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Frequencies, Variations, and Significance of Rouviere's Sulcus in the Context of Difficult Laparoscopic Cholecystectomy

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ABSTRACT

Objective: Researchers described several anatomical landmarks, a method of identification of the cystic structures referred as "critical view of safety", and operative techniques to avoid vascular and biliary injuries due to the laparoscopic cholecystectomy (LC). In this present study, we aimed to determine the frequencies, variations, and significance of Rouviere's sulcus (RS) in the context of difficult laparoscopic cholecystectomy (DLC).

Methods: The video records of 102 patients with gallbladder disease who underwent LC were reviewed. DLCs were determined according to Tokyo Guidelines. RS type and dimensions, if present, were noted. The features of RS were shown using descriptive statistics and collected data were analyzed using SPSS version 25.0.

Results: Out of 102 patients RS was present in 80 (78.4%) patients. The most frequent type of the sulcus was horizontal, less frequently oblique, and rarely vertical. The most frequent sulcus type was type 1A, less frequently type 1B and type 2, and rarely type 3. The average dimension was 12.5 mm in length and 6.9 mm in width. A vessel or a biliary structure was commonly seen in type 1A sulci. We identified almost half of the cholecystectomy operations as DLCs and the RS was present in two-third of these DLCs while the RS was present in majority of standard LC. LC was performed in majority of the patients except for four patients in whom open surgery was preferred due to intense inflammation. No mortalities or bile duct injuries were identified.

Conclusion: The frequency and type of RS in this sample from Turkey were found to be like the reports in literature. When available (present and visualized), RS contributes a lot to the safety measures of LC. When it comes to DLCs, the availability and convenience of RS might be limited or misleading for surgeons.

Keywords: Rouviere's sulcus, laparoscopic cholecystectomy, liver, anatomy

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INTRODUCTION

Gallstones are frequently seen clinical entities causing significant morbidity and mortality in the United States and when associated with symptomatic gall bladder disease, they require surgical removal (1). Similarly, cholecystectomy is the most performed surgical procedure after caesarean section in Turkey. It was reported that more than 120,000 cholecystectomies were performed by surgeons working in state hospitals per 2017 due to the State Hospitals Report of Turkey (2). After the introduction of laparoscopic cholecystectomy (LC) by Erich Mühe of Germany on September 12, 1985 under direct scope vision, it has been accepted rapidly and become the gold standard surgical procedure for treatment of gallbladder stones due to its advantages such as need for small incision, short hospital stay, cost-effectiveness, and others (3). Despite its advantages, biliary duct injury rates increased significantly at the beginning and showed a fluctuating course during the past three decades. Vasculobiliary injuries, one of the most feared iatrogenic complications, have been encountered in 0.3-0.6% of LCs. Although the mortality rates declined from 90-100% to 2-4%, thanks to the evolution of diagnosis and treatment of these injuries, morbidity is still as high as 40-50% (4,5). Misidentification of the bile duct anatomy is the prominent reason for these iatrogenic injuries to the bile ducts or hepatic arteries.

Some safety measures and anatomical landmarks have been proposed to avoid these iatrogenic injuries (6). The most well-known and accepted identification technique is the critical view of safety (CVS). The CVS has three components: dissecting fat and fibrous tissues at the triangle of Calot, separating the lowest part of the gallbladder from the cystic plate, which is the flat fibrous surface to which the non-peritonealized side of the gallbladder is attached, and lastly defining two structures, and only two, entering the gallbladder (7). Once these three criteria have been met, the CVS has been secured. In addition, the imaginary line between Rouviere's sulcus (RS) and umbilical fissure at the base of segment IVb of the liver to the hepatic ligament was defined as R4U line, and dissecting ventrally to this was suggested to be safe to achieve CVS while avoiding bile duct injuries during LC operations (6,8,9).

The RS is a transverse sulcus on the inferior surface of the right lobe of the liver, running to the right of the hepatic hilum. It was first described by Henrie Rouviere in 1924 and named as "sillon du processus caudé". Gans named it "incisura dextra" in 1955, Couinaud modified it as "le sillion du processus caudé de Rouviere" in 1957, and it was used as "incisura dextra of Gans" in 1991. Subsequently, the researchers preferred the term "RS" (8). RS is seen best when the gallbladder neck is retracted towards the umbilical fissure during LC (10). This anatomical landmark, laparoscopically easily identified structure was thought to be unaffected from inflammation of the gallbladder and biliary tract. On the other hand, in difficult cholecystectomy surgeries, the identification and feasibility of this sulcus are not established well. Inflammation around the hilum of the liver and gallbladder can interfere with safe dissection (11). The anatomical researchers reported the presence of RS in 11-82% of the livers, either as open or fused type, perhaps due to geographical differences (12,13).

