Prevalence and structural variants of Rouviere’s sulcus in a sample of Kenyan livers: A cadaveric study with implications for laparoscopic cholecystectomy

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Prevalence and structural variants of Rouviere’s sulcus in a sample of Kenyan livers: A cadaveric study with implications for laparoscopic cholecystectomy

Short title: Nairobi, Kenya: Rouviere’s sulcus prevalence and variants

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Abstract

Background: The sudden increase in the number of centers offering laparoscopy services in our setting and the wide acceptance of laparoscopic cholecystectomy (LC) has generated a large volume of procedures being performed by surgeons with limited experience in this area, resulting in a surge of the number of complications. Knowledge of important anatomical landmarks may help prevent damage of important structures during LC. Rouviere’s Sulcus (RS) is one such landmark whose utility in preventing bile duct and vascular injury during LC is highly recognized. The aim of the study was to determine the frequency and anatomical variants of the RS in the Kenyan population.

Methods: This cadaveric study was carried out at the department of Human Anatomy, University of Nairobi. One hundred and sixteen (116) livers were examined to assess the presence of, and the anatomical variant types of Rouviere’s sulcus.

Results: The sulcus was present in 98 of the livers (84.5%). Type 1A was seen in 54.3%, 1B in 12.1%, type 2 in 9.5% and type 3 in 8.3%. The sulcus was absent in 18(15.5%) of the livers.

Conclusion: Rouviere’s sulcus is a frequent anatomical landmark present in 84.5% of the livers of the Kenyan population studied, either as open or fused type. It can therefore be reliably used as a landmark in LC to avoid bile duct and concomitant vascular injury and to enable vascular control during segmental surgery of the right liver.
Keywords: Rouvière’s sulcus, laparoscopic cholecystectomy, bile duct injury

Introduction

A clear understanding of normal, variant and pathologic laparoscopic anatomy of the hepatobiliary apparatus is important for the safe execution of any surgical procedure and should minimize the risks of inadvertent injuries. Laparoscopic cholecystectomy (LC) is one of the commonest general surgical procedures (1) and with the sudden increase in the number of centers offering laparoscopy services locally, this has generated a large volume of procedures being performed by surgeons with limited experience, resulting in a surge of the number of complications.

Despite its numerous advantages, the advent of LC was linked to higher rates of bile duct injury (BDI) than those that were observed in open cholecystectomy (2). These rates have notwithstanding, been reported to reduce and mirror those of OC in the era beyond the laparoscopic learning curve (3). Regardless of this reduced incidence, the reported rate of 0.3% BDI that occurs in LC (4) is still high in an era where between 0.75 – 1 million LCs are being performed annually in United States of America only (5).

In the last decade, researchers have focused on many strategies to avoid complications during laparoscopic cholecystectomy [6, 7]. Other than the Calot’s triangle anatomy, another anatomical landmark is the Rouvière’s sulcus (RS) [8-10]; identified by Rouvière (11) in 1924 as a 2-to 5-centimetres sulcus lying anterior to the caudate lobe and running to the right of the liver hilum and usually containing the right portal triad. He used it as a reference point to guide the commencement of safe liver dissection [12–14]. Based on anatomic studies and supported by LC studies, this sulcus has been shown to accurately identify the plane of the CBD as substantiated by cholangiogram (15). Peti and Moser [16] determined that RS dissection is a lesser known, but an important landmark in every surgeon’s strategy for safe laparoscopic cholecystectomy and the segment-oriented approach to right liver resection. RS was hardly seen and described in the open surgery era, but is very clearly seen during LC due to the pressure of CO₂ insufflation opening up the sulcus widely, and due to the enhanced illumination and image quality of the digital endoscopic cameras (17). Thus, with the advent of laparoscopy, there has been a renewed surgical interest in the RS and its relation to the right portal pedicle and has been simply defined in three simple terms- a deep sulcus, a slit or a scar (17). The use of RS as an anatomical landmark in LC has been associated with reduced instances of BDI, minimal blood loss and less operative time (18, 19).

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RS has been described to be present in about 52% (11) to 90% (17) of the population. It also displays morphological variants with regards to its depth i.e. deep or shallow (17, 20). Although these morphological variants do not affect clinical outcomes, they have been reported as key in prediction of anomalous bile duct organization (21). With the advent and quick progression of LC procedures in Kenya (22), knowledge of anatomical landmarks particularly the RS remains pertinent. The aim of our study was to determine the frequency and the anatomical variants of the RS in a select Kenyan population.

