 1955.
20. Reynaud BH, Coucoravas GO, and Giuly JA. Basis to improve several hepatectomy techniques involving the surgical anatomy of incisura dextra of Gans. Surgery Gynecology and Obstetrics. 1991;172:490–492.
21. Stringer MD, Eponyms in Surgery and Anatomy of the Liver, Bile Ducts and Pancreas, Royal Society of Medicine Press, London, UK. 2009.
22. Couinaud C. Surgical Anatomy of the Liver Revisited. Paris. 1989.
23. Hugh TB, Kelly MD, and Mekisic A. Rouviere's sulcus: a useful landmark in laparoscopic cholecystectomy. British Journal of Surgery. 1997;84:1253–1254.
24. Peti N and Moser MAJ. Graphic reminder of Rouviere's sulcus: a useful landmark in cholecystectomy. ANZ Journal of Surgery. 2012;82:367–368.
25. Rouviere H and Delmas A. Anatomie Humaine Descriptive, Topographique Et Fonctionnelle, Masson, Paris, France, 13th edition. 1991.
26. Kawarada Y, Das BC, and Taoka H. Anatomy of the hepatic hilar area: the plate system. J Hepatobiliary Pancreat Surg. 2000;7:580–586.
27. Vakili K and Pomfret EA. Biliary Anatomy and Embryology. Surg Clin N Am. 2008;88:1159–1174.
28. Arora B and Ranga HR. Rouviere's Sulcus as Landmark during Laparoscopic Cholecystectomy. Global Journal for Research Analysis. 2016;5:449-450.
29. Galketiya KP, Beardsley CJ, Gananadha S and Hardman DT. Rouviere's sulcus: Review of an anatomical landmark to prevent common bile duct injury. Surgical Practice. 2014;1:136-139.
30. Yu H, Huajie C, Bailiang Y, Xiaojiao R, Bingren H, Heyi Y. et al., Laparoscopic determination of the incidence and types of Rouviere's sulcus in Chinese people. Chinese Journal of Hepatobiliary Surgery. 2014; 20:425-427.