In this present study, we aimed to determine the frequency of RS in Turkish population and assess its surgical relevance and impact in difficult cholecystectomy operations (LCs).

METHODS

Study Subjects

This retrospective descriptive study was conducted in coordination with the University of Health Sciences Turkey Gaziosmanpaşa Training and Research Hospital. We obtained the Ethics Committee approval from the University of Health Sciences Hamidiye Scientific Research Ethics Committee (decision no: 12/9, date: 02.04.2021).

In accordance with ethical provisions, LC video records of 102 patients who were operated in between August 2019 and December 2019 were reviewed. The patients who were older than 18 years and presented to the hospital with symptomatic benign gallbladder disease secondary to gallstones were included. Patients with previous upper abdominal surgeries (laparoscopic or open) and suspected malignant diseases were excluded. The consent form was not required in this study because it was a retrospective study.

Procedure

The four-trocar LC method was preferred in all patients. After dissecting the hepatocystic triangle (also known as Calot's triangle), two structures entering the gallbladder were identified, clipped, and cut. Intraoperative findings related to inflammation of the gallbladder, like fibrotic adhesions, edematous, necrotic, or easily bleeding at dissection were identified according to the video records. As outlined and recommended in Tokyo Guidelines (14); we attempted to assess intraoperative findings as objective indicators of surgical difficulty and when we did not obtain a CVS, we converted to open cholecystectomy or other bail-out procedures, and it was evaluated as difficult cholecystectomy (14). The RS was identified when seen at any moment of the entire video record and classified according to the Péré et al.'s (8) classification (Table 1). Directions of RS were classified as horizontal, vertical, or oblique according to Cantlie's line (15). The dimensions of RS were measured intra-operatively by a ruler or a feeding tube. If the length was not measured intra-operatively, the measurement was performed on the video screen by comparing it with a known sized instrument such as a dissector. Also, we noted any other sulcus-like structures during the evaluation of the records. We conducted a cadaveric dissection. After opening the abdominal cavity, the falciform ligament was cut off. The liver was released from the visceral surface, keeping the gallbladder in the statute. The section at the falciform ligament was advanced to the coronal ligament and the coronal ligament with the right and left triangular ligaments were cut off. The free border of the lesser omentum and hepatic

portion of the inferior vena cava were cut off. The diaphragmatic surface through which inferior vena cava passed was cut off, and the liver was released (Figure 1). After dissection of the hepatic tissue around the RS, we exposed the right portal vein of the liver sulcus (Figure 2).

Statistical Analysis

According to the power analysis result using G power 3.1.9.7 version, we determined that a total of 108 images should be obtained with 80% effect size and 95% power ratio. The features of RS were displayed using descriptive statistics and collected data were analyzed using SPSS version 25.0 (IBM SPSS Statistics for Windows. Armonk, NY: IBM Corp.). The analysis of RS presence was performed using chi-squared test. The statistically significant value was set as $p<0.05$.

RESULTS

Out of the 102 patients included in the study, 70 (68.6%) were female and 32 (31.4%) were male patients. The mean ages were 43.71 and 51.06, respectively. Out of the 102 patients, RS was present in 80 of 102 patients (78.4%).

In terms of the direction of RS, the most frequent type of the sulcus was horizontal, less frequently oblique, and rarely vertical (Table 2). In terms of morphology of the sulcus; the most frequent type was type 1A (a deep sulcus which was continuous medially within the hilum of the liver, Figure 3), less frequently type 1B (a deep sulcus which was fused medially, Figure 4) and type 2 (slit-like, superficial and narrow, Figure 5), and rarely type 3 (as a scar, since it appeared as a fused line, Figure 6) (Table 2).