**Methods**

**Study design and setting**

This was a descriptive cross-sectional cadaveric study conducted at the Department of Human Anatomy, University of Nairobi.

**Subjects**

One hundred and sixteen (116) formalin-fixed cadaveric livers were used for this study. Livers with visible damage, shrinkage or any gross pathology were excluded.

**Assessment and definition of types of the Rouviere’s sulcus**

The presence of the sulcus was established by studying the posterior aspect of the right lobe and noting any fissure, sulcus or line coursing towards the caudate lobe. The open type of sulcus was defined as a cleft in which branches of the right hepatic pedicle were visualized and the sulcus was open throughout its length. The parenchymatous fused type was defined as the one in which the sulcus was open only in its lateral end (18). The type of sulcus was determined as per Singh and Prasad (17) proposed criteria: If a clear fissure was seen, its depth was measured, those whose depth was greater than 0.5cm were described as deep sulci (type 1) while those whose depth was less than 0.5cm were described as shallow sulci (Type 2). The deep sulci were further described as either open or closed where, the open ones were continuous with the hepatic hilum medially (type 1A) while the closed ones were fused medially (type 1B). If a white hazy line was observed, this was described as a scar like sulcus (Type 3).

**Study outcome**

The primary outcome of this study was the prevalence of the RS, while the secondary outcome was the morphological types.
Data synthesis

Quantitative data on frequency of the RS and its various morphological types were entered into Statistical Package for Social Sciences (SPSS) software (Version 21.0 Chicago, Illinois) for analysis using descriptive statistics (frequency). Data was presented in images and charts.

Results

Primary outcome

The Rouviere’s sulcus was present in 98 of the 116 (84.5%) livers studied (Figure 1)

Secondary outcome

The open RS was identified in 77 (66.4%) livers, the fused type in 11 (9.5%) and 10 (8.3%) were scar-like (Figure 1). According to the Proposed Singh and Prasad classification criteria, the sulci were classified as follows: Type 1A was present in 63(54.3%) of livers while Type 1B was present in 14(12.1%) of livers, Type 2 was observed in 11 (9.5%) of livers and Type 3 was present in 10 (8.3%) of livers. The sulcus was absent in 18 livers (15.5%) (Fig. 2)

Discussion

Laparoscopic cholecystectomy (LC) is currently considered the “gold-standard” treatment for symptomatic cholelithiasis (23). Its advent in the late 1980s and subsequent uptake was rapid and unregulated, resulting in a three-fold higher incidence of iatrogenic bile duct injuries (IBDI) over that reported in the open approach (2). Recent large-scale studies have however demonstrated that it is possible to perform LC with IBDI incidence rate similar to that for open surgeries (3). Despite the relatively low incidence of IBDI, the large volume of LC performed annually worldwide accentuates the magnitude of the problem (4). Bile duct injuries therefore remain a major cause of morbidity, mortality and reduced quality of life among patients undergoing LC (24).

Misinterpretation of hepatobiliary anatomy has been identified as the major contributor of IBDI (25). During LC, the surgeon is presented with a 2-dimensional view of structures that are 3-dimensional (26). This, coupled with impaired haptic feedback makes it difficult to distinguish anatomical structures (27). Presence of inflammation, hemorrhage and aberrant biliary anatomy further increase the risk of IBDI (28)
Several techniques have been proposed applied in an attempt to reduce the frequency of BDI such as: intraoperative cholangiography (IOC) and the critical view of safety (CVS) (29). These techniques have however been presented only relatively effective. The critical view of safety for instance has been shown to be difficult to expose in instances of inflammation (29) whereas intraoperative cholangiography (IOC) has been shown to be a cost ineffective venture (30). Moreover and disappointingly, the number of BDI cases did not reduce over the years despite the introduction of IOC, CVS & efforts to facilitate surgical education (25). Flourescent cholangiography with the use of indocyanine green is also rapidly growing but no statistically significant changes in BDI have been reported with its use, hence, several authors continually suggest that anatomical landmarks remain to offer better outcomes at relatively low costs (31).

A fixed extra-biliary landmark, such as the Rouviere’s sulcus, is therefore needed to facilitate anatomical orientation and guide safe dissection of the hepatobiliary triangle, therefore preventing IBDI. This is particularly relevant here in Kenya, where LC is increasingly being utilized in the treatment of symptomatic cholelithiasis (22).