Table 1. Types of Rouviere's sulcus due to morphology of the sulcus

Type 1A	A deep sulcus, open at the hilar side
Type 1B	A deep sulcus, closed at the hilar side
Type 2	Slit-like sulcus
Type 3	Scar-like sulcus appears as a white line of fusion

Figure 1. At the visceral surface of the liver Rouviere's (type 1A) sulcus exposed

In terms of dimension of the sulcus, the average dimension was 12.5 mm in length and 6.9 mm in width. We measured the width only in deep ones. A vessel or a biliary structure was frequently seen in type 1A sulci. We also noted additional sulci at the inferior surface of the right liver in 25 of 102 (24.5%) video records. They were in various dimensions and directions, but two of them were very close to RS and thought to be duplicate RS at first sight (Figure 7, 8).

Out of the 102 operations, 48 (47.1%) were classified as difficult laparoscopic cholecystectomies (DLCs) according to the Tokyo Guidelines (14). We identified the RS in 29 of 48 (60.4%) of DLC operations while identified the RS in 51 of 54 (94.4%) standard LCs ($p<0.01$) (Table 3).

The LC was performed in 98 of 102 (96.1%) patients. The surgeons converted to open surgery in 4 patients (3.9%) because of intense inflammation around the Calot's triangle which prevented the achievement of CVS. One patient appeared to have Mirizzi's syndrome type 3, and a T-tube was placed after cholecystectomy. There were no mortalities or bile duct injuries.

DISCUSSION

In this present study, the RS was present in most patients and was nicely visible during laparoscopy, being visible in one form or another such as a sulcus, or a variation. It was visible in 78.4% of the patients. In terms of the direction of RS, the most frequent type was horizontal, less frequently oblique, and rarely vertical. In terms of morphology of the sulcus, the most frequent type was type 1A (a deep sulcus which was continuous medially within the hilum of the liver), less frequently type 1B (a deep sulcus which was fused medially) and type 2 (slit-like, superficial and narrow), and rarely type 3 (as a scar, since it appeared as a fused line). In terms of dimension of the sulcus, the average dimension was 12.5 mm in length and 6.9 mm in width. A vessel or a biliary structure was commonly seen in type 1A sulci. We also observed additional sulci at the inferior surface of the right liver in one fourth of the

Figure 2. The right portal vein of the liver within the sulcus

patients with various dimensions and directions. We identified almost half of the cholecystectomy operations as DLCs and the RS was present in two-third of these DLCs while the RS was present in majority of standard LCs. Finally, LC was performed in majority of the patients except for four patients in whom open surgery was preferred due to intense inflammation around the Calot's triangle which prevented the achievement of CVS. No mortalities or bile duct injuries were identified (15).

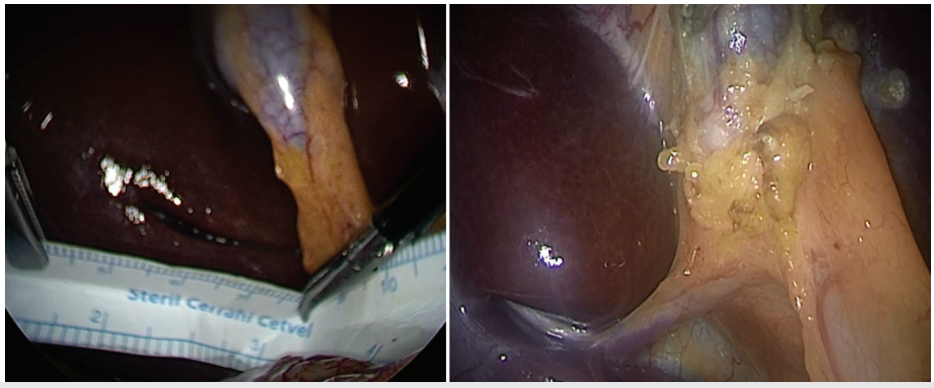

Figure 3. Type 1A

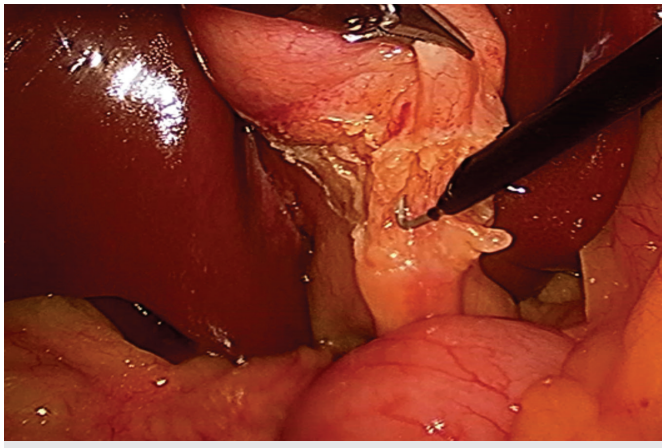

Figure 4. Type 1B

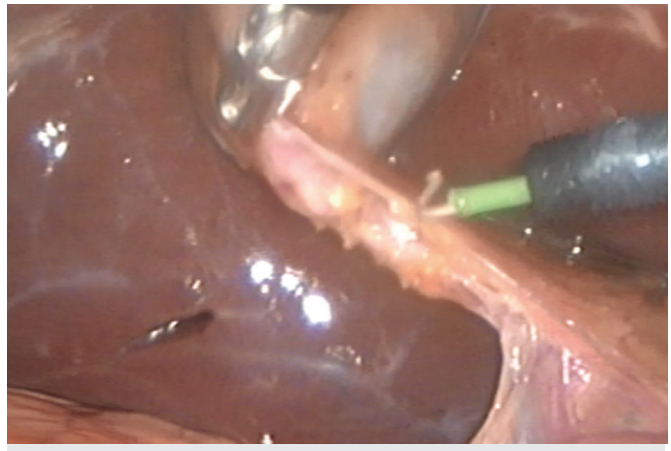

Figure 5. Type 2

Table 2. The morphology and direction of the sulcus of Rouviere's sulcus

Rouviere's sulcus type	Horizontal	Oblique	Vertical	Total	%
Type 1A	39	11	1	51	63.75
Type 1B	4	9	1	14	17.50
Type 2	2	4	1	7	08.75
Type 3	4	4	-	8	10.00
Total	49	28	3	80	-
%	61.25	35.00	3.75		100

Table 3. Statistical comparison per Rouviere's sulcus availability

	Rouviere's sulcus			p
	Available	Absent	Total	
Normal LC	51 (94.4%)	3 (5.6%)	54 (100%)	0.001
DLC	29 (60.40%)	19 (39.6%)	48 (100%)	<0.01
Total	80 (78.40%)	22 (21.60%)	102 (100%)	-

Chi-square test; χ^2=17.394; df=1
LC: laparoscopic cholecystectomy, DLC: difficult laparoscopic cholecystectomy, df: degrees of freedom

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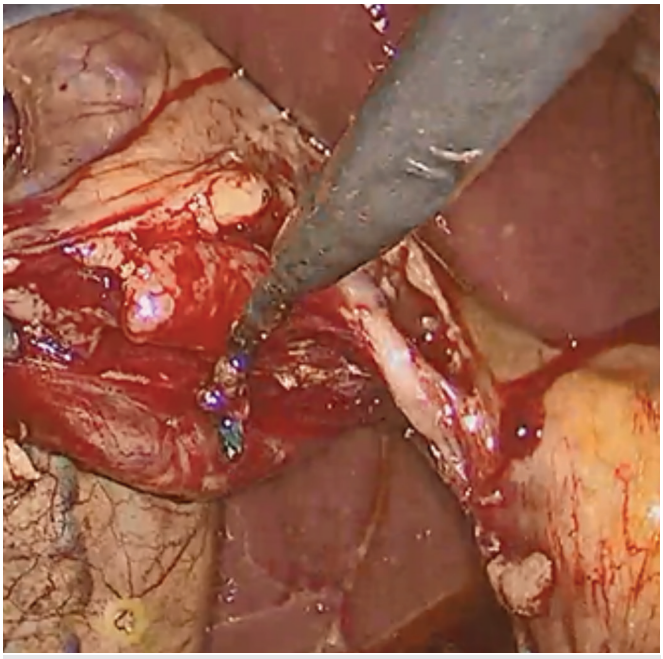

Figure 6. Type 3

The frequency of RS (78.4%) in this present study is similar to the frequencies reported in the literature, ranging from 68 to 90.6% (16). According to a recent meta-analysis, overall pooled prevalence of RS was 83% (95% confidence interval: 78-87), which was similar to our results. In addition, no significant differences were found in terms of prevalence between cadaveric studies and laparoscopic studies (17). When we compared difficult and normal cholecystectomies, we found a significant difference in terms of frequencies. Since laparoscopic studies differ from cadaveric ones, the first no harm rule must be obeyed. Dissection around the inflamed area might cause injury to adjacent tissue including the common bile duct, portal vein, hepatic artery, duodenum, or colon. So, additional dissection was not performed to identify RS (18). This may cause inability to see RS due to inflammation around. Moreover, other fissures can be misidentified as RS and can be misleading surgeons during difficult cholecystectomies.