In the present study, RS was found to be present in a majority of the subjects (84.5%) in either of its 3 morphological types (deep, shallow or scar like). This is a relatively high prevalence, though not as high as what is reported by Elwan et al (32) who reports a prevalence of 97.7% in the Egyptian population. Its presence can be attributed to genetic factors influenced by atavism, phylogeny or costal/ diaphragmatic pressure during development (33). This prominent prevalence shows that it can be reliably utilized as an anatomical landmark in laparascopic procedures to avert CBD and right posterior portal pedicle injuries.

The distribution of the different types of RS in different populations is illustrated in Table 1.

A majority of subjects including those in the present Kenyan study present with the type 1 RS, which as earlier described appears deep and hosts branches of the right posterior portal pedicle hence, it can be used for vessel clipping in liver segmentectomy procedures (39). The variant anatomy of the sulci is equally accredited to genetic factors (33). The significance of these morphological variants has not been extrapolated with certainty: Shimizu et al (21) explains that the closed type of sulci (1B, 2 and 3) are associated with anomalous biliary tree organization whereas Kim et al (36) states that these RS variants don’t affect LC procedure outcomes. Notwithstanding these gray areas, we can extrapolate that the deep RS is a fairly common structure that can be relied upon during LC to prevent BDI and concomitant vascular injury in the Kenyan population.
After port insertion and CO₂ insufflation, RS can be best visualized by retracting gall-bladder cephalad and to the left to expose the hepatocytic triangle. The RS can then be safely applied to map out the R4U line as proposed outlined by Gupta and Jain (40). The R4U line is an imaginary line extending from the roof of the sulcus to segment 4b of the liver. The CD and CA lie above this line, while the CBD lies below it. Dissection ventral and cephalad to this line are considered safe as there is a minimal chance of encountering the CBD (41) (Figure 3).

Lockart and Singh-Ranger (42) also propose that once the RS has been identified, the CBD can be located below it and the cystic duct and artery above it. When the gall bladder is retracted, the sulcus points towards the neck of the gall bladder which could facilitate dissection of the Calot’s triangle and a resultant safe LC. Compared to conventional LC, use of RS as a fixed landmark (RS-first LC) is associated with a shorter operative duration, lower blood loss, lower conversion rates, and lower incidence of IBDI (15;18;19;43;44). As an extrabiliary landmark, the RS visualization is not affected by inflammatory process and this enhances its reliability (45).

The avoidance of complications in LC is difficult to achieve but promotion of a culture of safe cholecystectomy is still paramount in the prevention of IBDI. Mastery of the hepatobiliary anatomy and surgical landmarks of LC, as well as the proper understanding of the mechanisms of BDI still play a central role in prevention of hepatobiliary tree complication.

This study was limited by small sample size. A large scale intra-operative laparoscopic study is recommended for more findings.

References
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Table 1: Table outlining distribution of RS among different populations

<table>
<thead>
<tr>
<th>Author (Year)</th>
<th>Sample Size (n)</th>
<th>Frequency of RS (%)</th>
<th>Type 1 (%)</th>
<th>Type 2 (%)</th>
<th>Type 3 (%)</th>
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<tbody>
<tr>
<td>Rouviere (1924)</td>
<td>-</td>
<td>52</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Gans (1955)</td>
<td>-</td>
<td>80</td>
<td>-</td>
<td>-</td>
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<td>73</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Hugh et al., (1997)</td>
<td>100</td>
<td>78</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Zubair et al., (2009)</td>
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<td>68.13</td>
<td>30</td>
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<tr>
<td>Dahmane et al., (2013)</td>
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<td>82</td>
<td>70</td>
<td>-</td>
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<td>66</td>
<td>25</td>
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<td>62</td>
<td>12</td>
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<tr>
<td>Singh and Prasad (2017)</td>
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<td>100</td>
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<td>23</td>
<td>6</td>
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<tr>
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<td>24.4</td>
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<tr>
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<td>25.33</td>
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<td>Elwan et al., (2019)</td>
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<td>97.7%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Present Study</td>
<td>116</td>
<td>84.5</td>
<td>69.8</td>
<td>8.6</td>
<td>9.5</td>
</tr>
</tbody>
</table>

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Prevalence and structural variants of Rouviere’s sulcus in a sample of Kenyan livers: A cadaveric study with implications for laparoscopic cholecystectomy.
**Figure 2**: Pie chart illustrating the proportions in % of the different RS types in a Kenyan population.

**Figure 3**: Illustration of RS and its application in LC.

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