The clinical significance of the types of RS is still unclear (17). It has not been associated with a clinical condition so far. Emphasis is placed on the ability to guide the surgeon to the dissection site, and when there is an RS, it guides well. The CVS is not a dissection

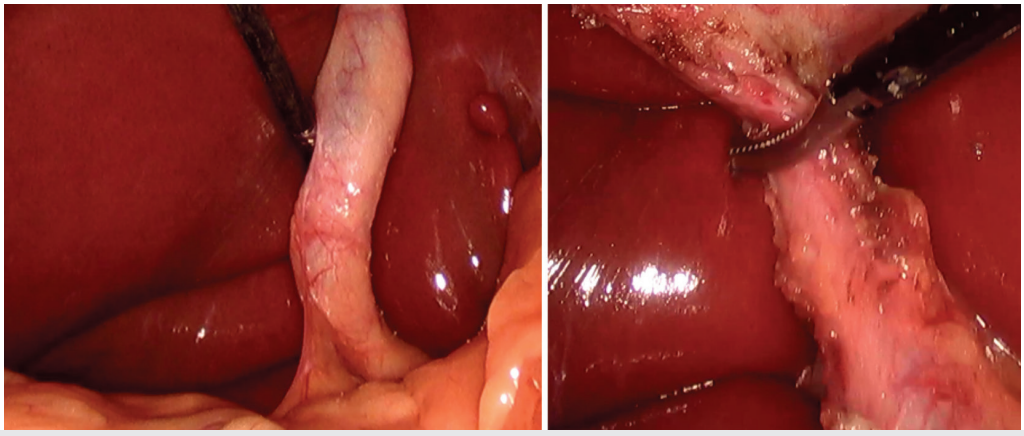

Figure 7. Double RS 1
RS: Rouviere's sulcus

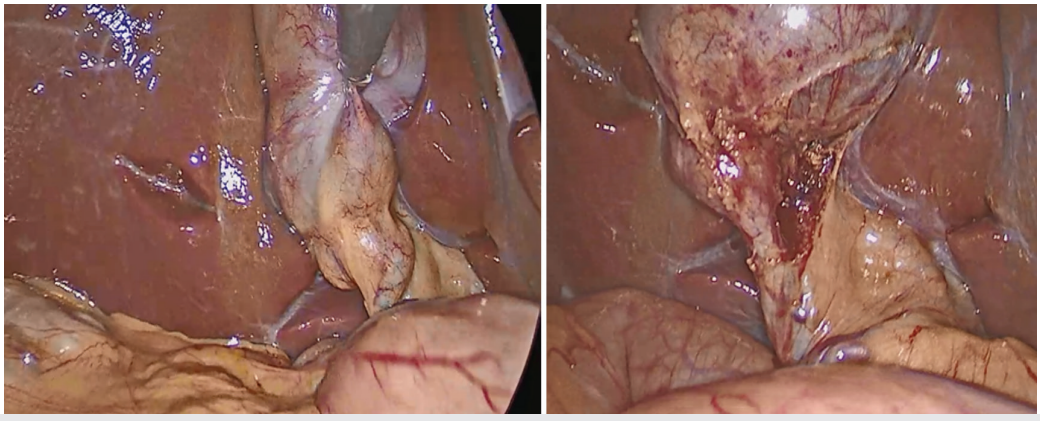

Figure 8. Double RS 2
RS: Rouviere's sulcus

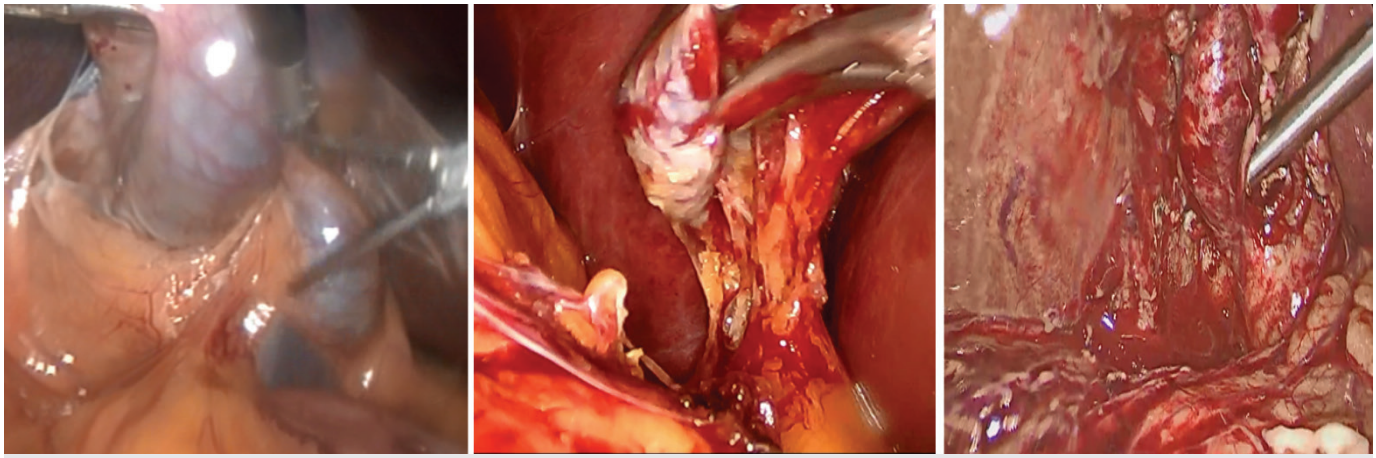

Figure 9. RS was not available due to chronic adhesions or was absent in normal and inflammatory patients
RS: Rouviere's sulcus

method but an identification tool to prevent bile duct injuries. If a surgeon cannot perform safe dissection and achieve CVS, bail-out strategies should be used freely for patient safety. As the inventor of CVS Strasberg and Brunt (7) once said, "The simple method to handle the difficult gallbladder is do not handle!". Those patients should be evaluated carefully preoperatively, and operation should be performed after the inflammation is treated (17). Fibrotic adhesions may not regress, even if an appropriate antibiotic therapy and a sufficient waiting period in some patients have been commenced. Although the surgeries in our study were elective surgeries, 48 of them were difficult cholecystectomies according to the Tokyo Guidelines (14). We recognized RS in 29 (60.4%) of the 48 DLCs. In these patients, RS cannot be seen due to adhesions and cannot guide the surgeon (Figure 9). Therefore, surgeons should use other safety measures during the operations like perioperative cholangiography, subtotal cholecystectomy, or simply drainage.

Study Limitations

The present study has certain limitations. First, our study sample was composed of video recordings of LCs. Second, our sample size was small to generalize our findings. However, despite these limitations, one of the strengths of the study was that it provided data for significance of RS in DLCs. On the other hand, due to relatively small number of our patients, it cannot be claimed that not detecting the RS during the operation will increase the complications. Then again, visualizing RS and not dissecting below that line certainly give surgeons a sigh of relief.

CONCLUSION

In summary, the present study contributes to an understanding of the significance of RS in DLC operations. The frequency and type of RS in this sample from Turkey were found to be similar to the reports in literature. When available (present and visualized), RS contributes a lot to the safety measures of LC. On the other hand, when it comes to DLC, the availability and convenience of RS might be limited or misleading for surgeons.

Besides precise knowledge of anatomy, awareness of variations and misidentification set-ups are the key elements for patient safety during surgery. It is especially true for laparoscopic surgeries that with two-dimensional images and perspective misidentification might end up with a surgical disaster. Since the LC is among the most performed surgeries worldwide, surgeons need to be aware of anatomical landmarks, safety measurements, and bail-out strategies.

Ethics Committee Approval: We obtained the ethics committee approval from the University of Health Sciences Hamidiye Scientific Research Ethics Committee (decision no: 12/9, date: 02.04.2021).

Informed Consent: The consent form was not required in this study because it was a retrospective study.

Peer-review: Externally and internally peer-reviewed.

Author Contributions: Surgical and Medical Practices - E.A., M.K.; Concept - E.A., M.K.; Design - E.A., M.K., M.B., B.K., H.A.B.; Data Collection and/or Processing - E.A., M.K., M.B., B.K., H.A.B.; Analysis and/or Interpretation - E.A., M.K., M.B., B.K., H.A.B.; Literature Search - E.A., M.K., M.B., B.K., H.A.B.; Writing - E.A., M.K., M.B., B.K., H.A.B.

Conflict of Interest: The authors have no conflict of interest to declare.

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